MAHATMA JYOTIBA PHULE ROHILKHAND UNIVERSITY, BAREILLY

महात्मा ज्योतिबा फुले
रुहेलखण्ड विश्वविद्यालय, बरेली

General Guidelines, Credit Framework & Course Curriculum

(As per the ICAR BSMA guidelines for P.G. degree)

of

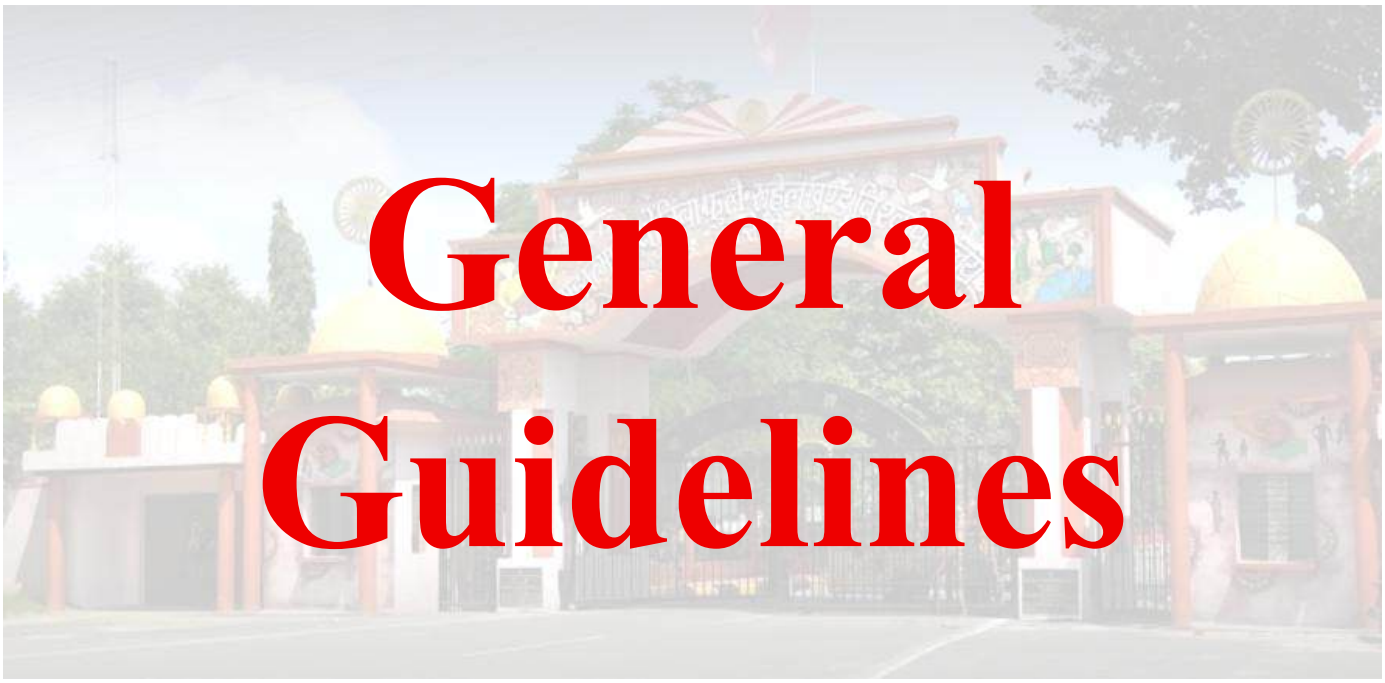
Master of Science (Ag.)

FACULTY OF AGRICULTURE SCIENCE & TECHNOLOGY,
MJPRU, Bareilly (Uttar Pradesh)

2025

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General Guidelines

Academic General Guidelines for PG Degree programme (M.Sc.) as per ICAR BSMA, 2021

Faculty of Agriculture Science & Technology

Mahatma Jyotiba Phule Rohilkhand University

Bareilly, UP

1. Scope:

The regulations made here shall be called "Faculty of Agriculture Science & Technology, Mahatma Jyotiba Phule Rohilkhand University (MJPRU), 2025" governing the M.Sc. (Ag.) degree Programme in the following subjects. The subject's nomenclature is as per BSMA 2021.

S. No	Degree Programme	Discipline
1	M.Sc. (Ag.)	Agronomy
2	M.Sc. (Ag.)	Genetics and Plant Breeding
3	M.Sc. (Ag.)	Horticulture
4	M.Sc. (Ag.)	Soil Science/Agriculture Chemistry

2. Academic Year and Registration

2.1. 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. Each semester will be of 110-day duration. The 1st (autumn) semester is during the months of July –December and 2nd (spring) semester is during months of January – June.

2.2. Dates of registration, commencement of instructions, semester end examination, end of semester and academic year etc. The Academic Calendar shall be developed by the University from time to time and notified accordingly by the Registrar in advance.

2.3. An orientation programme shall be organized by Dean for the benefit of the newly admitted students immediately after commencement of the semester.

2.4. On successful completion of a semester, the continuing students shall register for subsequent semester on the date specified in the Academic/Semester Callender 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.

3. Eligibility for admissions

A bachelor's degree in the respective / related subjects 6.00 /10 or equivalent OGPA / equivalent percentage of marks for general category candidates and 5.50/ 10 or equivalent OGPA/equivalent percentage of marks for SC/ST/PH category candidates at Bachelor's degree level. Those who are coming

from the 3-year Bachelor's Degree stream should undergo one-year remedial programme before registering for regular courses.

3.1. Mode of Admission and Reservation of seats

The University shall adopt entrance examination or merit at the bachelor's level or a combination of both while making admissions. Particularly for admission out of University / State students should be based on common entrance test and not by merit only. This followed to minimize the problems of disparate grading and academic standards followed across universities. Reservation on admission will applicable as per U.P. Govt. rules.

4. System of Education

Every enrolled student will be required to take a specified load of course work in the chosen subject of specialization (major, minor, supporting, and common courses) and also complete a research project and present this in the form of a dissertation.

5. Credit Requirements

The following Credit hours need to be followed while providing the syllabus for all the disciplines:

Courses	Masters' Programme
i. Course work	**40**
Major courses	20
Minor courses	08
Supporting courses	06
Common courses	05
Seminar	01
ii. Thesis/Research	**30**
Total	70

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.

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

1. Library and Information Services

2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

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 Dean/HoD/ BoS.

Supporting Courses

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

Course Title	Credits
Mathematics for applied sciences	2+0
Statistical methods for applied sciences	3+1
Experimental designs	2+1
Basic sampling techniques	2+1
Applied regression analysis	2+1
Data analysis using statistical packages	2+1
Computers fundamentals and programming	2+1
Computer organization and architecture	2+0
Introduction to communication Technologies, computer networking and Internet	1+1
Information technology in agriculture	1+1
Basic biochemistry	3+1
Techniques in biochemistry	2+2

5.1 Maximum permissible course work load per semester

Master's Programme: 18 credits

5.2 Mandatory requirement of seminars

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.

6. Residential requirements

The minimum and maximum duration of residential requirement for Master's Degree programme shall be as follows:

Degree Programme	Duration of Residential Requirement	
	Minimum	Maximum
Masters' Degree	2 Academic Years	5 Academic Years

In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/her admission shall stand cancelled. The requirement shall be treated as satisfactory in the cases in which a student submits his/her thesis any time during the 4th semester of his/her resident ship at the University for Masters' programme.

6.1 Attendance requirements:

Minimum 75% to be counted separately for theory and practical.

7. Advisory System

7.1. Advisory Committee: There shall be an Advisory Committee for every student consisting of not fewer than three members in the case of a candidate for Masters' degree with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and minor fields amongst the members of the post-graduate faculty accredited for appropriate P.G. level research. However, in those departments where qualified staff exists but due to unavoidable reasons post-graduate degree programs do not exist, the staff having post-graduate teaching experience of two years or more may be included in the Advisory Committee as member representing the minor.

At any given time, a P.G. teacher shall not be a Chairperson, Advisory Committee (including Master's programme) for more than five students.

The chair person 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 and Registrar for information.

Approval of the advisory committee has to be obtained by submitting it in prescribed form (PG1) by HOD to Dean within three months from start of the first semester for both M.Sc. programme.

A semester wise minimum credit requirement for M.Sc. programme of a student has to be submitted by chairperson of advisory committee through HOD for approval by Dean in prescribed form (PG2).

7.2. Constitution of the 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.

7.3. 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 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 based on 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.

7.5. Changes in the Advisory Committee: Change of the Chairperson or any member of the Advisory Committee is not ordinarily permissible. However, in exceptional cases, the change may be affected with due approval of the Dean.

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, Dean may permit them to continue to serve as advisor subject to the following conditions:

a) 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 Dean for guiding as Chairperson or Member, Advisory Committee the thesis/theses of the student(s) concerned only.

b) 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.

c) 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.

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

Approval of Synopsis:

The synopsis has to be accomplished in the first semester for master's programme.

8. Conduct of Research Work:

8.1. Post graduate students should necessarily complete the post graduate programme in the college where they joined. However, they can conduct the research work elsewhere (other locations recognized by the university for this purpose) with the prior permission of the University.

8.2. As soon as the thesis work is completed and data etc. have been processed, student will deliver a thesis seminar. If teachers or other students suggest any improvement in the presentation and interpretation of results, the same may be incorporated with the approval of the major advisor.

8.3. A student shall submit his/her thesis for Degree after he/she has completed his/her course work requirement, the required number of research credits. The thesis shall be type written and temporarily bound as specified and submitted in quadruplicate along with a "no dues certificate" and a certificate in the prescribed proforma by the advisor.

8.4. Six copies of thesis abstracts of about 150-200 words shall be submitted (two copies for the department, one for the dean's office and three for university) along with bound copy certificate. PG students should submit two CDs of thesis (one each to library and one to Head of Department) along with bound copies of thesis.

8.5. After approval by the advisory committee, the thesis submitted by the student shall be sent to an external examiner for evaluation who shall be required to send a detailed report on the thesis preferably within three weeks to the Dean. In case, the external examiner recommends acceptance of the thesis, the report will be forwarded to the chairperson of the student's advisory committee who shall arrange for the conduct of final oral examination. The head of department shall also be a co-opted member of the final thesis oral examination committee, even if he is not a member of the student's advisory committee for the purpose of conducting the thesis final oral examination. The advisory committee while conducting this examination, shall take into account, the remarks of the external examiner and may suggest changes if any to be made in the thesis. A certificate regarding performance of the candidate in the final viva-voce examination on the thesis in the form prescribed, duly signed by all the members of the committee, shall be forwarded to Dean by the chairperson of the student's advisory committee through the head of the department. After the certificate is sent, the thesis shall be bound as specified after effecting changes if any by the advisory committee and it shall be submitted by the student in quadruplicate to the chairperson of the student's advisory committee. Unless final thesis copies are bound by the student concerned and handed over to the chairperson of the student's advisory committee, his/her final result shall not be declared.

8.5. If a student is not successful in the final oral examination, he/she shall be examined again after a period of three months.

8.6. In case if the external examiner suggests major modification to be made before acceptance, the same shall be communicated to the chairperson of the student's advisory committee who shall arrange for the revision of the thesis and resubmission, after a period of three months. It shall be considered in the same manner as in the original submission and the thesis shall be forwarded to the same examiner for re-evaluation. However, if for any reason, the examiner concerned is not available to re-evaluate the thesis either due to relocation or for other reasons, in such a rare instance, the Dean will forward the thesis to an alternate examiner for re-evaluation. In such instances, the modified version of thesis along with the comments made by the first examiner shall be forwarded by the Dean to the alternate examiner for re-evaluating the thesis.

8.7. If the student who has been directed to resubmit the thesis after carrying out the corrections indicated by the external examiner, has to submit within six months from the date of issue of orders by the university. The student should appear for the final thesis viva-voce examination and submit a certificate of having submitted bound copies of thesis within a maximum period of six months from the date of issue of orders by the university.

Note: If the external examiner recommends resubmission of thesis after 3 months, the candidates should resubmit thesis within six months thereafter i.e., Between 3 and 9 months from the date of issue of orders by the university.

8.8. Student may be permitted to carry on their research work at institutions/ Research stations under this university other than those imparting institutions or at other institutions and under persons recognized for the purpose.

9. Evaluation of course work

For M.Sc., multiple levels of evaluation (First Test, Midterm and Final semester) will be done. No comprehensive examination for M.Sc. programme.

Course- evaluation

Theory- Internal

Practical- Internal, to be conducted by the course teacher +one more external examiner to be nominated by the Dean/VC.

The evaluation of the student in a course shall be based on his/ her performance in various kinds of exanimations, records, class work and other types of exercises.

Each course may be evaluated @ 50 marks for each credit (theory/ practical) which may finally be converted to 100 for awarding grade. The marks to be allotted between the theory and practical work shall be in the proportion of their respective credit hours. For e.g. a course having 2 theory and 1 practical credit, the weightage for theory and practical examinations may be as follows:

Theory		**Practical**	
Exam	Marks	Exam	Marks
Assignment/ term papers/ seminar etc. (Internal)	20	Record and class work (Internal)	25
Mid-term examination (Two) (Internal)	30	Final examination (External)	25
Semester final examination of 2 to 3 hrs. duration (External)	50	-	-
Total	100	Total	50

The schedule for mid-term examination and semester final examination shall be indicated in the Academic calendar of each semester test/ examinations to be conducted on the dates as prescribed therein. The examination schedules shall confirm to the following programme, namely:

Mid-term examinations after about 50 days from the commencement of the semester.

Semester Final examination at the end of the semester.

9.1. It shall be the responsibility of the Head of the Department to ensure proper conduct of examinations in all the courses offered in the department.

9.2. The Dean / Head of Departments shall constantly exercise supervision and control to see that the syllabus listed under each course is adequately covered and assessment of student is done strictly in accordance with the regulations.

9.3. All answer scripts shall be shown to the students by the teachers as soon as evaluation is completed.

9.4. Students registered for a particular course shall take all the examinations conducted during the period of the course, viz. hourly and final semester examination both in theory and practical. If a student is genuinely prevented from taking examination as in the case of serious illness or accident or any other case, a special re-examination may be arranged by the teacher concerned in consultation with Head of the Department. This repeat examination shall be held within two weeks from the date of examination for all the students who have missed that hourly examination.

9.5. In the case of students deputed to represent the university in inter- collegiate or inter – university meets in N.C.C /N.S.S due consideration shall be given in regards to missed tests/ examination so that the students may not suffer while on absence on university directive .In all such cases, make –up examination/test (except semester final examination) given for the missed examination/tests (except semester final examination) within two weeks of the return of the students. The name of the student deputed for such meets may be intimated in advance to the teacher concerned through the Head of the Department.

9.6. Supplementary Examination: A student failed in a particular course (having back log), can appear this examination in a particular semester, if the concerned course is offered in that semester.

9.7. Examination on Demand (EOD): EOD will be conducted for the benefit of students who have backlogs from previous semesters on a pre-announced schedule.

9.8. Minimum & Maximum Time Limit to Complete the Course/Thesis: If a student fails to complete the degree requirements within the maximum time limit prescribed, his /her admission shall stand cancelled. A student may submit thesis after securing 75% attendance in the final semester of study provided that research credits only are registered during that semester and that all the courses prescribed for the award of degree are successfully completed by previous semester.

9.9. Temporary discontinuous and Resumption of studies**:** If a student to discontinue studies temporarily or take long leave he/she may do so after completion of one semester of study from the date of admission with the approval of the dean concerned or if this is not possible, the student should seek the approval from the concerned dean within 30 calendar days from the date of discontinuation (discontinuation before completion of two semesters of study shall result in cancellation of admission).

9.10. If the students fail to seek approval of the dean concerned within 30 days of discontinued due to genuine reasons like serious illness/domestic problems, such student may be accorded permission by the dean on payment of late fee of Rs.1000/-per month or part there of up to 5 months. The student who is permitted to temporarily discontinue studies should necessarily complete the entire requirement with in the time limit prescribed.

9.11. The student with such approval may be permitted to resume studies within 4 semesters by Dean concerned under intimation to the university. If a student temporarily discontinues in the middle of a semester, he/she is deemed to have discontinued from the beginning of that semester. The dis-continuation is allowed only once in a P.G programme. The maximum period of discontinuation allowed is two years (four semesters). The maximum time limit prescribed for the completion of graduation requirements, however, shall remain unchanged.

9.12. Students, who discontinue without the permission of the Dean, shall not be permitted to resume studies. The Dean shall not send proposals for readmission/ resumption of studies, if the student discontinues studies without permission.

9.13. Unfair means in Examination**:** A student found using unfair means in the examinations shall be penalized as per the norms of the University.

10. Grading System

Master's Programme

a. Scale:10 point

b. Minimum passing grade in a course: 6.00

c. Minimum OGPA to continue and to obtain degree: 6.50

Time between Synopsis and Thesis submission

Master's Programme: One semester

11. Thesis Submission

Comprehensive Exam: No Comprehensive exam

Master's Programme: After thesis seminar

Evaluation: External (one)

Viva Voce: By Advisory committee

Assessment: Satisfactory / Unsatisfactory

12. Evaluation of research work

12.1. 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. **The maximum permissible limit for plagiarism is 20%.**

12.2. 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 enrol 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 following points are to be followed while integrating the online courses:

i. 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.

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

iii. 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.

13. Internship during Masters programme

Internship for Development of Entrepreneurship in Agriculture (IDEA)

To provide the students an opportunity to have a real-time hands-on experience in the industry as per ICAR guidelines (BSMA 2021), an optional internship/ in- plant training to enable the development of highly learned and skilled manpower to start their- own enterprises IDEA shall be implemented.

The main objectives of the programme:

i. To promote the linkages between academia and industry

ii. To establish newer University - Cooperative R&D together with industry for knowledge creation, research and commercialization

iii. Collaboration between Universities and industries through pilot projects

iv. To develop methods for knowledge transfer, innovation and networking potential

v. To enhance skill, career development and employability 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 and 10 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.

14. Calculation of marks

% of marks = OGPA x 100/10

The per cent of marks in a subject will be divided by 10 to obtain the grade point.

The grade point average for a semester will be calculated as follows.

$$\text{GPA} = \frac{\sum(Grade\ Point \times credit\ Hours)\ in\ one\ semester}{Total\ Credit\ Hours\ in\ the\ Semester}$$

The Overall grade point earned at any stage of the course will be calculated as overall grade point average (OGPA) as follows.

$$\text{OGPA} = \frac{\sum(Grade\ Point \times credit\ Hours)\ until\ last\ semester}{Total\ Credit\ Hours\ Until\ Last\ Semester}$$

If a student passes in a subject in a second attempt, for calculation of OGPA, the grade point for the subject in the second attempt will only be considered. The final OGPA will be named as overall grade point average (OGPA), which will be mentioned in the final transcript of the students.

15. Award of Degree

A degree under the seal of the university and duly signed by the officers authorized in this behalf shall be presented at convocation, to each candidate who has successfully completed the graduation requirements for the award of the degree. Diplomas of the candidates who have successfully completed graduation requirements for the award of the degree and are admitted in absentia to a degree, at convocation, shall be sent. The diploma shall set forth the name of the candidate, father's name, mother's name, degree, month, and year of the successful completion of the graduation requirements etc.

16. Guide lines to prevent unethical practices in publication of articles etc.

In order prevent changing the order of priority in the authorship of research publications, the following guidelines are framed as in case of other institutes for strict adherence by all the concerned, while preparing the research articles, etc. for publication or their subsequent use.

16.1. For all research papers prepared on the basis of student research, the authorship should be in the

order of student, chairperson, co-chairperson and members of advisory committee who have put in considerable efforts in the research work.

16.2. The first author should certify that due weightage was given to all those who contributed for the research work and also clearly indicate the source of material for the research article / publication i.e. student research /scheme work etc. and the period of conduct of such research work. If any part/ whole of the article/ paper/ manual of others is used by the students / staff, acknowledgement should invariably be made with regard to its original author to give a kind of gratification to him/her.

16.3. The research papers (along with one extra copy) should be routed through the head of the department where the work was carried out. The heads of department shall maintain a record of all extra copies so received. The heads of departments shall forward the articles to the dean, after recording the following details in a register of publications which shall be shown to the superior officers during their visit.

i. Date of dispatch;
ii. Title of the article/ bulletin;
iii. Name of authors;
iv. Source of material for publication.

All the concerned teachers/ students are requested to strictly adhere to the above instructions.

17. Schedule of submissions

17.1. Proposal for formation of advisory committee has to be submitted within 6 weeks from the commencement of the first semester. Subsequent changes to be sent in triplicate whenever required in proper format.

17.2. Proposal for programme of work has to be submitted in proper format at the end of first semester. Proposal for subsequent permanent changes in programme of work has to be sent in triplicate to Dean.

17.3. Synopsis of research work to be carried has to be sent to dean at the end of first semester. For any subsequent change in title/ programme of work has to be submitted in proper format to Dean in triplicate.

17.4. During III/IV semester, the chairman of the advisory committee shall submit in proper format to the Head of department for action to conduct qualifying examination. After conduct of qualifying examination (written and oral) the result should be sent to the Dean in proper format. One copy to be retained in the department.

17.5. Within a month from the commencement of the semester, GPA reports pertaining to the previous semester must be obtained and kept in student's file.

17.6. Before end of each semester, proposal for evaluation of Research credits in proper format should be submitted to Dean through chairman and Head of department.

17.7. Proposal for submission of thesis along with one copy of thesis (one extra copy of thesis shall be preserved in the department), 4 Colour photographs (write name and Reg no. on back side), Course completion certificate, G.P.A. Reports, copy of degree certificate of qualifying examination and

Convocation application form stating that degree will be received in person/absentia are to be sent to Dean.

17.8. After conduct of final via –voce examination, the result has to be communicated in proper format to Dean along with three copies of thesis and abstracts of thesis and CD with bound copy certificate. One bound copy to be presented in the department.

18. Compliance with the National Education Policy-2020

While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) has to be complied with the provisions of National Education Policy-2020.

19. 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 hours of 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.

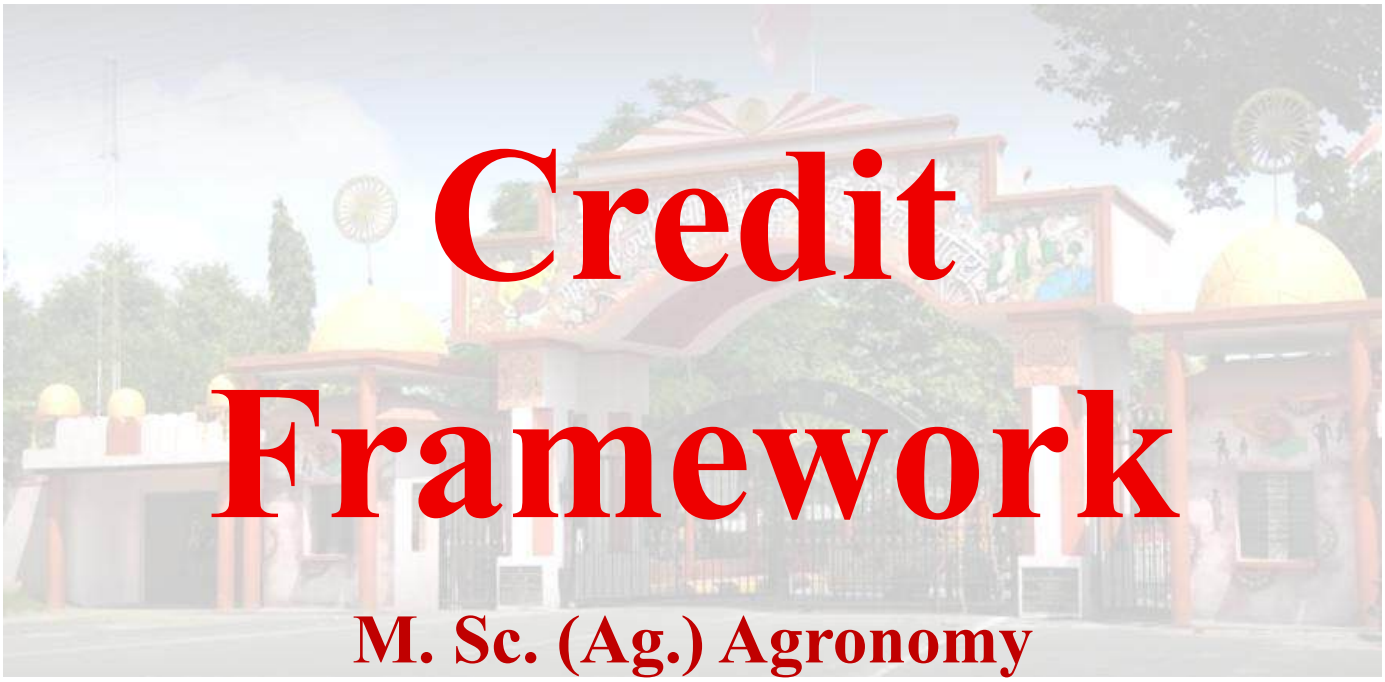
Grade point (GP) of a course is a measure of performance. It is obtained by dividing the per cent mark secured by a student in a particular course by 10, expressed and rounded off to second decimal place.

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.

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.

The final grading of student shall be done on a 10-point scale. The Grade point shall be obtained by dividing the total percentage of marks earned in a course by 10. The grade point shall be expressed in this scale up to one decimal place.



Credit Framework

M. Sc. (Ag.) Agronomy

MAHATMA JYOTIBA PHULE ROHILKHAND UNIVERSITY, BAREILLY

FACULTY OF AGRICULTURE SCIENCE & TECHNOLOGY

Department of Agronomy

COURSE WORK

Major courses:

Course code	Course title	Credit Hours
AGRON 501*	Modern concept in Crop production	3 (3+0)
AGRON 502*	Principles and Practices of Soil fertility and nutrients management	3 (2+1)
AGRON 503*	Principles and practices of weed management	3 (2+1)
AGRON 504*	Principles and practices of water management	3 (2+1)
AGRON 506	Agronomy of major cereals and pulses	3 (2+1)
AGRON 507	Agronomy of oilseed, fibre and sugar crops	3 (2+1)
AGRON 513	Principles and Practices of Organic farming	3 (2+1)
AGRON 550	Master seminar	01
AGRON 560	Master research	30

Total = 52

Minor courses:

Course code	Course title	Credit Hours
SOIL 502	Soil fertility and Fertilizers use	3 (2+1)
SOIL 504	Soil mineralogy genesis and classification	3 (2+1)
SOIL 505	Soil erosion and conservation	3 (2+1)

Total = 09

Supporting courses:

Course code	Course title	Credit Hours
HORT 506	Principles of Vegetable Breeding	3 (2+1)
AST 501	Experimental Design	3 (2+1)

Total = 06

Common courses:

Course code	Course title	Credit Hours
PGS 501	Library and Information services	1 (0+1)
PGS 502	Technical writing and Communications skills	1 (0+1)
PGS 503	Intellectual property right & Its management in Agriculture	1 (1+0)
PGS 504	Basic concept in laboratory techniques	1 (0+1)
PGS 505	Agricultural research, Research ethics and Rural development programmes	1 (1+0)

Total = 05

MAHATMA JYOTIBA PHULE ROHILKHAND UNIVERSITY, BAREILLY

FACULTY OF AGRICULTURE SCIENCE & TECHNOLOGY

Department of Agronomy

SEMESTER WISE DISTRIBUTION OF COURSES WITH CREDIT HOURS

First Semester

Course code	Course title	Credit Hours
AGRON 501*	Modern concept in Crop production	3(3+0)
AGRON 503*	Principles and practices of weed management	3(2+1)
AGRON 506	Agronomy of major cereals and pulses	3(2+1)
SOIL 502	Soil fertility and Fertilizers use	3(2+1)
HORT 506	Principles of Vegetable Breeding	3(2+1)
PGS 501	Library and Information services	1(0+1)
PGS 502	Technical writing and Communication skills	1(0+1)
PGS 503	Intellectual property right & Its management in Agriculture	1(1+0)
	Total Credit =	**18**

Second Semester

Course code	Course title	Credit Hours
AGRON 504*	Principles and practices of water management	3(2+1)
AGRON 502*	Principles and Practices of Soil fertility and nutrients management	3(2+1)
AGRON 507	Agronomy of oilseed, fibre and sugar crops	3(2+1)
SOIL 505	Soil erosion and conservation	3(2+1)
AST 501	Experimental Design	3(2+1)
PGS 504	Basic concept in laboratory techniques	1(0+1)
PGS 505	Agricultural research, Research ethics and Rural development programmes	1(1+0)
AGRON 550	Master seminar	01
	Total Credit =	**18**

Third Semester

Course code	Course title	Credit Hours
AGRON 513	Principles and Practices of Organic farming	3(2+1)
AGRON 560	Master research	15
	Total Credit =	**18**

Fourth Semester

Course code	Course title	Credit Hours
SOIL 504	Soil mineralogy genesis and classification	3(2+1)
AGRON 560	Master research	15
	Total Credit =	**18**



Syllabus

M. Sc. (Ag.) Agronomy

Course Title: Modern Concepts in Crop Production
Course Code: AGRON 501*
Credit Hours: 3+0

Aim of the course

To teach the basic concepts of soil management and crop production.

Theory

Unit I

Crop growth analysis in relation to environment; geo-ecological zones of India.

Unit II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Unit III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modelling for desired crop yield.

Unit IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

Unit V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture. Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on soil management and crop production

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Introduces crop growth analysis by explaining how plants accumulate biomass and how environmental factors shape growth.	2
2.	Covers major growth indices such as CGR, RGR, and NAR that help quantify productivity.	2
3.	Adds LAD, LAR, and SLA to understand leaf efficiency.	1
4.	Explains how light, temperature, moisture, and CO_2 influence crop performance.	1
5.	Discusses India's diverse geo-ecological regions and physiographic zones.	1

6.	Explains agro-ecological and agro-climatic zones and their cropping patterns.	1
7.	Introduces quantitative agro-biological principles governing yield formation.	1
8.	Describes the inverse yield–nitrogen law.	1
9.	Explains Mitscherlich's yield equation and nutrient efficiency constants.	1
10	Interprets the equation graphically and evaluates its practical applications.	2
11	Introduces the Baule unit, defining nutrient quantity needed for specific yield levels.	2
12	Compares different yield response models and their suitability for field use.	2
13	Begins lodging in cereals with causes such as wind, rain, and weak stems.	2
14	Highlights lodging effects on yield and strategies for reduction through strong-stem varieties and regulators.	2
15	Covers the physiology of grain yield through source–sink relationships.	1
16	Focuses on plant population and its influence on competition and yield.	1
17	Explains planting geometry and its role in light interception and disease reduction.	2
18	Describes ideal plant type concepts used in modern breeding.	1
19	Introduces crop modelling tools like DSSAT and APSIM for predicting crop performance.	2
20	Discusses scientific principles of crop production including limiting factors and resource efficiency.	2
21	Explains crop response production functions such as linear, quadratic, and diminishing models.	2
22	Describes soil–plant relations, nutrient uptake, and root–soil interactions.	2
23	Focuses on yield reduction under stresses like drought, heat, and salinity.	2
24	Explains roles of auxins, gibberellins, and cytokinins in growth regulation.	2
25	Covers ABA, ethylene, and their importance in stress adaptation.	2
26	Explains integrated farming systems and their components for sustainable income.	2
27	Focuses on organic farming concepts, principles, and certification.	2
28	Describes resource conservation technologies such as zero tillage, residue retention, and crop rotation.	2
29	Covers dry farming techniques and moisture conservation methods.	1
30	Explains nutrient needs, diagnosis, and the importance of balanced nutrition.	2
31	Covers integrated nutrient management combining fertilizers, organics, and biofertilizers.	2
32	Concludes with modern crop production concepts like hydroponics, aeroponics, vertical farming, robotic farming, and the use of GIS, GPS, and remote sensing in precision agriculture.	2

Suggested Reading

• Balasubramaniyan P and Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.

• Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.

• Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.

• Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.

