Department of Agricultural Botany, College of Agriculture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli

1. About Department:

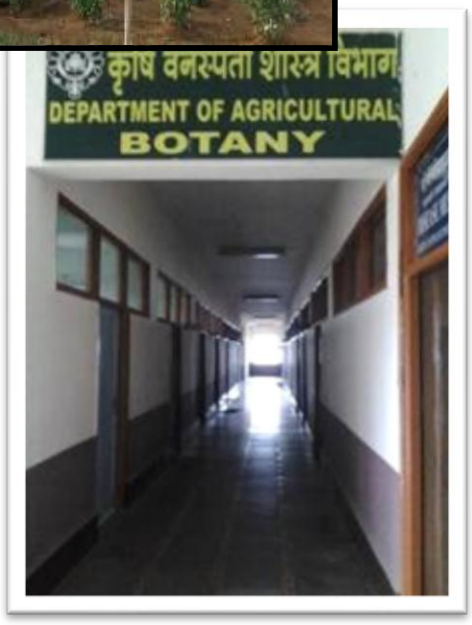
Department of Agricultural Botany was established with the establishment of Konkan Krishi Vidyapeeth in 1972 with an objective to cater the educational, research and extension activities in the subject of agricultural botany. Since its inception, department has significantly contributed in the university achievements in all the three spheres *viz.,* Education, Research and Extension.

Currently, besides offering number of undergraduate courses, leading to B. Sc. in Agriculture, Horticulture and Forestry, this department offer M. Sc. in two major disciplines namely Genetics and Plant Breeding and Plant Physiology, as well as Ph. D. in Genetics and Plant Breeding. Conducting research on crop improvement through conventional and molecular breeding in major field crops of this region *viz*. Rice, Finger millet, Wal, Pulses, Ground nut, etc., for yield and quality improvement and controlling physiological disorders in Mango, are some of the major focused areas of research, in which this department has contributed significantly thorough Departmental and PG research. The department is well equipped with field and laboratory facilities with sophisticated instruments *viz.,* Xylem sap flow meter, leaf water potential monitoring system, Infrared Gas Analyzer (IRGA) and Porometer etc.

Department has privilege of having fleet of most experienced and dedicated faculty members with diversified areas of specialization. Majority of faculty possessing Ph.D and many of them acquired training abroad and have regular participation in the national and international Seminars and Symposia in country and abroad.

This department, so far, has played direct or indirect role in development and release of 24 Rice varieties and 5 hybrids, Two varieties each of Nagli, Wal, Cowpea and Ground nut and One each of Tur and Horse gram and Rubber, Beside this, the faculty under subject Plant Physiology of this department, have developed more than 15 technologies related to crop regulation and control of physiological disorders in Alphonso Mango.

This department attracts majority of Meritorious students admitted in this university for PG. admissions. Many M.Sc. and Ph.D. alumni of this department are currently occupying key positions in National and International Educational and Research institutes and Agri. business in the country and abroad.



2. **AcademicProgrammers:**

a. DoctoralProgrammes

NameoftheProgramme:**GeneticsandPlantBreedingPh.D.(Agri.)**

Semester No.	Term No.	CourseNo.	Credits	Titleofthecourseofferedbythedepartment
		Major:09Credits		
I	I	GPB-601*	3(3+0)	Advances in Plant Breeding system
		GPB-604	2(2+0)	Plant Genetic Recourses, Conservation and Utilization
		GPB-607	3(3+0)	Crop Evolution
		GPB-609*	1(1+0)	IPR and Regulatory mechanism (e-course)
		Manor:3Credits		
		SST-601	3(2+1)	Hybrid Seed Production Technology
		Supporting and optional Course :03 Credit		
		VSC-602	3(3+0)	Advances in Breeding of Vegetable crops
		Total Credits	**15(14+1)**	
II	II	**Major:3Credits**		
		GPB-605*	3(3+0)	Genomics in Plant breeding
		GPB-699	9(0+9)	Doctoral Research
		Minor:3Credits		
		PP-607	3(3+0)	Physiological and Molecular Aspects of Source Sink Capacity for Enhancing Yield
		Supporting and optional Course :03 Credit		
		PL. PATH-604	3(2+1)	Molecular Basis of Host Pathogen Interaction
		Total	**18(8+10)**	
III	I	**Seminar: 1Credit**		
		GP-691	0+1=1	DoctoralSeminar-I
		Minor:3/2Credits		
		PP-608	2+1=3	SeedPhysiology
		NonCreditCompulsoryCourse(NCCC):2credits		
		PGS-505	1+0=1	AgricultureResearchEthicsandRuralDevelopmentProgrammes
		PGS-506	1+0=1	DisasterManagement
		Total	**1+2=3/4+3=7/2+2=4**	
IV	II	**Seminar: 1Credit**		
		GP-692	0+1=1	DoctoralSeminar–II
TotalofI,II,III&IV			**13+13/14+3/7+1=31/34/35**	
V&VI	I		**0+45=45**	**DoctoralResearch**
	II		**76/79/80**	**GrandTotal**

Compulsorycourse***

Course Curricula and syllabi:

GPB-601 Advances in Plant Breeding Systems* 3 (3+0)

OBJECTIVE:-

This course is an advancement of principles, various plant breeding methodologies and procedures in the development of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker-based utilization of exotic Germplasm and introgression libraries.

Theory

Unit I

Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer.

Unit II

Plant Breeding methodologies: Classic versus modern; Over view of Pre and Post Mendelian
breeding methods in self and cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed
breeding, participatory plant breeding, breeding for organic situations.

Unit III

Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops – Assumptions and realities.

Unit IV

Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.

Unit V

Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular and biochemical basis of self-incompatibility and male sterility, nucleocytoplasmic interactions
with special reference to male sterility – genetic, biochemical and molecular bases.

Unit VI

Genetic engineering technologies to create male sterility, prospects and problems, use of self incompatibility and sterility in plant breeding – case studies; Fertility restoration in male
sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies; Case studies - Generating new cyto-nuclear interaction system for

diversification of male sterile; Stability of male sterile lines – Environmental influence on sterility, Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility and its use heterosis breeding; Apomixis and its use in heterosisbreeding; Incongruity: Factors influencing incongruity Methods to overcome incongruitymechanisms.

Unit VII

Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fixation and assimilation, greenhouse gases and carbon sequestration; Breeding for bio-fortification.

Lecture No.	**Topics**	**Weightage**
1	Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed;	2
2	Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for genetransfer.	2
3	Plant Breeding methodologies: Classic versus modern;	2
4	Over view of Pre and Post Mendelian breeding methods in self and cross pollinated crops;	4
5	Molecular and transgenic breeding approaches; doubled haploidbreeding,	4
6	Shuttle breeding,	2
7	Forward and reverse breeding,	2
8	Speed breeding,	2
9	Participatory plant breeding,	4
10	Breeding for organic situations	4
11	Principles and procedures in the formation of a complex population	4
12	Genetic basis of population improvement in crop plants;	2
13-14	Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection	4
15	Selection in clonally propagated crops – Assumptions and realities.	4
16	Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment	2

17	Application of MAS for selection of qualitative and quantitative traits	4
18	Gene pyramiding, accelerated backcrossing,	4
19	Marker-based utilization of exotic germplasm, introgression libraries.	2
20	Genetic resources: primary, secondary, tertiary and alien trans genepool	4
21-22	Male sterility and self-incompatibility Molecular and biochemical basis of self-incompatibility and male sterility, nucleocytoplasmic interactions with special reference to male sterility – genetic, biochemical and molecular bases.	4
23-25	Genetic engineering technologies to create male sterility, prospects and problems, use of self-incompatibility and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programs;	4
26	Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies;	4
27	Case studies - Generating new cyto-nuclear interaction system for diversification of male sterile	4
28-30	Stability of male sterile lines – Environmental influence on sterility, Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility and its use heterosis breeding;	4
31	Apomixis and its use in heterosis breeding	2
32	Incongruity: Factors influencing incongruity Methods to overcome incongruity mechanisms	2
33-36	Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance;	4
37-38	Breeding for Biotic stress tolerance;	4
39	Breeding for Nutrient use efficiency,	4
40-41	Breeding for nitrogen fixation and assimilation, greenhouse gases and carbon sequestration;	4
42	Breeding for bio-fortification	2
	Total	100

Suggested Reading

Agarwal R L. 1996. Fundamentals of Plant Breeding and Hybrid Seed Production. Oxford &IBH.

Allard R W. 1966. Principles of Plant Breeding. John Wiley & Sons.

Briggs F N and Knowles P F. 1967. Introduction to Plant Breeding. Reinhold.

Fehr W R. 1987. Principles of Cultivar Development: Theory and Technique. Vol I.Macmillan. Hayes H K, Immer F R and Smith D C. 1955. Methods of Plant Breeding.

McGraw-Hill.

Kang M S and Priyadarshan P M (Edit.). 2007. Breeding Major Food Staples. BlackwellPublishing.

Kole C. 2013. Genomics and Breeding for Climate-Resilient Crops. Springer. Volume 2-Target Traits.

Mandal A K, Ganguli P K and Banerji S P. 1995. Advances in Plant Breeding. Vol. I, II.CBS.

Richards A J. 1986. Plant Breeding Systems. George Allen & Unwin.

Sharma J R. 1994. Principles and Practice of Plant Breeding. Tata McGraw-Hill. Simmonds N W. 1979. Principles of Crop Improvement. Longman.

Singh B D. 1997. Plant Breeding: Principles and Methods. 5th Ed., Kalyani Publishers, NewDelhi.

Singh P. 1996. Essentials of Plant Breeding. Kalyani Publishers, New Delhi. Welsh JR. 1981. Fundamentals of Plant Genetic and Breeding. John Wiley.

GPB-604 Plant Genetic Resources, Conservation and Utilization 2 (2+0)

Objective:-

This course is needed to make the student aware about the importance of Plant Genetic Resources its Conservation and Utilization in crop improvement and to impart knowledge on the methods of germplasm conservation and its utilization.

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

Cryopreservation- procedure for handling seeds of orthodox and recalcitrant-cryo- protectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead.

Unit V

Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and mini core; collections and registration of plant germplasm.

LECTURE SCHEDULE

Lec No.	Topics	Weightage
1	Concept of natural reserves and natural gene banks	4
2	In situ conservation of wild species in nature reserves: in situ conservation components,	8
3	Factors influencing conservation value, national plan for in situ conservation.	6
4	In situ conservation of agro-biodiversity on-farm; scientific basis of in situ conservation on-farm, building on-farm conservation initiatives,	8
5-6	Implementation of on-farm conservation, management of in situ conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.	6
7-10	Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories,	8
11	Preservation of genetic materials under natural conditions.	4
12-13	Perma-frost conservation, Guidelines for seed multiplication and exchange to network of active/ working collections, Orthodox, recalcitrant seeds- differences in handling	8
14	Clonal repositories, genetic stability under long term storage condition.	4
15	In-vitro storage, maintenance of in-vitro culture under different conditions,	4
16-19	In-vitro bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species,.	8
20-22	Conservation of embryos and ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of in-vitro gene bank	8
23-24	Cryopreservation- procedure for handling seeds of orthodox and recalcitrants-cryoprotectants,	4
25-26	Dessication, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques	4
27-28	National facilities, achievements, application of cryopreservation in agriculture, horticulture and forestry crops.	4

29	Problems and prospects; challenges aheads.	4
30-31	Concept and procedure for PGR management, germplasm characterization, evaluation and utilization;	4
32	Concept of core and mini core; collections and registration of plant germplasm.	4
	Total	100

Suggested Reading :

Ellis RH, Roberts EH and White Head J. 1980. A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks.FAO/ IBPGR Pl. Genet. Resources News 41-3-18.

Frankel OH and Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow.

Cambridge University Press, Cambridge.

Paroda RS and Arora RK.1991. Plant Genetic resource Conservation and management,NBPGR, New-Delhi.

Simmonds NW. 1979. Principles of Crop Improvement, Longman.

Westwood MN. 1986. Operation Manual for National Clonal Germplasm Repository.

Processed Report. USDA-ARS and Oregon State Univ. Oregon, USA.

Withers LA. 1980. Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep.

IBPGR, Rome, Italy.

GPB-605 Genomics in Plant Breeding 3 (3+0)

Objective:-

The knowledge of recent trends in plant genomics, genome sequencing, molecular maps, and concepts of high-throughput proteomics, metabolomics and phenomics is essential in rapid crop improvement programmes.

Theory

Unit I

Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA.

Unit II

Genome sequencing: Principles and techniques of conventional approaches and neXt generation sequencing including sequencing-by-synthesis/ ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.

Unit III

Molecular maps: Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/ QTL mapping,genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Diversity array technology: concepts and applications.

Unit IV

Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement; Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR and molecular beacon.

Unit V

Development and management of database; Applications of bioinformatics tools/ software in genomics for crop

improvement. Basic concepts of high-throughput proteomics, metabolomics and phenomics.

Unit VI

Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement. Cisgenesis and Intragenesis tools as twin sisters for Crop Improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single Genes and QTL, Marker Assisted Selection (Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection).

LECTURE SCHEDULE

Lec. No.	Topics	Weightage
1-3	Introduction to the plant genomes: Nuclear genome, Concept of genome size and complexity :C-value paradox, repetitive and unique DNA	6
4-5	Chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA	4
6-9	Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ ligation	6
	and single molecule real time (SMRT) technologies;	
10-11	Applications of sequence information: structural, functional and comparative genomics;	4
12-13	Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.	4
14-15	Molecular maps: Use of molecular markers/ SNPs for development of genetic and physical maps;	4
16-18	Linkage and LD-based gene mapping approaches including gene/ QTL mapping, genome wide association studies (GWAS) and association analysis;	4
19-22	Integration of genetic and physical map for map-based cloning of economically important genes.;	4
23	Concept of allele mining	4
24	Diversity array technology: concepts and applications	4
25-26	Functional genomics: concept of reverse and forward genetics;	4
27-28	Use of activation tagging, transposon tagging, insertional mutagenesis,	4
29-30	TILLING and ecoTILLING for crop improvement;	4

31-32	Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing,.	4
33-34	Next generation sequencing, microarray, northern hybridization,	4
35-36	RT-PCR, qRT-PCR and molecular beacon	4
37	Concept of database development, management and bioinformatics.	4
38	Applications of bioinformatics tools/ software in genomics for crop improvement..	4
39	Basic concepts of high-throughput proteomics, metabolomics and phenomics	4
40-41	Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement.	4
42-43	Cisgenesis and Intragenesis tools as twin sisters for Crop Improvement;	4
44-45	Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies,	4
46	Identification of molecular markers linked to single Genes and QTL,	4
47-48	Marker Assisted Selection (Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection).	4
	Total	100

Suggested Reading

Alonso J M, Stepanova A N. 2015. Plant Functional Genomics: Methods and Protocols.
Springer.

Chopra V L, Sharma R P, Bhat S R and Prasanna B M. 2007. Search for New Genes. Academic Foundation, New Delhi.

Hackett P B, Fuchs J A and Messing J W. 1988. An Introduction to Recombinant DNA Technology— Basic Experiments in Gene and Manipulation. 2nd Ed. BenjaminPublication Co.

Primose S B and Twyman R M. 2006. Principles of Gene Manipulation and Genomics. 7th
Wiley-Blackwell Publishing.

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

Singh BD. 2005. Biotechnology: Expanding Horizons. Kalyani Publishers, New Delhi.Somers DJ, Langridge P, Gustafson JP. 2009. Plant Genomics: Methods and Protocols.

GPB-607 Crop Evolution 3 (3+0)

Objective :

To impart knowledge on crop evolutionary aspects and role of mutations,hybridizations and polyploidy in crop evolution and improvement.

Theory

Unit I

Origin and evolution of species; Centres of diversity/ origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies; Domestication and uniformity – Characteristics of early domestication and changes –Concept of gene pools and crop evolution; Selection and Genetic drift – Consequences.

Unit II

Speciation and domestication–The process of speciation, Reproductive isolation barriers; Genetic differentiation during speciation; Hybridization - speciation and extinction; Exploitation of natural variation: Early attempts to increase variation, Distant hybridization and introgression, Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools andtechniques; Validation of transferred genes and their expression; Controlled introgressions.

Unit III

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution, Multifactorial genome, Intragenomic interaction, Intergenomic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis andcomparative genomics.

Unit IV

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

LECTURE SCHEDULE

Lecture No.	**Topic**	**Weightage**
1-2	Origin and evolution of species, Centres of diversity/origin, diffused centres	4
3-4	Time and place of domestication Patterns of evolution and	4
	domestication-examples and case studies	
5-6	Domestication and uniformity, Characteristics of early domestication and changes	6
7-8	Concept of gene pools and crop evolution Selection and Genetic drift-consequences	4

9-10	Speciation and domestication -The process of speciation Reproductive isolation barriers	6
11-12	Genetic differentiation during speciation. Hybridization-speciation and extinction	4
13-14	Exploitation of natural variation- Early attempts to increase variation	4
15-18	Distant hybridization and introgression Interspecific, inter-generic hybridization Scope and limitations Techniques to overcome the limitations	8
19-20	Gene transfer into cultivated species, tools and techniques	4
21-22	Validation of transferred genes and their expression	4
23	Controlled intogression	4
24-25	Process in crop evolution and stabilization of polyploids, cytogenetics and genetic stabilization	4
26	Genome organization-transgenesis in crop evolution	6
27-28	Multifactorial genome-intragenomic interaction-Genome introgression	4
29-30	Methods to study crop evolution-Contemporary methods based on morphological features	6
31-32	Cytogenetic analysis-Allozyme variations and crop evolution	6
33-35	DNA markers, genome analysis and comparative genomics	6
36-39	Evolutionary significance of polyploidy, Evolution of crop plants through ploidy manipulations	6
40-41	Polyploids: methods, use of autopolyploids: haploidy-method of production and use.	4
42-46	Allopolyploids-synthesis of new crops-case studies- cereals,pulses, oilseeds, vegetables, fibre crops, plantation crops, forage crops,tuber crops and medicinal plants	6
	Total	**100**

Suggested Reading :

Hancock J F. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI. Ladizinsky G. 1999. Evolution and Domestication. Springer.

Miller A J. 2007. Crop Plants: Evolution. John Wiley & Sons.

Smartt J and Simmonds N W. 1995. Evolution of Crop Plants. Blackwell.

GPB-609 IPR and Regulatory Mechanism (e-course)* 1 (1+0)

Objective :

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

Theory

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

LECTURE SCHEDULE

Lecture No.	Topic	Weightage
1	Historical perspectives and need for the introduction of Intellectual Property Right regime;	8
2	TRIPs and various provisions in TRIPS Agreement;	6
3	Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs;	8
4	Indian Legislations for the protection of various types of Intellectual Properties;	6
5	Fundamentals of patents,.	6
6	Copyrights,	6
7	Geographical indications,	6
8	Designs and layout,	6
9	Trade secrets and traditional knowledge, Trademarks,	6
10	Protection of plant varieties and farmers' rights and biodiversity protection;	8

11	Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection	8
12	National Biodiversity protection initiatives;	6
13	Convention on Biological Diversity	6
14	; International Treaty on Plant Genetic Resources for Food and Agriculture;	6
15-16	Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement	8
	Total	

Suggested Reading :

Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V.

Technology Generation and IPR Issues. Academic Foundation.

Name of the Programme: Plant Physiology Ph.D. (Agri.)

Course type	Course No.	Course Title	Credits
		Semester I	
Major	**PP 601**	Functional genomics and genes associated with a few physiological processes	2 + 0 = 2
	PP 602*	Signal perception and transduction and regulation of physiological processes	2 + 0 = 2
	PP 604	Plant phenomics- Next generation phenomics platforms	2 + 0 = 2
	PP 606	Global climate change and crop response	2 + 0 = 2
Minor	**SST 601**	Hybrid seed production technology	3 + 0 = 3
		Semester II	
Major	**PP 607***	Physiological and molecular aspects of source- sink capacity for enhancing yield	3 + 0 = 3
	PP 608	Seed and fruit growth and their quality improvement	2 + 0 = 2
Minor	**GPB 605**	Genomics in plant breeding	3 + 0 = 3
Research	**PP 699**	Research Work	(0 + 8 = 8)
		Semester III	
Seminar	**PP 691**	Doctoral Seminar-I	0 + 1 = 1
Research	**PP 699**	Research Work	0 + 17 = 17
		Semester IV	
Seminar	**PP 692**	Doctoral Seminar-II	0 + 1 = 1
Research	**PP 699**	Research Work	0 + 17 = 17
		Semester V	
Research	**PP 699**	Research work/ Thesis writing	0 +18 = 18
		Semester VI	
Research	**PP 699**	Research work/ Thesis writing	0 +15 = 15

Course Curricula and syllabi:

PP-602* - Signal Perceptions and Transduction And Regulation of PhysiologicalProcesses

Objective

Objective of this course is to provide comprehensive eXposure on different signaling events and associated cellular changes in plants. The course will include lectures on the signalling mechanisms employed by plants to perceive and transduce environmental signals.

Theory

Block 1: Signal Perceptions and Transduction: Regulation of Physiological Processes Unit 1: Concept of Receptor and Ligands

Signal, signal types, long (diffusible) and short (contact) range signaling and components of signaling. Types of receptors, nature of ligands, downstream components like primary, secondary signaling components.

Unit 2: Receptors – Signal Perception and Transfer

Cell surface trans-membrane receptors- GPCRs, Receptor Tyrosine Kinases (RTKs), Receptors Serine Threonine kinases (RSTKs), Receptor-Like Kinases (RLKs), receptor two component systems. Signal transfer phosphor-relay and generation of secondary signaling components and activation of TFs or enzymes. Downstream components- G-proteins, second messengers-Cyclic AMP, Adenylate cyclase cascade, cyclic GMP, calcium-calmodulin- kinases; effector molecules (transcription factor).

Unit 3: Hormone Signaling

Hormone binding receptors-Transduction process. Effector molecules and gene eXpression. Specific signaling pathways of AuXins, Cytokinin, Gibberellins, Ethylene, ABA, Brassinosteroids, Salicylic Acid, Strigolactone, polyamines, Jasmonic acid, etc. which leads to formative effects. Cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

Unit 4: Light Signaling

Perception of light-pigments involved- activation of phytochrome/cryptochrome (study of mutants). Light signal transduction. Multiple signaling cascades- identification of signaling components through mutant analysis-changes in gene eXpression.

Unit 5: Abiotic Stress Signaling and Nutrient Signalling

Sensing of environmental factors (Temperature-Osmotic-Ionic stress), Activation of specific molecules and secondary messengers, activation of downstream components-leading to stress gene eXpression, Case studies with different abiotic stresses, Retrograde signaling, Nitrogen fiXation, nitrogen and phosphorus uptake, nutrient translocation.

Unit 6: Signaling Cascade during Developmental Events

Leaf senescence/fruit development and ripening, Tuberization, Sugar signaling. Signaling during seed germination.

Unit 7: Signal Perception and Transduction in Plant Defense Responses

General mechanisms to pathogen response, Role of salicylic acid and active oXygen species, Cross

Talk Signaling- Stress matriX under field conditions, cross talk between abiotic-abiotic stress, biotic-abiotic stress signaling networks.

TEACHING SCHEDULE

Lecture No.	Name of the topic	Weigh tage
Block 1: Signal Perceptions and Transduction: Regulation of Physiological Processes		
	Unit 1: Concept of Receptor and Ligands	**10**
1&2	Signal, signal types, long (diffusible) and short (contact) range signaling and components of signaling.	5
3&4	Types of receptors, nature of ligands, downstream components like primary, secondary signaling components.	5
	Unit 2: Receptors – Signal Perception and Transfer	**20**
5&6	Cell surface trans-membrane receptors- GPCRs, Receptor Tyrosine Kinases (RTKs), Receptors Serine Threonine kinases (RSTKs), Receptor- Like Kinases (RLKs), receptor two component systems	7
7&8	Signal transfer phosphor-relay and generation of secondary signaling components and activation of TFs or enzymes	6
9&10	Downstream components- G-proteins, second messengers-Cyclic AMP, Adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-kinases; effector molecules (transcription factor)	7
	Unit 3: Hormone Signaling	**15**
11 &12	Hormone binding receptors-Transduction process	4
13&14	Effector molecules and gene expression. Specific signaling pathways of Auxins, Cytokinin, Gibberellins, Ethylene, ABA, Brassinosteroids, Salicylic Acid, Strigolactone, polyamines, Jasmonic acid, etc. which leads to formative effects	6
15&16	Cross talk in the signaling of different hormones-significance of studies with hormone action mutants	5
	Unit 4: Light Signaling	**13**
17&18	Perception of light-pigments involved- activation of phytochrome/ cryptochrome (study of mutants)	6
19&20	Light signal transduction. Multiple signaling cascades- identification of signaling components through mutant analysis-changes in gene expression	7
	Unit 5: Abiotic Stress Signaling and Nutrient Signalling	**18**
21&22	Sensing of environmental factors (Temperature-Osmotic-Ionic stress)	5
23&24	Activation of specific molecules and secondary messengers, activation of downstream components-leading to stress gene expression	7
25&26	Case studies with different abiotic stresses, Retrograde signaling, Nitrogen fixation, nitrogen and phosphorus uptake, nutrient translocation	6
	Unit 6: Signaling Cascade during Developmental Events	**12**
27&28	Leaf senescence/fruit development and ripening, Tuberization, Sugarsignaling	**7**
	Signaling during seed germination	5
	Unit 7: Signal Perception and Transduction in Plant DefenseResponses	**12**
29&30	General mechanisms to pathogen response, Role of salicylic acid and	6
	active oxygen species	

31&32	Cross Talk Signaling- Stress matrix under field conditions, cross talk between biotic-abiotic stress, biotic-abiotic stress signaling networks	6
	Total	**100**

Suggested Reading

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Ben-Ari, G. and Lavi, U., 2012. *Marker-assisted selection in plant breeding.*
Plant Biotechnology and Agriculture (163-184). Academic Press.

PP 604: Plant Phenomics-next Generation Phenomics Platforms

Objective

The course aims at providing cutting edge knowledge on the current progress made in various phenotyping techniques and approaches. The students will be versed with principles of various phenotyping approaches. The aim is to provide hands- on eXpertise in analyzing trait diversity. EXposure will be provided on Non-invasive imaging technologies that drive the phenomics platforms. The course provides comprehensive eXposure on recent developments in phenomics platforms imaging tools/techniques and recent trends in designing specific phenomics platforms e.g. drought studies/root phenotyping etc.

Theory

Block 1: Concepts of High throughput Phenotyping and its Requirement

Unit 1: Concepts of Phenotyping

The concepts of "phene and trait" analogous to gene and allele. Genome-phenomerelationship, definition of phenotyping, GXE interaction on phenome.

Unit 2: Physio-Morphological Traits Associated with Crop Performance

Overview of phenotyping needs to complement genomic resources, specific traits associated with yield potential, stress adaptation (both biotic and abiotic stresses). Need for high throughput precision phenotyping approaches for basic studies and to generate genetic and genomic resources.

Unit 3: Features of Phenomic Platforms

Precision growth conditions, maintenance of light, temperature/VPD and RH to realize the potential crop growth response, Controlled environmental facilities for simulating challenging climatic conditions to phenotype diverse plant traits, Concept of sensors, diverse sensors and their utility in precise quantification of environmental variables, soil

moisture sensors, Imaging to capture plant traits, image acquisition. Automated big data access, processing, etc.

Unit 4: Trends in Phenomics

Types of phenomic platforms- Laboratory, Greenhouse and the field-based platforms. Platforms designed for specific needs i.e., root phenotyping, drought studies etc., Crop specific phenotyping, mobile and stationary platforms, Global trends in establishing major phenomics platforms, and their characteristic features and impact.

Unit 5: Non-invasive Phenotyping Approaches

The concept of non-invasive capturing of plant growth and health, Imaging technologies - image acquisition, segmentation and data analysis, Critical aspects of Visual, IR Thermal, Fluorescence, NIR, Hyperspectral imaging, Development and validation of models for deriving relevant physiological traits from image phenome. Concepts of Plants to sensors and sensors to plants, Stationary and ground based tractor mounted sensors/imaging tools, Unmanned aerial vehicle (UAV) sensors, Machine learning and its integration to analyze ground and aerial based images.

Block 2: Applications of the Phenomics Platforms Unit 1: Basic Studies to Assess the Crop Response

Functional validation of genes, chemicals and other interventions, Characterize the growth and stress response in contrasts to identify the relevance of adaptive trait.

Unit 2: Applied Studies Focused on Crop Improvement Programs Characterizing the pre-released promising lines for productivity under defined environmental variables. Phenotyping germplasm accessions, mapping populations for specific traits for mapping, Concept of Phenome Wide Association

Studies (PWAS). Genomic selection, gene-based crop models to predict complex traits, Impact of phenomics platform, progress made, case studies.

TEACHING SCHEDULE

Lecture No.	Name of the topic	Weightage
Block 1: Concepts of High throughput Phenotyping and its Requirement		
	Unit 1: Concepts of Phenotyping	**10**
1&2	The concepts of "phene and trait" analogous to gene and allele	5
3&4	Genome-phenome relationship, definition of phenotyping, GxE interactionon phenome	5
	Unit 2: Physio-Morphological Traits Associated with Crop Performance	**15**
5&6	Overview of phenotyping needs to complement genomic resources, specific traits associated with yield potential, stress adaptation (both biotic and abiotic stresses)	7
7&8	Need for high throughput precision phenotyping approaches for basic studies and to generate genetic and genomic resources	8
	Unit 3: Features of Phenomic Platforms	**20**
9&10	Precision growth conditions, maintenance of light, temperature/VPD andRH to realize the potential crop growth response	5
11&12	Controlled environmental facilities for simulating challenging climatic conditions to phenotype diverse plant traits	5
13&14	Concept of sensors, diverse sensors and their utility in precise quantification of environmental variables, soil moisture sensors	5
15&16	Imaging to capture plant traits, image acquisition. Automated big dataaccess, processing, etc.	5
	Unit 4: Trends in Phenomics	**11**
17	Types of phenomic platforms- Laboratory, Greenhouse and the field-basedplatforms.	3
18	Platforms designed for specific needs i.e., root phenotyping, drought studiesetc.,	4
19	Crop specific phenotyping, mobile and stationary platforms, Global trends inestablishing major phenomics platforms, and their characteristic features andimpact.	4
	Unit 5: Non-invasive Phenotyping Approaches	**20**
20	The concept of non-invasive capturing of plant growth and health	3
21	Imaging technologies - image acquisition, segmentation and data analysis	3
22	Critical aspects of Visual, IR Thermal, Fluorescence, NIR, Hyperspectralimaging	4
23	Development and validation of models for deriving relevant physiological traits from image phenome	4
24	Concepts of Plants to sensors and sensors to plants, Stationary and groundbased tractor mounted sensors/imaging tools	3
25	Unmanned aerial vehicle (UAV) sensors, Machine learning and its integration to analyze ground and aerial based images	3
Block 2: Applications of the Phenomics Platforms		
	Unit 1: Basic Studies to Assess the Crop Response	**12**

26&27	Functional validation of genes, chemicals and other interventions	6
28&29	Characterize the growth and stress response in contrasts to identify the relevance of adaptive trait	6
	Unit 2: Applied Studies Focused on Crop Improvement Programs	**12**
30	Characterizing the pre-released promising lines for productivity under defined environmental variables	4
31	Phenotyping germplasm accessions, mapping populations for specific traitsfor mapping, Concept of Phenome Wide Association Studies (PWAS)	4
32	Genomic selection, gene-based crop models to predict complex traits, Impact of phenomics platform, progress made, case studies	4
	Total	**100**

Suggested Reading

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Golzarian MR, Frick RA, Rajendran K, Berger B, Roy S, Tester M and Lun DS. 2011. *Accurate inference of shoot biomass from high-throughput images of cereal plants*. *Plant Methods*, 7(1), 2.

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Berger B, Parent B and Tester M. 2010. *High-throughput shoot imaging to study drought responses. Journal of Experimental Botany*, 61(13), 3519-3528.

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PP 606: Global Climate Change and Crop Response

Objective

The course is designed to provide basic knowledge on the subjects of crop responses to climate change. The aim of this course is to address both long-term and short- term effects of climate change on crops, natural vegetations and ecosystems.

Theory

Block 1: Climate Change: Crop Response and Mitigation

Unit 1: Fundamentals of Climate Change

Definition of climate change, history and evidences of climate change and its implications. Natural and anthropogenic climate change. Sources of Greenhouse Gas (GHG) emission, Global Warming Potential of GHGs, accumulation of GHGs in the atmosphere and science behind climate change, industrial revolution and GHG build-up in the atmosphere, Energy-Emission-Economy Interactions, carbon intensity of economy, carbon equity/justice.

Unit 2: Manifestations of Climate Change

Impact on monsoons, occurrence of eXtreme weather events, hydrological cycle and water availability, effect on crop growing period in tropics, subtropics and temperate regions, shifts in distribution of flora and fauna, effects on biodiversity and migration of tropical plant species to higher latitudes and altitudes.

Unit 3: Major GHGs (CO_2, Methane, NO_2, etc.), their Production Rates, Monitoring and their Influence on Climate Change

GHGs: An Overview, - role of CO_2, methane and major uncertainties. Mechanism of their production and emission from various, source and sinks of GHGs; and contribution of GHGs to global warming. Techniques used in monitoring GHGs.

Unit 4: Agricultural Practices on GHG Production

Carbon footprint analysis of agriculture and various agricultural practices contribute to climate change. Impacts of natural factors and farming practices on greenhouse gas emissions. Sources of agricultural GHG emission- Agricultural Soil Management, enteric fermentation, manure management, other sources. Opportunities to reduce GHG emission from Agriculture.

Unit 5: Direct and Indirect Effects of Climate Change on Plant Processes

Problems and Prospects of Crops with changing temperature: Growth and Development of Crop plants, Thermo-morphogenesis, phenology, Physiological processes such as photosynthesis, Net carbon assimilation, C_3 and C_4 plants adaptation,Respiration, Nutrient acquisition and metabolisms, Plant water relations and Heat shock proteins, Grain/seed development: Grain Quality parameters and yield.

Unit 6: Climate Change Scenario and Impact on Crops

Different scenarios for temperature, rainfall in different agro-climatic zones of India and their impact on crop growth and productivity. Major climate change (temperature, CO_2, and rainfall) impact quantification using field or controlled environment eXperiments, meta-analysis and simulation models. Some eXamples of crop simulation models calibration and their application in short-term and long- term predictions.

Unit 7: Ozone Depletion leading to Increased Ionizing Radiations and its Implications on Crop Growth

Role of CFCs in ozone depletion, penetration of ionizing UV radiations and its implications on crop growth.

Unit 8: Long-term and Short-term Projections of Climate Change: Effects on Natural Vegetation and Ecosystems

Response of natural ecosystems to increasingatmospheric CO_2 concentration and climate warming, effect of climate change on quality of feed i.e leaf and stored grains/seeds, its implications on pollinators and pests

Unit 9: Technologies for Climate Change Mitigation in Agriculture

Agricultural biotechnology to produce crop varieties with enhanced carbon uptake. Nutrient management: Management of nitrogenous fertilizers.

Tillage/residue management:

1. Conservation tillage CO_2 mitigation technology; 2.Biochar: A potentialtechnique for carbon sequestration.

Methane mitigation using reduced tillage technology, change in methanogenic bacterial activity using electron acceptors. Carbon sequestration potential, concept and measurement.

Unit 10: Climate-resilient Agriculture

Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of "Genome wide mutants" to identify genes/processes for improved adaptation to changing environments.

Unit 11: Climate Change: Technologies for Crop response studies

Temperature Gradient Chambers, Temperature Gradient Greenhouses, Soil plant atmosphere research system (SPAR), Infra-red warming Technology, Free Air temperature enrichment technology, Soil Warming system etc.

Unit 12: Politics of Climate Change Negotiations

IPCC, Major International conventions/treaties, Kyoto Protocol, Paris Agreement, Global initiatives on Carbon sequestration, carbon trading.

TEACHING SHEDULE

Lecture No.	Name of the topic	Weightage
	Block 1: Climate Change: Crop Response and Mitigation	
	Unit 1: Fundamentals of Climate Change	**10**
1	Definition of climate change, history and evidences of climate change and its implications. Natural and anthropogenic climate change.	3
2&3	Sources of Greenhouse Gas (GHG) emission, Global Warming Potential of GHGs, accumulation of GHGs in the atmosphere and science behind climate change, industrial revolution and GHG build-up in the atmosphere, Energy- Emission-Economy Interactions, carbon intensity of economy, carbon equity/justice	7
	Unit 2: Manifestations of Climate Change	**08**
4&5	Impact on monsoons, occurrence of extreme weather events, hydrological cycle and water availability, effect on crop growing period in tropics, subtropics and temperate regions	4
6	Shifts in distribution of flora and fauna, effects on biodiversity andmigration of tropical plant species to higher latitudes and altitudes	4
	Unit 3: Major GHGs (CO_2, Methane, NO_2, etc.), their Production Rates, Monitoring and their Influence on Climate Change	**08**
7	GHGs: An Overview, - role of CO_2, methane and major uncertainties	3

8&9	Mechanism of CO_2, methane and major uncertainties production and emission from various, source and sinks of GHGs; and contribution of GHGs to global warming. Techniques used in monitoring GHGs	5
	Unit 4: Agricultural Practices on GHG Production	**08**
10&11	Carbon footprint analysis of agriculture and various agricultural practices contribute to climate change. Impacts of natural factors and farming practices on greenhouse gas emissions	4
112&13	Sources of agricultural GHG emission- Agricultural Soil Management, enteric fermentation, manure management, other sources. Opportunities to reduce GHG emission from Agriculture	4
	Unit 5: Direct and Indirect Effects of Climate Change on PlantProcesses	**10**
14	Problems and Prospects of Crops with changing temperature: Growth and Development of Crop plants	4
15&16	Thermo-morphogenesis, phenology, Physiological processes such as photosynthesis, Net carbon assimilation, C_3 and C_4 plants adaptation, Respiration, Nutrient acquisition and metabolisms, Plant water relations and Heat shock proteins, Grain/seed development: Grain Quality parameters and yield	6
	Unit 6: Climate Change Scenario and Impact on Crops	**10**
17	Different scenarios for temperature, rainfall in different agro-climatic zones of India and their impact on crop growth and productivity.	4
18&19	Major climate change (temperature, CO_2, and rainfall) impact quantification	6
	using field or controlled environment experiments, meta-analysis and simulation models. Some examples of crop simulation models calibration and their application in short-term and long- term predictions.	
	Unit 7: Ozone Depletion leading to Increased Ionizing Radiations and its Implications on Crop Growth	**08**
20	Role of CFCs in ozone depletion	4
21	Penetration of ionizing UV radiations and its implications on crop growth	4
	Unit 8: Long-term and Short-term Projections of Climate Change: Effects on Natural Vegetation and Ecosystems	**08**
22	Response of natural ecosystems to increasingatmospheric CO_2 concentration and climate warming	4
23	Effect of climate change on quality of feed i.e leaf and stored grains/seeds, its implications on pollinators and pests	4
	Unit 9: Technologies for Climate Change Mitigation in Agriculture	**10**
24	Agricultural biotechnology to produce crop varieties with enhanced carbonuptake.	3
25	Nutrient management: Management of nitrogenous fertilizers. 1. Conservation tillage CO_2 mitigation technology; 2. Biochar: A potentialtechnique for carbon sequestration.	3
26	Methane mitigation using reduced tillage technology, change in methanogenic bacterial activity using electron acceptors. Carbon sequestration potential, concept and measurement.	4
	Unit 10: Climate-resilient Agriculture	**07**
27	Conventional and biotechnological approaches to improve the crop adaptation to climate change	3

28	Relevance of "Genome wide mutants" to identify genes/processes for improved adaptation to changing environments	4
	Unit 11: Climate Change: Technologies for Crop response studies	**07**
29	Temperature Gradient Chambers, Temperature Gradient Greenhouses	3
30	Soil plant atmosphere research system (SPAR), Infra-red warming Technology, Free Air temperature enrichment technology, Soil Warming system etc	4
	Unit 12: Politics of Climate Change Negotiations	06
31&32	IPCC, Major International conventions/treaties, Kyoto Protocol, Paris Agreement, Global initiatives on Carbon sequestration, carbon trading	6
	Total	**100**

Suggested Reading

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PP 607*: Physiological and Molecular Aspects of Source-sink Capacity forEnhancing Yield

Objective

The course addresses the recent development in photosynthetic processes that can be eXploited to improve yield potential. Besides, other major emphasis is to provide eXposure on recent developments in regulating the sink characters ie., yield attributes at molecular level to achieve higher potential yields.

Theory

Block 1: Source Size and Function–Basic Concepts, Physiological and MolecularMechanisms, Genomic Resources to Regulate Source Characters

Unit 1: Source Establishment

MaXimize energy capture by improved light interception, light distribution and its utilization efficiency, concepts of shade avoidance response (SAR) and option to increase, Increase canopy size by vertical eXpansion – concept of increasing optimum LAIlevels, Concepts of semi-tall varieties with resistance to

lodging: traits associated with lodging resistance, Sustain net carbon gain with age – the relevance of stay greencharacter, photon capture and achieve high CO_2 reduction to photon ratio under low light, Options for increasing canopy photosynthesis, Relevance of maintaining cell turgor and nutrient status.

Unit 2: Source Function- Photochemical Reactions

MaXimize conversion efficiency of intercepted radiation by improving net carbon gain - Emerging solutions to increase carbon fiXation rate, Improve efficiency of photochemical reaction by - Engineering the pigments to eXpand PAR spectrum into IR range; reduce antenna size, optimize energy dissipation mechanisms; optimize components of ETC and downstream acceptors; accelerate adaptation for shifting light intensities.

Unit 3: Source Function- CO_2 Diffusion and Concentration

Enhance stomatal conductance (g_s) and mesophyll conductance (g_m) – guard cell metabolism; concepts of leaf mesophyll tissue thickness (SLW), Concepts of VPD responses of g_s to enhance duration of photosynthesis during the day, Bicarbonate transports and aquaporins; achieve higher CCM - Engineering C4 cycle, CAM, cyanobacteria, carboXysomes, algal pyrenoids.

Unit 4: Source Function- Metabolic Engineering of CO_2 Fixation

RuBisCO carbon fiXation activity - Increase and optimize kinetics of RuBisCO with enhanced specificity to CO_2, Engineer RuBisCO to minimize feedback regulation by metabolite inhibitors, Increased activation state by improving stability and function of RuBisCOactivase; optimize RuBp regeneration – modulate specific enzyme levels. New concepts on photorespiratory synthetic bypass.

Unit 5: Case Studies to Improve Source Capacity

Genetic and genomic resources, genes/QTLs associated with specific yield potential traits and/or photosynthetic mechanisms, Genetic resources to improve source traits- case studies.

Block 2: Improving Sink Size and CapacityUnit 1: Sink Establishment

Optimise duration of phenological stages related to sink establishment, genetic and environmental factors, GDD and phenology.

Unit 2: Increase the Sink Size by Enhancing the Relevant Constituent Traits

Role of hormones in regulating molecular mechanisms of yield structure development, Genomic and genetic resources developed for regulation/improvement of such traits. – Sink Size: Tillering associated traits, branching patterns/fruiting points, spikelet number, pod number, fruit number. – Sink development: Basic concepts and molecular mechanisms associated with pollination, fertilization, ovary development in determining the spikelet fertility/sterility components and strategies for engineering seed/fruit size in crop plants.

Unit 3: Genetic and Genomic Resources, Genes/ QTLs, Genetic Resourcesto Improve Sink Traits- Case Studies. Progress and status in developing genomic and genetic resources of validated genes/ QTLs to improve sink traits- Specific case studies.

Unit 4: Source to Support the Sink Capacity

Canopy architecture to support sink requirements in cereals: plant height, tillering, leaf area, shading or senescence of lower canopy leaves, canopy photosynthesis, Canopy architecture to support sink requirements in Pulses: Leaf senescence, abscission, mobilization of N and other nutrients, Symbiotic N fiXation to support sink size and capacity in pulses.

TEACHING SCHEDULE

Lecture No.	Name of the topic	Weightage
Block 1: Source Size and Function–Basic Concepts, Physiological and Molecular Mechanisms, Genomic Resources to Regulate Source Characters		
	Unit 1: Source Establishment	**12**
1&2	Maximize energy capture by improved light interception, light distribution and its utilization efficiency, concepts of shade avoidance response (SAR) and option to increase	4
3&4	Increase canopy size by vertical expansion – concept of increasing optimum LAI levels, Concepts of semi-tall varieties with resistance to lodging: traits associated with lodging resistance	3
5&6	Sustain net carbon gain with age – the relevance of stay green character, photon capture and achieve high CO_2 reduction to photon ratio under low light, Options for increasing canopy photosynthesis, Relevance of maintaining cell turgor and nutrient status	5
	Unit 2: Source Function- Photochemical Reactions	12
7, 8 &9	Maximize conversion efficiency of intercepted radiation by improving net carbon gain- Emerging solutions to increase carbon fixation rate, Improve efficiency of photochemical reaction by - Engineering the pigments to expand PAR spectrum into IR range	6
10,11 &12	Reduce antenna size, optimize energy dissipation mechanisms; optimize components of ETC and downstream acceptors; accelerate adaptation for shifting light intensities	6
	Unit 3: Source Function- CO_2 Diffusion and Concentration	**10**
13&14	Enhance stomatal conductance (g_s) and mesophyll conductance (g_m) – guard cell metabolism	3
15&16	Concepts of leaf mesophyll tissue thickness (SLW), Concepts of VPD responses of g_s to enhance duration of photosynthesis during the day, Bicarbonate transports and aquaporins; achieve higher CCM	4
16&17	Engineering C4 cycle, CAM, cyanobacteria, carboxysomes, algal pyrenoids	3
	Unit 4: Source Function- Metabolic Engineering of CO_2 Fixation	**12**

18,19 &20	RuBisCO carbon fixation activity - Increase and optimize kinetics of RuBisCO with enhanced specificity to CO_2, Engineer RuBisCO to minimize feedback regulation by metabolite inhibitors	6
21, 22 &23	Increased activation state by improving stability and function of RuBisCOactivase; optimize RuBp regeneration – modulate specific enzyme levels. New concepts on photorespiratory synthetic bypass	6
	Unit 5: Case Studies to Improve Source Capacity	**10**
24, 25 &26	Genetic and genomic resources, genes/QTLs associated with specific yield potential traits and/or photosynthetic mechanisms	6
	Genetic resources to improve source traits- case studies	4
Block 2: Improving Sink Size and Capacity		
	Unit 1: Sink Establishment	**10**
27& 28	Optimise duration of phenological stages related to sink establishment	4
29, 30 &31	Optimise duration of phenological stages related to genetic and environmental factors, GDD and phenology.	6
	Unit 2: Increase the Sink Size by Enhancing the Relevant ConstituentTraits	**14**
32 & 33	Role of hormones in regulating molecular mechanisms of yield structure development, Genomic and genetic resources developed for regulation/improvement of such traits.	4
34 &35	Sink Size: Tillering associated traits, branching patterns/fruiting points, spikelet number, pod number, fruit number	4
36, 37 &38	Sink development: Basic concepts and molecular mechanisms associated with pollination, fertilization, ovary development in determining the spikelet fertility/sterility components and strategies for engineering seed/fruit size in crop plants	6
	Unit 3: Genetic and Genomic Resources, Genes/ QTLs, Genetic Resources to Improve	**10**
39 &40	Sink Traits- Case Studies	4
41 & 42	Progress and status in developing genomic and genetic resources of validated genes/ QTLs to improve sink traits- Specific case studies	4
	Unit 4: Source to Support the Sink Capacity	**10**
43, 44 & 45	Canopy architecture to support sink requirements in cereals: plant height, tillering, leaf area, shading or senescence of lower canopy leaves, canopy photosynthesis, Canopy architecture to support sink requirements in Pulses	6
46 & 47	Leaf senescence, abscission, mobilization of N and other nutrients,Symbiotic N fixation to	4

	support sink size and capacity in pulses	
	Total	**100**

Suggested Reading

Ray DK, Mueller ND, West PC, Foley JA. 2013. *Yield Trends Are Insufficient to Double Global Crop Production* by 2050. PLoS ONE 8(6): e66428. doi: 10.1371/journal.pone.0066428

Hunter MC, Smith RG, Schipanski ME, Atwood LW and Mortensen DA. 2017. *Agriculture in 2050: Recalibrating Targets for Sustainable Intensification*. BioScienceApril 2017 / Vol. 67 No. 4

PirjoPeltonen-Sainio, TapioSalo, Lauri Jauhiainen, HeikkiLehtonen, ElinaSievila¨inen. 2015. *Static yields and quality issues: Is the agri-environment program the primary driver*? Ambio 2015, 44: 544–556 DOI 10.1007/s13280-015-0637-9

Zhu G, Li G, Wang D, Yuan S, Wang F. 2016. *Changes in the Lodging-Related Traits along with Rice Genetic Improvement in China. PLoS ONE* 11(7): e0160104. doi: 10.1371/ journal.pone.0160104

Burgess AJ, Retkute R, Herman T and Murchie EH. 2017. *Exploring Relationships between Canopy Architecture, Light Distribution, and Photosynthesis in Contrasting Rice Genotypes Using 3D Canopy Reconstruction. Front. Plant Sci*. 8: 734. doi: 10.3389/fpls.2017.00734

Orta DR, Merchantd BS, Alricf J, Barkan A *et al*. 2015. *Redesigning photosynthesis to sustainably meet global food and bioenergy demand*. PNAS, 112, 8529–8536

TANG Yun-jia, Liesche J. 2017. *The molecular mechanism of shade avoidance in crops- How data from Arabidopsis can help to identify targets for increasing yield and biomass production. Journal of Integrative Agriculture* 16(6): 1244–1255

Sessa G, Carabelli M, Possenti M, Morelli G and Ruberti I. 2018. *Multiple Pathways in the Control of the Shade Avoidance Response*. *Plants* 7, 102; doi: 10.3390/plants7040102

Wille W, Pipper CB, Rosenqvist E, Andersen SB, Weiner J. 2017. *Reducing shade avoidance responses in a cereal crop. AoB Plants* 9: plX039; doi: 10.1093/aobpla/plX039

Haroa RJ, Baldessaria J, Otegui ME. 2017. *Genetic improvement of peanut in Argentina between 1948 and 2004: Light interception, biomass production and radiation use efficiency. Field Crops Research* 204, 222–228

Jiang D, Chen W, Dong J, Li J, Yang1 F, Wu Z, Zhou H, Wang W and Zhuang C. 2018. *Overexpression of miR164b-resistant OsNAC2 improves plant architecture and grain yield in rice. Journal of Experimental Botany*, vol. 69, (7) 1533–1543.

