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Jananayak Chandrashekhar University, Ballia-277001 (U. P.)

FACULTY OF AGRICULTURE

(As per ICAR Recomendation 2021)

Common Academic Regulations for PG Programmes

Restructured and Revised ICAR Syllabi 2021

M.Sc. (Agriculture)

GENETICS AND PLANT BREEDING
ACADEMIC SESSION -2022-23

M.Sc. (Agriculture)

Genetics and Plant Breeding
Faculty of Agriculture

Jananayak Chandrashekhar University, Ballia, India

M.Sc. (Agriculture)

GENETICS AND PLANT BREEDING

FACULTY OF AGRICULRE

Dean Dr. (U.P. Singh)

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Dr. (O.R.Singh)
Convener

Common Academic Regulations for PG Programmes

As per Recommendation with *mutatis mutandis* ICAR Committee 2021

Restructured and Revised Syllabi of Post-graduate Programmes

Preamble

Plant improvement has a long history for its growth and development. Plant Breeding became established as a science in the twentieth century following the rediscovery of Mendel's laws of inheritance. Nearly 50% of global increase in food production is attributed to plant breeding. Since genetic improvement in an inherent feature, products of plant breeding can have wide global impact as exemplified by the Green Revolution for wheat and rice varieties of 1960s or transgenic crops of recent decades. Therefore developing sufficient human resources in Genetics and Plant Breeding with advanced knowledge and technical skill will further elevate the agricultural sector to attain a new peak in increasing food production matching the requirement of population.

Present agriculture research and international market demand the need for specialized human resource for teaching cutting edge technology with application of biotechnology, nano technology, artificial intelligence in crop improvement, increasing entrepreneurship, etc., would warrant students to have strong knowledge of practical and management skills which will help them to face the competitiveness in public and private sector.

Hence, restructuring of course curricula and delivery system to match with the present situation is the need of the time. In this proposed revision of curriculum in Genetics and Plant Breeding, the BSMA sub-group organized a series of meetings and electronic media-led consultations to develop a set of courses suitable for M. Sc. discipline.

The meetings were focused on the basic principles as well as the innovative developments in Genetics and Plant Breeding, as the platform building status of Plant Sciences. Built on this platform with the latest state of the art technologies including biotechnology and molecular biology will enable a complete coverage of the subjects. The basic courses have therefore been kept as compulsory courses which need to be taken by all the students irrespective of the subject specialization or stream from which they entered into PG education. The BSMA Committee had thread bare discussions over four sessions on the topical issues concerning Genetics and Plant Breeding, Seed Science and Technology and Plant Genetic Resources. The curricula and syllabi of all these disciplines were discussed at length in the meetings and workshops. The opinions and suggestions invited from institutions, eminent scientists and other stakeholders were also reviewed by the committee. The new look and restructured PG programmes in Genetics and Plant Breeding have been designed in considerations based on demands of private sector harnessing commercial aspects, modern research tools and their applications, supplementary skills required, and to enhance the global competitiveness and employability of our students. Considerable efforts have, therefore gone in for the preparation of this document.

Many existing courses were upgraded with addition and deletion as per the need of the present situation. The new courses have been incorporated based on their importance and social need both at national and international level are Molecular Breeding and Bioinformatics, Breeding for Quality and Special Traits, Seed Production and Certification, Breeding Vegetable Crops, Breeding Fruit Crops, Breeding Ornamental Crops for M.Sc.(Ag) programme.

Common Academic Regulation

1. Academic Year and Registration

• An academic year shall be normally from July to June of the following calendar year otherwise required under special situations. It shall be divided into two academic terms known as semesters. Dates of registration, commencement of instructions, semester end examination, end of semester and academic year, etc. The Academic Calendar shall be developed by the concerned University from time to time and notified accordingly by the Registrar in advance.

• An orientation programme shall be organized by the Director (Education)/ Dean PGS for the benefit of the newly admitted students immediately after commencement of the semester.

• On successful completion of a semester, the continuing students shall register for subsequent semester on the date specified in the Academic/ Semester Calendar or specifically notified separately. Every enrolled student shall be required to register at the beginning of each semester till the completion of his/ her degree programmes.

2. Credit requirements

2.1 Framework of the courses

The following nomenclature and Credit Hrs need to be followed while providing the syllabus for M.Sc.(Ag.) Genetics and Plant Breeding:

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

Maximum permissible course workload per semester

Master's Programme- 18 credits

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence.

2.2Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

1. Comm.501 Library and Information Services (0+1)

2. Comm.502 Technical Writing and Communications Skills (0+1)

3. Comm.503 Intellectual Property and its management in Agriculture (1+0)

4. Comm.504 Basic Concepts in Laboratory Techniques (0+1)

5. Comm.505 Agricultural Research, Research Ethics and Rural Development Programmes (1+0)

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the Head of Department (HOD)/ Board of Studies (BOS).

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

2.4 Mandatory requirement of seminars

- It has been agreed to have mandatory seminars one in Masters (One Credit)
- The students should be encouraged to make presentations on the latest developments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.
- The evaluation of seminar presentation shall be done by the departmental committee which shall be constituted by the Head of Department /Principal of College
- Result should be satisfactory.

3. Duration of the Programme

Minimum -4 semesters (2 academic years)
Maximum-8 semesters

4. Evaluation of course work

For M.Sc.(Ag.) multiple levels of evaluation (**Midterm and Final semester**) is desirable. However, it has been felt that the comprehensive examination is redundant for M.Sc. students. Each paper have maximum marks-100.

Mid term- 25 marks

Practical - 25 marks

Final semester- 50 marks

4.1. Grading System

Scale: 10 point
i. Minimum passing grade in a course 5.00
ii. Minimum OGPA to continue and to obtain degree: 5.50

Attendance requirements

Minimum 75%, to be counted separately for theory and practical Course evaluation

5. Advisory System

5. 1 Advisory Committee

- Minimum 3 members (2 from major subject including Chairman, and one from minor subject) to be constituted within three months of the 1st Semester

- Theory – Internal/External
- Practical – Internal, to be conducted by the course teacher + one external examiner for all paper in each semester to be nominated by the University.

i. Thesis Evaluation:	External (One examiner)
ii. Thesis Viva-Voce:	By Advisory Committee and External (One examiner)
iii. Assessment:	Satisfactory/Unsatisfactory

•The Advisor should convene a meeting of the Advisory Committee at least once in a Semester. The summary record should be communicated to the Head of Department, Dean of the College of concerned, Dean PGS and Registrar for information.