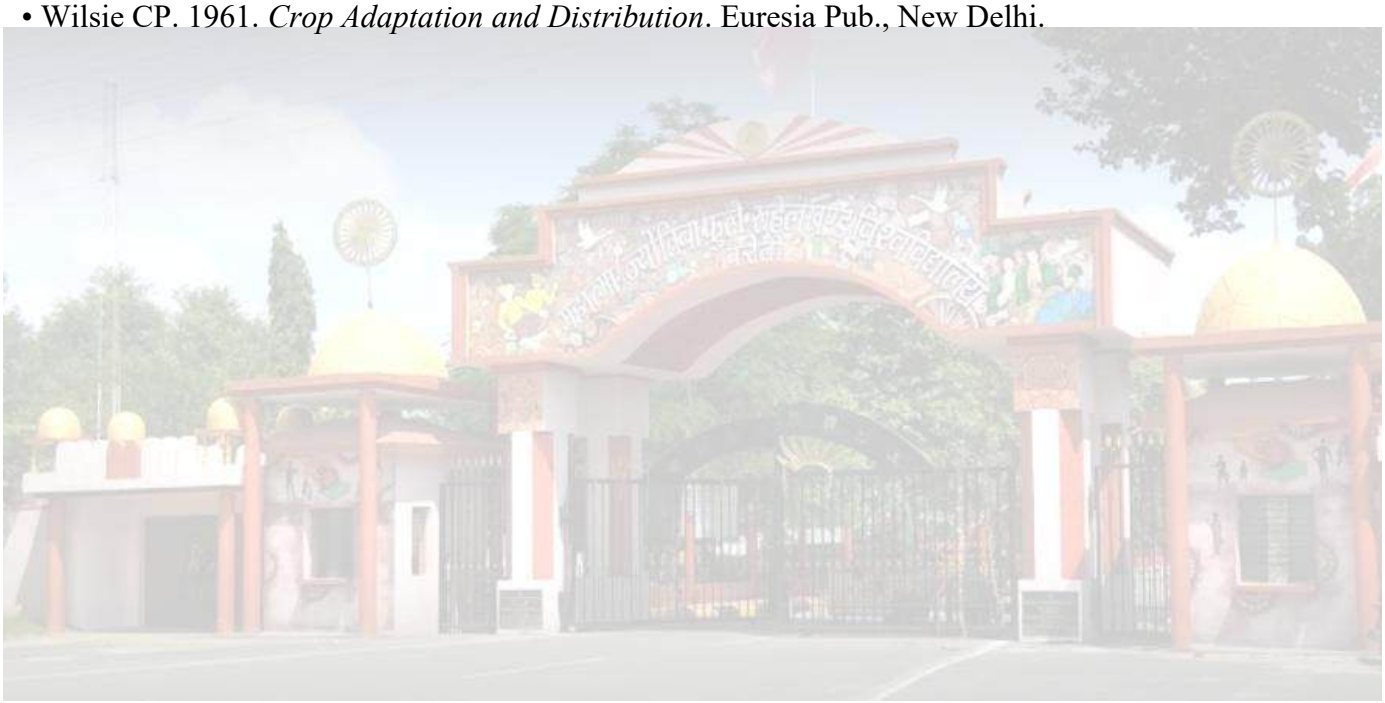
• Sankaran S and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.

• Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.

• Alvin PT and kozlowski TT (ed.). 1976. *Ecophysiology of Tropical Crops*. Academia Pul., New York.

• Gardner PP, Pearce GR and Mitchell RL. 1985. *Physiology of Crop Plants*. Scientific Pub. Jodhpur.

• Wilsie CP. 1961. *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.



Course Title: Principal and Practices of Soil Fertility and Nutrient Management
Course Code: AGRON 502*
Credit Hours: 2+1

Aim of the course

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

Unit I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermincompost and residue wastes in crops.

Practical

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Computation of optimum and economic yield

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on soil fertility and management

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Soil fertility and productivity are fundamental concepts in crop production. Various factors affect soil fertility, including climate, parent material, and management practices. Good soil management ensures long-term sustainability of crop yields.	2
2.	Soil productivity refers to the capacity of soil to support plant growth. Several biological, chemical, and physical properties determine productivity. Sustainable practices help maintain productivity over time.	2
3.	Nutrient supply issues arise due to imbalanced fertilization and poor soil health. Availability of nutrients depends on soil pH, moisture, and organic matter content. Proper planning helps avoid deficiency and toxicity problems.	2
4.	The relationship between nutrient supply and crop growth is highly significant. Plants respond differently to varying levels of nutrients. Balanced nutrition ensures optimum growth and development.	1
5.	Organic farming is based on natural inputs and ecological balance. Definitions and concepts of organic farming emphasize sustainability and soil health. Use of organic inputs minimizes environmental damage.	2
6.	Essentiality criteria help identify nutrients required for plant growth. A nutrient is considered essential if its absence restricts growth and cannot be replaced by another element. Understanding essentiality helps in effective nutrient management.	2
7.	Plants require both macro and micronutrients for completion of their life cycle. Each nutrient performs specific functions in plant physiology. Proper supply prevents growth inhibition.	1
8.	Nutrient deficiency symptoms provide visual clues of imbalances. Different nutrients produce unique symptoms on leaves, stems, or roots. Timely diagnosis helps avoid yield loss.	1
9.	Transformation and dynamics of nutrients occur continuously in soil. Microbial activity, temperature, and moisture influence these processes. Understanding transformations helps improve fertilizer strategies.	1
10.	Farmyard manure is a common organic amendment in agriculture. Proper preparation and handling preserve its nutrient content. Application improves soil properties and crop yield.	1
11.	Compost is produced by controlled decomposition of organic waste. Use of compost enhances soil structure and nutrient availability. Modern composting techniques improve efficiency.	1
12.	Green manuring improves soil fertility through nitrogen fixation and organic matter addition. Legume crops are often used for green manure. Incorporation at proper stage provides maximum benefit	1
13.	Vermicompost is produced through earthworm activity. Vermicompost contains readily available nutrients for plants. Its application enhances soil biological activity.	1
14.	Biofertilizers contain living microorganisms that enhance nutrient availability. Their use reduces dependence on chemical fertilizers. Application methods determine their effectiveness.	1
15.	Recycling of organic wastes reduces environmental pollution. Residue management improves soil carbon and enhances productivity. Proper recycling conserves resources.	1

16.	Soil-less cultivation techniques allow plant growth without soil. Hydroponics and aeroponics are prominent methods. These systems ensure efficient use of water and nutrients.	1
17.	Commercial fertilizers provide concentrated nutrient sources. Their composition determines suitability for specific crops. Knowledge of fertilizer grades helps select correct products.	1
18.	Relative fertilizer value helps compare efficiency of different fertilizers. Cost analysis ensures economic application. Proper evaluation improves profitability.	1
19.	Crop response to nutrients varies according to soil and climate. Residual effects influence nutrient availability in subsequent crops. Fertilizer use efficiency measures performance of inputs.	2
20.	Agronomic, chemical, and physiological efficiencies are important indicators. These efficiencies determine how much nutrient is utilized by plants. Improvement measures enhance overall productivity.	2
21.	Fertilizer mixtures and grades provide balanced nutrition to crops. Customized blends address specific nutrient deficiencies. Their use reduces application effort.	2
22.	Nutrient interactions can be synergistic or antagonistic. Understanding interactions prevents hidden hunger and toxicity. Balanced application ensures proper growth.	1
23.	Timing of manure application influences nutrient availability. Methods such as broadcasting, band placement, and fertigation affect efficiency. Proper techniques improve uptake.	1
24.	Foliar application provides quick correction of nutrient deficiencies. This method is useful under stress conditions. Concentration and timing must be carefully managed.	2
25.	Integrated nutrient management combines organic and inorganic sources. Balanced nutrition enhances soil fertility and crop productivity. Use of vermicompost and residues reduces chemical load.	2
26.	Economics of fertilizer use determines profitability of farming. Cost-benefit analysis helps farmers choose appropriate nutrient strategies. Efficient management ensures sustainable production.	1

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	To determine soil pH for assessing soil acidity or alkalinity.	2
2.	To measure soil EC for identifying soil salinity status.	2
3.	To estimate soil organic carbon for evaluating soil fertility.	2
4.	To determine available nitrogen in soil for fertilizer recommendation.	1
5.	To estimate available phosphorus and potassium in soil for nutrient management.	2
6.	To determine available sulphur in soil for assessing sulphur requirement.	2
7.	To analyze total N, P, K, and S in soil for long-term fertility evaluation..	2
8.	To determine total N, P, K, and S in plant samples for nutrient uptake assessment.	2
9.	To compute optimum yield using graded fertilizer applications.	1
10.	To calculate economic yield and fertilizer use efficiency for profitable farming.	2

Suggested Reading

• Brady NC and Weil RR. 2002. *The Nature and Properties of Soils.* 13th Ed. Pearson Edu.

• Fageria NK, Baligar VC and Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker.

• Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.

• Prasad R and Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

• Yawalkar KS, Agrawal JP and Bokde S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.



Course Title: Principles and Practices of Weed Management
Course Code: AGRON 503*
Credit Hours: 2+1

Aim of the course

To familiarize the students about the weeds, herbicides and methods of weed control.

Theory

Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and classification management; weed indices, weed shift in different eco-systems

Unit II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio-agents, and allelochemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance, residue, persistence and management; development of herbicide resistance in weeds and crops and their management, herbicide combination and rotation.

Unit IV

Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

Unit V

Integrated weed management; recent development in weed management- robotics, use of drones and aeroplanes, organic etc., cost: benefit analysis of weed management.

Practical

• Identification of important weeds of different crops, Preparation of a weed herbarium, weed survey in crops and cropping systems, Crop-weed competition studies, weed indices calculation and interpretation with data, Preparation of spray solutions of herbicides for high and low-volume sprayers, Use of various types of spray pumps and nozzles and calculation of swath width, Economics of weed control, Herbicide resistance analysis in plant and soil,

• Bioassay of herbicide resistance residues,

• Calculation of herbicidal herbicide requirement

Teaching methods/activities

Classroom teaching with AV aids, group discussion, field visit to identify weeds.

Learning outcome

Basic knowledge on weed identification and control for crop production

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Weed biology: definition, growth habits, seed biology, dormancy, viability, vegetative propagation, life cycle patterns, and factors influencing weed survival in cultivated fields.	2
2.	Weed ecology: ecological adaptations, succession, weed behavior under different environments, classification of weeds based on morphology, habitat, life cycle, and special characteristics.	2
3.	Crop–weed competition: nature, intensity, critical period, resource competition (light, water, nutrients), role of allelopathy, crop losses due to weeds, and allelochemical interactions.	2
4.	Principles and methods of weed control: preventive, cultural, mechanical, chemical, and biological methods; integrated approaches and classification of weed control techniques.	2
5.	Weed indices (weed control efficiency, weed smothering efficiency, weed index), weed flora changes, weed shift due to continuous cropping, herbicide use, and changes in different ecosystems.	2
6.	Introduction to herbicides: definition, importance, discovery, history of development, major milestones, and evolution of modern herbicides.	2
7.	Classification of herbicides based on chemical composition: phenoxy acids, triazines, ureas, amides, sulfonylureas, glyphosate group, and other important categories.	2
8.	Classification based on physiological application and selectivity: pre-plant, pre-emergence, post-emergence, soil-applied, foliar-applied, selective and non-selective herbicides.	2
9.	Mode and mechanism of action: influence on photosynthesis, amino acid synthesis, lipid biosynthesis, respiration, cell division, pigment inhibition, and hormonal disruption.	2
10.	Herbicide structure–activity relationship: molecular properties, absorption, translocation, and factors that determine herbicide performance in field conditions.	1
11.	Factors affecting herbicide efficiency: soil properties, climate, application techniques, nozzle types, water quality, timing, crop stage, and weed growth stage.	2
12.	Herbicide formulations, herbicide mixtures, compatibility, tank mixes, sequential applications, advantages and limitations of combined herbicides.	1
13.	Herbicide rotation strategies, nano-herbicides, bio-herbicides and modern biodegradable herbicidal molecules for sustainable weed control.	1
14.	Myco-herbicides, microbial bio-agents, allelochemicals, plant-based weed suppressants, and natural weed control products.	1
15.	Herbicide movement in soil and plant: leaching, volatilization, adsorption, absorption, translocation, and pathways of herbicide behavior.	1
16.	Degradation of herbicides: microbial, chemical, and photodegradation; herbicide residues, persistence, residue detection, and environmental concerns.	1
17.	Herbicide resistance: types, mechanisms, genetic basis, resistance in major weeds; resistance development in crops and strategies for prevention and management.	2
18.	Weed management in major crops like rice, wheat, maize, soybean, cotton, sugarcane, and pulses; weed management in different cropping systems.	2

19.	Alien, invasive and parasitic weeds: identification, biology, impact, and management of *Striga, Orobanche, Lantana, Parthenium, Eichhornia* and other problematic weeds.	2
20.	Management of aquatic weeds (floating, submerged, emergent), perennial weeds (rhizomatous, stoloniferous), and weed control in non-crop areas like roadsides, industrial sites, and orchards.	2
21.	Integrated weed management: combination of preventive, cultural, mechanical, biological and chemical methods; recent technologies including robotics, drones, sensors, aeroplane spraying, organic weed management, and cost–benefit analysis of weed control practices.	2

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	Major weeds of field and horticultural crops identified based on morphology and life cycle.	2
2.	Collection, pressing, drying, labeling, and mounting of weed specimens.	2
3.	Quadrat method used to record weed flora, density, frequency and dominance.	2
4.	Observation of crop and weed competition for nutrients, water, and light.	1
5.	Computation of weed density, biomass, WCE, WSE, and interpretation.	1
6.	Calculation of herbicide requirement and preparation for HV/LV sprayers.	1
7.	Handling sprayers, identifying nozzle types, and understanding spray characteristics.	1
8.	Calculation of discharge rate, walking speed, spray volume, and swath width.	2
9.	Cost calculation of weeding practices and estimation of B:C ratio.	1
10.	Identification of resistance symptoms and collection of resistant weed samples.	1
11.	Study of herbicide persistence and soil residue detection methods.	1
12.	Use of test plants to detect herbicide residues through germination and growth.	1
13.	Calculation of required herbicide quantity based on area and spray volume.	1
14.	Field demonstration of mechanical, cultural, biological, and chemical methods.	1

Suggested Reading

• Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development*. *Mode of Action*, *Targets*, *Genetic Engineering*, *Chemistry*. Springer.

• Chauhan B and Mahajan G. 2014. *Recent Advances in Weed Management*. Springer.

• Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi).

• Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.

• Gupta OP. 2007. *Weed Management*: *Principles and Practices*, 2nd Ed.

• Jugulan, Mithila (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press

• Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley

• Powles SB and Shaner DL. 2001. Herbicide Resistance and World Grains, CRC Press.

• Walia US. 2006. *Weed Management*, Kalyani.

• Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub.*

Course Title: Principles and Practices of Water Management
Course Code: AGRON 504*
Credit Hours: 2+1

Aim of the course

To teach the principles of water management and practices to enhance the water productivity

Theory

Unit I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in of India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit II

Field water cycle, water movement in soil and plants; transpiration; soil-water plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and loses.

Unit III

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

UNIT IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

Unit VI

Quality of irrigation water and management of saline water for irrigation, water management in problem soils

Unit VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit VIII

Hydroponics,

Unit IX

Water management of crops under climate change scenario.

Practical

• Determination of Field capacity by field method

• Determination of Permanent Wilting Point by sunflower pot culture technique

• Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus

• Determination of Hygroscopic Coefficient

• Determination of maximum water holding capacity of soil

• Measurement of matric potential using gauge and mercury type tensiometer

• Determination of soil-moisture characteristics curves

• Determination of saturated hydraulic conductivity by constant and falling head method

• Determination of hydraulic conductivity of saturated soil below the water table by auger hole method

• Measurement of soil water diffusivity

• Estimation of unsaturated hydraulic conductivity

• Estimation of upward flux of water using tensiometer and from depth ground water table

• Determination of irrigation requirement of crops (calculations)

• Determination of effective rainfall (calculations)

• Determination of ET of crops by soil moisture depletion method

• Determination of water requirements of crops

• Measurement of irrigation water by volume and velocity-area method

• Measurement of irrigation water by measuring devices and calculation of irrigation efficiency

• Determination of infiltration rate by double ring infiltrometer

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and field visit

Learning outcome

Basic knowledge on water management for optimization of crop yield

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Water and its role in plants is discussed with emphasis on how water supports physiological and biochemical functions. Irrigation is explained through its definition and objectives, highlighting the importance of supplying adequate moisture for plant growth.	2
2.	Water resources of India and the concerned state are described in detail. The lecture covers how surface and groundwater resources contribute to irrigation development in different regions.	2
3.	Major irrigation projects of India are introduced along with their significance. The extent of irrigated area and the crops irrigated in India and various states is also explained for better understanding.	2
4.	The field water cycle is discussed, including processes such as infiltration, percolation, runoff and evaporation. Understanding these components helps in planning irrigation more scientifically.	2
5.	Water movement in soil and plants is covered along with the concept of transpiration. Soil-water-plant relationships are explained to understand how water moves from soil to plant tissues.	2

6.	Water absorption by plants is explained with physiological aspects. Plant response to water stress is discussed to understand how crops behave under moisture-deficit conditions.	2
7.	Crop plant adaptation to moisture stress conditions is described. The lecture also covers water availability and its relationship with nutrient availability and nutrient losses through leaching or runoff.	2
8.	Soil, plant and meteorological factors determining water needs of crops are introduced. These factors help in calculating accurate crop water requirement.	2
9.	Scheduling of irrigation and determining depth of irrigation are explained in detail. Different methods of irrigation are also introduced to understand which method suits which condition.	2
10.	Micro-irrigation systems such as drip and sprinkler irrigation are described. Concepts of deficit irrigation and fertigation are also included for modern water management.	1
11.	Management of water in controlled environments and polyhouses is explained. Irrigation efficiency and water use efficiency are discussed along with ways to improve them.	2
12.	Water management of different crops and cropping systems is covered. This includes how individual crops respond to water availability in various cropping patterns.	2
13.	Quality of irrigation water is studied along with methods of managing saline water used for irrigation. This is important for areas facing water quality problems.	1
14.	Water use efficiency is explained with practical examples. Crop water requirement is discussed along with the estimation of evapotranspiration (ET) and effective rainfall.	2
15.	Water management of major crops and cropping systems is elaborated. Automated irrigation systems are introduced to highlight modern irrigation technology.	1
16.	Excess soil water and its effect on plant growth are explained. Water management practices in problem soils are discussed to improve crop performance.	1
17.	Drainage requirements of crops are described, including different methods of field drainage. Layout and spacing of drainage systems are also introduced.	2
18.	Rainwater management and its utilization for crop production are discussed. Importance of capturing and storing rainwater in agriculture is highlighted.	2
19.	Soil moisture conservation practices are explained along with water harvesting methods. Rainwater management and its utilization for crop production are repeated here in detail as per given content.	2
20.	Hydroponics is introduced as a modern soilless cultivation method. This lecture focuses on its principles, advantages and role in future agriculture.	2

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	Determination of Field Capacity by field method.	1
2.	Determination of Permanent Wilting Point by sunflower pot culture technique.	1
3.	Determination of Field Capacity and Permanent Wilting Point by Pressure Plate Apparatus.	2
4.	Determination of Hygroscopic Coefficient and Determination of maximum water holding capacity of soil.	1
5.	Measurement of matric potential using gauge and mercury type tensiometer.	1

6.	Determination of soil-moisture characteristics curves.	1
7.	Determination of saturated hydraulic conductivity by constant and falling head method.	1
8.	Determination of hydraulic conductivity of saturated soil below the water table by auger hole method.	2
9.	Measurement of soil water diffusivity and estimation of unsaturated hydraulic conductivity.	1
10.	Estimation of upward flux of water using tensiometer and from depth ground water table.	1
11.	Determination of irrigation requirement of crops (calculations).	1
12.	Determination of effective rainfall (calculations).	1
13.	Determination of ET of crops by soil moisture depletion method and determination of water requirements of crops.	1
14.	Measurement of irrigation water by volume and velocity-area method.	1
15.	Measurement of irrigation water by measuring devices and calculation of irrigation efficiency; Determination of infiltration rate by double ring infiltrometer.	2

Suggested Reading

• Majumdar DK. 2014. *Irrigation Water Management: Principles and Practice*. PHL Learning private publishers

• Mukund Joshi. 2013. *A Text Book of Irrigation and Water Management Hardcover*, Kalyani publishers

• Lenka D. 1999. *Irrigation and Drainage*. Kalyani.

• Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.

• Paliwal KV. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi.

• Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.

• Prihar SS and Sandhu BS. 1987. *Irrigation of Food Crops - Principles and Practices*. ICAR.

• Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

• Singh Pratap and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ.

Course Title: Agronomy of Major Cereals and Pulses.
Course Code: AGRON 506
Credit Hours: 2+1

Aim of the course

To impart knowledge of crop husbandry of cereals and pulse crops.

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of:

Unit I: *Rabi* cereals.

Unit II: *Kharif* cereals.

Unit III: *Rabi* pulses.

Unit IV: *Kharif* pulses.

Practical

• Phenological studies at different growth stages of crop

• Estimation of crop yield on the basis of yield attributes

• Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities

• Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)

• Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)

• Estimation of protein content in pulses

• Planning and layout of field experiments

• Judging of physiological maturity in different crops

• Intercultural operations in different crops

• Determination of cost of cultivation of different crops

• Working out harvest index of various crops

• Study of seed production techniques in selected crops

• Visit of field experiments on cultural, fertilizer, weed control and water management aspects

• Visit to nearby villages for identification of constraints in crop production

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on cereals and pulse growing in the country.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Scientific Cultivation of Wheat Covers the detailed agronomic practices for wheat cultivation including climate requirements, soil preferences, high-yielding varieties, sowing techniques, seed rate, spacing, nutrient management, irrigation scheduling, weed control, major pests and diseases, harvesting methods, and expected yields.	2
2.	Scientific Cultivation of Barley Discusses barley cultivation with emphasis on its adaptability to marginal soils, climate needs, improved varieties for malt and feed, sowing time, nutrient requirements, water management, common pests and diseases, harvesting, and yield potential.	2
3.	Scientific Cultivation of Oat Discusses Oat cultivation with emphasis on its adaptability to marginal soils, climate needs, improved varieties for malt and feed, sowing time, nutrient requirements, water management, common pests and diseases, harvesting, and yield potential.	2
4.	Scientific Cultivation of Maize Details maize cultivation practices covering hybrid and composite varieties, sowing time for kharif and rabi seasons, spacing, nutrient and irrigation management, pest and disease control, harvesting for grain and silage, and yield expectations.	2
5.	Scientific Cultivation of Rice Explains rice cultivation methods including transplanting and direct seeding, water management practices such as flooded and alternate wetting-drying systems, high-yielding and aromatic varieties, nutrient management, pest and disease control, harvesting, and yield.	2
6.	Scientific Cultivation of Sorghum (Jowar) Focuses on sorghum cultivation under rainfed conditions, including climate and soil requirements, dual-purpose varieties, sowing practices, nutrient management, pest and disease control, harvesting, and yield.	2
7.	Scientific Cultivation of Pearl Millet (Bajra) Covers pearl millet cultivation in arid regions, including drought-tolerant varieties, sowing methods, spacing, nutrient and water management, pest and disease control, harvesting, and yield.	2
8.	Scientific Cultivation of Chickpea (Chana) Discusses chickpea cultivation including desi and kabuli types, climate and soil requirements, improved varieties, sowing time, seed treatment, nutrient management, irrigation, pest and disease control, harvesting, and yield.	2
9.	Scientific Cultivation of Lentil (Masoor) Details lentil cultivation practices covering climate sensitivity, improved varieties, sowing time, nutrient management, irrigation needs, pest and disease control, harvesting, and yield.	2
10	Scientific Cultivation of Field Pea (Matar) Explains field pea cultivation including climate requirements, frost tolerance, improved varieties, sowing practices, nutrient management, pest and disease control, harvesting, and yield.	2

11	Scientific Cultivation of Arhar (Pigeon Pea) Discusses pigeon pea cultivation including short and long duration varieties, climate and soil requirements, sowing methods, nutrient management, pest and disease control, harvesting, and yield.	2
12	Scientific Cultivation of Rajmash (Kidney Bean) Covers rajma cultivation focusing on climate needs, soil preferences, improved varieties, sowing time, nutrient management, irrigation, pest and disease control, harvesting, and yield.	2
13	Scientific Cultivation of Urd (Black Gram) Details black gram cultivation covering kharif and summer sowing, improved varieties, climate and soil needs, nutrient management, pest and disease control, harvesting, and yield.	2
14	Scientific Cultivation of Moong (Green Gram) Explains green gram cultivation including kharif and summer seasons, improved varieties, climate and soil requirements, nutrient management, pest and disease control, harvesting, and yield.	1
15	Scientific Cultivation of Cowpea (Lobia) Covers cowpea cultivation for grain and fodder purposes, including drought-tolerant varieties, climate and soil needs, sowing practices, nutrient management, pest and disease control, harvesting, and yield.	2
16	Scientific Cultivation of Soybean Details soybean cultivation including climate requirements, improved varieties, seed inoculation with rhizobium, nutrient management, pest and disease control, harvesting, and yield.	1
17	Nutrient Management in Cereals and Pulses Compares nutrient requirements between cereals and pulses, focusing on nitrogen management, micronutrient needs, fertilizer application methods, and soil health improvement through pulse cultivation.	1
18	Water Management Strategies for Rabi and Kharif Crops Covers irrigation scheduling for rabi crops like wheat and chickpea, water management in kharif crops like rice and maize, and water-saving techniques including drip and sprinkler systems.	2
19	Integrated Pest Management in Cereals and Pulses Discusses common pests and diseases in cereals and pulses, preventive and control measures, use of resistant varieties, biological control methods, and integrated pest management strategies.	1
20	Post-Harvest Handling and Value Addition Covers post-harvest practices including threshing, drying, storage methods for different crops, prevention of storage losses, and value addition through processing and by-product utilization.	1
21	Cropping Systems and Sustainable Cultivation Discusses important cropping systems like rice-wheat and soybean-wheat rotations, intercropping of cereals and pulses, sustainable practices for soil health, and climate-resilient cultivation methods.	1

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	Phenological Studies at Different Growth Stages of Crop	1
2.	Estimation of Crop Yield on the Basis of Yield Attributes	1
3.	Formulation of Cropping Schemes and Calculation of Cropping & Rotational Intensities	2

4.	Working Out Growth Indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW)	2
5.	Assessment of Land Use and Yield Advantage	1
6.	Estimation of Protein Content in Pulses	1
7.	Planning and Layout of Field Experiments	1
8.	Judging Physiological Maturity in Different Crops	1
9.	Intercultural Operations in Different Crops	1
10	Determination of Cost of Cultivation of Different Crops	1
11	Working Out Harvest Index of Various Crops	1
12	Study of Seed Production Techniques in Selected Crops	1
13	Visit of Field Experiments on Cultural, Fertilizer, Weed Control, and Water Management	1
14	Visit to Nearby Villages for Identification of Constraints in Crop Production	1
15	Integrated Practical Exercise on Crop Management and Yield Estimation	2

Suggested Reading

• Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.

• Hunsigi G and Krishna KR. 1998. *Science of Field Crop Production*. Oxford & IBH.

• Jeswani LM and Baldev B. 1997. *Advances in Pulse Production Technology*. ICAR.

• Khare D and Bhale MS. 2000. *Seed Technology*. Scientific Publ.

• Kumar Ranjeet and Singh NP. 2003. *Maize Production in India: Golden Grain in Transition*. IARI, New Delhi.

• Pal M, Deka J and Rai RK. 1996. *Fundamentals of Cereal Crop Production*. Tata McGraw Hill.

• Prasad Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.

• Singh C, Singh P and Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.

• Singh SS. 1998. *Crop Management*. Kalyani.

• Yadav DS. 1992. *Pulse Crops*. Kalyani.

Course Title: Agronomy of Oilseed, Fibre and Sugar Crops
Course Code: AGRON 507
Credit Hours: 2+1

Aim of the course

To teach the crop husbandry of oilseed, fibre and sugar crops

Theory

Origin and history, area and production, classification, improved varieties, Physical Sciences: Agronomy adaptability, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing of the produce for maximum production of:

Unit I

Rabi oilseeds – Rapeseed and mustard, Linseed and Niger

Unit II

Kharif oilseeds - Groundnut, Sesame, Castor, Sunflower, Soybean and Safflower

Unit III

Fiber crops - Cotton, Jute, Ramie and Mesta.

Unit IV

Sugar crops – Sugar-beet and Sugarcane.

Practical

• Planning and layout of field experiments

• Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane

• Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop

• Intercultural operations in different crops

• Cotton seed treatment

• Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)

• Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land

Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)

• Judging of physiological maturity in different crops and working out harvest index

• Working out cost of cultivation of different crops

• Estimation of crop yield on the basis of yield attributes

• Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities

• Determination of oil content in oilseeds and computation of oil yield

• Estimation of quality of fibre of different fibre crops

• Study of seed production techniques in various crops

• Visit of field experiments on cultural, fertilizer, weed control and water management aspects

• Visit to nearby villages for identification of constraints in crop production

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on production of oil seed, sugar and fibre crops.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Scientific Cultivation of Rapeseed Covers the detailed agronomic practices for Rapeseed cultivation including climate requirements, soil preferences, high-yielding varieties, sowing techniques, seed rate, spacing, nutrient management, irrigation scheduling, weed control, major pests and diseases, harvesting methods, and expected yields.	2
2.	Scientific Cultivation of Mustard Discusses Mustard cultivation with emphasis on its adaptability to marginal soils, climate needs, improved varieties for malt and feed, sowing time, nutrient requirements, water management, common pests and diseases, harvesting, and yield potential.	2
3.	Scientific Cultivation of Oat Discusses Oat cultivation with emphasis on its adaptability to marginal soils, climate needs, improved varieties for malt and feed, sowing time, nutrient requirements, water management, common pests and diseases, harvesting, and yield potential.	2
4.	Scientific Cultivation of Linseed Details linseed cultivation practices covering hybrid and composite varieties, sowing time for rabi seasons, spacing, nutrient and irrigation management, pest and disease control, harvesting for grain, and yield expectations.	2
5.	Scientific Cultivation of Niger Explains Niger cultivation methods including sowing, water management practices such as flooded and alternate wetting-drying systems, high-yielding and varieties, nutrient management, pest and disease control, harvesting, and yield.	2
6.	Scientific Cultivation of Groundnut Focuses on Groundnut cultivation including climate and soil requirements, varieties, sowing practices, nutrient management, pest and disease control, harvesting, and yield.	2
7.	Scientific Cultivation of Sesame Covers Sesame cultivation in arid regions, including drought-tolerant varieties, sowing methods, spacing, nutrient and water management, pest and disease control, harvesting, and yield.	2
8.	Scientific Cultivation of Castor Discusses Castor cultivation including climate and soil requirements, improved varieties, sowing time, seed treatment, nutrient management, irrigation, pest and disease control, harvesting, and yield.	2
9.	Scientific Cultivation of Sunflower Details Sunflower cultivation practices covering climate sensitivity, improved varieties, sowing time, nutrient management, irrigation needs, pest and disease control, harvesting, and yield.	2

10	Scientific Cultivation of Soybean Explains Soybean cultivation including climate requirements, improved varieties, sowing practices, nutrient management, pest and disease control, harvesting, and yield.	2
11	Scientific Cultivation of Safflower Discusses Safflower cultivation including short and long duration varieties, climate and soil requirements, sowing methods, nutrient management, pest and disease control, harvesting, and yield.	2
12	Scientific Cultivation of Cotton Covers cotton cultivation focusing on climate requirements, soil preferences, improved varieties, sowing methods and time, nutrient and water management, weed, pest, and disease control, harvesting techniques, and yield optimization.	2
13	Scientific Cultivation of Ramie Covers ramie cultivation focusing on climate requirements, soil preferences, improved varieties, sowing methods and time, nutrient and water management, weed, pest, and disease control, harvesting techniques, and fibre yield optimization.	2
14	Scientific Cultivation of Sugarcane Covers sugarcane cultivation focusing on climate and soil requirements, improved varieties, planting methods and time, nutrient and irrigation management, weed, pest, and disease control, harvesting techniques, and yield improvement.	2
15	Scientific Cultivation of Sugar-beet Covers Sugar-beet cultivation focusing on climate and soil requirements, improved varieties, planting methods and time, nutrient and irrigation management, weed, pest, and disease control, harvesting techniques, and yield improvement.	2
16	Nutrient Management in Oilseed, Fibre and Sugar crops Compares nutrient requirements between oilseed, fibres and sugar crops, focusing on nitrogen management, micronutrient needs, fertilizer application methods, and soil health improvement through pulse cultivation.	1
17	Water Management Strategies for Rabi oilseed and Kharif oilseed Crops Covers irrigation scheduling for rabi crops like mustard and linseed, water management in kharif oilseed and sugar crops like groundnut and soybean, Sugarcane and water-saving techniques including drip and sprinkler systems.	2
18	Integrated Pest Management in Oilseed, Fibre and Sugar crops Discusses common pests and diseases in Oilseed, Fibre and Sugar crops, preventive and control measures, use of resistant varieties, biological control methods, and integrated pest management strategies.	1
19	Post-Harvest Handling and Value Addition Covers post-harvest practices including threshing, drying, storage methods for different crops, prevention of storage losses, and value addition through processing and by-product utilization.	1
20	Cropping Systems and Sustainable Cultivation Discusses important cropping systems like rice-wheat and soybean-wheat rotations, intercropping of cereals and pulses, sustainable practices for soil health, and climate-resilient cultivation methods.	1

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	Planning and layout of field experiments:	2

	Involves selecting the field, leveling the land, choosing an experimental design such as RBD, CRD, or LSD, and marking plots with proper randomization. Treatments, replications, and plot boundaries are clearly marked to ensure accurate data recording and smooth crop management.	
2.	Cutting, treatment, sowing, tying and propping of sugarcane setts: Students learn to cut healthy sugarcane setts with 2–3 buds, treat them with fungicides or insecticides, and plant them using trench or furrow methods. Tying and propping operations are also demonstrated to prevent lodging and promote better cane growth and yield.	2
3.	Determination of cane maturity and calculation of purity, recovery and sucrose: Cane maturity is assessed by observing external signs and analyzing juice quality. Laboratory methods are used to determine brix, sucrose percentage, purity percentage, and recovery, helping identify the right time for harvest and potential sugar output.	1
4.	Phenological studies at different growth stages of crops: Focuses on recording crop growth stages such as germination, vegetative growth, flowering, grain formation, and maturity. Students prepare a phenological calendar to understand crop development and environmental influences.	1
5.	Intercultural operations in different crops: Students practice intercultural operations such as weeding, hoeing, thinning, gap filling, mulching, and earthing-up. These operations improve soil aeration, reduce weed competition, conserve moisture, and enhance crop growth and health.	1
6.	Cotton seed treatment: Cotton seeds are treated with acid delinting, fungicides, insecticides, and bio-agents to improve germination and protect seedlings from early pests and diseases. Proper seed handling and sowing methods are demonstrated for better crop establishment.	1
7.	Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW): Students measure plant dry matter and leaf area at intervals to calculate growth indices such as CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, and SLW. These indices help analyze crop vigor, biomass production, and photosynthetic efficiency.	1
8.	Assessment of land use and yield advantage: This practical includes calculating rotational intensity, cropping intensity, diversity index, sustainable yield index, crop equivalent yield, land equivalent ratio, aggressiveness, relative crowding coefficient, competition ratio, and ATER to evaluate cropping system efficiency.	1
9.	Judging physiological maturity and working out harvest index: Students identify physiological maturity by observing changes in grain or pod color, dryness, and hardness. Harvest index is calculated using economic and biological yield to understand crop efficiency in converting biomass into economic produce.	1
10.	Working out cost of cultivation of different crops: All input costs such as seed, fertilizers, labor, irrigation, machinery, pesticides, and harvesting are recorded. Total cost, cost per unit, net returns, and benefit–cost ratio are calculated to assess the economic feasibility of crops.	1
11.	Estimation of crop yield on the basis of yield attributes: Students measure yield attributes like number of plants, tillers, spikes or pods per plant, grains per spike, and 1000-grain weight. Using these parameters, expected yield per hectare is estimated before final harvest.	1

12.	Formulation of cropping schemes and calculation of intensities: Cropping schemes are prepared for different farm sizes considering resources and crop duration. Cropping intensity and rotational intensity are calculated to understand land use efficiency and optimal farm planning.	1
13.	Determination of oil content in oilseeds and computation of oil yield: Oil content is estimated using Soxhlet extraction or similar methods. Oil percentage and oil yield per hectare are calculated to compare varieties and evaluate seed quality.	1
14.	Estimation of fibre quality of different fibre crops: Fibre crops like cotton, jute, sunhemp, and ramie are tested for fibre length, strength, fineness, and color. Fibre extraction and grading methods are demonstrated to assess fibre quality and industrial suitability.	1
15.	Study of seed production techniques in various crops: Seed production practices including isolation distance, rouging, field inspection, fertilizer management, plant protection, harvesting, cleaning, grading, drying, and storage are studied to ensure high-quality certified seed production.	1
16.	Visits to field experiments and nearby villages to identify constraints: Students visit research plots to observe cultural, fertilizer, weed, and water management experiments. They also visit villages to interact with farmers and identify real-world constraints such as soil problems, pests, water shortages, and market issues.	1

Suggested Reading

• Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.