Smolikova G, Dolgikh E, Vikhnina M, Frolov A and Medvedev S. 2017. *Genetic and Hormonal Regulation of Chlorophyll Degradation during Maturation of Seeds with Green Embryos*. *Int. J. Mol. Sci.* 18, 1993; doi: 10.3390/ijms18091993

Zhu X, Chen J, Qiu K and Kuai B. 2017. *Phytohormone and Light Regulation of Chlorophyll Degradation. Front. Plant Sci*. 8: 1911. doi: 10.3389/fpls.2017.01911

Sato T, Shimoda Y, Matsuda K, Tanaka A, Ito H. 2018. *Mg-dechelation of chlorophyll a by Stay-Green activates chlorophyll b degradation through expressing Non-Yellow Coloring in Arabidopsis thaliana*. *Journal of Plant Physiology* 222 (2018) 94–102

Christophera M, Chenub NK, Jenningsa R, Fletchera S, Butlera D, Borrellc A, Christopher J. 2018. *QTL for stay-green traits in wheat in well-watered and water- limited environments. Field Crops Research* 217 (2018) 32–44

Thomas H and Ougham H. 2014. *The stay-green trait. Journal of Experimental Botany*, Vol. 65, No. 14, pp. 3889–3900, 2014

PP 608: Seed and Fruit Growth and their Quality Improvement

Objective

The major aim of the course is to train and educate the students about the importance of seeds and fruits as a source of nutrition for human health. Further, this course also addresses how to improve the nutritional status besides protecting the nutritive value of seeds and fruits. In addition, the other aim of the course is to address to regulate the post harvest deterioration of seeds and fruits to minimizethe losses.

Theory

Block 1: Physiological and Molecular Aspects of Seed and Fruit Growth: QualityImprovement

Unit 1: Physiology of Seed Growth and Development

Mechanism of seed development and different developmental stages; synthesis, mobilization and accumulation of stored reserves, Forms of stored reserves and their localization, Sink drawing ability (SDA) and its relevance in seed growth and development, Role of plant hormones in seed growth and development and SDA.

Unit 2: Seed as a Propagule

Seed as a propagation material; seed size and seed chemical composition and their relevance in seed germination, Physiological, biochemical and molecular mechanisms and approaches to regulate seed germination, seedling emergence and establishment and seedling vigour, Physiological, biochemical and molecular mechanisms and approaches to regulate seed priming and crop establishment: seed dormancy, precocious germination and controlling pre-harvest sprouting in crops, Physiological, biochemical and molecular mechanisms and approaches to regulate seed viability, improving the viability and storability of seeds.

Unit 3: Seed as a Source of Nutrition

Seed as a source of nutrition to humans: approaches to improve the quality of seeds through synthesis of seed storage reserves and other constituents, Genes/ QTL's regulating these processes and concept of pathway engineering to improve the quantity and quality of seed constituents, Carbohydrates- Amylose and amylopectin ratios for glycemic indeX, resistant and digestable starch, improving dietary fibre, alter gelatinisation, Protein content, modified proteins, essential amino acids, Oil content, fatty acid composition, Omega 3 fatty acids. Carotenoids and vitamins, Biofortification strategies to enhance the grain zinc, iron, other minerals and other essential compounds, Engineering for low protease inhibitors, phytic acid, tannins, phenolic substances, lectins, oXalates as anti-nutritional factors, Case studies of improving seed nutrition components by molecular breeding and transgenic approaches.

Unit 4: Quality Deterioration during Storage

Changes in chemical composition during storage; factors influencing the deterioration of nutritional quality of seeds during storage; approaches to minimize nutritional quality deterioration, Effect of quality

deterioration on human and animal health

Unit 5: Fruit Growth and Development

Flower and fruit development; concept of parthenocarpy, Physiological and biochemical changes during fruit development and chemical composition, Molecular approaches to regulate flower and fruit drop/ abscission; Role of hormones.

Unit 6: Fruit as a Source of Phytochemicals: Nutraceuticals

Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of AntioXidants, Flavanoids, anthocyanins, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Vitamins- Vitamin C, Tocopherol, Carotenoids, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Alkaloids, Mangiferin, tomatins, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of DigestableFiber lycopene, stillbeans, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Aroma, monoterpenoids and Fatty acid esters.

Unit 7: Fruit Ripening, Post Harvest Deterioration and Shelf life

Physiological and molecular mechanisms of fruit ripening, Postharvest deterioration of fruits; factors regulating fruit deterioration; hormonal and environmental aspects of reducing post harvest deterioration of fruits, Physiological and Molecular approaches to regulate fruit ripening and shelf life: Role of Ethylene and Ethylene response factors regulating specific processes of fruit ripening; Approaches to regulate specific shelf life characters, Improving fruit ripening and shelf life by molecular approaches- Case studies.

TEACHING SCHEDULE

Lecture No.	**Name of the topic**	**Weightage**
Block 1: Physiological and Molecular Aspects of Seed and Fruit Growth: QualityImprovement		
	Unit 1: Physiology of Seed Growth and Development	**10**
1	Mechanism of seed development and different developmental stages; synthesis, mobilization and accumulation of stored reserves	5
2& 3	Forms of stored reserves and their localization, Sink drawing ability (SDA) and its relevance in seed growth and development, Role of plant hormones in seed growth and development and SDA	5
	Unit 2: Seed as a Propagule	**17**
4& 5	Seed as a propagation material; seed size and seed chemical composition and their relevance in seed germination, Physiological, biochemical and molecular mechanisms and approaches to regulate seed germination, seedling emergence and establishment and seedling vigour	6

6& 7	Physiological, biochemical and molecular mechanisms and approaches to regulate seed priming and crop establishment	5
8& 9	seed dormancy, precocious germination and controlling pre-harvest sprouting in crops, Physiological, biochemical and molecular mechanisms and approaches to regulate seed viability, improving the viability and storability of seeds	6
	Unit 3: Seed as a Source of Nutrition	**18**
10& 11	Seed as a source of nutrition to humans: approaches to improve the quality of seeds through synthesis of seed storage reserves and other constituents, Genes/ QTL's regulating these processes and concept of pathway engineering to improve the quantity and quality of seed constituents	6
12& 13	Carbohydrates- Amylose and amylopectin ratios for glycemic index, resistant and digestable starch, improving dietary fibre, alter gelatinisation, Protein content, modified proteins, essential amino acids, Oil content, fatty acid composition, Omega 3 fatty acids, Carotenoids and vitamins, Biofortification strategies to enhance the grain zinc, iron, other minerals and other essential compounds	6
14& 15	Engineering for low protease inhibitors, phytic acid, tannins, phenolic substances, lectins, oxalates as anti-nutritional factors, Case studies of improving seed nutrition components by molecular breeding and transgenic approaches	6
	Unit 4: Quality Deterioration during Storage	**12**
16& 17	Changes in chemical composition during storage; factors influencing the deterioration of nutritional quality of seeds during storage	6
18& 19	Approaches to minimize nutritional quality deterioration, Effect of quality deterioration on human and animal health	6
	Unit 5: Fruit Growth and Development	**13**
20& 21	Flower and fruit development; concept of parthenocarpy, Physiological and biochemical changes during fruit development and chemical composition	7
22& 23	Molecular approaches to regulate flower and fruit drop/ abscission; Role of hormones	6
	Unit 6: Fruit as a Source of Phytochemicals: Nutraceuticals	**17**
24	Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Antioxidants, Flavanoids, anthocyanins,	4
25	Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Vitamins- Vitamin C, Tocopherol, Carotenoids	4
26	Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Alkaloids, Mangiferin, tomatins	3
27	Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of DigestableFiber lycopene, stillbeans	3
28	Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Aroma, monoterpenoids and Fatty acid esters	3
	Unit 7: Fruit Ripening, Post Harvest Deterioration and Shelf life	**13**

29	Physiological and molecular mechanisms of fruit ripening, Postharvest deterioration of fruits; factors regulating fruit deterioration	3
30	Hormonal and environmental aspects of reducing post harvest deterioration of fruits, Physiological and Molecular approaches to regulate fruit ripening and shelf life	3
31	Role of Ethylene and Ethylene response factors regulating specific processesof fruit ripening	4
32	Approaches to regulate specific shelf life characters, Improving fruitripening and shelf life by molecular approaches-Case studies	3
	Total	**100**

Suggested Reading

Bewley, JD, Bradford K, Hilhorst H, Nonogaki H. (2013). *Seeds: Physiology of Development, Germination and Dormancy*, Springer-Verlag

Larkins BA and Vasil IK (Ed). 2010. *Cellular and Molecular Biology of Plant SeedDevelopment*, Springer

Vanangamudi K, Natarajan K and Vanangamudi M, *Seed Physiology*, AssociatedPublishing Company.

Pammenter NW and Berjak P. 2000. *Aspects of recalcitrant seed physiology*. *R.Bras. Fisiol.Veg*., 12: 56-69.

Prakash M. 2011. *Seed Physiology of Crops*.(ed). Satish Serial Publishing house, New Delhi..

Lee KR, Chen GQ and Kim HU. 2015. *Current progress towards the metabolic engineering of plant seed oil for hydroxy fatty acids production. Plant Cell Reports*, 34(4): 603-615.

Zhu Y, Xie L, Chen GQ, Lee MY, Loque D and Scheller HV. 2018. *A transgene design for enhancing oil content in Arabidopsis and Camelina seeds. Biotechnology for biofuels*, 11(1), p.46.

b. Masters Programmes

1. Name of the programme: **Genetics and Plant Breeding M.Sc.(Agri.)**

Semester	Course	Course No.	Title	Credits
I.	**Major:** 9Credits	GPB-501	Principles of Genetics	2+1=3
		GPB-502	Principles of Plant Breeding	2+1=3
		GPB-505	Principles of Cytogenetics	2+1=3
	Minor: 3 Credits	PP-501	PrinciplesofPlantPhysiology-1 Plant Water Relations And Mineral Nutrition	2+1=3
	Supporting 4Credits	STAT-502	Statistical Methods for Applied Sciences	3+1=4
	NCCC: 2Credits	PGS-501	Library and Information Services	0+1=1
		PGS-504	Basic Concepts in Laboratory Techniques	0+1=1
			Total Course Credits	**11+7=18**
	Major: 8 Credits	GPB-503	Fundamentals of Quantitative Genetics	2+1=3
		GPB-506	Molecular Breeding And Bioinformatics	2+1=3
		GPB-510	Seed Production And Certification	1+1=2
	Minor: 6 Credits	BIOCHEM-501	Basic Biochemistry	3+1=4
		SST-503	Seed Production Principles and Techniques in Field Crops	1+1=2

II.	**Supporting** 3Credits	STAT-511	Experimental Designs	2+1=3
	NCCC: 2 Credits	PGS-502	Technical Writing and Communication Skills	0+1=1
		PGS-503	Intellectual Property and it's| management in Agriculture	1+0=1
	Total Course Credits			**12+7=19**
III.	**Major:** 3 Credits	GPB-511	CropBreeding-1(Kharif Crops)	2+1=3
	Research: 15Credits	GPB-599	Master's Research	0+15=15
	NCCC: 1 Credit	PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0=1
	Total Course Credits			**3+16=19**

Course Curricula and syllabi:

GPB 501 PRINCIPLES OF GENETICS 2 + 1

Objective

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

Theory

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

Practical :

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms;Chromosome mapping using three-point test cross;

Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification;

Electrophoresis: basic principles and running of amplified DNA;Extraction of proteins and isozymes;

Use of Agrobacterium mediated method and Biolistic gun; Detection of transgenes in the exposed plant material;

Visit to transgenic glasshouse and learning the practical considerations.

LECTURE SCHEDULE

Theory

Lecture No.	Topic	Weightage
1.	**Introduction to Genetics** :Beginning of genetics**,** early concepts of inheritance	5
2.	Mendel's laws; Discussion on Mendel's paper,	8
3.	Chromosomal theory of inheritance; Multiple alleles,	
4.	Gene interactions,	10
5.	SeX determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits;	
6.	**Linkage:** Linkage-detection, estimation Recombination and genetic mapping in eukaryotes	10
7.	Somatic cell genetics, EXtra chromosomal inheritance**.**	
8. & 9	**Population** : Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium	8
10.	Nature, structure and replication of the genetic material	8
11.	**Genetic Material:** Organization of DNA in chromosomes, ,	
12 & 13	Genetic code; Protein biosynthesis	
14 &15	Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters	8
16	Regulation of gene activity in prokaryotes and eukaryotes;	
17	Molecular mechanisms of mutation, repair and suppression;	
18	**Plasmid:** Bacterial plasmids, insertion (IS) and transposable (Tn) elements	8

19	Molecular chaperones and gene expression, RNA editing	
20 &21	Gene isolation, synthesis and cloning, genomic and cDNA libraries	8
22 & 23	PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection;	
24	DNA sequencing; DNA restriction and modification	8
25	Anti-sense RNA and ribozymes;Micro-RNAs (miRNAs	
26 & 27	Genomics and proteomics; metagenomics	5
28	**Transgenic:** Transgenic bacteria and bioethics	5
29	Gene silencing;	9
30	Genetics of mitochondria and chloroplasts	
31 &32	Concepts of Eugenics, Epigenetics, Genetic disorders	
	Total	**100**

Practical

Practical No.	**Topic**
1.	Estimation of probability and chi-square.
2 &3	Demonstration of genetic principles using laboratory organisms.
4	Study of Chromosome mapping using three-point test cross.
5	Study of tetrad analysis
6	Study of Induction and detection of mutations through genetic test
7 & 8	Study of genomic DNA eXtraction.
9	PCR amplification
10 & 11	Electrophoresis: basic principles and running of amplified DNA.
12	Study of eXtraction of proteins
13 &14	Study of extraction of isozymes
15	Study of Gene Transfer (Indirect method): Use of *Agrobacterium* mediated method
16	Study of Gene Transfer (direct method) Biolistic gun;
	Total

Suggested reading:

Daniel LH and Maryellen R. 2011. *Genetics:* "*Analysis of Genes and Genomes* Gardner EJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley and Sons. 8th ed.2006

Klug WS and Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education India; Tenth edition

Lewin B. 2008. *Genes XII*. Jones and Bartlett Publ. (International Edition) Paperback, 2018 Russell PJ. 1998. *Genetics*. The Benzamin/ Cummings Publ.Co.

Singh BD. 2009. *Genetics*. Kalyani Publishers (2nd Revised Edition)

Snustad DP and Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition

Stansfield WD.1991. *Genetics.*Schaum Outline Series Mc Graw Hill

Strickberger MW. 2005. *Genetics* (*III Ed*). Prentice Hall, New Delhi, India; 3rd ed.,2015 Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs., McGraw Hill Education; 7 edition

Uppal S, Yadav R, Singh S and Saharan RP. 2005. *Practical Manual on Basic and applied Genetics.* Dept. of Genetics *CCS HAU Hissar*

GPB 502 PRINCIPLES OF PLANT BREEDING 2 + 1

Objective

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

Theory Unit

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

Unit II

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

Unit III

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

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, malesterility and apomixes in crop plants and their commercial eXploitation.

Unit V

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

Unit VI

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

Unit VII

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

Practical

Floral biology in self and cross pollinated species;Selfing and crossing techniques;

Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA);

Estimation of heritability and genetic advance;Maintenance of eXperimental records;

Learning techniques in hybrid seed production using male-sterility in field crops; Prediction of performance of double cross hybrid

LECTURE SCHEDULE

Lecture No.	Topic	Weightage
1	**Plant Breeding**, Early Plant Breeding; Accomplishments through plant breeding; Objectives of plantbreeding;	4
2	**Aims, Objective and scope of plant breeding ,** Characteristics improved by plant breeding	4
3	**Pattern of evolution in crop plants –** Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance.	3

4	**Prebreeding**-Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.	3
5	**Genetics Basis of Breeding** Genetic basis of breeding: self and cross pollinated crops including mating systemsand response to selection	3
6	**Nature of variability** – Types and components of variation	3
7	**Heritability**-Types, genetic advance and genotype environment interaction;	3
8	**Combining ability** 1. Types – General combing ability, specific combining ability 2. Utilizations in crop improvement	4
9	Types of gene actions and implications in plant breeding	3
10	**Methods of plant breeding for self- pollinated crops**-Introduction: definition and types, procedure merits and demerits	3
11	**Incompatibility** – definition, 1.Types incompatibility 2. Commercial exploitation 3. Mechanism, of incompatibility 4. Utilization in crop improvement	4
12	**Male sterility** – 1.Types of Male sterility 2. Commercial exploitation 3.Methods of transfer of male sterility, methods of transfer of restorer genes, 4. Utilization of male sterility in crop improvement achievements, limitations.	4
13	**Breeding Methods**- Selection: 1 Pure line theory (Johanssons) 2 Pure line selection 3 Mass Selection. Types, Procedure, Merits and demerits and achievements	4
14	**Pedigree method**- definition, Pedigree record, maintenance of pedigreerecord, procedure of pedigree methods, Applications, merits, demerits & achievements.	4
15	**Back cross method**- definition, procedure, Applications, merits, demerits, achievements	4
16	**Single seed descent methods and multiline breeding methods** definition, procedure, Applications, merits, demerits, achievements	4

17	**Population breeding** -Self-pollinated crops, diallel selective mating approach Transgressive breeding.	3
18	**Breeding methods in cross pollinated crops** -definition, procedure, Applications, merits, demerits, achievements	4
19	**Population Breeding** : 1.Mass selection and ear to row method , S1 and S2 progeny testing, progeny selection	3
20	**Population improvement programme –** Recurrent selection, schemes for intra and inter population improvement	3
21	**Synthetic Variety** – definition ,steps involved in developments of Synthetic merits, demerits, achievements	3
22	**Composites Variety** – definition ,steps involved in developments of composites merits, demerits, achievements	3
23&24	**Breeding methods in asexually propagated crops,** Clonal selection, apomixis, A pom ix i s in crop plants and their commercial eXploitation, clonal selection - definition ,steps involved in developments merits, demerits, achievements	3
25	**Hybrid breeding**: Genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance	4
26	**Plant ideotypes** – Concepts of Plant ideotypes, role in crop improvement, transgressive breeding	3
27	**Special breeding techniques** – 1. Mutation breeding : definition, types , procedure of mutation breeding , application in crop improvement , achievements limitations	4
28 & 29	**Special breeding techniques-** 1. Biotic and abiotic stresses	4
30 & 31	**Cultivar development** – testing, release and notification, Maintenance breeding	3
32	Plant Breeding , Plant Breeders rights, Regulation for plant variety protection and farmers rights	3
	Total	**100**

Practical :

Practical No.	Topic
1.	Plant Breeder's Kit.
2	Selfing , Emasculation and crossing technique.
3	Botanical description and floral biology ; Floral morphology, Selfing emasculation and crossing techniques in Cotton.
4	Botanical description and floral biology ; Floral morphology, Selfing emasculation and crossing techniques in Sorghum, Pearl millet.
5	Botanical description and floral biology ; Floral morphology, Selfing emasculation and crossing techniques in Pigeonpea, Green gram and Soybean
6	Botanical description and floral biology ; Floral morphology, Selfing emasculation and crossing techniques in Sunflower,
7	Botanical description and floral biology ; Floral morphology, Selfing emasculation and crossing techniques in Maize
8	Botanical description and floral biology ; Floral Morphology, Selfing emasculation and crossing techniques in Chilli, Tomato and Brinjal
9	Botanical description and floral biology ; Floral morphology, Selfing emasculation and crossing techniques in Okra
10	Selection methods in segregating populations
11	Evaluation of breeding material
12	Analysis of variance (ANOVA)
13	Estimation of heritability and genetics advance
14	Maintenance of experimental records
15	Techniques in hybrids seed production
16	Use of male – sterility in field crops Prediction of performance of double cross hybrid.

Suggested reading.

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.

Chahal GS and Gossal, SS. 2002. *Principles and Procedures of Plant Breeding : Biotechnological and Conventional approaches.* Narosa Publishing House.

Chopra VL. 2004. *Plant Breeding.* OXford & IBH.

George A. 2012. *Principles of Plant Genetics and Breeding*. John Wiley &Sons.

Gupta SK. 2005. *Practical Plant Breeding*. Agribios.

Jain HK and Kharakwal MC. 2004. *Plant Breeding and–Mendelian to Molecular Approach*, Narosa Publications, New Delhi

Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ.House.

Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill. Sharma J P. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi.

Simmonds NW.1990. *Principles of Crop Improvement*. English LanguageBook Society.

Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.

GPB 503 FUNDAMENTALS OF QUANTITATIVE GENETICS* 2 + 1

OBJECTIVE:

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

Theory Unit I

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

Unit II

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

Unit III

Association analysis- Genotypic and phenotypic correlation, Path analysis Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D^2, Generation mean analysis, Parent progeny regression analysis

Unit IV

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

Unit V

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

Practical

Analysis and interpretation of variability parameters; Analysis and interpretation of IndeX score and Metroglyph; Clustering and interpretation of D2 analysis; Genotypic and phenotypic correlation analysis and interpretation; Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation; A, B and C Scaling test; L × T analysis and interpretation, QTL analysis; Use of computer packages; Diallel analysis; G × E interaction and stability analysis

LECTURE SCHEDULE

Lecture No.	Topic	Weightage
1	**Introduction Quantitative Genetics :** Introduction and historical background of quantitative genetics	2
2	**Mendelian traits *vs* polygenic traits. :** Nature of quantitative traitsand its Inheritance. Genetical foundation of quantitative traits.	2
3 &4	**Multiple factor hypothesis.:** Analysis of continuous variation. Important features of multiple factor hypothesis	8
5 & 6	**Variations associated with polygenic traits.:** Phenotypic, genotypic & environmental. Non allelic interactions. Nature of gene action - additive, dominance, epistatic and linkage effects.	6
7 & 8	**Principles of Analysis of Variance (ANOVA):** Expected variance components, random and fixed models; MANOVA.	8
9 &10	**Biplot analysis:** Comparison of means and variances for significance.	8
11	**Designs for plant breeding experiments:** Principles and applications.	2
12 & 13	**Genetic diversity analysis Association analysis. Path analysis:** Metroglyph, cluster and D^2 analyses phenotypic and genotypiccorrelations Parent. Progeny regression analysis.	8
14 &15	**Discriminant function Selection indices:** Principal component analysis selection of parents. Simultaneous selection models.	8
16	**Concepts of selection:** Heritability and genetic advance.	2
17	**Generation mean analysis action:** 3, 5, and 6 parameter models, scaling tests.	2
18,19, 20 & 21	**Mating designs:** Diallel, Partial diallel, line x tester analysis, NCDs and TTC	12
22	**Combing ability:** Concepts of combining ability and gene action	2
23	**Analysis of genotype x environment interaction:** Adaptability and	4
	stability.	
24 & 25	**Models for GxE analysis and stability parameters:** Methods & features of stability models.	8
26	**AMMI analysis:** Principles and interpretation.	2
27	**QTL mapping:** Strategies for QTL mapping - desired populations for QTL mapping.	4
28 & 29	**Statistical methods in QTL mapping:**QTL mapping in Genetic Analysis. Marker assisted selection (MAS).	4
30 & 31	**Approaches to apply MAS in Plant breeding:** Selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.	8
	Total	100

Practical :

Practical No	Topic
1 &2	**Variability** :Analysis and interpretation of variability parameters
3	**Metroglyph** :Analysis and interpretation of IndeX score and Metroglyph
4	**D^2 analysis** : Clustering and interpretation.
5	Correlation: Genotypic and phenotypic correlation analysis andinterpretation
6	**Path analysis** : Path coefficient analysis and interpretation
7	**Heterosis** :Estimation of different types of heterosis, inbreeding depression
8 & 9	**Generation mean analysis** :-A,B and C scaling test, Analytical part andInterpretation – Estimation of different types of gene actions.
10	QTL analysis
11&12	Use of computer packages
13 & 14	Diallel analysis. Griffing's methods I and II – Diallel analysis. Hayman's graphical approach. Diallel analysis: interpretation of Results. NCD and theirinterpretations.
15 &16	Stability : G × E interaction and stability analysis

Suggested Reading

Bos I and Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall. Falconer DS and Mackay J. 1998. Introduction to Quantitative Genetics (3rd Ed.).ELBS/

Longman, London.

Mather K and Jinks JL.1985. Biometrical Genetics (3rd Ed.). Chapman and Hall, London.

Nandarajan N and Gunasekaran M. 2008. Quantitative Genetics and Biometrical Techniquesin Plant Breeding. Kalyani Publishers, New Delhi.

Naryanan SS and Singh P. 2007. Biometrical Techniques in Plant Breeding. KalyaniPublishers, New Delhi.

Roy D. 2000. Plant Breeding: Analysis and Exploitation of Variation. Narosa PublishingHouse, New Delhi.

Sharma JR. 2006. Statistical and Biometrical Techniques in Plant Breeding. New AgeInternational Pvt. Ltd.

Singh P and Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. KalyaniPublishers, New Delhi.

Singh RK and Chaudhary BD. 1987. Biometrical Methods in Quantitative Genetic analysis.

Kalyani Publishers, New Delhi.

Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data.

Sinauer Associates.

Wricke G and Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding.

Walter de Gruyter.

GPB 505 PRINCIPLES OF CYTOGENETICS 2 +1

OBJECTIVE :

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

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 invivo and in-vitro; Demonstration of polyploidy.

LECTURE SCHEDULE

Lecture No.	Topic	Weightage
1	**Introduction to Cytogenetics**: Important concepts of cytogenetics, important landmarks of cytogenetics	4
2	**Chromosome:** Structure of Chromosomes in prokaryotes and eukaryotes, chromonemata, chromosome matrix, chromomere, centromere, secondary constriction and teleomere. Special types of chromosomes.	7
3 & 4	**Chromosomal theory of inheritance** **Cell**: Cell structure, Cell cycle, cell division, mitosis and meiosis; differences, significance and deviation. Synapsis, structure and functions of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes.	7
5 & 6	**Crossing over**: mechanism of crossing over, mechanism and theories of crossing over, recombination models, cytological basis. Variation in chromosome structure. Evolutionary significance	7
7	**Karyotype:** Introduction to techniques of Karyotyping, Chromosome banding and painting, in situ hybridization and various application	4
8, 9 & 10	**Chromosomal aberrations:** Structural and numerical variations of chromosomes and implication. Symbols and terminologies for chromosome number euploidy, haploids, diploids and polyploids. Utilization of aneuploids in gene location.	8

11 & 12	**Variation in chromosome behaviour:**, somatic segregation and chimeras, endomitosis and somatic reduction. Evolutionary significance of chromosomal aberrations, balanced lethals and chromosome complexes.	7
13 & 14	Inter-varietal chromosome substitutions **Polyploidy**: concept of polyploidy, role of polyploidy in crop breeding. Evolutionary advantages of auto polyploids and allopolyploids.	7
15 & 16	**Aneuploids:** Role of aneuploids in basic and applied aspects of crop breeding, maintenance and utilization in gene mapping.	7
17	**Alien Addition and Alien substitution lines**, creation and utlization.	6
18	**Apomixis** Evolutionary and genetic problems in crop with apomixes.	4
19	Reversion of autopolyploids to diploids. Genome mapping in polyploids. Interspecific hybridization and allopolyploids.	5
20 & 21	Synthesis of new crops viz., wheat, triticale and brassica.	7
22, 23 & 24	**Distant Hybridization:** Hybrids between species with same chromosome number, alien translocations. Hybrids between species with different chromosome number. Gene transfer using amphidiploids in Bridge species.	8
25	Fertilization barriers in crop plants at pre and post fertilization levels In-vitro techniques to overcome the fertilization barriers in crops.	4
26, 27 & 28	Chromosome manipulations in wide hybridization; production and use of haploids, dihaploids and doubled haploids in genetics and plant breeding.	8
	Total	**100**

Practical

Practical No.	**Topic**
1	Study of cytological techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning
2	Study of various types of microscope.
3	Preparation of specimen for observation.

4	Study of Mitosis in agricultural crop
5	Study of Meiosis in agricultural crop
6	Study of Micrometery and study of pollen grain of agricultural crop
7	Study of pollen germination *in vivo and in vitro*
8	Study of staining and preparations of permanent slides
9	Study of Polyploidy.
10	Study of induction of haploids (Anther culture & Ovule culture)

Suggested Reading

Becker K and Hardin J. 2004. World of the Cell. 5th Ed. Pearson Edu. 9th edition.Carroll M. 1989. Organelles. The Guilford Press.

Charles B. 1993. Discussions in Cytogenetics. Prentice Hall Publications.

Darlington CD and La Cour LF. 1969. The Handling of Chromosomes. George Allen &Unwin Ltd.

Elgin S C R. 1995. Chromatin Structure and Gene Expression. IRLPress,OXford.

Gupta PK and Tsuchiya T. 1991. Chromosome Engineering in Plants: Genetics, Breeding andEvolution. Part A.

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Karp G. 1996. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons.Khush G S. 1973. Cytogenetics of aneuploids. Elsevier. 1 edition.

Roy D.2009. Cytogenetics. Alpha Science Intl Ltd.

Schulz S J.1980. Cytogenetics- Plant, animals and Humans. Springer.

Sharma A K and Sharma A. 1988. Chromosome Techniques: Theory and Practice.

Butterworth- Heinemann publisher 2014.3rd edition Singh R J. 2016. Plant Cytogenetics 3rd Edition. CRC Press.

Sumner A.T. 1982. Chromosome Banding. Unwin Hyman Publ. 1 edition, Springer pub. Swanson C.P. 1960. Cytology and Cytogenetics. Macmillan & Co.

GPB 506 MOLECULAR BREEDING AND BIOINFORMATICS* 2 + 1

OBJECTIVE:

The course will provide deep knowledge to the students on genotyping and kinds of markers including biochemical and molecular, mapping populations, allele mining. This will also add ways to perform marker-assisted selection and gene pyramiding to evolve superior varieties. To impart knowledge and practical skills to use innovative approaches and Bioinformatics in Plant Breeding.

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer; Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc. and commercial releases; Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application

of Tissue culture in molecular breeding; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary and secondary), implications in crop improvement.

Practical

Requirements for plant tissue culture laboratory;Techniques in plant tissue culture;

Media components and media preparation;

Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations;

Inoculation of explants, callus induction and plant regeneration; Standardizing the protocolsfor regeneration;

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

Transformation using Agrobacterium strains;GUS assay in transformed cells/ tissues;

DNA isolation, DNA purity and quantification tests;

Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship;

Construction of genetic linkage maps using computer software;

NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene Prediction Tool, expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder;

Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl); Primer designing- Primer 3/ Primer BLAST.

GPB 510 SEED PRODUCTION AND CERTIFICATION 1 + 1

Objective:

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Practical

Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; Identification of rogues and pollen shedders, supplementary pollination, detasseling, handemasculation 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 seedreplacement rate;

General procedure of seed certification, identification of weed and other crop seeds as per specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results, inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement;Specifications for tags and labels to be used for certification purpose.

Lecture schedule

Lecture No.	Topic	Weightage
1	Seed as basic input in agriculture; seed development in cultivated plants;	5
2	Seed quality concept and importance of genetic purity in seed production	10
3	Generation system of seed multiplication; maintenance of Nucleus seed, production of Breeder, Foundation and Certified seed– criteria involved	10
4	Seed multiplication ratios, seed replacement rate, demand and supply	5
5	Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.	10
6	Nucleus seed production and its maintenance - Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance;	10
7	Principles of seed production in self- and cross-pollinated crops	5
8	Hybrid seed production - system and techniques involved in Seed village concept;.	5
9	Organic seed production and certification	5
10 &11	Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self- and cross-pollinated cereals and millets.	10
12	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	5
13	Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres. Hybrid-seed production techniques in major vegetatively propagated crops	5
14	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;	5
15 & 16	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	10
	Total	100

Practical No.	Topic
1 & 2	Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines,
3	Synchronization of parental lines and methods to achieve synchrony
4	Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination
5	Pollen storage, hand emasculation and pollination in Cotton, detasseling in Corn,
6	Identification of rogues and pollen shedders; Pollen collection, storage, viability and stigma receptivity;
7	Pre-harvest sanitation, maturity symptoms, harvesting techniques
8	Visits to seed production plots and seed industries
9	Planning for seed production: cost benefit ratio, seed multiplication ratio and seed replacement rate

10 &11	Study of General procedure of seed certification, identification of weed and other cropseeds as per specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results,
	Inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement
12	To study the specifications for tags and labels to be used for certification purpose.

Suggested Reading

Agrawal PK and Dadlani M. 1987. Techniques in Seed Science and Technology, South Asian Publishers, Delhi.

Agrawal RL. 1997. Seed Technology, OXford & IBH Publishing.

Anon, 1965. Field Inspection Manual and Minimum Seed Certification Standards, NSC Publication, New Delhi.

Anon. 1999. Manual of Seed Certification procedures. Directorate of Seed Certification, Coimbatore, Tamil Nadu.

Joshi AK and Singh BD. 2004. Seed Science and Technology, Kalyani Publishers, NewDelhi.

Kelly AF. 1988. Seed Production of Agricultural Crops. John Wiley, New York.

Mc Donald MB and Copeland LO. 1997. Seed Science and Technology, Scientific Publisher,Jodhpur.

Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. Seed Legislation in India.

Agrobios (India), Jodhpur, Rajasthan.

Singhal NC. 2003. Hybrid Seed Production in Field Crops, Kalyani Publications, New DelhiTunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed

Certification Board, Ministry of Agriculture, New Delhi.

GPB 511 CROP BREEDING I (*KHARIF* CROPS) 2 + 1

OBJECTIVE :

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

Theory :

Unit I

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

biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, its implications and droughtresistance breeding.

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

Sorghum: 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- biofortified varieties – strategies and implications

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

Unit II

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

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

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

Unit III

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

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

Unit IV

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

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

Unit V

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

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

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

Practical

Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea,soybean, sesame, cotton;

Study of range of variation for yield and yield components;

Study of segregating populations in cereal, pulses and oilseed crops;

Learning on the crosses between different species; attempting crosses between black gramand green gram;

Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton;

Visit to Cotton Technology Laboratory and Spinning Mills;

Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval;

Practical learning on the cultivation of fodder crop species on sewage water, analysing them for yield components and palatability;

Laboratory analysis of forage crops for crude protein, digestibility percent and other qualityattributes;

Visit to animal feed producing factories;

Learning the practice of value addition; Visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

LECTURE SCHEDULE

Lecture No.	Topic	Weightage
1-3	**Rice**: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding.	8
4 &5	**Maize:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement- QPM and Bt maize – strategies and implications	8
6 &7	**Sorghum:** 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- biofortified varieties – strategies and implications	8

8& 9	**Small millets:** Evolution and distribution of species and forms - wild	8
	relatives and germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance, etc	
10 &11	**Pigeon pea:** evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes	8
12 & 13	**Groundnut**: Origin, evolution mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement10	6
14-16	**Other pulses: Urdbean, mungbean, cowpea**,: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.	8
17 & 18	**Soybean:** Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement	6
19- 21	**Castor and Sesame:** Origin, evolution mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement; Hybrid breeding in castor – opportunities, constraints and achievements	8
22 & 23	**Cotton:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton	8
24 & 25	**Jute:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.	4
26 & 27	**Sugarcane:** Evolution and distribution of species and forms, wild relatives	8

	and germplasm; Cytogenetics and genome relationship – Breeding objectives-yield, quality characters, biotic and abiotic stress resistance,etc.	
28 &29	**Forage crops:** Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives-yield, quality characters and palatability studies; Biotic and abiotic stress resistance, etc.	6
30-32	**Seed spices:** Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties,examples of MAS used for improvement Achievements of important spice crops.	6
	Total	100

PRACTICAL

Practical No.	Topic
1 & 2	Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton;
3	Study of range of variation for yield and yield components
4	Study of segregating populations in cereal, pulses and oilseed crops
5	Learning on the crosses between different species; attempting crosses between black gram and green gram
6	Evaluating the germplasm of cotton for yield, quality and resistance parameters,
7	Learning the procedures on development of Bt cotton
8	Visit to Cotton Technology Laboratory and Spinning Mills
9	Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval
10	Practical learning on the cultivation of fodder crop species on sewage water, analysing them for yield components and palatability
11 & 12	Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes
13	Visit to animal feed producing factories
14	Learning the practice of value addition
15 & 16	Visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder

Suggested Reading

Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. OXford & IBH.

Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. OXford & IBH.

Chandraratna MF. 1964. Genetics and Breeding of Rice. Longmans.

Chopra VL and Prakash S. 2002. Evolution and Adaptation of Cereal Crops. OXford & IBH. Gill KS. 1991. Pearl Millet and its Improvement. ICAR.

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Murty D S, Tabo R and Ajayi O. 1994. Sorghum Hybrid Seed Production and Management. ICRISAT, Patancheru, India.
Nanda J S. 1997. Manual on Rice Breeding. Kalyani Publishers.
Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of Horticultural
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Poehlman, JM. 1987. Breeding of Field Crops. AVI Publishing Co. Inc. East PostConnecticut, USA.
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Sharma, AK. 2005. Breeding Technology of Crop Plant. Yesh Publishing House, BikanerSlafer
GA. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.
Singh HG, Mishra SN, Singh TB, Ram HH and Singh DP. (Eds.). 1994. Crop Breeding inIndia. International Book Distributing Co.
Walden DB. 1978. Maize Breeding and Genetics. John Wiley & Sons

1. Name of the programme: Plant Physiology M.Sc.(Agri.)

Semester		Course No	Title	Credits
I.	**Major :** 9 Credits	PP-501	Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition	2+1=3
		PP-502	Principles of Plant Physiology-II Metabolic Processes and Growth Regulation	2+1=3
		PP-504	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1=3
	Minor : 3 Credits	AGRON-501	Modern Concepts in Crop Production	2+1=3
	Supporting 4 Credits	STAT-502	Statistical Methods for Applied Sciences	3+1=4
	NCCC : 2 Credits	PGS-501	Library and Information Services	0+1=1
		PGS-504	Basic Concepts in Laboratory Techniques	0+1=1
	Total Course Credits			**11+7=18**
II.	**Major :** 8 Credits	PP-503	Plant Development Biology: Physiological and Molecular Basis	2+1=3
		PP-505	Hormonal Regulation of Plant Growth and Development	2+1=3
		PP-508	Physiology of Field Crops	2+0=2
	Minor : 6 Credits	BIOCHEM-501	Basic Biochemistry	3+1=4
		AGRON-505	Conservation Agriculture	1+1=2
	Supporting 3 Credits	STAT-511	Experimental Designs	2+1=3
	NCCC : 3 credits	PGS-502	Technical Writing and Communications Skills	0+1=1
		PGS-503	Intellectual Property and its Management in Agriculture	1+0=1
		PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0=1
	Total Course Credits			**14+5=19**
III.	**Major :** 3 Credits	PP-510	Seed Physiology	2+0=3
	NCCC : 1 Credits	PGS - 505	Agricultural Research, Research Ethics and Rural Development Programmers	1+0=1
	Research	PP-599	Masters Research	0+15=15
	Total Course Credits			**3+16=19**

IV.	**Seminar**	PP-591	Masters Seminar	1+0=1
	Research	PP-599	Masters Research	0+15=15
	Total Course Credits			**1+15=16**
	Grand Total I +II+ III+ IV			**27+45=72**

Course Curricula and syllabi:

PP 501*: Principles of Plant Physiology I –
Plant Water Relations and MineralNutrition

Objective

The aim of this course is to impart knowledge in the field of water relations and mineral nutrition and how plants acquire water and transport it under different soil water regimes and also make use of the water in an effective way to maXimize use efficiency. In addition, the other aim is to impart knowledge of how plants minimize water loss under stress conditions besides educating the students of how plants make use of nutrients in a best possible way.

Theory

Block 1: Plant Water Relations

Unit 1: Soil and Plant Water Relations

Water and its importance; Molecular structure of water; Properties and functions of water. Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils; Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

Unit 2: Water Absorption and Translocation

Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories eXplaining water absorption and translocation; Aquaporins. Mycorrhizal association and its relevance in water mining.

Unit 3: Transpiration and Evaporative Cooling

Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.

Unit 4: Water Productivity and Water Use Efficiency

WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.

Unit 5: Moisture Stress and Plant Growth

Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level. Drought indices and drought tolerance strategies. Drought tolerance traits.

Block 2: Mineral Nutrition

Unit 1: Nutrient Elements and Their Importance

Role of mineral nutrients in plant's metabolism; Essential elements and their classification; beneficial elements; factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants. Deficiency and toXicitysymptoms in plants.

Unit 2: Nutrient Acquisition

Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; Xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels. Role of mycorrhiza, root eXudates and PGPRs in plant nutrient acquisition.

Unit 3: Concept of Foliar Nutrition

Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

LECTURE

Lecture No.	Name of the topic	Weightage
	Block 1: Plant Water Relations	
	Unit 1: Soil and Plant Water Relations	**18**
1	Water and its importance; Molecular structure of water; Properties and functions of water.	4
2	Concept of water potential; Plant cell and soil water potential and their components;	4
3 &4	Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils;	6
5 & 6	Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.	4
	Unit 2: Water Absorption and Translocation	**10**
7& 8	Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation;	5
9	Theories explaining water absorption and translocation; Aquaporins. Mycorrhizal association and its relevance in water mining.	5
	Unit 3: Transpiration and Evaporative Cooling	**15**
10	Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration;	3
11	Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution;	4
12 & 13	Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure;	4
14 & 15	Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.	4
	Unit 4: Water Productivity and Water Use Efficiency	**15**
16 &17	WUE and its relevance in water productivity; Transpiration efficiency, ameasure of intrinsic WUE	7
18 & 19	Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.	8
	Unit 5: Moisture Stress and Plant Growth	**10**
20 & 21	Physiology of water stress in plants; Effect of moisture stress at molecular,cellular, organ and plant level.	6
22	Drought indices and drought tolerance strategies. Drought tolerance traits.	4
	Block 2: Nutrient Acquisition	

	Unit 1: Nutrient Elements and Their Importance	**10**
23	Role of mineral nutrients in plant's metabolism; Essential elements and their classification; beneficial elements;	4
24 & 25	Factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants. Deficiency and toxicity symptoms inplants.	6
	Unit 2: Nutrient Acquisition	**12**
26	Mechanism of mineral uptake and translocation; Ion transporters;	3
27 & 28	Genes encoding for ion transporters; localization of transporters; xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels.	5
29	Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition.	4
	Unit 3: Concept of Foliar Nutrition	**10**
30 & 31	Foliar nutrition; significance and factors affecting total uptake of minerals;	5
32	Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.	5
	Total	**100**

Practical

Expt. No.	Title of the experiment
1	Standard solutions and preparation of different forms of solutions
2	Studies on the basic properties of water
3	Demonstration of surface tension of water and other solvents
4	Measurement of plant water status: Relative water content and rate of water loss
5	Determination of water potential through tissue volume and Chardakov's test
6	Determination of water potential using pressure bomb, osmometer, psychrometer
7	Determination of soil moisture content and soil water potential
8	Use of soil moisture probes and soil moisture sensors
9	Measurement of transpiration rate in plants; use of porometry
10	Measurement of CCATD and its relevance
11	Demonstration and use of anti-transpirants to reduce transpiration
12	Influence of potassium and ABA on stomatal opening and closing respectively
13	Deficiency and toxicity symptoms of nutrients
14	Effect of water stress on plant growth and development

Suggested Reading

Vilalta JM and Forner NG. 2017. *Water potential regulation, stomatal behaviour and hydraulic transport under drought: deconstructing the iso/anisohydricconcept Plant, Cell and Environment* 40, 962–976

Mangrich AS, Cardoso EMC, Doumer ME, Romão LPC, Vidal M, Rigol A, Novotny EH. *Improving the Water Holding Capacity of Soils of Northeast Brazil by Biochar Augmentation*. Chapter 16, pp 339–354.

McElrone AJ, Choat B, Gambetta GA and Brodersen CR. 2013. *Water Uptake and Transport in Vascular Plants*. *Nature Education Knowledge* 4(5): 6

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Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 383 pages.

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General Source of Information

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- Taiz L and Zeiger E. 2015. *Plant Physiology and development*.6th Ed
- Salisbury FB and Ross C. 1992 (4th Ed.) *Plant Physiology*
- Epstein E and Bloom AJ. 2004. *Mineral nutrition of plants: principles andperspectives*.2nd Ed.
- Hopkins WG and Huner NPA. 2004. *Introduction to Plant Physiology*
- Kramer, P. J., *Water relations of plants*
- Kirkham, M. B., *Principles of soil and plant water relations*
- Hopkins WG, 2008, *Introduction to Plant Physiology*

PP 502*: Principles of Plant Physiology-II: Metabolic Processes and GrowthRegulation

Objective

This course will impart knowledge on cellular structure and function that determine of carbon and nitrogen metabolism, lipids, enzymes and secondary metabolites in plants. Relevance of metabolic processes on growth and development leading toproductivity will be dealt.

Theory

Block 1: Metabolic Processes and Growth Regulation Unit 1: Carbon Metabolism – Photochemical Processes

- Chloroplast ultrastructure with special mention of lamellar system
- EXcitation, electron and proton transfers and their relevance in energy conservation
- Concepts of pigment systems and generation of powerful reductant and oXidant
- Water oXidation, Water-water cycle and other aspects of electron transfer

Unit 2: Carbon Metabolism: Biochemical Processes

- CO_2 diffusion mechanisms and diffusive conductances, concept of Ci determiningPhotosynthesis
- RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation of Calvin cycleand metabolite fluXes
- Photorespiration: the advantages and inefficiencies of photosynthesis because ofphotorespiration
- Concepts of CO_2 concentrating mechanisms (CCM) and spatial and temporal differences in carboXylation
- Ecological aspects of C4and CAM photosynthesis
- Product synthesis, Starch and Sucrose biosynthesis

Unit 3: Carbon Metabolism: Respiration

- Mitochondrial organization and functions
- Aspects of Glycolysis, TCA cycle and mitETC.
- Relevance of growth and maintenance respiration
- Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC

Unit 4: Product Synthesis and Translocation Leading to Crop Growth

- Phloem loading and sugar transporting, concepts of bi-directional transport of sugars andother metabolites
- Source-Sink relationship and modulation of photosynthesis
- Concepts and definitions of Growth and Differentiation
- Growth and yield parameters, NAR, CGR, HI and concepts of LAI, LAD

Unit 5: Nitrogen Assimilation and Protein Synthesis

- Developments in d-nitrgen fiXation
- Nitrate reduction and assimilation GS-GOGAT process for amino acid synthesis
- Inter-Dependence of carbon assimilation and nitrogen metabolisms

Unit 6: Lipid Metabolism and Secondary Metabolites

- Storage, protective and structural lipids.
- Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids of storage lipids.
- Secondary metabolites and their significance in plant defense mechanisms.

Unit 7: Hormonal Regulation of Plant Growth and Development

- Growth promoting and retarding hormones: biosynthesis, transport, conjugation
- Mode of action of these hormones and their application in plant physiology

Unit 8: Synthetic Growth Promoters

- Different synthetic hormones: Salicylic acid, strigolactones etc
- Roles and biological activities of various synthetic hormones
- Commercial application of hormones to maXimize growth and productivity

Unit 9: Morphogenesis and Reproductive Phase

- Photoperiodism: Phytochromes, their structure and function
- Circadian rhythms,
- Blue light receptors: Cryptochrome and morphogenesis.
- Vernalization and its relevance in germination.

