DAV UNIVERSITY JALANDHAR

FACULTY OF AGRICULTURAL SCIENCES

COURSE CURRICULUM

FOR

M.Sc. Ag. (Genetics & Plant Breeding)

1st to 4th SEMESTER

Examinations 2024-2025 session onwards

Applicable for admissions in 2024

Vision of the Department:

Develop human resource to be able to cater to the needs of stakeholders in academia, industry and public/private sector for achieving livelihood security through sustainable agriculture.

Mission of the Department:

- Developing excellence in agriculture education and emerging as leader
- Imparting education to foster inter- disciplinary approach for sustainable agriculture
- Training manpower for upcoming challenges in agriculture with an aim at resource conservation and enhancing farm income

Programme Educational Objectives

- **PEO 1**- Enhance the students' understanding of plant breeding and genetics principles and enable them to apply this knowledge to solve real world problems in crop improvement.
- **PEO 2**- Develop practical and research skills in plant breeding and genetics to design and conduct experiments, analyze data and interpret results.
- **PEO 3**- Foster critical thinking, problem-solving, and decision-making abilities to develop human resource to take informed decisions in plant science context.
- **PEO 4**- Encourage interdisciplinary collaboration and professional development to make students understand the importance of ethics, sustainability and global food security in their work.
- Instructional Methods:
  Power point presentation
  Chalk and Board
  Smart board
  Lectures
  Assignments, quiz
  Group tasks, student's presentations
- Name of the Programme:
  M. Sc. Agriculture (Genetics & Plant Breeding)

❖ **Key Facts & Figures (about the Programme)**

- Type: Masters
- Degree: M. Sc. Agriculture (Genetics & Plant Breeding)
- Eligibility: B.Sc. (Agriculture /Horticulture with a minimum CGPA of 6.50 in 10 point scale, 3.25 in 5 point scale or 2.60 in 4 point scale (60% marks if CGPA is not given). For SC/ST candidates, a minimum CGPA of 5.50 in 10 point scale, 2.75 in 5 point scale or 2.20 in 4 point scale (50% marks where CGPA is not given)
- Mode of study: Full-time
- Medium of Instruction: English
- Credit Points: 40 + 30

- Location: DAV University Campus
- Start date: July-August

❖ Overview of the Programme

A master's degree in Genetics and Plant Breeding is a two-year postgraduate study in agriculture. Genetics and Plant Breeding is a rapidly growing field of contemporary biology and modify plant features to create desirable qualities and, as a result, increase the quality of nutrition in human and animal products are covered in the curriculum. Students will largely learn various techniques for developing improved varieties and genetic stocks, changing the genetic make-up of plants and developing innovative breeding strategies to increase food, feed, and fibre production.

During the study, students would gain theoretical and practical knowledge of crop improvement methods and strategies for the improvement of cereals, pulses, oilseeds and forage crops. Students would also learn innovative techniques like marker assisted selection, QTL mapping and allele mining. Practical training in laboratories and fields is an integral part of this programme. Students would conduct research experiments and write thesis to complete the requirement of Master's degree. Students would interact with the breeders and scientists of other state research universities and private seed industries.

❖ The programme outline

(i) Course work	
Major courses	20
Minor courses	08
Supporting course	06
Common courses	05
Seminar	01
(ii) Thesis Research	30
Total	70

Scheme of Courses

M. Sc. Ag. (Genetics & Plant Breeding)

Semester 1

Outline of the Courses

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	AGS 511	Principles of Genetics	Major	2	0	1	3
2	AGS 512	Principles of Plant Breeding	Major	2	0	1	3
3	CSA 559	Computer fundamentals and programming	Supporting Course	2	0	1	3
4		Departmental elective- I	Major	2	0	1	3
5		Departmental elective- II	Major	2	0	1	3
6		Open elective or Interdisciplinary elective-I	Minor	2	0	1	3
	Total			12		6	18

Departmental Elective- I & II (Choose any two course)

S. No	Paper Code	Course Title	Course Type	L	T	P	Cr
1	AGS513A	Breeding Vegetable Crops	Major	2	0	1	3
2	AGS514A	Breeding Fruit Crops	Major	2	0	1	3
3	AGS 515A	Breeding for Stress Resistance and Climate Change	Major	2	0	1	3
4	AGS 516A	Crop Breeding - I (*Kharif Crops*)	Major	2	0	1	3
5	AGS517A	Breeding Ornamental Crops	Major	2	0	1	3
6	AGS 518A	Germplasm Characterization and Evaluation	Major	1	0	1	2
7	AGS 519	Seed Production and Certification	Major	1	0	1	2

L: Lectures T: Tutorial P: Practical Cr: Credits

Semester II

S. No	Paper Code	Course Title	Course Type	L	T	P	Cr
1	AGS 522A	Fundamentals of Quantitative Genetics	Major	2	0	1	3
2	AGS 523A	Molecular Breeding and Bioinformatics	Major	2	0	1	3
3	ENG 551	Technical Writing and Communication skills	Common Course	0	1	1	1
4	AGS 503	Intellectual Property and its management in Agriculture	Common Course	1	0	0	1
5		Departmental elective- III	Major	2	0	1	3
6		Open elective or Interdisciplinary elective-II	Minor	1	0	1	2
7	AGS500	Masters' Research	Research	0	1	4	4
				10	2	5+4	13+4

L: Lectures T: Tutorial P: Practical Cr: Credits

Departmental elective- III (Choose any one course)

S. No	Paper Code	Course Title	Course Type	L	T	P	Cr
1	AGS 521	Principles of Cytogenetics	Major	2	0	1	3
2	AGS 524	Mutagenesis and mutation breeding	Major	2	0	1	3
3	AGS 526A	Breeding for Quality and Special Traits	Major	2	0	1	3
4	AGS 527A	Hybrid Breeding	Major	2	0	1	3
5	AGS 528A	Varietal Development and Maintenance Breeding	Major	1	0	1	2
6	AGS525A	Crop Breeding-II (*Rabi* Crops)	Major	2	0	1	3
7	AGS 529A	Genetic enhancement for PGR Utilization	Major	1	0	1	2

L: Lectures T: Tutorial P: Practical Cr: Credits

Semester III

S. No	Paper Code	Course Title	Course Type	L	T	P	Cr
1	MTH670	Statistical Methods for Applied Sciences	Supporting Course	3	0	1	4
2	AGS501	Library and Information services	Common Course	0	1	1	1
3	AGS504	Basic concepts of Laboratory Techniques	Common Course	0	1	1	1
4	AGS 505	Agricultural Research, ethics and rural developmental programmes	Common Course	1	0	0	1
5	EVS 658	Disaster Management	Common Course	1	0	0	1
6		Open elective or Interdisciplinary elective-III	Minor Course	1	0	1	2
7	AGS 550	Master's Seminar	Major Course	0	1	1	1
8	AGS500A	Master's Research	Research	0	1	6	6
				7		6+6	11+6

L: Lectures T: Tutorial P: Practical Cr: Credits

Semester IV

S. No	Paper Code	Course Title	Course Type	L	T	P	Cr
1.	AGS500B	Master's Research	Research	0	1	15	15
2.	AGS500C	Thesis work	Research	0	1	5	5

L: Lectures T: Tutorial P: Practical Cr: Credits

Course Code	**AGS511**						
Course Title	**Principles of Genetics**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Understanding of pre Mendelian and Mendelian genetics and importance of hereditary material in crop evolution **CO2:** Demonstrate the nature, structure and expression of genetic material **CO3:** Illustrate the regulation of gene activity and techniques of gene cloning, nucleic acid hybridization and immunochemical detection **CO4:** Understanding of various omic approaches and their use in treating genetic disorders						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** Beginning of genetics, Early concepts of inheritance, Mendel's laws, Discussion on Mendel's paper and 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.						**CO1**
	Unit 2: (6 hours) Mendelian population, random mating population, frequencies of genes and genotypes, causes of change, Hardy-Weinberg equilibrium. 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, transposable genetic elements, overlapping genes, pseudogenes, oncogenes,						**CO2**

	Gene families and clusters.	
	Unit 3: (6 hours) Regulation of gene activity in prokaryotes, molecular mechanisms of mutation, repair and suppression, Bacterial plasmids, insertion (IS) and transposable (Tn) elements, molecular chaperones and gene expression, Gene regulation in eukaryotes, genome editing, 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).	**CO3**
	Unit 4: (6 hours) Genomics, Proteomics, Metagenomics, Transgenic bacteria and bioethics, Gene silencing, genetics of mitochondria and chloroplasts, Concepts of eugenics, epigenetics, Genetic disorders,	**CO4**
	Practical: (24) 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.	