• Das PC. 1997. *Oilseed Crops of India*. Kalyani.

• Lakshmikantam N. 1983. *Technology in Sugarcane Growing*. 2nd Ed. Oxford & IBH.

• Prasad Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.

• Singh C, Singh P & Singh R. 2003. *Modern Techniques of Raising FieldCrops.* Oxford & IBH.

• Singh SS. 1998. *Crop Management*. Kalyani.

Course Title: Principles and Practices of Organic Farming
Course Code: AGRON 513
Credit Hours: 2+1

Aim of the course

To study the principles and practices of organic farming for sustainable crop production.

Theory

Unit I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; principles of organic agriculture; organics and farming standards; organic farming and sustainable agriculture; selection and conversion of land, soil and water management - land use, conservation tillage; shelter zones, hedges, pasture management, agro-forestry.

Unit II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures, bio-fertilizers and biogas technology.

Unit III

Farming systems, selection of crops and crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

Unit IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, bio-pesticides.

Unit V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

- Method of making compost by aerobic method
- Method of making compost by anaerobic method
- Method of making vermicompost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
- Visit to a biogas plant
- Visit to an organic farm
- Quality standards, inspection, certification and labelling and accreditation procedures for farm produce from organic farms

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment. exposure visit

Learning outcome

Basic knowledge on organic farming for sustainable agriculture and development

of entrepreneurship on organic inputs.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Organic farming – concept and definition, its relevance to India and global agriculture, and future prospects.	2
2.	Principles of organic agriculture and their role in sustaining long-term soil and plant health.	2
3.	Organics and farming standards, national and international organic standards, and regulatory frameworks.	2
4.	Organic farming and sustainable agriculture – linkages, ecological balance, and long-term productivity.	2
5.	Selection and conversion of land for organic farming, including transition period and certification needs.	2
6.	Soil and water management in organic systems – land use planning, conservation tillage practices, soil protection.	2
7.	Shelter zones, hedges, pasture management, and agroforestry as components of organic resource management.	2
8.	Organic farming and water use efficiency, emphasizing moisture conservation and efficient resource use.	2
9.	Soil fertility management, nutrient recycling, and organic residues – importance and methods.	2
10	Organic manures and composting: preparation, properties, role in soil improvement.	1
11	Soil biota and decomposition of organic residues – role of microorganisms in nutrient cycling.	2
12	Earthworms and vermicompost production – methods, benefits, and applications.	2
13	Green manures, biofertilizers, and biogas technology as nutrient and energy sources in organic farming.	1
14	Farming systems approach in organic agriculture and integration of enterprises.	2
15	Selection of crops and crop rotations suitable for organic farming systems.	1
16	Multiple cropping, relay cropping, and intercropping in relation to maintenance of soil productivity.	1
17	Control of weeds, diseases, and insect pests using organic and ecological approaches.	2
18	Biological agents, pheromones, and bio-pesticides used in organic production systems.	2
19	Socio-economic impacts of organic farming, cost–benefit aspects, and livelihood opportunities.	2
20	Marketing and export potential; inspection, certification, labeling, and accreditation procedures; organic farming and national economy.	2

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	Method of making compost by aerobic method.	1
2.	Method of making compost by anaerobic method.	1
3.	Method of making vermicompost.	2
4.	Identification of important agro-forestry trees.	1
5.	Nursery raising of important agro-forestry trees.	1
6.	Identification and nursery raising of trees for shelter belts.	1
7.	Efficient use of biofertilizers in field conditions.	1
8.	Technique of treating legume seeds with Rhizobium cultures.	2
9.	Use of Azotobacter and Azospirillum cultures in field.	1
10	Use of PSB (Phosphate Solubilizing Bacteria) cultures in crops.	1
11	Visit to a biogas plant.	1
12	Visit to an organic farm.	1
13	Quality standards for organic produce and inspection procedures.	1
14	Certification and labeling of organic farm produce.	1
15	Accreditation procedures for organic farming systems.	2

Suggested Reading

• Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.

• Gaur AC. 1982. *A Manual of Rural Composting*, FAO/UNDP Regional Project Document,FAO.

• Joshi M. 2016. *New Vistas of Organic Farming*. Scientific Publishers

• Lampin N. 1990. *Organic Farming*. Press Books, lpswitch, UK.

• Palaniappan SP and Anandurai K. 1999. *Organic Farming – Theory and Practice.* Scientific Publ.

• Rao BV Venkata. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*: Publ.3, Parisaraprajna Parishtana, Bangalore.

• Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.

• Sharma A. 2002. *Hand Book of Organic Farming*. Agrobios.

• Singh SP. (Ed.). 1994. *Technology for Production of Natural Enemies.* PDBC, Bangalore.

• Subba Rao NS. 2002. *Soil Microbiology*. Oxford & IBH.

• Trivedi RN. 1993. *A Text Book of Environmental Sciences*, Anmol Publ.

• Veeresh GK, Shivashankar K and Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture.* Association for Promotion of Organic Farming, Bangalore.

• WHO. 1990. *Public Health Impact of Pesticides Used in Agriculture*. WHO.

• Woolmer PL and Swift MJ. 1994. *The Biological Management of Tropical Soil Fertility*. TSBF & Wiley.

Course Title: Soil Fertility and Fertilizer Use
Course Code: SOIL 502
Credit Hours: 2+1

Aim of the course

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory

Unit I

Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit II

Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behaviour in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit V

Sulphur - source, forms, fertilizers and their behaviour in soils; role in crops and human health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Unit VI

Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit VII

Common soil test methods for fertilizer recommendations; quantity– Intensity relationships; soil test crop response correlations and response functions.

Unit VIII

Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers uses in soils and crops of India;

Unit IX

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS

Unit X

Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.

Practical

• Soil and plant sampling and processing for chemical analysis

• Determination of soil pH, total and organic carbon in soil

• Chemical analysis of soil for total and available nutrients (major and micro)

• Analysis of plants for essential elements (major and micro)

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Soil fertility and soil productivity; fertility status of major soils group of India; Special emphasis on Maharashtra	1
2.	Nutrient sources- fertilizers and manures	1
3.	Criteria of essentiality, classification, law of minimum and maximum	1
4.	Functions and deficiency symptoms of primary, secondary and micronutrients nutrients	1
5.	Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity	1
6.	Sources and forms of nitrogen in soils immobilization and mineralization (nitrification, denitrification,)	2
7.	Biological N fixation Factors affecting N fixation,	1
8.	Nitrogen fertilizers, their classification and fertilizer N management in Low land upland conditions, fertilizer N use efficiency	2
9.	Soil fertilizer Phosphorus, forms and Sources of soil P, immobilization and mineralization of soil P	2
10.	Factors affecting the P availability in soil	1
11.	Phosphatic fertilizers, their classification and behaviour and management of P fertilizers under field conditions.	1
12.	Forms and sources of potassium in soil, factors affecting Potassium availability (soil and plant factors)	1
13.	Mechanism of potassium fixation factors affecting it	1
14.	K fertilizers and their classification and management of K fertilizers under field conditions	1
15.	Sulphur- forms, and sources of sulphur in soils, S behaviour in soils	1
16.	Sulphur fertilizers and their behaviour in soils, role in crop and human health	1
17.	Calcium and magnesium- forms and sources of Ca & Mg in soils, Ca & Mg availability in soils	1
18.	Management of sulphur, calcium and magnesium fertilizers.	1
19.	Micronutrients Sources, critical limits in soil and plants, micronutrient availability in soil and factors affecting it.	2
20.	Deficiency symptoms and their corrections in plants.	1

21.	Role of chelates in nutrient availability	1
22.	Common soil test methods for fertilizer recommendations	1
23.	Quantity /intensity of phosphorus and potassium,	1
24.	Soil test crop response correlations and response functions	1
25.	Fertilizer use efficiency –site specific nutrient management and plant need based nutrient management	1
26.	Integrated nutrient management specialty fertilizers concept, need and category. Current status of specialty fertilizers use in soils and crops of India	2
27.	Soil fertility evaluation classification DRIS, Methods of determination of critical limit biological methods	1
28.	Soil and plant tissue test	1
29.	Soil quality to sustainable agriculture-	1
30.	Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.	2

Practical Schedule

Exercise No.	Name of Exercise
1	Soil and plant sampling and processing technique for chemical analysis.
2	Determination of available nitrogen
3	Determination of ammonical and nitrate nitrogen
4	Determination of available phosphorus
5	Determination of available potassium
6	Determination of exchangeable cations Ca, Mg, Na and K
7	Determination of available S
8	Determination of total and organic carbon in soil.
9	Principles of colorimetric,
10	Flame photometry
11	Atomic absorption spectrophotometry

Suggested Reading

• Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.

• Kabata-Pendias A and Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.

• Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.

• Leigh J G. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.

• Mengel K and Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.

• Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

• Pierzinsky GM, Sims TJ and Vance JF. 2002. *Soils and Environmental Quality.* 2nd Ed. CRC Press.

• Stevenson FJ and Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.

• Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. *Soil Fertility and Fertilizers.* 5th Ed. Prentice Hall of India.

• Troeh FR and Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

Course Title: Soil Mineralogy, Genesis and Classification
Course Code: SOIL 504
Credit Hours: 2+1

Aim of the course

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

Unit I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

Unit II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystal line and non-crystal line clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

Unit III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

Unit IV

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness.

Practical

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soil using available database in terms of soil quality

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil taxonomy and genesis and and their utility in research for solving field problem.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Fundamentals of crystallography, space lattice, coordination theory isomorphism and polymorphism	3
2.	Classification, structure, chemical composition and properties of minerals	2
3.	Genesis and transformation of crystalline and non-crystalline clay minerals.	2
4.	Identification of clay minerals, amorphous soil constituents and other non-crystalline silicate minerals in Indian soil by using advance methods (XRD, SEM, TEM, IR, DTA etc)	4
5.	Role of minerals in plant nutrition interaction of clay with humus	2
6.	Factors of soil formation and soil formation model and soil forming processes	2
7.	Weathering of rocks and minerals transformations	2
8.	Soil profile and master and Subsurface horizon	2
9.	Weathering sequences of minerals with special reference to Indian soil	2
10.	Soil individual and its concept,	2
11.	Soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy	3
12.	Soil survey, type of soil survey conventional and modern, data interpretations; soil mapping, thematic soil maps by using GIS, cartography, mapping units, techniques for generation of soil maps.	4
13.	Landform – soil relationship; major soil groups of India with special reference to respective states	2
14.	Land capability classification and land irritability classification;	2
15.	Land evaluation and land use type (LUT) – concept and application;	2

Practical Schedule

Exercise No.	Name of Exercise
1-2	Mechanical analysis of soil
3-4	Determination of specific surface area of clay fraction
5-6	Determination of CEC of clay fraction
7-9	Identification and quantification of minerals in soil fractions
10-12	Morphological properties of soil profile in different land forms Viz, Vertisols, Inceptisols and Entisols etc. (Specially emphasis on Maharashtra)
13-14	Classification of soils by using USDA classification (Soil Taxonomy)
15-16	Calculation of weathering indices and its application in soil formation.
17-18	Grouping of soils by using available data base in terms of soil quality

Suggested Reading

• Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu. Buol EW, Hole ED, MacCracken RJ and Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.

• Dixon JB and Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.

• Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.

• Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

• Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi

• Wade FA and Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
• Wilding NE and Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy*. I.



Course Title: Soil Erosion and Conservation
Course Code: SOIL 505
Credit Hours: 2+1

Aim of the course

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

Unit I

History, distribution, identification and description of soil erosion problems in India.

Unit II

Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; type sand mechanisms of water erosion; raindrops and soil erosion; rainfall erosity -estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

Unit III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

Unit IV

Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

Unit V

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

Unit VI

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement

Practical

• Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index

• Computation of kinetic energy of falling rain drops

• Computation of rainfall erosivity index (EI30) using rain gauge data

• Land capability classification of a watershed

• Visits to a watershed

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil conservation and their utility in research for

solving field problem.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	History, distribution, identification and description of soil erosion problems in India.	2
2.	Forms/type of soil erosion; Effects of soil erosion and factors affecting soil erosion;	2
3.	Types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity –estimation as EI30 index and kinetic energy;	3
4.	Factors affecting water erosion; empirical and quantitative estimation of water erosion;	2
5.	Methods of measurement and prediction of runoff;	1
6.	Soil losses in relation to soil properties and precipitation.	2
7.	Wind erosion- types of wind erosion	2
8.	Mechanism and factors affecting wind erosion;	2
9.	Extent of problem in the country of wind erosion	1
10.	Principles of erosion control	1
11.	Erosion control measures–agronomical and engineering;	2
12.	Erosion control structures- their design and layout.	3
13.	Soil conservation planning;	1
14.	Land capability classification;	1
15.	Soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wetlands.	3
16.	Watershed management-concept, objectives and approach;	2
17.	Water harvesting and recycling;	1
18.	Flood control in watershed management; socio economic aspects of watershed management	2
19.	Use of remote sensing in assessment and planning of watersheds, sediment measurement.	2
20.	Case studies in respect to monitoring and evaluation of watersheds.	1

Practical Schedule

Exercise No.	Name of Practical
1-2	Determination of(erodibility indices) soil suspense on percentage.
3-4	Determination of soil (erodibility indices) dispersion ratio.
5-6	Determination of soil erosion ratio.
7-8	Determination of clay ratio from soil.
9-10	Determination of clay/moisture equivalent ratio.
11-12	Determination of percolation ratio of soil.
13-14	Determination of raindrop perodibility index
15	Computation of kinetic energy of falling rain drops
16	Computation of rainfall erosivity index (EI30) using rain gauge data
17	Land capability classification of a watershed
18	Visits to a watershed

Suggested Reading

• Biswas TD and Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.

• Doran JW and Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.

• Gurmal Singh, Venkataramanan C, Sastry G and Joshi BP. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

• Hudson N. 1995. *Soil Conservation*. Iowa State University Press.

• Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

• Oswal MC. 1994. *Soil Physics*. Oxford & IBH.



Course Title: Principles of Vegetable Breeding
Course Code: HORT 506
Credit Hours: 3 (2+1)

Theory

Unit I: Importance and history- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.

Unit II: Selection procedures- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests, and nematode), abiotic stress (temperature, moisture, and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).

Unit III: Heterosis breeding- Types, mechanisms, and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility, and sex forms.

Unit IV: Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.

Unit V: Ideotype breeding- Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of In-vitro and molecular techniques in vegetable improvement.

Practical

Floral biology and pollination behaviour of different vegetables; Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.; Breeding system and handling of filial generations of different vegetables; Exposure to biotechnological lab practices; Visit to breeding farms.

Theory Lecture Schedule

Sr. No.	Name of Topic	No. of Lectures
1	Introduction to vegetable breeding—scope & significance; Historical development of vegetable breeding	1
2	Evolutionary aspects of vegetable crops; Vegetable vs. cereal crop breeding; Achievements & future prospects in vegetable breeding	1
3	Techniques of selfing & crossing—principles; Selfing: methods, precautions, applications; Controlled crossing techniques	1
4	Breeding systems in vegetables	1
5	Mass, progeny & pure-line selection	1
6	Hybridization: objectives, steps, types	2
7	Genetic architecture of vegetable crops	1
8	Breeding for biotic stress diseases resistance insect-pest & nematode resistance	4
9	Breeding for abiotic stress—temperature tolerance moisture & salt tolerance	2
10	Breeding for quality improvement	1
11	Breeding for water-use efficiency (WUE)	1
12	Breeding for nutrient-use efficiency (NUE)	1
13	Concept, types & genetic basis of heterosis; Mechanisms underlying heterosis	2
14	Hybrid breeding in vegetables	1

15	Role of male sterility systems	2
16	Self-incompatibility in hybrid seed production	2
17	Sex forms and their role in heterosis breeding	1
18	Mutation breeding—concept, mutagens, procedures, Applications of mutation breeding in vegetables	2
19	Polyploidy—types & induction, Role of polyploidy in vegetable improvement	1
20	Breeding asexually propagated vegetables for protected cultivation	2
21	Ideotype breeding—concept & principles	1
22	Designing ideotypes for vegetable crops	1
23	Varietal release procedures	1
24	DUS testing in vegetables	1
25	In-vitro techniques in vegetable improvement	1
26	Molecular techniques in vegetable breeding	1

Practical Schedule

Sr. No.	Name of Topic	No. of Practical
1	Floral biology & pollination behavior of different vegetables	1
2	Techniques of selfing and crossing in Cole crops	2
3	Techniques of selfing and crossing in okra	1
4	Techniques of selfing and crossing in cucurbits	1
5	Techniques of selfing and crossing in tomato	1
6	Techniques of selfing and crossing in eggplant	1
7	Techniques of selfing and crossing in hot pepper	1
8	Breeding systems in vegetables	1
9	Handling of filial generations	1
10	Exposure to biotechnological lab practices	1
11	Visit to breeding farms	1

Suggested Reading

- Allard RW. 1960. Principle of plant breeding. John Willey and Sons, USA.
- Kalloo G. 1988. Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA.
- Kole CR. 2007. Genome mapping and molecular breeding in plants-vegetables. Springer, USA.
- Peter KV and Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p. 488.
- Prohens J and Nuez F. 2007. Handbook of plant breeding-vegetables (Vol I and II). Springer, USA.
- Singh BD. 2007. Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi.
- Singh Ram J. 2007. Genetic resources, chromosome engineering, and crop improvement-vegetable crops (Vol. 3). CRC Press, Fl, USA.

Course Title: Experimental Designs
Course Code: AST 501
Credit Hours: 3 (2+1)

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.

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.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lectures
1	Need for designing experiments – introduction, Importance of proper experimental design, Characteristics of a good design	2
2	Basic principles of designs- Randomization, Replication and Local control	1
3	Uniformity trials – purpose & procedure Size and shape of plots and blocks	1
4	ANOVA- Analysis of variance	2
5	CRD –Completely randomized design,	2
6	RBD – Randomized block design	2
7	LSD – Latin square design	2
8	Factorial experiments (Symmetrical factorials and Asymmetrical factorials)	2
9	Orthogonality – concept & importance	1
10	Partitioning degrees of freedom	1
11	Concept of confounding	2
12	Split-plot design	1
13	Strip-plot design	1
14	ANCOVA – Analysis of covariance	2
15	Missing plot techniques in RBD	2
16	Missing plot techniques in LSD	2
17	Transformations	2
18	Balanced Incomplete Block Design	1
19	Resolvable designs and their applications	1

20	Lattice designs & Alpha design - concepts, randomization procedure, analysis and interpretation of results	4
21	Response surface methodology	1
22	Combined analysis	1

Practical Schedule

S. No.	Name of Exercise	No. of Lectures
1	Uniformity trial data analysis,	2
2	Formation of plots and blocks,	2
3	Fairfield Smith's Law	2
4	Analysis of data obtained from Completely Randomized Design (CRD)	2
5	Analysis of data obtained from Randomized Block Design (RBD)	2
6	Analysis of data obtained from Latin Square Design (LSD)	2
7	Analysis of factorial experiments	2
8	Analysis with missing data	2
9	Split plot and strip plot designs	2

Suggested Reading

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

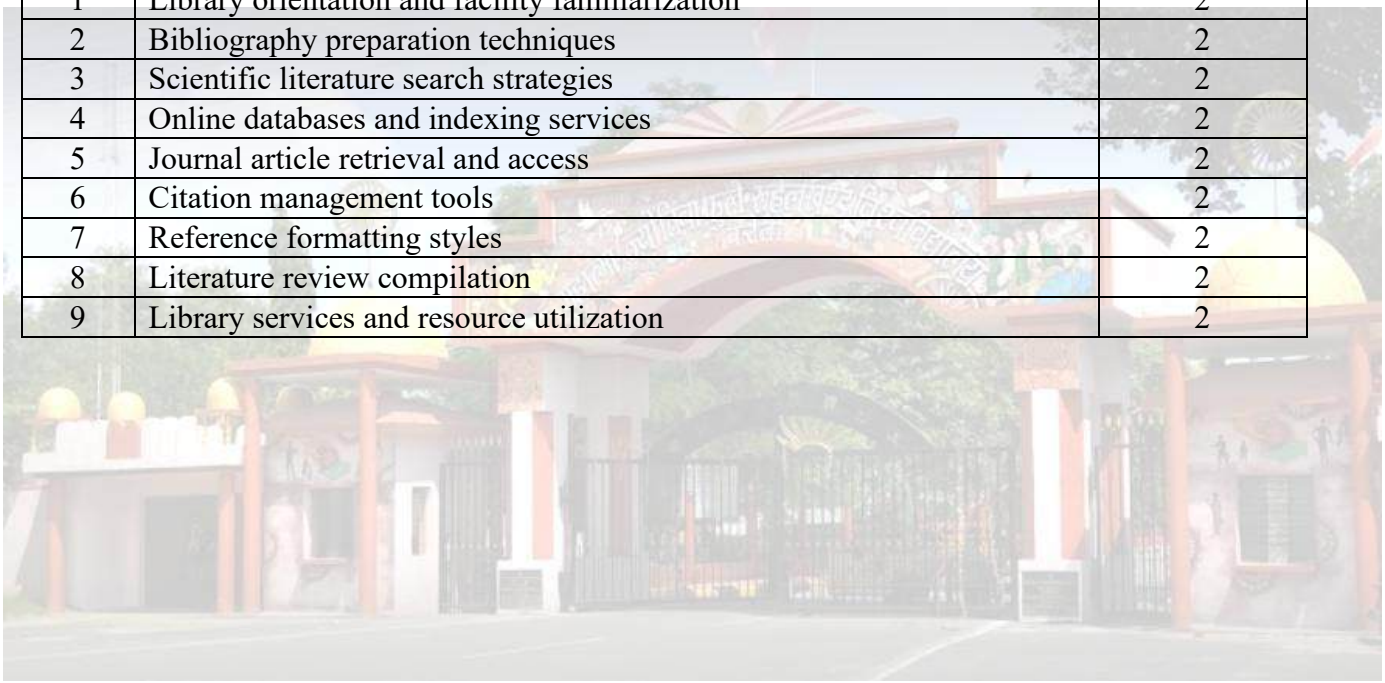
Course Title: Library and Information Services
Course Code: PGS 501
Credit Hours: 1 (0+1)

Practical

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

PRACTICAL SCHEDULE

S. No.	Name of Topic	No. of Practical
1	Library orientation and facility familiarization	2
2	Bibliography preparation techniques	2
3	Scientific literature search strategies	2
4	Online databases and indexing services	2
5	Journal article retrieval and access	2
6	Citation management tools	2
7	Reference formatting styles	2
8	Literature review compilation	2
9	Library services and resource utilization	2



Course Title: Technical Writing and Communication Skills
Course Code: PGS 502
Credit Hours: 1 (0+1)

Practical (Technical Writing)

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

PRACTICAL SCHEDULE

Sr. No.	Name of Topic	No. of Lecture
1.	Covers the meaning, purpose and importance of scientific writing, including theses, dissertations, technical papers, manuals, reports, and review articles. Introduces how each form serves a different scientific objective.	1
2.	Explains research notes, short communications, popular articles, bulletins, monographs, and extension leaflets, describing when and why each is written in the scientific community.	1
3.	Discusses the title page, authorship details, certification, declaration, acknowledgments, contents page, and formatting standards used in thesis writing.	1
4.	Explains major thesis components such as the introduction, review of literature, materials and methods, results, discussion, summary, references, and appendices.	1
5.	Covers the format of research papers including the title, abstract, keywords, introduction, methodology, results, discussion, conclusion, references, and author contributions.	1
6.	Explains how to write effective abstracts, concise summaries, and well-structured précis, including length, style, purpose, and evaluation criteria.	1
7.	Covers citation styles (APA, MLA, Chicago, JRF, ICAR), in-text citations, reference lists, footnotes, and commonly used abbreviations in theses and research articles.	1
8.	Explains how to use photographs, graphs, charts, maps, and scientific drawings with appropriate captions, legends, resolutions, and placement guidelines.	1
9.	Describes rules for table numbering, figure numbering, page numbering (Roman & Arabic), table titles, footnotes, and alignment in scientific documents.	1
10	Covers rules for writing numeric data, units (SI units), measurements, formulas, equations, and scientific dates following international writing standards.	1

11	Teaches proofreading marks, identifying typographical, grammatical, logical, and formatting errors, and using checklists for editing scientific content.	1
12	Explains how to choose a topic, search literature, structure sections, synthesize findings, compare studies, and write high-quality review papers.	1
13	Covers basic grammar essentials including tense forms, verb agreement, noun forms, pronouns, adverbs, clauses, and correct sentence structure.	1
14	Explains punctuation marks, subject–verb agreement (concord), commonly misused word combinations (collocations), and how they affect scientific writing.	1
15	Focuses on spelling errors, redundancy, run-on sentences, misplaced modifiers, incorrect prepositions, and other frequently occurring writing problems.	1
16	Introduces phonetic symbols (IPA), stress patterns, weak forms in connected speech, and pronunciation techniques important for oral scientific communication.	1
17	Covers participation techniques for group discussions, confidence building, questioning strategies, and handling academic or job interviews effectively.	1
18	Explains preparing PPTs, slide design, sequence of presentation, verbal and non-verbal communication, answering audience questions, and professional presentation ethics.	1

Suggested Readings

- Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
- Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
- Collins' Cobuild English Dictionary. 1995.
- Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.
- Holt, Rinehart, and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
- James HS. 1994. Handbook for Technical Writing. NTC Business Books.
- Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
- Mohan K. 2005. Speaking English Effectively. MacMillan India.
- Richard WS. 1969. Technical Writing.
- Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
- Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

Course Title: Intellectual Property and Its Management in Agriculture
Course Code: PGS 503
Credit Hours: 1 (1+0)

Theory

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

THEORY SCHEDULE

S. No.	Name of Topic	No. of Lectures
1	Intellectual property concepts and definitions	2
2	Patents: types and filing procedures	2
3	Plant varieties protection	2
4	Trade secrets and confidential information	1
5	Copyright and trademark in agriculture	2
6	Licensing and technology transfer	2
7	IPR in biotechnology and agriculture	2
8	Management of research outputs	2
9	Agricultural policies and regulations	1

Suggested Readings

- Erbisch, F. H. and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli, P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
- Rothschild, M. and Scott, N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- Saha, R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

Course Title: Basic Concepts in Laboratory Techniques
Course Code: PGS 504
Credit Hours: 1 (0+1)

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, sand bath, water bath, oil bath; 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.

PRACTICAL SCHEDULE

S. No.	Name of Topic	No. of Practicals
1	Laboratory safety and hazard management	2
2	Personal protective equipment (PPE)	2
3	Laboratory equipment identification and use	2
4	Measurement and precision techniques	2
5	Weighing and volumetric glassware	2
6	Solution preparation and standardization	2
7	Basic chemistry and biochemistry techniques	2
8	Microscopy and observation techniques	2
9	Laboratory record keeping and documentation	2

Suggested Readings

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

Course Title: Agriculture Research, Research Ethics and Rural Development Program
Course Code: PGS 505
Credit Hours: 1 (1+0)

Theory

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

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

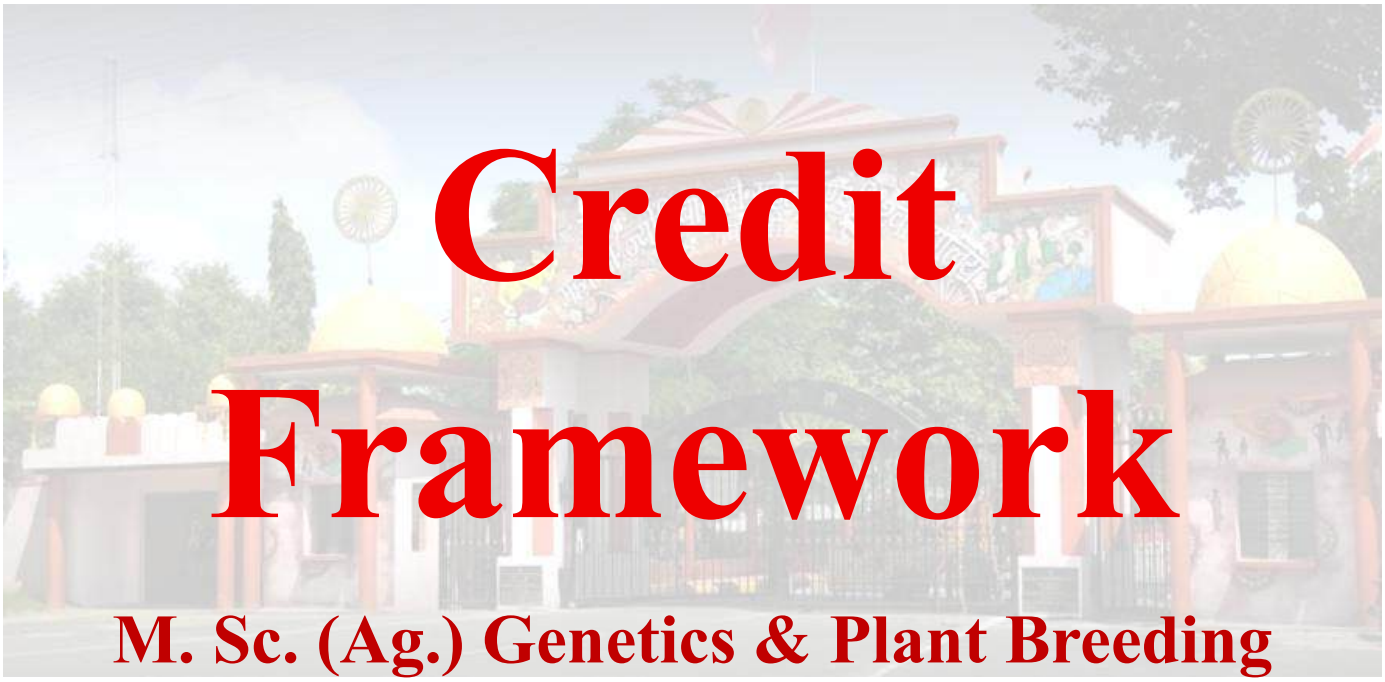
UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati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

THEORY SCHEDULE

S. No.	Name of Topic	No. of Lectures
1	Research ethics principles and guidelines	2
2	Informed consent and research participant rights	2
3	Research misconduct and plagiarism	2
4	Ethical issues in genetic research	2
5	Institutional Review Board (IRB) procedures	1
6	Data management and confidentiality	2
7	Rural development and agriculture	2
8	Sustainable agriculture practices	2
9	Community engagement and extension services	1

Suggested Readings

- Bhalla, G.S. and Singh, G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
- Punia, M.S. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.
- Rao, B.S.V. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations, and Initiatives. Mittal Publ.
- Singh, K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.