LECTURE SCHEDULE

Lecture No.	Name of the topic	Weightage

	Block 1: Metabolic Processes and Growth Regulation	
	Unit 1: Carbon Metabolism – Photochemical Processes	**12**
1	Chloroplast ultrastructure with special mention of lamellar system	4
2	Excitation, electron and proton transfers and their relevance in energy conservation	4
3	Concepts of pigment systems and generation of powerful reductant andoxidant	4
4	Water oxidation, Water-water cycle and other aspects of electron transfer	4
	Unit 2: Carbon Metabolism: Biochemical Processes	**15**
5	CO_2 diffusion mechanisms and diffusive conductances, concept of Ci determining Photosynthesis	3
6	RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation of Calvin cycle and metabolite fluxes	3
7	Photorespiration: the advantages and inefficiencies of photosynthesis because of photorespiration	3
8	Concepts of CO_2 concentrating mechanisms (CCM) and spatial and temporal differences in carboxylation	3
9	Ecological aspects of C4 and CAM photosynthesis Product synthesis, Starch and Sucrose biosynthesis	3
	Unit 3: Carbon Metabolism: Respiration	**13**
10	Mitochondrial organization and functions	3
11 & 12	Aspects of Glycolysis, TCA cycle and mitETC	4
13	Relevance of growth and maintenance respiration	3
14	Concepts of CN resistance respiration – Alternate and SHAM sensitiveETC	3
	Unit 4: Product Synthesis and Translocation Leading to Crop Growth	**15**
15	Phloem loading and sugar transporting, concepts of bi-directional transportof sugars and other metabolites	4
16	Source-Sink relationship and modulation of photosynthesis	3
17	Concepts and definitions of Growth and Differentiation	4
18	Growth and yield parameters, NAR, CGR, HI and concepts of LAI, LAD	4
	Unit 5: Nitrogen Assimilation and Protein Synthesis	**10**
19	Developments in d-nitrgen fixation	3
20	Nitrate reduction and assimilation GS-GOGAT process for amino acidsynthesis	4
21	Inter-Dependence of carbon assimilation and nitrogen metabolisms	3
	Unit 6: Lipid Metabolism and Secondary Metabolites	**10**
22	Storage, protective and structural lipids.	3
23	Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids ofstorage lipids	4
24	Secondary metabolites and their significance in plant defense mechanisms	3
	Unit 7: Hormonal Regulation of Plant Growth and Development	**07**
25	Growth promoting and retarding hormones: biosynthesis, transport,conjugation	3
26	Mode of action of these hormones and their application in plant physiology	4
	Unit 8: Synthetic Growth Promoters	**09**
27	Different synthetic hormones: Salicylic acid, strigolactones etc	3
28	Roles and biological activities of various synthetic hormones	3
29	Commercial application of hormones to maximize growth and productivity	3
	Unit 9: Morphogenesis and Reproductive Phase	**09**

30	Photoperiodism: Phytochromes, their structure and function	3
31	Circadian rhythms, Blue light receptors: Cryptochrome and morphogenesis	3
32	Vernalization and its relevance in germination.	3
	Total	**100**

Practical

Expt. No.	**Title of the experiment**
1	Radiant energy measurements
2	Separation and quantification of chlorophylls
3	O_2 evolution during photosynthesis
4	Anatomical identification of C_3 and C_4 plants
5	Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration
6	Measurement of respiration rates
7	Estimation of reducing sugars, starch
8	Estimation of NO_3, free amino acids in the xylem exudates, quantification of soluble proteins
9	Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene
10	Demonstration of photoperiodic response of plants in terms of flowering

Suggested Reading

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Jafari T, Moharreri E, Amin A, Miao R, Song W and Suib S. 2016. *Photocatalytic water splitting—the untamed dream: a review of recent advances*. *Molecules*, *21*(7), 900.

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General Text books

- *Taiz, Lincoln, Zeiger. 2007 Plant Physiology, Eduardo Original American edition Sinauer Associates, Inc., 2006; 4th ed., XXVI, ISBN: 978-3-8274-1865-4; © Springer.*
- *Plant Physiology* Frank Boyer Salisbury and Cleon Ross.

PP 503*: Plant Developmental Biology: Physiological and Molecular Basis

Objective

To explain about basic physiological and molecular processes concerning various facets of growth and development of plants. It provides knowledge on basic physiological processes governing developmental events in plants including senescence and fruit development and ripening. Development of vegetative tissue like shoot, leaf and root and morphogenetic phenomena like flower induction and development, factors associated with photoperiod and thermoperiod response. Regulation of morphogenesis would be studied at the molecular level providing information on genes involved. In

addition, students will study how to apply the knowledge on plant development and morphogenesis using tissue culture.

Theory

Block 1: Plant Developmental Biology

Unit 1: Evolutionary Development of Plants and Role of Environment

Plant development and plasticity, evolution, Biodiversity. Novel features of plant growth and development, Concept of plasticity-evolution and biodiversity, Model plants for study; Environment and development. Developmental stages and program; Cell-cycle, totipotency and regeneration.

Unit 2: Physiological and Molecular Determinants of Seed Biology

Seed development- Physiology of seed development, role of hormones in embryo development; seed development and maturation. Seed dormancy- Physiological and molecular mechanism of seed dormancy regulation. Seed germination- seed structure and Hormonal regulation of germination, Mobilization of food reserves during seed germination. **Unit 3: Vegetative Growth and Organ Development**

Regeneration and totipotency- organ differentiation and development – role of hormones- developmental control genes in crop plants. Meristems in plant development. Shoot, Leaf, Trichome and stomate development and differentiation. AXillary shoot branching; Bud dormancy and growth**.** Root development; Nodule development; Tuber

development- hormonal control, signaling and molecular regulation- genes involved. Vascular bundle development- Xylem and phloem differentiation.

Unit 4: Physiological and Molecular Aspects of Reproductive Growth and Development

Floral Induction and Development: Molecular and physiological mechanism of transition

-vegetative to reproductive phase- floral organ initiation and development their controls. Development of male and female gametophyte; gametophytic mutants: pollen-stigma interaction- Pollen germination and tube growth; role of imprinting; Male sterility: and fertility restoration; Self incompatibility; Sterility and fertility restoration, Maternal gene effects, Zygotic gene effects. SeX determination in plants, mate choice in plants. Embryo and endosperm development- fertilization, role of imprinting; Parthenocarpy and apomiXes

Unit 5: Ripening and Senescence

Fruit development, enlargement, maturation and ripening; climacteric and non- climacteric fruit ripening mechanism. Hormonal, biochemical & Molecular aspects of fruit ripening. Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

Unit 6: Physiological and Molecular Regulation of Plant Development Influenced by Light and Temperature

Light control of plant development: Phytochromes and cryptochromes, phototropins, their structure, biochemical properties and cellular distribution. Molecular mechanisms of light perception, signal transduction and gene regulation. Photoperiodism and its significance, vernalization and hormonal control. Circadian rhythms-biological clocks and their genetic and molecular determinants. Thermomorphogenesis- Thermoperiodism

Block 2: Application of Morphogenesis and its Practical Application Unit 1: Tissue culture and micro-

propagation

Applications of tissue culture for plant production, callus induction, somatic embryogenesis, regeneration from different eXplants. Micro-propogation, tip and aXillary node culture of commercially important crops, hardening and eX-vitro establishment, concept of somatic hybridization and protoplast culture.

Unit 2: Application of *in-vitro* techniques for crop improvement

Development of somoclones, identification and eXploitation of somoclonal variants. Haploid production, pollen/anther, ovule/ovary culture. Production of secondarymetabolites by tissue culture, concept of bio-fermenters. Plant transformation, development of transgenic plants and their characterization. Germplasm storage,cryopreservation and regulation

LECTURE SCHEDULE

Lecture No.	Name of the topic	Weightage
	Block 1: Plant Developmental Biology	
	Unit 1: Evolutionary Development of Plants and Role of Environment	**12**
	Plant development and plasticity, evolution, Biodiversity.	3
	Novel features of plant growth and development	5
	Concept of plasticity-evolution and biodiversity, Model plants for study;	4
	Environment and development. Developmental stages and program; Cell- cycle, totipotency and regeneration	4
	Unit 2: Physiological and Molecular Determinants of Seed Biology	**10**
	Seed development- Physiology of seed development, role of hormones in embryo development; seed development and maturation	3
	Seed dormancy- Physiological and molecular mechanism of seed dormancy regulation	3
	Seed germination- seed structure and Hormonal regulation of germination, Mobilization of food reserves during seed germination	4
	Unit 3: Vegetative Growth and Organ Development	**13**
	Regeneration and totipotency- organ differentiation and development – role of hormones- developmental control genes in crop plants	4
	Meristems in plant development. Shoot, Leaf, Trichome and stomate development and differentiation. Axillary shoot branching; Bud dormancy and growth	3
	Root development; Nodule development; Tuber development- hormonal control, signaling and molecular regulation- genes involved	3
	Vascular bundle development- xylem and phloem differentiation	3
	Unit 4: Physiological and Molecular Aspects of Reproductive Growth and Development	**15**
	Floral Induction and Development: Molecular and physiological mechanism of transition -vegetative to reproductive phase- floral organ initiation and development their controls.	5
	Development of male and female gametophyte; gametophytic mutants: pollen-stigma interaction- Pollen germination and tube growth; role of imprinting; Male sterility: and fertility restoration; Self incompatibility; Sterility and fertility restoration, Maternal gene effects, Zygotic gene effects.	5
	Sex determination in plants, mate choice in plants. Embryo and endosperm development- fertilization, role of imprinting; Parthenocarpy and apomixes	5
	Unit 5: Ripening and Senescence	**12**

	Fruit development, enlargement, maturation and ripening; climacteric and non-climacteric fruit ripening mechanism	5
	Hormonal, biochemical & Molecular aspects of fruit ripening	3
	Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants	4
	Unit 6: Physiological and Molecular Regulation of Plant Development Influenced by Light and Temperature	**13**
	Light control of plant development: Phytochromes and cryptochromes, phototropins, their structure, biochemical properties and cellular distribution	4
	Molecular mechanisms of light perception, signal transduction and gene regulation	3
	Photoperiodism and its significance, vernalization and hormonal control	3
	Circadian rhythms-biological clocks and their genetic and moleculardeterminants. Thermomorphogenesis- Thermoperiodism	3
Block 2: Application of Morphogenesis and its Practical Application		
	Unit 1: Tissue culture and micro-propagation	**12**
	Applications of tissue culture for plant production, callus induction, somatic	6
	embryogenesis, regeneration from different explants	
	Micro-propogation, tip and auxillary node culture of commercially important crops, hardening and ex-vitro establishment, concept of somatic hybridization and protoplast culture	6
	Unit 2: Application of *in-vitro* techniques for crop improvement	**13**
	Development of somoclones, identification and exploitation of somoclonalvariants	4
	Haploid production, pollen/anther, ovule/ovary culture. Production of secondary metabolites by tissue culture, concept of bio-fermenters	4
	Plant transformation, development of transgenic plants and their characterization. Germplasm storage, cryopreservation and regulation	5
	Total	**100**

Practical

S No.	Title of the experiment
1	Studying shoot apical meristem, floral meristem development and pollen tube development
2	Phenotyping photomorphogenesis: (a) Studying effect of day length (short day and long day) in regulating floral induction/ flowering time in short day/long day/day neutral plants and (b) effect of light on seed germination in light-sensitive and - insensitive seeds.
3	Studying effect of temperature on– (a) thermomorphogenesis- measuring hypocotyl elongation under different temperature conditions and (b) sex determination usingcucurbits/sesame plants.
4	Measure physiological parameters of fruit ripening and study the expression of key genes regulating ripening.
5	Study the effect of ethylene, its inhbibitor and scrubber on ripening (tomato)
6	Study different sterilization techniques, prepare media stocks and plant hormones
7	Inoculate explant (seed and leaf tissue) of model plant for callus induction
8	Subculture the callus and standardize regeneration protocol for shoot and root induction using callus and leaf explant
9	Micro-propagation using meristem tip and auxiliary node culture
10	Standardize anther/ pollen culture for haploid production in model/crop/horticultural plant

11	Isolation of protoplast from Arabidopsis/tobacco and its culturing
12	Study about selectable marker, reporter gene, PCR, southern and northern blotting techniques
13	Transformation of tobacco callus or leaf explant by *Agrobacterium tumefacines* and *Agrobacterium rhizogenes* for production of transgenic
14	Molecular characterization of transgenic- PCR, southern blotting, gene expression

Suggested Reading

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Bahadur *B et al*. (eds.), *Plant Biology and Biotechnology:* Volume I: Plant Diversity, Organization, Function and Improvement

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General Source Information

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- B. Bahadur *et al*. (eds.), *Plant Biology and Biotechnology*: Volume I: Plant Diversity, Organization, Function and Improvement.
- Bewley JD *et al*., *Seeds-Physiology of Development, Germination and Dormancy*.
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PP 504: Physiological and Molecular Responses of Plants to Abiotic Stresses

Objective

This course aims to describe students the abiotic-stress physiology and their effects on plant growth and productivity. This will also help students gain insights into latest developments in stress physiology and stress tolerance mechanisms, approaches for crop improvement under stressful environment.

Theory

Block 1: Abiotic Stresses

Unit 1: Introduction to Abiotic Stresses

Abiotic stresses major constraints to realize potential yields of crop plants, yield losses. Drought prone areas in India- Frequency of occurrence of drought, Rainfed- kharif, Rabi, Areas affected by salinity, heavy metals, water logging, high temperature scenario due to global warming.

Block 2: Drought Stress

Unit 1: Moisture Stress Responses in Plants

Drought-characteristic features; water potential in the soil-plant-air continuum. Physiological and biochemical processes affected by drought.OXidative stress- generation of ROS and other cytotoXic compounds, their effect on cellular process. Effect on total carbon gain- decrease in photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages.

Unit 2: Stress Perception and Molecular Responses of Plants to Drought Stress

Stress perception andsignal transduction leading to eXpression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes associated with adaptive mechanisms.

Unit 3: Plant Adaptive Mechanisms to Drought

(a) Escape and desiccation avoidance mechanism

Concept of stress escape- eXploiting genetic variability in phenology, Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters. Moisture conservation- Regulation of transpiration- traits reducing heat load, Stomatalfactors guard cell metabolism, moisture conservation by waXes. Water use efficiency (WUE) and concept of water productivity- regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency, relevance of WUE and Passioura's model.

(b) Desiccation tolerance- Concept of acquired tolerance

Decreased turgor mediated upregulation of cellular tolerance mechanisms, Osmolytes, managing cytotoXic compounds, ROS, RCC, scavenging - enzymatic and non-enzymatic, protein turnover, stability, chaperones, membrane stability, photo- protection of chlorophylls.

Unit 4: Approaches to Improve Drought Tolerance

Development of genetic resources- donor genotypes for specific traits, Genomic resources- genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression.

Block 3: Salt, Heavy Metal, Water Logging, Temperature and Light Stress Unit 1: Salt Stress

Soil salinity-Effect of salt stress, ionic and osmotic effects; species variation in salt tolerance; glycophytes and halophytes, Salt tolerance mechanisms - eXclusion, eXtrusion and compartmentalization, Signaling during salt stress – SOS pathway, Approaches to improve salt tolerance.

Unit 2: Heavy Metal Stress and Water Logging

Heavy metal toXicity in plants (eg., Al, Cd), tolerance mechanisms and approaches to improve. Plant response to water logging, role of hormones- ethylene, mechanism of tolerance and approaches to improve.

Unit 3: Temperature and Light Stress

High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes. High light and high ionizing radiation- photo oXidation and photo- inhibition; mechanisms of tolerance, plant adaptation to low light,

concept of shade avoidance response (SAR).

LECTURE SCHEDULE

Lecture No.	Name of the topic	Weightage
	Block 1: Abiotic Stresses	
	Unit 1: Introduction to Abiotic Stresses	**10**
1	Abiotic stresses major constraints to realize potential yields of crop plants, yield losses	4
2&3	Drought prone areas in India- Frequency of occurrence of drought, Rainfed- kharif, Rabi, Areas affected by salinity, heavy metals, water logging, high temperature scenario due to global warming	6
	Block 2: Drought Stress	
	Unit 1: Moisture Stress Responses in Plants	**15**
4	Drought-characteristic features; water potential in the soil-plant-air continuum	3
5	Physiological and biochemical processes affected by drought	3
6	Oxidative stress- generation of ROS and other cytotoxic compounds, theireffect on cellular process	4
7&8	Effect on total carbon gain- decrease in photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages	5
	Unit 2: Stress Perception and Molecular Responses of Plants to DroughtStress	**12**
9&10	Stress perception and signal transduction leading to expression of regulatorygenes	5
11&12	Stress specific kinases, stress specific transcription factors, functional genes associated with adaptive mechanisms	7
	Unit 3: Plant Adaptive Mechanisms to Drought	**20**
13	**a) Escape and desiccation avoidance mechanism** Concept of stress escape- exploiting genetic variability in phenology, Drought avoidance mechanisms- Maintenance of cell turgor,	4
	water mining by root characters.	
14	Moisture conservation- Regulation of transpiration- traits reducing heat load, Stomatalfactors guard cell metabolism, moisture conservation by waxes.	4
15	Water use efficiency (WUE) and concept of water productivity- regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency, relevance of WUE and Passioura's model.	4
16	**b) Desiccation tolerance- Concept of acquired tolerance** Decreased turgor mediated upregulation of cellular tolerance mechanisms, Osmolytes, managing cytotoxic compounds,	4
17	ROS, RCC, scavenging - enzymatic and non-enzymatic, protein turnover,stability, chaperones, membrane stability, photo- protection of chlorophylls.	4
	Unit 4: Approaches to Improve Drought Tolerance	**11**
18 &19	Development of genetic resources- donor genotypes for specific traits	4
20&21	Genomic resources- genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression	7
	Block 3: Salt, Heavy Metal, Water Logging, Temperature and Light Stress	
	Unit 1: Salt Stress	**10**

2	Soil salinity-Effect of salt stress, ionic and osmotic effects; species variation in salt tolerance; glycophytes and halophytes	4
23&24	Salt tolerance mechanisms - exclusion, extrusion and compartmentalization, Signaling during salt stress – SOS pathway, Approaches to improve salt tolerance	6
	Unit 2: Heavy Metal Stress and Water Logging	**11**
25&26	Heavy metal toxicity in plants (eg., Al, Cd), tolerance mechanisms and approaches to improve.	6
27&28	Plant response to water logging, role of hormones- ethylene, mechanism of tolerance and approaches to improve	5
	Unit 3: Temperature and Light Stress	**11**
29&30	High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes	6
31&32	High light and high ionizing radiation- photo oxidation and photo- inhibition; mechanisms of tolerance, plant adaptation to low light, conceptof shade avoidance response (SAR)	5
	Total	100

Practical

S No.	**Title of the experiment**
1	Measurement of soil and plant water status
2	Drought stress imposition and measurement of physiological and biochemical changes in plants under stress –gas exchange and fluorescence measurements
3	Determination of water use efficiency as a drought resistant trait
4	Drought Susceptibility Index (DSI) -precise field technique to identify productive genotypes under stress
5	Approaches to quantify root characters
6	Determination of stomatal parameters and canopy temperature as a reflection of transpiration and root activity
7	Determination of Salinity Tolerance Index
8	Studying acclimation response - Temperature induction response
9	Heat tolerance and membrane integrity- Sullivans heat tolerance test
10	Quantification of osmolytes – proline under stress
11	Oxidative stress imposition- Quantification of oxidative stress
12	Quantification of ROS under stress
13	Estimation of ABA content in leaf and root tissues under stress
14	Determination of Sodium and Potassium in plant tissue grown under salt stress
15	Estimation of antioxidant enzymes

Suggested Reading

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Plant Physiology Book by Frank B. Salisbury, Cleon W. Ross Salisbury, Frank B Pereira A. 2016. *Plant Abiotic Stress Challenges from the Changing Environment. Front.*

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PP 505: Hormonal Regulation of Plant Growth and Development

Objective

It provides knowledge on the fundamentals of hormone biosynthesis, homeostasis, transport and signaling and the role in regulating basic physiological processes governing developmental events in plants. The role of classical hormones on developmental processes from germination, shoot and root apical meristem differentiation, flowering, seed maturation and senescence. The aim of this course is to appraise the students about structure and function of plant growth regulators.

Theory

Block 1: Plant Growth and Development: Hormonal Regulation

Unit 1: Introduction to Plant Hormones

Growth, differentiation and development regulated by plant growth substances,Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances: Endogenous growth substances other than hormones, Synthetic chemicals.

Unit 2: Plant Hormones – Discovery and Metabolism

Discovery, biosynthetic pathways and metabolism of AuXin, Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins, Discovery, biosynthetic pathways and metabolism of Abscisicacid, Discovery, biosynthetic pathways and metabolism of Ethylene, Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones.

Unit 3: Physiological Role of Hormones in Plant Growth and Development

Physiological functions of AuXin and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Gibberellins and useof mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Abscisic acid and use of mutants andtransgenic plants in elucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Brassinosteroidsand Strigolactones and use of

mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

Unit 4: Endogenous Growth Substances other than Hormones

Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles ofJasmonates and Tricontanol, Discovery, biosynthetic pathways metabolism andphysiological roles of systemins Concept of death hormone, Recent developments inelucidating responses of Salicylic acid, Peptide hormones and Polyamines atphysiological and molecular level, Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular

level.

Unit 5: Hormone Signaling

Hormone signal perception, transduction - Receptors, components and mechanism (AuXin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones.

Unit 6: Key Genes Regulating Hormone Levels and Functions

Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.

Unit 7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development

Unit 8: Practical Utility of Growth Regulators in Agriculture and Horticulture

Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

LECTURE SCHEDULE

Lecture No.	Name of the topic	Weightage
Block 1: Plant Growth and Development: Hormonal Regulation		
	Unit 1: Introduction to Plant Hormones	11
1	Growth, differentiation and development regulated by plant growthsubstances	4
2 & 3	Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances	4
4	Endogenous growth substances other than hormones, Synthetic chemicals	3
	Unit 2: Plant Hormones – Discovery and Metabolism	**14**
5	Discovery, biosynthetic pathways and metabolism of Auxin	3
6 & 7	Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins	4
8 & 9	Discovery, biosynthetic pathways and metabolism of Abscisic acid,	4
	Discovery, biosynthetic pathways and metabolism of Ethylene	
10	Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones	3
	Unit 3: Physiological Role of Hormones in Plant Growth andDevelopment	**20**
11	Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions	4
12	Physiological functions of Gibberellins and use of mutants and transgenicplants in elucidating the physiological functions,	4

13	Physiological functions of Cytokinins and use of mutants and transgenicplants in elucidating the physiological functions	4
14	Physiological functions of Abscisic acid and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions	4
15&16	Physiological functions of Brassinosteroids and Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles ofSalicylic acid and Peptide hormones	4
	Unit 4: Endogenous Growth Substances other than Hormones	**13**
17&18	Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricontanol, Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone	7
19	Recent developments in elucidating responses of Salicylic acid, Peptidehormones and Polyamines at physiological and molecular level	3
20	Recent developments in elucidating responses of Jasmonates, Systemins,Karrikins and Tricontanol at physiological and molecular level	3
	Unit 5: Hormone Signaling	**12**
21&22	Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid)	4
23	Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones)	4
24	Advances in elucidating the structure and function of receptors and signaling components of important hormones	4
25&26	**Unit 6: Key Genes Regulating Hormone Levels and Functions** Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.	**07**
	Unit 7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes	**08**
27	Crosstalk of Hormones in Regulation of Plant Growth and DevelopmentProcesses	4
28	Crosstalk of Hormones in Regulation of Floral transition, reproductive development, Shoot and root apical meristem development	4
	Unit 8: Practical Utility of Growth Regulators in Agriculture andHorticulture	**15**
29&30	Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits	8
31&32	Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop	7
	Total	**100**

Practical

S No.	**Title of the experiment**
1	Extraction of Auxins from plant tissue
2	Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological technique
3	Bioassay of auxin- effect on rooting of cuttings

4	Extraction of abscisic acid (ABA) from plant tissue
5	Separation and detection of ABA by HPLC/Immunological technique
6	ABA bioassays- effect on stomatal movement
7	Preparation of samples for ethylene estimation in plant tissue
8	Estimation of ethylene in plant tissues using gas chromatography
9	Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut
10	Extraction of Gibberellins from plant tissue- GC / GC-MS / HPLC
11	Separation and detection of GA by GC / GC-MS / HPLC/Immunological technique
12	GA bioassays- effect on germination of dormant seeds
13	Cytokinin- extraction from plant tissue
14	Separation and detection of cytokinin by GC / GC-MS / HPLC
15	Cytokinin bioassays- effect on apical dominance and senescence / stay green

Suggested Reading

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PP 508: Physiology of Field Crops

Objective

This course provides a broad eXposure on the physiological aspects of field crops. The objective is to impart comprehensive information on physiological processes and physiological basis of growth, development and productivity of field crop plants. Besides,the emphasis is on unique crop specific features.

Broad categories of crops that can be selected for this course are as follows.

1. Cereals– Rice, Wheat, Maize etc.
2. Millets– Finger millet, Sorghum etc.
3. Pulse crops– Green gram, Black gram, Lentil, Pigeon pea, Chickpeas, Cowpea, Beans etc.Oilseed crops– Groundnut, Rapeseed Mustard, Soybean etc.
4. Sugarcane
5. Fibre crops– Cotton, Jute, Ramie, Hemp etc.

Theory

Block 1: Physiology of Field Crops

Unit 1: Introduction

Origin- Variability in physiology of crop plants between wild species and cultivated. Adaptability to growing environments (ecosystems), Importance in food grain contribution.

Unit 2: Crop Establishment, Crop Growth and Development

Seed characteristic features, dormancy, viability, concept of seed priming seedling establishment and crop stand. Different crop growth stages, concept of source establishment and optimum LAI, Canopy architecture, light interception/radiation use efficiency, thermal time, heat units, GDD, determining growth duration.

Unit 3: Reproductive Growth

Photo and thermo-periodic response for flowering, sink development, sink source relationship, partitioning efficiency, improvement in HI, yield determining factors, genetic gain in yield over years, structuring of ideal plant type, limitations to improve source to sink size, options to improve yield potential.

Unit 4: Seed Nutrient Quality

Seed quality, seed as a source of nutrients, seed constituents and their improvement, concept of pathway engineering to improve seed quality.

Unit 5: Plant Nutrition

Nutrient requirement, genetic variability in nutrient acquisition under constraint conditions, specific nutrient disorders.

Unit 6: Abiotic Stress Response

Response to different abiotic stresses, plant traits/mechanics to improve adaptation to realize potential yields. Global warming responses, thermomorphogenesis, approaches to overcome the constraints.

Unit 7: Crop Specific Physiological Processes and Importance

Choosing location specific crop species eXposure will be given on physiological process as described above. Besides, emphasis is on providing information on crop specific features/productivity constraints.

TEACHING SCHEDULE

Lecture No.	Name of the topic	Weightage
Block 1: Physiology of Field Crops		
	Unit 1: Introduction	**10**
1&2	Origin- Variability in physiology of crop plants between wild species and cultivated.	5
3&4	Adaptability to growing environments (ecosystems), Importance in food grain contribution.	5
	Unit 2: Crop Establishment, Crop Growth and Development	**18**
5&6	Seed characteristic features, dormancy, viability, concept of seed primingseedling establishment and crop stand	6
7&8	Different crop growth stages, concept of source establishment andoptimum LAI	6
9&10	Canopy architecture, light interception/radiation use efficiency, thermal time, heat units, GDD, determining growth duration.	6

	Unit 3: Reproductive Growth	**18**
11&12	Photo and thermo-periodic response for flowering, sink development, sink source relationship	6
13&14	Photo and thermo-periodic response for partitioning efficiency, improvement in HI, yield determining factors, genetic gain in yield over years	6
15&16	Photo and thermo-periodic response for genetic gain in yield over years, structuring of ideal plant type, limitations to improve source to sink size, options to improve yield potential.	6
	Unit 4: Seed Nutrient Quality	**14**
17&18	Seed quality, seed as a source of nutrients, seed constituents and their improvement	7
17&20	Concept of pathway engineering to improve seed quality	7
	Unit 5: Plant Nutrition	**12**
21&22	Nutrient requirement, genetic variability in nutrient acquisition under constraint conditions	7
23&24	Specific nutrient disorders	5
	Unit 6: Abiotic Stress Response	**15**
25&26	Response to different abiotic stresses, plant traits/mechanics to improve adaptation to realize potential yields	8
27&28	Global warming responses, thermomorphogenesis, approaches to overcome the constraints	7
	Unit 7: Crop Specific Physiological Processes and Importance	13
29&30	Choosing location specific crop species exposure will be given on physiological process as described above	7
31&32	Besides, emphasis is on providing information on crop specific features/productivity constraints	6
	Total	**100**

Suggested Reading

Grain Legumes: Ed De Ron, Antonio M. (Ed.) 2015. Springer

Legumes under Environmental Stress: Yield, Improvement and Adaptations. Eds MM Azooz P Ahmad and Hoboken, NJ: John Wiley and Sons, Ltd., 328 pages. ISBN: 978-1- 118-91708- 4

Pulse Crops: Biotechnological Strategies to Enhance Abiotic Stress Tolerance. Ganeshan S, Gaur PM, Chibbar RN, Tuteja N, Gill SS, Tuteja R. chapter 17

Climate Change and Management of Cool Season Grain Legume *Crops*. Eds Yadav GS, McNeil DL, Redden R, Patil SA. Springer *Nature's pulse power: legumes, food security and climate change.* Considine MJ, Siddique

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Von Caemmerer, S., Quick, W.P. and Furbank, R.T., 2012. *The development of C4 rice: current progress and future challenges. Science*, 336(6089), pp.1671-1672.
Hubbart S, Peng S, Horton P, Chen Y, Murchie EH. 2007. *Trends in leaf photosynthesis in historical rice varieties developed in the Philippines since 1966; Journal ofExperimental Botany*, Vol. 58 (12), 3429–3438
Fahad S, Bajwa AA, Nazir U, Anjum SA, Farooq A, Zohaib A, Sadia S, Nasim W, Adkins S, Saud S and Ihsan MZ. 2017. *Crop production under drought and heat stress: plant responses and management options. Frontiers in Plant Science* 8(1147): 1-16.
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Kole C. 2006. *Cereals and millets. Genome Mapping and Molecular Breeding in Plants. Springer.*
Samuel A. Matz. 2006. Cereal science
Rinki, Mamrutha HM, Sareen S, Tiwari V, Singh GP. 2018. *Dissecting the physiological and anatomical basis for high yield potential in HD 2967. Vegetos*. 31: 121-124.
Kumar R, Kaur A, Ankita P, Mamrutha HM, Singh GP 2019. *CRISPR based genome editing in wheat: A comprehensive review and future prospects. Molecular Biology Reports* 10.1007/ s11033-019-04761-3
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Reynolds *M. Wheat Physiological Breeding volume I and II (CIMMYT): Wheat Physiological Breeding: A Field Guide to Wheat Phenotyping*.
Mamrutha HM *et al*. 2019. *Physiological and Molecular Basis of Abiotic Stress Tolerancein Wheat*. In: Rajpal V., Sehgal D., Kumar A., Raina S. (eds) *Genetic Enhancement of Crops for Tolerance to Abiotic Stress: Mechanisms and Approaches*, Vol. I. Sustainable Development and Biodiversity, vol 20. Springer, Cham
Tiwari V. *et al*. 2017. *Managing Abiotic Stresses in Wheat.* In: Minhas P., Rane J., Pasala R. (eds) *Abiotic Stress Management for Resilient Agriculture*. Springer, Singapore

PP 510*: Seed Physiology

Objective This course will approach the subjects from two perspectives –physiology of seed development and seed germination. It aims to describe students the physiological processes involved in regulation and mechanism of seed development, dormancy and germination. Further, to provide an insight into physiological processes governing seed quality and its survival.

Theory

Block 1: Physiology of Seed Development Unit 1: Introduction to Seed Physiology

Importance of seed as a propagule, seed structure and functions; chemical composition of seeds. Embryogenesis: pollination and fertilization, pollen and pistil interaction, signal for interaction; pollen load hypothesis; genetical and environmental influence on seed development. Source-Sink relationship affecting seed yield and quality. Concept of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds. Physiological and molecular mechanisms of seed germination; approaches to improve seed germination; seed size and its influence on seed germination.

Unit 2: Seed Development

Physiology and molecular mechanisms of embryo, endosperm and seed coat development; cellularization during endosperm development; morphological and cellular changes during seed coat development, anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development.

Unit 3: Seed Maturation

Seed maturation and maturation indices; physiological and anatomical changes during seed maturation; Seed drying and acquisition of desiccation tolerance in seeds; mechanisms of desiccation tolerance; role of ABA LEA's, HSP's, dehydrins and other stress proteins during seed maturation and drying, Seed abortion and approaches to reduce it.

Unit 4: Metabolism in Developing Seed

Chemical composition of seeds (carbohydrates, proteins, fats etc.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds. Seed respiration and mitochondrial activity; seed respiration rate and storability of seeds. Seed ageing, Mobilization of stored resource in seeds; Chemistry of oXidation of starch, proteins and fats; Utilization of breakdownproducts by embryonic aXis.

Block 2: Physiology of Seed Germination and Dormancy Unit 1: Seed germination

Seed germination, types of germination, imbibition kinetics of germinating seed; Physiological events during germination: seed respiration, mitochondrial activity, mobilization of food reserve; energy utilization by the germinating seed. Environmental regulation of germination: hydro-time, thermal time and hydrothermal time models; Influence of environmental factors on germination; Role of plant hormones/PGR's during seed germination.

Unit 2: Seed Dormancy and Viability

Physiological and molecular basis of seed dormancy, hormonal regulation of dormancy, After ripening, dormancy breaking treatments; Ecological perspective of seed dormancy. Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds; methods to prolong seed viability; Conservation of orthodoX and recalcitrant seeds. Seed vigour: concept, importance, measurement; Physiological, biochemical and molecular basis of seed vigour.

TEACHING SCHEDULE

Lecture No.	Name of the topic	Weightage
	Block 1: Physiology of Seed Development	
	Unit 1: Introduction to Seed Physiology	**20**
1	Importance of seed as a propagule, seed structure and functions; chemical composition of seeds.	3
2&3	Embryogenesis: pollination and fertilization, pollen and pistil interaction, signal for interaction; pollen load hypothesis; genetical and environmental influence on seed development.	5
4	Source-Sink relationship affecting seed yield and quality.	3
5	Concept of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds.	4
6&7	Physiological and molecular mechanisms of seed germination; approaches to improve seed germination; seed size and its influence on seedgermination.	5
	Unit 2: Seed Development	**15**
8&9	Physiology and molecular mechanisms of embryo, endosperm and seed coat development	5
10&11	Cellularization during endosperm development; morphological and cellularchanges during seed coat development	5
12&13	Anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development	5
	Unit 3: Seed Maturation	**15**
14&15	Seed maturation and maturation indices; physiological and anatomical changes during seed maturation	5
16&17	Seed drying and acquisition of desiccation tolerance in seeds; mechanisms of desiccation tolerance	5

18&19	role of ABA LEA's, HSP's, dehydrins and other stress proteins during seed maturation and drying, Seed abortion and approaches to reduce it	5
	Unit 4: Metabolism in Developing Seed	**20**
20&21	Chemical composition of seeds (carbohydrates, proteins, fats etc.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds	8
22&23	Seed respiration and mitochondrial activity; seed respiration rate andstorability of seeds	8
24&25	Seed ageing, Mobilization of stored resource in seeds; Chemistry of oxidation of starch, proteins and fats; Utilization of breakdown products by embryonic axis	8
Block 2: Physiology of Seed Germination and Dormancy		
	Unit 1: Seed germination	**15**
26	Seed germination, types of germination, imbibition kinetics of germinating seed; Physiological events during germination	5
27	Seed respiration, mitochondrial activity, mobilization of food reserve; energy utilization by the germinating seed	5
28	Environmental regulation of germination: hydro-time, thermal time and hydrothermal time models, Influence of environmental factors on germination; Role of plant hormones/PGR's during seed germination	5
	Unit 2: Seed Dormancy and Viability	**15**
29	Physiological and molecular basis of seed dormancy, hormonal regulation of dormancy, After ripening, dormancy breaking treatments, ecological perspective of seed dormancy	4
30	Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds, methods to prolong seed viability	4
31	Conservation of orthodox and recalcitrant seeds	3
32	Seed vigour: concept, importance, measurement; Physiological, biochemical and molecular basis of seed vigour	4
	Total	**100**

Practical

S No.	Title of the experiment
1	Determination of seed reserves: carbohydrates, proteins and lipids
2	Study of different seed structures
3	Kinetics of seed imbibition; Seed germination test, enzymatic activities and respiration during germination and vigour testing methods etc.
4	Accelerated ageing test to know the seed vigour and storability
5	Measurement of seed moisture content
6	Determination of amylase activity in germinating seeds
7	Measurement of electrical conductivity in seed leachate
8	Measurement of seed viability using tetrazolium chloride
9	Determination of dehydrogenase activity
10	Seed germination study- Determination of Germination Index and seedling growth
11	Measurement ofseed vigour index
12	Dormancy breaking treatments
13	Seed priming techniques
14	Effect of environmental stresses on seed germination and seedling growth
15	Effect of hormones on seed germination

IX. Suggested Reading

Bewley, JD, Bradford K, Hilhorst H, Nonogaki H. (2013). *Seeds: Physiology of Development, Germination and Dormancy*, Springer-Verlag.

Larkins BA and Vasil IK (Ed), *Cellular and Molecular Biology of Plant Seed Development*, 2010,Springer.

Vanangamudi K, Natarajan K and Vanangamudi M *et al.* 2017. *Seed Physiology*. AssociatedPublishing Company.

Bewley JD and Black M. 1994. *Seeds: Physiology of Development and Germination*, Springer Pammenter NW and Patricia Berjak. 2000. *Aspects of recalcitrant seed physiology*. R.Bras. Fisiol.

Veg., 12: 56-69.

Prakash. M. 2011. *Seed physiology of crops*.(ed). Satish Serial Publishing house, New Delhi. Roberto Benech-Arnold, Rodolfo Sanchez. 2004. *Handbook of Seed Physiology: Applications to Agriculture*. CRC Press.

Vijayakumar A. 2001. *Seed Dormancy an overview. In: Recent techniques and Participatory Approachs in Quality seed production* (eds. K. Vanangamudi *et al*.) TNAU, Coimbatore. 287-396.

Padmavathi SM, Prakash S, Ezhil Kumar G, Sathianarayanan and Kamaraj A. 2012. *A Text Book of Seed Science and Technology*. New India Publishing Agency, New Delhi.

Tina Steinbrecher Gerhard Leubner-Metzger. 2017. *The biomechanics of seed germination.* *Journal of Experimental Botany*, 68(4): 765–783.

http://sbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/.

Bench ALR and Sanchez RA. 2004. *Handbook of Seed Physiology*. Food Product Press.

a. Bachelor Programmes

Sr. No.	Semester	Course No.	Credits	Course Title
1	I	BIO 111	2(1+1)	Introductory biology
2	II	GPB 121	3(2+1)	Fundamentals of Genetics
3	II	BOT 121	2(1+1)	Fundamentals of Crop Physiology
4	III	GPB 232	2(1+1)	Fundamentals of Plant Breeding
5	III	ESDM 231	3 (2+1)	Environmental Studies and DisasterManagement
6	IV	GPB 243	3(1+2)	Principles of Seed Technology
7	IV	ELE GPB 244	3(1+2)	Commercial Plant breeding
8	IV	ELE BOT 242	3(1+2)	Micropropogation Technologies
9	V	GPB 355	2(1+1)	Crop Improvement – I (Kharif Crops)
10	V	BOT 353	1(1+0)	Intellectual Property Right
11	VI	GPB 366	2(1+1)	Crop Improvement – II (Rabi crops)
12	VIII	ELM BOT 484	10(0+10)	Seed Production and Technology
13	VIII	ELM BOT 485	10(0+10)	Tissue Culture

Course Curricula and syllabi of each subject:

Course :	GPB 121	**Credit:**	3(2+1)	**Semester-II**
Course title:	Fundamentals of Genetics			

Syllabus

Theory

Pre and Post Mendelian concepts of heredity, Mendelian principles of heredity.Architecture of chromosome; chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; special types of chromosomes.Chromosomal theory of inheritance- cell cycle and cell division- mitosis and meiosis.Probability and Chi- square.Dominance relationships, Epistatic interactions with example.

Multiple alleles, pleiotropism and pseudoalleles, Sex determination and sex linkage, sex limited and sex influenced traits, Blood group genetics, Linkage and its estimation, crossing over mechanisms, chromosome mapping. Structural and numerical variations in chromosome and their implications, Use of haploids, dihaploids and doubled haploids in Genetics.Mutation, classification, Methods of inducing mutations & CIB technique, mutagenic agents and induction of mutation.Qualitative & Quantitative traits, Polygenes and continuous variations, multiple factor hypothesis, Cytoplasmic inheritance.Genetic disorders.Nature, structure & replication of genetic material. Protein synthesis, Transcription and translational mechanism of genetic material, Gene concept: Gene structure, function and regulation, Lac and Trp operons.

Practical

Study of microscope.Study of cell structure.Mitosis and Meiosis cell division. Experiments on monohybrid, dihybrid, trihybrid, test cross and back cross, Experiments on epistatic interactions including test cross and back cross, Practice on mitotic and meiotic cell division, Experiments on probability and Chi-square test. Determination of linkage and cross-over analysis (through two point test cross and three point test cross data).Study on sex linked inheritance in Drosophila. Study of models on DNA and RNA structures.

Teaching Schedule

A) Theory

Lecture	Topic	Weightages (%)
1	**Pre and post Mendelian concepts of heredity: Pre Mendelian concepts: (500 BC -1850 A.D.)** 1.Pre formation Theory 2.Theory Epigenesis 3.Theory of Acquired characters4.Theory of Pangenes 5.Germplsm theory Other contributions during pre-Mendelian era **Mendelian Era:(1850 -1900):**Contributions during Mendelian era **Post Mendelian concepts:** Contributions during Post-Mendelianera and recent advances after 1900. Role of different disciplines in the advancement of Genetics.	2
	Impact of Genetics and its applications in different disciplines (Role in Agriculture)	
2	**Mendelian principles of heredity:** Laws of Mendel, Reasons of Mendel's success Mendelian deviations or exceptions or anomalies	3
3 & 4	**Cell division: Mitosis, Meiosis:** Cell: Ultra structure, Cell organells& their functions. Types of Cell, Difference between animal cell and plant cell. **Stages of mitosis & meiosis.** Significance of mitosis & meiosis Difference between mitosis & meiosis.	4
5	**Dominance relationships:** Different patterns of dominance relationship like Complete dominance, Incomplete dominace, Co-dominance, Overdominanceand Lethal gene action.	2
6, 7 & 8	**Gene interaction, Epistasis interactions with examples:** Difference and similarities between epistasis and dominance.1.Recessive epistasis (Supplementary gene action) 2.Dominant epistasis (Simple epistasis) 3. Dominant Inhibitory epistasis (Inhibitory gene action) 4. Duplicate recessive epistasis (Complementary gene action) 5. Duplicate dominant epistasis (Duplicate gene action) 6. Polymeric gene action7.Typical dihybrid ratio	8
9	**Multiple alleles:** Important features of multiple allelesExamples of multiple alleles 1) Fur colour in a rabbit, 2) ABO blood group in man	3
10	Pleiotropism , pseudo-alleles, penetrance and expressivity	2

11 & 12	**Sex determination and sex linkage, Sex limited and sexinfluenced traits.** Introduction, Importance of Sex determination, Difference betweenautosomes and allosomes. Allosomal sex determination: 1.XX-XY System 2. XX-XO System3.XO-XX System 4. ZW-ZZ (XY-XX) System Sex linked characters: (Colour blindness in human being)Difference between Sex limited and sex influenced traits:	6
13	**Linkage and its estimation:** Introduction, Features of Linkage, Phases of Linkage, Types of Linkage, Linkage and pleiotropy, Significance of Linkage.	4
14	**Crossing over mechanisms:** Introduction; main features of crossing over; Types of crossingover; Molecular Mechanism of Crossing over; Factors affecting crossing over, Interference and Coincidence; Differences betweencrossing over and linkage; Significance of Crossing over.	4
15	**Probability and Chi-square :** Definition of Probability and Chi-square; The application and requirement of Chi-square test.	2
16	**Chromosome mapping:** Definition and Concept.	2
17	**Structural changes in chromosome:** Introduction; Types of Structural chromosome changes; Genetic effects and Significance.	4
18 &19	**Mutation**: Introduction; Characteristics of Mutation;classification ofMutation; Kinds of Mutation, Mutagenic agents and induction of mutation;Application in crop improvement.	8
20	**Qualitative & quantitative traits, Polygenes and continuousvariations:** Introduction; Characteristics ofQualitative & quantitative traits; Examples of Qualitative & quantitative traits.	4
21	**Multiple factor hypothesis:** Introduction; Concept of multiple factor hypothesis by Nilsson –Ehle in Wheat.	4
22	**Cytoplasmic inheritance:** Introduction; Characteristics of Cytoplasmic inheritance; Difference between mendelian inheritance and Cytoplasmic inheritance; classes of cytoplasmic inheritance; Plastid and mitochondrial inheritance; Significance of Cytoplasmic inheritance in crop improvement.	3
23	**Genetic disorders:** Introduction; Gene action in man, diseases caused by metabolicdisorders like Alkaptonuria, Phenyl ketonuria, Albinism, tyrosinosis and Goitrosus Cretinism, Sickel cell anemia.	3
24 & 25	**Nature, structure & replication of genetic material:** Introduction; DNA as a genetic material, Structure of DNA;Replication of DNA-Dispersive, Conservative, Semi-Conservative. Difference between DNA and RNA	8

26 & 27	**Protein synthesis, Transcription and translational mechanismof genetic material:** Introduction;Transcription; mechanism of transcription; Translational; mechanism of translational; Difference betweentranscription and translational.	8
28 & 29	**Gene concept** : Gene structure, fine structure of gene, Classicaland modern concept of gene, Benzer concept of fine structure of gene., Citron, Recon, Muton	8
30, 31 & 32	**Gene function and gene regulations, Lac and operons:** Introduction; Mechanism of gene regulation 1. Negative regulation 2. Positive regulationThe Operon Model	8
	Total	**100**

B) Practical

Exercise	Topic
1	Study of microscopes
2	Study of cell structure
3	Preparation of microscopic Slides of mitosis - onion root tips
4	Preparation of microscopic Slides of meiosis – tradescantia/onion /Wheat inflorescence
5.	Methods of finding out the gametes and gameticrecombination
6.	Problems on monohybrid ration and its modification
7	Problems on dihybrid ratio and its modification
8	Experiments on test cross and back cross
9	Gene interaction – I Gene interaction without modification of F_2ratio (comb-shape) and complementary gene interaction.
10	Gene interaction – II Gene interaction with modification of F_2ratio:supplementary factor, epistatis factor, inhibitory factor
11	Gene interaction – III Gene interaction with modification of F_2ratio: Additivefactor, duplicate factor and lethal factor
12	Problems on probability and Chi-square test
13	Chi-square test Problems on
14	Determination of linkage and cross over analysis (though two point test cross and three point test cross data)
15	Study on sex linked inheritance in Drosophila
16	Study of models on DNA and RNA structure

Suggested Reading:

Sr. No	Title of Book	Author/Authors	Publisher
1.	Principle of Genetics	E. J. Gardner , M. J. Simmons, D. P. Snustad	Wiley India (P) Ltd.
2.	Genetics	P. K. Gupta	Restogi publication Meerut -(p)
3.	Fundamentals of Genetics	B. D. Singh	Kalyani Publication, New Delhi.
4.	Genetics	M.W. Strickbearger	Peerson education, Inc.
5.	Elements of Genetics	Phundansingh	Kalyani Publication, New Delhi
6.	Genetics	Sushant Elrod and William Stansfield	McGraw Hill Publishing company Limited, New Delhi.

Course :	BOT 121		**Credit:**	2(1+1)	**Semester-II**
Course title:	Fundamentals of Crop Physiology				

Syllabus

Theory

Introduction to Crop Physiology and its importance in Agriculture; Plant cell: an Overview; Diffusion and osmosis; Absorption of water, transpiration and Stomatal Physiology; Mineral nutrition of Plants: Functions and deficiency symptoms of nutrients, nutrient uptake mechanisms; Photosynthesis: Light and Dark reactions, C3, C4 and CAM plants; Respiration: Glycolysis, TCA cycle and electron transport chain; Fat Metabolism: Fatty acid synthesis and Breakdown; Plant growth regulators: Physiological roles and agricultural uses, Physiological aspects of growth and development of major crops: Growth analysis, Role of Physiological growth parameters in crop productivity.