Advisor/ Co-guide/ Member, Advisory Committee from other collaborating University/ Institute/ Organization

• In order to promote quality Post-graduate research and training in cutting edge areas, the University may enter into Memorandum of Understanding (MOU) with other Universities/ Institutions for conducting research. While constituting an Advisory Committee of a student, if the Chairperson, Advisory Committee feels the requirement of involving of a faculty member/ scientist of such partnering university/ Institute/ Organization, he/ she may send a proposal to this effect to Director (Education)/ Dean PGS along with the proposal for consideration of Student's Advisory Committee (SAC).

• The proposed faculty member from the partnering institution can be allowed to act as Chairperson/ Co-guide/ Member, SAC, by mutual consent, primarily on the basis of intellectual input and time devoted for carrying out the research work at the particular institution. The faculty member/ scientist of partnering institutions in the SAC shall become a temporary faculty member of the University by following the procedure approved by the Academic Council.

Allotment of students to the retiring persons

Normally, retiring person may not be allotted M. Sc.(Ag.) Student if he/ she is left with less than 2 years of service and Ph.D. student if left with less than 3 years of service. However, in special circumstances, permission may be obtained from the Director (Education)/ Dean PGS, after due recommendation by the concerned Head of the Department.

Changes in the Advisory Committee:

(i) Change of the Chairperson or any member of the Advisory Committee is not ordinarily permissible. However, in exceptional cases, the change may be effected with due approval of the Director of Education/ Dean PGS.

(ii) Normally, staff members of the university on extra ordinary leave or on study leave or who leave the University service will cease to continue to serve as advisors of the Post-graduate students of the University. However, the Director (Education)/ Dean PGS may permit them to continue to serve as advisor subject to the following conditions:

(a) The concerned staff member must be resident in India and if he/ she agrees to guide research and must be available for occasional consultations;

(b) An application is made by the student concerned duly supported by the Advisory Committee;

(c) The Head of the Department and the Dean of the College concerned agree to the proposal;

(d) The staff member, after leaving the University service is granted the status of honorary faculty's membership by the Vice-Chancellor on the recommendation of the Director (Education)/ Dean PGS for guiding as Chairperson or Member, Advisory Committee the thesis/ theses of the student(s) concerned only.

(iii) In case the Chairperson/ member of a Student's Advisory Committee retires, he/ she shall be allowed to continue provided that the student has completed his course work and minimum of 10 research credits and the retiring Chairperson/ member stays at the Headquarters of the College, till the thesis is submitted.

(iv) If the Chairperson/ member proceeds on deputation to another organization, he/ she may be permitted to guide the student provided his/ her new organization is at the Headquarters of the College and his/ her organization is willing for the same.

(v) The change shall be communicated to all concerned by the Head of Department.

5.2 Approval of synopsis: Should be accomplished by Advisory Committee

6. Evaluation of research work

- It is highly desirable for M.Sc.(Ag.) programme and this should be done external and internal examiner
- The research work may be initiated in any of I to IV^{rth} semester but the thesis shall be submitted at the end of IV semester.
- The viva voce will be conducted for evaluation research work for PG after submission of thesis by external examiner
- The result should be satisfactory

6.1 Prevention of plagiarism

• An institutional mechanism should be in place to check the plagiarism. The students must be made aware that manipulation of the data/ plagiarism is punishable with serious consequences.

7. Learning through online courses

• In line with the suggestion in new education policy and the initiatives taken by ICAR and MHRD in the form of e-courses, MOOCs, SWAYAM, etc. and also changes taking place globally in respect of learning through online resources it has been agreed to permit the students to enroll for online courses. It is expected that the provision of integrating available online courses with the traditional system of education would provide the students opportunities to improve their employability by imbibing the additional skills and competitive edge.

The Committee recommends the following points while integrating the online courses:

1. Board of Studies (BoS) of each Faculty shall identify available online courses and a student may select from the listed courses. The interested students may provide the details of the on-line courses to the BoS for its consideration.

2. A Postgraduate student may take up to a maximum of 20% credits in a semester through online learning resources.

3. The host institute offering the course does the evaluation and provide marks/ grades. The BoS shall develop the conversion formula for calculation of GPA and it may do appropriate checks on delivery methods and do additional evaluations, if needed.

8. <u>Internship during Masters programme</u>

Internship for Development of Entrepreneurship in Agriculture (IDEA) Currently, a provision of 30 credits for dissertation work in M.Sc.(Ag). programmes helps practically only those students who aspire to pursue their career in academic/ research. There is hardly any opportunity/ provision under this system to enhance

the entrepreneurship skills of those students who could start their own enterprise or have adequate skills to join the industry. Therefore, in order to overcome this gap, an optional internship/ in-plant training (called as IDEA) in **lieu** of thesis/ research work is recommended which will give the students an opportunity to have a real-time hands-on experience in the industry.

It is envisaged that the internship/ in-plant training would enhance the interactions between academic organizations and the relevant industry. It would not only enable the development of highly learned and skilled manpower to start their-own enterprises but also the industry would also be benefitted through this process. This pragmatic approach would definitely result in enhanced partnerships between academia and industry.

The main objectives of the programme:

1. To promote the linkages between academia and industry
2. To establish newer University – Cooperative R&D together with industry for knowledge creation, research and commercialization
3. Collaboration between Universities and industries through pilot projects
4. To develop methods for knowledge transfer, innovation and networking potential
5. To enhance skill, career development and employability
6. Following criteria for IDEA will be taken into consideration:

• At any point of time there will not be more than 50% of students who can opt under IDEA

• Major Advisor will be from Academia and Co-advisor (or Advisory Committee member) from industry

• Total credits (30) will be divided into 20 for internship/ in-plant training and10 for writing the report followed by viva-voce similar to dissertation

• Work place will be industry; however, academic/ research support would be provided by the University or both. MoU may be developed accordingly

• The IPR, if any, would be as per the University policy

9. Teaching assistantship

• Teaching assistantship shall be encouraged. This will give the required experience to the students on how to conduct courses, practical classes, evaluation and other related academic matters.

10.Inter-institutional Transfer of Credits

Once the unified national PG curriculum and common academic regulations get implemented, the students may be permitted to transfer credits from one institution to another in case of unavoidable migration. Migration of students admitted through ICAR quota should not be allowed. The migration rules may be framed by the individual SAUs, and due care need be exercised to avoid inbreeding in students.

11. Compliance with the National Education Policy-2020

• While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) are required to comply with the provisions of National Education Policy-2020, especially the following aspects:

• Given the 21st century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals. It must enable an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and 21st century capabilities across a range of

disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education must enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. It must prepare students for more meaningful and satisfying lives and work roles and enable economic independence (9.1.1. of NEP-2020).