Credit Framework

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

MAHATMA JYOTIBA PHULE ROHILKHAND UNIVERSITY, BAREILLY

FACULTY OF AGRICULTURE SCIENCE & TECHNOLOGY

Department of Genetics & Plant Breeding

COURSE WORK

Major Courses

Course Code	Course Title	Credit Hours
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)
GPB 506*	Molecular Breeding and Bioinformatics	3 (2+1)
GPB 509	Hybrid Breeding	3 (2+1)
GPB 511	Crop Breeding-I (Kharif Crops)	3 (2+1)
GPB 512	Crop Breeding-II (Rabi Crops)	3 (2+1)
		Total Credit = 21

Minor Courses

Course Code	Course Title	Credit Hours
BI 511	Principles of Biotechnology	3 (3+0)
BI 512	Fundamentals of Molecular Biology	3 (3+0)
BI 514	Genomics and Proteomics	2 (2+0)
		Total Credit = 08

Supporting Courses

Course Code	Course Title	Credit Hours
HORT 506	Principles of Vegetable breeding	3 (2+1)
AST 501	Experimental design	3 (2+1)
		Total Credit = 06

Common Compulsory Courses

Course Code	Course Title	Credit Hours
PGS 501	Library and Information Services	1 (0+1)
PGS 502	Technical Writing and Communication Skills	1 (0+1)
PGS 503	Intellectual Property and Its Management in Agriculture	1 (1+0)
PGS 504	Basic Concepts in Laboratory Techniques	1(0+1)
PGS 505	Agriculture Research, Research Ethics and Rural Development Program	1(1+0)
		Total Credit = 05

Seminar/Thesis/Research

Course Code	Course Title	Credit Hours
GPB 591	Master Seminar	01
GPB 599	Master Thesis/Research	30

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SEMESTER WISE DISTRIBUTION OF COURSES WITH CREDIT HOURS

First Semester (Total Credits = 18)

Course Code	Course Title	Credit Hours
GPB 501*	Principles of Genetics	3 (2+1)
GPB 502*	Principles of Plant Breeding	3 (2+1)
HORT 506	Principles of Vegetable Breeding	3 (2+1)
BI 511	Principles of Biotechnology	3 (3+0)
BI 512	Fundamentals of Molecular Biology	3 (3+0)
PGS 501	Library and Information Services	1 (0+1)
PGS 502	Technical Writing and Communication Skills	1 (0+1)
PGS 503	Intellectual Property and Its Management in Agriculture	1 (1+0)

Second Semester (Total Credits = 15)

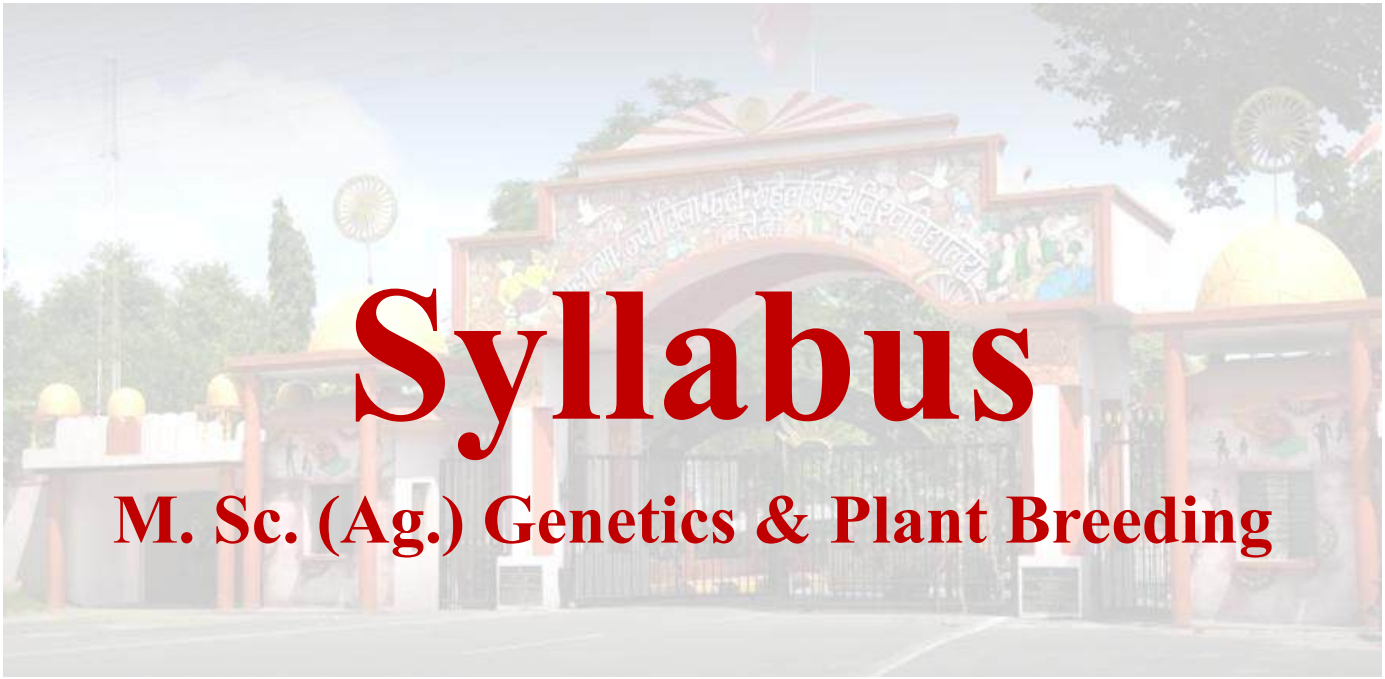
Course Code	Course Title	Credit Hours
GPB 503*	Fundamentals of Quantitative Genetics	3 (2+1)
GPB 506*	Molecular Breeding and Bioinformatics	3 (2+1)
GPB 512	Crop Breeding-II (Rabi Crops)	3 (2+1)
AST 501	Experimental Design	3 (2+1)
PGS 504	Basic Concepts in Laboratory Techniques	1(0+1)
PGS 505	Agriculture Research, Research Ethics and Rural Development Program	1(1+0)
GPB 591	Master Seminar	01

Third Semester (Total Credits = 20)

Course Code	Course Title	Credit Hours
GPB 511	Crop Breeding-I (Kharif Crops)	3 (2+1)
BI 514	Genomics and Proteomics	2 (2+0)
GPB 599	Master Thesis/Research	15

Fourth Semester (Total Credits = 18)

Course code	Course Title	Credit Hours
GPB 509	Hybrid Breeding	3 (2+1)
GPB 599	Master Thesis/Research	15



Syllabus

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

Course Title: Principles of Genetics*
Course Code: GPB 501
Credit Hours: 3 (2+1)

Theory

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

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

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

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

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

Practical

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three-point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification; Electrophoresis: basic principles and running of amplified DNA; Extraction of proteins and isozymes; Use of Agrobacterium mediated method and Biolistic gun; Detection of transgenes in the exposed plant material; Visit to transgenic glasshouse and learning the practical considerations.

LECTURE SCHEDULE

Theory

Sr. No.	Topic	No. of Lecture
1.	**Introduction to Genetics**: Beginning of genetics**,** early concepts of inheritance	1
2.	Mendel's laws; Discussion on Mendel's paper,	1
3.	Chromosomal theory of inheritance; Multiple alleles,	1
4.	Gene interactions,	1
5.	Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits;	1

6.	**Linkage:** Linkage-detection, estimation Recombination and genetic mapping in eukaryotes	1
7.	Somatic cell genetics, Extra chromosomal inheritance**.**	1
8.	**Population**: Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy- Weinberg equilibrium	2
9.	Nature, structure, and replication of the genetic material	2
10.	**Genetic Material:** Organization of DNA in chromosomes,	1
11.	Genetic code; Protein biosynthesis	2
12.	Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families, and clusters	2
13.	Regulation of gene activity in prokaryotes and eukaryotes;	1
14.	Molecular mechanisms of mutation, repair and suppression;	2
15.	**Plasmid:** Bacterial plasmids, insertion (IS) and transposable (Tn) elements	1
16.	Molecular chaperones and gene expression, RNA editing	2
17.	Gene isolation, synthesis and cloning, genomic and cDNA libraries	2
18.	PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection;	2
19.	DNA sequencing; DNA restriction and modification	2
20.	Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs)	2
21.	Genomics and proteomics; metagenomics	2
22.	**Transgenic:** Transgenic bacteria and bioethics	2
23.	Gene silencing;	1
24.	Genetics of mitochondria and chloroplasts	1
25.	Concepts of Eugenics, Epigenetics, Genetic disorders	2

Practical

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

Suggested reading

- Gardner EJ and Snustad DP. 1991. Principles of Genetics. John Wiley and Sons. 8th ed. 2006
- Russell PJ. 1998. Genetics. The Benzamin/ Cummings Publ. Co
- Singh BD. 2009. Genetics. Kalyani Publishers (2nd Revised Edition)
- Stansfield WD.1991. Genetics.Schaum Outline Series Mc Graw Hill



Course Title: Principles of Plant Breeding*
Course Code: GPB 502
Credit Hours: 3 (2+1)

Theory

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

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

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

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

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

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

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

Practical

Floral biology in self and cross-pollinated species; Selfing and crossing techniques; Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field crops; Prediction of performance of double cross hybrid.

Lecture Schedule Theory

Sr. No.	Topic	No. of Lecture
1	**Plant Breeding**, Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding;	1
2	**Aims, Objective and scope of plant breeding,** Characteristics improved by plant breeding	1
3	**Pattern of evolution in crop plants –** Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity, and its significance.	1
4	**Pre-breeding**-Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.	1
5	**Genetics Basis of Breeding** Genetic basis of breeding: self- and cross-pollinated crops including mating systems and response to selection	1
6	**Nature of variability** – Types and components of variation	1
7	**Heritability-**Types, genetic advance and genotype environment interaction;	1
8	**Combining ability** 1. Types – General combing ability, specific combining ability 2. Utilizations in crop improvement	1
9	Types of gene actions and implications in plant breeding	1
10	**Methods of plant breeding for self- pollinated crops**-Introduction: definition and types, procedure merits, and demerits	1
11	**Incompatibility** – definition, 1. Types incompatibility 2. Commercial exploitation 3. Mechanism, of incompatibility 4. Utilization in crop improvement	2
12	**Male sterility** – 1. Types of Male sterility 2. Commercial exploitation 3. Methods of transfer of male sterility, methods of transfer of restorer genes, 4. Utilization of male sterility in crop improvement achievements, limitations.	2
13	**Breeding Methods**- Selection: 1 Pure line theory (Johanssons) 2 Pure line selection 3 Mass Selection. Types, Procedure, Merits and demerits and achievements	2
14	**Pedigree method**- definition, Pedigree record, maintenance of pedigree record, procedure of pedigree methods, Applications, merits, demerits & achievements.	1
15	**Back cross method**- definition, procedure, Applications, merits, demerits, achievements	1
16	**Single seed descent methods and multiline breeding methods** definition, procedure, Applications, merits, demerits, achievements	1
17	**Population breeding** -Self-pollinated crops, diallel selective mating approach Transgressive breeding.	1
18	**Breeding methods in cross pollinated crops** -definition, procedure, Applications, merits, demerits, achievements	1
19	**Population Breeding**: 1.Mass selection and ear to row method, S1 and S2 progeny testing, progeny selection	1
20	**Population improvement programme –** Recurrent selection, schemes for intra and inter population improvement	1

21	**Synthetic Variety** – definition, steps involved in developments of Synthetic merits, demerits, achievements	1
22	**Composites Variety** – definition, steps involved in developments of composites merits, demerits, achievements	1
23	**Breeding methods in asexually propagated crops,** Clonal selection, apomixis, Apomixis in crop plants and their commercial exploitation, clonal selection - definition, steps involved in developments merits, demerits, achievements	2
24	**Hybrid breeding**: Genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance	2
25	**Plant ideotypes** – Concepts of Plant ideotypes, role in crop improvement, transgressive breeding	1
26	**Special breeding techniques** – Mutation breeding: definition, types, procedure of mutation breeding, application in crop improvement, achievements limitations	1
27	**Special breeding techniques-** Biotic and abiotic stresses	2
28	**Cultivar development** – testing, release and notification, Maintenance breeding	2
29	Plant Breeding, Plant Breeders rights, Regulation for plant variety protection and farmers rights	1

Practical

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

Suggested Readings

- 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.
- George A. 2012. Principles of Plant Genetics and Breeding. John Wiley & Sons.
- Gupta SK. 2005. Practical Plant Breeding. Agribios.
- 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.



Course Title: Fundamentals of Quantitative Genetics*
Course Code: GPB 503
Credit Hours: 3 (2+1)

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 analysisMetroglyph and D2, Generation mean analysis, Parent progeny regression analysis

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

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

Practical

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

Lecture Schedule Theory

Sr. No.	Topic	No. of Lecture
1.	**Introduction Quantitative Genetics:** Introduction and historical background of quantitative genetics	1
2.	**Mendelian traits *vs* polygenic traits:** Nature of quantitative traits and its Inheritance. Genetical foundation of quantitative traits.	1
3.	**Multiple factor hypothesis.:** Analysis of continuous variation. Important features of multiple factor hypothesis	2
4.	**Variations associated with polygenic traits.:** Phenotypic, genotypic & environmental. Non allelic interactions. Nature of gene action - additive, dominance, epistatic and linkage effects.	3

5.	**Principles of Analysis of Variance (ANOVA):** Expected variance components, random and fixed models; MANOVA.	2
6.	**Biplot analysis:** Comparison of means and variances for significance.	2
7.	**Designs for plant breeding experiments:** Principles and applications.	1
8.	**Genetic diversity analysis Association analysis. Path analysis:** Metroglyph, cluster and D^2 analyses phenotypic and genotypic correlations Parent. Progeny regression analysis.	2
9.	**Discriminant function Selection indices:** Principal component analysis selection of parents. Simultaneous selection models.	2
10.	**Concepts of selection:** Heritability and genetic advance.	2
11.	**Generation mean analysis action:** 3, 5, and 6 parameter models, scaling tests.	2
12.	**Mating designs:** Diallel, Partial diallel, line x tester analysis, NCDs and TTC	4
13.	**Combing ability:** Concepts of combining ability and gene action	2
14.	**Analysis of genotype x environment interaction:** Adaptability and stability.	1
15.	**Models for GxE analysis and stability parameters:** Methods & features of stability models.	2
16.	**AMMI analysis:** Principles and interpretation.	1
17.	**QTL mapping:** Strategies for QTL mapping - desired populations for QTL mapping.	2
18.	**Statistical methods in QTL mapping:** QTL mapping in Genetic Analysis. Marker assisted selection (MAS).	3
19.	**Approaches to apply MAS in Plant breeding:** Selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.	2

Practical Schedule:

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

Suggested Reading

- Bos I and Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall.
- Singh, P., Narayanan, S.S. Biometrical Techniques in Plant Breeding. Kalyani Publication

Course Title: Molecular Breeding and Bioinformatics*
Course Code: GPB 506
Credit Hours: 3 (2+1)

Theory

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

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

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

Unit IV: Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer; Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc. and commercial releases; Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary and secondary), implications in crop improvement.

Practical

Requirements for plant tissue culture laboratory; Techniques in plant tissue culture; Media components and media preparation; Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations; Inoculation of explants, callus induction and plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures; Visit to commercial micropropagation unit; Transformation using Agrobacterium strains; GUS assay in transformed cells/ tissues; DNA isolation, DNA purity and quantification tests; Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship; Construction of genetic linkage maps using computer software; NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene Prediction Tool,

Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder; Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl); Primer designing- Primer 3/ Primer BLAST.

Lecture Schedule Theory

Sr. No.	Topic	No. of Lecture
1	Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, etc.), Functional markers.	3
2	Mapping populations (F2s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits.	2
3	Statistical tools in marker analysis.	1
4	Allele mining.	1
5	Marker-assisted selection for qualitative and quantitative traits.	2
6	QTLs analysis in crop plants.	1
7	Marker-assisted backcross breeding for rapid introgression.	1
8	Genomics- assisted breeding; Generation of EDVs; Gene pyramiding.	2
9	Introduction to Comparative Genomics	1
10	Large scale genome sequencing strategies.	1
11	Genome projects: Human genome project; Arabidopsis genome project; Rice genome project.	2
12	Comparative genomics tools.	1
13	Introduction to proteomics.	1
14	2D gel electrophoresis; chromatography and sequencing by Edman degradation and mass spectrometry; Endopeptidases.	2
15	Nanotechnology and its applications in crop improvement.	1
16	Recombinant DNA technology, transgenes, method of transformation. selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer.	2
17	Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc. and commercial releases.	2
18	Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding.	2
19	MOs and related issues (risk and regulations);	1
20	GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues.	2
21	Intellectual property rights.	2
22	Introduction to bioinformatics.	1
23	Bioinformatics tools.	2
24	Biological data bases (primary and secondary), implications in crop improvement.	2

Practical

Sr. No.	Practical
1	Requirements for plant tissue culture laboratory;
2	Techniques in plant tissue culture;
3	Media components and media preparation
4	Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations
5	Inoculation of explants, callus induction, and plant regeneration;
6	Standardizing the protocols for regeneration;
7	Hardening of regenerated plants; Establishing a greenhouse and hardening procedures

8	Visit to commercial micropropagation unit
9	Transformation using Agrobacterium strains GUS; assay in transformed cells/ tissues
10	DNA isolation, DNA purity and quantification tests;
11	Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship
12	Construction of genetic linkage maps using computer software
13	NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p,
14	Gene Prediction Tool, Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder;
15	Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl);
16	Primer designing- Primer 3/ Primer BLAST

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.
- Sambrook J and Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
- Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani Publishers, New Delhi.
- Watson J. 2006. Recombinant DNA. Cold Spring harbor laboratory press.

Course Title: Hybrid Breeding
Course Code: GPB 509
Credit Hours: 3 (2+1)

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

Unit II: Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in 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.

Unit V: Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed mustard, sunflower, safflower, and castor oilseed crops and pigeon pea.

Practical

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

Lecture Schedule Theory

Sr. No.	Topic	No. of Lecture
1	**History of heterosis** – Nomenclature, definitions of heterosis, Heterosis in natural population & inbred population.	**1**
2	**Genetic consequences** - Selfing in self-pollinated crops, cross pollinated crops & asexually propagated crops.	**2**
3	Pre Mendelian & post Mendelian ideas.	**2**
4	**Heterosis concept;** Genetic Basis: 1. Dominance Hypothesis 2. Over dominance Hypothesis 3. Epistasis	**1**
5	**Physiological basis of heterosis.** 1. Embryo development & heterosis 2. Early Seedling growth & heterosis. 3. Later growth & heterosis 4. Mitochondrial complementation.	**2**
6	**Biochemical & molecular basis of heterosis.**	**1**
7	**Estimation of heterosis** 1. Average heterosis 2. Heterobeltiosis 3. Standard heterosis Biometrical basis of heterosis	**1**
8	Evolutionary concepts of heterosis & Prediction of heterosis from various crosses.	**1**
9	Inbreeding depression, Definition, Frequency of inbreeding, Genetic basis of inbreeding depression, Degrees of inbreeding depression.	**1**
10	Effects of inbreeding: 1. Genetic effect 2. Morphological effect.	**2**
11	Estimation of inbreeding depression. 1. High 2. Moderate 3. Low 4. No inbreeding depression Importance of inbreeding in exploitation of heterosis	**1**
12	Relationship between genetic distance & expression of divergence & Genetic distance analysis.	**1**
13	Morphological & molecular genetic distance in predicting heterosis.	**1**
14	Development of heterosis pools in germplasm/ genetic stocks & in breeds, Improvement of increase heterosis.	**1**
15	Male sterility: Definition, Feature of Male sterility, Types of male sterility 1. Genetic Male sterility 2. Cytoplasmic Male sterility 3. Cytoplasmic genetic Male sterility 4. Chemical induced Male sterility 5. Transgenic Male sterility	**2**
16	Use of Male sterility: In heterosis breeding maintenance, transfer & restoration of different types of Male sterility	**1**
17	Self-incompatibility: Definition Types; 1. Heteromorphic system 2. Homomorphic system a) Gametophytic	**2**

	b) Sporophytic use of self in compatibility in development of hybrids.	
18	Hybrid seed production system - 3-line, 2 line & 1 line system.	**1**
19	Development of inbred lines: 1. Conventional method / Selfing of heterozygous. 2. Non-Conventional method: Use of monoploids.	**2**
20	Evaluation of inbred lines: 1. Top cross methods (Conventional method) General combining ability 2. Single cross method.	**1**
21	Maintenance of A, B & R lines Commercial exploitation of heterosis.	**1**
22	Fixation of heterosis in self, cross & asexually propagated crops. 1. Asexually reproduction. 2. Apomixis 3. Balanced lethal system. 4. Polyploidy.	**1**
23	Development of male sterile line - Transfer of male sterile line, problems & prospects	**2**
24	Organceller heterosis & Complementation.	**1**
25	Creation of male sterility through genetic engineering & its exploitation in heterosis.	**1**
26	Heterosis breeding in wheat, rice, maize, cotton, pearl millet, sorghum & oil seed crops. (rapeseed- mustard, sunflower, safflower and castor oilseed crops) and pigeon pea.	**3**

Practical

Sr. No.	Practical
1.	Calculation of selection indices and selection differential.
2.	Characterization of male sterile line in millets using morphological descriptors
3.	Identification of restorer lines & diversification of male sterile source.
4.	Creation of male sterile, its diversification & identification of restorer lines in forage crops.
5.	Development of male sterile in oilseeds pulses & cotton.
6.	Problems of Apomicts breeding.
7.	Estimation of heterotic parameters in self-pollinated crops
8.	Estimation of heterotic parameters in cross pollinated crops
9.	Estimation of heterotic parameters in asexually propagated crops
10.	Estimation of heterosis: Estimation from the various models for heterosis parameters
11	Hybrid seed production in field crops-an account on the released hybrids, their potential, problems and ways of overcoming it
12.	Current status & future trends of hybrid of different crops. Hybrid breeding at National and International level, opportunities ahead.

Suggested Reading

- Agarwal RL. 1998. Fundamental of Plant Breeding and hybrid Seed Production. Science Publisher London.
- Akin E. 1979. The Geometry of Population Genetics. Springer-Verlag.
- Chal GS and Gossal SS. 2002. Principles and procedures of Plant Breeding, Biotechnology and Convetional Approaches. Narosa Publishing House. New Delhi
- Hartl DL. 2000. A Primer of Population Genetics. 3rd Ed. Sinauer Assoc.
- Mettler LE and Gregg TG. 1969. Population Genetics and Evolution. Prentice-Hall. 25 April 1988
- Montgomery DC. 2001. Design and Analysis of Experiments. 5th Ed., Wiley & Sons. 2013
- Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin. 30 May 1997
- Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.
- Srivastava S and Tyagi R. 1997. Selected Problems in Genetics. Vols. I, II. Anmol Publ.

Course Title: Crop Breeding I (*Kharif* Crops)
Course Code: GPB 511
Credit Hours: 3 (2+1)

Theory

Unit I: Rice: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding. **Maize:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement- QPM and Bt maize – strategies and implications. **Small millets:** Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance, etc.

Unit II: **Pigeon pea:** evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes. **Groundnut:** Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement. **Other pulses: Urdbean, mungbean, cowpea:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

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

etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement; Hybrid breeding in castor – opportunities, constraints, and achievements.

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

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

Practical

Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton; Study of range of variation for yield and yield components; Study of segregating populations in cereal, pulses and oilseed crops; Learning on the crosses between different species; attempting crosses between black gram and green gram; Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton; Visit to Cotton Technology Laboratory and Spinning Mills; Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval; Practical learning on the cultivation of fodder crop species on sewage water, analysing them for yield components and palatability; Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes; Visit to animal feed producing factories; Learning the practice of value addition; Visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

Lecture Schedule Theory

Sr. No.	Topic	No. of Lecture
1	**Rice**: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, its implications, and drought resistance breeding.	3
2	**Maize:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement-QPM and Bt maize – strategies and implications	3
3	**Sorghum:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, Examples of MAS used for improvement-biofortified varieties – strategies and implications	2
4	**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	2
5	**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.	2
6	**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.	2
7	**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.	4
8	**Soybean:** Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement	2

9	**Castor and Sesame:** Origin, evolution mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement; Hybrid breeding in castor – opportunities, constraints, and achievements	2
10	**Cotton:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines – Hybrid development and seed production, Scenario of Bt cottons, evaluation procedures for Bt cotton.	4
11	**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.	2
12	**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.	2
13	**Forage crops:** Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, and palatability studies; Biotic and abiotic stress resistance, etc.	2
14	**Seed spices:** Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement Achievements of important spice crops.	4

Practical

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

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

Suggested Reading

- Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
- Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. Oxford & IBH.
- 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.
- Jennings PR, Coffman WR and Kauffman HE. 1979. Rice Improvement. IRRI, Los Banos, Manila, Philippines.
- Murty DS, Tabo R and Ajayi O. 1994. Sorghum Hybrid Seed Production and Management. ICRISAT, Patancheru, India. Nanda
- JS. 1997. Manual on Rice Breeding. Kalyani Publishers.
- Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of Horticultural Crops Vol.1 (Part-B), Today and Tomorrow Printers and Publishers
- Poehlman, JM. 1987. Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connecticut, USA.
- Ram HH and Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
- Sharma, AK. 2005. Breeding Technology of Crop Plant. Yesh Publishing House, Bikaner
- Slafer GA. (Ed.). 1994. Genetic Improvement of Field Crops.
- Marcel Dekker. Singh HG, Mishra SN, Singh TB, Ram HH and Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
- Walden DB. 1978. Maize Breeding and Genetics. John Wiley & Sons.

Course Title: Crop Breeding II (Rabi Crops)
Course Code: GPB 512
Credit Hours: 3 (2+1)

Theory

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

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

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

Unit IV: **Mesta and minor fibre crops:** Origin, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic

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

Practical

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

Lecture Schedule Theory

Sr. No.	Topic	No. of Lecture
1	**Wheat:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement	4
2	**Oats:** Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.	3
3	**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.	3
4	**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	3

5	**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.	4
6	**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.	4
7	**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	3
8	**Mesta and minor fiber crops:** Origin, mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement	4
9	**Forage crops:** Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance	4
10	**Seed spices:** Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement Achievements of important spice crops.	4

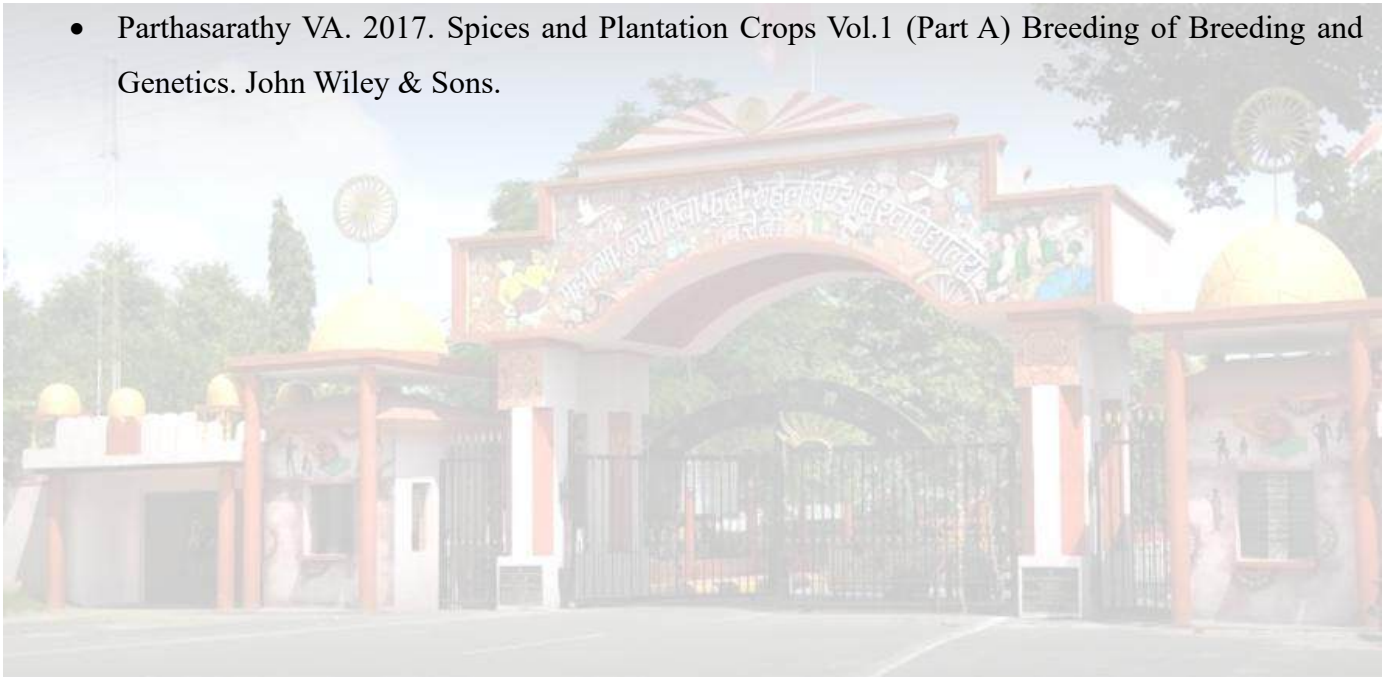
Practical

Sr. No.	Practical
1	Floral biology, emasculation, pollination techniques in wheat, oats, barley
2	Floral biology, emasculation, pollination techniques in oats
3	Floral biology, emasculation, pollination techniques in barley
4	Floral biology, emasculation, pollination techniques in Chick Pea and Rajma
5	Floral biology, emasculation, pollination techniques in rapeseed mustard
6	Floral biology, emasculation, pollination techniques in sunflower and safflower
7	Study of range of variation for yield and yield components
8	Study of segregating populations in cereal, pulses and oilseed crops;
9	Use of descriptors for cataloguing; Learning on the crosses between different species

10	Trait based screening for stress resistance
11	Learning on the Standard Evaluation System (SES) and descriptors
12	Use of software for database management and retrieval

Suggested Reading

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



Course Title: Principles of Biotechnology
Course Code: BI 511
Credit Hours: 3 (3+0)

Theory

Unit I: History, scope, and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology etc. Basics of Biotechnology, Primary metabolic pathways, Enzymes, and its activities.

Unit II: Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.

Unit III: Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc, and their applications; DNA sequencing, different methods; Plant cell and tissue culture techniques and their applications. Introduction to genomics, transcriptomics, ionomics, metabolomics, and proteomics. Plant cell and tissue culture techniques and their applications.

Unit IV: Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions, Success stories in Biotechnology, Careers, and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Lecture Schedule Theory

S. No.	Name of Topic	No. of Lectures
1	History and scope of biotechnology	2
2	Specializations in agricultural biotechnology	2
3	Primary metabolic pathways	2
4	Enzymes and enzymatic activities	2
5	Structure of DNA, RNA and proteins	2
6	Physical and chemical properties of nucleic acids	2
7	DNA function: expression and exchange	2
8	Mutation mechanisms and effects	2
9	DNA modifying enzymes	2
10	Expression of genetic material	2
11	Gene transfer methods	2
12	Genetic vectors and systems	2
13	Methods of recombinant DNA technology	2
14	Nucleic acid hybridization techniques	2
15	DNA and RNA libraries construction	2
16	Gene cloning and applications	2
17	Plant transformation techniques	2
18	Applications of GM crops	2
19	PCR and its applications	2

20	Molecular markers: RFLP, RAPD, SSR, SNP	2
21	DNA sequencing methods	2
22	Plant cell and tissue culture	2
23	Genomics and transcriptomics overview	2
24	Proteomics and metabolomics introduction	2
25	Genome editing and gene silencing	2
26	Success stories and Careers in biotechnology	3

Suggested Reading

- Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R. 2014. Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York
- Brown T A. 2010. Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell
- Primrose SB and Twyman R. 2006. Principles of gene Manipulation 7th edition, Wiley Blackwell
- Singh BD. 2012. Biotechnology: Expanding Horizons 4th edition, Kalyani publisher, New Delhi, India



Course Title: Fundamentals of Molecular Biology
Course Code: BI 512
Credit Hours: 3 (3+0)

Theory

Unit I: Historical developments of molecular biology, Nucleic acids as genetic material, Chemistry and Nomenclature of nucleic acids; Structure of DNA: primary structure; secondary structure, Forms of DNA: A, B, Z and their function; Structure and Types of RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA reassociation kinetics, Types of repeat sequences.

Unit II: Central dogma of Molecular Biology; DNA replication- Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication - initiation, elongation, and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in brief. Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, Genetic consequences.

Unit III: Prokaryotic transcription, initiation, elongation and termination, promoters, Structure, and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription – RNA polymerase I, II and III, Elongation and Termination, Eukaryotic promoters and enhancers, Transcription factors, Post transcriptional processing, Splicing: Catalytic RNAs, RNA stability and transport, RNA editing.

Unit IV: Genetic code and its characteristics, Universal and modified genetic code and its characteristics, Wobble hypothesis; Translational machinery; Ribosomes in prokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation: translocation, transpeptidation and termination of translation; Co- and Post-translational modifications of proteins; Translational control; Protein stability -Protein turnover and degradation.

Unit V: Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: lac and trp operons, attenuation, anti-termination, stringent control. Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, Silencers, insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: turn-helix, helix-loop-helix etc. Epigenetic regulations.