Reference Books:

1. Gardner EJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley & Sons.
2. Klug WS and Cummings MR. 2003. Concepts of Genetics. Peterson Edu.
3. Lewin B. 2008. Genes IX. Jones & Bartlett Publ.
4. Russell PJ. 1998. Genetics. The Benzamin/Cummings Publ. Co.

5. Snustad DP & Simmons MJ. 2006. Genetics. 4th Ed. John Wiley & Sons.
6. Strickberger MW. 2005. Genetics. 3rd Ed. Prentice Hall.
7. Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publs.
8. Uppal S, Yadav R, Subhadra and Saharan RP. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU, Hisar.
9. Sharma, A. K. and Sharma, R. A. 2013. Crop Improvement and Mutagenesis. Scientific Publishers, Jodhpur.
10. Daniel LH and Maryellen R. 2011. Genetics: 'Analysis of Genes and Genomes'.

Course Code	**AGS512**						
Course Title	**Principles of Plant Breeding**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Learn the role and genetics of breeding in crop improvement and evolution of crop plants **CO2:** Illustrate breeding methods for the improvement of self-pollinated and cross pollinated crops **CO3:** Demonstrate population improvement and hybrid breeding schemes for the improvement of cross pollinated crops **CO4:** Understand breeding scheme for clonally propagated crops and special breeding techniques of varietal development						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** Early plant breeding, accomplishment 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, 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;						**CO1**
	Unit 2: (6 hours) General and specific combining ability; Types of gene actions and implications in plant breeding Pure line theory, pure line selection and mass selection methods, line breeding,						**CO2**

	Pedigree, bulk, backcross, single seed descent and multiline method, Population breeding in self-pollinated crops with special reference to diallel selective mating approach. Transgressive breeding, Breeding methods in cross pollinated crops, population breeding-mass selection and ear-to-row methods, S1 and S2 progeny testing,	
	Unit 3: (6 hours) Progeny selection schemes, recurrent selection schemes for intra and Interpopulation improvement and development of synthetics and composites, Hybrid breeding, genetical, physiological and molecular basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance, Seed production of hybrid and their parent varieties/inbreds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation	**CO3**
	Unit 4: (6 hours) Breeding methods in asexually/clonally propagated crops, clonal selection and clonal hybridization. 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. Cultivar development- testing, release and notification, maintenance breeding, Participatory plant breeding, plant breeders' rights and regulations for plant variety protection and farmers rights.	**CO4**
	Practical (24) Floral biology in self and cross pollinated species, Selfing and crossing techniques self and cross pollinated crops 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 Demonstration of MAS.	

Reference Books:

1. Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.
2. Chopra VL. 2001. Breeding Field Crops. Oxford & IBH.
3. Chopra VL. 2004. Plant Breeding. Oxford & IBH.
4. Gupta SK. 2005. Practical Plant Breeding. Agribios.
5. Pohlman JM and Bothakur DN. 1972. Breeding Asian Field Crops. Oxford & IBH.
6. Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House.
7. Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
8. Simmonds NW. 1990. Principles of Crop Improvement. English Language Book Society.
9. Singh BD. 2022. Plant Breeding: Principles and Methods. Kalyani Publishers.
10. Singh P. 2002. Objective Genetics and Plant Breeding. Kalyani Publishers.
11. Singh P. 2006. Essentials of Plant Breeding. Kalyani Publishers.
12. Singh S and Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS

<table>
<tr><td>Course Code</td><td colspan="7">AGS513A</td></tr>
<tr><td>Course Title</td><td colspan="7">Breeding Vegetable Crops</td></tr>
<tr><td>Hours</td><td colspan="7">48 L:24, T:0, P:24</td></tr>
<tr><td>Credits</td><td colspan="7">3</td></tr>
<tr><td>Type</td><td colspan="7">Multi-Disciplinary Course</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On the completion of the course, the student will gain the following knowledge and skills:

CO1: Learn different breeding methodologies for the improvement of leafy and cucurbitaceous vegetables
CO2: Demonstrate breeding methods for the improvement of solanaceous and root vegetables
CO3: Illustrate breeding methods for the improvement of cole crops
CO4: Explain breeding approaches for the improvement of other important vegetable crops</td></tr>
<tr><td>Examination Type</td><td colspan="7">Theory + Practical</td></tr>
<tr><td>Assessment Tools</td><td>Written Quiz</td><td>Assignment/Project Work</td><td>MSE</td><td>MSP</td><td>ESE</td><td>ESP</td><td>ABL/PBL</td></tr>
<tr><td>Weightage</td><td>10%</td><td>0</td><td>25%</td><td>0</td><td>35%</td><td>25%</td><td>5%</td></tr>
<tr><td>Examination Mode</td><td colspan="6">Theory + Practical</td><td></td></tr>
<tr><td>Syllabus</td><td colspan="6">Unit 1: (6 hours)
Breeding for Leafy vegetables:
Amaranth,
Chenopods and
Lettuce,
Breeding for Cucurbits:
Gourds,
Melons,
Pumpkins and squashes.</td><td>CO1</td></tr>
<tr><td></td><td colspan="6">Unit 2: (6 hours)
Breeding for Solanaceae vegetables:
Potato and
Tomato,
Eggplant,
Hot pepper and sweet pepper
Breeding for Root vegetables:
Carrot,
beetroot,</td><td>CO2</td></tr>
<tr><td></td><td colspan="6">Unit 3: (6 hours)
Breeding for Root vegetables:
Radish,</td><td>CO3</td></tr>
</table>

	Sweet potato and Tapioca. Breeding for Cole crops: Cabbage, Cauliflower, Broccoli	
	Unit 4: (6 hours) Breeding for Cole crops: knolkhol. Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.	**CO4**
	Practical (24) 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 invegetable 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 andspecial breeding techniques; Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.	

Reference Books:

1. Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons.
2. Fageria MS, Arya PS and Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production.
3. Vol. I. Kalyani Publishers, New Delhi.
4. Kalloo G. 1988. Vegetable Breeding. Vols. I-III. CRC Press.
5. 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.
6. Rai N and Rai M. 2006. Heterosis Breeding in Vegetable Crops. New India Publication Agency.
7. Ram HH. 2005. Vegetable Breeding-Principles and Practices. Kalyani

Publishers
8. Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publishers, New Delhi.
9. Singh BD. 2015. Plant Breeding. Kalyani Publishers

Course Code	**AGS514A**						
Course Title	**Breeding Fruit Crops**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Learn the importance of fruit crop breeding and its historical aspects **CO2:** Understand various issues related to fruit breeding **CO3:** Illustrate the role of biotechnology in the improvement of fruit crops **CO4:** Demonstrate various breeding methods for the improvement of major fruit crops						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** Fruit crop breeding: History, Importance of fruit breeding, Center of diversity,distribution, domestication and adaptation of commercially important fruits.						**CO1**
	Unit 2: (6 hours) Issues in fruit crop breeding – Heterozygosity, Polyploidy, Polyembryony, Parthenocarpy and seed lessness, Incompatibility and Sterility systems						**CO2**
	Unit 3: (6 hours) Apomixes - merits and demerits, types, Variability for economic traits, Role of genetic engineering and biotechnology in improvement of fruit crops. Crop improvement in Mango, Banana, Citrus, Grapes						**CO3**

	Unit 4: (6 hours) Crop improvement in Papaya, Sapota and Pomegranate, Pineapple and Guava, Apple and other Rosaceous crops and region specific fruit crops.	**CO4**
	Practical: (24 hours) 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.	