• At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation (9.1.3. of NEP-2020).

• Flexibility in curriculum and novel and engaging course options will be on offer to students, in addition to rigorous specialization in a subject or subjects. This will be encouraged by increased faculty and institutional autonomy in setting curricula. Pedagogy will have an increased emphasis on communication, discussion, debate, research, and opportunities for cross-disciplinary and interdisciplinary thinking (11.6 of NEP-2020).

• As part of a holistic education, students at all HEIs will be provided with opportunities for internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/ research institutions, so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability (11.8 of NEP-2020).

• HEIs will focus on research and innovation by setting up start-up incubation centres; technology development centers; centers in frontier areas of research; greater industry-academic linkages; and interdisciplinary research including humanities and social sciences research (11.12. of NEP-2020).

• Effective learning requires a comprehensive approach that involves appropriate curriculum, engaging pedagogy, continuous formative assessment, and adequate student support. The curriculum must be interesting and relevant, and updated regularly to align with the latest knowledge requirements and to meet specified learning outcomes. High-quality pedagogy is then necessary to successfully impart the curricular material to students; pedagogical practices determine the learning experiences that are provided to students, thus directly influencing learning outcomes. The assessment methods must be scientific, designed to continuously improve learning and test the application of knowledge. Last but not least, the development of capacities that promote student wellness such as fitness, good health, psycho-social well-being, and sound ethical grounding are also critical for high-quality learning (12.1. of NEP-2020).

12. Definitions of Academic Terms

Chairperson means a teacher of the major discipline proposed by the Head of Department through the Dean of the College and duly approved by the Director of Education/ Dean Post Graduate Studies (or as per the procedure laid down in the concerned University regulations) to act as the Chairperson of the Advisory Committee and also to guide the student on academic issues.

Course means a unit of instruction in a discipline carrying a specific number and credits to be covered in a semester as laid down in detail in the syllabus of a degree programme.

Credit means the unit of work load per week for a particular course in theory and/ or practical. One credit of theory means one class of one clock hour duration and one credit practical means one class of minimum two clock hoursof laboratory work per week.

Credit load of a student refers to the total number of credits of all the courses he/ she registers during a particular semester. Grade Point (GP) of a course is a measure of performance. It is obtained by dividing the per cent mark secured by a student in a particular course by 10, expressed and rounded off to second decimal place.

Credit Point (CP) refers to the Grade point multiplied by the number of credits of the course, expressed and rounded off to second decimal place.

Grade Point Average (GPA) means the total credit point earned by a student divided by total number of credits of all the courses registered in a semester, expressed and rounded off to second decimal place. **Cumulative Grade Point Average (CGPA)** means the total credit points earned by a student divided by the total number of credits registered by the student until the end of a semester (all completed semesters), expressed and rounded off to second decimal place.

Overall Grade Point Average (OGPA) means the total credit points earned by a student in the entire degree programme divided by the total number of credits required for the P.G. degree, expressed and rounded off to second decimal place.

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

Major courses(Minimum)		**20 Credit**
Course Code	Course Title	Credit Hours
GPB 501*	Principles of Genetics	3 (2+1)
GPB 502*	Principles of Plant Breeding	4 (3+1)
GPB 503*	Fundamentals of Quantitative Genetics	3 (2+1)
GPB 504	Varietal Development and Maintenance Breeding	2 (1+1)
GPB 505	Principles of Cytogenetics	3 (2+1)
GPB 506*	Molecular Breeding and Bioinformatics	3 (2+1)
GPB 507	Breeding for Quality and Special Traits	3 (2+1)
GPB 508	Mutagenesis and Mutation Breeding	3 (2+1)
GPB 509	Hybrid Breeding	3 (2+1)
GPB 510	Seed Production and Certification	2 (1+1)
GPB 511	Crop Breeding-I (Kharif Crops)	3 (2+1)
GPB 512	Crop Breeding-II (Rabi Crops)	3 (2+1)
GPB 513	Breeding Vegetable Crops	3 (2+1)
GPB 514	Breeding Fruit Crops	3 (2+1)

GPB 515	Breeding Ornamental Crops	3 (2+1)
GPB 516	Breeding for Stress Resistance and Climate Change	3 (2+1)
GPB 517	Germplasm Characterization and Evaluation	2 (1+1)
GPB 518	Genetic enhancement for PGR Utilization	2 (1+1)
Minor course		**08 Credit**
Opt from the subjects (M.Sc.(Ag.) closely related to a major subject		
Supporting courses(Minimum) \		**07 Credit**
STAT 502	Statistical Methods for Applied Sciences	4(3+1)
STAT 511	Experimental Designs	3 (2+1)
Total Credit		**07**
Common compulsory courses		**05 Credit**
Comm.501	Library and Information Services	1(0+1)
Comm. 502	Technical Writing and Communications Skills	1 (0+1)
Comm. 503	Intellectual Property and its management in Agriculture	1 (1+0)
Comm.504	Basic Concepts in Laboratory Techniques	1(0+1)
Comm. 505	Agricultural Research, Research Ethics and Rural Development Programmes	(1+0)
Total Credit		**05**
Master's Seminar		**1**
*GPB 591	Master's Seminar	1(1+0)
Master,s Thesis/ Research		**30 Credit**
*GPB 599	Master's Research	30
Total Credit (Minimum**)**		**70**

*Indicates Core Courses which are Compulsory

14. Semester wise Allocation of Selected courses

Course Title with Credit Load

M.Sc. (Ag.) in Genetics and Plant Breeding

First Semester

Major Course		
Course code	Course Title	**Credit**
GPB 501	Principles of Genetics	**3 (2+1)**
GPB 502*	Principles of Plant Breeding	3 (2+1)
GPB 503*	Fundamentals of Quantitative Genetics	3 (2+1)
Miner Course		
Opt from the subjects (M.Sc.(Ag.) closely related to a major subject (one paper)		2 or 3
Common Course		

Comm.501	Library and Information Services	1(0+1)
Comm. 502	Technical Writing and Communications Skills	1 (0+1)
Supporting Course		
STAT 502	Statistical Methods for Applied Sciences	4(3+1)
Total Credit		**17 or 18**