Practical

Study of plant cells, structure and distribution of stomata, imbibitions, osmosis, plasmolysis, measurement of root pressure, rate of transpiration, Separation of photosynthetic pigments through paper chromatography, Rate of transpiration, photosynthesis, respiration, tissue test for mineral nutrients, estimation of relative water content, Measurement of photosynthetic CO_2 assimilation by Infra Red Gas Analyser (IRGA).

Teaching Schedule

a) Theory

Lecture	Topic	Weightage (%)
1	Introduction to Crop Physiology and its importance in Agriculture	5
2	Plant cell- structure, cell organelles and their role	5
3-4	Absorption of water and path of water. Ascent of sap and theories of ascent of sap	10
5	Transpiration- Definition, types , structure of stomata, physiology of stomata, factors affecting transpiration, Water use efficiency & factors affecting W.U. E.	5

6	Mineral nutrition of plants. Classification of mineral element, criteriaof essentiality. General and specific role of mineral element and deficiency symptoms, mechanism of mineral element uptake.	10
7-8	Photosynthesis : Definition pigment involved, structure of chloroplast,light reaction- Photolysis of water, Emersion effect, Cyclic and non cyclic electron transfer, Significance of light reaction.	10
9	Dark reaction- C_3, C_4 and CAM plants factors affecting photosynthesis, Photorespiration	5
10	Respiration- Definition, types, glycolsis TCA cycle and electron transport chain	10
11	Fat metabolism- fatty acid synthesis and break down	5
12	Plant Growth Regulators, Definition, types , physiological role and Agricultural uses of PGRS.	10
13	Growth : Definition, types of growth, measurement of growth, growth analysis	5
14-15	Physiological aspects of growth and development of important cereals, pulses and oil seed crops	15
16	Photoperiodism- Definition, types, SDP, LDP and Day neutral plants- Induction a flowering and florigene concept	5
Total		100

b) Practical

Experiment	Topic
1	Study of plant cell
2	Study of imbibitions
3	Study of osmosis
4	Study of plasmolysis
5	Study of root pressure
6	Measurement of rate of transpiration
7	Study of structure and distribution of stomata
8	Estimation of relative water content of tissue
9	Study of separation of photosynthetic pigment through paper chromatography
10	Measurement of rate of photosynthesis by different methods
11	Study of respiration and respiratory quotient
12	Rapid tissue tests for macro-elements
13	Rapid tissue tests for micro-elements
14	Study of use of PGR in fruit ripening
15	Effect of osmotic pressure on seed germination.
16	Measurement of Plant growth.

Suggested Readings:

SR	Name of Book	Author	Publisher
1	A Text Book Plant Physiology*	Dr. V. Verma	Emkay Publisher, Delhi-110 051
2	Plant Physiology*	S. N. Pandey& B. K. Sinha	Vikas Publishing House, New Delhi-110 014
3	Practical Plant Physiology*1967	Amar Singh	Kalyani Publisher, Ludhiana
4	Plant Physiology*2005	C. P. Malik	Kalyani Publisher, Ludhiana
5	Plant Physiology@	K. N. Dhumal, T. N. More and M. R. Munnali	Niraliprakashan, Pune
6	Plant Physiology	Robert M. Devlin & Francis H. Witham	CBS Publisher & Distributors, Delhi-110032
7	Plant Physiology@	H. S. Shrivastava	Rustogi Publications, Meerut-250 002
8	Crop Physiology*	C. N. Chore, S. R. Ghadekar& R. K. Patil	Agromet Publisher, Nagpur-440 010
9	Plant physiology 2005@	S. Mukharji and A. K. Ghosh	New central book agency, Kolkatta
10	Plant physiology*2010	Taiz&Zeiger, E	Sinaurasso.Inc,USA
11	Introductory Plant physiology* 2013	G. Roy Noggle& Georgefriz	PHI learning pvt ltd, N.Delhi
12	A Text Book Plant Physiology* 2005	c. P. Malik & A. K. Srivastava	Kalyani publisher, Ludhiyana
13	Plant Physiology@1993	S. Chandra Datta	Wiley Eastern ltd, Daryaganj, N. Delhi
14	Experiment in Plant Physiology –A Lab. Manual * 1998	DayanandBajracharya	Narosa publishing house, panchshil park, N. Delhi
15	Plant Physiology – fundamentals & applications @2005	Arvindkumar& S. S. Purohit	Agrobios (India), Jodhpur
16	Modern Plant physiology 2007@	R. K. Sinha	Narosa publishing house, panchshil park, N. Delhi

*Text book & practical book
@Reference book

Course :	GPB 232	Credit:	2(1+1)	Semester-III
Course title:	Fundamentals of Plant Breeding			

Syllabus

Theory

Historical development, concept, nature and role of plant breeding, major achievements and future prospects; Genetics in relation to plant breeding, modes of reproduction and apomixes, self-incompatibility and male sterility- genetic consequences, cultivar options. Domestication, Acclimatization and Introduction; Centres of origin/diversity, components of Genetic variation; Heritability and genetic advance; Genetic basis and breeding methods in self- pollinated crops - mass and pure line selection, hybridization techniques and handling of segregating population; Multiline concept. Concepts of population genetics and Hardy-Weinberg Law, Genetic basis and methods of breeding cross pollinated crops, modes of selection; Population improvement Schemes- Ear to row method, Modified Ear to Row, recurrent selection schemes;Heterosis and inbreeding depression, development of inbred lines and hybrids, composite and synthetic varieties; Breeding methods in asexually propagated crops, clonal selection and hybridization; Maintenance of breeding records and data collection; Wide hybridization and pre-breeding; Polyploidy in relation to plant breeding, mutation breeding-methods and uses; Breeding for important biotic and abiotic stresses; Biotechnological tools-DNA markers and marker assisted selection. Participatory plant breeding; Intellectual Property Rights, Patenting, Plant Breeders and & Farmer's Rights.

Practical

Plant Breeder's kit, Study of germplasm of various crops. Study of floral structure of self-pollinated and cross pollinated crops. Emasculation and hybridization techniques in self & cross pollinated crops.Consequences of inbreeding on genetic structure of resulting populations.Study of male sterility system.Handling of segregation populations.Methods of calculating mean, range, variance, standard deviation, heritability. Designs used in plant breeding experiments, analysis of Randomized Block Design. To work out the mode of pollination in a given crop and extent of natural out-crossing.Prediction of performance of double cross hybrids.

Teaching Schedule

a) Theory

Lecture	Topic	Weightages (%)
1.	Definition, history of plant breeding, aims and general objectiveof plant breeding Land marks of plant breeding, Indian plant breeders,General objectives of plant breeding Major achievements, Future Prospects	8
2.	**Self incompatibility-** Definition, classification, heteromorphic SI, its features, distyly, tristyly, homomorphic SI, its types i.e. gametophytic SI and sporophytic SI, its features, utilization of self incompatibility in plant breeding	6
3	**Male sterility-** Definition, Classification/types, Genetic MS, Thermosensitive Genetic MS, Photosensitive Genetic MS, Transgenic MS, Cytoplasmic MS, Cytoplasmic Genetic MS, Chemical Hybridizing Agents	6
4	**Heritability-** Definition, types-narrow and broad senseheritability **Components of genetic variation-** Classification, definition and features of additive, dominance and epistatic variance, geneaction	5

5	**Concepts of population genetics-** Definition and concept of population genetics, random mating population, gene and genotypic frequency **Hardy-Weinberg law-** Law, its validity, factors affecting gene frequency	5
6	**Breeding Methods in self pollinated cropsList of breeding methods** **Plant Introduction-** Definition, purpose, types i.e. primary andsecondary introduction, advantages and disadvantages **Acclimatization-** Definition, concept, factors affecting acclimatization	5
7	**Pure line selection-** uses of pure line, merits, demerits,achievements **Mass selection-** Definition, genetic basis, main features, positive and negative selection, detailed procedure of development ofvariety by mass selection, its merits, demerits, achievements	5
8	**Handling of segregating population through Pedigreemethod-** detailed procedure of pedigree method, its merits, demerits, achievements	5
9	**Handling of segregating population through Bulk method-**Concept of bulk method, short term, long term, its application,procedure of bulk method, its merits, demerits, achievements **Handling of segregating population through Single seeddescent method-** concept of SSD method, its application,detailed procedure of SSD method, its merits, demerits, achievements	4
10	**Back cross method-** Definition of backcross, its objective, requirements and applications of backcross method, procedure fortransfer of dominant gene **Back cross method-** procedure for transfer of recessive gene, merits, demerits, achievements of backcross method	5
11	**Methods of breeding in cross pollinated crops-** list of plantbreeding methods for cross pollinated crops **Modes of selection-** Recurrent selection, its types and itsprocedure	5
12	**Hybridization techniques-** Definition, aim and objectives, types of hybridization, steps and procedure of hybridization programme **Wide hybridization-** Definition, types, main features, interspecific and intergeneric hybridization, its examples, incompatibility barriers for wide hybridization, techniques forovercoming incompatibility barriers, achievements	10
13	**Composite and synthetic varieties-** Definition, steps for development of composites and synthetics, procedure of developing composites and synthetics, its merits, demerits and achievements	5
14	**Breeding methods in asexually propagated crops:** List ofbreeding methods for asexually propagated crops. **Clonal selection-** Definition, features of asexually propagatedcrops, procedure of clonal selection, its merits and demerits **Hybridization-** steps and procedure of hybridization in clonal crops	6
15	**Mutation breeding method and its uses –** Definition of mutation breeding, conditions in which mutation is rewarding, procedure of mutation breeding for seed and vegetatively propagated crops, applications, its merits, demerits and achievements **Polyploidy in relation to plant breeding-** Definition of haploid, monoploid, diploid, polyploid, genome, heteroploidy, annuploidy, euploidy, types of annuploidy its application in crop improvement, types of polyploidy (natural occurring and artificial) and its role in crop improvement, effects of polyploidy, its application in crop improvement and limitation	12

16	**Heterosis-** Definition, heterosis and hybrid vigour, effects andestimation of heterosis, genetic basis/theories of heterosis **Inbreeding depression-** Definition, effects of inbreeding	8
Total		**100**

b) Practical

Experiment	Exercise
1	Plant Breeder's kit
2	Study of germplasm of various crops
3	Study of floral structure of self pollinated crops
4	Study of floral structure of cross pollinated crops
5	Emasculation and hybridization techniques in self pollinated crops : Greengram, Black gram, Rice, Wheat, Groundnut, Soybean,
6	Emasculation and hybridization techniques in self pollinated crops : Sesame, Chickpea, Okra, Tomato, Brinjal, Chilli,
7	Emasculation and hybridization techniques in cross pollinated crops : Maize, Bajra,Sunflower, Papaya, Sugarcane,
8	Emasculation and hybridization techniques in often cross pollinated crops :Cotton, Sorghum, Pigeonpea, Safflower
9	Consequences of inbreeding on genetic structure of resulting populations
10	Study of male sterility system
11	Handing of segregation populations
12	Methods of calculating mean, range, variance, standard deviation, heritability
13	Designs used in plant breeding experiment
14	Analysis of Rondomized Block Design
15	To work out the mode of pollination in a given crop and extent of natural out crossing
16	Prediction of performance of double cross hybrids

Suggested Readings:

Sr. No	Title of Book	Author/Authors	Publisher
1.	Plant Breeding Principles and Methods	B. D. Singh	KalyaniPublication New Delhi.
2.	Essentials of Plant Breeding	Phundansingh	Kalyani Publication NewDelhi
3.	Principles and Practices Plant Breeding	J. R. Sharma	McGraw Hill Publishing company Limited , NewDelhi.
4.	Plant Breeding Theory and Practices	V. L. Chopra	Oxford and IBH. Publishing Company , New Delhi.
5.	Introduction to Plant Breeding	R. C. Choudhary	Oxford and IBH. Publishing Company ,New Delhi.
6.	Elementary Principles of Plant Breeding	R. C. Choudhary	Oxford and IBH. Publishing Company , New Delhi.

Course :	GPB 243		Credit:	3(1+2)	Semester-IV
Course title:	Principles of Seed Technology				

Syllabus

Theory

Seed and seed technology: introduction, definition and importance. Deteriorationcauses of crop varieties and their control; Maintenance of genetic purity during seed production, seed quality; Definition, Characters of good quality seed, different classes of seed. Foundation and certified seed production of important **cereals, pulses, oilseeds, fodder and vegetables**. Seed certification, phases of certification, procedure for seed certification, field inspection. Seed Act and Seed Act enforcement. Duty and powers of seed inspector, offences and penalties. Seeds Control Order 1983, Varietal Identification through Grow Out Test and Electrophoresis, Molecular and Biochemical test. Detection of genetically modified crops, Transgene contamination in non-GM crops, GM crops and organic seed production.

Seed drying, processing and their steps, seed testing for quality assessment, seed treatment, its importance, method of application and seed packing. Seed storage; general principles, stages and factors affecting seed longevity during storage. Measures for pest and disease control during storage. Seed marketing: structure and organization, sales generation activities, promotional media. Factors affecting seed marketing, Role of WTO and OECD in seed marketing. Private and public sectors and their production and marketing strategies.

Practical

Seed production in major cereals: Wheat, Rice, Maize, Sorghum, Bajra and Ragi. Seed production in major pulses: Urd, Mung, Pigeonpea, Lentil, Gram, Field bean, pea. Seed production in major oilseeds: Soybean, Sunflower, Rapeseed, Groundnut and Mustard. Seed production in important vegetable crops. Seed sampling and testing: Physical purity, germination, viability, etc. Seed and seedling vigour test. Genetic purity test: Grow out test and electrophoresis. Seed certification: Procedure, Field inspection, Preparation of field inspection report. Visit to seed production farms, seed testing laboratories and seed processing plant.

Teaching Schedule

a) Theory

Lecture	Topic	Weightages (%)
1	Seed and seed technology : introduction, definition and importance	5
2	Deterioration causes of crop varieties and their control & Maintenance of genetic purity during seed production	5
3	Seed quality : definition. Characters of good quality seed	4
4	Different classes of seed.	4
5	Foundation and certified seed production of important cereals **(Wheat, Sorghum, Maize, Rice &Bajara)**	5
6	Foundation and certified seed production of important pulses **(Pigeon Pea, Green Gram, Black Gram & Chick Pea)**	5
7	Foundation and certified seed production of important oil seeds **(Soybean, Sunflower, Safflower ,Groundnut and Cotton)**	5

8	Foundation and certified seed production of important fodder crops **(Fodder Sorghum, Lucern, Berseem,)**	5
9	Foundation and certified seed production of important vegetable crops **(Tomato, Brinjal, Chilli, Onion & Okra)**	5
10	Seed certification, phases of certification, procedure for seed certification, field inspection	4
11	Seed Act and Seed Act enforcement. Duty and powers of seed inspector, offences and penalties. Seeds control order 1983.	5
12	Varietal identification through Grow Out Test and Electrophoresis. **Molecular and biochemical test. Detection of genetically modified crops. Transgene contamination in non-GM crops, GM cropsand organic seed production.**	15
13	Seed drying, processing and their steps. Seed testing for quality assessment.	5
14 & 15	Seed treatment, its importance, method of application and seedpacking. Seed storage : general principles, stages and factors affecting seed longevity during storage. Measures for pest anddisease control during storage	14
16	Seed marketing : structure and organization, sales generation activities ,promotional media. Factors affecting seed marketing, Roleof WTO and OECD in seed marketing.	14
	Total	100

b) Practical

Experiment	Topic
1	Seed production in major cereals : Wheat and Rice
2	Seed production in : Sorghum and Bajara
3	Seed production in : Maize.
4	Seed production in major pulses : Green gram and Black gram
5	Seed production in pulses : Pigeonpea and Lentil
6	Seed production in pulses : Gram and Field pea
7	Seed production in major oil Seeds : Soybean, Rapeseed & Mustard
8	Seed production in major vegetable crops :Brinjal and Tomato.
9	Seed production in vegetable crops :Chilli and Okra.
10	Seed production in vegetable crops : Onion
11	Seed production in : Pumpkin, Bottle gourd
12	Seed production in : Bitter gourd, Ridge gourd, Sponge gourd
13	Seed sampling and testing procedure
14	Physical purity test
15	Seed moisture test
16	Germination test – types of germination
17	Germination test – different methods of germination
18	Seed viability test
19	Seed and seedling vigour test
20	Genetic purity test : Grow Out Test
21	Genetic purity test : Electrophoresis
22	Seed certification : Procedure
23	Field inspection, preparation of field inspection report
24	Visit to seed production farms of cereal crops

25	Visit to seed production farms of oilseed crops
26	Visit to seed production farms of pulse crops
27	Visit to seed production farms of fiber crops
28	Visit to seed testing laboratories
29 & 30	Visit to seed processing plant

Suggested Readings:

Sr. No	Title of Book	Author/Authors	Publisher
1.	Seed Technology	R. L. Agrawal	Oxford and IBH. Publishing Company , New Delhi.
2.	Seed Science and Technology	SubirSen N Ghosh	Kalyani Publication NewDelhi
3.	Principles of Seed Technology	Phundan Singh	KalyaniPublication New Delhi.
4.	Seed Science and Technology	N. C. Singhal	KalyaniPublication New Delhi.
5.	Seed Technology	Dhirender Khare and Mohan Bhale	Scientifice Publishers, JodhaPur
6.	Vegetable Seed Production	Nempal Singh, D.K. Singh, Y.K. Singh and Virendirekumar	International Book Distribution Company, Lucknow.

Course :	ELE GPB 244		**Credit:**	3(1+2)	**Semester-IV**
Course title:	Commercial Plant Breeding				

Syllabus

Theory

Types of crops and modes of plant reproduction.Line development and maintenance breeding in self and cross pollinated crops (A/B/R and two line system) for development of hybrids and seed production.Genetic purity test of commercial hybrids. Advances in hybrid seed production of maize, rice, sorghum, pearl millet, castor, sunflower, cotton pigeon pea, Brassica etc. Quality seed production of vegetable crops under open and protected environment. Alternative strategies for the development of the line and cultivars: haploid inducer, tissue culture techniques and biotechnological tools. IPR issues in commercial plant breeding: DUS testing and registration of varieties under PPV & FR Act. Variety testing, release and notification systems in India. Principles and techniques of seed production, types of seeds, quality testing in self and cross pollinated crops.

Practical

Floral biology in self and cross pollinated species, selfing and crossing techniques. Techniques of seed production in self and cross pollinated crops using A/B/R and two line system. Learning techniques in hybrid seed production using male-sterility in field crops. Understanding the difficulties in hybrid seed production, Tools and techniques for optimizing hybrid seed production. Concept of rouging in seed production plot.Concept of line its multiplication and purification in hybrid seed production.Role of pollinators in hybrid seed production.Hybrid seed production techniques in sorghum, pearl millet, maize, rice, rapeseed-mustard, sunflower, castor, pigeon pea, cotton and vegetable crops.Sampling and analytical procedures for purity testing and detection of spurious seed. Seed drying and storage structure in quality seed management. Screening techniques during seed processing viz., grading and packaging. Visit to public private seed production and processing plants.

Teaching Schedule

a) Theory

Lecture	Topics to be covered	Weightage (%)
1.	Types of Crop: Classifications of crops.	4
2-3	Male sterility-Definition, Transfer of MS to a new strain, maintenance of MS, Production of hybrid seed and limitations in using malesterility systems.	12
4-5	Hybrid varieties & features, Development of hybrid varieties: Development and evaluation of inbred lines, selection of productiveinbred lines & production of hybrid seeds. Maintenance of nucleus & breeder seed in self and cross pollinatedcrops, Maintenance of pre-released or newly released varieties; Breeder seed of established varieties, Maintenance of nucleus & breeder seed of inbred lines.	14
6	Genetic purity test of commercial hybrids: Maintenance of geneticpurity and safeguards for maintenance of genetic purity, Factor affecting genetic purity.	6
7-9	Advances in hybrid seed production of Rice, Sorghum, Maize, Perl-millet, Sunflower, Cotton, Pigeon-pea, etc. Steps and factor affectinghybrid seed production.	20
10	Principles of quality seed production of vegetables crops under open and protected environment	6
11	Development of parental lines and cultivars: Haploid production by anther and pollen culture.	8
12	IPR issue in commercial plant breeding	2
13-14	DUS testing -The Protection of Plant Varieties and Farmer's Right Act, 2001 (PPVFR, 2001): Main objective, Power and duties of PPV& FR Authority, Criteria for protection, Registration, Plant varieties qualifying for registration and Compulsory licensing. DUS testingcenters.	10
15	Variety testing, release and notification major steps in India, Generalprocedure for variety testing. Central Variety Release Committee, State Variety Release Committee. Seed production organizations; NSC, MSSC.	10
16	Genetic and Agronomic principles of quality seed production and its characteristics	8
Total		**100**

b) Practical

Experiment	Title
1.	Floral Biology in self pollinated species
2.	Floral Biology in cross pollinated species
3	Selfing techniques in different crops
4.	Crossing techniques in different crops
5.	Learning techniques in hybrid seed production using male-sterility in fields crops

6.	Techniques of seed production using A, B and R systems in self pollinated crops.
7.	Techniques of seed production using A, B and R systems in cross pollinated crops.
8	Techniques of seed production using two line systems in self and cross pollinated crops.
9	Problems in hybrid seed production.
10	Tools and Techniques for optimizing hybrid seed production
11	Multiplication and purification of line in hybrid seed production
12	Rouging concept in seed production plot
13	Role of pollinators in hybrid seed production
14-17	Hybrid seed production techniques in field crops: Sorghum, pearl-millet, maize, rice, sunflower, pigeon-pea, cotton crops.
18-20	Hybrid seed production techniques in vegetable crops: Okra, Brinjal, Onion, Chilli, tomato etc.
21	Seed sampling.
22	Physical purity test and detection of spurious seed.
23	Genetic purity test under field and laboratory conditions.
24	Seed drying
25	Storage structure in quality seed management
26	Seed screening techniques during seed processing: Seed grading
27	Seed screening techniques during seed processing :Seed packaging
28-29	Visit to public / private seed production plots
30-31	Visit to public / private seed processing plants
32	Economics of commercial seed production

Suggested Readings:

1) Hybrid Seed Production in Field Crops: Principles and Practices by N. C. Singhal, 2003,
a. Kalyani publication, Delhi
2) Principles of Seed Technology by P.K. Agrawal, 2002, Oxford
3) Seed Production of Vegetables. By Prabhakar Singh and B. S. Asati
4) Seed Technology, 1996, Agarwal R L, Oxford
5) Plant Breeding; Principles and Methods by B.D. Singh, 2006, Kalyani publication, Delhi
6) Genetics 2002 by P. K. Gupta, Rastogi publication
7) An Introduction to Seed Technology by Thomson J.R.
8) Seed science and technology laboratory manual, 1997 by M. B. Mdonald and L.O.
9) Copeland, Chapman & hill.
10) Seed Technology by DhirendraKhare and Mohan S. B. Bhale, 2005
11) Principles and practices of plant breeding by Sharma J. R.1984, Tata McGraw –Hill.
12) Practical plant breeding by Gupta S. K. 2004, Agribios publication
13) Principles of Vegetable Seed Production by Prem Narayan
14) Principles Plant Breeding, 1981 by Allard R W, Jhon Willy and sons

15) Fundamentals of Plant Breeding, 2005 Kalyani publication, Delhi
16) Fundamentals of Plant Breeding & hybrid seed production, 1996, Agarwal R L, Oxford

Course :	ELE BOT 242		Credit:	3(1+2)	Semester-IV
Course title:	Micro-propagation Technologies				

Syllabus

Theory

Introduction, History, Advantages and limitations; Types of cultures (seed, embryo, organ, callus, cell), Stages of micropropagation, Axillary bud proliferation (Shoot tip and meristem culture, bud culture),Organogenesis (callus and direct organ formation), Somatic embryogenesis, cell suspension cultures, Production of secondary metabolites,Somaclonal variation, Cryopreservation

Practical

Identification and use of equipments in tissue culture Laboratory, Nutrition media composition, sterilization techniques for media, containers and small instruments, sterilization techniques for explants, Preparation of stocks and working solution, Preparation of working medium, Culturing of explants:Seeds, shoot tip and single node, Callus induction, Induction of somatic embryos regeneration of whole plants from different explants, Hardening procedures.

Teaching Schedules

a) Theory

Lecture	Topic	Weightages (%)
1 & 2	Meaning and concept of *in vitro* culture and micro-propagation, Historical milestones.	05
3	Tissue culture methodology: Sterile techniques	10
4	Synthetic and natural media components, growth regulators, environmental requirement.	10
5	Totipotency, dedifferentiation;genetic control of regeneration;	05
6	Plant regeneration pathways - Organogenesis and Somatic embryogenesis;	10
7	Organogenesis- Purpose, methods and requirements for organogenesis, indirect and direct organogenesis;	10
8, 9 & 10	Somatic embryogenesis- Procedures and requirements for organogenesis, indirect and direct embryogenesis; Differences between somatic and gametic embryogenesis,	15
11, 12 & 13	Micro-propagation- Definition, methods, stages of micro-propagation and its significance; Advancement and future prospects of micro-propagation.	20
14 & 15	Micropropagation - Axillary bud proliferation approach- Shoot tip and meristem culture;	10
16	Synthetic seed- Concepts, necessity, procedure and requirements for production of synthetic seeds.	5
	Total	**100**

b) Practical

Experiment	Topic
1	Laboratory organization of Plant Tissue Culture Laboratory
2	Safety Measures in Laboratory
3, 4, 5	Sterilization techniques: Common Contaminant in Laboratory, Sterilization of glassware, Working of Laminar air flow cabinet
6, 7	Culture Media: Definition, Components of Media, Stock Solution, Working Solution, Sterilization of Media.
8, 9	Preparation and sterilization of growth regulators/thermolabile compounds.
10,11	Preparation of working medium
12,13	Experimentation on determining optimum concentration of growth regulators.
14	Sterilization techniques for explants.
15, 16, 17, 18	Callus induction from different parts of plants
19, 20, 21, 22	Regeneration of whole plants from induced callus using different parts of plants.
23, 24	Induction of somatic embryos.
25, 26	Experiments of synthetic seeds production and testing storability and germination efficiency.
27, 28, 29, 30, 31 ,32	Direct regeneration into whole plants using bud, node and other tissues.

Suggested readings:

1) Plants from Test Tubes: An introduction to Micropropagation (Fourth Edition) – Lydiane Kyte, John Kleyn, Holly Scoggins and Mark Bridgen (Timber Press)
2) Introduction top Plant Tissue Culture- M. K. Razdan (Science Publisher)
3) Somatic Embryogenesis: Fundamental Aspects and Application – Loyola-Vargas, Victor, Ochoa-Aleja, Neftali (Springer)
4) Plant Tissue Culture, Techniques and Experiment – Robert H Smith (AP)
5) Plant Tissue Culture- Protocols in Plant Biotechnology - M.C. Gayatri and R. Kavyashree (Narosa Publishing)
6) Practical biotechnology and Plant Tissue Culture- Prof. Santosh Nagar, Dr. Madhavi Adhav (S Chand)

Course :	GPB 355		Credit:	2(1+1)	Semester-V
Course title:	Crop Improvement –I *(Kharif Crops)*				

Syllabus

Theory

Centers of origin, distribution of species, wild relatives in different cereals; pulses; oilseeds; fibres; fodders and cash crops; vegetable and horticultural crops; Plant genetic resources, its utilization and conservation, study of genetics of qualitative and quantitative characters; Important concepts of breeding self pollinated, cross pollinated and vegetatively propagated crops; Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, adaptability, stability, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional); Hybrid seed production technology in Maize, Rice, Sorghum, Pearl millet and Pigeonpea, etc. Ideotype concept and climate resilient crop varieties for future.

Practical

Floral biology, emasculation and hybridization techniques in different crop species; viz., Rice, Jute, Maize, Sorghum, Pearl millet, Ragi, Pigeonpea, Urdbean, Mungbean, Soybean, Groundnut, Seasame, Caster, Cotton, Cowpea, Tobacco, Brinjal, Okra and Cucurbitaceous crops. Maintenance breeding of different *kharif* crops. Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods; Study of field techniques for seed production and hybrid seeds production in *Kharif* crops; Estimation of heterosis, inbreeding depression and heritability; Layout of field experiments; Study of quality characters, donor parents for different characters; Visit to seed production plots; Visit to AICRP plots of different field crops.

Teaching Schedule

a) Theory

Lecture	Topic	Weightages (%)
1	Centre of origin, Distribution of species, wild relative in different crops **Cereals**- Rice, Maize, Sorghum, Pearl millet, Ffinger millet. **Pulses**-Pigeonpea, Urdbean, Black gram, Mung bean, Cowpea, Soybean. **Oil seed-** Groundnut, Castor, Sesame, Sunflower.	4
2	**Fodder:**Berseem, Lucerne, rice bean. **Cash crops:** Cotton, Tobacco. **Vegetable:** Ridge gourd, bottle gourd, Snake gourd, Bitter gourd. **Horticultural crop**- Mango, Cashewnut, Citrus, Pomegranate, Guava.	4
3	Definition of PGR, Gene pool, Kinds of germplasm, gene pool concept, Genetic erosion, Germplasm collection and conservation, Types and methods.	10
4 &5	Floral Biology- Emasculation and mode of pollination (Definition and Types) Study of genetics of qualitative and quantitative characters-	10

Lecture	Topic	Weightages (%)
	Inheritance of qualitative characters, pleiotrophy, Penetrance and Expressivity, Threshold character and modifying genes. Inheritance of quantitative character- Multiple factor hypothesis, Transgenic segregation, Role of environment of quantitative inheritance, Difference between quantitative and qualitative character	
6'7 &8	Major Specific Breeding objective, Conventional Breeding methods- Introduction, Mass selection, pure line selection, Pedigree method, Bulk method and backcross method along with examples of varieties. Modern innovative approaches- somatic Hybridization, transgenic breeding and marker assisted selection.	20
9& 10	**Biotic stress tolerance: Breeding for disease and insect resistance** **Disease resistance**: Introduction, mechanism of disease resistance genetic resistance type of genetic resistance, gene for gene hypothesis, Genetics of resistance sources of resistance breeding methods and practical achievement. **Insect resistance**: Introduction, mechanism of insect resistance basis of insect resistance, Genetics of insect resistance sources of insect resistance, breeding methods, practical achievement.	12
11 & 12	**Breeding for Abiotic stress:** **Drought resistance-** Drought introduction, Drought resistance, Mechanism of drought resistance, Basis of drought resistance sources of drought resistance, breeding method. **Salinity:** Breeding for salt tolerance, breeding approaches, screening techniques, practical achievements. **Breeding for quality:** Introduction, Quality traits, Nutrition and nutrients, Nutritional quality of cereals and pulses, Genetic of nutritional traits, Sources of nutritional quality, Breeding methods, screening techniques, Breeding for low toxic substance, practical achievements.	12
13	**Seed production technology in self pollinated crops-** Rice wheat, Cross pollinated -Maize, Sorghum Vegetatively propagated crop. Potato, Sugarcane	8
14	Hybrid seed production of Maize, Rice Sorghum, Pigeonpea and Pearl millet.	8
15 & 16	Ideotype concept in crop improvement- Introduction, Types of ideotype, characteristics of Ideotype, Major steps in Ideotype breeding, Ideotype of Rice, wheat, Sorghum, practical achievements, merits and demerits. Characteristics of climate resilient crops Viz. Wheat, Sorghum, maize, soybean, cotton,	12
	Total	**100**

b) Practical

Experiment	Topic
1	Emasculation and hybridization techniques in different crop species : Rice, Maize
2	Emasculation and hybridization techniques in Sorghum & Pearl Millet
3	Emasculation and hybridization techniques in Ragi&Pigeonpean
4	Emasculation and hybridization techniques in Urdbean&Mungbean, Soybean

5	Emasculation and hybridization techniques in Groundnut, Seasame& Sunflower
6	Emasculation and hybridization techniques in Caster, Cotton
7	Emasculation and hybridization techniques in Cowpea & Tobacco
8	Maintenance breeding of different Kharif crops
9	Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods
10	Study of field techniques for seed production and hybrid seeds production in Kharif crops
11	Estimation of heterosis, inbreeding depression and heritability
12	Layout of field experiments
13	Study of quality characters, donor parents for different characters
14	Visit to seed production plots
15	Visit to AICRP plots of pulse & sorghum
16	Visit to AICRP plots of oilseed & cotton

Suggested Reading:

Sr. No	Title of Book	Author/Authors	Publisher
1.	Crop Breeding and Biotechnology	HariHar Ram	KalyaniPublication New Delhi.
2.	Breeding of Asian Field crops	D. A. Sleper J.M. Poehlman	Blackwell Publishers
3.	Principle and Procedures of Plant Breeding Biotechnological and Conventional Approach	G. S. Chahal S. S. Gosla	Narosa Publishers House. New Delhi.
4.	Plant Breeding Principle and Methods.	B. D. Singh	KalyaniPublication New Delhi.

Course :	BOT 353		**Credit:**	1(1+0)	**Semester-V**
Course title:	Intellectual Property Right				

Syllabus

Theory

Introduction and meaning of intellectual property, brief introduction to GATT, WTO, TRIPs and WIPO, Treaties for IPR protection: Madrid protocol, Berne Convention, Budapest treaty, etc.

Types of Intellectual Property and legislations covering IPR in India:-Patents, Copyrights,

Trademark, Industrial design, Geographical indications, Integrated circuits, Trade secrets. Patents Act 1970 and Patent system in India, patentability, process and product patent, filing of patent, patent specification, patent claims, Patent opposition and revocation,

infringement, Compulsory licensing, Patent Cooperation Treaty, Patent search and patent database.

Origin and history including a brief introduction to UPOV for protection of plant varieties, Protection of plant varieties under UPOV and PPV&FR Act of India, Plant breeders rights, Registration of plant varieties under PPV&FR Act 2001, breeders, researcher and farmers rights. Traditional knowledge-meaning and rights of TK holders.

Convention on Biological Diversity, International treaty on plant genetic resources for food and agriculture (ITPGRFA). Indian Biological Diversity Act, 2002 and its salient features, access and benefit sharing.

Teaching Schedule

Lecture	Topic	Weightage (%)
1-2	Introduction and meaning of intellectual property, brief introduction to GATT, WTO, TRIPs and WIPO	**10**
3	Treaties for IPR protection: Madrid protocol, Berne Convention, Budapest treaty, etc.	**5**
4-5	Types of Intellectual Property and legislations covering IPR in India:-Patents, Copyrights, Trademark, Industrial design, Geographical indications, Integrated circuits, Trade secrets.	**15**
6-7	Patents Act 1970 and Patent system in India, patentability, process and product patent, filing of patent, patent specification, patent claims, Patent opposition and revocation,	**12**
8	Penalties for infringement, Compulsory licensing, Patent Cooperation Treaty, Patent search and patent database.	**4**
9-10	**UPOV-** Origin and history including a brief introduction to UPOV for protection of plant varieties, Protection of plant varieties under UPOV	**14**
11-12	PPV&FR Act of India, Plant breeders rights, Registration of plant	**14**
	varieties under PPV&FR Act 2001	
13-14	Researcher and farmers rights, Traditional knowledge-meaning and rights of TK holders.	**12**
15-16	Convention on Biological Diversity, International treaty on plant genetic resources for food and agriculture (ITPGRFA). Indian Biological diversity Act,2002 and its salient features, access and benefit sharing	**14**
	Total	**100**

Suggested Readings:

1) Introduction to Intellectual Property Rights by H.S. Chawla, Oxford & IBH Publishing Co. Pvt. Ltd. 113-B ShahpurJat, 2nd Floor, *Asian Games Village side* New Delhi 110 049, India

2) Encyclopedia of Intellectual Property rights Volume No. 1 to 10 by Priyanjan Trivedi (2008)

3) Plant Breeding by B.D. Singh (2006), Kalyani Publication

4) Intellectual Property Right Under Golbalization by Tawar S. Serials Publication, New Delhi.

Course No:	GPB 366		**Credit:**	2(1+1)	**Semester-VI**
Course title:	Crop Improvement- II *(Rabi crops)*				

Syllabus

Theory

Centers of origin, distribution of species, wild relatives in different cereals; pulses; oilseeds; fodder crops and cash crops; vegetable and horticultural crops; Plant genetic resources, its utilization and conservation; study of genetics of qualitative and quantitative characters; Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, adaptability, stability, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional); Hybrid seed production technology of *rabi* crops. Ideotype concept and climate resilient crop varieties for future.

Practical

Floral biology, emasculation and hybridization techniques in different crop species namely Wheat, Oat, Barley, Chickpea, Lentil, Field pea, Rajma, Horse gram, Rapeseed Mustard, Sunflower, Safflower, Potato, Berseem. Sugarcane, Tomato, Chilli, Onion; Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods; Study of field techniques for seed production and hybrid seeds production in *Rabi* crops; Estimation of heterosis, inbreeding depression and heritability; Layout of field experiments; Study of quality characters, study of donor parents for different characters; Visit to seed production plots; Visit to AICRP plots of different field crops

Teaching Schedule

a) Theory

Lecture	Topic	Weightage (%)
1	Cereals –Wheat, oat and barley - Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	10
2	Pulses –Chickpea- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	8

3	Oilseeds –Sunflower and Safflower- Centers of origin, Distribution of species, Wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	10
4	Oilseeds –Linseed, Rapeseed and Mustard- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	8
5	Fodders –Napier, Bajra, Sorghum, Maize and Berseem- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	5
6	Cash -Sugarcane - Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	6
7	Vegetable-Potato- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	5
8	Vegetable-Field pea- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	5
9	Horticultural crops-Mango, Aonla and Guava- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	8
10-11	Plant genetic resources, its utilization and conservation	8
12	Adaptability and stability	5
13- 14	Hybrid seed production technology in Rabi crops -Sunflower, Safflower, Castor, Rabi Sorghum	12
15 - 16	Ideotype concept and climate resilient crop varieties for future- Wheat, Rice, Maize, Sorghum and Cotton	10
	Total	**100**

b) Practical

Experiment	Exercise
1	Emasculation and hybridization techniques in wheat, oat & barley
2	Emasculation and hybridization techniques in chickpea & lentil
3	Emasculation and hybridization techniques in field pea, rapeseed & mustard
4	Emasculation and hybridization techniques in sunflower
5	Emasculation and hybridization techniques in potato &berseem
6	Emasculation and hybridization techniques in sugarcane & cowpea
7	Emasculation and hybridization techniques in safflower
8	Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods
9	Study of field techniques for seed production and hybrid seeds production in Rabi crops
10	Estimation of heterosis, inbreeding depression and heritability
11	Layout of field experiments
12	Study of quality characters, study of donor parents for different characters
13	Visit to seed production plots
14	Visit to AICRP plots of Safflower & Chickpea
15	Visit to AICRP plots of Sunflower & Rabi sorghum

Suggested Readings:

Sr. No	Title of Book	Author/Authors	Publisher
1.	Crop Breeding and Biotechnology	HariHar Ram	KalyaniPublication New Delhi.
2.	Breeding of Asian Field crops	D. A. Sleper J.M. Poehlman	Blackwell Publishers
3.	Principle and Procedures of Plant Breeding Biotechnological and Conventional Approach	G. S. Chahal S. S. Gosla	Narosa Publishers House. New Delhi.
4.	Plant Breeding Principle and Methods.	B. D. Singh	KalyaniPublication New Delhi.

Course :	ESDM 231		**Credit:**	3(2+1)	**Semester-III**
Course title:	Environmental Studies and Disaster Management				

Syllabus

Theory

Multidisciplinary nature of environmental studies Definition, scope and importance.Natural Resources: Renewable and non-renewable resources, Natural resources and associatedproblems. a) Forest resources: Use and over-exploitation, deforestation, case studies. Timberextraction, mining, dams and their effects on forest and tribal people. b) Water resources: Use andover-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefitsand problems. c) Mineral resources: Use and exploitation, environmental effects of extracting andusing mineral resources, case studies. d) Food resources: World food problems, changes causedby agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies. e) Energy resources: Growing energy needs, renewable and nonrenewableenergy sources, use of alternate energy sources. Case studies. f) Land resources: Landas a resource, land degradation, man induced landslides, soil erosion and desertification.

• Roleof an individual in conservation of natural resources.

• Equitable use of resources for sustainablelifestyles.

Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Producers,consumers and decomposers, Energy flow in the ecosystem. Ecological succession, Food chains,food webs and ecological pyramids. Introduction, types, characteristic features, structure andfunction of the following ecosystem: a. Forest ecosystem
b. Grassland ecosystem c. Desertecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity and its conservation: - Introduction, definition, genetic, species & ecosystemdiversity and biogeographical classification of India. Value of biodiversity: consumptive use,productive use, social, ethical, aesthetic and option values. Biodiversity at global, National andlocal levels, India as a mega-diversity nation.Hot-sports of biodiversity. Threats to biodiversity:habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species ofIndia. Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.Environmental Pollution: definition, cause, effects and control measures of:a. Air pollutionb. Water pollution c. Soil pollution d. Marine pollution e. Noise pollution f. Thermal pollutiong. Nuclear hazards. Solid Waste Management: causes, effects and control measures of urban andindustrial wastes. Role of an individual in prevention of pollution.

Social Issues and the Environment: From Unsustainable to Sustainable development, Urbanproblems related to energy, Water conservation, rain water harvesting, watershed management.Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain,ozone layer depletion, nuclear accidents and holocaust. dies. Wasteland reclamation.Consumerismand waste products.Environment Protection Act.Air (Prevention and Control of Pollution) Act.Water (Prevention and control of Pollution) Act.Wildlife Protection Act.Forest ConservationAct. Issues involved in enforcement of environmental legislation. Public awareness.Human Population and the Environment: population growth, variation among nations,population explosion, Family Welfare Programme. Environment and human health: HumanRights, Value Education, HIV/AIDS. Women and Child Welfare.Role of Information Technologyin Environment and human health.

Disaster Management

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.

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire,coal fire, forest fire, oil fire, air pollution, water pollution, deforestation, industrial waste waterpollution, road accidents, rail accidents, air accidents, sea accidents.

Disaster Management- Effect to migrate natural disaster at national and global levels.International strategy for disaster reduction.Concept of disaster management, national disastermanagement framework; financial arrangements; role of NGOs, community –based organizationsand media.Central, state, district and local administration; Armed forces in disaster response;Disaster response; Police and other organizations.

Practical

Pollution case studies. Case Studies- Field work: Visit to a local area to document environmentalassets river/ forest/ grassland/ hill/ mountain, visit to a local polluted site-Urban/Rural/Industrial/Agricultural, study of common plants, insects, birds and study of simple ecosystems-pond, river,hill slopes, etc.

Teaching Schedule

a) Theory

Lecture	**Topic**	**Weightage (%)**
1.	Environmental studies:- Nature, Definition, scope and importance	3
2	Natural Resources:-Renewable and non-renewable resources, Natural resources and associated problems.	16
3-6	a) Forest resources: Use and over-exploitation, deforestation. Timber extraction, mining, dams and their effects on forest and tribal people. b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources. d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity. e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of non-conventional energy sources. f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.	
7	Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.	
8	Ecosystems: -Concept of an ecosystem, Structure and function.	

9	Study of Producers, Consumers and Decomposers, Energy flow in the ecosystem. Ecological succession, Food chains, food webs and ecological pyramids.	14
10	Types of Ecosystem Introduction, characteristic features, structure and function of Forest, Grassland, Desert and Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)	
11-12	Biodiversity: - Introduction, definition, genetic, species & ecosystem diversity and bio-geographical classification of India, Value of biodiversity.	
13-14	Biodiversity at global, National and local levels, India as a mega-diversity nation. Hot-spots of biodiversity, Threats to biodiversity: Endangered and endemic species of India., Conservation of biodiversity:	12
15-17	Environmental Pollution:- Types of pollution, definition, cause, effects and control measures of Air, Water, Soil, Marine, Noise, Thermal pollutions and Nuclear hazards.	14
18	Solid Waste Management: causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution.	
19-20	Carbon Credit: Concept, Exchange of carbon credits. Carbon Sequestration, Importance, Meaning and ways.	08
21-22	Environmental ethics: Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation. Consumerism and waste products.	
23-24	Environment (Protection) Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act and Forest Conservation Act. Issues involved in enforcement of environmental legislation. Public awareness.	08
25	Human Population and the Environment: Population growth, variation among nations, population explosion. Environment and human health: Human Rights, Value Education.	04
26-27	Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves.	10
28	Climatic change: global warming, Sea level rise, ozone depletion.	
29-30	Man Made Disasters:- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, air pollution, water pollution, deforestation, industrial waste water pollution, road accidents, rail accidents, air accidents, sea accidents.	08

31-32	Disaster Management:-Concept, Effect to migrate natural disaster at national and global levels. International strategy for disaster reduction. National disaster management framework; financial arrangements. Role of NGOs, community –based organizations and media. Central, state, district and local administration; Armed forces in disaster response; Police and other organizations.	03
	Total	**100**

b) Practical

Exercise	**Topic**
1	Study of collection, processing and storage of effluent samples.
2	To estimates solids in water samples.
3	To measure the dissolved O_2 content in pond water by Winkler's method.
4	Estimation of respirable and non respirable dust in the air by using portable dust sampler.
5	Determination of sound level by using sound level meter.
6	Study of community structure.
7	Study of pond / River/ hill slopes ecosystem-abiotic and biotic components.
8	Study of grass land and agro-ecosystem and measurement of their productivity.
9	Crop adaptation to different ecosystems. A. Hydrophytes
10	Crop adaptation to different ecosystems. B. Mesophytes
11	Crop adaptation to different ecosystems. C. Xerophytes
12	Crop adaptation to different ecosystems. D. Halophytes
13	Study and Visit of flora and Fauna.
14	Visit to local polluted site - Urban / Rural: observations and remedial control measures.
15	Visit to local polluted site - Industrial: observations and remedial control measures.
16	Collection, identification, herbarium, maintenance and study of plants grown in various ecosystems.

Suggested Readings:

1 Text book of Environmental Studies for undergraduate courses by Erach Bharucha University Grants Commission, New Delhi.

2 Ecology and Environment by P.D. Sharma, Rastogi Publication. Meerut.

3 Environmental Sciences by S.S. Purohit, Q.J. Shammi and A.K. Agrawal, Student Edition, Jodhpur.

4 A text book on Ecology and Environmental Science by M.Prasanthrajan and P.P. Mahendran., Agrotch Publishing Academy, Udaipur-313002.

5 The biodiversity of India, Maplin Publishing Pvt. Ltd., Ahmadabad.

6 Disaster Management by Sarthak Singh. Oxford Book Company.

7 Disaster - Strengthening community Mitigation and Preparedness by Dr. B.K. Khannna and Nina Khanna. New India Publication Agency.