Reference Books:

1. Bhojwani SS and Razdan MK. 2006. *Plant Tissue Culture -Theory and Practice*. Elsevier Publication, Amesterdam.
2. Chadha KL and Pareek, OP. 1996. (Eds.). *Advances in Horticulture.* Vol. I to IV. Malhotra Publ. House, New Delhi.
3. Chadha KL and Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House, New Delhi.
4. 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.
5. Kumar N. 2006. *Breeding of Horticultural Crops - Principles and Practices*. New India Publishing Agency, New Delhi.
6. Moore JN and Janick Jules. 1996. *Methods in Fruit Breeding*. Purdue University Press, South Campus Court D., USA.
7. Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK. and Mohanadas S. 2001. *Biotechnology of Horticultural Crops.* Vols. I-III. Naya Prokash, Kolkata.
8. Ray PK. 2002. *Breeding of Tropical and Sub-tropical Fruits*. Narosa Publishing House, New Delhi.
9. Simmonds NW. 1976. *Evolution of Crop Plants*, Orient Longman, London.

Course Code	**AGS515A**						
Course Title	**Breeding for Stress Resistance and Climate Change**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Understanding of various abiotic and biotic stresses influencing crop yield and host defense responses **CO2:** Identify the mechanism and genetics of resistance against biotic stresses **CO3:** Classification of abiotic stresses and breeding methodologies to develop tolerant varieties **CO4:** Role of genomics and transgenics in the management of biotic and abiotic stresses						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** 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, Concepts in insect and pathogen resistance, Analysis and inheritance of resistance, Host defense responses to pathogen invasions-Biochemical and molecular mechanisms, Acquired and induced immunity and systemic acquired resistance (SAR), Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions, Concept of signal transduction and other host-defense mechanisms against viruses and bacteria.						**CO1**
	Unit 2: (6 hours) Types and genetic mechanisms of resistance to biotic stresses - Horizontal and vertical resistance in crop plants, Quantitative resistance/adult plant resistance and slow						**CO2**

	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.	
	Unit 3: (6 hours) Classification of abiotic stresses- Stress inducing factors, moisture stress/drought and water logging & submergence, Acidity, salinity/alkalinity/sodicity, high/low temperature, wind, etc. Stress due to soil factors and mineral toxicity, Physiological and phenological responses, Emphasis of abiotic stresses in developing breeding methodologies. Genetics of abiotic stress resistance, Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/freezing temperatures.	**CO3**
	Unit 4: (6 hours) 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, PR proteins and Bt for diseases and insect pest management- achievements.	**CO4**
	Practical: (24 hours) 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 combatingthem; 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 andbreeding strategies; Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.	

Reference Books:

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

Course Code	**AGS516A**						
Course Title	**Crop Breeding- I (*Kharif* Crops)**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Learn origin, distribution, gene pools, genetics, breeding objectives, breeding approaches and recent advances in the improvement of *kharif* cereals **CO2:** Illustrate origin, distribution, gene pools, genetics, breeding objectives, breeding approaches and recent advances in the improvement of *kharif* pulses **CO3:** Understand origin, distribution, gene pools, genetics, breeding objectives, breeding approaches and recent advances in the improvement of *kharif* oilseed crops **CO4:** Demonstrate origin, distribution, gene pools, genetics, breeding objectives, breeding approaches and recent advances in the improvement of *kharif* fibre, fodder and spice crops						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** Rice: Origin, evolution and distribution of species and forms, wild relatives and germplasm, genetics, cytogenetics and genome relationship, breeding objectives, yield, quality characters, biotic and abiotic stress resistance etc., Breeding approaches, introgression of alien gene(s) (if required), hybrid rice breeding, potential and outcome, examples of MAS used for improvement, aerobic rice, its implications and drought resistance breeding. Maize: Origin, 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., Breeding approaches, introgression of alien gene(s) (if required), heterosis breeding, released varieties, examples of MAS						**CO1**

	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 2: (6 hours) Pigeon pea: Origin, 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. Breeding approaches, introgression of alien gene(s) (if required), 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 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. Breeding approaches, introgression of alien gene(s) (if required), heterosis breeding, released varieties, examples of MAS used for improvement. Other Pulses: Urdbean, mungbean, cowpea: Origin, 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. Breeding approaches, introgression of alien gene(s) (if required), heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.	**CO2**
	Unit 3: (6 hours) Soybean: Origin, 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. Breeding approaches, introgression of alien gene(s) (if required), heterosis breeding, released varieties, examples of MAS used for improvement. Castor and Sesame: Origin, 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	**CO3**

	etc. Breeding approaches, introgression of alien gene(s) (if required), heterosis breeding, released varieties, examples of MAS used for improvement. Hybrid breeding in castor – opportunities, constraints and achievements. Cotton: Origin, 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. Breeding approaches, introgression of alien gene(s) (if required), heterosis breeding, released varieties, examples of MAS used for improvement. Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario and evaluation procedures for Bt cotton.	
	Unit 4: (6 hours) Jute: Origin, 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. Breeding approaches, introgression of alien gene(s) (if required), heterosis breeding, released varieties, examples of MAS used for improvement. Sugarcane: Origin, evolution and distribution of species and forms, wild relatives and germplasm, cytogenetics and genome relationship, breeding objectives, yield, quality characters, biotic and abiotic stress resistance etc., Forage grasses: Origin, 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 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. Breeding approaches, introgression of alien gene(s) (if required), heterosis breeding, released varieties, examples of MAS used for improvement. Achievements of important spice crops.	**CO4**
	Practical: (24 hours) 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 betweenblack 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 softwarefor database management and retrieval; Practical learning on the cultivation of fodder crop species on sewage water, analysing them for yield components and palatability; Laboratory analysis of forage crops for crude protein, digestibility percent andother quality attributes; Visit to animal feed producing factories; Learning the practice of value addition; Visiting the animal husbandry unit andlearning the animal experiments related with palatability and digestibility of fodder.	

Reference Books:

1. Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl PN & Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol.
   I. Pulses and Oilseeds. Oxford & IBH.
3. Chandraratna MF. 1964. Genetics and Breeding of Rice. Longmans.
4. Chopra VL & Prakash S. 2002. Evolution and Adaptation of Cereal Crops. Oxford and IBH.
5. Gill KS. 1991. Pearl Millet and its Improvement. ICAR.
6. IRRI. 1986. Rice Genetics. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
7. IRRI. 1991. Rice Genetics II. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
8. IRRI. 1996. Rice Genetics III. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
9. IRRI. 2000. Rice Genetics IV. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
10. Kannaiyan S, Uthamasamy S, Theodore RK & Palaniswamy S. 2002. New Dimensions and Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU, Coimbatore.
11. Murty DS, Tabo R & Ajayi O. 1994. Sorghum Hybrid Seed Production and Management. ICRISAT, Patancheru, India.
12. Nanada JS. 1997. Manual on Rice Breeding. Kalyani.

13. Ram HH & Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
14. Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
15. Slafer GA. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.
16. Walden DB. 1978. Maize Breeding and Genetics. John Wiley& Sons.