Second Semester

Major Course		
GPB 505	Principles of Cytogenetics	3(2+1)
GPB 506*	Molecular Breeding and Bioinformatics	3(2+1)
Miner Course		
Opt from the subjects (M.Sc.Ag.) closely related to a major subject (one paper)		2 or 3
Common Course		
Comm. 503 1	Intellectual Property and its management in Agriculture	1(1+0)
Supporting Course		
STAT 511	Experimental Designs	3 (2+1)
Total Credit		**12 or 13**

Third Semester

Major Course		
GPB 511	Crop Breeding-I (Kharif Crops)	3 (2+1)
GPB 516	Breeding for Stress Resistance and Climate Change	3 (2+1)
Miner Course		
Opt from the subjects(M.Sc.Ag.) closely related to a major subject (one paper)		2 or 3
Common Course		
Comm.504	Basic Concepts in Laboratory Techniques	1(0+1)
Comm. 505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)
Total Credit		**10 or 11**

Fourth Semester

Major Course		
GPB 512	Crop Breeding-II (Rabi Crops)	3 (2+1)
Other essential requriments		
*GPB 591	Master,s Seminar	1(1+0)
*GPB 599	Master,s Research	30(Satisfactory)
Total Credit		**34**
Grand Total Credit(minimum)		**70**

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Paper wise Allocation course credit & Maximum Marks
M.Sc.(Ag) Genetics and Plant Breeding

Sr. No.	Paper Code	Course Title / Paper Title	Credit (Th.+Pr.)	Maximum Marks M.T	E.T.	Pr./Ass	Total Marks
		1st Semester					
1	GPB 501	Principles of Genetics	3 (2+1)	25	50	25	100
2	GPB 502*	Principles of Plant Breeding	3 (2+1)	25	50	25	100
3	GPB 503*	Fundamentals of Quantitative Genetics	3 (2+1)	25	50	25	100
4		Opt from the subjects (M.Sc.Ag.) closely related to a major subject (one paper)	2 or 3	25	50	25	100
5	Comm.501	Library and Information Services	1 (0+1)	--	--	100	100
6	Comm.502	Technical Writing and Communications Skills	1 (0+1)	--	--	100	100
7	STAT 502	Statistical Methods for Applied Sciences	4 (3+1)	25	50	25	100
Sr.No. 1,2,3- Major, 4-Minor, 5,6- Common & 7- Supporting Course			**17 or 18**				700
		2nd Semester					
1	GPB 505	Principles of Cytogenetics	3(2+1)	25	50	25	100
2	GPB 506*	Molecular Breeding and Bioinformatics	3(2+1)	25	50	25	100
3		Opt from the subjects (M.Sc.Ag.) closely related to a major subject (one paper)	2 or 3	25	50	25	100
4	Comm.503	Intellectual Property and its management in Agriculture	1 (1+0)	25	50	25	100
5	STAT 511	Experimental Designs	3 (2+1)	25	50	25	100
Sr.No. 1,2- Major, 3-Minor, 4- Common & 5- Supporting Course			**12 or 13**				500
		3rd Semester					
1	GPB 511	Crop Breeding-I (Kharif Crops)	3 (2+1)	25	50	25	100
2	GPB 516	Breeding for Stress Resistance and Climate Change	3 (2+1)	25	50	25	100
3		Opt from the subjects(M.Sc.Ag.) closely related to a major subject (one paper)	2 or 3	25	50	25	100
4	Comm.504	Basic Concepts in Laboratory Techniques	1(0+1)	--	--	100	100
5	Comm.505	Agricultural Research, Research Ethics and Rural Development Programmes	1 (1+0)	25	50	25	100
Sr.No. 1,2- Major, 3 -Minor & 4,5-Common Course			**10 or 11**				500
		4th Semester					
1	GPB 512	Crop Breeding-II (Rabi Crops)	3 (2+1)	25	50	25	100
2	*GPB 591	Master Seminar	1 (0+1)	--	--	100	100
3	*GPB 599	Master Research (Thesis)	30	Satisfactory/Unsatisfactory			
Sr.No. 1- Major Course, 2-Master Seminar & 3-Master Research			**34**				200

NOTE: M.T. = Mid Term, E.T.= End Tem, Pr./Ass.= Practical/Assignment +Viva-Voce.

***Total credit should not less than 70**

15. Course contents

(Major Course)

M.Sc. (Ag.) in Genetics and Plant Breeding

I. **Course Title: Principles of Genetics***

II. Course Code: GPB 501

III. Credit Hour : 3 (2+1)

IV. Why this course?

Genes are the backbone of all crop improvement activities. Their chemical structure and physical inheritance are pivotal for any breeding program. Therefore, it has to be the core course for master's degree in Genetics and Plant Breeding.

V. **Objective of the course**

Understanding the basic con`cepts of inheritance of genetic traits, helping students to develop their analytical, quantitative and problem-solvingskills from classical to molecular genetics.

VI. Theory

Unit I

Beginning of genetics, early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance; Multiple alleles, Gene interactions, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance. Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

Unit II

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 III

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 IV

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

VII 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.

VIII. Teaching methods

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

IX. Learning outcome

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

X. 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 EditionInternational Student Version edition

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

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

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

I. **Course Title: Principles of Plant Breeding***

II. Course Code : GPB 502

III. Credit Hours : 4(3+1)

IV. Why this course?

Development of plant variety is the ultimate aim of any plant breeding program. 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

V. **Objective of the Course:**

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

VI. **Theory**

Unit I

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

Unit II

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

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 III

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.

Unit IV

Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Breeding methods in asexually/ clonally propagated crops, clonal selection.Special breeding techniques: Concept of plant ideotype and its role in crop improvement, concept of MAS.

VII. 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.

VIII. Teaching methods

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

IX. Learning outcome

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

X. Suggested Reading

Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.
Chahal GS and Gossal, SS. 2002. Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches. Narosa Publishing House.
Chopra VL. 2004. Plant Breeding. Oxford & IBH.
George A. 2012. Principles of Plant Genetics and Breeding. John Wiley & Sons. Gupta SK. 2005. Practical Plant Breeding. Agribios.
Jain HK and Kharakwal MC. 2004. Plant Breeding and–Mendelian to Molecular Approach, Narosa Publications, New Delhi
Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House. Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi. Simmonds NW.1990. Principles of Crop Improvement. English Language Book Society. Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.
Singh S and Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.

I. **Course Title: Fundamentals of Quantitative Genetics***

II. Course Code : GPB 503

III. Credit Hours : 3 (2+1)

IV. Why this course?

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

V. **Objective of the course**

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

VI. 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. 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.

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.

VII. Practical

- Analysis and interpretation of variability parameters;
- Analysis and interpretation of Index score and Metroglyph;
- Clustering and interpretation of D^2 analysis;
- Genotypic and phenotypic correlation analysis and interpretation;
- Path coefficient analysis and interpretation, Estimation of different types ofheterosis, 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.