Lecture Schedule Theory

S. No.	Name of Topic	No. of Lectures
1	Historical development of molecular biology	2
2	Nucleic acids as genetic material	2
3	Chemistry and nomenclature of nucleic acids	2
4	DNA primary structure	2
5	DNA secondary structure	2
6	Forms of DNA: A, B, Z forms	2
7	DNA topology and properties	2
8	Structure and types of RNA	2
9	Genome organization in prokaryotes	2

10	Genome organization in eukaryotes	2
11	DNA reassociation kinetics	2
12	Types of repeat sequences	2
13	Chromatin structure and nucleosomes	2
14	DNA replication: mechanisms	2
15	DNA replication: regulation	2
16	Transcription in prokaryotes	2
17	Transcription in eukaryotes	2
18	Translation: genetic code and tRNA	2
19	Translation: ribosomal function	2
20	Gene expression regulation	2
21	Mutations and DNA repair	2
22	Recombination mechanisms	2
23	Epigenetics and gene regulation	2
24	Signal transduction pathways	2
25	Cell cycle and apoptosis	2
26	Development and differentiation	2
27	Molecular aspects of immunity	1

Suggested Reading

- Nelson DL and CoX M.M. 2017. Lehinger's Principles of Biochemistry, 7th edition, W H Freeman Publication New York.
- Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. 2017. Lewin's Genes XII 12th edition, Jones & Bartlett Learning publisher, Inc.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M and Losick R. 2014. Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York.
- Alberts, B. 2017. Molecular Biology of the Cell 5th edition, WW Norton & Co, Inc.

Course Title: Genomics and Proteomics
Course Code: BI 514
Credit Hours: 2 (2+0)

Theory

UNIT-I: Genomics: Whole genome analysis and comparative genomics, classical ways of genome analysis, large fragment genomic libraries; Physical mapping of genomes; Genome sequencing, sequence assembly, and annotation.

UNIT-II: Functional genomics: Candidate gene identification, DNA chips, Mutants and RNAi, Metabolomics for elucidating metabolic pathways, etc.

UNIT-III: Proteomics - Introduction to basic proteomics technology, Bio-informatics in Proteomics, Gene to Protein Function: a Roundtrip, Proteome analysis.

UNIT-IV: Linkage analysis, genotyping analysis, pharmacogenomics, human/plant genome, and science after genomic era; Applications of genomics and proteomics in agriculture, human health, and industry.

Lecture Schedule Theory

S. No.	Name of Topic	No. of Lectures
1	Genomics: definition and scope	2
2	Genome sequencing technologies	2
3	Sequence assembly and annotation	2
4	Comparative genomics	2
5	Genome evolution and variation	2
6	Functional genomics approaches	2
7	Expression profiling technologies	2
8	Systems genomics and integration	2
9	Personalized genomics	1
10	Proteomics: definition and techniques	2
11	Protein mass spectrometry	2
12	Two-dimensional gel electrophoresis	2
13	Protein quantification methods	2
14	Post-translational modifications	2
15	Protein-protein interactions	2
16	Structural proteomics	2
17	Functional proteomics	2

Suggested Reading

- Thangadurai, D. 2015. Genomics and Proteomics: Principles, technologies and applications, 5th edition, Taylor, and Francis.
- Krebs, J.E. 2017. Lewine's Genes XII, Jones, and Bartlett P.
- Brown, T. A. 2007. Genome III. Garland Science P.
- Campbell, A. M. and Heyer, L. 2004. Discovery Genomics, Proteomics & Bioinformatics. Pearson Education.

Course Title: Principles of Vegetable Breeding
Course Code: HORT 506
Credit Hours: 3 (2+1)

Theory

Unit I: Importance and history- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.

Unit II: Selection procedures- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests, and nematode), abiotic stress (temperature, moisture, and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).

Unit III: Heterosis breeding- Types, mechanisms, and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility, and sex forms.

Unit IV: Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.

Unit V: Ideotype breeding- Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of In-vitro and molecular techniques in vegetable improvement.

Practical

Floral biology and pollination behaviour of different vegetables; Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.; Breeding system and handling of filial generations of different vegetables; Exposure to biotechnological lab practices; Visit to breeding farms.

Lecture Schedule Theory

Sr. No.	Name of Topic	No. of Lectures
1	Introduction to vegetable breeding—scope & significance; Historical development of vegetable breeding	1
2	Evolutionary aspects of vegetable crops; Vegetable vs. cereal crop breeding; Achievements & future prospects in vegetable breeding	1
3	Techniques of selfing & crossing-principles; Selfing: methods, precautions, applications; Controlled crossing techniques	1
4	Breeding systems in vegetables	1
5	Mass, progeny & pure-line selection	1
6	Hybridization: objectives, steps, types	2
7	Genetic architecture of vegetable crops	1
8	Breeding for biotic stress diseases resistance insect-pest & nematode resistance	4
9	Breeding for abiotic stress—temperature tolerance moisture & salt tolerance	2
10	Breeding for quality improvement	1
11	Breeding for water-use efficiency (WUE)	1
12	Breeding for nutrient-use efficiency (NUE)	1
13	Concept, types & genetic basis of heterosis; Mechanisms underlying heterosis	2
14	Hybrid breeding in vegetables	1

15	Role of male sterility systems	2
16	Self-incompatibility in hybrid seed production	2
17	Sex forms and their role in heterosis breeding	1
18	Mutation breeding—concept, mutagens, procedures, Applications of mutation breeding in vegetables	2
19	Polyploidy—types & induction, Role of polyploidy in vegetable improvement	1
20	Breeding asexually propagated vegetables for protected cultivation	2
21	Ideotype breeding—concept & principles	1
22	Designing ideotypes for vegetable crops	1
23	Varietal release procedures	1
24	DUS testing in vegetables	1
25	In-vitro techniques in vegetable improvement	1
26	Molecular techniques in vegetable breeding	1

Practical Schedule

Sr. No.	Name of Topic	No. of Lectures
1	Floral biology & pollination behavior of different vegetables	1
2	Techniques of selfing and crossing in Cole crops	2
3	Techniques of selfing and crossing in okra	1
4	Techniques of selfing and crossing in cucurbits	1
5	Techniques of selfing and crossing in tomato	1
6	Techniques of selfing and crossing in eggplant	1
7	Techniques of selfing and crossing in hot pepper	1
8	Breeding systems in vegetables	1
9	Handling of filial generations	1
10	Exposure to biotechnological lab practices	1
11	Visit to breeding farms	1

Suggested Reading

- Allard RW. 1960. Principle of plant breeding. John Willey and Sons, USA.
- Kalloo G. 1988. Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA.
- Kole CR. 2007. Genome mapping and molecular breeding in plants-vegetables. Springer, USA.
- Peter KV and Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p. 488.
- Prohens J and Nuez F. 2007. Handbook of plant breeding-vegetables (Vol I and II). Springer, USA.
- Singh BD. 2007. Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi.
- Singh Ram J. 2007. Genetic resources, chromosome engineering, and crop improvement-vegetable crops (Vol. 3). CRC Press, Fl, USA.

Course Title: Experimental Designs
Course Code: AST 501
Credit Hours: 3 (2+1)

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.

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.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lectures
1	Need for designing experiments – introduction, Importance of proper experimental design, Characteristics of a good design	2
2	Basic principles of designs- Randomization, Replication and Local control	1
3	Uniformity trials – purpose & procedure Size and shape of plots and blocks	1
4	ANOVA- Analysis of variance	2
5	CRD –Completely randomized design,	2
6	RBD – Randomized block design	2
7	LSD – Latin square design	2
8	Factorial experiments (Symmetrical factorials and Asymmetrical factorials)	2
9	Orthogonality – concept & importance	1
10	Partitioning degrees of freedom	1
11	Concept of confounding	2
12	Split-plot design	1
13	Strip-plot design	1
14	ANCOVA – Analysis of covariance	2
15	Missing plot techniques in RBD	2
16	Missing plot techniques in LSD	2
17	Transformations	2
18	Balanced Incomplete Block Design	1
19	Resolvable designs and their applications	1

20	Lattice designs & Alpha design - concepts, randomization procedure, analysis and interpretation of results	4
21	Response surface methodology	1
22	Combined analysis	1

Practical Schedule

S. No.	Name of Exercise	No. of Lectures
1	Uniformity trial data analysis,	2
2	Formation of plots and blocks,	2
3	Fairfield Smith's Law	2
4	Analysis of data obtained from Completely Randomized Design (CRD)	2
5	Analysis of data obtained from Randomized Block Design (RBD)	2
6	Analysis of data obtained from Latin Square Design (LSD)	2
7	Analysis of factorial experiments	2
8	Analysis with missing data	2
9	Split plot and strip plot designs	2

Suggested Reading

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

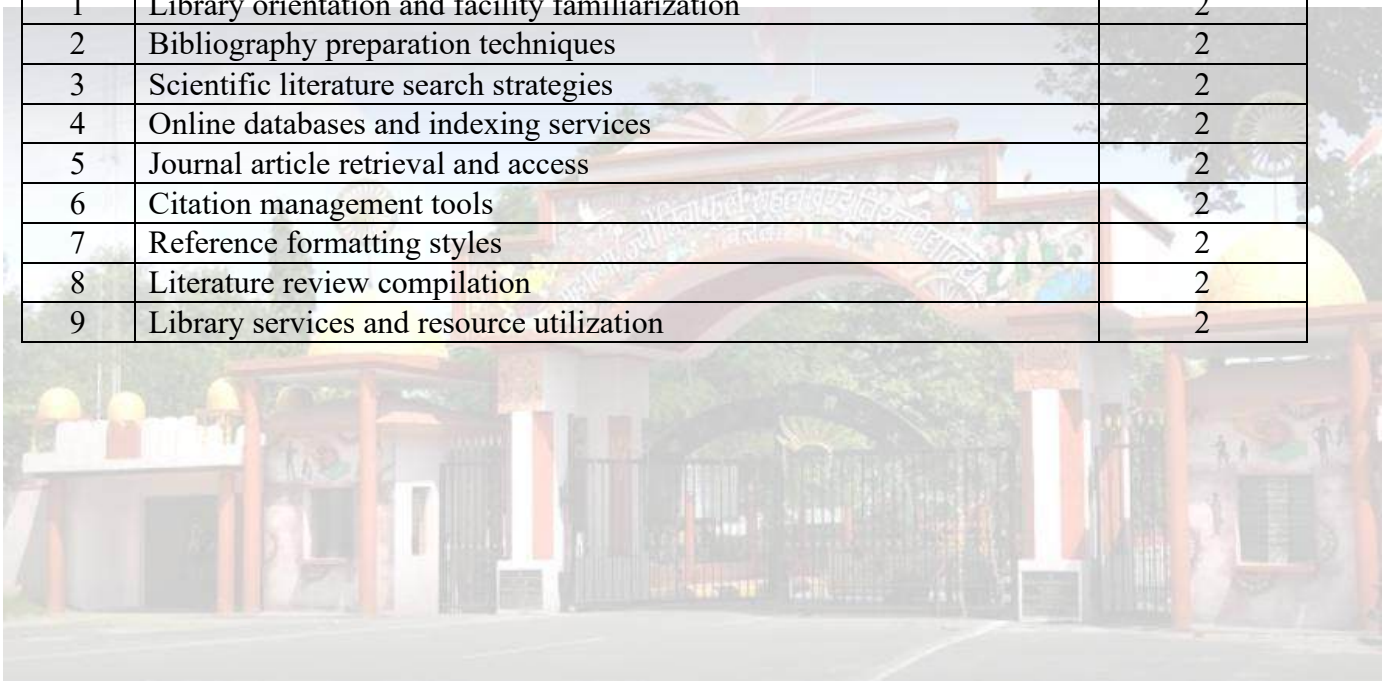
Course Title: Library and Information Services
Course Code: PGS 501
Credit Hours: 1 (0+1)

Practical

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

Practical Schedule

S. No.	Name of Topic	No. of Practical
1	Library orientation and facility familiarization	2
2	Bibliography preparation techniques	2
3	Scientific literature search strategies	2
4	Online databases and indexing services	2
5	Journal article retrieval and access	2
6	Citation management tools	2
7	Reference formatting styles	2
8	Literature review compilation	2
9	Library services and resource utilization	2



Course Title: Technical Writing and Communication Skills
Course Code: PGS 502
Credit Hours: 1 (0+1)

Practical (Technical Writing)

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

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	Covers the meaning, purpose and importance of scientific writing, including theses, dissertations, technical papers, manuals, reports, and review articles. Introduces how each form serves a different scientific objective.	1
2.	Explains research notes, short communications, popular articles, bulletins, monographs, and extension leaflets, describing when and why each is written in the scientific community.	1
3.	Discusses the title page, authorship details, certification, declaration, acknowledgments, contents page, and formatting standards used in thesis writing.	1
4.	Explains major thesis components such as the introduction, review of literature, materials and methods, results, discussion, summary, references, and appendices.	1
5.	Covers the format of research papers including the title, abstract, keywords, introduction, methodology, results, discussion, conclusion, references, and author contributions.	1
6.	Explains how to write effective abstracts, concise summaries, and well-structured précis, including length, style, purpose, and evaluation criteria.	1
7.	Covers citation styles (APA, MLA, Chicago, JRF, ICAR), in-text citations, reference lists, footnotes, and commonly used abbreviations in theses and research articles.	1
8.	Explains how to use photographs, graphs, charts, maps, and scientific drawings with appropriate captions, legends, resolutions, and placement guidelines.	1
9.	Describes rules for table numbering, figure numbering, page numbering (Roman & Arabic), table titles, footnotes, and alignment in scientific documents.	1
10.	Covers rules for writing numeric data, units (SI units), measurements, formulas, equations, and scientific dates following international writing standards.	1
11.	Teaches proofreading marks, identifying typographical, grammatical, logical, and formatting errors, and using checklists for editing scientific content.	1
12.	Explains how to choose a topic, search literature, structure sections, synthesize findings, compare studies, and write high-quality review papers.	1
13.	Covers basic grammar essentials including tense forms, verb agreement, noun forms, pronouns, adverbs, clauses, and correct sentence structure.	1

14.	Explains punctuation marks, subject–verb agreement (concord), commonly misused word combinations (collocations), and how they affect scientific writing.	1
15.	Focuses on spelling errors, redundancy, run-on sentences, misplaced modifiers, incorrect prepositions, and other frequently occurring writing problems.	1
16.	Introduces phonetic symbols (IPA), stress patterns, weak forms in connected speech, and pronunciation techniques important for oral scientific communication.	1
17.	Covers participation techniques for group discussions, confidence building, questioning strategies, and handling academic or job interviews effectively.	1
18.	Explains preparing PPTs, slide design, sequence of presentation, verbal and non-verbal communication, answering audience questions, and professional presentation ethics.	1

Suggested Readings

- Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
- Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
- Collins' Cobuild English Dictionary. 1995.
- Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.
- Holt, Rinehart, and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
- James HS. 1994. Handbook for Technical Writing. NTC Business Books.
- Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
- Mohan K. 2005. Speaking English Effectively. MacMillan India.
- Richard WS. 1969. Technical Writing.
- Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
- Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

Course Title: Intellectual Property and Its Management in Agriculture
Course Code: PGS 503
Credit Hours: 1 (1+0)

Theory

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

Theory Schedule

S. No.	Name of Topic	No. of Lectures
1	Intellectual property concepts and definitions	2
2	Patents: types and filing procedures	2
3	Plant varieties protection	2
4	Trade secrets and confidential information	1
5	Copyright and trademark in agriculture	2
6	Licensing and technology transfer	2
7	IPR in biotechnology and agriculture	2
8	Management of research outputs	2
9	Agricultural policies and regulations	1

Suggested Readings

- Erbisch, F. H. and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli, P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
- Rothschild, M. and Scott, N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- Saha, R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

Course Title: Basic Concepts in Laboratory Techniques
Course Code: PGS 504
Credit Hours: 1 (0+1)

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, sand bath, water bath, oil bath; 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.

Practical Schedule

S. No.	Name of Topic	No. of Practical
1	Laboratory safety and hazard management	2
2	Personal protective equipment (PPE)	2
3	Laboratory equipment identification and use	2
4	Measurement and precision techniques	2
5	Weighing and volumetric glassware	2
6	Solution preparation and standardization	2
7	Basic chemistry and biochemistry techniques	2
8	Microscopy and observation techniques	2
9	Laboratory record keeping and documentation	2

Suggested Readings

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

Course Title: Agriculture Research, Research Ethics and Rural Development Program
Course Code: PGS 505
Credit Hours: 1 (1+0)

Theory

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

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

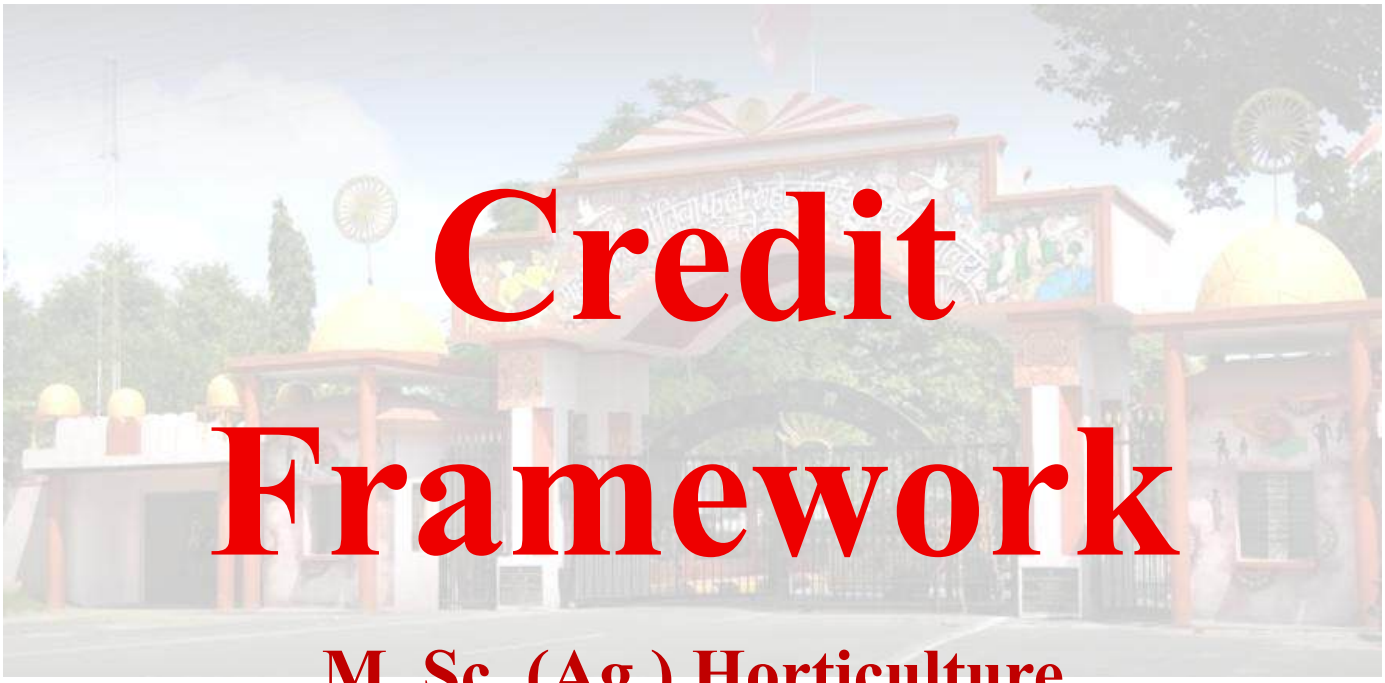
UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati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

Theory Schedule

S. No.	Name of Topic	No. of Lectures
1	Research ethics principles and guidelines	2
2	Informed consent and research participant rights	2
3	Research misconduct and plagiarism	2
4	Ethical issues in genetic research	2
5	Institutional Review Board (IRB) procedures	1
6	Data management and confidentiality	2
7	Rural development and agriculture	2
8	Sustainable agriculture practices	2
9	Community engagement and extension services	1

Suggested Readings

- Bhalla, G.S. and Singh, G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
- Punia, M.S. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.
- Rao, B.S.V. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations, and Initiatives. Mittal Publ.
- Singh, K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.



Credit Framework

M. Sc. (Ag.) Horticulture

MAHATMA JYOTIBA PHULE ROHILKHAND UNIVERSITY, BAREILLY

FACULTY OF AGRICULTURE SCIENCE & TECHNOLOGY

Department of Horticulture

COURSE WORK

Major Courses

Course Code	Course Title	Credit Hours
HORT 501	Tropical Fruit Production	3 (2+1)
HORT 502	Sub-Tropical and Temperate Fruit Production	3 (2+1)
HORT 503	Propagation and Nursery Management in Fruit Crops	3 (2+1)
HORT 504	Production of Cool Season Vegetable Crops	3 (2+1)
HORT 505	Production of Warm Season Vegetable Crops	3 (2+1)
HORT 506	Principles of Vegetable Breeding	3 (2+1)
HORT 507	Ornamental Gardening and Landscaping	3 (2+1)

Total Credit = 21

Minor Courses

Course Code	Course Title	Credit Hours
AGRON 501	Modern Concepts in Crop Production	3 (3+0)
AGRON 502	Principal and Practices of Soil Fertility and Nutrient Management	3 (2+1)
AGRON 503	Principles and Practices of Weed Management	3(2+1)

Total Credit = 09

Supporting Courses

Course Code	Course Title	Credit Hours
AST 501	Experimental Design	3 (2+1)
SOIL 502	Soil Fertility and Fertilizer Use	3 (2+1)

Total Credit = 06

Common Compulsory Courses

Course Code	Course Title	Credit Hours
PGS 501	Library and Information Services	1 (0+1)
PGS 502	Technical Writing and Communication Skills	1 (0+1)
PGS 503	Intellectual Property and Its Management in Agriculture	1 (1+0)
PGS 504	Basic Concepts in Laboratory Techniques	1(0+1)
PGS 505	Agriculture Research, Research Ethics and Rural Development Program	1(1+0)

Total Credit = 05

Seminar/Thesis/Research

Course Code	Course Title	Credit Hours
HORT 591	Master Seminar	01
HORT 599	Master Research	30

MAHATMA JYOTIBA PHULE ROHILKHAND UNIVERSITY, BAREILLY

FACULTY OF AGRICULTURE SCIENCE & TECHNOLOGY

Department of Horticulture

SEMESTER WISE DISTRIBUTION OF COURSES WITH CREDIT HOURS

First Semester

Course Code	Course Title	Credit Hours
HORT 501	Tropical Fruit Production	3 (2+1)
HORT 504	Production of Cool Season Vegetable Crops	3 (2+1)
HORT 506	Principles of Vegetable Breeding	3 (3+0)
AGRON 501	Modern Concepts in Crop Production	3 (3+0)
SOIL 502	Soil Fertility and Fertilizer Use	3 (2+1)
PGS 501	Library and Information Services	1 (0+1)
PGS 502	Technical Writing and Communication Skills	1 (0+1)
PGS 503	Intellectual Property and Its Management in Agriculture	1 (1+0)

Second Semester

Course Code	Course Title	Credit Hours
HORT 502	Sub-Tropical and Temperate Fruit Production	3 (2+1)
HORT 505	Production of Warm Season Vegetable Crops	3 (2+1)
HORT 503	Propagation and Nursery Management in Fruit Crops	3 (2+1)
HORT 507	Ornamental Gardening and Landscaping	3 (2+1)
HORT 591	Master Seminar	01
AST 501	Experimental Design	3 (2+1)
PGS 504	Basic Concepts in Laboratory Techniques	1(0+1)
PGS 505	Agriculture Research, Research Ethics and Rural Development Program	1(1+0)

Third Semester

Course Code	Course Title	Credit Hours
AGRON 503	Principles and Practices of Weed Management	3 (2+1)
HORT 599	Master Research	15

Fourth Semester

Course code	Course Title	Credit Hours
AGRON 502	Principal and Practices of Soil Fertility and Nutrient Management	3 (2+1)
HORT 599	Master Research	15



Syllabus

M. Sc. (Ag.) Horticulture

Course Title: Tropical Fruit Production*
Course Code: HORT 501
Credit Hours: 3 (2+1)

Theory

Unit I: Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements.

Unit II: Propagation, Planting and Orchard Floor Management: Asexual and sexual methods of propagation, planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Unit III: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders – causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management. Crops- Mango, Banana, Guava, Pineapple, Papaya, Avocado, Jackfruit, Annonas, Aonla, Ber, etc.

Practical

Distinguished features of tropical fruit species, cultivars and rootstocks. Demonstration of planting systems, training and pruning. Hands on practices on pollination and crop regulation. Leaf sampling and nutrient analysis. Physiological disorders-malady diagnosis. Physico-chemical analysis of fruit quality attributes. Field/ Exposure visits to tropical orchards. Project preparation for establishing commercial orchards.

Theory Lecture Schedule:

S. No.	Name of Topic	No. of lecture
1.	Importance, origin and distribution	1
2.	Major species, rootstocks and commercial varieties of regional, national and international importance	1
3.	Eco-physiological requirements	1
4.	Asexual and sexual methods of propagation	1
5.	Planting systems and planting densities	1
6.	Training and pruning methods, rejuvenation, intercropping	1
7.	Nutrient management	1
8.	Water management and fertigation.	1
9.	Use of bio-fertilizers	1
10.	Role of bio-regulators	1
11.	Abiotic factors limiting fruit production.	1
12.	Physiology of flowering, pollination management.	1

13.	Fruit set and development.	1
14.	Physiological disorders – causes and remedies, crop regulation, quality improvement by management practices.	2
15.	Maturity indices, harvesting, grading, packing, storage and ripening techniques.	1
16.	Insect and disease management.	2
17.	Production Technology of tropical fruit crops- Mango, Banana, Guava, Pineapple, Papaya, Avocado, Jackfruit, Annonas, Aonla, Ber, etc.	10

Practical Schedule:

S. No.	Name of Topic	No. of practical
1.	Distinguished features of tropical fruit species, cultivars and rootstocks.	1
2.	Demonstration of planting systems, training and pruning.	1
3.	Hands on practices on pollination and crop regulation.	1
4.	Leaf sampling and nutrient analysis.	1
5.	Physiological disorders-malady diagnosis.	1
6.	Physico-chemical analysis of fruit quality attributes.	1
7.	Field/ Exposure visits to tropical orchards.	1
8.	Project preparation for establishing commercial orchards.	1

Suggested Reading

- Bartholomew DP, Paull RE and Rohrbach KG. 2002. *The Pineapple: Botany, Production, and Uses.* CAB International.
- Bose TK, Mitra SK and Sanyal D. 2002. *Fruits of India – Tropical and Sub-Tropical*.3rd Edn.
- Naya Udyog, Kolkata.
- Dhillon WS. 2013. *Fruit Production in India.* Narendra Publ. House, New Delhi.
- Iyer CPA and Kurian RM. 2006. *High Density Planting in Tropical Fruits: Principlesand Practices.* IBDC Publishers, New Delhi.
- Litz RE. 2009. *The Mango: Botany, Production and Uses*. CAB International. Madhawa Rao VN. 2013. *Banana.* ICAR, New Delhi.
- Midmore D. 2015. *Principles of Tropical Horticulture*. CAB International. Mitra SK and Sanyal D. 2013. *Guava,* ICAR, New Delhi.

Course Title: Subtropical and Temperate Fruit Production*
Course Code: HORT 502
Credit Hours: 3 (2+1)

Theory

Unit I: Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements.

Unit II: Propagation, Planting and Orchard Floor Management: Asexual and sexual methods of propagation, planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Unit III: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders – causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management. Crops- Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond, Pecan, etc.

Practical

Distinguished features of fruit species, cultivars and rootstocks. Demonstration of planting systems, training and pruning. Hands on practices on pollination and crop regulation. Leaf sampling and nutrient analysis. Physiological disorders-malady diagnosis. Physico-chemical analysis of fruit quality attributes. Field/ Exposure visits to subtropical and temperate orchards. Project preparation for establishing commercial orchards.

Theory Lecture Schedule:

S. No.	Name of Topic	No. of lecture
1.	Importance, origin and distribution	1
2.	Major species, rootstocks and commercial varieties of regional, national and international importance	1
3.	Eco-physiological requirements	1
4.	Asexual and sexual methods of propagation	1
5.	Planting systems and planting densities	1
6.	Training and pruning methods, rejuvenation, intercropping	1
7.	Nutrient management	1
8.	Water management and fertigation.	1
9.	Use of bio-fertilizers	1
10.	Role of bio-regulators	1
11.	Abiotic factors limiting fruit production.	1

12.	Physiology of flowering, pollination management.	1
13.	Fruit set and development.	1
14.	Physiological disorders – causes and remedies, crop regulation, quality improvement by management practices.	2
15.	Maturity indices, harvesting, grading, packing, storage and ripening techniques.	1
16.	Insect and disease management.	2
17.	Production Technology of Sub-tropical fruit crops- Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond, Pecan, etc.	15

Practical Schedule:

S. No.	Name of Topic	No. of practical
1.	Distinguished features of sub-tropical fruit species, cultivars and rootstocks.	1
2.	Demonstration of planting systems, training and pruning.	1
3.	Hands on practices on pollination and crop regulation.	1
4.	Leaf sampling and nutrient analysis.	1
5.	Physiological disorders-malady diagnosis.	1
6.	Physico-chemical analysis of fruit quality attributes.	1
7.	Field/ Exposure visits to tropical orchards.	1
8.	Project preparation for establishing commercial orchards.	1

Suggested Reading

- Chadha KL and Awasthi RP. 2005. *The Apple*. Malhotra Publishing House, New Delhi. Chadha TR. 2011. *A Text Book of Temperate Fruits*. ICAR, New Delhi
- Childers NF, Morris JR and Sibbett GS. 1995. *Modern Fruit Science: Orchard and Small Fruit Culture*. Horticultural Publications, USA.
- Creasy G and Creasy L. 2018. *Grapes.* CAB International. Davies FS and Albrigo LG. 1994. *Citrus.* CAB International.
- Dhillon WS. 2013. *Fruit Production in India.* Narendra Publishing House, New Delhi. Jackson D, Thiele G, Looney NE and Morley-Bunker M. 2011. *Temperate and Subtropical*
- Ladanyia M. 2010. *Citrus Fruit: Biology, Technology and Evaluation*. Academic Press. Layne DR and Bassi D. 2008. *The Peach: Botany, Production and Uses*. CABI.

Course Title: Propagation and Nursery Management in Fruit Crops*
Course Code: HORT 503
Credit Hours: 3 (2+1)

Theory

Unit I: General Concepts and Phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras. Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing.

Unit II: Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods. Budding and grafting – principles and methods, establishment and management of bud wood bank. Stock, scion and inter stock relationship – graft incompatibility, physiology of rootstock and top working.

Unit III: Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques – *in-vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.

Unit IV: Management Practices and Regulation: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.

Practical

Hands on practices on rooting of dormant and summer cuttings. Anatomical studies in rooting of cutting and graft union. Hands on practices on various methods of budding and grafting. Propagation by layering and stooling. Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening. Visit to commercial tissue culture laboratories and accredited nurseries.

Theory Lecture Schedule:

S. No.	Name of Topic	No. of lecture
1.	Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras.	2
2.	Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth.	2
3.	Seed quality, treatment, packing, storage, certification and testing.	2
4.	Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds.	2

5.	Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings.	2
6.	Layering – principle and methods.	1
7.	Budding and grafting – principles and methods, establishment and management of bud wood bank.	2
8.	Stock, scion and inter stock relationship – graft incompatibility, physiology of rootstock and top working.	2
9.	Micro-propagation – principles and concepts, commercial exploitation in horticultural crops.	1
10.	Techniques – *in-vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.	1
11.	Management Practices and Regulation: Nursery – types, structures, components, planning and layout.	2
12.	Nursery management practices for healthy propagule production.	1
13.	Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.	2

Practical Schedule:

S. No.	Name of Topic	No. of practical
1.	Hands on practices on rooting of dormant and summer cuttings.	1
2.	Anatomical studies in rooting of cutting and graft union.	1
3.	Hands on practices on various methods of budding and grafting.	1
4.	Propagation by layering and stooling.	1
5.	Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening.	1
6.	Visit to commercial tissue culture laboratories and accredited nurseries.	1

Suggested Reading

- Bose TK, Mitra SK and Sadhu MK. 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash, Kolkatta.
- Davies FT, Geneve RL and Wilson SB. 2018. *Hartmann and Kester's Plant Propagation-Principles and Practices.* Pearson, USA/ PrenticeHall of India. New Delhi.
- Gill SS, Bal JS and Sandhu AS. 2016. *Raising Fruit Nursery*. Kalyani Publishers,New Delhi. Jain S and Ishil K. 2003. *Micropropagation of Woody Trees and Fruits*. Springer.

Course Title: Production of Cool Season Vegetable Crops*
Course Code: HORT 504
Credit Hours: 3 (2+1)

Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery, sowing/ planting time and methods, hydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

Unit I: Bulb and tuber crops—Onion, garlic and potato.

Unit II: Cole crops—Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale.

Unit III: Root crops—Carrot, radish, turnip and beetroot.

Unit IV: Peas and Beans—Garden peas and broad bean.

Unit V: Leafy Vegetables—Beet leaf, fenugreek, coriander and lettuce.