Course Code	**AGS517A**						
Course Title	**Breeding for Ornamental Crops**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Learn historical aspects of ornamental plant breeding **CO2:** Illustrate breeding methods for the improvement of major ornamental crops **CO3:** Demonstrate the role of heterosis and its exploitation of heterosis in hybrid variety development **CO4:** Learn production and certification of open pollinated seeds of ornamental crops						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (4 hours)** History of improvement of ornamental plants; Centre of origin of ornamental crops; Objectives and techniques in ornamental plant breeding.						**CO1**
	Unit 2: (8 hours) Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, *viz*., Rose, Jasmine, *Chrysanthemum*, Tuberose, *Gerbera*, *Gladiolus*, *Dahlia*, *Lilium*, *Gaillardia*, *Petunia*, *Bouganvillea*, Pansy, Marigold, *Geranium*, *Antirrhinum*, China aster, Orchids, *Carnation*, *Hibiscus*, etc.						**CO2**
	Unit 3: (6 hours) Development of promising cultivars of important ornamental and flower crops, Role of heterosis and its exploitation, production of F_1 hybrids and utilization of male sterility.						**CO3**
	Unit 4: (6 hours) Production of open pollinated seeds, harvesting, processing and storage of seeds;						**CO4**

	Seed certification.	
	Practical: (24 hours) Study of floral biology and pollination in important species and cultivars of ornamental crops; Techniques of inducing polyploidy and mutation; Production of pure and hybrid seed; Methods of breeding suited to seed propagated plants; Polyploidy and mutations to evolve new varieties; Breeding methods for biotic and abiotic stresses; Visit to research institutes involved in ornamental crop breeding	

Reference Books:

1. Alexander V. 2002. Breeding for ornamentals: Classical and Molecular Approaches. Kluwer Academic Publishers, London.
2. Allard RW. 1999. Principles of Plant Breeding. John Wiley & Sons. INC. New York.
3. Bhattacharjee SK and De LC. 2003. Advanced Commercial Floriculture Vol. 1. Aavishkar Publishers & Distributors, Jaipur.
4. Bose TK and Yadav LP. 2003. Commercial Flowers. Naya Prokash Publishers, Kolkata.
5. Chadha KL and Bhattacharjee SK. Advances in Horticulture Vol. 12, Malhotra Publishing House, New Delhi.
6. Mc Donald MB and Kwong FY. 2005. Flower Seeds Biology and Technology, CABI Publishing, Oxfordshire, UK.
7. Watts L.1980. Flower and Vegetable Plant Breeding. Grower Books.

Course Code	**AGS518A**						
Course Title	**Germplasm Characterization and Evaluation**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Demonstrate germplasm characterization and diversity studies **CO2:** Learn germplasm evaluation and development of core and mini core collections **CO3:** Illustrate evaluation and exploitation of crop wild relatives in crop improvement **CO4:** Discover high throughput phenotyping for nutritional and resistance traits						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** 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,						**CO1**
	Unit 2: (6 hours) 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. Principles and practices of germplasm regeneration and maintenance,						**CO2**
	Unit 3: (5 hours) Breeding systems and mode of reproduction; Maintaining sufficiently large populations for effective conservation of farmer landraces,						**CO3**

	Evaluation and maintenance of wild relatives of crop plants Genetic enhancement, Use of CWRs genetic resources for crop improvement.	
	Unit 4: (6 hours) High throughput phenotyping systems- imaging and image processing, Concepts for automated germplasm characterization Evaluation for nutritional traits, Evaluation for resistance traits Biochemical and molecular markers for characterization.	**CO4**
	Practical: (24 hours) 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	

Reference Books:

1. Dhillon BS, Varaprasad KS, Kalyani Srinivasan, Mahendra Singh, Sunil Arachak, Umesh Srivastava & Sharma GD. 2001. Germplasm Conservation A Compendium of Achievements. NBPGR, New Delhi.
2. Di Castri, F &Younes T. 1996. Biodiversity Science and Development: Towards New Partnership. CABI, In association with International Union for Biological Science, France.
3. Gurcharan Singh. 2004. Plant Systematics: An Integrated Approach. Science Publ.
4. John H Wiersema. 1999. World Economic Plants: A Standard Reference. Blanca Leon.
5. Lorentz C Pearson. 1995. The Diversity and Evolution of Plants. CRC Press.
6. Paroda RS & Arora RK. 1991. Plant Genetic Resources Conservation and Management Concepts and Approaches. IBPGR Regional office for south and south Asia New Delhi.
7. Singh BP. 1993. Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management. Indo-US PGR project management.
8. Sivarajan VV. 1991. Introduction of Principles of Plant Taxonomy. Science Publ.
9. Takhrajan A. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
10. 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.

11. 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. 50 p

Course Code	**AGS519**						
Course Title	**Seed production and Certification**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Importance of quality seed, production and maintenance of seeds of improved classes **CO2:** Knowledge of principles of varietal and hybrid seed production in field crops **CO3:** Understand the principles of varietal and hybrid seed production in pulses, oilseeds, fiber and vegetatively propagated crops **CO4:** Illustrate **s**eed certification and Minimum Seed Certification Standards (MSCS)						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** 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 purityin seed production; Factors responsible for varietal and genetic deterioration, Nucleus seed production and its maintenance - Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance;						**CO1**
	Unit 2: (6 hours) Principles of seed production in self- and cross-pollinated crops; Hybrid seed production - system and techniques involved in Seed village concept;						**CO2**

	Organic seed production and certification. Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self- and cross-pollinated cereals and millets.	
	Unit 3: (6 hours) 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. Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres, Hybrid-seed production techniques in major vegetatively propagated crops.	**CO3**
	Unit 4: (9 hours) 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	**CO4**
	Practical: (24) 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 at harvesting/ threshing, processing and after processing for seed law enforcement; Specifications for tags and labels to be used for certification purpose.	

Reference Books:

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

Course Code	**AGS521**						
Course Title	**Principles of Cytogenetic**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Learn the structure and composition of eukaryotic and prokaryotic chromosomes and their role in evolution **CO2:** Illustrate the chromosomal variations and their evolutionary significance **CO3:** Techniques to overcome fertilization barriers and role of polyploidy in crop breeding **CO4:** Demonstrate techniques of genome mapping in polyploids and chromosomal manipulations in wide hybridization						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** Cell cycle and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; Artificial chromosome construction and its uses; Special types of chromosomes Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting -*In situ* hybridization and various applications.						**CO1**
	Unit 2: (6 hours) Structural and numerical variations of chromosomes and their implications; Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction;						**CO2**

	Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Inter-varietal chromosome substitutions	
	Unit 3: (6 hours) 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.	**CO3**
	Unit 4: (6 hours) Reversion of autopolyploids to diploids, genome mapping in polyploids, interspecific hybridization and allopolyploids, Synthesis of new crops (wheat, triticale and brassica), Hybrids between species with same chromosome number, alien translocations, Hybrids between species with different chromosome number, Gene transfer using amphidiploids, bridge species. Chromosome manipulations in wide hybridization, Case studies, Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.	**CO4**
	Practical: (24 hours) 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.	

Reference Books:

1. Becker K & Hardin. 2004. The World of Cell. 5th Ed. Pearson Edu.
2. Carroll M. 1989. Organelles. The Guilford Press.
3. Charles B. 1993. Discussions in Cytogenetics. Prentice Hall.
4. Darlington CD & La Cour LF. 1969. The Handling of Chromosomes. Georger Allen & Unwin Ltd.
5. Elgin SCR. 1995. Chromatin Structure and Gene Expression. IRL Press.
6. Gray P. 1954. The Mirotomist's Formulatory Guide. The Blakiston Co.
7. Gupta PK & Tsuchiya T. 1991. Chromosome Engineering in Plants: Genetics, Breeding and Evolution. Part A. Elsevier.
8. Gupta PK. 2000. Cytogenetics. Rastogi Publ.
9. Johannson DA. 1975. Plant Microtechnique. McGraw Hill.
10. Karp G. 1996. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons.
11. Khush GS, 1973. Cytogenetics of Aneuploids. Academic Press.
12. Sharma AK & Sharma A. 1988. Chromosome Techniques: Theory and Practice. Butterworth.
13. Sumner AT. 1982. Chromosome Banding. Unwin Hyman Publ.
14. Swanson CP. 1960. Cytology and Cytogenetics. Macmillan & Co.