VIII. Teaching methods

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

IX. Learning outcome

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

X. 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. Kalyani Publishers,New Delhi.

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

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

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

Singh RK and Chaudhary BD. 1987. Biometrical Methods in Quantitative Genetic analysis. Kalyani Publishers, New Delhi.

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

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

I. **Course Title : Varietal Development and Maintenance Breeding**

II. Course Code : GPB 504

III. Credit Hours : 2(1+1)

IV. Why this course?

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

V. Aim of the course

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

VI. Theory

Unit I

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

Unit II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties - safeguards during seed production.Maintenance of varieties in self and cross pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, certified.

Unit III

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

Unit IV

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

VII. Practical

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

VIII. Teaching methods

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

IX. Learning outcome

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

X. Suggested Reading

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

Course Title: Principles of Cytogenetics

I. Course Code: GPB 505

II. Credit Hour : 3 (2+1)

III. Why this course?

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

breeding.

IV. **Objective of the course**

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

V. 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-varietal chromosome substitutions.

Unit III

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

Unit IV

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

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

VI 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 in vivo and in-vitro;
- Demonstration of polyploidy.

VIII. Teaching methods

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

IX. Learning outcome

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

X. Suggested Reading

Becker K and Hardin J. 2004. World of the Cell. 5th Ed. Pearson Edu. 9th edition. Carroll M. 1989. Organelles. The Guilford Press.
Charles B. 1993. Discussions in Cytogenetics. Prentice Hall Publications.
Darlington CD and La Cour LF. 1969. The Handling of Chromosomes. George Allen & Unwin Ltd.
Elgin SCR. 1995. Chromatin Structure and Gene Expression. IRL Press, Oxford.

Gupta PK and Tsuchiya T. 1991. Chromosome Engineering in Plants: Genetics, Breeding and Evolution. Part A.
Gupta PK. 2010. Cytogenetics. Rastogi Pubishers. Johannson DA. 1975. Plant Micro technique. McGraw Hill.
Karp G. 1996. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Khush GS. 1973. Cytogenetics of aneuploids. Elsevier. 1 edition.
Roy D.2009. Cytogenetics. Alpha Science Intl Ltd.
Schulz SJ.1980. Cytogenetics- Plant, animals and Humans. Springer.
Sharma AK and Sharma A. 1988. Chromosome Techniques: Theory and Practice. Butterworth-Heinemann publisher 2014.3rd edition
Singh RJ. 2016. Plant Cytogenetics 3rd Edition. CRC Press.
Sumner AT. 1982. Chromosome Banding. Unwin Hyman Publ. 1 edition, Springer pub. Swanson CP. 1960. Cytology and Cytogenetics. Macmillan & Co.

I. **Course Title: Molecular Breeding and Bioinformatics***

II. Course Code : GPB 506

III. Credit Hours : 3(2+1)

IV. Why this course?

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.

V. **Objective of the course**

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

VI. 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.

VII. Practical

- Requirements for plant tissue culture laboratory;
- Techniques in plant tissue culture;
- Media components and media preparation;
- Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations;
- Inoculation of explants, callus induction and plant regeneration; Standardizing the protocols for regeneration;
- Hardening of regenerated plants; Establishing a greenhouse and hardening procedures;
- Visit to commercial micropropagation unit;
- Transformation using Agrobacterium strains;

- GUS assay in transformed cells/ tissues;
- DNA isolation, DNA purity and quantification tests;
- Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship;
- Construction of genetic linkage maps using computer software;
- NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene PredictionTool, 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.

VIII. Teaching methods

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

IX. Learning Outcome

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

X. Suggested Reading

Azuaje F and Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics. John Wiley and Sons.

Brown TA. 1991. Essential Molecular Biology: a practical Approach. Oxford university press, 2002, 2nd edition

Chawala HS. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt.Ltd.

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

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

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

Jollès P and Jörnvall H. 2000. Proteomics in Functional Genomics: Protein Structure Analysis.Birkhäuser.

Lewin B. 2017. Genes XII. Jones & Bartlett learning, 2017.

Robert NT and Dennis JG. 2010. Plant Tissue Culture, Development, and Biotechnology. CRCPress.

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

Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani Publishers, New Delhi.Watson J. 2006. Recombinant DNA. Cold Spring harbor laboratory press.

I. **Course Title : Breeding for Quality and Special Traits**

II. Course Code : GPB 507

III. Credit Hours : 3(2+1)

IV. Why this course?

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

V. Aim of the course

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

VI. Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

VII. Practical

- Grain quality evaluation in rice; Correlating ageing and quality improvement in rice;
- Quality analysis in millets;
- Estimation of anti-nutritional factors like tannins in different varieties/ hybrids: A comparison;
- Quality parameters evaluation in wheat, pulses and oilseeds;
- Evaluation of quality parameters in cotton, sugarcane and potato;
- Value addition in crop plants

Post-harvest processing of major field crops;

- Quality improvement in crops through tissue culture techniques;
- Evaluating the available populations like RIL, NIL, etc. for quality improvement using MAS procedures;
- Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

VIII. Teaching methods

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

IX. Learning outcome

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

X. Suggested Reading

Chahal GS and SS Ghosal. 2002. Principles and procedures of plant breeding - Biotechnological and Conventional approaches, Narosa Publications Chopra VL. 1997. Plant Breeding. Oxford & IBH. 2018.
FAO 2001. Speciality Rices of the World - Breeding, Production and Marketing. Oxford & IBH, 1 Nov 2001.
Ghosh P. 2004. Fibre Science and Technology. Tata McGraw Hill.
Gupta SK. 2007. Advances in Botanical Research Vol. 45 Academic Press USA. Hay RK. 2006. Physiology of Crop Yield. 2nd Ed. Blackwell.
Nigam J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH. Singh BD. 1997. Plant Breeding. Kalyani Publishers, New Delhi.
Singh RK, Singh UK and Khush GS. 2000. Aromatic Rices. Oxford & IBH.

Course Title : Mutagenesis and Mutation Breeding

I. Course Code : GPB 508

II. Credit Hours : 3 (2+1)

III. Why this course?

The knowledge of this course will enable the students to learn about mutation, various methods of inducing mutations and their utilization in plant breeding. It will also give in depth knowledge about genomics, allele mining, TILLING, etc. and their utilization in crop improvement programmes.

IV. Aim of the course

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

V. Theory

Unit I

Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations; Detection of mutations. Paramutations in crops plants.