8 Laboratory Manual of Ecology and Environmental Studies by Amrit Kaur, Paragon
International Publisher, New Delhi.

Course :	BIO 111	**Credit:**	2(1+1)	**Semester-I**
Course title:	Introductory Biology			

Syllabus

Teaching Schedule (Theory)

Lecture	Topic	Weightages (%)
1	Introduction to the living world. Composition and biological classification.	5
2	Diversity and characteristics of life.Definition of diversity; studying relationship between different organisms.	5
3	Origin of life ; theories of origin of life ,Oparin-Haldane theory of chemical origin of life.	5
4	Evolution and Eugenics ; evidences of organic evolution, theories of evolution; Definition of Eugenics , genetics and Mendel's experiment.	10
5	Binomial nomenclature and classification.	10
6 & 7	Cell and cell division: Cell Structure, Composition and cell organelles and their functions; Mitosis and meiosis their significance	15
8,9,10 & 11	Morphology of flowering plants. (roots, stems, leaves, flowers and fruits)	25
12	Seed and seed germination: Structure of monocot and dicot seed, Types of germination, factors affecting germination	5
13,14 &15	Plant systematic – Study of families *viz.*	15
	A) Brassicaceae, B) Fabaceae, C) Poaceae	
16	Role of animals in agriculture.	5
	Total	**100**

Practical

Experiment	Topic covered
1	Morphological studies of flowering plant.
2	Study of different root system and their Modifications.
3	Study of different forms of stems and their modifications.
4	Study of Branching pattern of plants.
5	Study of leaves and their modifications.
6	Study of stipules of leaves, leaf blade leaf venation.
7	Study of inflorescence, flowers and aestivation
8	Study of reproduction organs and placentation.
9	Study of fruits and their different parts.
10	Seed germination studies in different crops.
11	Study of Cell, Tissue and cell division through specimens and slides
12	Internal structure of root, stem and leaf of monocot and dicot plants.
13	Description of plant belongs to family Brassicacea. viz. Mustard/ Cabbage/ Cauliflower/ Radish. (Any one)
14	Description of plant belongs to family Fabaceae. viz. Pigeon pea/ Pea/ Cowpea/ Wal. (Any one)
15	Description of plant belongs to family Poaceae. viz. Rice/ wheat/ Jowar/ Maize. (Any one)

Suggested Readings:

1) Cell Biology, Genetics, Molecular Biology and Evolution by P.S. Verma, V.K. Agrwal. **Publisher-** S. Chand and Company Ltd. Ram Nagar New Delhi.
2) Evolution of Vertebrates by Edwin H. Colbert, Publisher- A Wiley, Interscience Publication, John Wiley and Sons New York.
3) A class- book of Botany by A.C. Dutta, Publisher- Oxford University press YMCALibrary Building. 1 Jai Singh Road, New Delhi 110001, India
4) Fundamentals of Genetics by B.D. Singh, Publisher- Kalyani Publishers B-I/1292,Rajinder Nagar, Ludhiana- 141008
5) A Text book of Practical Btoany-2 by Dr. Ashok M. Bendre, Dr. Ashok Kumar,Publisher- Rastogi Publications Shivaji Road, Meerut – 25002, India
6) Botany- An introduction to Plant Biology by Jamesh D. Mauseth, Publisher- Continental Prakashan 1962, Pune
7) Anatomy of seed Plants by A.C. Datta, Sigh V. Pande P.G, Publisher- Sai printopackNew Delhi Rastogi, Publication Meerut
8) Hand book of Animal Husbandry by ICAR, New Delhi Publication, Publisher- Directorate of knowledge management in agriculture, Krishi Anusandhan Bhavan, Pusa New Delhi 110012

4. Infrastructure

a. **Laboratories:**i)Genetic&PlantBreedingLab.iii)PG-Lecturehall.
ii)PlantPhysiologyLab iv)Seminarhall.

b. Nameoftheimportantinstrument/Facilities:

1) Infraredgasanalyzer(IRGA)
2) LeafAreameter(PortableLicor3000)
3) Leafwaterpotentialmeasuringsystem.
4) Electronicbalancesupto0.1mg
5) Binocularmicroscope
6) Seedgerminator
7) Spectrophotometer
8) P^{H}Meter
9) Hotairoven
10) Refrigerator(Remi)
11) Seed counter
12) Seed Separator

c. **Activities:**Post–GraduatestudentResearchexperimentobservations.foreg.Leafarea,ovendrying,germinationetc.

d. Photographs:

<table>
<tr><td> 
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</td></tr>
<tr><td>Leaf Water Potential Meter</td><td>Automatic Seed counter</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Infra Red Gas Analyzer</td><td>Leaf Area Meter</td></tr>
</table>

5. Faculty

Academicstaff:

Name of the Faculty	Dr. Ramesh Laxman Kunkerkar
Post Held	Associate Professor & Head
Date of Birth	02/06/0969
Qualification	Ph. D Agri.
Area of specialization	Genetics and Plant Breeding
Experience (Years)	28
Research Project guided	
Ph.D	-
M.Sc.	6
Present area of research	Rice, Small Millet, Pulses, Oil seeds etc.
Contact Details	
Mobile	8879034388
Email	rlkramesh@rediffmail.com

6.

NameoftheFaculty	DR **PETHE UDAYKUMAR BALKRISHNA**
PostHeld	Associate Professor (CAS)
DateofBirth	28/05/1966
Qualification	**Ph D (Agri) PBG**
Areaofspecialization	Genetics and Plant Breeding
Experience(Years)	27
ResearchProjectguided	
Ph.D	-
M.Sc.	9
Presentareaofresearch	Pulses - Cowpea Line X Tester analysis in Cowpea (*Vignaunguiculata* (L.) Walp)
ContactDetails	
Mobile	9422372347/7499650148
Email	ubpethe@dbskkv.ac.in

NameoftheFaculty	Sanjay Sankar Chavan
DateofBirth	01/06/1967
Qualification	PHD,AGRI.
Areaofspecialization	Plant Physiology
Experience(Years)	18
ResearchProjectguided	2
Ph.D	-
M.Sc.	2
Presentareaofresearch	Pulse crop *Lablab purpureous* L.Sweeet.
ContactDetails	98/2, Shriram Ali, A/P/TAL.:Dapoli.PIN:415712 Dist.Ratnagiri (M.S) Mobile No+919423295590
Mobile	9423295590
Email	sschavan@dbskkv.ac.in

NameoftheFaculty	Dr. M. G. Palshetkar
PostHeld	Assistant Professor
DateofBirth	28.08.1978
Qualification	Ph. D. (Ag.)
Areaofspecialization	Genetics and Plant Breeding
Experience(Years)	15 years and 11 months
ResearchProjectguided	
Ph.D	Nil
M.Sc.	1
Presentareaofresearch	Pulses- Pigeonpea Mutation Breeding
ContactDetails	
Mobile	9405960170
Email	mgpalshetkar@dbskkv.ac.in

	NameoftheFaculty	Dr. S. N. Joshi.
	PostHeld	Assistant Professor
	DateofBirth	02.01.1982
	Qualification	Ph. D. (Ag.)
	Areaofspecialization	Genetics and Plant Breeding
	Experience(Years)	14
	ResearchProjectguided	Nil
	Ph.D	Nil
	M.Sc.	Nil
	Presentareaofresearch	Genetics and Plant Breeding
		Research trial on mung bean (*Vigna radiata* L.)
	ContactDetails	
	Mobile	9623159921
	Email	snjoshi@dbskkv.ac.in

6. InstructionalFarm

a. **Location:**EducationandResearchFarm,DepartmentofAgril.Botany,Dr.B. S.KonkanKrishiVidyapeeth,Dapoli.
TotalArea–7.43haArea underCultivation–Kharif– 4.40ha
Rabi–2.00haRubber- 1.12haJackfruit-0.31ha
AreaunderConstruction,yardsandRoadetc.-1.60ha

b. Infrastructure:

1) Sourceofirrigation–Well2Nos
2) IrrigationSystem-DripandSprinkler
3) Farmequipment–Tractor,PowerTiller,Trolley,Rotawator,weeder.
4) SeedStorageGodown-2
5) EquipmentShed–1
6) FarmShed-3

c. Activities:

1) FieldtrialsunderM.Sc.&Ph.D.ProgrammeandDepartmentalresearch.
2) MaintenanceofGermplasmofNagali,Cowpea,Wal,Tur, Udid etc.
3) DepartmentalresearchtrialsonCowpea,Wal,Tur, Udid,Mungbean,Nagli,Prosomilletetc.
4) DemonstrationofRicevarietiesreleasedbyDSKKV,Dapoli.
5) DemonstrationofRubberCrop,tapping.
6) Demonstration of millet crops

7. ResearchactivitiesandAchievements(includingprojects)

a. Varietyreleased:

Sr. No.	Variety	Year ofrelease	Parentage	GrainType	Yield(t/ha)	Daystomaturity	Specialfeatures
	Rice						
1	Karjat-184	1971	TN-1XK-540	MediumSlender	3.0 to3.5	100-105	Moderatelyresistant toblast
2	Karjat14-7	1975	IR8xZ149	LongSlender	4.0 to4.5	140-145	Moderatelyresistant toblast & bacterialleafblight
3	Karjat-1	1987	Holmaldigax IR36	Shortbold	3.0 to3.5	105-110	Resistancetobacterialblight andBPH
4	Karjat–2	1994	RPW6-17x RP4-14	LongSlender	4.0 to4.5	135-140	Moderatelyresistant toblast & bacterialleafblight
5	Karjat3	1994	IR36xKJT35-3	Short Bold	4.5 to5.0	110-115	Moderatelyresistant toblast &bacteriallea fblight
6	Karjat4	1998	IR22xZinia 63	Short Slender	3.0to 3.5	110-115	Superfinegrain
7	Karjat-5	2006	Selection from BR-827-35-3-1-1-1R	Longbold	4.5 to5.5	125-130	Moderatelyresistant toblast &bacteriallea fblightSuitable forbeatenrice
8	Karjat-6	2005	Heera xKarjat-184	ShortSlender	3.5 to4.0	130-135	Superfine,dwarf,Resistant toleaf folderand Neckblast
9	Karjat7	2007	Patel 3 X KJT9-333	LongSlender	4.0 to4.5	115to 120	Moderatelyresistant toblast &bacterialleafblight

10	Karjat8 *		Ratna/Heera //KJT-4	Shortslender	3.5 to4.0	140to 145	Moderatelyresistantto blastandNeck blast &bacterialleafblight
11	Karjat 9	2014		Medium Slender	4.5 to 5	120 to 125	Moderatelyresistantbacterialleafblight
12	Karjat 10						
13	Karjat Shatabdi	2019		Short Bold	3.8 to 4.0	125 to 130	short stature variety developed through tissue culture, suitable for beaten rice
14	Trombay Karjat Kolam	2018		Short slender	4.0 to 5.0	130 to 135	Fine rice Variety similar to Vada Kolam
15	Konkan Sanjay						
16	Sahyadri(Hybrid)	1998	IR58025AxBR827-35-3-1-1-1R,	LongSlender	6.0 to6.5	125-130	Moderatelyresistant to blast & bacterialleafblight
17	Sahyadri-2(Hybrid)	2005	IR58025AxKJTR-2	LongSlender	5.5 to6.5	115-120	Moderatelyresistant toblast,bacterialleaf blight&falsesmut

18	Sahyadri-3(Hybrid)	2005	IR58025AxKJTR-3	LongSlender	6.5 to7.5	125-130	Moderatelyresistant toblast,bacterialleafblight.Goodmilling and cookingquality
19	Sahyadri-4(Hybrid)	2008	IR58025AxKJTR-4	LongSlender	6.0 to6.5	115-120	Goodmillingand cookingqualityModerate resistance toleaf blast,neck blast,BrownSpot
20	Palghar1	1988	IR22xPalghar141-1	Mediumslender	4.0 to4.5	120-125	Moderatelyresistant tobacterial blight
21	Palghar2	2002	IR-5xZinia–63	Shortslender	3.0 to3.5	125-130	Mediumduration andfinegrain
22	Panvel1	1984	IR8xBhurarata4-10	Shortbold	3.5 to4.00	125-130	Tolerant tosalinity,resistant to blight
23	Panvel2	1987	Bhurarata4-10xIR8	LongSlender	3.3 to4.1	110-115	Tolerant tosalinity,Moderatelyresistant toblast,bacterialleaf blight
24	Panvel3	2000	DamodarxPankaj	Shortbold	4.5to5.0	125-130	Tolerant tosalinity,M.R.toblast,
25	TrombayPanvelKhara						
26	Ratnagiri24	1971	Zinia63xTN1	Shortslender	3.5 to4.0	105	For Rabi – Summerseason
27	Ratnagiri711	1978	IR8xRatnagiri24	Longslender	4.0 to4.5	115	Moderatelyresistant to blast & bacterialleafblight

28	Ratnagiri 68-1	1975	IR8x Sigadis.	Longbold	4.5 to5.0	140-145	Resistant tobacterialblight
29	Ratnagiri 73-1	1979	RTN-23-1x Karjat-87-2	Shortbold	3.5 - 4.0	98	Moderatelyresistant to blast & bacterialleafblight
30	Ratnagiri1	1986	IR-8x Ratnagiri-24	Long Bold	4.5 to5.0	115	Moderatelyresistant to blast & bacterial leaf blight
31	Ratnagiri2	1986	RTN68x Varangal487	Shortbold	4.5 to5.0	150	Moderatelyresistant to blast & bacterialleafblight
32	Ratnagiri3	1994	CR-57-MR-1523 /IR-36//RTN-68	LongBold	4.5 to5.0	140-145	Resistant togall midge,Moderatelyresistant to blast & bacterialleafblight
33	Ratnagiri4	2009	G11/IR64	Longslender	4.9	125-130	MRtoBlast, Neck blastandBLB
34	Ratnagiri5*	2010	Zinia63xIR64	Shortslender	3.6	115-120	Moderatelyresistant toleaf blast,Neckblast &bacterialleafblight
35	Ratnagiri 6						
36	Ratnagiri7	2018		Short Bold	4.5 to5.0	122-125	Red Rice variety, rich in nutrients suitable for diabetic patient.
37	Ratnagiri8	2018		Medium slender	5.0-5.8	135-138	High yielding variety suitable for Konkan region

38	Sahyadri-5*(Hybrid)	2012	RTN 13A xSHR-R5	Longslender	6.6	140-145	Moderatelyresistant toleaf blast,Neckblast&bacterialeafblight
39	Phondaghat1	2000	RP-4-14xR-711,	Long slender	4.5to5	115-120	Resistant to blight

Sr. No.	**Name**	**Duration (Days)**	**Production (Q/ha)**	**Characteristics**	**Yearof release**
Nagli					
1	Dapoli-1	125-130	15-20	Openearheadsandlong fingers.	1985
2.	DapoliSafed1	120-125	15	Whitegrainswithseedingopenfingers andhigh calcium andmagnesium	2010
3.	Dapoli 2	119-121	18-20	blast resistant variety developed through tissue culture.	2016
4.	Dapoli 3	125-130	20-22	midlate high yielding variety	2020
Little Millet					
1.	Konkan Satwik	118	19	high yielding, tolerant to water stress, resistant to insect and pest	2022
Cowpea					
1	KonkanSadabahar	55-60	10-11	Dwarf,earlymaturingplantwithuprightgreenpendumcles. Allseasonvariety.	1991
2	KonkanSafed	75-80	9-10	Shortplant,Resistanttoyellow vein	1991
Horsegram(Kulthi)					
1	Dapoli-1	90-100	7-8	Photo-thermoinsensitive	1984
Tur					
1	KonkanTur-1	130-135	9-10	Early,suitableforcultivationon ricebunds.	1991
Wal					

1	Konkanwal-1	110-115	9-10	Boldsigedseed,Resistantto yellowmosoicvirus.	1982
2	KonkanWal-2	100-105	10	Shortplant, Toleranceto yelod mosaicvirl	1991
FodderCrops					
1	KonkanFodder-Cowpea-1	60-65 (Kharif)	23-25t/ha	Luxuriantgrowth,Succulent, SuitableforKharifandRabiSeason.	1995
		75-80(Rabi)	20-25t/ha		
2	KonkanRice Bean-1	85-90 (Kharif)	36t/ha	Luxuriantgrowth with lightgreenleaves.	1997
		100(Rabi)	22-22t/ha		
Groundnut					
1	KonkanGaurav	120-130	18-20	Semispreading,Mediumsize oblongpods	1990
2	Trombay KonkanTapora	120	25-26	30daysdormancy	1993
3	Konkan Bhurtana	११५—१२० (ज्ञ) १२०—१२५ (रब्बी)	२५—३० q/ha	तेलाचेप्रमाण ५०.०१ टक्के, प्रथिने २३.४४ टक्के, बीजसुप्तावस्था २६दिवस	2017

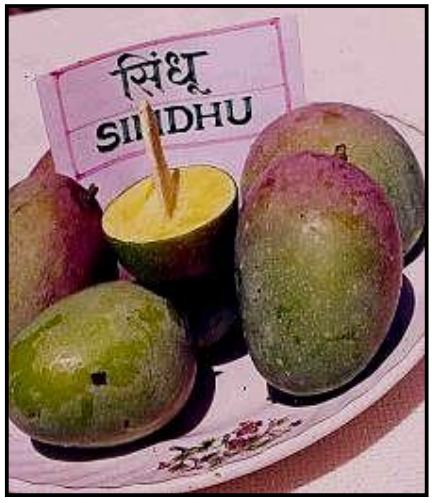
b. ResearchRecommendations:

I. PaclobutrazoltechnologyforearlyandregularfloweringwithprofusefruitinginAlphonsoMango.

Pioneerresearch,conductedfirsttimeintheIndiaduring1986-1992,onuseofpaclobutrazol for control of alternate bearing in Alphonso mango, is one of the majorresearch technologies developed in the country as an sustainable answer to alternatebearinginAlphonsomangointherecentyears.Asinglesoildrenchofpaclobutrazol@ 20 ml /tree in July - August can boost mango production by about two and half foldover untreatedtrees. **Earlyand regular floweringwithprofuse fruitingare thespecial features of this technology**. This technology has been commercially adoptedandthereisaspontaneousresponsefromallmangogrowingbeltsacrossthecountry.

MethodofPaclobutrazolapplication

II. Development ofthreemangohybridsincluding“SINDHU”,thefirstparthenocarpicmango hybridand “KONKANRUCHI”,the firstpicklemango hybrid.



IV. Recommendation of pruning technology and use of PBZ forrejuvenationofoldmangoorchardsinKonkan

.

V. Controlofsubsequentmortalityofmangostonegraftsinnursery:

Epicotylgraftingiscommerciallyadoptedtechniqueforraisingoveramillionof mango grafts annually in tropical humid conditions of Konkan. Though the initialsuccess in this technique is very high (80-90%),about 30 to 40 per cent of sproutedgraftsshowsubsequent mortality undertheshedsduetoetiolationcausingheavylosseseveryyear.Afundamentalstudywascond uctedrelatedtovariousphysiologicalaspects*viz*., effectoflightintensity, etiolation,effectof leaf clippingand growth regulators on subsequent mortality.Fromthreeyears experimentation itwas recommended to take a foliar spray of Paclobutrazol @ 250 ppm concentration onfourthday of sprouting to check the subsequent mortality andtoimprove the survivalofgraftstotheextentof80percent.

VI. Controlofrecurrentflowering:

Publishedfirstreportaboutoccurrenc eofrecurrentfloweringasanewphysiological disorderinAlphonsomango, responsiblefor severfruitdrop,leading to heavy yield losses,particularlyofearlyharvestfruits.Dev elopedarecommendation of twofoliar spraysofGA-3 @ 50 ppm starting from full bloom,forthecontrolof subsequentfruitdrop

Due to recurrent flowering in Alphonso mango.

VII. Useofpotassiumforimprovingyieldandqualityofalphonsomango:

InternationallysponsoredAdhocresearchprojectconductedatthedepartment ,resultedfirsttimeintoconcreterecommendationaboutdose,sourceandtimeofapplicationofp otassiumforhighyieldandquality

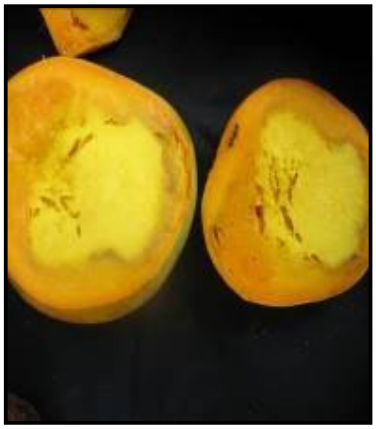
improvement with significant reduction in occurrence of**spongy tissue** in Alphonso mango. This is the recenttechnology towhich farmers have responded quickly.This recommended technology holds great potential insignificantreductioninlevelof**spongytissue**occurrencein Alphonsomango.

VIII. 1-MCPtechnologytoboostupexportofAlphonsomangostoEurope.

Adhocresearchproject,developedfirsttimeinthecountry,a1-**MethyleCyclopropene vapour treatment**technology to delay the mango ripening by 9 ± 1days, and to prolong the storage and shelf life of Alphonso mango fruits upto 26 ± 2dayswithoutaffectingfruitquality.

IX. Development of non destructive on line system for auto detection andautosortingofspongytissueaffectedalphonsomangofruits.

Undermultidisciplinaryapproach,DBSKKV,DapoliincollaborationwithCEERI, Chennai, conducted research project and developed non destructive, onlinesystem,usingsoftx-rayimagingtechnique.



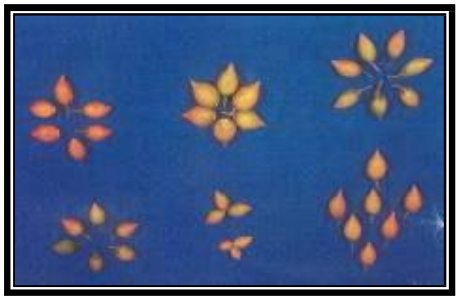
C.ResearchOutcome/FindingsofAdhockResearchProjects:

Sr. No.	NameoftheProject	Duration(Status)	TotalProject Cost(Rs./-)
1.	Studies on the use of potassiumforimprovingyieldandfruitquality of Alphonsomango.(2001-2003)	3years (completedwithrecommendation)	11lakh
2.	Efficiencyofsmartfresh(1-MCP) on mango after prolongedstorage andfollowing shelf life(2006-2008).	3years (Completed withrecommendation)	6lakh
3.	QuantificationofCO2absorptionrates of fewtropicaltreesofKonkanregionofMaharashtra.(2010-2011)	1year(Completed)	1.5lakh
4.	Conduction of impact studies ofthermalpowerplantonmangocashewplantationandmarinelife(JSW-Interdisciplinaryproject),2007-2011.	3years(Ongoing)	1.87Crors
5.	WorldbankfundedNAIPprojecton “Understandingthemechanismoff-seasonflowering and fruiting in mangounderdifferentenvironmentalconditions”.(2009-2011)	3years(Ongoing)	34.5Lakh

d. CompletedResearchProjectes/Programmes/Schemes

Title	:	NATPoncollection,evolutionandmaintenanceofmedicinal plantofKonkanregion.
URNos.	:	
Objectives	:	Collection, evolution, documentation and maintenance of medicinalplantofKonkanregion.
Nameof	:	
PI		Dr.B.B.Jadhav
Co-PI		
Sponsoring Agency	:	NationalAgricultureTechnologyProject,ICAR,NewDelhi
Duration	:	Fiveyears
TotalOutlay	:	7.35lakh
Summary ofAchievements	:	1. Collectionoftotal701accessions(BBJ1toBBJ701)ofmedicinalplantsfrom‘Sahyadri’regionalongwithpassportdata was initiatedin Feb. 2000 to 2003 and sent to NBPGR,NewDelhiforcryo-preservation.Total480AccessionshasbeenRegisteredwithNBPGR,NewDelhiandallottedICnumbers.ThiswillhelptopreventtheUnauthorizedPatenting /Registrationofspecieswhichareindigenoustothisregion. 2. Total130speciesofmedicinalandaromaticplantswereconservedwhichincludesmany Endangered,Endemic,RareandVulnerablespecies. 3. Total 35 different wild relatives of crop/ fruit plants viz.Vignacapensis,Vignavaxilleta,Canvoliaensiformis,Dioscoria bulbefera, Teraminus labelis, Sesamum muliannum, Syzegiumcuminii were collected or conservationandfor future use incropimprovement programmefromWesternGhats.
Relevant Photographs	:	






Title	:	Biotechnologicalapproachesforproductionandcultivationof Patchouli
URNos.	:	
Objectives	:	Tostandardizedpracticesforproductionandcultivationpatchouli inKonkan.
Nameof	:	
PI		Dr.B.B.Jadhav
Co-PI		Dr.M.M.Burondkar
Sponsoring Agency	:	DBT,NewDelhi
Duration	:	Threeyears
TotalOutlay	:	
Summary ofAchievements	:	Standardizedrootingtechniques,cuttingtechniques,Fertilizerdose,and useof shednet,inpatchoulicultivation.
RelevantPhotographs	:	

Title	:	Efficacyofsmartfresh(1-MCP) onMangoafterprolonged storageandfollowingshelflife.
URNos.	:	
Objectives	:	1. T evaluate the responses of Mango to Smart Fresh after coldstorage as for present commercial storage and after prolongedcoldstrongconditionsfollowedbyshelflifeatambienttemperature. 2. ToevaluatetheeffectofSmartFreshtreatmentonmangofruits ripening inrelationtotheir storagebehaviorandshelflife. 3. TostudytheeffectofSmartFreshtreatmentonfruitquality andoccurrenceofspongytissueundercoldstorageofAlphonso mango.
Nameof	:	
PI		Dr.M.M.Burondkar
Co-PI		Prof.A.V.Mane
Sponsoring Agency	:	GlobalAgri.SystemPVT.,K-13A,HauzKhasEnclave,New Delhi-110016
Duration	:	2006-2008
TotalOutlay	:	

Summary ofAchievements	:	Alphonso mangos**,** traditionallygrown inKonkan region, areincreasingly gaining popularity in European countries. However,high shipment cost by air transportation (>Rs.50/kg), is one of themajor bottle necks. Adhoc research project, conducted for threeyears(2007-09),coulddevelopfirsttimeinthecountry,a1-**MethyleCyclopropenevapour treatment**technology todelaythe mango ripening by 9 ± 1 days, and to prolong the storage andshelf life ofAlphonso mango fruits upto 26 ± 2 dayswithoutaffectingfruitquality.Technology hasgeneratedhugeinterestamong mangoexporters.
Relevant Photographs	:	

Title	:	StudiesonuseofPotassiumforImprovingYieldandFruit QualityofAlphonsoMango
URNos.	:	
Objectives	:	1. To study the effect of recommended dose of Potassium in theform of sulphate of Potassium (SOP) and Muriate of potassium(MOP) onyieldandqualityof "Alphonso"mango. 2. Tostudy the effect of higher levels of potassium(1and2kgpertreeperyearintheformof SOPonyieldandqualityaspectsof"Alphonso" mango. 3. TostudytheeffectoffoliarspraysofPotassiumNitrate(KNO_3)inaddi tiontorecommendedandhigherlevelofKgivenintheformofSOPony ieldandqualityaspectsof "Alphonso"mango.
Nameof	:	
PI		Dr.B.B.Jadhav
Co-PI		Dr.M.M.Burondkar Prof.D.J.Dabke

Sr. No.	CONTENT

		Dr.A.K.Shinde
Sponsoring Agency	:	M/SIndianpotashLTD.MumbaiandKaliundSalz,Germany
Duration	:	Fiveyears(2001-2005)
TotalOutlay	:	15lakh
Summary of Achievements	:	StandardizeddoseofpotassiumformangoinKonkan
RelevantPhotographs	:	

e.OngoingResearchProjects/Programmes/Schemes:

ProjectsTitle	:	Understandingthemechanismofoff-seasonfloweringandfruitingin mangounderdifferentenvironmentalconditions
Programmes	:	
Schemes	:	NationalAgriculturalInnovationProjectProjectImplementationUnit Kab-Ii,NewDelhi-110012

ProjectsTitle	:	Collection, maintenance, evaluation and development ofdescriptorsoffruitandplantationcropsandtreespicesthrough liverepository.
Programmes	:	
Schemes	:	PPV&FRAuthority,NewDelhi.

ProjectsTitle	:	Developmentofdescriptorsfornutmeg(Myristicafragrans).
Programmes	:	
Schemes	:	PPV&FRAuthority,NewDelhi.

FarmResearchfromRRCBotany,Physiology

8. Repository of abstracts of theses

Sr. No.	Content			
1.	Name of the candidate : Mr. Jadhav Somnath Maruti	Degree for which thethesis/project report submitted: Ph.D.(Ag.)(Plant Physiology)	Year ofsubmission : 2018	Name of Guide / Co-Guide : Dr. M. M. Burondkar
	Abstract : The present investigation entitled "Morpho-physiological and biochemical traits associated with growth yield and quality of lablab bean (*Lablab pupureus* (L.) Sweet)" genotypes under varying *Rabi* elimatic conditions in Konkan region was conducted at Educational and Research Farm, Department of Agricultural Botany, College of Agriculture, Dapoli, during *Rabi* season 2015-2016 and 2016-2017. The investigation was aimed at morphological, physiological and biochemical characterization of five lablab bean genotypes (*viz*. genotype 63, genotype 83, genotype 54, genotype 84 and a check Konkan Wal-2) in three sowing dates (*viz*. 5th Nov, 15th Nov and 25th Nov) under Konkan *Rabi* condition; with an object to study extent of thermo and photosensitivity of different lablab bean genotypes; study the effect of different sowing dates on yield and quality of lablab bean genotypes and identifying the morpho-physiologically efficient and consistent lablab bean genotype for higher yield under 'Konkan *Rabi* conditions. The whole experiment was analyzed in split plot design in four replications.			
2.	Name of the candidate: Mr.Sawant Gaurish Bhaskar	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(GPB)	Year of submission : 2018	Name of Guide / Co-Guide : Dr. S .G. Bhave
	Abstract : The present investigation entitled, "Studies on transformation technique in Rice (*Oryza sativa* L.)" to study the ery gene transformation technique in rice. Callus- mediated regeneration was studied in 22 rice varieties developed by Dr. B.S.K.K.V., Dapoli. The dehusked mature rice seed was treated with 70% alcohol for 1 minute followed by HgCl (1.0%) for 10 minutes and then washing the seeds 4-5 times was found to be the most effective treatment with establishment of maximum aseptic cultures. All the 22 varieties with all the media combinations and their interactions showed significantly differential response for callus-mediated regeneration. The variety Ratnagiri-711 was found to be superior showing carliest (7.67 days) induction on the medium M3+ 15 mg/12,4-D 0.5 mg/1 BAP with the highest callus induction frequency 187.56 %). The maximum callus weight at 45 days of inoculation was 269,37 mg with yellowish-white colour and it was embryogenic in nature The variety Ratnagiri-711 also showed earliest shoot induction (11.67 days) on medium MS-3.0 mg/1 BAP 1.0 mg/1 IAA showing the highest shoot induction frequency (87.50% with maximum shoots per callus bit (7.67). It rooted also earlier in 3,67 days on medium 1/2 MS+ 0.5 mg/1 IBA+ 0.1 mg/1 BAP with the highest root induction frequency (73.33%) with maximum roots per shoot (11.33). The potting mixture of soil, organic manure and cocopit in 1:1:1 proportion showed the highest plant survival rate (73.33%) The variety Ratnagiri-711 having better regene R ability was taken further for cry gene transformation study. Three different cry genes vix crylAabc, ory1Fal and cry2Aa were used for genetic transformation. The callus mediated transformation methods were employed using 0.7 -1 cm diameter callus bits whereas In Planta transformation method using embryonic shoot apical meristem of just germinating seeds as target tissue. Kanamycin sensitivity test showed albino seedlings at 100 mg/L kanamycin concentration rendering it optimum for selection of putative transgenics. The calli of 35 days age with acetosyringone incubation period of 45 min prior to colonization at the concentration of 350 M recorded the maximum transformation frequency (85.00 %) Further the complete elimination of A. tumefaciens from co-cultivated calli was found at cefotaxime concentration of 600 mg/L for washing and 300 mg/L in regeneration medium.			

	Among the five methods of colonization and co-cultivation tried with three cry genes, a callus mediated transformation method (MT) consisting of 20 minutes colonization and 3 days co-cultivation with the cry2Aa gene was found with highest transformation frequency (13.79%) but minimum survival percentage (5.27%) whereas considerable transformation frequency (6.35 %) with the highest survival percentage (79.42) was observed in an t Planta method (MTs) employing mild injury to embryonic shoot apical meristem of germinating seeds, injection with Agrobacterium culture with cry2Aa gene followed by 15 minutes colonization and then directly sowing in pots Hence, efficient regeneration and genetic transformation technique for an Indica rice variety Ratnagiri-711 has been developed from the present study. In future, transgenic plants will be analyzed for stem borer resistance through insect bioassay, RT-PCR and Southern blot analysis.

3.	Name of the candidate : Miss. Arya Gopinath MP.	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2018	Name of Guide / Co-Guide : Dr. S.S. Desai

Abstract: The present experiment entitled "Genetic variability and Diversity analysis in Black gram (*Vigna mungo* (L.) Hepper)" was undertaken to assess the genetic variability, correlation, path analysis and genetic diversity analysis in sixty four genotypes of Black gram in randomized block design with three replications at Educational and Research farm, Department of Agril. Botany, College of Agriculture,Dapoli, Dist. Ratnagiri, Maharashtra during *Rabi* 2017-2018.

The present investigation revealed that the estimates of mean sum of squares showed comparatively wide range of variation for the characters number of pods per plant, plant height, days to maturity, days to 50 per cent flowering, seed yield per plant and harvest index.Phenotypic variances were higher in magnitude than genotypic variances for all the characters. Number of pods per plant showed highest estimate of phenotypic and genotypic variance. PCV was higher in magnitude over respective GCV. High estimates of heritability coupled with genetic advance as per cent of mean was observed for characters seod yield per plant, plant height, number of pods per plant. number of clusters per plant, protein content and number of primary branches per plant The character number of pods per plant showed the highest estimate ofgenetic advance.

Genotypic correlation coefficient was higher in magnitude over the respective phenotypic correlation coefficients. Seed yield per plant showed positive and highly significant correlation with plant height. number of clusters per plant, number of pods per cluster, number of pods per plant, pod length and number of seeds per pod at both genotypic and phenotypic level. Path coefficient analysis revealed positive direct effect of days to maturity, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod, hundred seed weight, harvest index and protein content at both genotypic and phenotypic level.

Sixty four genotypes were grouped into 9 different clusters on the basis of magnitude of D2 values evaluated by Mahalanobis D2 analysis. Among sixty four genotypes, 16 genotypes were clustered into fourth and fifth cluster followed by cluster III having 13 genotypes. The cluster II included 10 genotypes, while cluster III had 5 genotypes, Cluster V. VII, VIII and IX were solitary. The maximum intra-cluster distance was observed in cluster V (D- 9.108).However, the lowest intra-cluster distance found in cluster 1 (D=5.865. The inter-cluster distance was high between cluster VI and VIII (D 46.48) and clusters VI and VII (D=37.06), there by indicated wide range of variation among the clusters formed. In contrast, the lowest inter-cluster distance (Between cluster I and II) suggested that the genetic constitution of the genotypes in both the clusters were in close proximity. Among the thirteen characters studied, 100 seed weight contributed maximum (62.80 %) followed by pod length (18.60%) towards genetic diversity.

On the basis of results the genotypes KU-16-87 exhibited maximum seed yield per plant followed by KU-16-92: hence observed as best performers in the studied population. PLU-703, PLU-250, JU-4, HPU-120, HPU-180, IC-10703, 1C-50748 and IPU-94-1 found to be resistant to yellow vein virus under natural screening. But their performance was low due to poor germination and adaptability problems.

4.	Name of the candidate : Mr. Hawaldar Ayyajahmad Harun	Degree for which the thesis/project report submitted : M.Sc.Ag.(GPB)	Year of submission : 2018	Name of Guide / Co-Guide : Dr. B. L. Thaware
	Abstract: An experiment was undertaken to study evaluation of F_6 generation for yield components in lablab bean *(Lablab purpureus* (L.) Sweet). An experiment was conducted with eighteen F. lines and one local check (Konkan Wal-2) in *Rabi* season in year 2016-17 at research and education farm Department of Agriculture Botany Farm, College of Agriculture, Dapoli. Observations were recorded for twelve quantitative characters *viz*., days to initiation of flowering, days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant, number of peduncles per plant, number of pods per plant, pod length, number of seeds per pod, hundred seed weight, harvest index and seed yield per plant. All the characters studied exhibited significant variability among all Fe lines. Most of the characters showed comparatively higher estimates of environmental variance indicating the influence of environment on those characters. However, seed yield per plant, number of pods per plant and plant height showed comparatively higher estimates of genotypic and phenotypic coefficients of variation indicating high level of variability and ample scope for effective improvement. The higher estimates of heritability coupled with high genetic advance as per cent of mean indicated additive gene action for above characters. Correlation studies revealed positive association of number of peduncles per plant, number of pods per plant and hundred seed weight with seed yield per plant for both at phenotypic and genotypic level. It indicates that, these characters are having great importance in breeding programme. The path analysis studies indicated that the characters number of primary branches per plant, number of peduncles per plant, number of pods per plant, pod length, number of seeds per pod and hundred seed weight had direct bearing positive effect on seed yield per plant could be the important selection criterion for genetic improvement in lablab bean population under study. The lines, No.1, No.11, No.10, No.12, No.15, No.3, No.16, No.17, No.9 and No.14 are observed as best performer in the studied generation as these lines had good performance for the important quantitative traits.			
5.	Name of the candidate : Mr.Bichukale Mahesh Shamrao	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2018	Name of Guide / Co-Guide : Dr. J. P. Deomore
	Abstract : The present investigation was carried out with a view to study the magnitude of heterosis, combining ability and gene action through Line x Tester analysis including ten parents, including one check and their twenty four F1 in green gram for *Rabi* 2017-18 conditions. The experimental material was planted in randomized block design with three replications at the research and educational farm, Department of Agriculture Botany, College of Agriculture, Dapoli. The analysis of variance for all the characters revealed that parents were found to be highly significant for all the character studied except branches per plant, pods per cluster and pods per plant indicating presence of considerable amount of genetic variability in the parental material tested. Also, all the yield contributing characters showed highly significant mean square due to hybrids vs parents' and hybrids were highly significant for all the characters, Parents vs. hybrids comparison was found to be highly significant for all the characters studied except hundred seed weight indicating presence of heterotic combination Among the Parents, TARM-2, M1-2056, TARM-1, and Karjat local as the best performing parents for grain yield per plant. were recorded High heterotic effects were observed for days to 50 per cent flowering days to maturity, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant pod length and grain yield per plant. It was observed from the present study that heterotic response for seed yield per plant was mainly due to high heterotic response observed for number of branches per plant, number of pods per plant, pod length and number of clusters per plant, number of pods per cluster.			

	Combining ability analysis revealed that the mean squares due to general combining ability and specific combining ability were highly significant for almost all the characters indicating importance of both additive as well as non-additive gene effects involved in the expression of all the characters. However, the variances due to general combining ability in general were lower than specific combining ability for days to maturity, plant height, branches per plant, clusters per plant, pods per plant, grains per pod, hundred seed weight and grain yield per plant thus on the basis of ratio of gea and sca results pointing out the preponderance of non-additive gene effects for the characters studied. The general combining ability effects revealed that ML-2333, ML- 2056, TARM-1 and Karjat local were the good general combiner for grain yield and other yield related traits. The crosses ML-2333 x TARM- 1, NVL-641 x TARM-1 and NVL-641 x Karjat local were found to be good in respect of sca effects for yield related characters. This might be due to effect of alleles of combining parents. Out of these best specific combinations, majority of the crosses showed high per se performance along with higher heterotic effects and higher sca effects cross for seed yield per plant indicating more reliability of per se performance. The per se performance of parents were more or less related to their gea effects. On the basis of per se performance, heterosis, combining ability, and gene action of the hybrids *viz*., ML-2333 x TARM-1, NVL-641 x TARM-1, PUSA-1477 x TARM-1, ML-2056 x TARM-1 and ML-2056 x Karjat local was found to be the most promising combination for most of the yield contributing traits *viz*., grain yield per plant (g), number of pod per plant, number of clusters per plant, number of pods per cluster, hundred seed weight (g), plant height, number of pods per plant and pod length (cm).

6.	Name of the candidate : Mr. Jadhav Akshay Hanamant	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2018	Name of Guide / Co-Guide : Dr. P. B. Vanave

Abstract : An experiment was conducted with thirty five genotypes in *Rabi* season of 2016-17 at research and education farm, Department of Agriculture Botany, College of Agriculture, Dapoli. Observations were recorded on eleven characters *viz*., days to initiation of flowering, day to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight, straw yield per plant, harvest index and grain yield per plant. The estimate, of phenotypic, genotypic and environmental variances revealed that, in general phenotypic variances for all the characters studied were higher than genotypic variances. Phenotypic coefficient of variation was greater than the genotypic coefficient of variation for all the characters for present study. The high phenotypic and genotypic coefficient of variation was observed for number of pods per plant, number of seeds per pod, hundred seed weight, straw yield per plant, harvest index and grain yield per plant, while lowest GCV and PCV was observed for days to initiation of flowering, day to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant. High heritability with high genetic advance as percentage of mean was observed for number of pods per plant, number of seeds per pod, hundred seed weight, straw yield per plant, harvest index and grain yield per plant. It indicates additive gene action and made it suitable for direct selection.

In general genotypic correlations were higher than phenotypic correlations. The correlation study revealed that the characters *viz*., plant height, number of primary branches per plant, number of pods per plant straw yield per plant and harvest index showed highly significant positive correlation with grain yield per plant at phenotypic and genotypic level.

The path coefficient analysis revealed that the characters *viz*., days to maturity, plant height (cm), number of pods per plant, number of seeds per pod, 100 seed weight, straw yield per plant and harvest index exhibited positive direct effect on grain yield per plant. While, the days to initiation of flowering and number of primary branches per plant showed negative direct effect on grain yield per plant at phenotypic level. Days to 50 per cent flowering and hundred seed weight showed negative direct effect on grain yield per plant at genotypic level. Path analysis at phenotypic and genotypic level reveals the casual relationship between different characters related to yield. On the basis of path analysis and correlation study for grain

	yield, it is concluded that selection on the basis of days to initiation of flowering number of primary branches per plant, pods per plant and hundred seeds weight could help in genetic improvement of grain yield per plant in lentil under study.			
7.	Name of the candidate : Mr. Sabale Govind Rajendra	Degree for which the thesis/project report submitted : M.Sc..(Ag.)(GPB)	Year of submission : 2018	Name of Guide / Co-Guide : Dr. S .G. Bhave
	Abstract : An experiment was conducted with twenty three genotypes in randomized block design with three replication *Rabi* season of 2017-18 at Research and Education farm, Department of Agriculture Botany, College of Agriculture, Dapoli. Observations were recorded on twelve characters *viz*., days to first flowering, days to maturity, number of primary branches per plant, plant height (cm), number of clusters per plant, number of pods per plant, number of pods per cluster, pod length (cm), number of seeds per pod, 100 seed weight, harvest index and seed yield per plant. The estimate, of phenotypic, genotypic and environmental variances revealed that, in general phenotypic variances for all the characters studied were higher than genotypic variances. Phenotypic coefficient of variation was greater than the genotypic coefficient of variation for all the characters for present study. The high phenotypic and genotypic coefficient of variation was observed for seed yield per plant, number of pods per plant. number of clusters per plant and number of primary branches per plant, while lowest GCV and PCV was observed for days to first flowering and days to maturity. High heritability with high genetic advance as percentage of mean was observed for seed yield per plant, number of pods per plant, plant height, number of primary branches per plant, hundred seed weight and harvest index. It indicates additive gene action and made it suitable for direct selection. In general genotypic correlations were higher than phenotypic correlations. The correlation study revealed that the characters *viz*., days to first flowering, days to maturity, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, pod length, hundred seed weight and harvest index showed highly significant positive correlation with seed yield per plant at phenotypic and genotypic level. The path coefficient analysis revealed that the characters *viz*., days to first flowering, days to maturity, number of clusters per plant, number of pods per plant, 100 seed weight and harvest index exhibited positive direct effect on seed yield per plant. While the plant height, number of primary branches per plant, number of pic level. Path analysis at phenotypic and genotypic level reveals the casual relationship between different characters related to yield. On the basis of path analysis and correlation study for seed yield, it is concluded that sepods per cluster and pod length exhibited negative direct effect on seed yield per plant at both phenotypic and genotylection on the basis of number of pods per plant, number of clusters per plant and hundred seeds weight could help in genetic improvement of seed yield per plant in cowpea under study.			
8.	Name of the candidate : Mr. Navatre Ramchandra Jalindar	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology)	Year of submission : 2018	Name of Guide / Co-Guide : Mrs. M. H. Keluskar
	Abstract :A field experiment was conducted at Regional Agriculture Research Station, Karjat, Dist. Raigad (Maharashtra, India) during Kharif 2017 to study Evaluation of rice (oryza sativa L.) genotypes for low light intensity. The experiment consisted of two factors viz. two treatments (T1-Without shade net and T2-Shade net condition) and sixteen genotypes laid out in factorial randomized block design with three replications. Data were collected on Days to 50% flowering, Days to maturity, No. of tillers/plant, No. of productive tillers/plant, Leaf area/plant (dcm2), No. of leaves/plant, Leaf wt./plant (g), Stem wt./plant(g), Total dry wt./plant(g), Plant height (cm), Total chlorophyll content (mg/g fresh wt.), Light intensity (Lux),			

AGR, RGR, NAR, LAI, SLW, No. of spikelet's/plant, No. of filled spikelet's/plant, Panicle length (cm), 1000 seed wt. (g), Grain yield/plant (g), Straw wt./plant (g) and HI (%) at the interval of 20, 40, 60, 80, 100 DAT and at Harvest. Data collected were subjected toanalysis of variance. Most of the yield and yield determining attributes recorded significant difference due to treatment effects.
The Morphological parameters i.e. No. of tillers/plant, No. of productive tillers/plant, No. of leaves/plant, Stem wt./plant (g), Leaf wt./plant (g), Total dry wt./plant (g), AGR, RGR, NAR, LAI, SLW, Total no. of spikelets/panicle, No. of filled spikelets/panicle, Panicle length (cm), 1000 grain weight (g). Grain yield/plant (g), Straw wt./plant (g) and HI (%) at various growth stages were significantly reduced under shade net condition. However, Days to 50% flowering, Days to maturity, Leaf area/plant, plant height and total chlorophyll content was recorded maximum in all the genotypes under shade net condition due to the shade stimulates cellular expansion and rapid cell division as compared to without shade net.
The highest grain yield was exhibited in genotype Palghar-2 and lowest was recorded Karjat-BM4 genotype under low light condition. The overall minimum yield reduction percentage was exhibited in genotype Karjat-5-8-13-15-7 and maximum was in Ratnagiri-4 under shade net condition. Whereas, the maximum harvest index was observed in Palghar-2 and minimum was in Karjat-8 under shade net condition.
Therefore, on the basis of overall yield reduction percentage, HI and other important traits under shade net, Palghar-2 genotype can be identified as relatively tolerant to light stress. Whereas, genotype Karjat-BM4 was most sensitive for the shade net condition or low light tress in all the tested genotypes. Therefore, Karjat-5-8-13-15-7 and Palghar-2 produced batter grain yield/plant under shade net condition and could be rated as shade tolerance genotype.

9.	Name of the candidate : Mr.Lagad Sanket Kailas	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology)	Year of submission : 2018	Name of Guide / Co-Guide : Prof. R. S. Deshpande

Abstract : A field experiment was conducted at education and research farm, Dept. of Agril. Botany, College of Agriculture, Dapoli during *Rabi* 2017-18 to study the effect of different bio- control agents *viz.Trichoderma viride* (Fungal strain), *Pseudomonas fluorescens* (Bacterial strain), *Bacillus subtils* (Bacterial strain), *Paecilomyces lilacinus* (Fungal strain). *Rhizobium leguminosarum* (Bacterial strain) on physio-chemical aspects of cowpea (*Vigna unguiculata* L). The experiment was laid out in randomized block design with seven treatment randomized in three replications. The treatment effects were studied for various parameters *viz*. plant height, no of branches, number of leaves, days to 50 percent flowering, days to physiological maturity, dry matter accumulation, leaf area per plant, leaf area index, absolute growth rate, relative growth rate, net assimilation rate, photosynthesis rate, transpiration rate, stomatal conductance, relative water content, total chlorophyll content of leaves, proline content of leaves, phenol content of leaves, nitrogen content of leaves, number of pods per plant, number of seeds per pod, pod yield per plant, pod yield per plot, seed yield per plot and harvest index. Data collected were subjected to analysis of variance. Most of the yield and yield determining attributes recorded significant difference due to treatment effects.
Maximum (57.44cm) plant height was recorded in treatment T6 (Paecilomyces lilacinus) while maximum (11.66) branching was recorded in treatment To (Paecilomyces lilacinus). Number of leaves were ranged from 31.44 to 36.89. Early flowering (39.67 days) and maturity (76.16 days) was recorded in treatment T (Paecilomyces lilacinus). The maximum (13.436 g per plant) and minimum (9.142 g per plant) total dry matter was recorded in treatments To (Paecilomyces lilacinus) and To (recommended dose of fertilizer only) respectively. Maximum (48.98 dm plant and minimum (33.50 dm^2 plant) leaf area was recorded in treatments T. (Paecilomyces lilacinus) and To (recommended dose of fertilizer only) respectively. Similarly, treatments To (Paecilomyces lilacinus) and To (recommended dose of fertilizer only) recorded highest leaf area index. The maximum AGR was recorded in 30 to 45 DAS facilitating the highest

	vegetative growth of a crop. In 30 to 45 DAS it ranged between 0.262g day and 0.385g day, RGR was recorded highest in between 15 to 30 DAS and ranged between 0.0369 g g day and 0.0462 g g¹day. NAR was higher for the period of 15 to 30 DAS and it ranged between 0.0000246 g dm2 day and 0.000230 gdm day ¹. At 60 DAS, rate of photosynthesis was ranged between 15.33 µmol CO2 m² s¹ and 20.83 µmol CO2 m2s¹ while stomatal conductance was ranged between 0.227 µmol m2 s¹ and 0.497 µmol ms.Transpiration rate increased with advancing age of the crop and ranged between 5.17 µmol H_2 O m²s-1 and 7.50 µmol H2O m² s¹. RWC recorded highest at 15 DAS while lowest at 60 DAS. During 60 DAS maximum chlorophyll (1.70 mg/g), phenol (24.97mg/g) and nitrogen (2.03%) content recorded in treatments To (Paecilomyces lilacinus). Treatment differences were non-significant for the proline at all growth stages. Although the proline levels elevated concomitantly with growth stages. At 60 DAS proline ranged between 0.53 µmol/g and 0.55 µmol/g. Maximum number of pods (14.50), number of grains per pod(10.13), pod yield per plant (29.00 g), pod yield per plot(1507.33 gm), seed yield per plot(1076.67g) and harvest index (43%) was posted by treatments T. (Paecilomyces lilacinus). Among all treatments, treatment To (Paecilomyces lilacinus) was recorded superior for yield and all yield contributing characters.