Course Code	**AGS522A**						
Course Title	**Fundamentals of Quantitative Genetics**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Understand the principle and concept of quantitative genetics **CO2:** Demonstrate principles of experimental designs and estimation of components of variations **CO3:** Illustrate different mating designs and models for stability analysis **CO4:** Learn strategies for QTL mapping and MAS						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters, Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect, Principles of analysis of variance and linear model, Expected variance components, Random and fixed effect model, Comparison of means and variances for significance						**CO1**
	Unit 2: (6 hours) Designs for plant breeding experiments- principles and applications; Variability parameters, concept of selection, simultaneous selection modes and selection of parents, MANOVA, Association analysis- Genotypic and phenotypic correlation, Path analysis, Discriminate function and principal						**CO2**

	component analysis, Genetic divergence analysis-Metroglyph and D^2, Generation mean analysis, Parent progeny regression analysis	
	Unit 3: (6 hours) 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.	**CO3**
	Unit 4: (6 hours) 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.	**CO4**
	Practical: (24 hours) Analysis and interpretation of variability parameters; Analysis and interpretation of Index score and Metroglyph; Clustering and interpretation of D^2 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	

Reference Books:

1. Bos I & Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall.
2. Falconer DS. 1983. Problems on Quantitative Genetics. Longman.
3. Falconer DS. 1998. Introduction to Quantitative Genetics. Longman.
4. Mather K & Jinks JL. 1971. Biometrical Genetics. Chapman & Hall.

5. Mather K & Jinks J L. 1983. Introduction to Biometrical Genetics. Chapman & Hall.
6. Nadarajan N & Gunasekaran M. 2005. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers.
7. Naryanan SS and Singh P. 2007. Biometrical Techniques in Plant Breeding. Kalyani Publishers.
8. Singh P & Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani Publishers.
9. Singh RK & Choudhary BD. 1987. Biometrical Methods in Quantitative Genetics. Kalyani Publishers.
10. Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.
11. Kearsey Michael J. and Pooni Harpal S. 1996. The Genetical Analysis of Quantitative Traits. Springer- Science + Business Media, B. V.

Course Code	**AGS523A**						
Course Title	**Molecular Breeding and Bioinformatics**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Learn about molecular markers, techniques of molecular mapping and allele mining and MAS in varietal development **CO2:** Illustrate the role of comparative genomics in crop improvement **CO3:** Realize the use of nanotechnology and recombinant DNA technology in crop improvement **CO4:** Learn implications of bioinformatics tools in crop improvement						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** 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, 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						**CO1**
	Unit 2: (6 hours) Introduction to Comparative Genomics; Large scale genome sequencing strategies; Human genome project; Arabidopsis genome project;						**CO2**

	Rice genome project; Comparative genomics tools; Introduction to proteomics; 2D gel electrophoresis; Chromatography and sequencing by Edman degradation and mass spectrometry; Endopeptidases;	
	Unit 3: (6 hours) Nanotechnology and its applications in crop improvement, 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	**CO3**
	Unit 4: (6 hours) Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding; MOs and relatedissues (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.	**CO4**
	Practical: (24 hours) Requirements for plant tissue culture laboratory; Techniques in plant tissue culture; Media components and media preparation; Aseptic manipulation of various explants, observations on the contaminantsoccurring in media, interpretations; Inoculation of explants, callus induction and plant regeneration; Standardizingthe protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardeningprocedures; 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 Ensembl); Primer designing- Primer 3/ Primer BLAST.	

Reference Books:

1. Azuaje F and Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics. John Wiley and Sons.
2. Brown TA. 1991. Essential Molecular Biology: a practical Approach. Oxford university press, 2002, 2nd edition
3. Chawala HS. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd.
4. Chopra VL and Nasim A. 1990. Genetic Engineering and Biotechnology: Concepts, Methods and Applications. Oxford & IBH.
5. Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.
- Hackett PB, Fuchs JA and Messing JW. 1988. An Introduction to Recombinant DNA Technology Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co.
6. Jollès P and Jörnvall H. 2000. Proteomics in Functional Genomics: Protein Structure Analysis. Birkhäuser.
7. Lewin B. 2017. Genes XII. Jones & Bartlett learning, 2017.
8. Robert NT and Dennis JG. 2010. Plant Tissue Culture, Development, and Biotechnology. CRC Press.
9. Sambrook J and Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
10. Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani Publishers, New Delhi. Watson J. 2006. Recombinant DNA. Cold Spring harbor laboratory press.

Course Code	**AGS524**						
Course Title	**Mutagenesis and Mutation Breeding**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Illustrate mutations, their detection, mutagenic agents and radiobiology **CO2:** Effect of radiation induced mutations and repair mechanism at DNA level **CO3:** Classification of chemical mutagens and effect of induced mutations on M1 and M2 generations **CO4:** Knowledge of mutation in genomics, allele mining and TILLING and role in creating variations						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations, Detection of mutations in lower and higher organisms, paramutations, Mutagenic agents: physical, radiation types and sources, ionising and non-ionizing radiations viz., X rays, γ rays, α and β particles, protons, neutrons and UV rays, Radiobiology: mechanism of action of various radiations, (photoelectric absorption, Compton scattering and pair production) and their biological effects, RBE and LET relationships.						**CO1**
	Unit 2: (6 hours) 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						**CO2**

	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 3: (6 hours) 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. 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	**CO3**
	Unit 4: (6 hours) 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 same species – case studies. Use of mutagens in creating oligogenic and polygenic variations, case studies, in vitro mutagenesis, callus and pollen irradiation, handling of segregating generations and selection procedures, validation of mutants, mutation breeding for various traits (disease resistance, insect resistance, quality improvement etc.) in different crops- procedures for micro mutations breeding /polygenic mutations. Achievements of mutation breeding- varieties released across the world- problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.	**CO4**
	Practical: (24 hours) Precautions on handling of mutagens; Dosimetry - studies of different mutagenic agents: physical mutagens and chemical mutagens; Learning on radioactivity; production of source and isotopes at BRIT; Trombay;	

	Learning about gamma chamber; radiation hazards; monitoring, safety regulations and safe transportation of radioisotopes; Visit to radio isotope laboratory; learning on safe disposal of radioisotopes. Hazards due to chemical mutagens, treating the plant propagules at different doses of physical and chemical mutagens; Procedure 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 to be observed; Study of M_2 generation, parameters to be observed; Mutation breeding in cereals and pulses; Achievements made and an analysis, Mutation breeding in oilseeds and cotton. Achievements and opportunities, Mutation breeding in forage crops and vegetatively propagated crops; Procedure for detection of mutations for polygenic traits in M_2 and M_3 generations.	

Reference Books:

1. Alper T. 1979. Cellular Radiobiology. Cambridge Univ. Press, London.
2. Chadwick KH & Leenhouts HP. 1981. The Molecular Theory of Radiation Biology. Springer-Verlag.
3. Cotton RGH, Edkin E & Forrest S. 2000. Mutation Detection: A Practical Approach, Oxford Univ. Press, USA.
4. International Atomic Energy Agency. 1970. Manual on Mutation Breeding. International Atomic Energy Agency, Vienna, Italy.
5. Singh BD. 2003. Genetics. Kalyani.
6. Strickberger MW. 2005. Genetics (III Ed). Prentice Hall
7. Q.Y. Shu, B.P. Forster, H. Nakagawa (Ed). 2012. Plant Mutation Breeding and Biotechnology. Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture International Atomic Energy Agency, Vienna, Austria
8. Manual on Mutation Breeding. 1977. 2nd edition. Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture

Course Code	**AGS525A**						
Course Title	**Crop Breeding- II (*Rabi* Crops)**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Learn origin, distribution, gene pools, genetics, breeding objectives, breeding approaches and recent advances in the improvement of *Rabi* cereals **CO2:** Illustrate origin, distribution, gene pools, genetics, breeding objectives, breeding approaches and recent advances in the improvement of *Rabi* pulses **CO3:** Understand origin, distribution, gene pools, genetics, breeding objectives, breeding approaches and recent advances in the improvement of *Rabi* oilseed crops **CO4:** Demonstrate origin, distribution, gene pools, genetics, breeding objectives, breeding approaches and recent advances in the improvement of *Rabi* fibre, fodder and spice crops						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** **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						**CO1**

	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 2: (6 hours) **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, reasonsfor failure, ways of overcoming them.	**CO2**
	Unit 3: (6 hours) **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 of 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.	**CO3**
	Unit 4: (6 hours) **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	**CO4**

	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. **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: (24 hours) 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.	