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

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

Unit III

Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.

Unit IV

Use of mutagens in creating oligogenic and polygenic variations – Case studies; In-vitro mutagenesis – Callus and pollen irradiation; Handling of segregating M2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits(disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

VI. Practical

- Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents:Physical mutagens and Chemical mutagens;
- Learning on Radioactivity- Production source and isotopes at BRIT, Trombay, Learning about gamma chamber;
- Radiation hazards: Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes;
- Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens;
- Procedures in combined mutagenic treatments;
- Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature;

- Study of M1 generation – Parameters;
- Study of M2 generation – Parameters;
- Mutation breeding in cereals and pulses-achievements made and an analysis;
- Mutation breeding in oilseeds and cotton- achievements and opportunities;
- Mutation breeding in forage crops and vegetatively propagated crops;
- Procedure for detection of mutations for polygenic traits in M2 and M3 generations.

VII. Teaching methods

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

VIII. Learning outcome

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

IX. Suggested Reading

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

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

I. **Course Title : Hybrid Breeding**

II. Course Code : GPB 509

III. Credit Hours : 3(2+1)

IV. Why this course?

This course will expose the students with the basic concepts of hybrid varietiesand various techniques for development of hybrids in crop plants. This will also give an overview of various kinds of male sterility and their utilization in hybrid seed production of important field crops.

V. Aim of the course

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

VI. Theory

Unit I

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemicaland molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

Unit II

Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds,their improvement for increasing heterosis.

Unit III

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

Unit IV

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

Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed- mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

VII. Practical

- Characterization of male sterile lines using morphological descriptors;
- Restorer line identification and diversification of male sterile sources;
- Male sterile line creation in crop plants, problems in creation of CGMS system,ways of overcoming them;
- Diversification and restoration;
- Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeonpea;
- Understanding the difficulties in breeding apomicts;
- Estimation of heterotic parameters in self, cross and asexually propagated crops;
- Estimation from the various models for heterosis parameters;
- Hybrid seed production in field crops—an account on the released hybrids, theirpotential, problems and ways of overcoming it;

- Hybrid breeding at National and International level,opportunities ahead.

VIII. Teaching methods

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

IX. Learning outcome

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

X. Suggested Reading

Agarwal RL. 1998. Fundamental of Plant Breeding and hybrid Seed Production. SciencePublisher London.
Akin E. 1979. The Geometry of Population Genetics. Springer-Verlag.
Ben HL. 1998. Statistical Genomics – Linkage, Mapping and QTL Analysis. CRC Press.
Chal GS and Gossal SS. 2002. Principles and procedures of Plant Breeding, Biotechnology andConvetional Approaches. Narosa Publishing House. New Delhi
De JG. 1988. Population Genetics and Evolution. Springer-Verlag. 30 January 2012Hartl DL. 2000. A Primer of Population Genetics. 3rd Ed. Sinauer Assoc.
Mettler LE and Gregg TG. 1969. Population Genetics and Evolution. Prentice-Hall. 25 April1988
Montgomery DC. 2001. Design and Analysis of Experiments. 5th Ed., Wiley & Sons. 2013Mukherjee BK. 1995.The Heterosis Phenomenon. Kalyani Publishers, New Delhi.
Proceedings of Genetics and Exploitation of Heterosis in Crops – An International SymposiumCIMMYT, 1998.
Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin. 30 May 1997Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.
Srivastava S and Tyagi R. 1997. Selected Problems in Genetics. Vols. I, II. Anmol Publ. Virmani SS. 1994. Heterosis and Hybrid Rice Breeding. Monographs of "Theoretical and Applied Genetics", Springer-Verlag.

I. **Course Title: Seed Production and Certification**

II. Course Code : GPB 510

III. Credit Hours : 2(1+1)

IV. Why this course?

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

V. Aim of the course

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

VI. 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

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.

VII. Practical

- Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony;
- Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination;
- Pollen collection and storage methods, pollen viability and stigma receptivity;
- Pre-harvest sanitation, maturity symptoms, harvesting techniques;
- Visits to seed production plots - visit to seed industries;
- Planning for seed production: cost benefit ratio, seed multiplication ratio and seedreplacement rate;
- General procedure of seed certification, identification of weed and other crop seedsas per specific crops, field inspection at different stages of a crop and observationsrecorded 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.

VIII. Teaching methods

- Power point presentation

Chalk and Board

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

IX. Learning outcome

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

X. Suggested Reading

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

e-Resources

www.gov.mb.ca www.agricoop.nic.in www.agri.nic.in www.fao.org www.seednet.gov.in

I. **Course Title: Crop Breeding I (Kharif Crops)**

II. Course Code: GPB 511

III. Credit Hour : 3(2+1)

IV. Why this course?

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

V. **Objective of the course**

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

VI. Theory

Unit I

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

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

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

Unit II

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

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

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

Unit III

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

Unit IV

Cotton: Origin, evolution, mode of reproduction, chromosome number; Genetics 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.

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.

VII. 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 betweenblack gram and green gram;
- Evaluating the germplasm of cotton for yield, quality and resistance parameters,learning the procedures on

development of Bt cotton;
- Visit to Cotton Technology Laboratory and Spinning Mills;
- Learning on the Standard Evaluation System (SES) and descriptors; Use of softwarefor database management and retrieval;
- Laboratory analysis of forage crops for crude protein, digestibility percent andother quality attributes;

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

IX. Learning outcome

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

X. Suggested Reading

Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I.
Pulses and Oilseeds. Oxford & IBH.
Chandraratna MF. 1964. Genetics and Breeding of Rice. Longmans.
Chopra VL and Prakash S. 2002. Evolution and Adaptation of Cereal Crops. Oxford & IBH. Gill KS. 1991. Pearl Millet and its Improvement. ICAR.
IRRI. 1964. Rice Genetics and Cytogenetics. Elsevier.
IRRI. 1986. Rice Genetics. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
IRRI. 1991. Rice Genetics II. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
IRRI. 1996. Rice Genetics III. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
IRRI. 2000. Rice Genetics IV. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
Jennings PR, Coffman WR and Kauffman HE. 1979. Rice Improvement. IRRI, Los Banos, Manila, Philippines.
Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. New Dimensions and Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU, Coimbatore.
Murty DS, Tabo R and Ajayi O. 1994. Sorghum Hybrid Seed Production and Management.
ICRISAT, Patancheru, India.
Nanda JS. 1997. Manual on Rice Breeding. Kalyani Publishers.
Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of HorticulturalCrops Vol.1 (Part-B), Today and Tomorrow Printers and Publishers
Poehlman, JM. 1987. Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connecticut,USA.
Ram HH and Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
Sharma, AK. 2005. Breeding Technology of Crop Plant. Yesh Publishing House, 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 in India. International Book Distributing Co.
Walden DB. 1978. Maize Breeding and Genetics. John Wiley & Sons.