10.	Name of the candidate : Mr. Adsul Vishal Dhansing	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology)	Year of submission : 2018	Name of Guide / Co-Guide : Dr. A.V. Mane

Abstract : A field experiment was conducted at education and research farm, Dept. of Agril. Botany, College of Agriculture, Dapoli during *Rabi* 2017-2018 to study effect of biocontrol agents on physiochemical aspects of Wal (*Lablab purpureus* L). Different bio control agents were applied through foliar spray at 2 and 4th week after sowing. The experiment laid out in randomized block design with seven treatments randomized inthree replications. The apllied seven treatment *VIZ* To RDF only, Ti Rhizobium treatment, T2 RDF+ T1. T3 Tricoderma viride (4ml/lit). Ti, T4 Pseudomonas fluorescence (4ml/lit)+ T1, Tas Bacillus subtilis (4ml/lit)+ T1, T6 Paceilomyces lilacinus (4ml/lit)+ T respectively. Beside yield and yield attributes data were collected on plant height, number of branches, number of leaves, days to 50% flowering, days to maturity, chlorophyll content, nitrogen content, phenol content, proline content, relative water content, Dry matter accumulation, leaf area, LAI, AGR, RGR, and NAR at the interval of 30, 60, 90 DAS and at physiological maturity. Result indicated that most of the yield and yield determining attributes recorded significant difference due to treatment effects. Among the treatments To (Paceilomyces lilacinus) recorded significant difference on yield and yield attribute, morphological, growth, physiological and biochemical parameter. The plant height was increased significantly in treatment To. The significant increase in leaf dry weight, stem dry weight and total dry weight were observed in treatment To (Paceilomyces lilacinus). The number of days required for days to 50% flowering and days to maturity significantly reduced with application of Paceilomyces lilacinus. Growth parameters *viz*. leaf area, leaf area index, RGR, AGR, LAI and NAR were significantly lower the in control and the application of Paceilomyces lilacinus have been found effective in increasing parameters. The application of biocontrol agent enhanced physiological and biochemical parameters i.c. photosynthesis, stomatal conductance, chlorophyll content, phenol content, nitrogen content and relative water content the effect was with application of Paceilomyces lilacinus. All biocontrol agent increases the accumulation of phenol but among them Paceilomyces more lilacinus is superior rest of treatment. There was no any significant difference in proline accumulation among the treatments. The application of bio control agent enhanced the yield and yield attributing character i.e number of pods, pod yield per plant), Pod yield per plot, seed yield per plot, harvest index and seed yield per plot. The effect was more with application of Paceilomyces lilacinus followed by Pseudomonas fluorescence treatment. Seed yield per plot ranged between 772.45g and 510.17g maximum and minimum value being in To and To respectively. It shows variation between treatments. Among all treatments To (Pacilomyces

	lilacinus) was significantly superior treatments in all characters.			
11.	Name of the candidate : Mr. Waghmare Pandurang Dilip	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2018	Name of Guide / Co-Guide : Dr. U. B. Pethe
	Abstract : The present experiment entitled "Variability and correlation studies in cowpea (*Vignaungiculata* (L.) Walp)" was undertaken to assess the genetic variability, correlation and path analysis in thirty genotypes of cowpea in randomized block design with two replications at educational and research farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during *Rabi* 2016- 2017. The estimates of phenotypic, genotypic and environmental variance revealed that phenotypic variance were higher in magnitude than genotypic variances for all the characters. The magnitude of phenotypic and genotypic variances was closer to each other for majority of the characters this indicating lesser role of environment in the expression of these characters. However plant height, dry matter yield per plant and days to maturity showed comparatively higher estimates of environmental variance indicating the influence of environment on these characters. In general, phenotypic coefficient of variation (PCV) was higher in magnitude over genotypic coefficient of variation (GCV) for all the characters. Different characters showed varying per cent of coefficient of variation at both genotypic and phenotypic levels. High genotypic and phenotypic coefficient of variation was observed for the characters number of pods per plant followed by seed yield per plant, hundred seed weight and number of seeds per pod, while these were low for the characters days to maturity, days to fifty per cent flowering and days to first flowering. In the present investigation, the genotypic correlation coefficients higher in magnitude than their phenotypic counterparts for most were of the characters. The characters dry matter yield per plant, harvest index, hundred seed weight, number of pods per plant, number of seeds per pod exhibited highly significant positive correlation with seed yield per plant at both phenotypic and genotypic levels. The character. plant height showed significant negative phenotypic correlation with seed yield per plant. The seed yield is complex character and each character had its own effect for establishing correlation with yield. The path coefficient analysis revealed that the character days to fifty per cent flowering, plant height, number of seeds per pod, dry matter yield per plant, hundred seed weight and harvest index had positive direct effect on seed yield per plant, while number of primary branches per plant and days to maturity had negative direct effect on seed yield per plant at genotypic and phenotypic level. It is concluded that genotype PCB-9796 followed by CPD-118 and RC-101 were the promising among all the genotypes studied on the basis of seed yield per plant by considering all yield attributing characters. The genotype PCB-9796 is bold seeded with maximum hundred seed weight, KBC-9 had maximum number of seeds per pod, while Mrugraj had the maximum number of pods per plant. These genotypes can be used as promising genetic material in future breeding program.			
12.	Name of the candidate : Ms. Tate Prajakta Tulshiram	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2019	Name of Guide / Co-Guide : Dr. U. B. Pethe
	Abstract : Abstract :The present experiment entitled "Genetic variability and character association studies in F2 generation of cowpea. (Vigna Unguiculata (L.) Walp)" was undertaken to assess the genetic variability, correlation and path analysis in twenty-one genotype of F2 generation of cowpea in Randomized Block Design with three replications at educational and research farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during Rabi 2017-2018.			

	The estimates of mean sum of squares due to genotypes was highly significant for all the characters under study. Phenotypic variances were higher in magnitude than genotypic variances for all the characters. Plant height showed highest estimate of phenotypic and genotypic variance. High estimates of heritability coupled with genetic advance as per cent of mean was observed for characters plant height, number of branches plant-^{1}, number of clusters plant, hundred seed weight, harvest index, protein content and seed yield plant. The character plant height and seed yield plant- showed the highest estimate of genetic advance. Genotypic correlation coefficient was higher in magnitude over the respective phenotypic correlation coefficients for all the characters. Seed yield per plant showed positive and highly significant correlation with harvest index, number of pods plant, hundred seed weight, number of pods cluster, pod length and number of seeds pod-'at both genotypic and phenotypic level. Path coefficient analysis revealed positive direct effect of number of pods plant, number of pods cluster-^{1}, pod length, number of seeds pod-^{1}, hundred seed weight and harvest index at both genotypic and phenotypic level. Thus the present investigation revealed that the F2 population No. T9 (CPD 31x PCP 97102) and T20 (CPD 83x GS 9240) were observed as best performers in the studied population as these had highest seed yield plant-1. The Fa population No. T16 (CPD173× NKO 32) and T20 (CPD 83×GS 9240) were white bold seeded among the twenty-one genotypes.

13.	Name of the candidate : Ms. Kalluru Sudhamani	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2019	Name of Guide / Co-Guide : Dr. S. S. Desai

Abstract : The present experiment entitled "Evaluation of F3 generation of interspecific crosses of cowpea (Vigna spp.)" was undertaken to assess the genetic variability, correlation and path analysis in fifteen families and two check varieties of cowpea in compact family block design with three replications at Educational and Research farm, Department of Agricultural Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during Rabi 2017-2018.

Results showed that mean sum of squares had comparatively wide range of variation for the characters plant height, number of pods per plant and days to maturity. Phenotypic variances were higher in magnitude than genotypic variances for all the characters. Plant height showed highest estimate of phenotypic and genotypic variance. PCV was higher in magnitude over respective GCV. High estimates of heritability coupled with genetic advance as per cent of mean was observed for characters plant height, pod length, number of pods per plant, hundred seed weight, seed yield per plant, number of clusters per plant, number of branches per plant, number of seeds per pod and number of pods per cluster. The character plant height showed the highest estimate of genetic advance.

Genotypic correlation coefficient was higher in magnitude over the respective phenotypic correlation coefficients. Seed yield per plant showed positive and highly significant correlation with harvest index, number of pods per plant, number of branches per plant, number of pods per cluster, hundred seed weight, pod length, number of clusters per plant and number of seeds per pod at both genotypic and phenotypic level. Path coefficient analysis revealed positive direct effect of number of primary branches per plant, hundred seed weight, harvest index, days to first flowering, number of pods per plant on seed yield per plant at both genotypic and phenotypic level.

It is concluded that the progenies Konkan safed x Arka garima, ACP-1264 x DPL-YB-5, ACP-1264 x UBA-1, PCP-97100 x Arka garima and Pusa dophasali x DPL-YB-5 were promising on the basis of seed yield and yield attributing characters. These crosses along with their progeny can be promoted to next generation for the selection of promising cultivars.

14.	Name of the candidate : Ms. Gimhavanekar Sayali Sunil	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2019	Name of Guide / Co-Guide : Prof. B .G. Thaware

Abstract : A field experiment was conducted at Education and Research farm, Dept. of Agril. Botany, College of Agriculture, Dapoli during *Rabi* 2017-18 to study "Evaluation of Promising Lines for Morphophysiological Basis of Grain Yield of Wal (*Lablab purpureus* L.(sweet))". The experiment consisted of eighteen treatments laid out in Randomized Block Design with three Replications. Data was collected on plant height, number of branches, number of leaves, days to initiation of flowering, days to 50 per cent flowering, days to maturity, leaf area, LAI, AGR, RGR, NAR, number of pods per plant, 100-seed weight and other yield related characters at the interval of 30, 60, 90 DAS and at physiological maturity. Data collected was subjected to analysis of variance. Most of the yield and yield determining attributes recorded significant difference due to treatment effects.

Maximum plant height was recorded in treatment T, (148.20 cm) while maximum branching was observed in T, (23.05). Genotypes ranged from 86.87 to 64.73 for number of leaves. Treatment T14 was early genotype, it recorded lowest days to 50 percent flowering and also days to physiological maturity, while Tis was late genotype and it recorded highest days to 50 per cent flowering. These genotypes start flowered between 51.67 to 57.67 days and maturity period did not exceed 100 days. Rate of photosynthesis was maximum in treatment To during 60 DAS while stomatal conductance was higher in T11. Transpiration rate increased with advancing age of the crop and recorded maximum in treatment T (11.92 µ mol m2 s^{1}). Maximum chlorophyll content recorded in To (2.997 mg/g) during 60 DAS. Highest dry weight was observed in To (17.119 g), while lowest dry weight recorded in T_2 (9.263 g). At 90 DAS, maximum leaf area was observed in T16 (1104.34 cm2) while minimum leaf area was in T19 (342.97 cm^2). The range of LAI during maximum leaf area stage (90 DAS) is 1.972 to 1.458. At harvest, AGR ranged between 46.01 to 32.48 g. At harvest RGR ranged between 0.004881 g g day to T18 0.000275 g g day-1. At harvest, NAR ranged from 0.00004858 g dm-2 day 1 to 0.00000202 g dm2 day-1.

Maximum number of pods were found in T14 (47.43) and pod yield per plant was also maximum in T: (52.27 g). Pod yield per plot was highest in T3 (1535.95 g) and 100-seed weight was found maximum in T: (21.59 g). The harvest index amongst genotypes varied from 21.32 to 43.56 per cent. Seed yield kg per hectore ranged between 847.16 kg to 1233.33 kg in T9 and T2 respectively. Seed yield per plot ranged between 1143.67 g and 1665.17 g in Ts and To respectively which indicates the large variation among genotypes. Among all genotypes treatment To was found superior for yield and for all yield contributing characters.

15.	Name of the candidate : Mr. Jadhav Sudhakar Prakash	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2019	Name of Guide / Co-Guide : Dr. R. L. Kunkerkar

Abstract : The present investigation entitled "Genetic variability and Diversity studies in Rice (*Oryza sativa* L.)" was undertaken at the Research and Experimental farm of Regional Agriculture Research Station, Karjat (Raigad); with research objectives. To study the nature and extent of genetic variability for yield and yield contributing traits. To measure the divergence between different genotypes by D2 statistics. The observations were recorded on twelve characters *viz*., days to 50 per cent flowering, days to maturity, plant height (cm), number of productive tillers plant', panicle length (cm), total number of spikelets panicle, number of filled spikelet panicle-^{1}, spikelet fertility (%), 1000 grain weight (g), grain yield plant^{1} (g), straw yield plant (g), harvest index (%). The results obtained in present study are summarized below: Mean sum of square due to treatments were highly significant for all the characters under study for

	variability. Among all the varieties shiddhagiri recorded maximum No. of tillers per plant, Panicle length (cm), 1000 grain weight, Grain yield per plant (g), Straw yield per plant (g) and Harvest index (%). Sorty found to be earliest in Days to 50 per cent flowering Days to maturity. Sambamashuri found late in days to 50 per cent flowering, Days to maturity, while Ghansal recorded maximum plant height (cm), 1000 grain weigh (g), grain yield per plant (g), the maximum harvest index was noticed in Jaldubi. The environmental variance was lower than genotypic variance but phenotypic variance was more than genotypic variance. Genotypic and phenotypic coefficient of Variance was highest in characters straw yield per plant (g) 1000 grain weight (g) number of tillers per plant while lower in days to maturity followed by days to 50 per cent flowering and harvest index (%). high heritability was observed in twelve character *viz*., 1000 grain weight (g), plant height (cm), number of tillers plant^{1}, harvest index (%), days to maturity, days to 50 per cent flowering, panicle length (cm), straw yield plant^{1} (g), number of filled spikelet panicle, Number of spikelets panicle', spikelet fertility (%) and grain yield plant^{1}(g). Twenty seven varieties were grouped into 6 cluster different clusters on the basis of magnitude of D2 values evaluated by Mahalanobis D2 analysis. Among the twenty seven varieties 16 varieties were grouped into first cluster followed by cluster II has 5 varieties. The IV and VI cluster include 2 varieties while cluster III and V were consisted of only one variety in both cluster. Inter cluster distance i.e divergence was highest between IV and VI (385973.83), while intra cluster distance is maximum in cluster (621.26) the character 1000 grain weight (g), days to maturity, plant height (cm), Number of tillers per plant, number of spikelets per panicle and harvest index (%).			
16.	Name of the candidate : Mr. Hemke Akshay Rajesh	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2019	Name of Guide / Co-Guide : Dr. B. D. Waghmode
	Abstract : The present investigation entitled "Stability analysis in promising extra long slender aromatic (Basmati) rice (*Oryza sativa* L.)" by using AMMI model" was conducted experimental farm of Agricultural Research Station, Shirgaon, Regional Agricultural Research Station, Karjat and College of at the Agriculture, Dapoli (M.S.) during *Kharif* 2018. Stability analysis of twenty five genotypes of Extra Long Slender Aromatic (Basmati) rice at three environments and at three locations. The results indicated that, Genotypes, 15BM6-124, 15BM6-220 and 15BM6-112 are high yielding and stable at Shirgaon and Karjat location. Genotypes, 15BM6-120, 15BM6-220, 15BM6-233 and 15BM6-124 are favourable for characters *viz*., amylose content, milling per cent and ASV per cent and stable at Shirgaon location In interaction principle axis of AMMI biplot, first interaction principle axis (IPCA I) are favourable for all characters. In AMMI 1 biplot, Dapoli location favourable for characters *viz*., day to 50 per cent flowering, plant height (cm), total number of spikelets panicle', and number of filled spikelets panicle 1. Karjat location favourable for characters *viz*., grain yield plot^{1}, grain yield plant', straw yield plot and straw yield plant^{1}. Shirgaon location favourable for number of tillers plant, number of panicles square meter-1, panicle length, spikelet fertility, test weight, grain yield plant^{1}, kernel elongation, amylose content and milling. Genotype, 15BM6-124 is stable for most of the characters *viz*., 50 per cent flowering, plant height, tillers plant', spikelet fertility, test weight grain yield plant, straw yield plant, straw yield plot, kernel length (mm) and amylose content. Genotype, 15BM6-233 is stable for grain yield plot, total number of spikelet penical and milling per cent.			
17.	Name of the candidate : Mr. Desai Chirag Prakash	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2019	Name of Guide / Co-Guide : Dr. P. B. Vanave

Abstract : The present experiment entitled "Genetic variability studies in F_3 generation of interspecific crosses of cowpea (*Vigna* ssp.)" was undertaken to assess the genetic variability, correlation and path analysis in twelve progenies and a check. The experiment was conducted in compact family block design with three replications at educational and research farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during *Rabi* 2017-2018. Observations were recorded for twelve characters *viz*., days to first flowering, day to fifty per cent flowering, days to first pod picking, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, pod length (cm), green pod weight (g). harvest index (%) and protein content in seed (%).

It is resulted that the estimates of mean sum of squares showed comparatively wide range of variation for the characters *viz*., plant height, green pod weight per plant, number of pods per plant days to 50% per cent flowering. Phenotypic variances were higher in magnitude than genotypic variances for all the characters. Green pod weight per plant showed highest estimate of phenotypic and genotypic variance followed by number of pods per plant and plant height. PCV was higher in magnitude over respective GCV. High estimates of heritability coupled with high genetic advance as per cent of mean was observed for characters plant height and green pod weight per plant. The character plant height showed the highest estimate of genetic advance.

Genotypic correlation coefficient was higher in magnitude over the respective phenotypic correlation coefficients. Green pod weight per plant showed positive and highly significant correlation with plant height, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant and pod length at both genotypic and phenotypic level. Path coefficient analysis revealed positive direct effect of plant height, number of clusters per plant, number of pods per cluster, number of pods per plant, pod length and harvest index at both genotypic and phenotypic level while, days to initiation of flowering and days to 50% per cent flowering at phenotypic and genotypic level respectively.

It can be concluded that Pusa dophasali × Konkan wali, Pusa dophasali x Arka garima, PCP- 9723 × Konkan wali, ACP-109 × Konkan wali and ACP-109 Konkan wali were found to be promising in terms of green pod weight per plant and yield contributing traits.

18.	Name of the candidate : Ms. Korpad Pratiksha Dhansing	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology)	Year of submission : 2019	Name of Guide / Co-Guide : Prof. S. S. Chavan

Abstract : A field experiment was conducted at education and research farm, Dept. of Agril. Botany, College of Agriculture, Dapoli during *Rabi* 2018-19 to study morphophysiological evaluation for yield and yield components in green gram (*Vigna radiata* (L.) Wilczek). The experiment consisted of twenty one genotypes laid out in randomized block design with three replications. Data were collected o branches, number of leaves, days to 50% flowering, days to maturity. on plant height, number of leaf area, LAI, AGR, RGR, NAR, number of pods per plant, 100 seed weight and other yield related characters at the interval of 15, 30, 45, 60 DAS and at physiological maturity. Data collected were subjected to analysis of variance. Most of the yield and yield determining attributes recorded significant difference due to treatment effects.

Maximum plant height was recorded in treatment Tis (46.95 cm) while maximum branching was observed in T7 (3.53). Genotypes ranged from 18.77 to 50.70 for number of leaves at 60DAS. Treatment Ts was early genotype and it recorded lowest days to 50% flowering and also days to physiological maturity. Maximum chlorophyll content recorded in Tis (1.694 mg/g) during 60 DAS. Maximum relative water content registered in Ts (87.93%) and minimum relative water content registered in T1 (44.74%) at 45 DAS. Highest dry weight was observed in T (15.970 g plant-1) while lowest total dry weight recorded in

	Tis (9.405 g plant¹) at harvest. At 60 DAS, maximum leaf area was observed in Tis (884.17 cm²) while minimum leaf area was in T18 (245.00 cm2). The range of LAI during maximum leaf area stage (60 DAS) was 2.916 to 0.817. The highest AGR was scored by T11 (0.621 gday-1) during 45-60 DAS. At harvest, RGR ranged between and 0.0055-0.0163 g g'day-1. At harvest, NAR ranged from 0.000136 g cm2 day-1 to 0.000506 g cm² day-1 Highest number of clusters per plant recorded in T12 (9.83) and highest number of pods per clusters observed in T13 (3.60). Maximum number of pods per plant was recorded in T7 (34.36) and pod yield per plant was also maximum in T7 (24.67 g). The highest protein content was in T13 (25.75%). Pod yield per plot was highest in T7 (2.140 g) and 100 seed weight was found maximum in T13 (6.52 g). The harvest index amongst genotypes varied from 15.36 to 35.06 per cent. Seed yield per plot ranged from to 0.696 kg (T3) to 1.649 kg (T18) which indicates the large variation among genotypes. Among all genotypes treatment T7 was found superior for yield and optimum for all yield contributing characters.

19.	Name of the candidate : Ms. Bonde Priyanka Jagdish	Degree for which the thesis/project report submitted: Ph.D.Ag.)(Plant Physiology)	Year of submission : 2019	Name of Guide / Co-Guide : Dr. A.K. Shinde

Abstract : The present investigation entitled "Effect of nutrients, growth regulators and antitranspirant on morpho-physiological and yield attributing parameters of lablab bean (*Lablabpurpureus* L. Sweet) grown under residual moisture in Konkan region" was carried out at Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli (Location 1) and Gaontale block, CES Wakawali (Location 2) during *Rabi* 2016- 2017 and *Rabi* 2017-2018. The lablab bean was sown during *Rabi* season after harvest of paddy under residual moisture. The foliar spray of nutrients, growth regulators and antitranspirantwas done at 30-45 DAS. The experiment were laid out in randomized block design with 14 treatment and three replications with an object to study the effect of nutrients, growth regulators and antitranspirant on dry matter production and it's partitioning. phenophasic development, morphological, physiological and yield attributesof lablab bean grown under residual moisture.
Results indicated that, among the fourteen treatment combination of nutrients, growth regulators and antitranspirant, treatment T, i.e. KNO, @ 2% and NAA 20 PPM increased plant height (78.47cm), number of leaves (36.72/plant), number of nodes (14.59/plant), leaf area (547.58cm³), leaf dry weight (8.997 g/plant), stem dry weight (6.47 g/plant), root dry weight (3.074 g/plant), pod dry weight (14.53 g/plant), total dry weight (32.81g/plant), photosynthetic rate (28.22 u mol CO; ms), chlorophyll content (1.152 mg g'), chlorophyll stability index (64.53%), relative water content (75.48%), relative growth rate (0.0024g/g/day), leaf area index (2.470), specific leaf weight (0.899 g/cm³), number of pod (20.44/plant), length of pod (5.01cm), 100 seed weight (15.97g). biological yield (38.50 g/plant), seed yield (906.70 kg/ha) and harvest index (32.54%) over control.
A strong positive correlation of seed yield/plant was observed with total dry weight rate (0.634) and pods/plants (0.623) than other characters. Therefore, these traits could be positively considered for yield improvement under moisture stress condition. Moisture stress resulted decrease in yield and yield components. From the present investigation treatment T, (Paclobutrazol @ 100 ppm) induces early flower initiation and early maturity followed by cycocel (100 PPM). It also shortend the height of the plant.Treatment T, kaolin (5%) improve water productivity by maintaining high relative water content by lowering the rate of transpiration, canopy temperature. Under water deficit condition proline content, increased. Treatment T, KNO; @ 2% and NAA 20 PPM increased height, number of branches, number of leaves, leaf area, leaf dry weight, stem dry weight, root dry weight, total dry matter accumulation, photosynthetic rate, chlorophyll content, chlorophyll stability index, water use efficiency, relative growth rate, leaf area index, specific leaf area, specific leaf weight, number of pod, length of pod, 100 seed weight, biological yield, seed yield and harvest index when compared with other foliar sprays. Integrated use of KNO, and NAA was found most effective than either by using KNO; or NAA alone Thus, the present

	investigations revealed that the use of foliar spray of nutrient KNO, (2%) and growth regulator NAA (20 PPM) enhanced the yield of lablab bean grown under residual moisture.			
20.	Name of the candidate : Ms. Sawant Sangita Sanjay	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(Plant Physiology)	Year of submission : 2019	Name of Guide / Co-Guide : Dr. S. G. Bhave
	Abstract : The present investigation "Exploitation of hybrid vigour and stability analysis in cucumber (*Cucumis sativus* L.)" was conducted at the Educational Experimental Farm, Department of Agricultural Botany, College of Agriculture, Dapoli during *Kharif* -2017, *Rabi*- 2017-18 and summer-2018-19. The experimental material for the present study comprised of F_1 population of twenty four crosses, developed by crossing four female parents *viz*., Sheetal, Shubhangi, Himangi, and Puna khira of cucumber with six male parents *viz*., AAUC-2, DC-2, AAUC-1, VRC- 19, DARL-103 and Fansu local. During *kharif* the hybrid Sheetalx Fansu local (5.22 kg), in *Rabi* Sheetal x AAUC-1(1.70 kg), Puna khira x AAUC-2(3,95 kg) in summer, on pooled basis, the hybrid Sheetal x Fansu local (3,34 kg) showed best results with respect to overall mean for marketable yield vine¹ The best hybrid was identified with respect to marketable yield vine-1 based on significant highest positive heterosis was Sheetal x Fansu local in the *kharif*, Sheetal x AAUC-1 in *Rabi*, during summer Puna khira x AAUC-2 and on the-pooled data of fruit yield over three environments was Sheetal x Fansu local. For the character marketable yield vine positive significant GCA effects served in the female parents *viz*.,Sheetal and Puna Khira while in male *viz*., Fars local and VRC-19 in *kharif*-2017 In summer-2019 same female parents and nly one male parent AAUC-2 exhibited positive GCA effects. In pooled analysis be female parents *viz*., Sheetal and Puna Khira and male parents AAUC-2 and Farsu local recorded positive significant GCA effects. This showed that the female parents Sheetal and Puna Khira and male parents AAUC-2 and Fansu local were good general combiner for marketable yield vine-1 The hybrids Sheetal x Fansu local, Sheetal x VRC-19 Sheetal x AAUC-2, and Puna Khira x Fansu local showed Highest positive significant SCA effects and these are also selected as best hybrids on the basis of their performance in given environment. The hybrids Sheetal x DARL-103, Sheetal x AAUC-2,Sheetal x VRC-19 and Shubhangi x DC-2 exhibited high mean, regression coefficient more than unity and non-significant deviation from regression and therefore it is classified as stable hybrids for favourable environment for marketable yield vine-¹ The role of non-additive gene action showed by most of the characters during harif, *Rabi*, summer and on pooled basis. The number of marketable fruits vine-1 2%) showed very high heritability during *kharif* Very high heritability mrded in days to first picking (71.25%) in *Rabi* season. In summer heritability estimates were very high recorded by fruit diameter (78.12%), none of the character showed very high heritability on pooled basis of three environments. The performance of the parent and hybrids varies for all the traits with the season. This indicated that every genotype responded differently to the environmental condition.			
21.	Name of the candidate : Mr. Gimhavanekar Vaibhav J.	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(Plant Physiology)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. A. K. Shinde
	Abstract :The present investigation entitled "Physiological evaluation of aromatic and non-aromatic rice (Oryza sativa L.) genotypes for growth, yield and quality characters of rice grown in Konkan region" was carried out at Regional Agricultural Research Station, Karjat, Dist. Raigad (MH) during Kharif 2017 and Kharif 2018. The experiment was laid out with 58 aromatic and non-aromatic rice genotypes in			

	Randomized Block Design (RBD) with two replications with an object to study the growth attributes, physiological functions, photothermic indexing and photosynthetic traits, physio-chemical analysis and yield and yield attributes in aromatic and non-aromatic rice genotypes. Results indicated that, among the fifty eight aromatic and non- aromatic rice genotypes, aromatic rice genotypes Belgaum Basmati showed maximum number of tillers (9.69 plant-^{1}) and number of leaves [28.90 plant). It also showed higher value of TDM (47.42 g plant-1), leaf area (16.39 dm2/plant), Chlorophyll content (0.75 mg g^{1}), chlorophyll stability index (0.73), photosynthesis rate (19.18 umol CO2 m^{2} sec^{1}), stomatal conductance (0.353 mmol m-2 sec-1), water use efficiency (3.73 umol/mmol-1), leaf area index (5.46), leaf area duration (60.55 days),grain yield (17.51 g plant-1) and harvest index (42.13%). Non-aromatic rice genotype Karjat-9 showed maximum number of tillers (10.36 plant-^{1}) and maximum number of leaves (35.05 plant-1). It also showed higher value of TDM (51.61 g plant-1), leaf area (16.55 dm2/plant), Chlorophyll content (0.94 mg g^{1}), chlorophyll stability index (0.79), photosynthesis rate (21.18 µmol CO2 m2 sec-1), stomatal conductance (0.384 mmol m-2 sec), water use efficiency (4.49 µmol/mmol-1), leaf area index (5.52), leaf area duration (61.20 days), grain yield (18.49 g plant-^{1}) and harvest index (45.93%). In non-aromatic rice genotypes highest grain yield of Karjat-3 (20.66 g plant-^{1}), Karjat-9 (18.49 g plant), Karjat-8 (18.20 g plant:^{1}), Karjat-7 (18.79 g plant), Karjat-2 (18.01 g plant-^{1}) and in aromatic rice genotypes Belgaum Basmati (17.51 g plant), quality rice Paras Sona (16.83 g plant-^{1}) non-aromatic rice genotype and Phule Maval (16.67 g plant^{1}) was due to the higher harvest index. Poor grain yield in Girga (7.03 g plant^{1}) was due to low harvest index. The quality traits of aromatic rice genotypes, viz., Patnijira (4.23), SKL-7 (4.77) and Parag (4.12) as fine grain genotypes for L/B ratio; Phule radha (1.52), quality rice Kundlika (1.47) non-aromatic rice genotype and Jirga (1.42) for elongation ratio; Elaichi (6.63), Mamala (6.50), Patnijira (6.50), Pusasugandha (6.38) and quality rice Kundlika (6.38) non-aromatic rice genotype for intermediate alkali value towards improvement of respective traits in quality rice breeding programme. Among 58 rice genotypes Ambemohar and Karjat-8 consumed highest GDD, HTU and PTU as compared to other rice genotypes. The generated information can be useful for rice research improvement and the selected rice genotypes can be used as a potential breeding materials in the future rice research programme.

22.	Name of the candidate : Ms. Gawas Dhanashri Prakash	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(Plant Physiology)	Year of submission : 2019	Name of Guide / Co-Guide : Dr. A. V. Mane
	Abstract : The present investigation entitled "Physiological and biochemical studies on effect of seasons and plant density on growth, yield and quality of groundnut *(Arachis hypogaea* L.) genotypes under Konkan condition" was carried out at the Education and Research Farm of the Department of Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra state during the *kharif* and *Rabi* 2017-18 and 2018-19 seasons. The investigation was aimed at morphological, physiological, biochemical and yield and yield attributes in different groundnut genotypes grown under different plant populations in the different seasons under Konkan conditions; study the effect of seasons on yield and quality of groundnut genotypes and identifying the morpho- physiologically efficient and consistent groundnut genotype for higher yield under Konkan conditions. The whole experiment was analyzed in split plot design in three replications. Results indicated that, among the seasons, *Rabi* season (Sa) exhibited better achievement than *kharif* season and recorded significantly higher total dry matter (35.05 %), chlorophyll content (20.65 %), chlorophyll stability index (24.25 %), photosynthetic rate (31.08 %), higher stomatal conductance (74.82 %), mesophyll efficiency 82.29 %), quantum efficiency (3.42 %), along with higher relative growth rate (22.72 %), leaf area index (36.09 %), leaf area duration (35.68 %) and sulphur content (7.40 %). Whereas reduction (56.10 %) in plant height, (9.28%) membrane stability index and (30.02 %) water use efficiency was evident in season S, over season S2. Among the eleven genotypes tested, genotype Ga was			

	found to be significantly superior over all the other genotypes, recording significantly higher chlorophyll content (24.30 %), chlorophyll stability index (22.90 %), higher photosynthetic rate (48.60 %), stomatal conductance (55.12 %), mesophyll efficiency (45.86 %), quantum efficiency (51.26 %), water use efficiency (86.57 %), leaf area index (52.83 %), leaf area duration (52.43 %) and sulphur content (25.33 %) than genotype Konkan Gaurav. Whereas, plant height was maximum and higher 43.61 % in genotype Go over genotype G1. Among the three plant spacings, spacing D: (30 X 20 cm) exhibited significantly higher total dry matter (33.09 %), chlorophyll content (8.96 %), chlorophyll stability index (5.48 %), membrane stability index (4.35 %), photosynthetic rate (13.12 %), stomatal conductance (14.20 %), mesophyll efficiency (6.33 %), quantum efficiency (9.15%), relative growth rate (91.75 %), net assimilation rate (75.83 %) and sulphur content (10.01 %) than spacing D3 (30 X 10 cm). Whereas, increase in plant height (4.54 %), water use efficiency (12.13%), leaf area index (77.72 %) and leaf area duration (78.22 %) was noted in spacing D3 (30 X 10 cm) over spacing D: (30 X 20 cm). Among two seasons, S2 (*Rabi*) registered significantly (38.71 q ha¹) maximum yield over S: (*kharif*). Genotype Ga, proving to be significantly superior over all the other genotypes, recorded higher no. of pods per plant ((30.78), pod weight plant-1 (24.62 g plant 1), pod yield q ha¹ (45.41 q ha¹), shelling percentage (73.22 %) and harvest index (41.90 %). Among the 11 genotypes of groundnut tried in 2 seasons, genotype G was found most consistent registering minimum deviation in seed yield as compared to other genotypes and proved to be comparatively more thermo and photo- insensitive genotype. Out of all the plant spacings studied, plant spacing 30 X 10 cm was observed to be the best with respect to seed yield (q ha¹). A strong positive correlation of seed yield plant with Leaf area index (0.708), photosynthetic rate (0.641), TDM (0.632), CC (0.650), WUE (0.441) and RGR (0.242) indicated the greater physiological efficiency for better photo assimilation towards reproductive growth in order to have better yield. Therefore, these traits could be positively.

23.	Name of the candidate : Mr. Tambitkar Naresh Bhiva	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. U. B. Pethe
	Abstract : The present experiment entitled "Genetic diversity studies in cowpea (*Vigna unguiculata* (L.) Walp)" was undertaken to assess the genetic variability, genetic divergence and path analysis in forty-one genotypes of cowpea in randomized block design with two replications at educational and research farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during *Rabi* 2019- 2020. The estimates of phenotypic, genotypic and environmental variance revealed that phenotypic variance were higher in magnitude than genotypic variance for all the characters. The magnitude of phenotypic and genotypic variance was closer to each other for majority of the characters thus indicating lesser role of environment in the expression of these characters. In general, phenotypic coefficient of variation (PCV) was higher in magnitude over genotypic coefficient of variation (GCV) for all the characters. Different characters showed varying per cent of coefficient of variation both genotypic and phenotypic levels. High genotypic and phenotypic coefficient of variation was observed for the characters iron content (ppm), plant height at maturity (cm), seed yield per plant (%), days to maturity, dry matter yield per plant (g), while this were low for the characters days to fifty percent flowering In present investigation, the genotypic correlation coefficient was higher in magnitude than their phenotypic counter parts for most of characters. Dry matter yield per plant and harvest index exhibited highly significant positive correlation with seed yield per plant both phenotypic and genotypic levels. The characters number of primary branches per plant, hundred seed weight, number of pods per plant, iron content, days to 50% flowering, number of seeds per pod and protein content had non-significant positive correlation with seed yield per plant at both phenotypic and genotypic levels,		

	Forty-one genotypes were grouped into 6 different clusters on the basis of magnitude of D2 values evaluated by Mahanlanobis D2 analysis. Among forty one genotypes, cluster I was comprising 12 genotypes followed by cluster II with 14 genotypes, cluster III with 5 genotypes, cluster IV with 4 genotypes, cluster V with 5 genotypes and cluster VI with 1 genotype. Inter cluster distance i.e. the maximum intra cluster distance was observed in cluster V (37.17) while the maximum inter cluster distance (117.49) was observed in cluster IV and clusters V. The seed yield is complex character and each character had its own effect for establishing correlation with yield. The path coefficient revealed that the character days to 50% flowering, number of pods per plant, plant height at maturity, dry matter yield per plant and harvest index had positive direct effect on seed yield at both phenotypic and genotypic levels, while days to initiation of flowering, days to maturity, number of primary branches per plant, pod length, hundred seed weight had negative direct effect on seed yield per plant at genotypic and phenotypic levels. It is concluded that IC-614758 followed by AKP-1264 and PGCP-27 are observed as best performance in the genotypes studied. These had highest seed yield per plant and also maximum yield attributing characters. The genotype CPD-31 had maximum seed weight; CP-13 had maximum number of seed per pod, while CP-25 had the maximum number of pods per plant. The genotype Phule vithai had highest protein content, CPD-219 had highest iron content and CPD-220 had minimum plant height. The genotype Konkan sadabahar had early maturating. These genotypes can be used as promising genetic material in future breeding program. There was significant diversity reported in present study among all the genotypes.

24.	Name of the candidate : Ms. Patil Snehal Eknath	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. U. B. Pethe

Abstract :The present experiment entitled "Genetic variability and character association studies in F3 generation of cowpea. (Vigna unguiculata (L.) Walp.)" was carried out for assessing the genetic variability, correlation and path analysis in F3 population of forty five crosses of cowpea in Randomized Block Design with two replications at Educational and Research Farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during Rabi 2018-2019.
The results revealed that estimates of mean sum of squares due to genotypes was highly significant for all the characters studied. In general it was found that magnitude of phenotypic variances were higher than respective genotypic variances for all the characters. Plant height had highest estimate of phenotypic and genotypic variance. High estimates of heritability coupled with genetic advance as per cent of mean was observed for characters plant height at maturity, harvest index, seed yield per plant, number of pods per plant, number of branches per plant, and number of clusters per plants.
Seed yield per plant showed positive and highly significant correlation with number of pods per plant, harvest index, 100 seed weight, pod length and number of cluster per plant at both genotypic and phenotypic level. Path coefficient analysis revealed positive direct effect of number of pods per plant, days to initiation of flowering and hundred seed weight at both genotypic and phenotypic level. Whereas, characters viz., days to maturity, number of clusters per plant, number of pods per cluster and plant height at genotypic level and characters viz., number of branches per plant and pod length at phenotypic level were having direct positive effect on seed yield per plant.
Thus from analysed data it could be concluded that F3 population No. T45 (CPD 83 x GS9240) 42.35g, T19 (CPD 219× NKO32) 41.35g, T17 (CPD 83× NKO 32) 39.80g, T18 (CPD 219x GS 9240) 39.30g and T24 (CPD 31 x GS 9240) 35.70 g were observed as best performers in the studied population as they had highest seed yield per plant. While, treatment No. T45 (CPD 83 x GS9240) 16.90g, T39 (CPD 25 x GS 9240) 15.90g, and (T17 CPD 83x NKO 32, T20 CPD 220x PCP 97102, T23 CPD 172 NKO 32) 15.65 g were white bold seeded among the forty five genotypes of F3 population.

25.	Name of the candidate : Mr. Sabale Parag Shantaram	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. B. D. Waghmode
	Abstract : The present research entitled "Variability studies in M3 generation of Finger millet (Eleusine coracana (L.) Gaertn)" was conducted on research field of Agricultural Research Station, Shirgaon, Ratnagiri, Dist. Ratnagiri. The experiment was conducted in kharif, 2019. Ma generation of thirty four mutant lines developed from Girge local genotype irradiated with 500 Gy dose of gamma rays was studied along with three checks viz., Dapoli-1, Dapoli-2 and Dapoli safed. The magnitude of genetic variability, heritability and genetic advance for quantitative and qualitative traits was estimated. The results indicated that, The analysis of variance showed significant differences among the entries for all the traits studied. The high GCV and PCV was observed for characters, iron content, number of productive tillers, calcium content, number of fingers plant, Straw yield plant and main earhead length. Higher heritability was observed in the traits viz., iron content, calcium content, protein content, number of productive tillers plant, main earhead length, main earhead length and number of fingers plant. The moderate (30-60%) heritability was observed in traits viz, straw yield plant, grain density. harvest index and weight of earhead plant, Calcium content showed high heritability accompanied with high genetic advance indicates that, most likely their heritability is due to additive gene effects and selection may be effective. The mutant lines viz., 18 NMS- 12 (81.33 days to 50% flowering and 115.67 days to maturity) and 18 NMS 34 (82.67 days to 50% flowering and 117.67 days to maturity) were found early flowering and early maturing. The mutant lines viz., 18 NMS 31 and 18 NMS 23 recorded significantly higher values for yield and yield contributing traits viz., grain yield plant^{1}, weight of earhead plant, number of fingers plant, main earhead length, grain density and number of productive tillers plant-1 and were also recorded with numerically higher harvest index. Regarding to quality parameters the mutant lines viz., 18 NMS-21 (11.05%) and 18 NMS - 15 (10.56%) recorded higher protein content. The mutant lines 18 NMS-10 (360 mg/100g) and 18 NMS - 20 (354 mg/100g) recorded higher calcium content. High iron content was observed in mutant lines 18 NMS-24 (23.72 mg/100g) and 18 NMS -18 (22.28 mg/100g).			
26.	Name of the candidate : Mr. Dhunde Bhushan Bhojraj	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. J. P. Deomore
	Abstract : The present investigation was undertaken in order to compare the nature and extent of variability for yield and yield contributing characters, their phenotypic and genotypic correlation coefficient and the direct and indirect effects between them for F2 generation of green gram. The experimental material containing twenty four F2 generation hybrids, ten parents and one check was planted in randomized block design with three replications during Rabi 2018-19 at the research and educational farm, Department of Agriculture Botany, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.). The analysis of variance for all the characters revealed that both parents and F2 generation were highly significant for all the characters studied indicating presence of considerable amount of genetic variability between them. The estimates of phenotypic and genotypic variances revealed that the characters like number of branches per plant number of pods per plant plant height and number of grains per pod showed more contribution of genotypic variance to total variance Plant height grain yield per plant and number of			

	pods per plant had moderate genotypic coefficient of variation estimates while rest of the characters were having low to moderate genotypic coefficient of variation per cent. The estimates of genetic advance as per cent of mean were high, coupled with moderate heritability for plant height. While. moderate genetic advance coupled with moderate heritability showed for number of branches per plant, number of pods per plant, and grain yield per plant. The grain yield per plant had highly significant and positive correlation at both genotypic and phenotypic levels with plant height. number of clusters per plant, number of pods per cluster, number of pods per plant and hundred seed weight, indicating possibility of simultaneous improvement for these traits. And thus, correlation study revealed the importance of these characters for increasing grain yield. Path coefficient analysis revealed that days to 50 per cent flowering number of branches per plant, number of clusters per plant. number of pods per cluster, number of pods per plant and plant height were major characters having high positive direct effect and significant association with grain yield per plant both at genotypic and phenotypic levels. It was advisable to select genotypes on the basis of grain yield per plant, number of clusters per plant, number of pods per plant, plant height and hundred seed weight. Considering the highest seed yield and high per se performance for grain yield per plant, number of clusters per plant, number of pods per plant, pod length, plant height and days to maturity, the best performing F2 generation crosses among the twenty-four F2 generation crosses were, ML-2333 X DGG-03, PUSA-1477 X TARM-1, TARM-2 X DGG-03, PUSA-1472 X TARM-1, NVL-641 X TARM-1, ML-2056 X Karjat local, ML-2056 X TARM-1 and TARM-2 X PKVAKM-04. The desirable plants from these crosses were selected for further studies.
27.	Name of the candidate : Mr. Kulkarni Ajinkya Ashok | Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology) | Year of submission : 2020 | Name of Guide / Co-Guide : Prof. R. S. Deshpande
	Abstract : Kokum (*Garcinia indica* Choisy) belongs to family Clusiaceae. It is important spice crop in the konkan region of Maharashtra. It is popularly known as "Ratamba" and widely grown in tropical rain forests of western ghat. Kokum has got multifarious uses and therefore, finds inevitable place in the lifestyle of local population. Micropropagation is promising method for clonal multiplication of plants on large scale. Establishment of an efficient technique for reducing microbial contamination and exudation of phenols to produce maximum sterile cultures of kokum, which are true-to-type is the most urgent need of the Konkan region. This study aims to standardize micropropagation of female cultures of Kokum cv. Konkan Amruta, hence focusing on the improvising sterilization techniques and minimize the effect of phenolic components for ensuring high survival rate of kokum cultures. Shoot tip and Nodal explants were collected from mature fruiting tree of kokum cv. Konkan Amruta. Kokum is proliferent producer of phenols and polyphenols and also prone to certain endogenous contamination. The treatment of the explants with sterile distilled water. TWEEN-20, 10%Savlon, and pre-conditioning of explants with 0.1%PVP along with anti-fungal agent 1% Bavistin fallowed by an aseptic treatment with 0.75% HgCl for 6 min. resulted 81.66 per cent survival of healthy and sterile buds. This study also conducted for induction of in-vitro shooting and in- vitro rooting using shoot tip and nodal explants on woody plant medium with different concentrations of plant growth regulator. From the result obtained, it is observed that the maximum shoot induction was showed on plant growth regulator combination WPM + 1mg kin + 2mg BAP 1mg IBA for both the explants 73.33 and 70.00 percent respectively. Better shoot induction was observed in explants which were collected in January than any other season.