Reference Books:

1. Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl PN & Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. Oxford & IBH.
3. Chahal GS & Ghosal SS. 2002. Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches. Narosa Publ.
4. Chopra VL. 1997. Plant Breeding. Oxford & IBH.
5. Nath V & Lal C. 1995. Oilseeds in India. Westvill Publ. House.
6. Nigam J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH.
7. Ram HH & Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
8. Singh DP. 1991. Genetics and Breeding of Pulse Crops. Kalyani.
9. Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
10. Smartt J. 1994. The Groundnut Crop - A Scientific Basis for Improvement. Chapman & Hall.

<table>
<tr><td>Course Code</td><td colspan="7">AGS526A</td></tr>
<tr><td>Course Title</td><td colspan="7">Breeding for Quality and Special traits</td></tr>
<tr><td>Hours</td><td colspan="7">45 L:0, T:0, P:6</td></tr>
<tr><td>Credits</td><td colspan="7">3</td></tr>
<tr><td>Type</td><td colspan="7">Multi-Disciplinary Course</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On the completion of the course, the student will gain the following knowledge and skills:

CO1: Understand developmental biochemistry and genetics of biomolecules
CO2: Explain breeding method for quality improvement in field crops
CO3: Learn breeding strategies for quality improvement in millets
CO4: Illustrate breeding methodologies for improving quality traits in sugarcane and potato</td></tr>
<tr><td>Examination Type</td><td colspan="7">Theory + Practical</td></tr>
<tr><td>Assessment Tools</td><td>Written Quiz</td><td>Assignment/Project Work</td><td>MSE</td><td>MSP</td><td>ESE</td><td>ESP</td><td>ABL/PBL</td></tr>
<tr><td>Weightage</td><td>10%</td><td>0</td><td>25%</td><td>0</td><td>35%</td><td>25%</td><td>5%</td></tr>
<tr><td>Examination Mode</td><td colspan="6">Theory + Practical</td><td></td></tr>
<tr><td>Syllabus</td><td colspan="6">Unit 1: (6 hours)
Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors, nutritional improvement, a human perspective, breeding for grain quality parameters in rice and its analysis, golden rice and aromatic rice, breeding strategies, achievements and application in Indian context, molecular basis of quality traits and their manipulation in rice, post-harvest manipulation for quality improvement</td><td>CO1</td></tr>
<tr><td></td><td colspan="6">Unit 2: (6 hours)
Breeding for baking qualities in wheat, characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat, breeding for quality improvement in barley and oats.</td><td>CO2</td></tr>
<tr><td></td><td colspan="6">Unit 3: (6 hours)
Breeding for quality improvement in Sorghum and pearl millet, quality protein maize, concept and breeding strategies, breeding for quality improvement in forage crops, genetic resource management for sustaining nutritive quality in crops.</td><td>CO3</td></tr>
</table>

	Unit 4: (9 hours) Breeding for quality in pulses, in groundnut, sesame, sunflower and minor oilseeds, molecular basis of fat formation and manipulation to achieve more PUFA in oil crops, genetic manipulation for quality improvement in cotton. Genetic engineering protocols for quality improvement, achievements made, value addition in crops, classification and importance, nutritional genomics and second generation transgenics.	**CO4**
	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; Quality parameters evaluation in pulses, Quality parameters evaluation in oilseeds; Value addition in crop plants; Post-harvest processing of major field crops; Quality improvement in crops through tissue culture techniques; Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures Successful example of application of MAS for quality trait in rice, mustard, maize, etc.	

Reference Books:

1. Chahal GS & Ghosal SS. 2002. Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches. Narosa Publ.
2. Chopra VL. 1997. Plant Breeding. Oxford & IBH.
3. FAO 2001. Speciality Rices of the World - Breeding, Production and Marketing. Oxford & IBH.
4. Ghosh P. 2004. Fibre Science and Technology. Tata McGraw Hill.
5. Hay RK. 2006. Physiology of Crop Yield. 2nd Ed. Blackwell.
6. Nigam J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH.
7. Singh BD. 2015. Plant Breeding. Kalyani.
8. Singh RK, Singh UK & Khush GS. 2000. Aromatic Rice. Oxford & IBH.

Course Code	**AGS527A**						
Course Title	**Hybrid Breeding**						
Hours	48 L:24, T:0, P:24						
Credits	3						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** Understand the concept of heterosis and its historical aspects **CO2:** Demonstrate the use of heterosis in hybrid seed production **CO3:** Illustrate the role of male sterility and self-incompatibility in hybrid production **CO4:** Heterosis breeding in cereal and oilseed crops						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (6 hours)** Historical aspect of heterosis, nomenclature and definitions of heterosis, heterosis in natural population and inbred population, evolutionary aspects, genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops. Genetic basis of heterosis, physiological, biochemical and molecular factors underlining heterosis, evolutionary concepts of heterosis.						**CO1**
	Unit 2: (6 hours) Prediction of heterosis from various crosses, inbreeding depression, frequency of inbreeding and 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 inbreds, their improvement for increasing heterosis.						**CO2**
	Unit 3: (6 hours) Types of male sterility and use in heterosis breeding, maintenance, transfer and restoration of different types of						**CO3**

	male sterility, use of self-incompatibility in development of hybrids, hybrid seed production system: 3-line, 2-line and 1-line system, development of inbreds and parental lines- A, B and R lines- functional male sterility, commercial exploitation of heterosis- maintenance breeding of parental lines in hybrids.	
	Unit 4: (6 hours) Fixation of heterosis in self, cross and often cross- pollinated crops, asexually/clonally propagated crops, male sterile line creation and diversification in self-pollinated, cross pollinated and asexually propagate crops, problems and prospects, apomixes in fixing heterosis-concept of single line hybrid. Organellar heterosis and complementation, creation of male sterility through genetic engineering and its exploitation in heterosis. Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.	**CO4**
	Practical: (24 hours) Selection indices and selection differential; calculations and interpretations; Male sterile line characterization in millets; using morphological descriptors; Restorer line identification and diversification of male sterile sources; Male sterile line creation in dicots comprising oilseeds, pulses and cotton ; Problems in creation of CGMS system; ways of overcoming them; Male sterile line creation; diversification and restoration in forage crops; Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops; Estimation from the various models for heterosis parameters; Hybrid seed production in field crops; an account on the released hybrids; their potential; problems and ways of overcoming it; Hybrid breeding at National and International level; opportunities ahead.	

Reference Books:

1. Abstracts of the Genetics and Exploitation of Heterosis in Crops - An International Symposium CIMMYT.
2. Akin E. 1979. The Geometry of Population Genetics. Springer-Verlag.
3. Ben Hiu Lin. 1998. Statistical Genomics–Linkage, Mapping and QTL Analysis. CRC Press.
4. De Joung G. 1988. Population Genetics and Evolution. Springer-Verlag.
5. Hartl DL. 2000. A Primer of Population Genetics. 3rd Ed. Sinauer Assoc.
6. Mettler LE and Gregg TG. 1969. Population Genetics and Evolution. Prentice Hall.
7. Montgomery DC. 2001. Design and Analysis of Experiments. 5th Ed., Wiley & Sons.
8. Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin.
9. Srivastava S and Tyagi R. 1997. Selected Problems in Genetics. Vols. I, II. Anmol Publ.