I. **Course Title: Crop Breeding-II (Rabi Crops)**

II. Course Code: GPB 512

III. Credit Hour : 3(2+1)

IV. Why this course?

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

V. **Objective of the course**

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

VI. Theory

Unit I

Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and

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

Unit II

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

Unit III

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

Unit IV

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

VII. Practical

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

VIII. Teaching methods

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

IX. Learning outcome

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

X. Suggested Reading

Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. Oxford & IBH.

Gupta SK. 2012. Technological Innovations in Major World Oil crops. Vol. I. Springer, USA. Gupta SK. 2012. Technological Innovations in Major World Oil crops. Vol. II. Springer, USA. Gupta SK. 2016. Breeding of Oilseed Crops for Sustainable Production. Academic Press, USA. Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. New Dimensions and
Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU, Coimbatore. Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of Breeding and Genetics. John Wiley & Sons.

I. **Course Title : Breeding Vegetable Crops**

II. Course Code : GPB 513

III. Credit Hours : 3(2+1)

IV. Why this course?

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

V. Aim of the course

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

VI. Theory

Unit I

Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II

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

Unit III

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

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

Unit IV

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

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

VII. Practical

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

VIII. Teaching methods

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

IX. Learning outcome

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

Suggested Reading

Allard RW. 1999. Principles of Plant Breeding. John Wiley & Sons.
Fageria MS, Arya PS and Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani Publishers, New Delhi.
Kalloo G. 1988. Vegetable Breeding. Vols. I-III. CRC Press.
Kalloo G. 1998. Vegetable Breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency. Peter KV and Pradeep KT. 2008. Genetics and Breeding of Vegetables. ICAR.
Rai N and Rai M. 2006. Heterosis Breeding in Vegetable Crops. New India Publication Agency. Ram HH. 2005. Vegetable Breeding-Principles and Practices. Kalyani Publishers
Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publishers, New Delhi. Singh BD. 1983. Plant Breeding. Kalyani Publishers

I. **Course Title : Breeding Fruit Crops**
II. Course Code : GPB 514
III. Credit Hours : 3(2+1)

IV. Why this course?

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

V. Aim of the course

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

VI. Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

VII. Practical

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

VIII. Teaching methods

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

IX. Learning outcome

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

X. Suggested Reading

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

Ray PK. 2002. Breeding of Tropical and Sub-tropical Fruits. Narosa Publishing House, New Delhi.
Simmonds NW. 1976. Evolution of Crop Plants, Orient Longman, London.

I. **Course Title : Breeding Ornamental Crops**

II. Course Code : GPB 515

III. Credit Hours : 3(2+1)

IV. Why this course?

The course will impart knowledge to student about breeding of Ornamental Cropsthrough conventional and biotechnological interventions.

V. Aim of the course

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

VI. Theory

Unit I

History of improvement of ornamental plants; Centre of origin of ornamental crop;Objectives and techniques in ornamental plant breeding.

Unit II

Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, viz., Rose, Jasmine, Chrysanthemum, Tuberose, Gerbera, Gladiolus, Dahlia, Lilium, Gaillardia, Petunia, Bouganvillea, Pansy, Marigold, Geranium, Antirrhinum, China aster, Orchids, Carnation, Hibiscus, etc.

Unit III

Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its exploitation, production of F1 hybrids and utilization of male sterility.

Unit IV

Production of open pollinated seeds, harvesting, processing and storage of seeds; Seed certification.

VII. Practical

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

VIII. Teaching methods

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

IX. Learning outcome

After completion of this course the students will be able to do the breeding of ornamental crops by conventional breeding and biotechnological methods and to know the genetics of major ornamental crops.

X. Suggested Reading

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

I. **Course Title: Breeding for Stress Resistance and Climate Change**

II. Course Code: GPB 516

III. Credit Hour : 3(2+1)

IV. Why this course?

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

V. **Objective of the course**

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

VI. Theory

Unit I

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

Unit II

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

Unit III

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.

Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; Acidity, salinity/ alkalinity/sodicity; High/ low temperature, wind, etc.; Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

Unit IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging and submergence, high and low/ freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment.

Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

VII. Practical

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

VIII. Teaching methods

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

- Group tasks, student's presentations

IX. Learning outcome

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

X. Suggested Reading

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

Turener NC and Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons.
Van der Plank JE. 1982. Host-Pathogen Interactions in Plant Disease. Academic Press.

Course Title : Germplasm Characterization and Evaluation

I. Course Code : GPB 517

II. Credit Hours : 2(1+1)

III. Why this course ?

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

IV. Aim of the course

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

V. Theory

Unit I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR.

Unit II

Evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit II

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

Unit III

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

VI. Practical

- Field layout and experimental designs;
- Recording field data on germplasm evaluation in different agri-horticultural crops,
- post harvest handling;
- Evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing;

· Documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.

Lectures

Power point presentations

assignments, quiz

Group tasks, student's presentations

Learning Outcome

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

Suggested Reading

Brown AHD, Clegg MT, Kahler AL, Weir BS (eds.) 1990. Plant Population Genetics, Breeding, and Genetic Resources, Sinauer Associates, USA.

Frankel R and Galun E 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics, Springer-Verlag, Berlin, Heidelberg.

Hayward MD, Bosemak NO and Romagosa I. 1993. Plant Breeding: Principles and Practices, Chapman & Hall.

Holden JHN and Williams JT 1984. Crop genetic resources: conservation and evaluation, IBPGR. Puzone, L and Th. Hazekamp 1996. Characterization and Documentation of Genetic Resources

Utilizing Multimedia Database. NBPGR, New Delhi.

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

Stoskopf NC 1993. Plant Breeding: Theory and Practice, Westview Press.

Sundeep Kumar, et al. 2016. Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch diseases. PloS One Vol 11, pages 0167702.

Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. Plant Genetic Resources Evaluation: Principles and Procedures, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi.

Course Title : Genetic enhancement for PGR Utilization

Course Code : GPB 518

Credit Hours : 2(1+1)

Why this course ?

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

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

Parental selection for pre breeding, search for superior genotypes, breeding methods for trait transfer;

moving the genes – un adapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cyto genetical approaches for gene transfer such as alien addition and substitution.