28.	Name of the candidate : Mr. Mahadik Sandip Gopal	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(Plant Physiology)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. M. M. Burondkar
	Abstract :			
29.	Name of the candidate : Mr. Chavan Sanjay Shankar	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(Plant Physiology)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. A. K. Shinde
	Abstract : The present investigation entitled "Physiological analysis for indentifying drought tolerance genotype of lablab bean (*Lablab purpureus* L. Sweet)" grown under residual moisture in Konkan region" was carried out at Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli (Location 1) and Gaontale block, CES Wakawali (Location 2) during 2016-2017 and 2017-2018. The experiment was laid out with 40 lablab bean genotypes in Randomized Block Design (RBD) with two replications with an object to study the growth attributes, and yield and yield attributes in wal genotypes. Results indicated that, among the fourty wal genotypes, G15, G10, G16, G26, G27, G29 and G39 were identified as drought tolerant genotypes as compare to other genotypes. Gis produced highest yield under residual moisture, since it has exhibited higher number of branches, leaf area, total dry matter, lower transpiration rate, higher chlorophyll content, chlorophyll stability index, relative water content, lower proline content, higher AGR, RGR, LAI and number of pods per plant. Among all genotypes Gio showed 2nd ranking for yield due to higher number of leaves, relative water content, lower proline content, higher RGR, NAR, number of pods/plant, 100 seed weight and seed yield (g/plant) when compared with other genotypes. G16 showed 3 ranking for yield under residual moisture, because it has exhibited higher photosynthesis rate, lower transpiration rate, higher water use efficiency, lower proline content, 100 seed weight. Among all genotypes G26 showed 4th ranking yield due to higher number of branches, total dry matter, lower proline content, number of pods/plant when compared with other genotypes. G27 showed 5th ranking for yield under residual moisture, because it has exhibited higher number of branches, leaf area, number of pods per plant, length of pods and number of seed per pod. Among genotype G showed 6th ranking for yield due to higher leaf area and leaf area index over other genotypes. Highest positive correlation with seed yield/plant was exhibited by relative water content (0.310) followed by total dry matter (0.225). This may be due to the better carbon assimilation and translocation efficiency and also tend to have greater efficiency for better partitioning of photo- assimilates towards reproductive growth in order to have better yield. Further study to identify lablab bean genotypes be conducted on residual moisture for at least two years. Then multi-location adaptive trials be conducted for identifying most drought tolerant lablab bean genotype.			
30.	Name of the candidate : Mr. Umate Avinash Tanaji	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. M. P. Gawai

Abstract : The present investigation entitled "Genetic variability studies in F_4 progenies of Rice (*Oryza sativa* L.)" was undertaken during *Kharif* 2019 at Research and Experimental farm of Regional Agricultural Research objectives. station Karjat, (Raigad), Maharashtra; with research
1. To study the nature of genotypic and phenotypic variability in F4 progenies of rice.
2. To study the character association using correlation and path analysis.
Observations were recorded on seventeen characters *viz*. plant height (cm), total number of tillers per plant, panicle length (cm), Straw yield/ plant (gm), harvest index (%), days to 50% flowering, days to maturity, no. of filled spikelet's per panicles, no, of filled spikelet's per panicle, spikelet fertility (%), 1000 grain weight (gm), amylose content (5) gel consistency (mm), grain elongation before cooking, grain elongation after cooking, head rice recovery (%), alkali spreading value, grain yield per plant (g). Mean sum of square due to treatments were highly significant for all the characters under study for variability. Among all the segregating lines line 2015-14-9-9-6 found to be earliest in days to 50% flowering, days to maturity. 2015- 14-17-8-8 found late in days to 50% flowering days to maturity, while Pusa Basmati-1 recorded maximum plant height (cm), panicle length (cm) and test weight. 2015- 14-9-9-6 recorded maximum number of tillers per plant. 2015-14-10-15-10 recorded maximum number of filled spikelet per panicle. 2015-14-8-9-3 recorded maximum grain yield per plant. Maximum harvest index was found in 2015-14-3-5-2 segregating line. The environmental variance was lower than genotypic variance but phenotypic variance was more than genotypic variance. Genotypic and phenotypic coefficient of variance was highest in characters number of filled spikelet per panicle, 50% flowering, plant height while lower in test weight followed by yield per plant, number of tillers per plant. High heritability was observed IN days to maturity, days to 50 per cent flowering, test weight, plant height, straw yield per plant, panicle length, spikelet fertility, grain yield per plant (g), number of spikelet per panicle, harvest index, number of tillers per plant and number of filled spikelet per panicle. The quality characters phenotypic and genotypic coefficient of variation was highest for amylose content followed by alkali spreading value, gel consistency and grain elongation after cooking.
Association of grain yield with straw yield, harvest index and test weight recorded highly significant plant height, number of tillers per plant, panicle length, days to 50% flowering, spikelet fertility recorded positive correlation respectively, whereas days to maturity recorded highly negative significant and number of spikelet per panicle recorded negative significant correlation
Plant height, number of tillers per plant, panicle length, straw yield, harvest index, number of spikelet per panicle, number of filled spikelet per panicle, test weight recorded direct positive effect on grain yield whereas days to 50% flowering, days to maturity and spikelet fertility recorded direct negative effect on grain yield

31.	Name of the candidate : Mr. Dubale Akash Sudhir	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. M. M. Burondkar

Abstract : The present study aimed at "Physiological variation in mango (*Mangifera indica* L.) cultivars under Konkan condition" was undertaken at experimental farm of College of Horticulture of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra) during cropping season of the year 2019-20. The experiment was laid out in randomized block design with five mango cultivars *viz*. Alphonso, Kesar, Ratna, Amrapali and Tommy Atkins as a treatment and five replications with an object to study the phenological characterization, physiological characterization and biochemical characterization and yield performance of five different mango (*Mangifera indica* L.) cultivars under different seasons of Konkan region.
The present investigation clearly established that, among five mango cultivars, Cv. Alphonso and Tommy Atkins exhibited early phenological events *viz*. early bud break and took minimum days to reach to the fruit maturation as compared to other three varieties under Konkan condition. Similarly; Amrapali and

	Tommy Atkins found to be physiological most efficient and climate resilient mango owing to significantly maximum photosynthesis rate (68.73 %), stomatal conductance (25 %). transpiration rate (29.01 %), water use efficiency (42.51 %), total chlorophyll content (29.90 %) and total non-structural carbohydrates (28.66 %), which were significantly associated with high fruit yield (3.932, 2.509 Kg/m³). Weather association clearly established that physiological parameters *viz*. rate of photosynthesis, transpiration, stomatal conductance, canopy temperature depression and biochemical parameters *viz*. total chlorophyll content and non-structural carbohydrate and its fraction *viz*. glucose, fructose, sucrose and starch were positively associated with maximum temperature and bright sunshine during winter among three seasons and November and December among the 12 months which under Konkan condition.			
32.	Name of the candidate : Mr. Kurhe Tukaram Mahada	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology)	Year of submission : 2020	Name of Guide / Co-Guide : Dr. A. V. Mane
	Abstract : A field experiment was conducted at agricultural research agronomy farm, College of Agriculture, Dapoli to study the "Study of Morpho- physiological and Biochemical traits associated with growth and yield of promising cultures of Wal (*Lablab purpureus* L. sweet)" under irrigated and residual moisture conditions." during *Rabi* season 2019-20. The genotypes were grown in strip plot design with three replications provided with two irrigation levels in horizontal strip and eleven genotypes on vertical strip. The experiment consisted of horizontal strip I residual moisture condition (no irrigation) and 12 irrigation condition, irrigation at critical stage (i.e. protective irrigation at sowing, vegetative stage, flowering and pod formation stage) and vertical strip eleven genotypes namely V1, V2, V3, V4, Vs Ve V, Va. Vs, Via and Vi Konkan Wal-2 (check). Among the two irrigation level 2 (irrigation at critical stage) recorded maximum plant height, number of leaves, number of branches, leaf area, leaf area index, relative growth rate, leaf area ratio, specific leaf area, specific leaf weight, total chlorophyll, relative water content, protein content, seed yield and straw yield. Accumulation of maximum proline was found at li residual moisture condition (no irrigation). A wide range of variability exists for different morpho-physiological and biochemical parameters among eleven genotypes of wal under different irrigation conditions. Among the eleven genotypes of wal studied under different irrigation conditions, genotypes V6 recorded high yield under 12 (irrigation at critical stage) irrigation condition, owing to their high efficiency to produce maximum economical yield. Iz irrigation condition (irrigation at critical stage) could be considered as the optimum level of irrigation frequency for higher yield with saving in water. This information may be helpful for better understanding of concept of critical stages of vegetative and reproductive growth and its application to the effect of drought at various aspects of growth and yield of wal. It can be employed for the improvement programme as well as efficient management practices for wal production in drought prone areas.			
33.	Name of the candidate : Ms. Ramteke Nutan Arvind	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. J. P. Devmore
	Abstract : The present investigation entitled "Genetic Variability Studies For Yield Components In Rice (*Oryza sativa* L.) Genotypes" was carried out with forty eight rice genotypes for its fifteen yield and yield contributing characters. The present experiment was conducted at Agriculture Research Farm of Regional Agricultural Research Station, Karjat, Dist. Raigad in a randomized block design with three replications to evaluate the experimental material during *kharif* 2020. In this study, nature and extent of genetic variability, degree of association between grain yield and its component traits, the direct and indirect effects of independent traits on dependent trait like grain yield and			

	genetic diversity present among the genotypes was estimated. Highly significant variation was observed for all the characters among all the genotypes under study. This indicated presence of substantial variation and there by an ample scope for selection of promising genotypes from present set of genotypes for yield improvement. In general, phenotypic coefficients of variation (PCV) recorded greater magnitude than the respective genotypic coefficients of variation (GCV). High genotypic and phenotypic coefficient of variation was observed for the charactersnumber of unfilled spikelets per panicle, number of filled spikelets per panicle, grain yield per plant (g), straw yield per plant (g) and total number of spikelets per panicle. Appreciable heritability values were observed for all the characters. All the characters under study exhibited high heritability except number of tillers per plant. Genetic advance were highfor total number of spikelets per panicle, number of filled spikelets per panicle and plant height. The characters number of filled spikelets per panicle, number of unfilled spikelets per panicle, total number of spikelets per panicle, straw yield per plantand grain yield per plant showed comparatively higher estimates of genetic advance as per cent of mean. The character association studies revealed that the genotypic correlation coefficient was higher in magnitude than their phenotypic counter parts for most of characters. Harvest index, straw yield per plant and panicle lengthexhibited highly significant positive correlation with grain yield per plant both at phenotypic and genotypic levels while number of unfilled spikelets per panicle and grain breadth had positive non- significant correlation. The path coefficient analysis at phenotypic and genotypic level revealed that the characters *viz*., plant height, number of tillers per plant, total number of spikelets per panicle, test weight, straw yield per plant, harvest index and grain length recorded positive direct effect both at phenotypic and genotypic level. While days to 50 per cent flowering, panicle length, number of unfilled spikelets per panicle recorded negative direct effect on grain yield per plant. Forty eight genotypes were grouped into six different clusters on the basis of magnitude of D^2 values evaluated by Mahalanobis's D analysis. Among forty eight genotypes, 33 genotype were clustered into first (1) cluster, followed by cluster (1) with 11 genotypes, cluster (III), cluster (IV), cluster (V) and cluster (VI) had 1 genotype each. Inter cluster distance i.e. divergence was highest between clustersIV and VI (D-22.17). while intra cluster distance is maximum for cluster II (D-9.89). On the basis of per se performance, genotypes *viz*, CR 3783-3-2-1-1-1-4-1, KPS-6262, Pusa 1702-10-271, GNV 1904, AD 16168, RP 6334-111-5-2-1 and JGL 3245 were found to be the best for yield and yield contributing traits. Therefore, these can be successfully utilized as parent's in future breeding programme.
34.	Name of the candidate : Ms. Dhaygude Pratiksha Sunil | Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB) | Year of submission : 2021 | Name of Guide / Co-Guide : Dr. U. B. Pethe
	Abstract : The present experiment entitled "Variability and Genetic Diversity Studies in Green gram (*Vigna radiata* (L.) Wilczek)" was undertaken to assess the genetic variability, correlation, path analysis and genetic diversity in twenty-fivegenotypes of cowpea in randomized block design with two replications at Educational and Experimental Research farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during *Rabi* 2020-2021. The estimates of phenotypic, genotypic and environmental variance revealed that phenotypic variance were higher in magnitude than genotypic variance for all the characters. The magnitude of phenotypic and genotypic variance was closer to each other for majority of the characters thus indicating lesser role of environment in the expression of these characters. In general, phenotypic coefficient of variation (PCV) was higher in magnitude over genotypic coefficient of variation (GCV) for all the characters. Different characters showed varying per cent of coefficient of variation at both genotypic and phenotypic levels. High genotypic and phenotypic coefficient of variation

was observed for the characters *viz*., number of pods per plant, harvest index (%) and plant height (cm), while these were low for the characters like hundred seed weight (g), number of pods per cluster, pod length and number of grains per pod.
In present investigation, the genotypic correlation coefficient was higher in magnitude than their phenotypic counter parts for most of characters. Harvest index and number of pods per plant exhibited highly positive significant correlation with seed yield per plant at both phenotypic and genotypic levels. The characters like days to maturity had non-significant positive correlation with seed yield per plant at both phenotypic and genotypic levels.
Seed yield is a complex character and each character had its own effect for establishing correlation with yield. The path coefficient revealed that the characters *viz*., harvest index, hundred seed weight, number of pods per plant, dry matter per plant, number of grains per pod, plant height, days to maturity and. number of clusters per plant had positive direct effect on seed yield at both phenotypic and genotypic levels. While number of branches per plant, pod length and protein content had negative direct effect on seed yield per plant at both genotypic and phenotypic levels. Simultaneously, at phenotypic level the traits like days to initiation of flowering and days to 50 per cent flowering registered negative direct effect on seed yield per plant whereas at genotypic level the traits like days to first flowering, days to 50 per cent flowering had positive direct effect on seed yield per plant.
It is concluded that the genotypes *viz*., KPS-2 followed by KPS-1 and AVMU-1688 are observed as best performers among all the genotypes studied. These had the highest seed yield per plant and also maximum yield attributing characters. The genotype KPS- 2 had maximum hundred seed weight, number of pods per plant, pod length and number of grains per pod. The genotype AVMU- 1677 had highest protein content and BOTHE-1 had maximum plant height. All these above mentioned genotypes can be used as promising genetic material in future breeding programs. There was significant and considerable amount of diversity recorded in present investigation among all the genotypes studied.

35.

Name of the candidate : Mr. Suthediya Vivek Rama	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. S. S. Desai

Abstract : The present investigation entitled, "Genetic diversity studies in kodo millet (*Paspalum scrobiculatum* L.)" was undertaken to access genetic variability, correlation, path analysis and genetic diversity in seventy genotypes of kodo millet in randomized block design with two replications at Educational and Research farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during *kharif* 2020-21.
The analysis of variance revealed significant variation among the genotypes for all the characters studied. The maximum range of variation was observed for the characters plant height, days to maturity, days to first flowering, harvest index, straw yield per plant and number of productive tillers per plant. Higher GCV, PCV, heritability and genetic advance as per cent mean were recorded for thumb raceme length, number of productive tillers per plant, length of panicle, raceme length and grain yield per plant, indicating that simple selection could be effective practice improving these traits.
The correlation studies revealed that days to first flowering. days to maturity, number of productive tillers per plant, length of panicle, raceme length, thumb raceme length, straw yield per plant and harvest index exhibited highly significant and positive correlation with grain yield per plant at both phenotypic and genotypic levels. Path coefficient analysis revealed that, the characters *viz*., days to first flowering and length of panicle had positive direct effect on grain yield per plant at both phenotypic and genotypic levels. Seventy genotypes were grouped into 7 different clusters on the basis of magnitude of D2 values evaluated by using Mahalanobis D2 analysis. The inter-cluster distance was high between cluster II and III, there by indicating wide range of variation among the clusters formed. Hence, the genotypes underlying in these clusters could be selected for hybridization to obtain potential segregants. The character grain yield per

	plant contributed maximum followed by harvest index towards genetic versity. On the basis of results obtained the genotype IPS-744 with high culm branching and semi-compact panicle, ERP-96 with high culm branching and open panicle, IPS-5 with medium culm branching and open panicle, ERP-49 with medium culm branching and semi-compact panicle, IPS-240 with medium culm branching and open panicle are promising genotypes with highest yield along with important yield contributing characters which are ideal for cultivation in *kharif* season.			
36.	Name of the candidate : Mr. Sagar Pareet	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. U. B. Pethe
	Abstract : The present experiment entitled "Variability and path analysis studies in red cowpea (*Vigna unguiculata* (L.) Walp)" was undertaken to assess the genetic variability, correlation and path analysis in twenty-four genotypes of cowpea in randomized block design with two replications at educational and research farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during late *Rabi* 2020-21. The estimates of phenotypic, genotypic and environmental variance revealed that phenotypic variance were higher in magnitude than genotypic variance for all the characters. The magnitude of phenotypic and genotypic variance was closer to each other for majority of the characters thus indicating lesser role of environment in the expression of these characters. In general, phenotypic coefficient of variation (PCV) was higher in magnitude over genotypic coefficient of variation (GCV) for all the characters. Different characters showed varying per cent of coefficient of variation both genotypic and phenotypic levels. High genotypic and phenotypic coefficient of variation was observed for the characters dry matter yield per plant(g), number of pods per plant, iron content (ppm) and seed yield per plant (%), while these were low for the characters like days to maturity and plant height at maturity. The genotypic correlation coefficient was higher in magnitude than their phenotypic counter parts for most of characters. Number of pods per plant and harvest index exhibited highly positive significant correlation with seed yield per plant both phenotypic and genotypic levels. The characters like pod length, plant height at maturity and protein content had non-significant positive correlation with seed yield per plant at both phenotypic and genotypic level. The path coefficient revealed that the characters pod length, hundred seed weight, dry matter yield per plant and harvest index had positive direct effect on seed yield at both phenotypic and genotypic levels. While number of primary branches per plant and protein content had negative direct effect on seed yield per plant at both genotypic and phenotypic levels. Simultaneously, at phenotypic level the traits like number of pods per plant, number of seeds per pod and iron content have recoded the positive direct effect on seed yield per plant. At the same time, at genotypic level the traits like number of pods per plant, number of seeds per pod and iron content have recoded the negative direct effect on seed yield per plant. There was significant and considerable amount of diversity recorded in present investigation among all the genotypes studied. The genotypes GC-0502-2 followed by V-8981-2 and V-4-40-1 are observed as best performers, as they had the highest seed yield per plant and also maximum yield attributing characters. The genotype GOA-local type had maximum hundred seed weight; EC 2027 86 had maximum number of seeds per pod, while CP-15 had the maximum number of pods per plant. The genotype EC-1071 55 had highest protein content, CP-08 had highest iron content and V-4-40-1 had maximum plant height. As per the quality concerned, the genotypes CP-13, CP-08 and CP-15 were the promising one's as they were with rich amount of iron content, protein content and good seed yielders also. All these above mentioned genotypes can be used as promising genetic material in future breeding programs.			

37.	Name of the candidate : Mr. Sirsat Shriniwas Mohan	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. P. B. Vanave
	Abstract : The present experiment entitled "Screening of rice (*Oryza sativa* L.) genotypes at seedling stage for salinity tolerance" was undertaken to assess the morpho-physiological and biochemical performance of thirty seven rice genotypes at seedling stage under salt stress(Control, 5dSm-1 and 10dSm-1) condition in completely randomized block design with two replications at Regional Agricultural Research Station, Karjat, Dist. Raigad during *Rabi*, 2020-21. Data was collected at 25 days after salt stress for seedling height (cm), number of tillers per plant, shoot fresh weight (g), shoot dry weight (g), root fresh weight (g), root dry weight (g), total chlotophyll (mg/g fresh weight), proline content (umol/g fresh weight), Na/k ratio in leaves and roots. Data collected were subjected to analysis of variance. All the characters recorded significant difference due to treatment effects. The morpho-physiological characters i.e. seedling height (cm), number of tillers per plant, shoot fresh weight (g), shoot dry weight (g), root fresh weight (g), root dry weight (g), total chlorophyll (mg/g fresh wt.) at salinity stress levels were significantly reduced. However proline content and Na+/k+ ratio in roots and leaves increased with increasing salinity levels as compared to non-stress condition. Lowest reduction in growth parameters was shown by Kalarata, CSR-36, Bhurarata, Pokkali under increasing salt stress: Whereas the highest reduction in growth parameters was showed by Karjat-6, Karjat-184, Karjat-10, karjat-4, Karjat-8. The lowest Na/k ratio in leaves and roots was found in Bhurarata, Pokkali, CSR-23 and Kalarata while highest Nat/K ratio was showed by Karjat-184, Karjat-6, Karjat-8 and Ratnagiri-5. Therefore on the basis of overall reduction in growth parameters, Na+/k+ ratio in leaves and roots and other studied traits under salt stress Kalarata, Pokkali Panvel-1-2, FL-478, Bhurarata can be identified as highly tolerant to salinity at seedling stage, whereas Karjat-6, Karjat-184, Karjat-10, karjat-4 are most sensitive to salt stress. Estimates of phenotypic, genotypic and environmental variance revealed that phenotypic variance were higher in magnitude than genotypic variance for all the characters. The magnitude of phenotypic and genotypic variance was closer to each other for majority of the characters thus indicating lesser role of environment in the expression of these characters. In general, phenotypic coefficient of variation (PCV) was higher in magnitude over genotypic coefficient of variation (GCV) for all the characters. Different characters showed varying per cent of coefficient of variation both genotypic and phenotypic levels. High genotypic and phenotypic coefficient of variation was observed for the characters Na+/K+ ratio in roots and root dry weight. In present investigation, the genotypic correlation coefficient was higher in magnitude than their phenotypic counter parts for most of characters. The genotypic correlation coefficient was higher in magnitude than their phenotypic counter parts for most of characters. Under salt stress all the traits showed highly significant positive phenotypic and genotypic correlation with shoot fresh weight except for Na*/k ratio in roots and leaves at both phenotypic and genotypic level.			
38.	Name of the candidate : Mr. Pardeshi Parajwal P.	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. R. L. Kunkerkar
	Abstract : The present investigation entitled, "Analysis of genetic diversity in retention of quality traits of rice under konkan coastal conditions (*Oryza sativa*. L)" was undertaken to asses genetic variability, correlation, path analysis and genetic diversity in 24 genotypes of rice in Randomized Block Design with			

	three replications at Educational and Research farm, Regional Agricultural Research Station, Karjat, Dist.Raigad, Maharashtra during *kharif* 2020. The analysis of variance revealed significant variation among the genotypes for all the characters studied. The maximum range of variation was observed for the characters, Number of filled spikelets per per panicle, Number of spikelets per panicle, Water uptake, Plant height, Gel consistency, Days to maturity and Days to 50% flowering. Higher GCV, PCV, heritability and genetic advance as per cent mean were recorded for Test weight, Number of filled spikelets per panicle, Grain yield per plant, Straw yield per plant and Number of filled spikelets per panicle, indicating that simple selection could be practiced for improving these traits. Genotype Karjat-3 demonstrate the maximum Grain yield per plant among all the genotypes. High genotypic coefficient of variation was observed for Number of spikelets per panicle, Test weight, Number of filled spikelets per panicle, Grain yield per plant, Amylose content, L:B ratio, Straw yield per plant, Days to maturity, Gel consistency, Days to 50% flowering and Spikelet fertility. These traits also possess high heritability with high. genetic advance hence the selection for these traits was effective. Association analysis indicated that there was positive correlation among Grain yield per plant with Straw yield per plant, Grain breadth and Harvest index while, the Test weight also showed highest highly significant positive correlation with Grain breadth followed by Grain yield per plant. Straw yield per plant and Volume expansion ratio. Test weight had significant positive correlation with Milling percentage followed by Hulling percentage and Harvest index. Selection for these traits can be effectively improve Grain yield. Among the yield components, Genotypic and phenotypic path coefficient analysis showed that Straw yield per plant, Test weight, Grain breadth Harvest Index and Panicle length had the highest positive direct effect on Grain yield per plant where as Grain length and Elongation ratio also found to positively significant for yield. Among these characters, Number of productive tillers per plant possessed both positive association and high direct effects. Hence, selection for this character could bring improvement in yield and yield components. The 24 genotypes were grouped into 5 different clusters on the basis of magnitude of D^2 values evaluated by Mahalanobis D^2 analysis. The inter-cluster distance was high between cluster IV and Cluster V, there by indicated wide range of variation among the clusters formed. Hence, the genotypes underlying in these clusters could be selected for breeding programme to obtain potential sergeants. Genotypes OR(CZ)-64, R 2054-147-2-104-1, CR 3663-261- 8-4, R1915-115-1-88-1 and JDP-S-38 was found to be aromatic rice with other desirable trait such as higher Number of tillers per plant and Straw yield per plant. These genotypes can be utilized in breeding programmes in future.
39.	Name of the candidate : Mr. Pendyala Saikiran | Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB) | Year of submission : 2021 | Name of Guide / Co-Guide : Dr. S. S. Desai
	Abstract : The present experiment entitled "Genetic Diversity Studies in Rice (*Oryza sativa* L.) Genotypes" was undertaken to assess the genetic variability, correlation, path analysis and Genetic divergence in fifty rice genotypes. These genotypes were evaluated during *Kharif* 2020 in a Randomized Block Design with three replications at Agricultural Research Station, Shirgaon, Dist. Ratnagiri and Quality Analysis was done at Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra. The estimates of phenotypic, genotypic and environmental variance revealed that phenotypic variance was higher in magnitude than genotypic variance and environmental variance for all the characters but the differences between phenotypic variance and genotypic variance for many characters was less, suggesting the less impact of environment for those characters.

	In general, phenotypic coefficient of variation (PCV) was higher in magnitude over genotypic coefficient of variation (GCV) and environmental coefficient of variation (ECV) for all the characters. High genotypic and phenotypic coefficient of variation was observed for the characters number of filled grains per panicle. number of tillers per plant, total number of spikelets per panicle, test weight and L/B ratio. Heritability and genetic advance are the essential selection parameters. High heritability estimates along with high genetic advance as percent of mean were recorded for number of tillers per panicle, number of filled grains per panicle, total number of spikelets per panicle, test weight, L/B ratio, grain breadth, grain length, amylose content, protein content, straw yield per plant, grain yield per plant and plant height. Therefore, improvement of these characters would be more effective in crop improvement programme. Character association studies observed that the genotypic correlation coefficients were higher in magnitude than their phenotypic counter parts. The genotypic and phenotypic correlation of grain yield per plant was recorded highly significant and positive correlation with straw yield per plant, number of filled grains per panicle, number of spikelets per panicle, harvest index, test weight and number of tillers per plant, while it had positive non-significant association with spikelet fertility and grain breadth at both phenotypic and genotypic levels. Path coefficient analysis revealed that, the characters *viz*., plant height, number of tillers per plant, grain breadth, L/B ratio, straw yield and harvest index had positive direct effect while, test weight, grain length and amylose content exhibited negative direct effect on grain yield per plant at both phenotypic and genotypic levels. The character number of filled grains per panicle and protein content had positive direct effect on grain yield per plant at phenotypic level and negative direct effect at genotypic level. The character days to 50% flowering, days to maturity, panicle length, number of spikelets per panicle and spikelet fertility had negative direct effect on grain yield per plant at phenotypic level and positive direct effect at genotypic level. The fifty genotypes were grouped into six clusters on the basis of mahalanobis D2 statistics. Among six clusters, The Cluster I was the largest which consisted of 45 genotypes, while remaining five clusters comprising with one genotype each (mono genotypic). The maximum intra-cluster distance was observed in cluster 1 (D-12.90), While the inter-cluster distance was high in cluster IV and VI followed by cluster III and VI indicated wide range of variation among the clusters formed. Hence, the genotypes underlying in these clusters could be used in hybridization programme for further crop improvement in rice. Out of seventeen characters studied, grain yield per plant (g) (16.51%) recorded highest contribution towards genetic divergence followed by harvest index (13.55%) and grain length (12.08%). Hence, these characters may be considered during selection of genotypes for further rice improvement programme. On the basis of results, 14 out of 50 genotypes were medium slender grain type based on magnitude of grain length and L/B ratio. The medium slender grain type is most preferred grain type. Intermediate to amylose content in rice is considered as good quality genotype. 24 genotypes were intermediate for amylose content and DRR-50-13 recorded high protein content. The genotypes *viz*., RTN-214-1-1-1-2 (26.76 g), RTN-8 (26.71 g), RTN- 11-2-1-3 (26.38 g), RTN-6 (24.83 g) and KJT-3R (24.71 g) were showed relatively high yield. These genotypes can be used as promising genetic material in future breeding programme.

40.	Name of the candidate : Mr. Salvi Sanjay Atmaram	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. V. V. Dalvi
	Abstract : The present investigation was undertaken to study variability, diversity and correlation in Kodo millet. The material for the present study comprised of forty eight genotypes collected from All India Co-ordinated Small Millets improvement project, GKVK, Bangaluru (India) which were grown in Randomized block design with two replications during *kharif* 2020-21. The analysis of variance revealed significant variation among the 48 genotypes for all the characters studied. The estimates of mean sum of squares showed comparatively wide range of variation for almost			

	all the characters studied. The maximum range of variation for the characters plant height (cm), days to first flowering, days to maturity, length of panicle (cm), while less range was observed in calcium content (%) raceme number and. In general, phenotypic coefficient of variation was higher in magnitude over the respective genotypic coefficient of variation for all the characters. Different characters showed varying percent of coefficient of variation at both phenotypic and genotypic levels. High genotypic and phenotypic coefficients of variation were observed for the characters length of panicle, thumb raceme length, grain yield per plant and straw yield per plant while these were low for the characters days to first flowering, days to maturity, protein content, calcium content and harvest index.. High heritability was observed for the characters plant height, length of panicle, straw yield per plant, raceme length, days to first flowering, grain yield per plant, thumb raceme length, raceme number, protein content and number of productive tillers per plant. High estimates of heritability coupled with higher genetic advance as per cent of mean was observed for length of panicle, straw yield per plant, thumb raceme length and grain yield per plant thus indicating the role of additive gene action in the expression of these characters and can be improved by selection. In the present investigation, the genotypic correlation coefficients were higher in magnitude than their phenotypic counter parts for most of the characters. The correlation studies revealed that days to first flowering, days to maturity, plant height, length of panicle, raceme length, thumb raceme length and straw yield per plant exhibited highly significant positive correlation with grain yield per plant at both phenotypic and genotypic levels. The character harvest index had positive highly significant correlation with grain yield per plant at phenotypic level and positive significant correlation at genotypic level. Among the remaining traits number productive tillers per plant and protein content showed positive non-significant correlation with grain yield per plant at both levels, whereas raceme number and calcium content showed negative non-significant correlation at phenotypic and genotypic level. Forty eight genotypes were grouped into 4 different clusters on the basis of magnitude of D2 values evaluated by Mahalanobis D^2 analysis. Among forty eight genotypes, 40 genotypes were clustered into first cluster followed by cluster III having 6 genotypes. Cluster II and IV were mono genotypic, which consisted of the genotypes GPLM-389 and GPLM- 506. The maximum intra-cluster distance was observed in cluster III (D= 10.93), thus suggesting that different genotypes included in this cluster might have different genetic architecture. The inter-cluster distance was high between cluster I and VI (D-31.58) and cluster II and IV (D=20.24), there by indicated wide range of variation among the clusters formed. Hence, the genotypes underlying in these clusters could be selected for hybridization to obtain potential segregants. Among the thirteen characters studied, grain yield per plant (20.06%) contributed maximum followed by straw yield per plant (14.5%) towards genetic diversity. Hence, these characters may be considered during selection of genotypes for further improvement. On the basis of results the genotypes GPLM-506 exhibited maximum grain yield per plant followed GPLM-288, hence observed as best performers in the studied population.
41.	Name of the candidate : Ms. Devrukhkar Asmita | Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology) | Year of submission : 2021 | Name of Guide / Co-Guide : Dr. S. G. Mahadik
	Abstract :The present investigation entitled "Evaluation of Wal (Lablab purpureus L.) cultures under residual moisture condition." grown under residual moisture in Konkan region was carried out at Agronomy Farm, Department of Agronomy, College of Agriculture, rabi 2020-2021. The lablab bean was sown during rabi season after harvest of paddy under residual moisture. The experiment were laid out in randomized block design with 11 treatment and three replications with an object to study the effect of moisture stress on morph physiological parameters, biochemical and yield attributing characters. Data were

	collected on moisture content in soil, days to flowering, 50% flowering, days to physiological maturity, plant height, number of branches, number of leaves, dry matter accumulation, total chlorophyll content, chlorophyll stability index, relative water content, AGR, RGR. NAR, Leaf area, LAI, LAD, number of pods per plant, pod yield per plot and other yield related character at the interval of 30, 60, 90 DAS and at physiological maturity. a collected were subjected to analysis of variance. Data Soil moisture content in initial stage was maximum 30.06% and decreased gradually with advancement of crop growth. The minimum soil moisture was observed at harvest it was 15.11%. Early days to flowering recorded in treatment T7 and lowest days to 50% flowering and physiological maturity observed in T2 and T4 respectively. Maximum plant height observed in treatment T6 (116.43 cm) and maximum branching was observed in T6 (22.77). Cultures ranged from 65.06 to 42.86 for number of leaves. Highest total dry weight was observed in T6 (21.276 g plant -1) and lowest was observed in T4 (10.886 g plant-^{1}). Maximum chlorophyll content was recorded in T6 (1.410 mg/g) during 60 DAS. Highest chlorophyll stability index was observed in treatment T6 (65.24 %) at harvest. Maximum relative water content noted in T6 (85.06 %) where minimum in T3 (74.96 %) during 90 DAS. At harvest AGR ranged between Ts (0.0722 g/day and T11 (0.0007 g/day). At harvest RGR ranged between T11 (0.0559 g/g/day) and T8 (0.00213 g/g/day). At harvest NAR ranged between T7 (0.000763 g dm-2 day-1) and T11 (0.00000523 g dm-2 days-1). Maximum leaf area was observed in T6 (911.04 cm² plant) and minimum was observed in T1 (531.03 cm² plant ^{1}). Maximum LAI was recorded in T6 (1.011) and minimum was in T: (0.589). Highest LAD was showed by treatment T6 (32.08 days). Highest harvest index found in T6 (23.72 %) and lowest in Ts (14.12%). Maximum number of pods per plant was found in T6 (16.53) and pod yield per plot also maximum found in T6 (728.33 g). 100 grains weight was found maximum in T6 and T7 (22.00 g). Number of primary branches was observed highest in T6 (5.73). Highest number of grains per pod was found in T11 (5.06). Maximum seed yield per plant was noted in T6 (32.33 g) and also seed yield per plot ranged between 435 g and 195.66 g. This indicates the large variation among cultures. Among all cultures treatment T6 (DPLW-6) was found superior for morphophysiological, biochemical and yield contributing character.
42.	Name of the candidate : Ms. Shinde Shweta Subhash | Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant Physiology) | Year of submission : 2021 | Name of Guide / Co-Guide : Dr. S. G. Mahadik
	Abstract : A field experiment was conducted at Vegetable Improvement Scheme, Central Experimentation Station, Wakawali, Tal. -Dapoli to study the "Morpho-physiological characterization of brinjal [(Solanum melongena L.)]" genotypes under konkan climatic conditions" during Rabi season 2020-21. The twenty nine brinjal genotypes were grown in randomized block design in two replications. The morphological, phenological, physiological and growth related observations were recorded at 60, 90 and 120 DAT. The yield and yield attributing characters were recorded at harvest, replication and genotype wise. The highest (99.7%) germination per cent were observed in genotypes Swarn Pratibha (Ti), Kasral local (Tis) and Konkan Prabha (T29); whereas maximum (1311.24) seedling vigour was recorded in genotype Arka Nidhi (T27). The genotype Swarn Pratibha (T1) showed maximum leaf area (11078.9 cm2/plant) and leaf area index (4.103) at 120 DAT among genotypes. Maximum branching (10.1) was observed in genotype Swarn Pratibha (T) and maximum (297.82 g) total dry matter production observed in genotype Swarn Pratibha (T). The genotype CHES-249 was required least days (65.1 days) to 1 flowering and the genotype D-79-19 required least days (73.6 days) to 1 fruit setting. The significant differences among the genotypes for RWC, CGR, AGR, RGR and NAR at various stages of growth played an important role in yield determining processes. The values of this growth parameter increased between 60 and 90 DAT and declined thereafter towards maturity. The maximum relative water content noted in genotype Swarn Pratibha (T) (90.37%) where minimum in Panhalekazi local (T20) (83.14%) during 120 DAT. At 90-120 DAT, CGR ranged

between Swarn Pratibha (T) (0.000879 g/m²/day) and Panhalekazi local (T20) (0.000144 g/m²/day). At 90-120 DAT maximum AGR was recorded in Swarn Pratibha (T_1) (2.373 g/day). The RGR was observed maximum in genotype Swarn Pratibha (T) (0.00395 g/g/day) and minimum (0.00201 g/g/day) was in genotype Arka Nilkanth (Ts) and BGTP-1 (T12) during 90-120 DAT. The highest NAR was recorded in Swarn Pratibha (T) (12.13×10 g/dm³/day) and was the lowest in genotype BGTP-1 (T2) (6.01x105 g/dm2/day). The genotype BB- 54 (To) (38.69) recorded the highest number of fruits per plant and the lowest in genotype Panhalekazi local (T20) (13.86). Swarn Pratibha (Ti) recorded the longest length of fruits (13.62 cm) and the shortest in genotype Kali Rawai (T) (5.32 cm). Diameter of fruit was maximum (5.43 cm) in genotype CHES-249 (T3), while minimum (2.44 cm) fruit diameter was found in genotype Dapoli local-2 (T23). Genotype Swarn Pratibha (Ti) produced the highest fruit yield per plant (3.54 kg); while Panhalekazi local (T20) produced the lowest fruit yield per plant (0.42 kg). Single fruit weight was the highest in the genotype Kasral local (Tis) (113.31 g) and the lowest in genotype Panhalekazi local (T20) (24.22 g). The genotype Swarn Pratibha (T) showed the highest (92.34%) harvest index and the lowest (66.9%) in genotype Panhalekazi local (T20). This indicates the large variation among genotypes.

The highest positive correlation with fruit yield per plant was exhibited by relative water content (r=0.8302). This may be due to the better carbon assimilation and translocation efficiency and also tend to have greater efficiency for better partitioning of photo- assimilates towards reproductive growth in order to have better yield. These studies will be helpful in determination of physiological traits responsible for fruit yield of brinjal, which as the result of derivable morpho-physiological attributes observed in these genotypes. Among all genotypes, Swarn Pratibha (Ti) was found superior for morphological, physiological and yield attributing characters.

43.	Name of the candidate : Mr. Thorat Balaji Shivaji	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. S. G. Bhave

Abstract : The present investigation entitled "Genetic variability, diversity and stability study in Niger (Guizotia abyssinica L.)"was undertaken at five environments Piz. ARS, Phondaghat (E1), ARS, Shirgaon (2), Department of Agril. Botany, Dapoli (13), RARS, Karjat (4) and ARS, Palghar (15) with research objectives (1) To study the nature and extent of genetic variability in yield and yield contributing traits (ii) To measure the divergence between different genotypes by D' statistics (ii) To study the stability of Niger genotypes under different environments and (iv) To study the G x E interaction for yield and yield contributing traits. The material for the present study comprised of forty genotypes of Niger collected from all over Maharashtra state. Evaluation of these genotypes in Randomized Block Design with three replications was done during Kharif, 2018 and Kharif, 2019 with all recommended package of practices. The observations were recorded on 13 characters viz, days to 50 per cent flowering, plant height (cm), number of primary branches plant, number of secondary branches plant, number of capitula plant!, capitulum diameter (cm). number of seeds capitulum, 1000 seed weight (g), seed yield plant (g), seed yield plot (g), days to maturity, oil content (%), protein content (%) etc.

From the present study it was concluded that the significant variation was present among the genotypes studied for all the traits except capitulum diameter and 1000 seed weight. Among all, G36, G24, G32, G40, C38, G10, G4 were recorded highest mean performance in most of the characters. The phenotypic coefficient of variation (PCV) was slightly more than genotypic coefficient of variation (GCV) for all the traits, indicating the role of environment in the expression of these traits.

Broad sense heritability was highest for days to 50 per cent flowering, number of primary branches plant, number of secondary branches plant, number of capitula plant¹, capitulum diameter and days to maturity indicating these traits were least influenced by environments and selection for improvement of such characters may be useful. The highest genetic advance and genetic advance per cent mean was observed in

	seed yield plant, seed yield plot, number of capitula plant¹ and number of seeds capitula¹. These traits were governed by additive genes and selection for improvement is useful. The high heritability coupled with high genetic advance indicated preponderance of additive gene action in the inheritance of most of the yield contributing traits and these were used for future crop improvement. As per inter and intra-cluster distance coupled with cluster means of different traits, the genotypes classified in clusters IV, V and III in El; clusters III and IV in E2; clusters II and IV in E3; clusters VIII, III, VI and VII in E4, and III and IV in E5 were found to be superior and showing the wealth of genetic diversity for exploitation in future breeding programs. The genotypes, G1, G2, G4, G8, G9, G10, G24, G25, G26, G28, G32, G35, G36, G39 and G40 were identified as diverse in all tested environments as per D2 statistics and these were suggested as potential parents in future crop improvement programme. The highest contributors towards the genetic divergence were days to 50 per cent flowering, number of primary and secondary branches plant, number of capitula plant¹ and capitulum diameter. Combined analysis of variance was highly significant for genotype, environment and their interaction (GED) for all the traits except capitulum Jmeter and 1000 seed weight Analysis of variance for AMV mo gope environment and their interaction (CE CAL, SPCA2 and CAS highly significant for all the characters, indicating envi diverse and affects the performance potential of genotypes. Consideration of b Regression as well as AMMI stability model, among all, GM, G32, 024 and G were found most stable and ideal genotypes which indicating highest mean yield and maximum additive main effect (AMMIT) with least interaction between genotype x environment. The genotypes located on vertex of GCE biglot polyg JAMM2 G25 and G1 were the best at El: G8 was classiest at E2 Ge was the escent at E3, G23 and G17 were the pre-eminent in E4, and G14 was the winning genotype at E5, suggesting highest interaction between gotype and environment for seed yield plot. The genotypes, G G G22 and G28 were suitable for favorable/rich environments while G2, G4, G7, G23 and C31 for unfavorable/poor environments in most of the traits. The genotypes, GL, GIT, G25 and GDS were best performers in some environments for few yield contributing traits. These genotypes behaved as a potential breeding materials sock for future crop improvement. AMMI GGE biplots were identified two different mega-environments (METS), the first MET consists EL E3 and E4 which are potential, highly discriminating and representative, and would be used to identification of superior genotypes and second MET includes E2 and E5 were sable places for most of the characters. On the basis of per se performance, genetic variability, genetic diversity and different stability parameters viz, high mean, regression coefficient (b) deviation from regression (S'di), IPCA1 scores, ASV, GSI revealed that the penotypes, G36, G32, G24 and G10 were found highly stable for yield and yield contributing traits over the seasons and over the environments. Therefore, these four genotypes were identified as candidate genotypes and are recommended for future investigations.

44.	Name of the candidate : Ms. Jasti Srivarsha	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. V. V. Dalvi
	Abstract : The present investigation on genetic variability, diversity, heterosis, combining ability and stability for fruit yield and its contributing traits and screening for yellow vein mosaic virus disease resistance in okra (*Abelmoschus* sps) was carried out during summer 2018 at Botany farm, Department of Agricultural Botany, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and *kharif* 2019 at Agricultural Research Station, Palghar, Agricultural Research Station, Phondaghat and Botany farm, Dapoli of three districts Palghar, Sindhudurg and Ratnagiri respectively. Twenty six genotypes of okra including indigenous and exotic lines were evaluated for fourteen yield and yield attributing traits during summer 2018 in randomized block design with three replications. The			

	analysis of variance (ANOVA) revealed significant differences for all the fourteen traits under study suggesting the existence of required genetic variation in the breeding material. Higher PCV and GCV estimates were recorded by plant height, fruit length, fruit yield per plant, shoot and fruit borer incidence on fruits, number of fruits per plant and yellow vein mosaic virus per cent disease incidence. High to very high heritability (broad sense) was observed for all the traits except number of ridges per fruit, number of locules per fruit and individual fruit weight. By diversity analysis, all the genotypes were grouped into four clusters based on Mahalanobis D' statistics. Cluster I was the largest consisting of eight genotypes. YVMV incidence contributed maximum followed by number of fruits per plant for the divergence. None of the genotypes were immune or free for the YVMV incidence. Twelve parents were selected based on the per se performance and diversity analysis. They are crossed in linex tester (7×5) fashion and thirty five hybrids are developed. These thirty five crosses along with twelve parents and standard checks Varsha Uphar and MH-10 are evaluated during *kharif* 2019 at three locations. Heterosis studies revealed that with respect to fruit yield per plant, significant and positive heterosis was exhibited by eleven hybrids over mid parent, ten hybrids over better parent, six hybrids over standard check Varsha Uphar and five hybrids over standard check MH10. On pooled basis, IC013664 × IC008991, IC013999-A IC008991, IC013999-A × IC006485, IC433645 x IC008991 and IC015540 IC008991 registered positive and significant mid-parent heterosis, better parent heterosis and standard heterosis over both the checks. Among them, two hybrids IC013664 IC008991 and IC013999-A × IC008991 exhibited positive and significant midparent heterosis, better parent heterosis and standard heterosis over checks Varsha Uphar and MH10 in the individual environments as well as on pooled basis. Combining ability studies revealed that across the environments, three lines *viz*.. IC013999-A, IC013664 and IC015540 and two testers *viz*., IC008991 and IC006485 registered positive and significant gea effects for fruit yield per plant. Eight crosses *viz*.. IC013999-A IC010265, EC306703 IC14018, IC013664 x IC16566, IC013664 × IC008991, IC009856-C IC006485, IC433645 IC16566, IC015540 IC16566 and IC015540 IC008991 registered positive and significant sca effects for fruit yield per plant across the environments. IC013664, IC433645, IC015540 and IC008991 registered regression coefficient (b.) value around one and deviation from regression (S'd) value around zero indicating their stability for fruit yield per plant. Five crosses, IC013664 IC008991, IC013664x IC16566, IC013999-A IC008991, IC015540 IC008991 and EC306697 IC008991 registered high mean performance, b, value around one and S'd value around zero indicating their stability across environments. The crosses IC013664 IC008991 and IC013999-A IC008991 registered high per se performance, positive and significant heterosis over mid-parent, better parent and standard checks Varsha Uphar and MH10 with desirable sca effects and high to moderate resistance to yellow vein Mosaic virus and Okra shoot and fruit borer in all the environments as well as on pooled level along with stability across environments for fruit yield per plant and some of its attributing traits. These hybrids may be further tested over locations, seasons and years before recommending for commercial cultivation.

45.	Name of the candidate : Mr. Palshetkar Mahendra G.	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. S. V. Sawardekar
	Abstract : The present investigation entitled "Induction of genetic variability through mutagens and it's assessment by molecular markers in Pigeonpea (*Cajanus cajan* L.)" was carried with aim to create genetic variability by using different mutagenic treatments of gamma rays, EMS and their combination in pigeonpea cultivar Konkan Tur 1. The trials were carried out during *kharif* 2019 and *kharif* 2020 at Botany farm, Department of Agriculture Botany, College of Agriculture and molecular analysis was carried out in the laboratory of Plant Biotechnology Centre, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli. Decreasing trend was observed for per cent germination in all mutagenic treatments with increased dose of			

mutagen under laboratory as well as under field condition. Similar trend was also recorded in germination index, mean daily germination, shoot length, root length and vigour index. Considering laboratory and field observation on per cent germination and other related parameters, LDso dose was optimized. For gamma rays mutagenic treatment 300Gy, for EMS mutagenic treatment, 0.20% of EMS and for combination treatment 300Gy + 0.20% EMS doses were optimized as a LD50 dose. During the generation, only three leaf shape mutants were observed in all mutagenic treatment out of them two were oblong leaf shape (300 Gy) and one obovate leaf shape (0.10% EMS). As well as early flowering. late flowering, yellow and red colour flowers with medium, dense and absent types of streaks on standard petal, green, green with purple streaks and purple colourpods and high yielding mutants were recorded during M, generation. Four types of chlorophyll mutations *viz*. Albina, Xantha, Chlorina and Striata, were noticed in all mutagenic treatments. Mutation frequency, mutagenic efficiency and mutagenic effectiveness were reduced as per the increased dose of mutagen. Wide range of variation was observed in quantitative characters during M_2 generation *viz*, days to Initiation of flowering (99-148 days), maturity duration (149-204 days), plant height (86-346 cm), number of primary branches (2-19), number of effective pods per plant (36-525), per cent pod borer damage (5.63-85.20), number of seed per pod (2.0-4.6), 100 seed weight (7.0-15.6 g) and seed yield per plant (12.8-128.1 g).

During My generation various phenotypic variants were recorded, obovate and narrowly oblong leaf shapes, two types of standard petal colour *viz*, yellow and red, determinate, spreading, semi spreading, erect and winy growth habit plants, three types of pod colours *viz*., green, green with purple streaks and purple pod and dark brown and purple seed coat colour mutants were noticed. The per cent polymorphism was estimated by using 20 ISSR primers. total of 5345 DNA fragments were produced and among them 3069 DNA fragments were found to be polymorphic in the 53 mutants of pigeonpea. The maximum per cent dissimilarity was observed in mutants T, (41)10 (83.90) followed by T10 (15)1 (83.50), T, (81)4 (83.40), T, (67)15 (81.60) and T, (72) 5 (80.70). It indicated that these mutants were more distinct than the control. The cluster analysis based on ISSR data divided the mutants in two main groups; first cluster contains 14 mutants and second cluster 39 mutants and one control.

46.	Name of the candidate : Mr. Kadam Siddharth Rajaram	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. S. G. Bhave

Abstract : The present investigation entitled, "Genetic analysis of red kernel rice (*Oryza sativa* L.)" was aimed at bio-fortification of rice, which was expected to develop Zinc and Iron rich high yielding red kernel rice genotypes with good plant stature, high consumer preference and good agronomical traits. Six female having white kernel and four restores having red kernel rice genotypes were employed in the present study.

The per se performance of hybrids for grain yield and its components was in general related to the heterotic effects. This revealed that selection of hybrids either on the basis of per se performance or on the basis of magnitude of heterotic effects and inbreeding depression would also be reliable. Among the lines, Palghar I and Trombay Karjat Kolam and among testers Munga and Valai were recognized as good general combiners for grain yield plant and some other yield related traits. SCA was higher than the GCA in most of the characters which indicated the presence of non-additive gene effect in that traits. The mode of inheritance of red pericarp was studied in 24 crosses. All F plants from white rice x red rice crosses produced red kernel colour, confirmed that red kernel colour was a dominant trait. Proportion of plants with red and white pericarp in F; population closely fitted in the ratio of 3:1 (red:white) seed colouration. It indicated that red colour of pericarp was governed by a single dominant gene. While, the ratio for the hull colour indicating the digenic inheritance with inhibitory and complimentary gene interaction.