<table>
<tr><td>Course Code</td><td colspan="7">AGS528A</td></tr>
<tr><td>Course Title</td><td colspan="7">Varietal Development and Maintenance Breeding</td></tr>
<tr><td>Hours</td><td colspan="7">36 L:12, T:0, P:24</td></tr>
<tr><td>Credits</td><td colspan="7">2</td></tr>
<tr><td>Type</td><td colspan="7">Multi-Disciplinary Course</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On the completion of the course, the student will gain the following knowledge and skills:

CO1: Understand the procedure of varietal development and maintenance
CO2: Demonstrate the procedure of DUS testing and factors responsible for varietal deterioration
CO3: Illustrate quality seed production technology in cereals, millets and pulses
CO4: Illustrate quality seed production technology in oilseeds, fibre and forage crops</td></tr>
<tr><td>Examination Type</td><td colspan="7">Theory + Practical</td></tr>
<tr><td>Assessment Tools</td><td>Written Quiz</td><td>Assignment/Project Work</td><td>MSE</td><td>MSP</td><td>ESE</td><td>ESP</td><td>ABL/PBL</td></tr>
<tr><td>Weightage</td><td>10%</td><td>0</td><td>0</td><td>20%</td><td>35%</td><td>30%</td><td>5%</td></tr>
<tr><td>Examination Mode</td><td colspan="6">Theory + Practical</td><td></td></tr>
<tr><td>Syllabus</td><td colspan="6">Unit 1: (3 hours)
Variety development and maintenance, definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers’ variety, hybrid and population, Variety testing, release and notification systems in India and abroad.</td><td>CO1</td></tr>
<tr><td></td><td colspan="6">Unit 2: (3 hours)
DUS testing- DUS Descriptors for major crops, Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties, safeguards during seed production, maintenance of varieties in self and cross-pollination crops, isolation distance, principles of seed production</td><td>CO2</td></tr>
<tr><td></td><td colspan="6">Unit 3: (3 hours)
Methods of nucleus and breeder seed production. Generation system of seed multiplication, nucleus, breeders, foundation, certified, quality seed production technology of self and cross- pollinated crop varieties viz. cereals & millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi etc.), pulses (greengram, blackgram, cowpea, pigeonpea,</td><td>CO3</td></tr>
</table>

	chickpea, fieldpea, lentil)	
	Unit 4: (3 hours) Generation system of seed multiplication, nucleus, breeders, foundation, certified, quality seed production technology of self and cross-pollinated crop varieties *viz*. oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard), fibres (cotton, jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne)., seed certification procedures, seed laws and plant variety protection regulations in India and international systems.	**CO4**
	Practical: (24 hours) 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; 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.	

Reference Books:

1. Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH.
2. Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Department of Plant Breeding. CCS HAU Hisar.
3. Kelly AF. 1988. Seed Production of Agricultural Crops. Longman.
4. McDonald MB Jr & Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.
5. Musil AF. 1967. Identification of Crop and Weed Seeds. Handbook No. 219, USDA, Washington, DC.
6. Poehlman JM & Borthakur D. 1969. Breeding Asian Field Crops. Oxford & IBH.
7. Singh BD. 2015. Plant Breeding: Principles and Methods. Kalyani.
8. Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill.
9. Tunwar NS & Singh SV. 1985. Handbook of Cultivars. ICAR.

Course Code	**AGS529A**						
Course Title	**Genetic enhancement for PGR Utilization**						
Hours	36 L:12, T:0, P:24						
Credits	2						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following Knowledge and skills: **CO1:** Understand the concept of gene pool and pre breeding programme **CO2:** Demonstrate handling and maintenance of crop wild relatives for use in pre breeding **CO3:** Illustrate different screening techniques to identify resistant sources and breeding methods for trait transfer **CO4:** Cytological approaches for gene transfer and pre and post zygotic barriers in wide hybridization						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**0**	**20%**	**35%**	**30%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (3 hours)** 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.						**CO1**
	Unit 2: (3 hours) 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 exotic and other unadapted germplasm.						**CO2**
	Unit 3: (3 hours) 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. Parental selection for prebreeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and						**CO3**

	its management, modern tools for incongruity management,	
	Unit 4: (3 hours) 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.	**CO4**
	Practical: (24 hours) 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.	

Reference Books:

1. Andey Pereira. 2006. Plant Reverse Genetics, Methods and Protocols, Humana Press
2. Bisht et al. 2004. Broadening the genetic base of sesame (Sesamum indicum L.) through genetic enhancement. Plant Genetic Resources 2(3): 143–151.
3. Dale JW and von Schantz M. 2007. From genes to genomes. Concepts and applications of DNA technology. John Wiley & Sons Ltd., Chichester, England.
4. Duvick DN. 1990. Genetic enhancement and plant breeding. p. 90–96. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland.
5. Goodman, RM. 2004. Encyclopedia of plant and crop science. Marcel Dekker Inc., Switzerland.
6. Kimber, G and Feldman, M. 1987. Wild Wheat: An introduction. Special report 353, College of Agriculture, University of Missouri-Columbia.
7. Lynch M. and Walsh B. 1998. Genetics and analysis of quantitative traits. Sinauer Associates Inc., MA, USA.
8. Murphy D. 2007. Plant breeding and biotechnology: Societal context and the future of agriculture. Cambridge University Press, Cambridge, UK.
9. Ram JS. 2010. Plant Cytogenetics. CRC Press.
10. Ramanatha Rao V, Brown AHD, Jackson M. 2001. Managing Plant Genetic Diversity. CABI publication.
11. Sharma S, Upadhyaya HD, Varshney RK, et al. 2013. Pre-breeding for diversification

of primary gene pool and genetic enhancement of grain legumes. Front. Plant Sci. 4: 309.
12. Yunbi Xu. 2010. Molecular plant breeding, CABI publishers

e- Resources

https://www.integratedbreedPlaning.net/pre-breeding-effective-use-plant-genetic-resources
http://www.croptrust.org/
http://www.bioversityinternational.org/training/training_materials/pre_breeding.htm
http://www.grdc.com.au/director/research/prebreeding

Course Code	**AGS501**						
Course Title	**Library and Information Services**						
Hours	24 L:0, T:1, P:2						
Credits	1						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** To study about library, its role, classification and organization. **CO2:** To study about source of information, intricacies of abstracting and indexing services **CO3:** To study about tracing information from reference sources **CO4:** To study about use of Internet including search engines and its resources; e-resources access methods						
Examination Type	Theory/ Practical/ Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**0**	**20%**	**0**	**30%**	**0**	**50%**	**0**
Examination Mode	Theory/ Practical/ Theory + Practical						
Syllabus	**Unit 1: (4 hours)** • Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library						**CO1**
	Unit 2: (6 hours) • 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.)						**CO2**
	Unit 3: (8 hours) • 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						**CO3**
	Unit 4: (6 hours) • Use of Internet including search engines and its resources; e-resources access methods.						**CO4**

Suggested Readings:

1. Wu Diana Yuhfen and Liu Mengxiong. 2001. Academic librarianship: changing roles in the digital age. Available at http//www.sssu.edu/ridwu/academic librarianship P&F. Accessed March 10, 2008

2. Library.2004. Encyclopedia Britannica premium service http//www.britannica.com/eb/ article eu=09616. Accessed March 10, 2008
3. Young, P.V. (1984). Scientific social survey and research. Rev. 4th Ed. Prentice Hall, New Delhi.
4. https://guides.library.manoa.hawaii.edu/PlantPath/Books
5. https://unl.libguides.com/c.php?g=51695&p=334113
6. https://libraries.unl.edu/citation-tools

Course Code	**AGS503**						
Course Title	**Intellectual Property and its Management in Agriculture**						
Hours	12 L: 12, T: 0, P: 0						
Credits	1						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following Knowledge and skills: **CO1:** Understand the concept and historical aspects of IPRs **CO2:** Learn the legislation for protection of intellectual properties in India context **CO3:** Learn about the protection of biological materials **CO4:** Aware of international treaties and licensing agreements						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**0**	**20%**	**35%**	**30%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (3 hours)** Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs;						**CO1**
	Unit 2: (3 hours) Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio- diversity protection.						**CO2**
	Unit 3: (3 hours) Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity.						**CO3**
	Unit 4: (3 hours) International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer Agreements, Research collaboration Agreement, License						**CO4**

	Agreement.	