Unit IV

Segregating populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods, pollen physiology and storage, pollen storage methods to facilitate wide hybridization, pre- and post- zygotic barriers.

Practical

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

Teaching methods

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

Learning outcome

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

Suggested Reading

Andey Pereira. 2006. Plant Reverse Genetics, Methods and Protocols, Humana Press
Bisht et al. 2004. Broadening the genetic base of sesame (Sesamum indicum L.) through genetic enhancement. Plant Genetic Resources 2(3): 143–151.
Dale JW and von Schantz M. 2007. From genes to genomes. Concepts and applications of DNA technology. John Wiley & Sons Ltd., Chichester, England.
Duvick DN. 1990. Genetic enhancement and plant breeding. p. 90–96. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland.
Goodman, RM. 2004. Encyclopedia of plant and crop science. Marcel Dekker Inc., Switzerland. Kimber, G and Feldman, M. 1987. Wild Wheat: An introduction. Special report 353, College of Agriculture, University of Missouri-Columbia.
Lynch M. and Walsh B. 1998. Genetics and analysis of quantitative traits. Sinauer Associates Inc., MA, USA.
Murphy D. 2007. Plant breeding and biotechnology: Societal context and the future of agriculture.
Cambridge University Press, Cambridge, UK. Ram JS. 2010. Plant Cytogenetics. CRC Press.
Ramanatha Rao V, Brown AHD, Jackson M. 2001. Managing Plant Genetic Diversity. CABI publication.
Sharma S, Upadhyaya HD, Varshney RK, et al. 2013. Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. Front. Plant Sci. 4: 309.
Yunbi Xu. 2010. Molecular plant breeding, CABI publishers

e-Resources

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

Syllabus of Supporting Courses for PG programmes

Code	Course Title	Credit Hours
***STAT 502**	**Statistical Methods for Applied Sciences**	**3+1**
***STAT 511**	**Experimental Designs**	**2+1**

***Indicates supporting Courses which are require for Master Programme

I. Course Title: Statistical Methods for Applied Sciences

II. Course Code: STAT 502

III. Credit Hours: 4(3+1)

IV. Objective of the course

This course is meant for students who do not have sufficient background of Statistical. Statistical Sciences: Agricultural Statistics. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

V. Theory

Unit I

Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

Unit II

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Norminal distribution and their applications. Concept of sampling distribution: chi-square, *t* and *F* distributions. Tests of significance based on Normal, chi-square, *t* and *F* distributions.

Unit III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression
coefficients, Coefficient of determination.

Unit IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test. Median test. Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

VI. Practical

• Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal.

• Large sample tests, testing of hypothesis based on exact sampling distributions ~chi square, t and F.

• Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model.

• Non-parametric tests. ANOVA: One way, Two Way, SRS.

VII. Suggested Reading

• Goon, A.M., Gupta, M.K and Dasgupta, B. (1977). *An Outline of Statistical Theory*. Vol. I. The World Press.

• Goon, A.M., Gupta, M.K. and Dasgupta, B. (1983). *Fundamentals of Statistics*. Vol. I. The World Press.

• Hoel, P.G. (1971). *Introduction to Mathematical Statistics*. John Wiley.

• Hogg, R.V. and Craig, T.T. (1978). *Introduction to Mathematical Statistics*. Macmillan.

• Morrison, D.F. (1976). *Multivariate Statistical Methods*. McGraw Hill.

• Hogg, R.V., McKean, J.W., Craig, A.T. (2012). *Introduction to Mathematical Statistics* 7th Edition.

• Siegel, S., Johan, N.andCasellan, Jr. (1956). *Non-parametric Tests for Behavior Sciences*. John Wiley.

• Anderson, T.W. (2009). *An Introduction to Multivariate Statistical Analysis*, 3rd Ed . John Wiley

• http://freestatistics.altervista.org/en/learning.php.
• http://www.statsoft.com/textbook/stathome.html.

I. Course Title: Experimental Designs
II. Course Code: STAT 511 **III. Credit Hours: (2+1)**
IV. Objective of the course
This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts in volvedin planning, designing their experiments and analysis of experimental data.

V. Theory
Unit I
Need for designing of experiments, characteristics of a good design. Basic principles of designs-randomization, replication and local control.
Unit II
Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.
Unit III
Factorial experiments, (symmetrical as well as asymmetrical). Orthogonality and partitioning of degrees of freedom. Concept of confounding.
Unit IV
Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.
VI. Practical
• Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
• Analysis with missing data,
• Split plot and strip plot designs.
VII. Suggested Reading
• Cochran, W.G. and Cox, G.M. (1957). Experimental Designs. 2nd Ed. John Wiley.
• Dean, A.M. and Voss, D. (1999). Design and Analysis of Experiments. Springer.
• Montgomery, D.C. (2012). Design and Analysis of Experiments, 8th Ed. John Wiley.
• Federer, W.T. (1985). Experimental Designs. MacMillan.
• Fisher, R.A. (1953). Design and Analysis of Experiments. Oliver & Boyd.
• Nigam, A.K. and Gupta, V.K. (1979). Handbook on Analysis of Agricultural Experiments. IASRI Publ.
• Pearce, S.C. (1983). The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.
• www.drs.icar.gov.in.

Syllabus of Common Courses for PG programmes
Comm. 501 LIBRARY AND INFORMATION SERVICES (0+1)
Objective
To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

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

Comm. 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

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

Practical (Technical Writing)

• Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
• Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
• Writing of abstracts, summaries, précis, citations, etc.; Course Code Course Title Credit Hours xiii Common Academic Regulations for PG and Ph.D. Programmes.
• Commonly used abbreviations in the theses and research communications;
• Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
• Writing of numbers and dates in scientific write-ups;
• Editing and proof-reading;
• Writing of a review article;
• Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
• Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
• Accentual pattern: Weak forms in connected speech;
• Participation in group discussion;
• Facing an interview;
• Presentation of scientific papers.

Suggested Readings

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

Comm.503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

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

Theory

Unit I

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;

Unit-II

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.

Unit III

Protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection.

Unit IV

National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

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

Comm.504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

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

Practical

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

Suggested Readings

1. Furr, A.K. (2000). CRC Hand Book of Laboratory Safety. CRC Press.
2. Gabb, M.H. and Latchem, W.E. (1968). A Handbook of Laboratory Solutions. Chemical Publ. Co.

Comm. 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Unit IV

Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla, G.S. and Singh, G. (200). Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia, M.S. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.
3. Rao, B.S.V. (2007). Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh, K. (1998). Rural Development - Principles, Policies and Management. Sage Publ.

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