Practical

Scientific raising of nursery and seed treatment. Sowing and transplanting. Description of commercial varieties and hybrids. Demonstration on methods of irrigation, fertilizers and micronutrients application. Mulching practices, weed management. Use of plant growth substances in cool season vegetable crops. Study of nutritional and physiological disorders. Studies on hydroponics, aeroponics and other soilless culture. Identification of important pest and diseases and their control. Preparation of cropping scheme for commercial farms. Visit to commercial farm, greenhouse/ polyhouses. Visit to vegetable market. Analysis of benefit to cost ratio.

Theory Lecture Schedule:

S. No.	Name of Topic	No. of lecture
1.	Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints.	2
2.	Soil requirements, climatic factors for yield and quality.	1
3.	Commercial varieties/ hybrids, seed rate and seed treatment.	1
4.	Raising of nursery, sowing/ planting time and methods, hydroponics and aeroponics.	2
5.	Precision farming and cropping system.	1

6.	Nutritional including micronutrients and irrigation requirements, intercultural operations.	1
7.	Special horticultural practices, weed control and mulching.	2
8.	Role of plant growth regulators.	1
9.	Physiological disorders.	1
10.	Maturity indices, harvesting and yield.	1
11.	Post-harvest management (grading, packaging and marketing).	2
12.	Pest and disease management and production economics of crops.	1
13.	Production technology of Bulb and tuber crops—Onion, garlic and potato.	3
14.	Production technology of Cole crops—Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale.	5
15.	Production technology of Root crops—Carrot, radish, turnip and beetroot.	4
16.	Production technology of Peas and Beans—Garden peas and broad bean.	3
17.	Production technology of Leafy Vegetables—Beet leaf, fenugreek, coriander and lettuce.	3

Practical Schedule:

S. No.	Name of Topic	No. of practical
1.	Scientific raising of nursery and seed treatment, Sowing and transplanting.	1
2.	Description of commercial varieties and hybrids.	1
3.	Demonstration on methods of irrigation, fertilizers and micronutrients application.	1
4.	Mulching practices, weed management.	1
5.	Use of plant growth substances in cool season vegetable crops.	1
6.	Study of nutritional and physiological disorders.	1
7.	Studies on hydroponics, aeroponics and other soilless culture.	1
8.	Identification of important pest and diseases and their control.	1
9.	Preparation of cropping scheme for commercial farms.	1
10.	Visit to commercial farm, greenhouse/ polyhouses.	1
11.	Visit to vegetable market.	1
12.	Analysis of benefit to cost ratio.	1

Suggested Reading

- Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya udyog.
- Bose TK, Som MG and Kabir J. (Eds.). 1993. *Vegetable crops*. Naya prokash.
- Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture* Vols. V-X. Malhotra publ. house.
- Chadha KL. (Ed.). 2002. *Hand book of horticulture*. ICAR.
- Chauhan DVS. (Ed.). 1986. *Vegetable production in India*. Ram prasad and sons.

Course Title: Production of Warm Season Vegetable Crops*
Course Code: HORT 505
Credit Hours: 3 (2+1)

Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery, sowing/ planting time and methods, hydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

Unit I: Fruit Vegetables—Tomato, brinjal, hot pepper, sweet pepper and okra.

Unit II: Beans—French bean, Indian bean (Sem), cluster bean and cowpea.

Unit III: Cucurbits—Cucumber, melons, gourds, pumpkin and squashes.

Unit IV: Tuber crops—Sweet potato, elephant foot yam, tapioca, taro and yam.

Unit V: Leafy vegetables—Amaranth and drumstick.

Practical

Scientific raising of nursery and seed treatment. Sowing, transplanting and vegetable grafting. Description of commercial varieties and hybrids. Demonstration on methods of irrigation, fertilizers and micronutrients application. Mulching practices, weed management. Use of plant growth substances in cool season vegetable crops. Study of nutritional and physiological disorders. Studies on hydroponics, aeroponics and other soilless culture. Identification of important pest and diseases and their control. Preparation of cropping scheme for commercial farms. Visit to commercial farm, greenhouse/polyhouses. Visit to vegetable market. Analysis of benefit to cost ratio.

Theory Lecture Schedule:

Sr. No.	Name of Topic	No. of Lecture
1.	Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints.	2
2.	Soil requirements, climatic factors for yield and quality.	1
3.	Commercial varieties/ hybrids, seed rate and seed treatment.	1
4.	Raising of nursery, sowing/ planting time and methods, hydroponics and aeroponics.	2
5.	Precision farming and cropping system.	1

6.	Nutritional including micronutrients and irrigation requirements, intercultural operations.	1
7.	Special horticultural practices, weed control and mulching.	2
8.	Role of plant growth regulators.	1
9.	Physiological disorders.	1
10.	Maturity indices, harvesting and yield.	1
11.	Post-harvest management (grading, packaging and marketing).	2
12.	Pest and disease management and production economics of crops.	1
13.	Production Technology of Fruit Vegetables—Tomato, brinjal, hot pepper, sweet pepper and okra.	5
14.	Production Technology of Beans—French bean, Indian bean (Sem), cluster bean and cowpea.	4
15.	Production Technology of Cucurbits—Cucumber, melons, gourds, pumpkin and squashes.	3
16.	Production Technology of Tuber crops—Sweet potato, elephant foot yam, tapioca, taro and yam.	3
17.	Production Technology of Leafy vegetables—Amaranth and drumstick.	2

Practical Schedule:

S. No.	Name of Topic	No. of practical
1.	Scientific raising of nursery and seed treatment, Sowing and transplanting.	1
2.	Description of commercial varieties and hybrids.	1
3.	Demonstration on methods of irrigation, fertilizers and micronutrients application.	1
4.	Mulching practices, weed management.	1
5.	Use of plant growth substances in cool season vegetable crops.	1
6.	Study of nutritional and physiological disorders.	1
7.	Studies on hydroponics, aeroponics and other soilless culture.	1
8.	Identification of important pest and diseases and their control.	1
9.	Preparation of cropping scheme for commercial farms.	1
10.	Visit to commercial farm, greenhouse/ polyhouses.	1
11.	Visit to vegetable market.	1
12.	Analysis of benefit to cost ratio.	1

Suggested Reading

- Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya udyog.
- Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture* Vols. V-X. Malhotra publ. house.
- Chadha KL. (Ed.). 2002. *Hand book of horticulture*. ICAR.
- Chauhan DVS. (Ed.). 1986. *Vegetable production in India*. Ram prasad and sons.
- Fageria MS, Choudhary BR and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol.II Kalyani.

Course Title: Principles of Vegetable Breeding*
Course Code: HORT 506
Credit Hours: 3 (2+1)

Theory

Unit I: Importance and history- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.

Unit II: Selection procedures- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests, and nematode), abiotic stress (temperature, moisture, and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).

Unit III: Heterosis breeding- Types, mechanisms, and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility, and sex forms.

Unit IV: Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.

Unit V: Ideotype breeding- Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of In-vitro and molecular techniques in vegetable improvement.

Practical

Floral biology and pollination behaviour of different vegetables; Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.; Breeding system and handling of filial generations of different vegetables; Exposure to biotechnological lab practices; Visit to breeding farms.

Theory Lecture Schedule:

Sr. No.	Name of Topic	No. of lecture
1.	Importance and history- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.	2
2.	Selection procedures- Techniques of selfing and crossing.	1
3.	Breeding systems and methods.	2
4.	Selection procedures and hybridization. Genetic architecture.	1
5.	Breeding for biotic stress (diseases, insect pests, and nematode).	2
6.	Breeding for abiotic stress (temperature, moisture, and salt) resistance and quality improvement.	2
7.	Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).	2
8.	Heterosis breeding- Types, mechanisms, and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility, and sex forms.	2
9.	Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.	2
10.	Ideotype breeding- Ideotype breeding; varietal release procedure.	1
11.	DUS testing in vegetable crops.	1
12.	Application of In-vitro and molecular techniques in vegetable improvement.	2

Practical Schedule:

S. No.	Name of Topic	No. of practical
1.	Floral biology and pollination behavior of different vegetables.	1
2.	Techniques of selfing and crossing of Cole crops.	1
3.	Techniques of selfing and crossing of Okra.	1
4.	Techniques of selfing and crossing of Cucurbits.	1
5.	Techniques of selfing and crossing of Tomato.	1
6.	Techniques of selfing and crossing of Eggplant.	1
7.	Techniques of selfing and crossing of Hot pepper.	1
8.	Breeding system and handling of filial generations of different vegetables.	1
9.	Exposure to biotechnological lab practices.	1
10.	Visit to breeding farms.	1

Suggested Reading

- Allard RW. 1960. Principle of plant breeding. John Willey and Sons, USA.
- Kalloo G. 1988. Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA.
- Kole CR. 2007. Genome mapping and molecular breeding in plants-vegetables. Springer, USA.
- Peter KV and Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p. 488.
- Prohens J and Nuez F. 2007. Handbook of plant breeding-vegetables (Vol I and II). Springer, USA.
- Singh BD. 2007. Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi.
- Singh Ram J. 2007. Genetic resources, chromosome engineering, and crop improvement-vegetable crops (Vol. 3). CRC Press, Fl, USA.

Course Title: Ornamental Gardening and Landscaping*
Course Code: HORT 507
Credit Hours: 3 (2+1)

Theory

Unit I: Styles and types of gardens: Historical background of gardening, Importance and scope of ornamental gardening, styles and types of gardens, formal and informal style gardens. English, Mughal, Japanese, Persian, Spanish, Italian, French, Hindu and Buddhist gardens.

Unit II: Garden components: Garden components (living and non-living): arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, colour wheels, clock garden, bamboo groves, bonsai; Non -living components like- path, garden gate, fencing, paving and garden features like fountains, garden seating, swings, lanterns, basins, bird baths, sculptures, waterfalls, bridge, steps, ramps, Lawn -genera and species, establishment and maintenance.

Unit III: Specialized gardens: Specialised gardens such as vertical garden, roof garden, terrace garden, water garden, sunken garden, rock garden, shade garden, temple garden, sacred gardens (with emphasis on native plants), Zen garden.

Unit IV: Principles and elements of landscaping: Basic drawing skills, use of drawing instruments garden symbols, steps in preparation of garden design, programmes phase, design, phase, etc. Elements and principles of landscape design. Organization of spaces, visual aspects of plan arrangement- view, vista and axis. Principles of circulation, site analysis and landscape, water requirement, use of recycled water.

Unit V: Landscaping for different situations: Urban landscaping, Landscaping for specific situations such as residential, farm houses, institutions, corporate sector, industries, hospitals, roadsides, traffic islands, Children parks, public parks, xeriscaping, airports, railway station and tracks, river banks and dam sites and IT/ SEZ parks. Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening.

Practical

Graphic language and symbols in landscaping, study of drawing instruments, viz., 'T' square, setsquare, drawing board, etc. Identification of various types of ornamental plants for different gardens and occasions. Preparation of land, planning, layout and planting, deviations from landscape principles. Case study. Site analysis, interpretation of map of different sites, use of GIS for selection. Enlargement from blue print. Landscape design layout and drafting on paper as per the scale. Preparation of garden models for home gardens, farm houses, industrial gardens, institutional gardens, corporate, avenue planting, practices in planning and planting of special

types of gardens. Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubbery borders. Project preparation on landscaping for different situations, creation of formal and informal gardens. Visit to parks and botanical gardens.

Theory Lecture Schedule:

S. No.	Name of Topic	No. of lecture
1.	Historical background of gardening, Importance and scope of ornamental gardening, styles and types of gardens, formal and informal style gardens.	2
2.	English, Mughal, Japanese, Persian, Spanish, Italian, French, Hindu and Buddhist gardens.	1
3.	Garden components (living and non-living): arboretum, shrubbery, fernery, palmatum, arches and pergolas.	1
4.	Edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, colour wheels, clock garden, bamboo groves.	4
5.	Bonsai.	1
6.	Non -living components like- path, garden gate, fencing, paving and garden features like fountains, garden seating, swings, lanterns, basins, bird baths, sculptures, waterfalls, bridge, steps, ramps, Lawn -genera and species, establishment and maintenance.	3
7.	Principles and elements of landscaping: Basic drawing skills, use of drawing instruments garden symbols, steps in preparation of garden design, programmes phase, design, phase, etc.	2
8.	Elements and principles of landscape design.	1
9.	Organization of spaces, visual aspects of plan arrangement- view, vista and axis. Principles of circulation, site analysis and landscape, water requirement, use of recycled water.	2
10.	Urban landscaping.	1
11.	Landscaping for specific situations such as residential, farm houses, institutions, corporate sector, industries, hospitals, roadsides, traffic islands, Children parks, public parks, xeriscaping, airports, railway station and tracks, river banks and dam sites and IT/ SEZ parks.	4
12.	Bio-aesthetic planning.	1
13.	Eco-tourism.	1
14.	Theme parks, indoor gardening, therapeutic gardening.	2

Practical Schedule:

S. No.	Name of Topic	No. of practical
1.	Graphic language and symbols in landscaping, study of drawing instruments, viz., 'T' square, setsquare, drawing board, etc.	1
2.	Identification of various types of ornamental plants for different gardens and occasions. Preparation of land, planning, layout and planting, deviations from landscape principles.	1
3.	Case study. Site analysis, interpretation of map of different sites, use of GIS for selection. Enlargement from blue print.	1
4.	Landscape design layout and drafting on paper as per the scale.	1

5.	Preparation of garden models for home gardens, farm houses, industrial gardens, institutional gardens, corporate, avenue planting, practices in planning and planting of special types of gardens.	1
6.	Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubbery borders.	1
7.	Project preparation on landscaping for different situations, creation of formal and informal gardens.	1
8.	Visit to parks and botanical gardens.	1

Suggested Reading

- Bose TK, Chowdhury B and Sharma SP. 2011. *Tropical Garden Plants in Colour*. Hort. and Allied Publ.
- Bose TK, Maiti RG, Dhua RS and Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.
- Grewal HS and Singh P. 2014. *Landscape Designing and Ornamental Plants*. Kalyani Publishers, New Delhi.
- Lauria A and Victor HR. 2001. *Floriculture-Fundamentals and Practices.*Agrobios Publ., Jodhpur.
- Misra RL and Misra S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi, India. Nambisan KMP. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co.,New Delhi, India.
- Randhawa GS and Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
- Sabina GT and Peter KV. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency, New Delhi, India.
- Singh A and Dhaduk BK. 2015. *A Colour Handbook: Landscape Gardening*. New India Publ.Agency, New Delhi, India.

Course Title: Modern Concepts in Crop Production
Course Code: AGRON 501
Credit Hours: 3(3+0)

Theory

Unit I: Crop growth analysis in relation to environment; geo-ecological zones of India.

Unit II: Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Unit III: Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modelling for desired crop yield.

Unit IV: Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

Unit V: Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture. Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Introduces crop growth analysis by explaining how plants accumulate biomass and how environmental factors shape growth.	2
2.	Covers major growth indices such as CGR, RGR, and NAR that help quantify productivity.	2
3.	Adds LAD, LAR, and SLA to understand leaf efficiency.	1
4.	Explains how light, temperature, moisture, and CO_2 influence crop performance.	1
5.	Discusses India's diverse geo-ecological regions and physiographic zones.	1
6.	Explains agro-ecological and agro-climatic zones and their cropping patterns.	1
7.	Introduces quantitative agro-biological principles governing yield formation.	1
8.	Describes the inverse yield–nitrogen law.	1
9.	Explains Mitscherlich's yield equation and nutrient efficiency constants.	1
10.	Interprets the equation graphically and evaluates its practical applications.	2
11.	Introduces the Baule unit, defining nutrient quantity needed for specific yield levels.	2

12.	Compares different yield response models and their suitability for field use.	2
13.	Begins lodging in cereals with causes such as wind, rain, and weak stems.	2
14.	Highlights lodging effects on yield and strategies for reduction through strong-stem varieties and regulators.	2
15.	Covers the physiology of grain yield through source–sink relationships.	1
16.	Focuses on plant population and its influence on competition and yield.	1
17.	Explains planting geometry and its role in light interception and disease reduction.	2
18.	Describes ideal plant type concepts used in modern breeding.	1
19.	Introduces crop modelling tools like DSSAT and APSIM for predicting crop performance.	2
20.	Discusses scientific principles of crop production including limiting factors and resource efficiency.	2
21.	Explains crop response production functions such as linear, quadratic, and diminishing models.	2
22.	Describes soil–plant relations, nutrient uptake, and root–soil interactions.	2
23.	Focuses on yield reduction under stresses like drought, heat, and salinity.	2
24.	Explains roles of auxins, gibberellins, and cytokinins in growth regulation.	2
25.	Covers ABA, ethylene, and their importance in stress adaptation.	2
26.	Explains integrated farming systems and their components for sustainable income.	2
27.	Focuses on organic farming concepts, principles, and certification.	2
28.	Describes resource conservation technologies such as zero tillage, residue retention, and crop rotation.	2
29.	Covers dry farming techniques and moisture conservation methods.	1
30.	Explains nutrient needs, diagnosis, and the importance of balanced nutrition.	2
31.	Covers integrated nutrient management combining fertilizers, organics, and biofertilizers.	2
32.	Concludes with modern crop production concepts like hydroponics, aeroponics, vertical farming, robotic farming, and the use of GIS, GPS, and remote sensing in precision agriculture.	2

Suggested Reading

- Balasubramaniyan P and Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.
- Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.
- Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.

- Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.
- Sankaran S and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.
- Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
- Alvin PT and kozlowski TT (ed.). 1976. *Ecophysiology of Tropical Crops*. Academia Pul., New York.
- Gardner PP, Pearce GR and Mitchell RL. 1985. *Physiology of Crop Plants*. Scientific Pub. Jodhpur.
- Lal R. 1989. *Conservation tillage for sustainable agriculture: Tropics versus Temperate Environments. Advances in Agronomy* 42: 85-197.
- Wilsie CP. 1961. *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.



Course Title: Principal and Practices of Soil Fertility and Nutrient Management
Course Code: AGRON 502
Credit Hours: 3 (2+1)

Theory

Unit I: Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II: Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III: Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV: Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V: Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermi compost and residue wastes in crops.

Practical

Determination of soil pH and soil EC. Determination of soil organic C. Determination of available N, P, K and S of soil. Determination of total N, P, K and S of soil. Determination of total N, P, K, S in plant. Computation of optimum and economic yield.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1	Soil fertility and productivity are fundamental concepts in crop production. Various factors affect soil fertility, including climate, parent material, and management practices. Good soil management ensures long-term sustainability of crop yields.	2
2	Soil productivity refers to the capacity of soil to support plant growth. Several biological, chemical, and physical properties determine productivity. Sustainable practices help maintain productivity over time.	2
3	Nutrient supply issues arise due to imbalanced fertilization and poor soil health. Availability of nutrients depends on soil pH, moisture, and organic matter content. Proper planning helps avoid deficiency and toxicity problems.	2
4	The relationship between nutrient supply and crop growth is highly significant. Plants respond differently to varying levels of nutrients. Balanced nutrition ensures optimum growth and development.	1

5	Organic farming is based on natural inputs and ecological balance. Definitions and concepts of organic farming emphasize sustainability and soil health. Use of organic inputs minimizes environmental damage.	2
6	Essentiality criteria help identify nutrients required for plant growth. A nutrient is considered essential if its absence restricts growth and cannot be replaced by another element. Understanding essentiality helps in effective nutrient management.	2
7	Plants require both macro and micronutrients for completion of their life cycle. Each nutrient performs specific functions in plant physiology. Proper supply prevents growth inhibition.	1
8	Nutrient deficiency symptoms provide visual clues of imbalances. Different nutrients produce unique symptoms on leaves, stems, or roots. Timely diagnosis helps avoid yield loss.	1
9	Transformation and dynamics of nutrients occur continuously in soil. Microbial activity, temperature, and moisture influence these processes. Understanding transformations helps improve fertilizer strategies.	1
10	Farmyard manure is a common organic amendment in agriculture. Proper preparation and handling preserve its nutrient content. Application improves soil properties and crop yield.	1
11	Compost is produced by controlled decomposition of organic waste. Use of compost enhances soil structure and nutrient availability. Modern composting techniques improve efficiency.	1
12	Green manuring improves soil fertility through nitrogen fixation and organic matter addition. Legume crops are often used for green manure. Incorporation at proper stage provides maximum benefit	1
13	Vermicompost is produced through earthworm activity. Vermicompost contains readily available nutrients for plants. Its application enhances soil biological activity.	1
14	Biofertilizers contain living microorganisms that enhance nutrient availability. Their use reduces dependence on chemical fertilizers. Application methods determine their effectiveness.	1
15	Recycling of organic wastes reduces environmental pollution. Residue management improves soil carbon and enhances productivity. Proper recycling conserves resources.	1
16	Soil-less cultivation techniques allow plant growth without soil. Hydroponics and aeroponics are prominent methods. These systems ensure efficient use of water and nutrients.	1
17	Commercial fertilizers provide concentrated nutrient sources. Their composition determines suitability for specific crops. Knowledge of fertilizer grades helps select correct products.	1
18	Relative fertilizer value helps compare efficiency of different fertilizers. Cost analysis ensures economic application. Proper evaluation improves profitability.	1
19	Crop response to nutrients varies according to soil and climate. Residual effects influence nutrient availability in subsequent crops. Fertilizer use efficiency measures performance of inputs.	2
20	Agronomic, chemical, and physiological efficiencies are important indicators. These efficiencies determine how much nutrient is utilized by plants. Improvement measures enhance overall productivity.	2
21	Fertilizer mixtures and grades provide balanced nutrition to crops. Customized blends address specific nutrient deficiencies. Their use reduces application effort.	2

22	Nutrient interactions can be synergistic or antagonistic. Understanding interactions prevents hidden hunger and toxicity. Balanced application ensures proper growth.	1
23	Timing of manure application influences nutrient availability. Methods such as broadcasting, band placement, and fertigation affect efficiency. Proper techniques improve uptake.	1
24	Foliar application provides quick correction of nutrient deficiencies. This method is useful under stress conditions. Concentration and timing must be carefully managed.	2
25	Integrated nutrient management combines organic and inorganic sources. Balanced nutrition enhances soil fertility and crop productivity. Use of vermicompost and residues reduces chemical load.	2
26	Economics of fertilizer use determines profitability of farming. Cost-benefit analysis helps farmers choose appropriate nutrient strategies. Efficient management ensures sustainable production.	1

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1	To determine soil pH for assessing soil acidity or alkalinity.	2
2	To measure soil EC for identifying soil salinity status.	2
3	To estimate soil organic carbon for evaluating soil fertility.	2
4	To determine available nitrogen in soil for fertilizer recommendation.	1
5	To estimate available phosphorus and potassium in soil for nutrient management.	2
6	To determine available sulphur in soil for assessing sulphur requirement.	2
7	To analyze total N, P, K, and S in soil for long-term fertility evaluation.	2
8	To determine total N, P, K, and S in plant samples for nutrient uptake assessment.	2
9	To compute optimum yield using graded fertilizer applications.	1
10	To calculate economic yield and fertilizer use efficiency for profitable farming.	2

Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils.* 13th Ed. Pearson Edu.
- Fageria NK, Baligar VC and Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.
- Prasad R and Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
- Yawalkar KS, Agrawal JP and Bokde S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.

Course Title: Principal and Practices of Weed Management
Course Code: AGRON 503
Credit Hours: 3 (2+1)

Theory

Unit I: Weed biology, and ecology and classification, crop-weed competition including alelopathy principles and methods of weed control and classification management; weed indices, weed shift in different eco-systems

Unit II: Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit III: Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio-agents, and allele chemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance, residue, persistence and management; development of herbicide resistance in weeds and crops and their management, herbicide combination and rotation.

Unit IV: Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

Unit V: Integrated weed management; recent development in weed management- robotics, use of drones and aeroplanes, organic etc., cost: benefit analysis of weed management.

Practical

Identification of important weeds of different crops. Preparation of a weed herbarium, weed survey in crops and cropping systems. Crop-weed competition studies, weed indices calculation and interpretation with data. Preparation of spray solutions of herbicides for high and low-volume sprayers. Use of various types of spray pumps and nozzles and calculation of swath width. Economics of weed control. Herbicide resistance analysis in plant and soil. Bioassay of herbicide resistance residues. Calculation of herbicidal herbicide requirement.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1	Weed biology: definition, growth habits, seed biology, dormancy, viability, vegetative propagation, life cycle patterns, and factors influencing weed survival in cultivated fields.	2
2	Weed ecology: ecological adaptations, succession, weed behavior under different environments, classification of weeds based on morphology, habitat, life cycle, and special characteristics.	2

3	Crop–weed competition: nature, intensity, critical period, resource competition (light, water, nutrients), role of allelopathy, crop losses due to weeds, and allelochemical interactions.	2
4	Principles and methods of weed control: preventive, cultural, mechanical, chemical, and biological methods; integrated approaches and classification of weed control techniques.	2
5	Weed indices (weed control efficiency, weed smothering efficiency, weed index), weed flora changes, weed shift due to continuous cropping, herbicide use, and changes in different ecosystems.	2
6	Introduction to herbicides: definition, importance, discovery, history of development, major milestones, and evolution of modern herbicides.	2
7	Classification of herbicides based on chemical composition: phenoxy acids, triazines, ureas, amides, sulfonylureas, glyphosate group, and other important categories.	2
8	Classification based on physiological application and selectivity: pre-plant, pre-emergence, post-emergence, soil-applied, foliar-applied, selective and non-selective herbicides.	2
9	Mode and mechanism of action: influence on photosynthesis, amino acid synthesis, lipid biosynthesis, respiration, cell division, pigment inhibition, and hormonal disruption.	2
10	Herbicide structure–activity relationship: molecular properties, absorption, translocation, and factors that determine herbicide performance in field conditions.	1
11	Factors affecting herbicide efficiency: soil properties, climate, application techniques, nozzle types, water quality, timing, crop stage, and weed growth stage.	2
12	Herbicide formulations, herbicide mixtures, compatibility, tank mixes, sequential applications, advantages and limitations of combined herbicides.	1
13	Herbicide rotation strategies, nano-herbicides, bio-herbicides and modern biodegradable herbicidal molecules for sustainable weed control.	1
14	Myco-herbicides, microbial bio-agents, allelochemicals, plant-based weed suppressants, and natural weed control products.	1
15	Herbicide movement in soil and plant: leaching, volatilization, adsorption, absorption, translocation, and pathways of herbicide behavior.	1
16	Degradation of herbicides: microbial, chemical, and photodegradation; herbicide residues, persistence, residue detection, and environmental concerns.	1
17	Herbicide resistance: types, mechanisms, genetic basis, resistance in major weeds; resistance development in crops and strategies for prevention and management.	2
18	Weed management in major crops like rice, wheat, maize, soybean, cotton, sugarcane, and pulses; weed management in different cropping systems.	2
19	Alien, invasive and parasitic weeds: identification, biology, impact, and management of *Striga, Orobanche, Lantana, Parthenium, Eichhornia* and other problematic weeds.	2
20	Management of aquatic weeds (floating, submerged, emergent), perennial weeds (rhizomatous, stoloniferous), and weed control in non-crop areas like roadsides, industrial sites, and orchards.	2
21	Integrated weed management: combination of preventive, cultural, mechanical, biological and chemical methods; recent technologies including robotics, drones, sensors, aeroplane spraying, organic weed management, and cost–benefit analysis of weed control practices.	2

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1	Major weeds of field and horticultural crops identified based on morphology and life cycle.	2
2	Collection, pressing, drying, labeling, and mounting of weed specimens.	2
3	Quadrat method used to record weed flora, density, frequency and dominance.	2
4	Observation of crop and weed competition for nutrients, water, and light.	1
5	Computation of weed density, biomass, WCE, WSE, and interpretation.	1
6	Calculation of herbicide requirement and preparation for HV/LV sprayers.	1
7	Handling sprayers, identifying nozzle types, and understanding spray characteristics.	1
8	Calculation of discharge rate, walking speed, spray volume, and swath width.	2
9	Cost calculation of weeding practices and estimation of B:C ratio.	1
10	Identification of resistance symptoms and collection of resistant weed samples.	1
11	Study of herbicide persistence and soil residue detection methods.	1
12	Use of test plants to detect herbicide residues through germination and growth.	1
13	Calculation of required herbicide quantity based on area and spray volume.	1
14	Field demonstration of mechanical, cultural, biological, and chemical methods.	1

Suggested Reading

- Chauhan B and Mahajan G. 2014. *Recent Advances in Weed Management*. Springer.
- Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi).
- Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. *Weed Management*: *Principles and Practices*, 2nd Ed.
- Jugulan, Mithila (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press.

Course Title: Experimental Designs
Course Code: AST 501
Credit Hours: 3 (2+1)

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.

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.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lectures
1	Need for designing experiments – introduction, Importance of proper experimental design, Characteristics of a good design	2
2	Basic principles of designs- Randomization, Replication and Local control	1
3	Uniformity trials – purpose & procedure Size and shape of plots and blocks	1
4	ANOVA- Analysis of variance	2
5	CRD –Completely randomized design,	2
6	RBD – Randomized block design	2
7	LSD – Latin square design	2
8	Factorial experiments (Symmetrical factorials and Asymmetrical factorials)	2
9	Orthogonality – concept & importance	1
10	Partitioning degrees of freedom	1
11	Concept of confounding	2
12	Split-plot design	1
13	Strip-plot design	1
14	ANCOVA – Analysis of covariance	2
15	Missing plot techniques in RBD	2
16	Missing plot techniques in LSD	2
17	Transformations	2
18	Balanced Incomplete Block Design	1
19	Resolvable designs and their applications	1

20	Lattice designs & Alpha design - concepts, randomization procedure, analysis and interpretation of results	4
21	Response surface methodology	1
22	Combined analysis	1

Practical Schedule

S. No.	Name of Exercise	No. of Practical
1	Uniformity trial data analysis,	2
2	Formation of plots and blocks,	2
3	Fairfield Smith's Law	2
4	Analysis of data obtained from Completely Randomized Design (CRD)	2
5	Analysis of data obtained from Randomized Block Design (RBD)	2
6	Analysis of data obtained from Latin Square Design (LSD)	2
7	Analysis of factorial experiments	2
8	Analysis with missing data	2
9	Split plot and strip plot designs	2

Suggested Reading

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

Course Title: Soil Fertility and Fertilizer Use
Course Code: SOIL 502
Credit Hours: 3 (2+1)

Theory

Unit I: Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit II: Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit III: Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behaviour in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit IV: Sulphur - source, forms, fertilizers and their behaviour in soils; role in crops and human health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Unit V: Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit VI: Common soil test methods for fertilizer recommendations; quantity– Intensity relationships; soil test crop response correlations and response functions.

Unit VII: Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers uses in soils and crops of India;

Unit VIII: Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS

Unit IX: Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.

Practical

Soil and plant sampling and processing for chemical analysis. Determination of soil pH, total and organic carbon in soil. Chemical analysis of soil for total and available nutrients (major and micro). Analysis of plants for essential elements (major and micro).