Reference Books:

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

Course Code	**AGS504**						
Course Title	**Basic Concepts in Laboratory Techniques**						
Hours	24 L:0, T:1, P:2						
Credits	2						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** To teach students about safety measures in lab, handing of chemical substances **CO2:** To teach students about handling, weighing and preparation of solution **CO3:** To teach students about use and handling of lab equipment **CO4:** To teach students about preparation of media and methods of sterilization, seed viability testing						
Examination Type	Theory/ Practical/ Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**0**	**20%**	**0**	**30%**	**0**	**50%**	**0**
Examination Mode	Theory/ Practical/ Theory + Practical						
Syllabus	**Unit 1: (6 hours)** • Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes, washing, drying and sterilization of glassware.						**CO1**
	Unit 2: (6 hours) • 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						**CO2**
	Unit 3: (6 hours) • Preparation of solutions of acids; Neutralization 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, sand bath, water bath, oil bath; Electric wiring and earthing.						**CO3**
	Unit 4: (6 hours) • 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						**CO4**

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.

Course Code	**AGS505**						
Course Title	**Agricultural Research, Ethics and Rural Developmental Programmes**						
Hours	12 L: 12, T: 0, P: 0						
Credits	1						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following Knowledge and skills: **CO1:** Understand the role of global agricultural research system **CO2:** Learn the role of International Agricultural Research Centre **CO3:** Learn about rural development policies and programmes **CO4:** Illustrate the constraints in implementation of rural development policies and programmes						
Examination Type	Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**0**	**20%**	**35%**	**30%**	**5%**
Examination Mode	Theory + Practical						
Syllabus	**Unit 1: (3 hours)** 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)						**CO1**
	Unit 2: (3 hours) 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. Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.						**CO2**
	Unit 3: (3 hours) Concept and connotations of rural development, rural development policies and strategies. Rural development programs: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development						**CO3**

	Programme (IRDP),	
	Unit 4: (3 hours) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations, Critical evaluation of rural development policies and programs. Constraints in implementation of rural policies and programs.	**CO4**

Reference Books:

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

<table>
<tr><td>Course Code</td><td colspan="7">ENG551</td></tr>
<tr><td>Course Title</td><td colspan="7">Technical Writing and Communications Skills</td></tr>
<tr><td>Hours</td><td colspan="7">24 L:0, T:0, P:2</td></tr>
<tr><td>Credits</td><td colspan="7">1</td></tr>
<tr><td>Type</td><td colspan="7">Multi-Disciplinary Course</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On the completion of the course, the student will gain the following knowledge and skills:

CO1: To teach students about technical writing and various parts of thesis and communication.
CO2: To teach students about writing of abstracts, summaries, précis, citations etc.
CO3: To teach students about writing of a review article. Communication Skills - Grammar
CO4: To teach students about accentual pattern</td></tr>
<tr><td>Examination Type</td><td colspan="7">Theory/ Practical/ Theory + Practical</td></tr>
<tr><td>Assessment Tools</td><td>Written Quiz</td><td>Assignment/Project Work</td><td>MSE</td><td>MSP</td><td>ESE</td><td>ESP</td><td>ABL/PBL</td></tr>
<tr><td>Weightage</td><td>0</td><td>20%</td><td>0</td><td>30%</td><td>0</td><td>50</td><td>0</td></tr>
<tr><td>Examination Mode</td><td colspan="6">Practical</td><td></td></tr>
<tr><td>Syllabus</td><td colspan="6">Unit 1: (6 hours)
• 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);</td><td>CO1</td></tr>
<tr><td></td><td colspan="6">Unit 2: (6 hours)
• Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the thesis 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;</td><td>CO2</td></tr>
<tr><td></td><td colspan="6">Unit 3: (6 hours)
• 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;</td><td>CO3</td></tr>
<tr><td></td><td colspan="6">Unit 4: (6 hours)</td><td>CO4</td></tr>
</table>

	• Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.	

Suggested Readings:

1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
2. Collins' Cobuild English Dictionary. 1995. Harper Collins.
3. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed. Holt, Rinehart & Winston.
4. Gupta RH. 2010. Essentials of Communication. 7th Ed. Pragati Prakashan. Hornby AS. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
5. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
6. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East West Press.
7. Mohan K. 2005. Speaking English Effectively. MacMillan India.
8. Richard WS. 1969. Technical Writing. Barnes & Noble.
9. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language. Abhishek.
10. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India

<table>
<tr><td>Course Code</td><td colspan="7">EVS658</td></tr>
<tr><td>Course Title</td><td colspan="7">Disaster Management</td></tr>
<tr><td>Hours</td><td colspan="7">12 L:1, T:0, P:0</td></tr>
<tr><td>Credits</td><td colspan="7">1</td></tr>
<tr><td>Type</td><td colspan="7">Multi-Disciplinary Course</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On the completion of the course, the student will gain the following knowledge and skills:

CO1: To study about natural disasters, floods and drought etc and global warming
CO2: To teach students about man-made disasters, different type of pollution
CO3: To teach students about disaster management
CO4: To teach students about Community-based organizations and armed forces in Disaster response</td></tr>
<tr><td>Examination Type</td><td colspan="7">Theory/ Practical/ Theory + Practical</td></tr>
<tr><td>Assessment Tools</td><td>Written Quiz</td><td>Assignment/Project Work</td><td>MSE</td><td>MSP</td><td>ESE</td><td>ESP</td><td>ABL/PBL</td></tr>
<tr><td>Weightage</td><td>10%</td><td>10%</td><td>25%</td><td>0</td><td>50%</td><td>0</td><td>5%</td></tr>
<tr><td>Examination Mode</td><td colspan="6">Theory/ Practical/ Theory + Practical</td><td></td></tr>
<tr><td>Syllabus</td><td colspan="6">Unit 1: (3 hours)
• Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion.</td><td>CO1</td></tr>
<tr><td></td><td colspan="6">Unit 2: (3 hours)
• Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents</td><td>CO2</td></tr>
<tr><td></td><td colspan="6">Unit 3: (3 hours)
• Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs</td><td>CO3</td></tr>
<tr><td></td><td colspan="6">Unit 4: (3 hours)
• Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations</td><td>CO4</td></tr>
</table>

Suggested Readings

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

Course Code	**MTH670**						
Course Title	**Statistical Methods for Applied Sciences**						
Hours	60 L:3, T:0, P:1						
Credits	4						
Type	**Multi-Disciplinary Course**						
Course Outcomes	On the completion of the course, the student will gain the following knowledge and skills: **CO1:** To teach students about different statistical methods and classifications **CO2:** To teach students about measures of central tendency and measure of dispersion **CO3:** To teach students about theory of probability **CO4:** To teach students about different distributions, their applications and statistical tests						
Examination Type	Theory/ Practical/ Theory + Practical						
Assessment Tools	Written Quiz	Assignment/Project Work	MSE	MSP	ESE	ESP	ABL/PBL
Weightage	**10%**	**0**	**25%**	**0**	**35%**	**25%**	**5%**
Examination Mode	Theory/ Practical/ Theory + Practical						
Syllabus	**Unit 1: (9 hours)** • Classification, tabulation and graphical, representation of data. • Box-plot, Descriptive statistics. Exploratory data analysis						**CO1**
	Unit 2: (9 hours) • Measures of central tendency- Mean, Median, Mode, Geometric mean, Harmonic mean. • Measures of Dispersion- Range, Quartile deviation, Mean deviation, Standard deviation						**CO2**
	Unit 3: (9 hours) • Theory of probability. Random variable and mathematical expectation. • Discrete and continuous probability distributions. Correlation and regression						**CO3**
	Unit 4: (9 hours) • Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. • Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions.						**CO4**

	Practical (24 hours) Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions-chi square, t and F; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis, fitting of orthogonal polynomial regression; applications of dimensionality reduction and discriminant function analysis; Nonparametric tests.	

Suggested Readings

1. Anderson TW. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley.
2. Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I
3. Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I.
4. Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.