	Regarding Zinc (Zn) and Iron (Fe) content in rice grains of F, hybrids Palghar 1 x Valai and Ratnagiri 6 x Valai recorded significantly higher Iron content and crosses Karjat 4 x Bela and Ratnagiri x Bela recorded higher Zinc content than existing red kernel rice variety Ratnagiri 7 in both brown and polished rice. After further evaluation of the F, crosses for Zinc (Zn) and Iron (Fe) content, it is concluded that the F_2 progeny of the crosses Karjat 4 x Kudai and Karjat 9 x Kudai recorded high Iron content. While Ratnagiri 6 x Bela and Palghar 1 x Bela showed high Zinc contents. Therefore, these genotypes would be promising for getting desirable segregants for Zn and Fe contents.			
47.	Name of the candidate : Mr. Chavan Bhagwat R.	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. V. V. Dalvi
	Abstract : The present investigation entitled, "Evaluation of Aromatic Compounds in Rice (*Oryza sativa* L.)" Under Different Environments in Konkan Region" was aimed for screening of rice cultivars for existence of aroma at various growth stages under different dates of sowing in Konkan conditions, detection of various volatile compounds in grains of rice cultivars under various dates of sowing and to study the growth and yield performance of aromatic rice at different dates of sowing. The experiment was carried out by collecting fifteen aromatic rice genotypes from the Regional Agriculture Research Station (Raigad) and sown at six dates of sowing during *kharif* 2019 and *Rabi* hot weather 2019-20. The experiment was laid out in a Randomized Block Design (RBD) with three replications. This experiment was undertaken at Educational and Research farm Department of Agricultural Botany, College of Agriculture, Dapoli. The large amount of variation was noticed for all the characters including quality parameters in each sowing. The genotype PR-115 had mild scent during seedling stage at all the six sowings and strong scent during flowering, maturity and after cooking followed by BM-4 showed the mild scent during seedling, maturity and after cooking, whereas it had strong scent during flowering stage at all six sowing. All the fifteen genotypes showed the mild to strong scent during flowering stage in all the six sowing environments, however only eight genotypes *viz*.. BM-4, Indrayani, Pawana, Bhogavati, Kothmirsal, Basmati-376, Basmati-386 and Basmati-370 showed mild to strong aroma during maturity stage in all the six sowing environments, Among the different dates of sowing, different volatile compounds were found *viz*. Ethanol. 2-Hexanol, 1-Propanol. 1-Pentanol. 2-Pentanol, Acetaldehyde, Hexanal, Pentanal, Butanal, Benzaldehyde, Formic acid. Acetic acid. Dodecanoic acid, Hexadecanoic acid. Benzene, 2-Butylfuran, 1,2- Benzenediol. Heptane. Cyclohexasiloxane. Phenol, Benzenethiozole and Trichloromethane. There is no any consistency in the aroma as well as in aromatic compound with genotype and dates of sowing. Aromatic compounds varies with the season/sowing even within a single genotype. The genotypes Indrayani, Pawana, Bhogavati, Chimansal, Basmati-376. Basmati-386, Basmati-370 and Basmati-1017 showed better performance and found superior for all the characters during *kharif* seasons. The sowing time significantly affects the entire yield and yield components of different rice varieties. Among all the dates of sowings D, (20th June) followed by D, (30th May) are best dates of sowings for Konkan region. Days to 50 % flowering, plant height (cm), number of tillers per plant, length of panicle (cm), number of grains per panicle, total filled grains per panicle, total unfilled grains per panicle, spikelet fertility (%), grain yield per plant (g), straw yield per plant (g) and harvest index (%) these characters showed the remarkable variations among different six sowing times. It indicated that these traits are highly influenced by the climate so they are more sensitive traits. Test weight (g), amylose content (%), kernel length (mm), kernel breadth (mm). L/B ratio (mm), cooked rice length (mm), cooked rice breadth (mm) and kernel elongation (mm) these traits showed that there was no any considerable variations in average values of all the genotypes among six sowing windows, indicate that these characters are less affected by the environment.			

	Thus, to find an optimal cultivation condition for fragrant rice cultivars. identification of interactions between environmental factors that can improve rice aroma quality and productivity is a prerequisite. The indigenous aromatic land races which possess excellent grain quality and can be a great source of increased farm income. The superior genotypes identified from the above study can be utilized as breeding material for genetic improvement.			
48.	Name of the candidate : Ms. Joshi Shilpa Narhar	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(GPB)	Year of submission : 2021	Name of Guide / Co-Guide : Dr. S. S. Desai
	Abstract : The present investigation entitled "Studies on Heterosis, Combining ability and Molecular Analysis in Red Cowpea (*Vigna unguiculata* (L.) Walp)." was carried out to assess the genetic diversity through ISSR markers, heterosis and combining ability in red cowpea for phenological traits, yield and yield contributing characters and quality attributes. The laboratory experiment was conducted during 2019-20 at Plant Biotechnology Centre and field experiment was conducted in 2020-21 at Education and Research Farm, Department of Agril. Botany, College of Agriculture, Dapoli using Randomized Block Design. The molecular diversity analysis carried out using ISSR markers revealed the substantial amount of genetic variability present among the 32 genotypes of red cowpea including 3 released varieties depicted through the dendrogram as well as clustering pattern among them.			
49.	Name of the candidate : Mr. Shinde Sandeep Govindappa	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(GPB)	Year of submission : 2022	Name of Guide / Co-Guide : Dr. B. D. Waghmode
	Abstract : The present investigation entitled as “Genetical studies, phenotyping and molecular profiling of diverse germplasm of rice (*Oryza sativa* L.)” was undertaken with the objectives of characterization of 95 diverse rice germplasm by 62 DUS morphological descriptors, supplemented with molecular profiling by using simple sequence repeat markers and their subsequent evaluation for distinctiveness, uniformity and stability. The nature and extent of variability, heritability, genetic advance and diversity present among the germplasm based on yield and yield contributing parameters was studied to identify potential parents/donors for the hybridization programme. RBD trials were conducted in two subsequent and independent *Kharif* seasons of 2020 and 2021 at experimental farms of Agricultural Research Station, Shirgaon and Regional Agricultural Research Station, Karjat respectively. Data was recorded for 27 metric characters inclusive of 14 measurable DUS traits and 62 DUS descriptors of rice as per PPV & FR guidelines. Whereas molecular profiling of 95 rice genotypes using 17 SSR primers was carried out at Plant Biotechnology Center, College of Agriculture, Dapoli. A perusal of genetic parameters *viz*., phenotypic and genotypic coefficients of variation revealed less influence of environment on the characters under study for both two seasons and locations. Therefore, response to direct selection may be effective in improving these traits.All the characters under study for both the locations exhibited high heritability except alkali spreading value which showed lowest heritability: Implying that these characters were under control of additive gene action and direct selection of these traits would be effective for crop improvement.Divergence studies through D2 statistic indicated the presence of substantial diversity by forming large number of clusters (22 clusters at Shirgaon and 20 clusters at Karjat) with wide range of inter-cluster distances.Seventeen SSR primers were used in this study and all amplified and showed the polymorphism in rice genotypes. A total of 139 loci were generated by 17 primers. Each primer thus produced on an average 8.17 loci in the size ranging from 132 bp to 884 bp in the 95 rice genotypes in relation to diversity assessment. Among 17 SSR markers, all the primers showed 100 per cent			

	polymorphism. The PIC values of primers ranged from 0.70 in SSR primer RM 7 to 0.92 in SSR primer RM 8225 with an average PIC value of 0.83. The Jaccard's pair wise similarity values ranged from 0.027 to 0.994. Dendrogram was constructed using Jaccard's similarity coefficient and rice genotypes were grouped into two clusters based on SSR markers. Among the total 62 DUS descriptors, 9 were monomorphic, 15 were dimorphic and 37 were polymorphic in nature. COY-D analysis with respect to 14 measurable traits indicated that all the genotypes were distinct from each other during both the years. All the visually assessed characteristics did not show any variation in their states of expression over the years of study and hence considered to be uniform. All the varieties studied for forty 62 assessed DUS descriptors exhibited the same state of expression over the two years and thus considered stable. It may be concluded from the present investigation that the morphological DUS descriptors can be effectively used for identification and grouping of the varieties. Application of biochemical and molecular markers may help in establishing distinctiveness to support morphological marker. The varieties studied for DUS descriptors can be registered with PPV & FR Authority for obtaining breeder's and farmers' rights.

50.	Name of the candidate : Mr. Pachpor Nageshkumar S.	Degree for which the thesis/project report submitted : Ph.D.(Ag.)(Plant Physiology)	Year of submission : 2022	Name of Guide / Co-Guide : Dr. A. K. Shinde

Abstract : The present study entitled “Studies on Physiological and Biochemical Aspects of Crop regulation in Alphonso mango under Konkan Condition" was undertaken at Centre of Excellence for Mango, Department of Horticulture Dr. BSKKV, Dapoli, during 2016-2017 and 2017-2018. The experiment was laid out in Randomized Block design consisting of three replications. The investigation consists of three trials to study Effect of foliar feeding of nutrients, plant growth regulators and irrigation on induction of post-harvest vegetative flush, to study effect of foliar application of plant growth regulator and cultural practices on suppression of post monsoon vegetative flush and to study effect of foliar application of nutrients and plant growth regulator to hastening maturity of post monsoon vegetative flush.The present investigation concluded that the foliar application of nutrients and plant growth regulator along with irrigation beneficial for induction of post-harvest new vegetative flush in summer and early harvesting with higher yield. Increase in vegetative flush, flowering intensity and fruit yield over control due to foliar application of 19:19:19 (Foliar grade) 2% with irrigation could be attributed due to the highest rate of photosynthesis (8.43 µ mole CO2/m2/sec), high C:N ratio (21.66) and higher water potential (-1.40 bar).
The present investigation helps to conclude that adoption of various cultural practices and plant growth regulator is beneficial for suppression of post monsoon vegetative flush and early induction of flowering and early harvesting. Basin exposure twice in last week of Sept. and Oct (T10) recorded maximum (63.68%) flowering intensity followed by T2- CCC @ 2500 ppm (61.83%) and highest fruit yield (4.90 t/ha), followed by T2- CCC 2500 ppm (4.74 t/ha) whereas, minimum flowering intensity (40.72%) and lowest fruit yield (2.34 t/ha) were observed in T1-Control.The foliar application of plant growth regulators after induction of new vegetative shoots after monsoon was beneficial to hastened the maturity of post monsoon vegetative flush and induction of early flowering, better flowering intensity and early harvesting Among various treatments foliar spraying of PBZ 1000 ppm (T11) was best for early flowering and early harvesting with promising yield. This could be attributed due to the highest Tate of photosynthesis (9.69 µ mole CO_2 /m²/sec), more negative leaf water potential (-2.59 bar) and lowest soil moisture (19.17%), respectively.

51.	Name of the candidate : Ms. Rupnnavar Saloni Bababsaheb	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2022	Name of Guide / Co-Guide : Dr. M. G. Palshetkar
	Abstract : The present investigation, entitled "Variability and character association studies in M3 generation of Pigeon pea (*Cajanus cajan* L. Millsp.)", was conducted at Research and Education farm, Department of Agriculture Botany, College of Agriculture, Dapoli during *Kharif* 2021. As a result of the current investigation, it is clear that a wide range of variability exists for various traits, along with high heritability and high genetic advance as percentage of the mean for significant yield traits. Five of the ten quantitative character the number of primary branches per plant, plant height, pod length, number of pods per plant and 100 seed weight were highly significant and positively correlated with seed yield per plant at simple level Based on the findings, the mutants *viz*., T3(6)16, T2(29)1, T1(47)3 and T1(51)11 can be used for further varietal improvement.			
52.	Name of the candidate : Mr. Khanvilkar Onkar Dilip	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2022	Name of Guide / Co-Guide : Dr. U. B. Pethe
	Abstract : The present experiment entitled "Variability and Genetic diversity studies in Black gram(*Vigna mungo* (L.) Hepper)" was undertaken to assess the genetic variability, genetic diversity correlation and path analysis in twenty-four genotypes of black gram in randomized block design with two replications at Educational and Experimental Research farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra during *Rabi* 2021-2022. The estimates of phenotypic, genotypic and environmental variance showed that phenotypic variance was slightly higher in magnitude than genotypic variance for all the characters studied. The magnitude of genotypic and phenotypic variance was nearer to each other for majority of the characters thus representing lesser role of environment in the expressionof these characters.Phenotypic coefficient of variation (PCV) was greater in magnitude over respective genotypic coefficient of variation (GCV) for all the 15 characters studied. Different characters revealed varying per cent of coefficient of variation at both genotypic and phenotypic levels. High phenotypic coefficient of variation was observed for the characters number of pods per plant, plant height, grain yield per plant and number of clusters per plant. High genotypic coefficient of variation was observed for number of pods per plant followed by plant height and grain yield per plant.coefficient of variation was observed for number of pods per plant followed by plant height and grain yield per plant.In present study, the genotypic correlation coefficient was greater in magnitude than their respective phenotypic counter parts for most of the characters. Number of pods per plant and number of clusters per plant exhibited highly significant positive correlation with seed yield per plant at both phenotypic and genotypic levels. The characters like hundred seed weight, protein content, days to maturity, number of grains per pod and days to initiation of flowering had non- significant positive correlation with seed yield per plant at both phenotypic and genotypic level.The seed yield is a complex character, and each character had its own effect on the establishment of a correlation with yield. The path coefficient reported that the characters hundred seed weight, harvest index, dry matter per plant, days to 50 per cent flowering, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of grains per pod and pod length had positive direct effect on seed yield at both phenotypic and genotypic levels. While days to initiation of flowering, days to maturity, plant height and protein content had negative direct effect on seed yield per plant at genotypic and phenotypic levels. Simultaneously, at phenotypic level the traits like plant height and pod length registered negative and positive direct effect on seed yield per plant respectively whereas at genotypic level the traits like plant height and pod length had positive and negative direct effect respectively on seed yield			

	per plant.It is concluded that the genotypes KKVVM-18 followed by KKVVM-20 and KKVVM-9 were observed as best performers in the genotypes studied. These had the highest seed yield per plant and also maximum yield attributing characters. The genotype KKVVM-I had maximum hundred seed weight, KKVVM-18 had maximum number of pods per plant, number of branches per plant and pod length. The genotype KKVVM-10 had highest protein content and KKVVM-13 had maximum plant height. All the genotypes mentioned above have the potential to be used as promising genetic material in future breeding programmes. The present investigation reported a significant and considerable amount of diversity among all the genotypes studied.			
53.	Name of the candidate : Ms. Sarak Komal Shivaji	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2022	Name of Guide / Co-Guide : Dr. S. S. Desai
	Abstract : The present study comprises of forty four genotypes out of which twenty seven genotypes collected from local area of konkan region while remaining seventeen genotypes were collected from zonal agriculture research station Kolhapur. These genotypes were cultivated in a Randomized Block Design with two replications at Education and Research Farm Department of Agricultural Botany, College of Agriculture, Dapoli during the *Kharif* 2021. As a result of the current investigation, it is clear that a wide range of variability exists for various traits, along with high heritability and high genetic advance as percentage of the mean for significant yield traits. Four of the thirteen quantitative characteristics the number of productive tillers per plant, protein content, calcium content, and the straw yield per plant, were highly significant and positively correlated with grain yield at both the phenotypic and genotypic levels. The current analysis also showed that clusters II and III had the most diversity among themselves. Based on the findings, the genotypes DPLV-27, DPLV-26, DPLV-16, and DPLV-11 are best performer having good genetic diversity used as a parent in a future hybridization programme.			
54.	Name of the candidate : Ms. Bhosale Mrunalini Anand	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2022	Name of Guide / Co-Guide : Dr. S. V. Sawardekar
	Abstract : Pigeon pea is farmed as the sole crop on a very small scale in Maharashtra's Konkan region. Farmers are hesitant to plant this crop due to a lack of irrigation infrastructure during the *Rabi* season because the crop lasts more than 180 days. As a result, there is a need for pigeon pea genotypes with early maturity (150 days). Present investigation meant to evaluate genetic diversity and variability of M3 generation of pigeon pea through ISSR markers where field work performed at Agricultural Botany farm, College of Agriculture, Dapoli and laboratory work at Plant biotechnology Centre, College of Agriculture, Dapoli. Phenotypically total 50 mutants were selected for growing further generation on the basis of yield and yield contributing characters. Out of these 50 mutants total eight mutants were found with reduced height and increased seed yield which is superior to Konkan Tur 1 and total fifteen mutants were significant over Konkan Tur 1 for less percent of pod damage with good seed yield. To confirm variability of 50 selected mutants, molecular markers are used which are not affected by environment. DNA isolation was done by using CTAB method. 40 ISSR primers are used out of them 20 were showed polymorphism. UBC 885 recorded maximum polymorphism percent i.e., it shows more variation. Primer UBC 886 exhibited minimum polymorphism percentage. The dendrogram demonstrated that mutants T1(21)7-8 and T1(67)11-5 had relatively more genetic distances over the control (Konkan Tur-1), i.e., 0.505 bp and 0.470 bp, respectively, while T1(77)9-1(0.095bp) and T2(36)15-2(0.058 bp) hada few			

	genotypic distances with respect to control.			
55.	Name of the candidate : Mr. Chendake Shubham Annaso	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(GPB)	Year of submission : 2022	Name of Guide / Co-Guide : Dr. R. L. Kunkerkar
	Abstract : Field experiment was conducted during *Kharif*, 2021 at Education and Research farm, Department of Agricultural Botany, College of Agriculture, Dapoli, Ratnagiri, the current study was conducted with objectives to estimate the genetic variability for yield and yield attributing characters and to estimate the genotypic and phenotypic correlation coefficient of different characters in thirty-two genotypes of rice (*Oryza sativa* L.). Based on the results of the current investigation, it is observed that the genotypes showed significant genetic variability for all the characters under study linked to the yield, most of the characteristics showed high estimates of heritability and genetic advance, demonstrating the dominance of additive gene action. The genotypes Palghar-1, BARCKKV-13, RP 6334-111-5-2-1, CR 4069-111-1-1-4-5-7, Ratnagiri-6 and SKL-07-11-177-50-65-60-14 were identified as the best for yield and yield attributing characters. In order to create a new high yielding, good quality fine rice variety these genotypes may be effectively used as parents in subsequent breeding programmes.			
56.	Name of the candidate : Ms. Namala Venkata Pushpavalli	Degree for which the thesis/project report submitted : M.Sc.(Ag.)(Plant physiology)	Year of submission : 2022	Name of Guide / Co-Guide : Prof. R. S. Deshpande
	Abstract : The present investigation on "In vitro studies in Teak (*Tectona grandis* Linn. f.) for induction of morphogenesis" was carried out at the Plant Biotechnology Centre, College of Agriculture, Dapoli, Dist. Ratnagiri 415 712 (Maharashtra).Among the matured and juvenile explants used, apical buds and nodes from juvenile plants were found best for shoot induction. Treatment T11 (Ethyl Alcohol 70% for 10 sec. +HgCl2 0.10%for 5 min.) recorded maximum (72.75%) aseptic culture establishment with 74.00% survival rate for surface sterilization of these explants. Browning of media was prevented by imposing the antioxidant treatment of PVP (100 mg 1^{1}) and dark incubation for three days which resulted in aseptic cultures. The Driver and Kuniyuki Walnut medium with 1 mgl" BAP found to be best for establishment and shoot induction in teak explants among the other treatments. Callus induction was better in leaf explants of juvenile plants of teak while the shoot induction was better in apical buds and nods in MS media supplemented with 0.5 mg 1' BAP and 0.5 mg 1^{1}NAA.			

9.**Extension Activities**

d.Radio/TVTalksdeliveredbythestaffmembersoftheDepartment/Section:

Dr. R. L. Kunkerkar	
List of the Radio/ TV talks delivered:-	
१.	भातउत्पादनामध्येबीजप्रक्रियेचेमहत्त्व (०१/०६/२०१३)
२.	रब्बीउन्हाळीभातलागवड (०८/०१/२०१३)

३.	भातजातीप्रक्षेत्रभेटदिन (१२/१०/२०१२)
४.	संकरीतभातउत्पादनातीलपूरकपरागीकरण (२१/०७/२०१२)
५.	रब्बीउन्हाळीभाताचीकापणी (०३/०३/२०१२)
६.	खरीपहंगामासाठीभातजातीचीनिवड (०८/०६/२०११)
७.	संकरीतवाणआणिचारसूत्रीभाताचीलागवड (२८/०७/२०१०)
८.	रब्बीहंगामातबिजोत्पादानाचेमहत्त्व (१९./०२/२०११)
९.	भातविकासआणिजतनज्ञानपेढी (०९/११/२०१०)
१०.	संकरीतभातलागवड (१७/०७/२०१०)
११.	सुधारितभातबिजोत्पादनतंत्र (२६/०२/२०१०)
१२.	रब्बीउन्हाळीभातपिकाचेनियोजन (१७/१०२००९)
१३.	संकरीतभातबिजोत्पादनाचेतंत्र (०६/०६/२००९)
१४.	भातबिजोत्पादनतंत्रज्ञान (११/०६/२०१७)
१५.	भातबिजोत्पादनाचीनिगा (११/०८/२०१४)
१६.	किफायतशीरउन्हाळीभातशेती (१०/११/२०१४)
१७.	बिजोत्पादन (२७/०१/२०१५)
१८.	प्रादेशिककृषीसंशोधनकेंद्रानेप्रसारितकेलेल्यासुधारितवसंकरीतजाती (२१/१०/२०२०) – दूरदर्शन
१९.	उन्हाळीभातलागवडतंत्रज्ञान (३१.१२.२०१६)
२०.	भातबिजोत्पादन (०१/०८/२०१६)
२१.	भातरोपवाटिकाव्यवस्थापन (२४/०५/२०१६)
२२.	भातलागवडतंत्रज्ञान (२२/०५/२०१८)
२३.	भातबिजोत्पादनतंत्रज्ञान (०४/१२/२०१८)

Name of Person	Name of topic	Name of radio station	Date of recording/ broadcasting
Radio talks			
Dr. U. B. Pethe	• Unhalyatchawalichilagwad	All India Radio	26-03-1998.
	• SankaritBhatLagwaditilMahatwacheMudde	All India Radio	09-07-1998.
	• AlambiSanvardhan	All India Radio	11-09-2004.
	• Vanilalagwad	All India Radio	09-02-2009
	• “Masala pikachyasudharitJati”	All India Radio	19-05-2009
	• “Masala pikachyasudharitJati”	All India	22-04-2010

		Radio	
	• "Masala pikachiKadhanianiSathvan"	All India Radio	31-01-2011
	• Navinlagwadkelelyamasalepikanchiniga	All India Radio	27-02-2012
	• DalchiniKadhani and Sathvan	All India Radio	24-02-2013
	• UnhaliMungLagwad	All India Radio	24-02-2020
	• Bhatkapanianikadhanipashatkalagi	All India Radio	18-09-2023

Name of Person	Name of topic	Name of TV channel	Date of telecast
TV Talks			
Dr. U. B. Pethe	• Tel Vrikshachilagead		25-06-1998
	• BhatBijotpadanatilMahatwacheMudde		04-10-2006.
	• Kali MiriLagwad	E TV Annadata	11-09-2008
	• Jaiphalkadhani	Z – 24 hrs.	
	• Dalchinichikadhani	Star maza	5-12-2009
	• SuparichiKadhani	Star maza	
	• Kokanatilkaddhanya pike	DD Sahyadri	30-09-2019

List of the Radio/ TV talks delivered:-	
Dr. S. S. Chavan	
1	DBSKKV,rice varities
2	Alphonso mango fruitdrop
3	surangi flower production

Name of Person	Name of topic	Name of radio station	Date of recording/ broadcasting
List of the Radio Talks			
Dr. M. G. Palshetkar	• Bhat Biyanyache kadhani pashyat tantradnan	All India Radio	22.10.2010
	• Bhatanantar dubar pikachya paryayi sandhi	All India Radio	26.03.2011
	• Bhat biyanyachi nivad aani upalbdhata	All India Radio	09.05.2012
	• Persal Lagavad padhat	All India Radio	14.06.2013
	• Unhali bhajipala pikansathi pani vyavashtapan	All India Radio	07.02.2014
	• Kokanamadhe tur lagavad	All India Radio	17.07.2023

Name of Person	Name of topic	Name of TV channel	Date of telecast
TV Talks			
Dr. M. G. Palshetkar	• Nursery management in paddy crop	Doordarshan	02.07.2013

List of the Radio/ TV talks delivered:-	
Dr. S. N. Joshi	
1	Delivered a Radio talk on 'Konkantil Shetit Jaivatantradnyanache mahatv'on All India Radio Station, Ratnagiri on 21.02.2012.
2	Delivered a Radio talk on 'Jaivatantradnyanadware Bhajeepala Vikas' on All India Radio Station, Ratnagiri on dated 20. 09.2010.

g.**Publication:**ProvidethedetailsofthefollowingpublicationpublishedbytheDepartment/Sectioninbibliographicalform

Books	:	• TextBookof**PrinciplesofGenetics.Publishedby**InternationalBookHouse P.LTD,Delhi.BySawardekarS.V.,DesaiS.S. and**Bhave S.G.(2010)** • **Plant Breeding Fundamentals principle and methods. Published By Vizcraft. By** Balaji S, Amit B. Kore, RameshL. Kunkerkar

ChapterinBooks		"HarmoniousPhenologicalData:ABasic NeedforUnderstandingtheImpactofclimatechangeofMango."PP53-65,**byBurondkar**(asone oftheauthors).InBook: Climate-ResilientHorticulture:AdaptationandMitigation strategies. Edited byHarishChandraPrasadSingh,N.K.Shrnivasa Rao, K.S.Shivshankara.Publishedby**SpringerPublication.** • Mutation Breeding in Rice for sustainable Crop Production and Food Security in India Chapter in Book Mutation Breeding, Genetic Diversity and Crop Adoptation to Climate change • Bijotpadan Tantradyan: chapter entitled, Bhat Pikachi Jati va tyachi vaishishtye • Bijotpadan Tantradyan: chapter entitled, Sankirit Bhat Bijotpadan
Booklet/bulletion/	:	1. vkcklmRiknur=Kku- 2. Mangoproductiontechnology 3. vkC;kP;kfu;fermRiknuk lkBh ltthodiDykC;Vk>kyvFkkdYVkj 4. CropVarieties

Folders	:	1- vkC;kP;kfu;fermRikpnuk lkBh lthod ^iDykC;Vk>ky* vFkkdYVkj- 2- vkck>kMkphNkVokh- 3- gkilvkckQGkrhylkdkfu;=ok 4- MangoSuvarna–Year2009 1- 'Sindhu'ANewHybridMango- June,1997 2- Use of 1 – Methyl cyclopropene (1-MCP)fordelayingripeningextendingshelflifeinAlphonsomangoforexport. 5- Development of non destructive onlinesystemforauto detectionand auto sorting of spongy tissue affectedAlphonsomangofruits.
Souvenir/Proceedings ofSeminar/Symposia/Conference/Workshop Organized	:	1. PhysiologicalandMolecularApproachesforIncreasingYieldandQualityofAgricultural,HorticulturalandMedicinalPlantsunderChangingenvironment. 2. ClimateResilientRiceProductionUnderRainfedEcosystem.

JournalResearchpapers

Sr. No.	Particular
Dr. R. L. Kunkerkar	
1.	D.S.Sawant, **R.L.Kunkerkar**, V.N. Shetye and M.M.Shirdhankar (2006*).* Inheritance of fertility restoration of five sources of cytoplasmic male sterility in Rice (*Oryza sativa* L.) *Ann. Agric. Res. 27(2):133-138.* **NAAS Rating 4.78, ISSN:2077-0472**
2.	D.S.Sawant, **R.L.Kunkerkar**, V.N. Shetye and M.M.Shirdhankar, (2006). Stability Assessment in Late Duration Rice Hybrids *Ann. Agric. Res. 27 (1) : 21-26.* **NAAS Rating 4.78, ISSN:2077-0472**
3.	B.D. Waghmode, D.S. Sawant, **R.L. Kunkerkar** and S.R. Kadam, (2008). An early rice hybrid Sahyadri-4 for five state of India. *J. Mah. Agril. Univ.*, 33 (3): 315-320. **NAAS Rating 4.50, ISSN: 0378-2395**
4.	**R.L. Kunkerkar**, D.S. Sawant, P.B. Vanave, B.B. Jadhav and S.R. Kadam, (2009). Fertility restoration of four sources of Cytoplasmic male sterility in rice (*Oryza sativa* L.), *Inter. J. Plant Sci.* 4(1):161-165. **NAAS Rating 4.15, ISSN:0973-1547**
5.	**R.L. Kunkerkar**, M. Sheshumadhav and T.R. Sharma, (2010). Characterization of Genetic Variability in different Rice lines using DNA Markers *Asian. J. Bio. Sci.* 5 (2):223-226. **NAAS Rating 4.31, ISSN:0973-4899**
6.	**R.L. Kunkerkar** and B.B. Jadhav, (2010). Medium duration fine grain rice cv. Palghar-2 for Konkan region of Maharashtra State. *Int. J.Forestry and Crop Imp.* 1(2):114-116. **NAAS Rating 4.04, ISSN: 0976-562X**

7.	**R.L. Kunkerkar**, B.D. Waghmode, P.B. Vanave, S.R. Kadam and B.B. Jadhav. (2010). Karjat 184, an early rice variety for Konkan region of Maharashtra State. *Int. J.Forestry and Crop Imp.* 1(2):91-93. **NAAS Rating 4.04, ISSN: 0976-562X**
8.	D.S. Sawant, B.D. Waghmode, **R.L. Kunkerkar**, P.B. Vanave and B.B. Jadhav, (2011). Karjat-7 An Early Rice Variety in Transplanted condition for Maharashtra State. *J. Agric. Res. Technol*. 36(3): 394-396. **NAAS Rating 4.50, ISSN: 0378-2395**
9.	B.L Thaware, R.L. Kunkerkar and Shivde H.A. Status paper on rice in Maharashtra, pp 1-48, march 2011. www.rkmp.co.in
10.	**R.L. Kunkerkar,** Vanave P.B., Thaware B.L. and Jadhav B.B.2012. Karjat-8: Super fine Rice Variety for Maharashtra State. Proceeding of International symposium on "100 years of rice Science and looking beyond" ISBN: 819080802-8; 1: 16-17
11.	B.L. Thaware, U.B. Apte, **R.L. Kunkerkar** and S.R. Kadam. 2012 Strategies for Increasing Rice Production in Maharashtra. Proceeding of International symposium on "100 years of rice Science and looking beyond" ISBN: 819080802-8; 1: 32-33
12.	**R.L. Kunkerkar**, D.S. Sawant, V. N. Shetye and P.B. Vanave, (2012). Heterosis studies in rice hybrids involving diverse cytosteriles. *Oryza* 49(1):60-61. **NAAS Rating 5.03, ISSN: 0474-7615**
13.	**R.L. Kunkerkar**, P.B. Vanave, B.D. Waghmode, B.L. Thaware and S.G. Bhave, (2014). Superfine rice variety Karjat 8 for low land areas of Maharashtra state. *Eco. Env. & Cons.* 20(1); 353-356. **NAAS Rating 5.41, ISSN:0971-765X**
14.	**R.L. Kunkerkar**, P.B. Vanave, B.D. Waghmode, U.B. Apte and M.P. Gawai, (2014). High yielding medium slender rice culture KJT 2-2-44-10. *Eco. Env. & Cons.* 20(1); 349-352. **NAAS Rating 5.41, ISSN:0971-765X**
15.	P.B. Vanave and **R.L. Kunkerkar (**2014**).** In vitro propagation in Kokam (Garcinia indica choisy.) *Eco. Env. & Cons.* 20(1); 377-379. **NAAS Rating 5.41, ISSN:0971-765X**
16.	P.B. Vanave and **R.L. Kunkerkar (**2014**).** Factor affecting clonal multiplication in Kokam (Garcinia indica choisy.) *Eco. Env. & Cons.* 20(1); 381-382. **NAAS Rating 5.41, ISSN:0971-765X**
17.	Supriya Bhagwat, N.B. Gokhale, S.V.Sawardekar, V.G.Kelkar, S.R.Kambale and **R.L.Kunkerkar** (2017). Evaluation of rice (*Oryza sativa* L.) germplasm for biotic and abiotic stresses and their genetic diversity using SSR markers *Oryza* 54(3) (258-265), **NAAS Rating 5.03, ISSN: 0474-7615**
18.	B.S.Thorat., **R.L.Kunkerkar.,** B.L.Thaware., M.M. Burandkar and S.G.Bhave (2017). Combining Ability Analysis and Yield Contributing Traits in Hybrid Rice (*Oryza Sativa* L.) *Journal of Rice Research* 10(1) : 21-25 **NAAS Rating 4.05, ISSN: 0367-8245**
19.	B.S.Thorat., **R.L.Kunkerkar** and T.A.Bagkar (2017). Studies on heterosis for yield and its contributing traits in hybrid rice (*Oryza Sativa* L.) *International Journal of Chemical Studies.* 5 (5) : 7-12 **NAAS Rating 5.31, ISSN:2249-8528**
20.	B.S.Thorat., **R.L.Kunkerkar** and M.R.Chavan (2017). Heritability study in hybrid rice (*Oryza sativa* L.) *Journal of Pharmacognosy and Phytochemistry* 6 (5) : 1450-1453 **NAAS Rating 5.21, ISSN:2278-4136**

21.	A.R.Khaire, **R.L.Kunkerkar**, B.S.Thorat, M.P.Gawai and S.G.Bhave (2017). Studies on genetic variability for yield and yield contributing traits in local rice (*Oryza sativa* L.) *J. of Pharma. and Phyto.* 6(5) : 1376-1378 **NAAS Rating 5.21, ISSN:2278-4136**
22.	**Kunkerkar.R.L**., Ingale S.N., Thorat B. S. and Devmore J. P. (2017). Studies on genetic variability for quantitative and qualitative traits in north-east Indian rice (*Oryza sativa* L.) *J. Rice Res.* 10 (2) : 18-22 **NAAS Rating 4.05, ISSN: 0367-8245**
23.	B.S.Thorat., **R.L.Kunkerkar.,** B.L.Thaware., M.M.Burondkar and S.G.Bhave (2017). Heterosis and Combining Ability in Hybrid rice (*Oryza Sativa* L.) Cont. Res. in India 7 (3) : 135-139 **NAAS Rating 3.23, ISSN: 2231-2137**
24.	B.S.Thorat and **R.L.Kunkerkar** (2017). Study of Nature and Magnitude of gene action in hybrid rice (*Oryza sativa* L.) *Cont. Res. in India* 7 (3) : 150-154 **NAAS Rating 3.23, ISSN: 2231-2137**
25.	Thorat B.S., **Kunkerkar.R.L**., Bhave. S.G. and Gawai. M.P (2017). Studies on genetic variability for quality traits in north-east Indian rice (**Oryza sativa** L.) *Cont. Res. in India* 4 : 151-154 **NAAS Rating 3.23, ISSN: 2231-2137**
26.	Shinde A.K., **Kunkerkar.R.L.,** Thorat V.A., Chavan L.S., Talathi M., Mandavkar P.,Devrukhakar A.C., Patil V.K., Rane A.D., Dodake S.B., Talathi J.M.,Haldankar P.M. and Bhattacharyya T. (2018).Technological interventions: Boon for Rice production in Konkan Region. Adv. Agril.Res. &Tech.J. Vol. No. II (2) PP 128-140 **ISSN:**2581-3749
27.	Anjali Chauhan, Vikas Kumar, Preethi. R. Iyer, GautamVishwakarma, J.P. Nair, P. Surendran, Hillary Sparrow, A. K. Gupta, A.S. Shitre, A.K. Shinde, **R.L. Kunkerkar**, Deepak Sharma, Ravi Raj Singh Patel and B.K. Das (2019). Effect of proton beam irradication on survival and seedling growth parameters of Indian rice (Oryza sativa L.)variety 'Indira Barani Dhan1' *Elec. J. Plant Breeding* 10 (2) : 490-499. **NAAS Rating 5.14, ISSN: 0975-928X**
28.	B.S. Thorat, **RL Kunkerkar**, S.M. Raut, S.S. Desai, M.P. Gawai, M.H. Keluskar and J.S. Dhekale (2019). Correlation Studies in hybrid Rice (*Oryza Sativa L.)Int. J. Curr. Microbiol. App. Sci.* 8(4) : 1657-1661 **NAAS Rating 5.38, ISSN:**2319-7692
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Genetic evaluation of M3 population of pigeon pea (*CajanusCajan* (L.) Millispaugh) through molecular markers	MA Bhosale, SV Sawardekar, **UB Pethe,** SG Mahadik, MG Palshetkar, SD Patil and SB Rupannavar	*The Pharma Innovation Journal* 2023; 12(2);*1143-1146*	2023	ISSN (E): 2277-7695	5.23
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Variability studies in M3 generation of pigeon pea (*Cajanuscajan* L. Millsp.)	SB Rupannavar, MG Palshetkar, **UB Pethe**, SV Sawardekar, RS Deshpande and MA Bhosale	*The Pharma Innovation Journal* 2023; 12(2);*973-976*	2023	ISSN (E): 2277-7695	5.23
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25. Chendage SA,Kunkerkar RL,Desai SS,SS Chavan,RV Dhopavkar and KS Sarak Assesment of genetic variability for grain yield and its components in fine rice (Oryza sativa L.)The Pharma Innovation Journal 2023,12(2):802-806.

Sr. No.	Title of research paper	Authors	Journal/Vol. No./Page No.	Publication Year	ISSN
Dr. M. G. Palshetkar					
1	Correlation and Path Analysis in F_3 Population of Brinjal (*Solanum melongena* L.) in Coastal Region of Maharashtra	G. L. Bachhav, B. L. Thaware And M. G. Palshetkar	J. Indian Soc. Coastal agric. Res., **28(**1), 58-61	2010	0972-1584
2	Correlation and path coefficient analysis for yield and yield components in segregating (F_4) generation of lablab bean (*Lablab Perpureus* L. Sweet)	S. S. Kamble, J. P. Devmore, S. V. Sawardekar, S.G.Bhave, and M.G.Palshetkar	International Journal Of Applied Biology And Pharmaceutical Technology. **6**(3):237-239	2015	0976-4550
3	Effect Of Different Growth Regulators On Growth Of Khirni (*Manilkara Hexandra* L.) Rootstock	K. V. Malshe, B. G. Desai and M. G. Palshetkar	Ann. Plant Physiol. **30**(2): 15-17	2016	0970-9924
4	PerformanceofDifferent Varieties Of Brinjal (Solanum Melongena L.) Under North Konkan Conditions Of Maharashtra, India	K. V. Malshe*, M. G. Palshetkar, B. G. Desai and S. B. Mane	Plant Archives Vol. **16** No.2 :568-571	2016	0972-5210
5	Comparative study of different capsicum varieties under open and protected conditions	K. V. Malshe, M. G. Palshetkar and B. G. Desai	Plant Archives. **16**(2) : 931-933	2016	0972-5210
6	Evaluation of bell pepper hybrid Indra under different growing structures	K. V. Malshe, B. G. Desai and M. G. Palshetkar	Journal of Eco-friendly Agriculture **11**(2): 109-112	2016	2229-628X
7	Influence of Magnetic Stimulation on Germination and Initial Growth of Paddy (*Oryza sativa*)	Y.M. Yadav, S.G Mahadik, V.V. Dalvi,, A.V. Mane, H.V. Borate, M.G Palshetkar	Advances in Life Sciences. **5**(1):256-259	2016	2278-3849
8	Genetic Variability Studies On F5 Generation Of Brinjal (*Solanum Melongena* L.)	S. B. Nilakh, B. L. Thaware, J. S. Dhekale and M. G. Palshetkar*	Plant Archives. **17**(1): 103-105	2017	0972-5210
9	Response of brinjal	K.V. Malshe, B.G.	Journal of	2018	2229-

	(*Solanummelongena* L.) to organic manures and foliar nutrition	Desai, M.G. Palshetkar and R.G. Khandekar	Eco-friendly Agriculture.**13**(1): 19-21		628X
10	Genetic Architecture in Proso Millet (*Panicum miliaceum* L.)	P. B. Vanave*, P. B. Shinde, S. S. Madav, M. G. Palshetkar, J. P. Devmore, S. G. Mahadik, B. L. Thaware and S. G. Bhave	Int. J.Curr. Microbiol.App. Sci (2018) Special Issue-**6**: 1079-1084	2018	2319-7692
11	Status of Organic farming in North Konkan of Maharashtra	Kshirsagr P.J. Chavan A.P., Palshetkar M.G. Phuge S.c. and Pawar R.S.	Bull. Env. Pharmacol. Life Sci., Vol **8**(1) :60-69	2018	2277-1808
12	Path Coefficient Analysis For Yield And Yield Components In Black Gram (*Vigna Mungo* (L.) Hepper)	M.P. Arya Gopinath, S.S. Desai, M.G. Palshetkar, Hawaldhar Ayyajahamad Harun, A.V. Mane	G.J.B.B., VOL**.7** (3): 435-438	2018	2278-9103
13	Character Association for Yield and its Components in Black Gram [*Vigna mungo* (L.) Hepper]	M.P. Arya Gopinath*, S.S. Desai, M.G. Palshetkar, Hawaldhar Ayyajahamad Harun and V.A. Raje Mahadik	Int.J.Curr.Microbiol.App.Sci**. 7**(7): 3964-3968	2018	2319-7706
14	Evaluation of Genetic Divergence in Black gram [*Vigna mungo* (L.) Hepper]	M.P. Arya Gopinath", S.S. Desai, M.G. Palshetkar, Hawaldar Ayyajahmad Harun and V.A. Raje Mahadik	Int. J.Curr.Microbiol.App.Sci**. 7**(8): 472-479	2018	2319-7706
15	Assessment Of Genetic Variability For Yield And Yield Contributing Traits In Black Gram (*Vigna mungo* (L.) Hepper).	Arya Gopinath.M.P., S.S. Desai, M.G.Palshetkar, A.V Mane, V.A. Raje Mahadik	G.J.B.B., VOL.**7**(3): 414-417	2018	2278-9103
16	Genetic variability studies in lentil (*Lens culinaris*	P. B. Vanave*, A. H.	Electronic Journal of	2019	0975-928X

	Medic.) genotypes for seed yield and attributes	Jadhav, A.V.Mane, S. G. Mahadik, M. G. Palshetkar and S. G. Bhave	Plant Breeding. **10** (2): 685-691		
17	Physio-biochemical Characterization in Wal	S. S. Gimhavanekar*, R. J. Navatre, P. J. Bonde, B. G. Thaware, A.V. Mane, T. N. Thorat and M. G. Palshetkar	Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-**11**: 1778-1785	2020	2319-7706
18	Genetic variability for yield and yield attributing traits in F5 Generation of Lablab bean (*Lablab purpureus* L. sweet) Genotypes	S.M.Ingle, J.P. Devmore*, S.G. Bhave, M.G. Palshetkar and B.S. Thorat	Int.J.Curr.Microbiol.App.Sci.**9**(4): 466-475	2020	2319-7706
19	Standardization of in vitro Regeneration Technique in Elephant Foot Yam (*Amorphophallus paeoniifolius* L.)	Pravin B. Pawar, S. V. Sawardekar', R. S. Deshpande', M. G. Palshetkar² and R. G. Khandekar³	Int. J.Curr.Microbiol.App.Sci. 10(03): 1246-1256	2021	2319-7706
20	Genetic Variability Studies in F_2 Generation for Yield and Yield Component Traits in Green Gram [*Vigna radiata* L. Wilczek]	B. B. Dhunde, J. P. Devmore, M. G. Palshetkar, D. N. Jagtap, J. S. Dhekale and M. M. Burondkar	Int. J.Curr.Microbiol.App.Sci. **10**(01): 321-327	2021	2319-7706
21	Correlation and path analysis studies on yield and its components in green gram *[Vigna radiata* L. Wilczek]	BB Dhunde, Dr. JP Devmore, Dr. SG Mahadik, MG Palshetkar, Dr. PB Vanve, Dr. SG Bhave and BS Thorat	The Pharma Innovation Journal. **10**(1): 727-730	2021	ISSN (E): 2277-7695 ISSN (P): 2349-8242
22	Genetic variability studies in cowpea genotypes	Tambitkar NB, Pethe UB, Desai SS, Palshetkar MG and Dhopavkar RV	Journal of Pharmacognosy and Phytochemistry. **100** (1) 239-242	2021	ISSN (E):2278-4136 ISSN (P):

					2349-8234
23	Survey of storage rot of onion and physiological weight loss of onion due to artificial inoculation of *Aspergillusniger* inciting pathogen of onion storage rot	Dhumal MS, Arekar JS, Potphode PD, Govekar YR, Palshetkar MG, Kore SK and Jagdale SG	The Pharma Innovation Journal. **10**(12): 2897-2900	2021	ISSN (E):2277-7659 ISSN (P): 2349-8242
24	Effect of mutagenic treatments on seed germination, seedling growth and survival of pigeon pea [*Cajanus cajan* (L.) Mill. Sp]	Palshetkar MG, Sawardekar SV, Dalvi VV, Narangalkar AL and JS Dhekale	The Pharma Innovation Journal. **11**(2): 1160-1164	2022	ISSN (E): 2277-7695 ISSN (P): 2349-8242
25	Genetic divergence study in rice (*Oryza sativa* L.)	SG Shinde, BD Waghmode, SV Sawardekar, AV Mane, MC Kasture, JS Dhekale, MG Palshetkar, TJ Bedse, RL Kunkerkar and NG Sonone	The Pharma Innovation Journal.**11**(12): 1890-1898	2022	ISSN (E) : 2277-7695 ISSN (P) : 2349-8242
26	Molecular profiling of rice for biotic and abiotic stresses	SG Shinde, BD Waghmode, SV Sawardekar, AV Mane, MC Kasture, JS Dhekale, MG Pals hetkar, TJ Bedse, RL Kunkerkar and NG Sonone	The Pharma Innovation Journal.**11**(12): 1457-1460	2022	ISSN (E) : 2277-7695 ISSN (P) : 2349-8242
27	Genetic variability analysis in rice (*Oryza sativa* L.)	SG Shinde, BD Waghmode, SV Sawardekar, AV Mane, MC Kasture, JS Dhekale, MG Pals he tkar, TJ Bedse, RL Kunkerkar and NG Sonone	The Pharma Innovation Journal.**11**(12): 1451-1456	2022	ISSN (E): 2277-7695 ISSN (P): 2349-8242
28	Path coefficient analysis	OD Khanvilkar, UB	The Pharma	2022	ISSN

	for important yield components in black gram [Vigna mungo (L.) Hepper]	Pethe, MG Palshetkar, SS More and JJ Kadam	Innovation Journal .**11**(12): 6064-6068		(E): 2277-7695 ISSN (P) :2349-8242
29	Variability studies in My generation of pigeon pea (*Cajanus cajan* L. Millsp.)	SB Rupannavar, MG Palshetkar, UB Pethe, SV Sawardekar, RS Deshpande and MA Bhosale	The Pharma Innovation Journal. **12**(2): 973-976	2023	ISSN (E): 2277-7695 ISSN (P): 2349-8242
30	Genetic evaluation of M3 population of pigeon pea (*Cajanus Cajan* (L.) Millispaugh) through molecularmarkers	MA Bhosale, SV Sawardekar, UB Pethe, SG Mahadik, MG Palshetkar, SD Patil and SB Rupannavar	The Pharma Innovation Journal **12**(2): 1143-1146	2023	ISSN (E): 2277-7695 ISSN (P): 2349-8242

List of the Journal research papers:-	
Dr. S. N. Joshi	
1	Analysis of Genetic Variability among Red Cowpea Genotypes by using ISSR markers.
2	Heterosis for yield and yield related traits in red cowpea (*Vigna unguiculata* L. Walp).
3	Analysis of combining ability for yield and its attributing characters in red cowpea (*Vigna unguiculata* L. Walp).
4	Genetic engineering for salt tolerance
5	Sex detection of kokum (*Garcinia indica* Choisy) by RAPD markers.
6	*In vitro* propagation of malkangni (*Celastrus paniculatus* Wild) a rare endangered medicinal species.
7	Chlorophyll deficient seedlings in *Dendrocalamus strictus*(Roxb.) Nees.
8	Analysis of Genetic Variability and Correlation Studies in Horsegram (*Macrotyloma uniflorum* (Lam.) Verdec.).
9	Analysis of genetic parameters for yield and certain yield contributing traits in Horsegram.

10. Details of other activities

Seed Production

Rabi 2021-22			*Rabi* 2022-23
Crop	Variety	Seed Production (kg)	Area (g)
Cowpea	Konkan Safed	19	18
	Konkan Sadabahar	136	58
	Konkan Fodder cowpea	6	-
Kulthi	Dapoli 1	20	24
Wal	Konkan Wal	45	21
Tur	Konkan Tur	2	-
Mustard	Varuna	5	16
Green gram	Dapoli 1	-	18
	Phule Gold	-	
	Total	**233**	**155**

Kharif 2022			
	Variety	Class	Seed Production (kg)
Rice	Karjat- 9	Foundation seed	625
	Ratnagiri - 8	Truthful seed	3465
Finger Millet	Dapoli-1	Breeder seed	105
	Dapoli-2	Truthful seed	74
	Dapoli Safed	Breeder seed	16
	Dapoli -3	Breeder seed	37
	Dapoli-1	Foundation seed	110
Little Millet	Konkan Satwik	Breeder seed	30
	Vari 1	-	15
Total			**4477**

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