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Soil fertility and soil productivity; fertility status of major soils group of India; Special emphasis on Maharashtra	1
2.	Nutrient sources- fertilizers and manures	1
3.	Criteria of essentiality, classification, law of minimum and maximum	1
4.	Functions and deficiency symptoms of primary, secondary and micronutrients nutrients	1
5.	Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity	1
6.	Sources and forms of nitrogen in soils immobilization and mineralization (nitrification, denitrification,)	2
7.	Biological N fixation Factors affecting N fixation,	1
8.	Nitrogen fertilizers, their classification and fertilizer N management in Low land upland conditions, fertilizer N use efficiency	2
9.	Soil fertilizer Phosphorus, forms and Sources of soil P, immobilization and mineralization of soil P	2
10.	Factors affecting the P availability in soil	1
11.	Phosphatic fertilizers, their classification and behaviour and management of P fertilizers under field conditions.	1
12.	Forms and sources of potassium in soil, factors affecting Potassium availability (soil and plant factors)	1
13.	Mechanism of potassium fixation factors affecting it	1
14.	K fertilizers and their classification and management of K fertilizers under field conditions	1
15.	Sulphur- forms, and sources of sulphur in soils, S behaviour in soils	1
16.	Sulphur fertilizers and their behaviour in soils, role in crop and human health	1
17.	Calcium and magnesium- forms and sources of Ca & Mg in soils, Ca & Mg availability in soils	1
18.	Management of sulphur, calcium and magnesium fertilizers.	1
19.	Micronutrients Sources, critical limits in soil and plants, micronutrient availability in soil and factors affecting it.	2
20.	Deficiency symptoms and their corrections in plants.	1
21.	Role of chelates in nutrient availability	1
22.	Common soil test methods for fertilizer recommendations	1
23.	Quantity /intensity of phosphorus and potassium,	1
24.	Soil test crop response correlations and response functions	1
25.	Fertilizer use efficiency –site specific nutrient management and plant need based nutrient management	1
26.	Integrated nutrient management specialty fertilizers concept, need and category. Current status of specialty fertilizers use in soils and crops of India	2
27.	Soil fertility evaluation classification DRIS, Methods of determination of critical	1

	limit biological methods	
28.	Soil and plant tissue test	1
29.	Soil quality to sustainable agriculture-	1
30.	Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.	2

Practical Schedule

Exercise No.	Name of Exercise
1	Soil and plant sampling and processing technique for chemical analysis.
2	Determination of available nitrogen
3	Determination of ammonical and nitrate nitrogen
4	Determination of available phosphorus
5	Determination of available potassium
6	Determination of exchangeable cations Ca, Mg, Na and K
7	Determination of available S
8	Determination of total and organic carbon in soil.
9	Principles of colorimetric,
10	Flame photometry
11	Atomic absorption spectrophotometry

Suggested Readings

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Kabata-Pendias A and Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Leigh J G. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.
- Mengel K and Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. *Micronutrients in Agriculture*. 2nd
- Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ and Vance JF. 2002. *Soils and Environmental Quality.* 2nd Ed. CRC Press.
- Stevenson FJ and Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. *Soil Fertility and Fertilizers.* 5th Ed. Prentice Hall of India.
- Troeh FR and Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

Course Title: Library and Information Services
Course Code: PGS 501
Credit Hours: 1 (0+1)

Practical

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

PRACTICAL SCHEDULE

S. No.	Name of Topic	No. of Practical
1	Library orientation and facility familiarization	2
2	Bibliography preparation techniques	2
3	Scientific literature search strategies	2
4	Online databases and indexing services	2
5	Journal article retrieval and access	2
6	Citation management tools	2
7	Reference formatting styles	2
8	Literature review compilation	2
9	Library services and resource utilization	2

Course Title: Technical Writing and Communication Skills
Course Code: PGS 502
Credit Hours: 1 (0+1)

Practical (Technical Writing)

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

PRACTICAL SCHEDULE

S. No.	Name of Topic	No. of Lecture
1.	Covers the meaning, purpose and importance of scientific writing, including theses, dissertations, technical papers, manuals, reports, and review articles. Introduces how each form serves a different scientific objective.	1
2.	Explains research notes, short communications, popular articles, bulletins, monographs, and extension leaflets, describing when and why each is written in the scientific community.	1
3.	Discusses the title page, authorship details, certification, declaration, acknowledgments, contents page, and formatting standards used in thesis writing.	1
4.	Explains major thesis components such as the introduction, review of literature, materials and methods, results, discussion, summary, references, and appendices.	1
5.	Covers the format of research papers including the title, abstract, keywords, introduction, methodology, results, discussion, conclusion, references, and author contributions.	1
6.	Explains how to write effective abstracts, concise summaries, and well-structured précis, including length, style, purpose, and evaluation criteria.	1
7.	Covers citation styles (APA, MLA, Chicago, JRF, ICAR), in-text citations, reference lists, footnotes, and commonly used abbreviations in theses and research articles.	1
8.	Explains how to use photographs, graphs, charts, maps, and scientific drawings with appropriate captions, legends, resolutions, and placement guidelines.	1
9.	Describes rules for table numbering, figure numbering, page numbering (Roman & Arabic), table titles, footnotes, and alignment in scientific documents.	1
10.	Covers rules for writing numeric data, units (SI units), measurements, formulas, equations, and scientific dates following international writing standards.	1

11.	Teaches proofreading marks, identifying typographical, grammatical, logical, and formatting errors, and using checklists for editing scientific content.	1
12.	Explains how to choose a topic, search literature, structure sections, synthesize findings, compare studies, and write high-quality review papers.	1
13.	Covers basic grammar essentials including tense forms, verb agreement, noun forms, pronouns, adverbs, clauses, and correct sentence structure.	1
14.	Explains punctuation marks, subject–verb agreement (concord), commonly misused word combinations (collocations), and how they affect scientific writing.	1
15.	Focuses on spelling errors, redundancy, run-on sentences, misplaced modifiers, incorrect prepositions, and other frequently occurring writing problems.	1
16.	Introduces phonetic symbols (IPA), stress patterns, weak forms in connected speech, and pronunciation techniques important for oral scientific communication.	1
17.	Covers participation techniques for group discussions, confidence building, questioning strategies, and handling academic or job interviews effectively.	1
18.	Explains preparing PPTs, slide design, sequence of presentation, verbal and non-verbal communication, answering audience questions, and professional presentation ethics.	1

Suggested Readings

- Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
- Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
- Collins' Cobuild English Dictionary. 1995.
- Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.
- Holt, Rinehart, and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
- James HS. 1994. Handbook for Technical Writing. NTC Business Books.
- Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
- Mohan K. 2005. Speaking English Effectively. MacMillan India.
- Richard WS. 1969. Technical Writing.
- Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
- Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

Course Title: Intellectual Property and Its Management in Agriculture
Course Code: PGS 503
Credit Hours: 1 (1+0)

Theory

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

THEORY SCHEDULE

S. No.	Name of Topic	No. of Lectures
1	Intellectual property concepts and definitions	2
2	Patents: types and filing procedures	2
3	Plant varieties protection	2
4	Trade secrets and confidential information	1
5	Copyright and trademark in agriculture	2
6	Licensing and technology transfer	2
7	IPR in biotechnology and agriculture	2
8	Management of research outputs	2
9	Agricultural policies and regulations	1

Suggested Readings

- Erbisch, F. H. and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli, P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
- Rothschild, M. and Scott, N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- Saha, R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

Course Title: Basic Concepts in Laboratory Techniques
Course Code: PGS 504
Credit Hours: 1 (0+1)

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, sand bath, water bath, oil bath; 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.

PRACTICAL SCHEDULE

S. No.	Name of Topic	No. of Practical
1	Laboratory safety and hazard management	2
2	Personal protective equipment (PPE)	2
3	Laboratory equipment identification and use	2
4	Measurement and precision techniques	2
5	Weighing and volumetric glassware	2
6	Solution preparation and standardization	2
7	Basic chemistry and biochemistry techniques	2
8	Microscopy and observation techniques	2
9	Laboratory record keeping and documentation	2

Suggested Readings

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

Course Title: Agriculture Research, Research Ethics and Rural Development Program
Course Code: PGS 505
Credit Hours: 1 (1+0)

Theory

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

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

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

THEORY SCHEDULE

S. No.	Name of Topic	No. of Lectures
1	Research ethics principles and guidelines	2
2	Informed consent and research participant rights	2
3	Research misconduct and plagiarism	2
4	Ethical issues in genetic research	2
5	Institutional Review Board (IRB) procedures	1
6	Data management and confidentiality	2
7	Rural development and agriculture	2
8	Sustainable agriculture practices	2
9	Community engagement and extension services	1

Suggested Readings

- Bhalla, G.S. and Singh, G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
- Punia, M.S. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.
- Rao, B.S.V. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations, and Initiatives. Mittal Publ.
- Singh, K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.



Credit Framework

M. Sc. (Ag.) Soil Science/ Agriculture Chemistry

MAHATMA JYOTIBA PHULE ROHILKHAND UNIVERSITY, BAREILLY

FACULTY OF AGRICULTURE SCIENCE & TECHNOLOGY

Department of Soil Science/ Agriculture Chemistry

COURSE WORK

Major courses:

Course code	Course title	Credit Hours
SOIL-501*	Soil Physics	3(2+1)
SOIL-502*	Soil Fertility and Fertilizer use	3(2+1)
SOIL-503*	Soil Chemistry	3(2+1)
SOIL-504*	Soil Mineralogy, Genesis and Classification	3(2+1)
SOIL 505	Soil erosion and conservation	3 (2+1)
SOIL-508	Soil, Water and Air Pollution	3(2+1)
SOIL-510	Analytical technique and instrumental methods in soil and plant analysis	2(0+2)
SOIL-591	Master seminar	01
SOIL-599	Master research	30
		Total = 51

Minor courses:

Course code	Course title	Credit Hours
AGRON-501	Modern concept in crop production	3(3+0)
AGRON-502	Principles and practices of soil fertility and nutrient management	3(2+1)
AGRON-504	Principles and practices of water management	3(2+1)
		Total = 09

Supporting courses:

Course code	Course title	Credit Hours
HORT 506	Principles of Vegetable Breeding	3 (2+1)
AST 501	Experimental Design	3 (2+1)
		Total = 06

Common courses:

Course code	Course title	Credit Hours
PGS 501	Library and Information services	1 (0+1)
PGS 502	Technical writing and Communications skills	1 (0+1)
PGS 503	Intellectual property right & Its management in Agriculture	1 (1+0)
PGS 504	Basic concept in laboratory techniques	1 (0+1)
PGS 505	Agricultural research, Research ethics and Rural development programmes	1 (1+0)
		Total = 05

MAHATMA JYOTIBA PHULE ROHILKHAND UNIVERSITY, BAREILLY

FACULTY OF AGRICULTURE SCIENCE & TECHNOLOGY

Department of Soil Science/ Agriculture Chemistry

SEMESTER WISE DISTRIBUTION OF COURSES WITH CREDIT HOURS

First Semester

Course code	Course title	Credit Hours
SOIL-501*	Soil Physics	3(2+1)
SOIL 502*	Soil fertility and Fertilizers use	3(2+1)
SOIL-508	Soil, Water and Air Pollution	3(2+1)
AGRON 501	Modern concept in Crop production	3(3+0)
HORT 506	Principles of Vegetable Breeding	3(2+1)
PGS 501	Library and Information services	1(0+1)
PGS 502	Technical writing and Communication skills	1(0+1)
PGS 503	Intellectual property right & Its management in Agriculture	1(1+0)
	Total Credit =	**18**

Second Semester

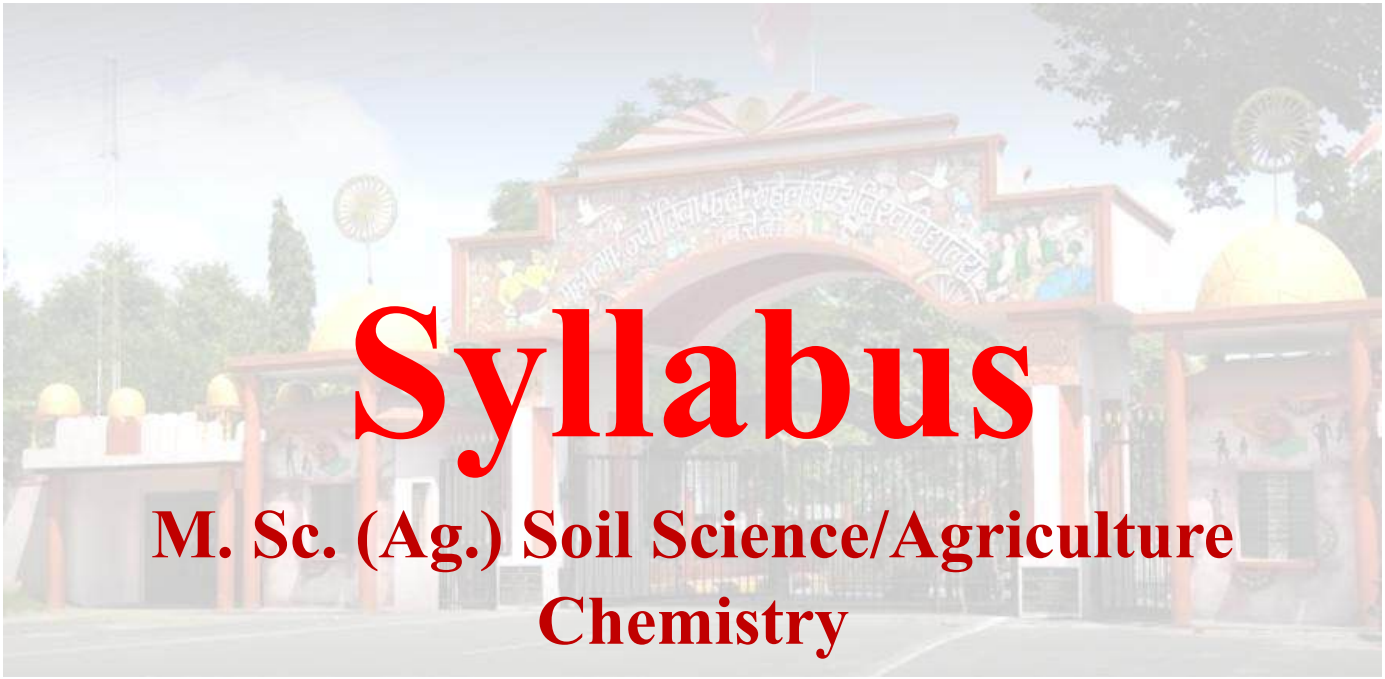
Course code	Course title	Credit Hours
SOIL 504*	Soil mineralogy genesis and classification	3(2+1)
SOIL 505	Soil erosion and conservation	3(2+1)
AGRON 502	Principles and Practices of Soil fertility and nutrients management	3(2+1)
AGRON 504	Principles and practices of water management	3(2+1)
AST 501	Experimental Design	3(2+1)
PGS 504	Basic concept in laboratory techniques	1(0+1)
PGS 505	Agricultural research, Research ethics and Rural development programmes	1(1+0)
SOIL-591	Master seminar	01
	Total Credit =	**18**

Third Semester

Course code	Course title	Credit Hours
SOIL-503*	Soil Chemistry	3(2+1)
SOIL-599	Master research	15
	Total Credit =	**18**

Fourth Semester

Course code	Course title	Credit Hours
SOIL-510	Analytical technique and instrumental methods in soil and plant analysis	2(0+2)
SOIL-599	Master research	15
	Total Credit =	**17**



Syllabus

M. Sc. (Ag.) Soil Science/Agriculture Chemistry

Course Title: Soil Physics
Course Code: SOIL 501
Credit Hours: 3 (2+1)

Theory

Unit I

Basic principles of physics applied to soils, soil as a three phase system.

Unit II

Soil texture, textural classes, mechanical analysis, specific surface.

Unit III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage- basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and erodability

Unit IV

Soil structure- genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting -mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

Unit V

Soil water: content and potential, soil water retention, soil- water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil- moisture potential.

Unit VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

Unit VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant- atmosphere continuum.

Unit VIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

Unit IX

Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

Determination of B.D,P.D and mass volume relationship of soil, Mechanical analysis by hydrometer

and international pipette method, Measurement of Atterberg limits, Aggregate analysis-dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore- size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

Suggested Reading

- Baver LD,Gardner WH and Gardner WR.1972. Soil Physics. John Wiley & Sons.
- Ghildyal BP and Tripathi RP.2001. Soil Physics. New Age International.
- Hanks JR and Ashcroft GL.1980. Applied Soil Physics. Springer Verlag.
- Hillel D.1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic Press.
- Hillel D.1980. Applications of Soil Physics. Academic Press.
- Hillel D.1980. Fundamentals of Soil Physics. Academic Press.
- Hillel D.1998. Environmental Soil Physics. Academic Press.
- Hillel D.2003. Introduction to Environmental Soil Physics. Academic Press.
- Indian Society of Soil Science. 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Kirkham D and Powers WL.1972. Advanced Soil Physics. Wiley-Interscience.
- Kohnke H.1968. Soil Physics. McGraw Hill.
- Lal R and Shukla MK.2004. Principles of Soil Physics. Marcel Dekker.
- Oswal MC.1994.Soil Physics. Oxford.
- Text books of soil physics by Arun Kumar Saha, Anuradha Saha Kalyani Publication New Delhi
- Soil Physics An Introduction By Manoj K. Shukla Published December 2, 2013 by CRC Press 478 Pages 201 B/W Illustrations
- Principles of Soil Physics By Rattan Lal, Manoj K. Shukla Published September 27, 2019 by CRC Press 736 Pages
- Applications of Soil Physics 1st Edition - October 28, 1980 Daniel Hillel Elsevier
- Fundamental Principal of Soil Science by Deepak Sarkar and Abhijit Haldar Today and tomorrows Printers and Publishers.

Teaching Schedule Theory

Sl No.	Name of Topic	No. of Lecture
1	Basic Principal of physics applied to soil	1
2	Soil as three phase system.	1
3	Soil texture, textural class, mechanical analysis, Stoke's law, specific surface	2

4	Soil consistence, dispersion and workability of soil, soil compaction and consolidation, soil strength, swelling and shrinkage basic concept, Alleviation of soil physical constraints for crop production. Soil erosion and edibility	3
5	Soil structure, genesis, types, characterization and management of soil structure, soil aggregation, aggregate stability, characteristics of good soil tilth	2
6	Soil crusting, mechanism, factor affecting and evaluation, soil conditioner, puddling its effect on soil physical properties, clod formation	2
7	Soil water content and potential, soil water retention, soil water constant	2
8	Measurement of soil water content, energy state of soil water, soil water potential	3
9	Soil moisture characteristics curve, hysteresis measurement of soil water potential	2
10	Water flow in saturated and unsaturated soil	1
11	Poiseuille's law, Darcy's law, hydraulic conductivity	1
12	Permeability and fluidity, hydraulic diffusivity	1
13	Measurement of hydraulic conductivity in saturated and unsaturated soil	1
14	Infiltration, internal drainage and redistribution	1
15	Soil water losses, Hydrologic cycle, field water balance soil plant atmosphere continuum	1
16	Composition of soil air, renewal of soil air convective flow and diffusion	2
17	Measurement of soil aeration, aeration requirement for plant growth, soil air management	2
18	Mode of energy transfer in soil, energy balance, thermal properties of soil, measurement of soil temperature modification of temperature	2
19	Soil temperature in relation to plant growth,	3
20	Soil temperature management	3

Practical Teaching Schedule

Sr. No.	Name of Exercise	Exercise No.	
1	Determination of BD by core and clod method,	1-2	
2	Determination PD by pychnometer method and Mass volume relationship of soil.	3-4	
3	Mechanical analysis by international pipette and hydrometer method and Determination of textural class by USDA Traingal	5-6	
4	Determination of soil consistence by Atterberg limits	7	
5	Water stable aggregate analysis by dry and wet sieving method (Yoder's apparatus)	8	
6	Determination of soil moisture content by Direct method-gravimetric	9	
9	Determination of soil moisture content by indirect method. Tenciometer and Gypsum block .	10-11	
10	Determination of soil moisture characteristics curve by pressure plate apparatus for coarse and fine textured soil	12	
11	Determination of macro and micro pore size distribution	13	

12	Determination of hydraulic conductivity under saturated and unsaturated condition	14	
13	Determination of infiltration rate by double ring infiltrometer	15	
14	Determination of oxygen diffusion rate by platinum electrode method	16	
15	Determination of soil temperature by soil thermometer	17	
16	Estimation of water balance component in bare and cropped field	18	



Course Title: Soil Fertility and Fertilizer Use
Course Code: SOIL 502
Credit Hours: 3 (2+1)

Theory

Unit I: Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit II: Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit III: Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behaviour in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit IV: Sulphur - source, forms, fertilizers and their behaviour in soils; role in crops and human health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Unit V: Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit VI: Common soil test methods for fertilizer recommendations; quantity– Intensity relationships; soil test crop response correlations and response functions.

Unit VII: Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers uses in soils and crops of India;

Unit VIII: Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS

Unit IX: Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.

Practical

Soil and plant sampling and processing for chemical analysis. Determination of soil pH, total and organic carbon in soil. Chemical analysis of soil for total and available nutrients (major and micro). Analysis of plants for essential elements (major and micro).

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Soil fertility and soil productivity; fertility status of major soils group of India; Special emphasis on Maharashtra	1
2.	Nutrient sources- fertilizers and manures	1
3.	Criteria of essentiality, classification, law of minimum and maximum	1
4.	Functions and deficiency symptoms of primary, secondary and micronutrients nutrients	1
5.	Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity	1
6.	Sources and forms of nitrogen in soils immobilization and mineralization (nitrification, denitrification,)	2
7.	Biological N fixation Factors affecting N fixation,	1
8.	Nitrogen fertilizers, their classification and fertilizer N management in Low land upland conditions, fertilizer N use efficiency	2
9.	Soil fertilizer Phosphorus, forms and Sources of soil P, immobilization and mineralization of soil P	2
10.	Factors affecting the P availability in soil	1
11.	Phosphatic fertilizers, their classification and behaviour and management of P fertilizers under field conditions.	1
12.	Forms and sources of potassium in soil, factors affecting Potassium availability (soil and plant factors)	1
13.	Mechanism of potassium fixation factors affecting it	1
14.	K fertilizers and their classification and management of K fertilizers under field conditions	1
15.	Sulphur- forms, and sources of sulphur in soils, S behaviour in soils	1
16.	Sulphur fertilizers and their behaviour in soils, role in crop and human health	1
17.	Calcium and magnesium- forms and sources of Ca & Mg in soils, Ca & Mg availability in soils	1
18.	Management of sulphur, calcium and magnesium fertilizers.	1
19.	Micronutrients Sources, critical limits in soil and plants, micronutrient availability in soil and factors affecting it.	2
20.	Deficiency symptoms and their corrections in plants.	1
21.	Role of chelates in nutrient availability	1
22.	Common soil test methods for fertilizer recommendations	1
23.	Quantity /intensity of phosphorus and potassium,	1
24.	Soil test crop response correlations and response functions	1
25.	Fertilizer use efficiency –site specific nutrient management and plant need based nutrient management	1
26.	Integrated nutrient management specialty fertilizers concept, need and category. Current status of specialty fertilizers use in soils and crops of India	2
27.	Soil fertility evaluation classification DRIS, Methods of determination of critical	1

	limit biological methods	
28.	Soil and plant tissue test	1
29.	Soil quality to sustainable agriculture-	1
30.	Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.	2

Practical Schedule

Exercise No.	Name of Exercise
1	Soil and plant sampling and processing technique for chemical analysis.
2	Determination of available nitrogen
3	Determination of ammonical and nitrate nitrogen
4	Determination of available phosphorus
5	Determination of available potassium
6	Determination of exchangeable cations Ca, Mg, Na and K
7	Determination of available S
8	Determination of total and organic carbon in soil.
9	Principles of colorimetric,
10	Flame photometry
11	Atomic absorption spectrophotometry

Suggested Readings

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Kabata-Pendias A and Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Leigh J G. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.
- Mengel K and Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. *Micronutrients in Agriculture*. 2nd
- Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ and Vance JF. 2002. *Soils and Environmental Quality.* 2nd Ed. CRC Press.
- Stevenson FJ and Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. *Soil Fertility and Fertilizers.* 5th Ed. Prentice Hall of India.
- Troeh FR and Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

Course Title: Soil Chemistry
Course Code: SOIL 503
Credit Hours: 3 (2+1)

Theory

Unit I

Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

Unit II

Elements of equilibrium thermo dynamics, chemical equilibria, electro chemistry and chemical kinetics.

Unit III

Soil colloids: inorganic and organic colloids- origin of charge, concept of point of zero- charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/ flocculation and peptization of soil colloids; electro metric properties of soil colloids sorption properties of soil colloids; soil organic matter- fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.

Unit IV

Ion eXchange processes in soil; cation eXchange- theories based on law of mass action(Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand eXchange– inner sphere and outer-sphere surface complex formation, fixation of oXyanions, hysteresis insorption-desorption of oXy-anions and anions, shift of PZC on ligand eXchange, AEC, CEC; eXperimental methods to study ion eXchange phenomena and practical implications in plant nutrition.

Unit V

Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation- dissolution equilibria; Concept of quantity/ intensity (Q/I) relationship; step and constant-rate K; management aspects.

Unit VI

Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

Unit VII

Chemistry of salt- affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.

Unit VIII

Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

Practical

Preparation of saturation pa st e extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, EXtraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophoto metric studies and the D(E4/E6) values at two pH values, Adsorption-desorption of phosphate/ sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/ fluoride / sulphate and ascertaining the mechanism of the ligand eXchange process involved, Determination of titratable acidity of an acid soil by BaCl2-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

Suggested Reading

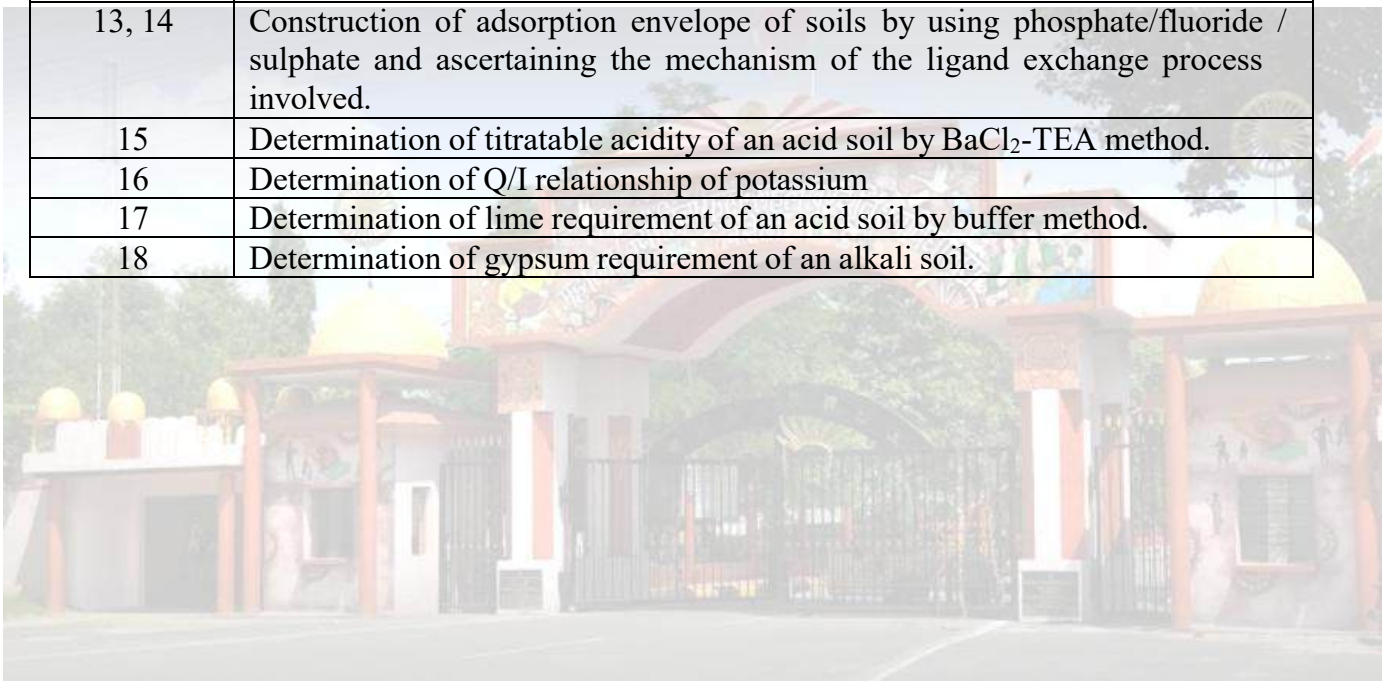
- Kim H. Tan , 2010. Principles of Soil Chemistry,4th Edition, Kindle Edition.
- Daniel G. Strawn, Hinrich L. Bohn, George A. O' Connor 2019 Soil Chemistry, 5th Edition
- Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New DelhiIndian Society of Soil Science 2015.Soil Science: An Introduction. ISSS, New Delhi
- Bear RE.1964.Chemistry of the Soil .OXford and IBH.
- Sanyal Text Book Of Soil Chemistry Jain Books & Periodicals 1586/113,Ganesh Pura, Tri Nagar, Delhi – 110035
- Bolt GH and Bruggenwert MGM.1978. Soil Chemistry. Elsevier.
- Greenland DJ and Hayes MHB. 1981.Chemistry of Soil Processes. John Wiley &Sons.
- Greenland DJ and Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.
- McBride MB.1994. Environmental Chemistry of Soils .OXford University Press.
- Sposito G.1981.TheThermodynamics of Soil Solutions. OXford University Press.
- Sposito G.1984. The Surface Chemistry of Soils .OXford University Press.
- Sposito G.1989. The Chemistry of Soils. OXford University Press.
- Stevenson FJ.1994. Humus Chemistry. 2ndEd. John Wiley & Sons.
- VanOlphan H.1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

Teaching Schedule Theory

S. No.	Name of Topic	No. of Lecture
1	Chemical (elemental) composition of the earth's crust and soils, Rocks and minerals in earth's crust	2
2	Elements of equilibrium thermo dynamics, Chemical equilibria, Chemical and SI units, Ion activity, Activity coefficient, Complex ion and ion pairs, Ionic strength, Hydrolysis and deprotonation, Acids and bases,	3
3	Solubility product, Soil reaction coefficient, Low of mass action, Soil solution, Electrochemistry and chemical kinetics, Reaction order and rate constant, Factors affecting rates of reactions, Microbes catalysis	3
4	Soil colloids: inorganic and organic colloids, Classification structure transformation and properties of inorganic colloids, Origin of charge, Concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, Surface charge characteristics of soils	3
5	Diffuse double layer theories of soil colloids, Zeta potential, stability, coagulation/flocculation and peptization of soil colloids	2
6	Electrometric properties of soil colloids; Sorption properties of soil colloids; Soil organic matter - fractionation of soil organic matter and different fractions, Characterization of organic matter, Humus formation, Clay-organic interactions	4
7	Ion exchange processes in soil; Cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), Schofield's Ratio Law	2
8	Adsorption isotherms, Equations used to described the adsorption isotherm, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics	3
9	Anion and ligand exchange–innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; Experimental methods to study ion exchange phenomena and practical implications in plant nutrition	3
10	Potassium, phosphate and ammonium fixation in soils covering specific and non- specific sorption; Precipitation-dissolution equilibria; Concept of quantity/intensity(Q/ I) relationship; Step and constant-rate K; Management aspects	4
11	Chemistry of acid soils; Active and potential acidity; Lime potential; Sub-soil acidity, Nutrient transformation in acid soils, Eh-pH diagram	2
12	Chemistry of salt-affected soils and amendments; Soil pH, ECe, ESP, SAR and important relations; Soil management and amendments	3
13	Chemistry and electrochemistry of submerged soils, Chemical Changes occurring in submerged soil, Geochemistry of micronutrients, Environmental soil chemistry	2

Practical Schedule

Exercise No.	Content
1, 2	Preparation of saturation paste extract and measurement of pHe, ECe, CO_3, HCO_3, Ca^{2+}, Mg^{2+}, K^+ and Na^+
3, 4	Determination of CEC and AEC of soils.
5	Analysis of equilibrium soil solution for pH, EC, E_h by use of E_h-pH meter and conductivity meter.
6	Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometer titration method.
7, 8	Extraction of soil humic substances
9	Potentiometer and condutometeric titration of soil humic and fulvic acids.
10	Determination of E_4/E_6 ratio of soil humic and fulvic acids by visible spectrophoto metric studies and the E_4/E_6values at two pH values.
11, 12	Determination of Adsorption- desorption of phosphate/sulphate by soil using simple adsorption isotherm.
13, 14	Construction of adsorption envelope of soils by using phosphate/fluoride / sulphate and ascertaining the mechanism of the ligand exchange process involved.
15	Determination of titratable acidity of an acid soil by $BaCl_2$-TEA method.
16	Determination of Q/I relationship of potassium
17	Determination of lime requirement of an acid soil by buffer method.
18	Determination of gypsum requirement of an alkali soil.



Course Title: Soil Mineralogy, Genesis and Classification
Course Code: SOIL 504
Credit Hours: 2+1

Aim of the course

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

Unit I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

Unit II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystal line and non-crystal line clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

Unit III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

Unit IV

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness.

Practical

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soil using available database in terms of soil quality

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil taxonomy and genesis and and their utility in research for solving field problem.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Fundamentals of crystallography, space lattice, coordination theory isomorphism and polymorphism	3
2.	Classification, structure, chemical composition and properties of minerals	2
3.	Genesis and transformation of crystalline and non-crystalline clay minerals.	2
4.	Identification of clay minerals, amorphous soil constituents and other non-crystalline silicate minerals in Indian soil by using advance methods (XRD, SEM, TEM, IR, DTA etc)	4
5.	Role of minerals in plant nutrition interaction of clay with humus	2
6.	Factors of soil formation and soil formation model and soil forming processes	2
7.	Weathering of rocks and minerals transformations	2
8.	Soil profile and master and Subsurface horizon	2
9.	Weathering sequences of minerals with special reference to Indian soil	2
10.	Soil individual and its concept,	2
11.	Soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy	3
12.	Soil survey, type of soil survey conventional and modern, data interpretations; soil mapping, thematic soil maps by using GIS, cartography, mapping units, techniques for generation of soil maps.	4
13.	Landform – soil relationship; major soil groups of India with special reference to respective states	2
14.	Land capability classification and land irritability classification;	2
15.	Land evaluation and land use type (LUT) – concept and application;	2

Practical Schedule

Exercise No.	Name of Exercise
1-2	Mechanical analysis of soil
3-4	Determination of specific surface area of clay fraction
5-6	Determination of CEC of clay fraction
7-9	Identification and quantification of minerals in soil fractions
10-12	Morphological properties of soil profile in different land forms Viz, Vertisols, Inceptisols and Entisols etc. (Specially emphasis on Maharashtra)
13-14	Classification of soils by using USDA classification (Soil Taxonomy)
15-16	Calculation of weathering indices and its application in soil formation.
17-18	Grouping of soils by using available data base in terms of soil quality

Suggested Reading

• Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu. Buol EW, Hole ED, MacCracken RJ and Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.

• Dixon JB and Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.

• Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.

• Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

• Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi

• Wade FA and Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
• Wilding NE and Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy*. I.



Course Title: Soil Erosion and Conservation
Course Code: SOIL 505
Credit Hours: 2+1

Aim of the course

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

Unit I

History, distribution, identification and description of soil erosion problems in India.

Unit II

Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; type sand mechanisms of water erosion; raindrops and soil erosion; rainfall erosity -estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

Unit III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

Unit IV

Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

Unit V

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

Unit VI

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement

Practical

• Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index

• Computation of kinetic energy of falling rain drops

• Computation of rainfall erosivity index (EI30) using rain gauge data

• Land capability classification of a watershed

• Visits to a watershed

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil conservation and their utility in research for

solving field problem.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	History, distribution, identification and description of soil erosion problems in India.	2
2.	Forms/type of soil erosion; Effects of soil erosion and factors affecting soil erosion;	2
3.	Types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity –estimation as EI30 index and kinetic energy;	3
4.	Factors affecting water erosion; empirical and quantitative estimation of water erosion;	2
5.	Methods of measurement and prediction of runoff;	1
6.	Soil losses in relation to soil properties and precipitation.	2
7.	Wind erosion- types of wind erosion	2
8.	Mechanism and factors affecting wind erosion;	2
9.	Extent of problem in the country of wind erosion	1
10.	Principles of erosion control	1
11.	Erosion control measures–agronomical and engineering;	2
12.	Erosion control structures- their design and layout.	3
13.	Soil conservation planning;	1
14.	Land capability classification;	1
15.	Soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wetlands.	3
16.	Watershed management-concept, objectives and approach;	2
17.	Water harvesting and recycling;	1
18.	Flood control in watershed management; socio economic aspects of watershed management	2
19.	Use of remote sensing in assessment and planning of watersheds, sediment measurement.	2
20.	Case studies in respect to monitoring and evaluation of watersheds.	1

Practical Schedule

Exercise No.	Name of Practical
1-2	Determination of(erodibility indices) soil suspense on percentage.
3-4	Determination of soil (erodibility indices) dispersion ratio.
5-6	Determination of soil erosion ratio.
7-8	Determination of clay ratio from soil.
9-10	Determination of clay/moisture equivalent ratio.
11-12	Determination of percolation ratio of soil.
13-14	Determination of raindrop perodibility index
15	Computation of kinetic energy of falling rain drops
16	Computation of rainfall erosivity index (EI30) using rain gauge data
17	Land capability classification of a watershed
18	Visits to a watershed

Suggested Reading

• Biswas TD and Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.

• Doran JW and Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.

• Gurmal Singh, Venkataramanan C, Sastry G and Joshi BP. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

• Hudson N. 1995. *Soil Conservation*. Iowa State University Press.

• Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

• Oswal MC. 1994. *Soil Physics*. Oxford & IBH.



Course Title: Soil, Water and Air Pollution
Course Code: SOIL 508
Credit Hours: 3 (2+1)

Aim of the course

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

Unit I

Soil, water and air pollution problems associated with agriculture, nature and eXtent.

Unit II

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants- their CPCB, MPCB standards and effect on plants, animals and human beings, Pollution Control Act, Policies

Unit III

Sewage and industrial effluents–their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

Unit IV

Pesticides– their classification, behavior in soil and effect on soil microorganisms.

Unit V

ToXic elements–their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.

Unit VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases–carbon dioxide, methane and nitrous oXide.

Unit VII

Risk assessment of polluted soil, Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oXygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammonical nitrogen and phosphorus, heavy metal content ineffluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safeguard foodsafety, Air sampling and determination of particulate matter and oXides of sulphur, NO2 and O2 conc. Visit to various industrial sites to study the impact of pollutants on soil and plants.

Teaching Schedule Theory

S. No.	Name of Topic	No. of Lecture
1.	Pollution-definition, Agril. Pollution soil water and air pollution, causes, nature and its extent, Classification and Discussion	3
2.	Nature and sources of pollutants – pesticides, fertilizer, industrial, urban waste, acid rains and oil spills	2
3.	Pollution of soil, water and air, CPCB, MPCB standards, Pollution Control Act, Policies	1
4.	Effect of pollutants on plant, animals, microorganisms in soil, and human beings	3
5.	Sewage and industrial effluents-definition, composition, properties and their extent	2
6.	Sewage and industrial effluents, their effect on soil, water and air and plants and human being, Microorganisms soil as sink for waste disposal their methods merits and demerits	2
7.	Pesticides definition, classification, degradation behaviour in soil, water and air. Their effect on soil properties and microorganisms	2
8.	Toxic elements in pollutants, their hazardous effects on plant growth, human health, effect on soil available elements, microbial population.	2
9.	Effect of pollutants on water resources due to leaching of nutrients and pesticides from soil.	1
10.	Effect of pollutants on emission of greenhouse gases, their extents, nature and effect on environment	2
11.	Use of improved techniques such as dilution, degradation, incineration, concentration, filtration, land disposal etc. nature and extents, merits and demerits	2
12.	Remote sensing definition, scope in agriculture, and its use in monitoring and management of soil and water pollution	1

Practical Schedule

Exercise No.	Topics to be covered
1	Visit to various industry to study the nature and impact on soil and plant
2, 3	Sampling of sewage water, sewage sludge soilid / liquid industrial waste, polluted soil and plant
4	Estimation of dissolved and suspended solids in liquid pollutant and pH, EC of solid samples
5, 6	Estimation of BOD (Biological) and COD (chemical oxygen demand) of liquid waste.
7, 8	Estimation of nitrate and ammonical nitrogen, phosphorus in sample
9, 10	Estimation of heavy metal in effluents
11, 12, 13	Estimation of heavy metals in soil and plants
14, 15	Management of contaminants in soil and plants to safe guard food safer
16	Collection of air sample
17	Determination of particulate matter in air samples
18	Determination of sulphur,NO_2 and O_2 in air sample

Suggested Reading

- Lal R, Kimble J, Levine E and Stewart BA.1995. Soil Management and Greenhouse Effect. CRC Press.
- Middlebrooks EJ.1979. Industrial Pollution Control. Vol.I .Agro-Industries .John Wiley Interscience.
- Ross SM. Toxic Metals in Soil Plant Systems .John Wiley & Sons.
- Vesilund PA and Pierce 1983. Environmental Pollution and Control. Ann Arbor Science Publ.
- A.K. Singh & Alka Tomar K.K. Singh, Asha Juwarka, 2007. Air, Water and Soil Pollution , Kalyani Publishers.
- Saha : Soil Pollution and Emerging Threat to Agriculture, 2018 Jain Books and Periodicals
- Soil Pollutions from monitoring to Remediation's By Duarte 2018 Jain Books and Perodicals



Course Title: Analytical Technique and Instrumental methods in Soil and Plant Analysis
Course Code: SOIL 510
Credit Hours: 2 (0+2)

Aim of the course

To familiarize the students with commonly used instruments–their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Practical

Unit I

Preparation of solutions for standard curves, indicators and standard solutions for acid- base, oXidation reduction and complex o metric titration; soil, water and plant sampling techniques, their processing and handling.

Unit II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Unit III

Principles of visible, ultra violet and infrared spectrophotometry, atomic absorption,flame- photometry, inductively coupled plasmaspectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometry; identification of minerals by X-ray by different methods, CHNS analyzer.

Unit IV

Electro chemical titration of clays; estimation of eXchangeable cations (Na, Ca, Mg, K); estimation of root cation eXchange capacity.

Unit V

Wet digestion/fusion/eXtraction of soil with aquaregia with soil for elemental analysis; triacid/ di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants

Unit VI

Drawing normalized eXchange isotherms; measurement of redoX potential. Teaching methods/activities Classroom teaching and laboratory practical's

Practical Schedule

Exercise No.	Name of Practical
1&2	Preparation of solutions for standard curves, indicators and standard solutions for acid-base; oxidation reduction and complex metric titration
3&4	Soil, water and plant sampling techniques, their processing and handling.
5	Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium.
6	Determination of phosphorus fixation capacities of soils.
7	Determination of ammonium fixation capacities of soils.
8	Determination of potassium fixation capacities of soils.

9 & 10	Principles of visible, ultra violet and infrared spectrophotometry,
11 & 12	Principles of atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery;
13 & 14	Identification of minerals by X-ray and by different methods.
15	Principles and application of CHNS analyzer.
16&17	Electro chemical titration of clays
18	Estimation of exchangeable cations (Na, Ca, Mg, K);
19	Estimation of root cation exchange capacity.
20	Wet digestion/fusion/ eXtraction of soil with aquaregia with soil for elemental analysis.
21	Estimation of available nitrogen from soil
22	Estimation of available phosphorus from soil
23	Estimation of available potassium from soil
24	Estimation of exchangeable Ca and Mg from soil
25	Estimation of available sulphur from soil
26	Estimation of DTPA extractable micronutrients from soil
27	Estimation of available boron from soil
28	Triacid / di-acid digestion of plant samples for analyzing nutrient content
29	Estimation of total nitrogen from plant sample
30	Estimation of total phosphorus from plant sample
31	Estimation of total potassium from plant sample
32	Estimation of total Ca and Mg from plant
33	Estimation of total sulphur from plant
34	Estimation of total Fe, Mn, Zn and Cu from plant
35&36	Drawing normalized exchange isotherms; measurement of redox potential.

Suggested Reading

- Tandon HLS.2017. Method of Analysis of Soils, Plants, Water, Fertilizers & Organic Manures. FDCO, New Delhi.
- Hesse P.971.Textbook of Soil Chemical Analysis .William Clowes & Sons.
- Jackson ML. 1967. Soil Chemical Analysis. Prentice Hall of India.
- Keith A Smith1991. Soil Analysis; Modern Instrumental Techniques. Marcel Dekker.
- Kenneth Helrich1990. Official Methods of Analysis. Association of Official Analytical Chemists.
- Page AL, Miller RH and Keeney DR.1982. Methods of Soil Analysis. PartII. SSSA, Madison.
- Piper CE. Soil and Plant Analysis. Hans Publ.
- Singh D, Chhonkar PK and Pandey RN.1999. Soil Plant Water Analysis-A Methods Manual. IARI, New Delhi.
- Tan KH.2003. Soil Sampling, Preparation and Analysis. CRC Press/ Taylor & Francis.
- Tandon HLS.1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
- Vogel AL. 1979. A Textbook of Quantitative Inorganic Analysis. ELBS Longman.

Course Title: Modern Concepts in Crop Production
Course Code: AGRON 501*
Credit Hours: 3+0

Aim of the course

To teach the basic concepts of soil management and crop production.

Theory

Unit I

Crop growth analysis in relation to environment; geo-ecological zones of India.

Unit II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Unit III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modelling for desired crop yield.

Unit IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

Unit V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture. Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on soil management and crop production

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Introduces crop growth analysis by explaining how plants accumulate biomass and how environmental factors shape growth.	2
2.	Covers major growth indices such as CGR, RGR, and NAR that help quantify productivity.	2
3.	Adds LAD, LAR, and SLA to understand leaf efficiency.	1
4.	Explains how light, temperature, moisture, and CO_2 influence crop performance.	1
5.	Discusses India's diverse geo-ecological regions and physiographic zones.	1

6.	Explains agro-ecological and agro-climatic zones and their cropping patterns.	1
7.	Introduces quantitative agro-biological principles governing yield formation.	1
8.	Describes the inverse yield–nitrogen law.	1
9.	Explains Mitscherlich's yield equation and nutrient efficiency constants.	1
10	Interprets the equation graphically and evaluates its practical applications.	2
11	Introduces the Baule unit, defining nutrient quantity needed for specific yield levels.	2
12	Compares different yield response models and their suitability for field use.	2
13	Begins lodging in cereals with causes such as wind, rain, and weak stems.	2
14	Highlights lodging effects on yield and strategies for reduction through strong-stem varieties and regulators.	2
15	Covers the physiology of grain yield through source–sink relationships.	1
16	Focuses on plant population and its influence on competition and yield.	1
17	Explains planting geometry and its role in light interception and disease reduction.	2
18	Describes ideal plant type concepts used in modern breeding.	1
19	Introduces crop modelling tools like DSSAT and APSIM for predicting crop performance.	2
20	Discusses scientific principles of crop production including limiting factors and resource efficiency.	2
21	Explains crop response production functions such as linear, quadratic, and diminishing models.	2
22	Describes soil–plant relations, nutrient uptake, and root–soil interactions.	2
23	Focuses on yield reduction under stresses like drought, heat, and salinity.	2
24	Explains roles of auxins, gibberellins, and cytokinins in growth regulation.	2
25	Covers ABA, ethylene, and their importance in stress adaptation.	2
26	Explains integrated farming systems and their components for sustainable income.	2
27	Focuses on organic farming concepts, principles, and certification.	2
28	Describes resource conservation technologies such as zero tillage, residue retention, and crop rotation.	2
29	Covers dry farming techniques and moisture conservation methods.	1
30	Explains nutrient needs, diagnosis, and the importance of balanced nutrition.	2
31	Covers integrated nutrient management combining fertilizers, organics, and biofertilizers.	2
32	Concludes with modern crop production concepts like hydroponics, aeroponics, vertical farming, robotic farming, and the use of GIS, GPS, and remote sensing in precision agriculture.	2

Suggested Reading

• Balasubramaniyan P and Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.

• Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.

• Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.

• Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.

• Sankaran S and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.

• Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.

• Alvin PT and kozlowski TT (ed.). 1976. *Ecophysiology of Tropical Crops*. Academia Pul., New York.

• Gardner PP, Pearce GR and Mitchell RL. 1985. *Physiology of Crop Plants*. Scientific Pub. Jodhpur.

• Wilsie CP. 1961. *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.



Course Title: Principal and Practices of Soil Fertility and Nutrient Management
Course Code: AGRON 502*
Credit Hours: 2+1

Aim of the course

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

Unit I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermincompost and residue wastes in crops.

Practical

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Computation of optimum and economic yield

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on soil fertility and management

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Soil fertility and productivity are fundamental concepts in crop production. Various factors affect soil fertility, including climate, parent material, and management practices. Good soil management ensures long-term sustainability of crop yields.	2
2.	Soil productivity refers to the capacity of soil to support plant growth. Several biological, chemical, and physical properties determine productivity. Sustainable practices help maintain productivity over time.	2
3.	Nutrient supply issues arise due to imbalanced fertilization and poor soil health. Availability of nutrients depends on soil pH, moisture, and organic matter content. Proper planning helps avoid deficiency and toxicity problems.	2
4.	The relationship between nutrient supply and crop growth is highly significant. Plants respond differently to varying levels of nutrients. Balanced nutrition ensures optimum growth and development.	1
5.	Organic farming is based on natural inputs and ecological balance. Definitions and concepts of organic farming emphasize sustainability and soil health. Use of organic inputs minimizes environmental damage.	2
6.	Essentiality criteria help identify nutrients required for plant growth. A nutrient is considered essential if its absence restricts growth and cannot be replaced by another element. Understanding essentiality helps in effective nutrient management.	2
7.	Plants require both macro and micronutrients for completion of their life cycle. Each nutrient performs specific functions in plant physiology. Proper supply prevents growth inhibition.	1
8.	Nutrient deficiency symptoms provide visual clues of imbalances. Different nutrients produce unique symptoms on leaves, stems, or roots. Timely diagnosis helps avoid yield loss.	1
9.	Transformation and dynamics of nutrients occur continuously in soil. Microbial activity, temperature, and moisture influence these processes. Understanding transformations helps improve fertilizer strategies.	1
10.	Farmyard manure is a common organic amendment in agriculture. Proper preparation and handling preserve its nutrient content. Application improves soil properties and crop yield.	1
11.	Compost is produced by controlled decomposition of organic waste. Use of compost enhances soil structure and nutrient availability. Modern composting techniques improve efficiency.	1
12.	Green manuring improves soil fertility through nitrogen fixation and organic matter addition. Legume crops are often used for green manure. Incorporation at proper stage provides maximum benefit	1
13.	Vermicompost is produced through earthworm activity. Vermicompost contains readily available nutrients for plants. Its application enhances soil biological activity.	1
14.	Biofertilizers contain living microorganisms that enhance nutrient availability. Their use reduces dependence on chemical fertilizers. Application methods determine their effectiveness.	1
15.	Recycling of organic wastes reduces environmental pollution. Residue management improves soil carbon and enhances productivity. Proper recycling conserves resources.	1

16.	Soil-less cultivation techniques allow plant growth without soil. Hydroponics and aeroponics are prominent methods. These systems ensure efficient use of water and nutrients.	1
17.	Commercial fertilizers provide concentrated nutrient sources. Their composition determines suitability for specific crops. Knowledge of fertilizer grades helps select correct products.	1
18.	Relative fertilizer value helps compare efficiency of different fertilizers. Cost analysis ensures economic application. Proper evaluation improves profitability.	1
19.	Crop response to nutrients varies according to soil and climate. Residual effects influence nutrient availability in subsequent crops. Fertilizer use efficiency measures performance of inputs.	2
20.	Agronomic, chemical, and physiological efficiencies are important indicators. These efficiencies determine how much nutrient is utilized by plants. Improvement measures enhance overall productivity.	2
21.	Fertilizer mixtures and grades provide balanced nutrition to crops. Customized blends address specific nutrient deficiencies. Their use reduces application effort.	2
22.	Nutrient interactions can be synergistic or antagonistic. Understanding interactions prevents hidden hunger and toxicity. Balanced application ensures proper growth.	1
23.	Timing of manure application influences nutrient availability. Methods such as broadcasting, band placement, and fertigation affect efficiency. Proper techniques improve uptake.	1
24.	Foliar application provides quick correction of nutrient deficiencies. This method is useful under stress conditions. Concentration and timing must be carefully managed.	2
25.	Integrated nutrient management combines organic and inorganic sources. Balanced nutrition enhances soil fertility and crop productivity. Use of vermicompost and residues reduces chemical load.	2
26.	Economics of fertilizer use determines profitability of farming. Cost-benefit analysis helps farmers choose appropriate nutrient strategies. Efficient management ensures sustainable production.	1

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	To determine soil pH for assessing soil acidity or alkalinity.	2
2.	To measure soil EC for identifying soil salinity status.	2
3.	To estimate soil organic carbon for evaluating soil fertility.	2
4.	To determine available nitrogen in soil for fertilizer recommendation.	1
5.	To estimate available phosphorus and potassium in soil for nutrient management.	2
6.	To determine available sulphur in soil for assessing sulphur requirement.	2
7.	To analyze total N, P, K, and S in soil for long-term fertility evaluation..	2
8.	To determine total N, P, K, and S in plant samples for nutrient uptake assessment.	2
9.	To compute optimum yield using graded fertilizer applications.	1
10.	To calculate economic yield and fertilizer use efficiency for profitable farming.	2

Suggested Reading

• Brady NC and Weil RR. 2002. *The Nature and Properties of Soils.* 13th Ed. Pearson Edu.

• Fageria NK, Baligar VC and Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker.

• Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.

• Prasad R and Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

• Yawalkar KS, Agrawal JP and Bokde S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.



Course Title: Principles and Practices of Water Management
Course Code: AGRON 504*
Credit Hours: 2+1

Aim of the course

To teach the principles of water management and practices to enhance the water productivity

Theory

Unit I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in of India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit II

Field water cycle, water movement in soil and plants; transpiration; soil-water plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and loses.

Unit III

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

UNIT IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

Unit VI

Quality of irrigation water and management of saline water for irrigation, water management in problem soils

Unit VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit VIII

Hydroponics,

Unit IX

Water management of crops under climate change scenario.

Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique

• Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus

• Determination of Hygroscopic Coefficient

• Determination of maximum water holding capacity of soil

• Measurement of matric potential using gauge and mercury type tensiometer

• Determination of soil-moisture characteristics curves

• Determination of saturated hydraulic conductivity by constant and falling head method

• Determination of hydraulic conductivity of saturated soil below the water table by auger hole method

• Measurement of soil water diffusivity

• Estimation of unsaturated hydraulic conductivity

• Estimation of upward flux of water using tensiometer and from depth ground water table

• Determination of irrigation requirement of crops (calculations)

• Determination of effective rainfall (calculations)

• Determination of ET of crops by soil moisture depletion method

• Determination of water requirements of crops

• Measurement of irrigation water by volume and velocity-area method

• Measurement of irrigation water by measuring devices and calculation of irrigation efficiency

• Determination of infiltration rate by double ring infiltrometer

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and field visit

Learning outcome

Basic knowledge on water management for optimization of crop yield

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lecture
1.	Water and its role in plants is discussed with emphasis on how water supports physiological and biochemical functions. Irrigation is explained through its definition and objectives, highlighting the importance of supplying adequate moisture for plant growth.	2
2.	Water resources of India and the concerned state are described in detail. The lecture covers how surface and groundwater resources contribute to irrigation development in different regions.	2
3.	Major irrigation projects of India are introduced along with their significance. The extent of irrigated area and the crops irrigated in India and various states is also explained for better understanding.	2
4.	The field water cycle is discussed, including processes such as infiltration, percolation, runoff and evaporation. Understanding these components helps in planning irrigation more scientifically.	2
5.	Water movement in soil and plants is covered along with the concept of transpiration. Soil-water-plant relationships are explained to understand how water moves from soil to plant tissues.	2

6.	Water absorption by plants is explained with physiological aspects. Plant response to water stress is discussed to understand how crops behave under moisture-deficit conditions.	2
7.	Crop plant adaptation to moisture stress conditions is described. The lecture also covers water availability and its relationship with nutrient availability and nutrient losses through leaching or runoff.	2
8.	Soil, plant and meteorological factors determining water needs of crops are introduced. These factors help in calculating accurate crop water requirement.	2
9.	Scheduling of irrigation and determining depth of irrigation are explained in detail. Different methods of irrigation are also introduced to understand which method suits which condition.	2
10.	Micro-irrigation systems such as drip and sprinkler irrigation are described. Concepts of deficit irrigation and fertigation are also included for modern water management.	1
11.	Management of water in controlled environments and polyhouses is explained. Irrigation efficiency and water use efficiency are discussed along with ways to improve them.	2
12.	Water management of different crops and cropping systems is covered. This includes how individual crops respond to water availability in various cropping patterns.	2
13.	Quality of irrigation water is studied along with methods of managing saline water used for irrigation. This is important for areas facing water quality problems.	1
14.	Water use efficiency is explained with practical examples. Crop water requirement is discussed along with the estimation of evapotranspiration (ET) and effective rainfall.	2
15.	Water management of major crops and cropping systems is elaborated. Automated irrigation systems are introduced to highlight modern irrigation technology.	1
16.	Excess soil water and its effect on plant growth are explained. Water management practices in problem soils are discussed to improve crop performance.	1
17.	Drainage requirements of crops are described, including different methods of field drainage. Layout and spacing of drainage systems are also introduced.	2
18.	Rainwater management and its utilization for crop production are discussed. Importance of capturing and storing rainwater in agriculture is highlighted.	2
19.	Soil moisture conservation practices are explained along with water harvesting methods. Rainwater management and its utilization for crop production are repeated here in detail as per given content.	2
20.	Hydroponics is introduced as a modern soilless cultivation method. This lecture focuses on its principles, advantages and role in future agriculture.	2

Practical Schedule

S. No.	Name of Topic	No. of Lecture
1.	Determination of Field Capacity by field method.	1
2.	Determination of Permanent Wilting Point by sunflower pot culture technique.	1
3.	Determination of Field Capacity and Permanent Wilting Point by Pressure Plate Apparatus.	2
4.	Determination of Hygroscopic Coefficient and Determination of maximum water holding capacity of soil.	1
5.	Measurement of matric potential using gauge and mercury type tensiometer.	1

6.	Determination of soil-moisture characteristics curves.	1
7.	Determination of saturated hydraulic conductivity by constant and falling head method.	1
8.	Determination of hydraulic conductivity of saturated soil below the water table by auger hole method.	2
9.	Measurement of soil water diffusivity and estimation of unsaturated hydraulic conductivity.	1
10.	Estimation of upward flux of water using tensiometer and from depth ground water table.	1
11.	Determination of irrigation requirement of crops (calculations).	1
12.	Determination of effective rainfall (calculations).	1
13.	Determination of ET of crops by soil moisture depletion method and determination of water requirements of crops.	1
14.	Measurement of irrigation water by volume and velocity-area method.	1
15.	Measurement of irrigation water by measuring devices and calculation of irrigation efficiency; Determination of infiltration rate by double ring infiltrometer.	2

Suggested Reading

• Majumdar DK. 2014. *Irrigation Water Management: Principles and Practice*. PHL Learning private publishers

• Mukund Joshi. 2013. *A Text Book of Irrigation and Water Management Hardcover*, Kalyani publishers

• Lenka D. 1999. *Irrigation and Drainage*. Kalyani.

• Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.

• Paliwal KV. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi.

• Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.

• Prihar SS and Sandhu BS. 1987. *Irrigation of Food Crops - Principles and Practices*. ICAR.

• Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

• Singh Pratap and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ.

Course Title: Principles of Vegetable Breeding
Course Code: HORT 506
Credit Hours: 3 (2+1)

Theory

Unit I: Importance and history- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.

Unit II: Selection procedures- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests, and nematode), abiotic stress (temperature, moisture, and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).

Unit III: Heterosis breeding- Types, mechanisms, and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility, and sex forms.

Unit IV: Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.

Unit V: Ideotype breeding- Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of In-vitro and molecular techniques in vegetable improvement.

Practical

Floral biology and pollination behaviour of different vegetables; Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.; Breeding system and handling of filial generations of different vegetables; Exposure to biotechnological lab practices; Visit to breeding farms.

Theory Lecture Schedule

Sr. No.	Name of Topic	No. of Lectures
1	Introduction to vegetable breeding—scope & significance; Historical development of vegetable breeding	1
2	Evolutionary aspects of vegetable crops; Vegetable vs. cereal crop breeding; Achievements & future prospects in vegetable breeding	1
3	Techniques of selfing & crossing—principles; Selfing: methods, precautions, applications; Controlled crossing techniques	1
4	Breeding systems in vegetables	1
5	Mass, progeny & pure-line selection	1
6	Hybridization: objectives, steps, types	2
7	Genetic architecture of vegetable crops	1
8	Breeding for biotic stress diseases resistance insect-pest & nematode resistance	4
9	Breeding for abiotic stress—temperature tolerance moisture & salt tolerance	2
10	Breeding for quality improvement	1
11	Breeding for water-use efficiency (WUE)	1
12	Breeding for nutrient-use efficiency (NUE)	1
13	Concept, types & genetic basis of heterosis; Mechanisms underlying heterosis	2
14	Hybrid breeding in vegetables	1

15	Role of male sterility systems	2
16	Self-incompatibility in hybrid seed production	2
17	Sex forms and their role in heterosis breeding	1
18	Mutation breeding—concept, mutagens, procedures, Applications of mutation breeding in vegetables	2
19	Polyploidy—types & induction, Role of polyploidy in vegetable improvement	1
20	Breeding asexually propagated vegetables for protected cultivation	2
21	Ideotype breeding—concept & principles	1
22	Designing ideotypes for vegetable crops	1
23	Varietal release procedures	1
24	DUS testing in vegetables	1
25	In-vitro techniques in vegetable improvement	1
26	Molecular techniques in vegetable breeding	1

Practical Schedule

Sr. No.	Name of Topic	No. of Practical
1	Floral biology & pollination behavior of different vegetables	1
2	Techniques of selfing and crossing in Cole crops	2
3	Techniques of selfing and crossing in okra	1
4	Techniques of selfing and crossing in cucurbits	1
5	Techniques of selfing and crossing in tomato	1
6	Techniques of selfing and crossing in eggplant	1
7	Techniques of selfing and crossing in hot pepper	1
8	Breeding systems in vegetables	1
9	Handling of filial generations	1
10	Exposure to biotechnological lab practices	1
11	Visit to breeding farms	1

Suggested Reading

- Allard RW. 1960. Principle of plant breeding. John Willey and Sons, USA.
- Kalloo G. 1988. Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA.
- Kole CR. 2007. Genome mapping and molecular breeding in plants-vegetables. Springer, USA.
- Peter KV and Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p. 488.
- Prohens J and Nuez F. 2007. Handbook of plant breeding-vegetables (Vol I and II). Springer, USA.
- Singh BD. 2007. Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi.
- Singh Ram J. 2007. Genetic resources, chromosome engineering, and crop improvement-vegetable crops (Vol. 3). CRC Press, Fl, USA.

Course Title: Experimental Designs
Course Code: AST 501
Credit Hours: 3 (2+1)

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.

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.

Theory Lecture Schedule

S. No.	Name of Topic	No. of Lectures
1	Need for designing experiments – introduction, Importance of proper experimental design, Characteristics of a good design	2
2	Basic principles of designs- Randomization, Replication and Local control	1
3	Uniformity trials – purpose & procedure Size and shape of plots and blocks	1
4	ANOVA- Analysis of variance	2
5	CRD –Completely randomized design,	2
6	RBD – Randomized block design	2
7	LSD – Latin square design	2
8	Factorial experiments (Symmetrical factorials and Asymmetrical factorials)	2
9	Orthogonality – concept & importance	1
10	Partitioning degrees of freedom	1
11	Concept of confounding	2
12	Split-plot design	1
13	Strip-plot design	1
14	ANCOVA – Analysis of covariance	2
15	Missing plot techniques in RBD	2
16	Missing plot techniques in LSD	2
17	Transformations	2
18	Balanced Incomplete Block Design	1
19	Resolvable designs and their applications	1

20	Lattice designs & Alpha design - concepts, randomization procedure, analysis and interpretation of results	4
21	Response surface methodology	1
22	Combined analysis	1

Practical Schedule

S. No.	Name of Exercise	No. of Lectures
1	Uniformity trial data analysis,	2
2	Formation of plots and blocks,	2
3	Fairfield Smith's Law	2
4	Analysis of data obtained from Completely Randomized Design (CRD)	2
5	Analysis of data obtained from Randomized Block Design (RBD)	2
6	Analysis of data obtained from Latin Square Design (LSD)	2
7	Analysis of factorial experiments	2
8	Analysis with missing data	2
9	Split plot and strip plot designs	2

Suggested Reading

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

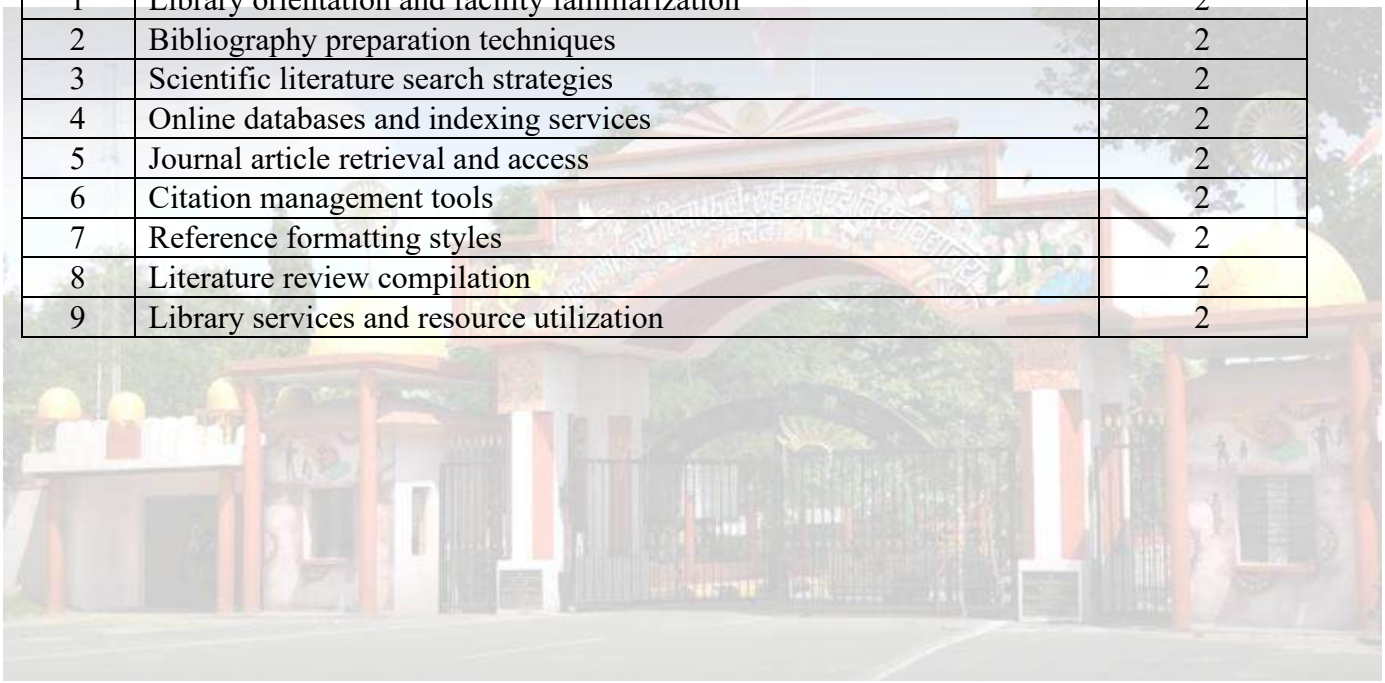
Course Title: Library and Information Services
Course Code: PGS 501
Credit Hours: 1 (0+1)

Practical

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

PRACTICAL SCHEDULE

S. No.	Name of Topic	No. of Practical
1	Library orientation and facility familiarization	2
2	Bibliography preparation techniques	2
3	Scientific literature search strategies	2
4	Online databases and indexing services	2
5	Journal article retrieval and access	2
6	Citation management tools	2
7	Reference formatting styles	2
8	Literature review compilation	2
9	Library services and resource utilization	2



Course Title: Technical Writing and Communication Skills
Course Code: PGS 502
Credit Hours: 1 (0+1)

Practical (Technical Writing)

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

PRACTICAL SCHEDULE

Sr. No.	Name of Topic	No. of Lecture
1.	Covers the meaning, purpose and importance of scientific writing, including theses, dissertations, technical papers, manuals, reports, and review articles. Introduces how each form serves a different scientific objective.	1
2.	Explains research notes, short communications, popular articles, bulletins, monographs, and extension leaflets, describing when and why each is written in the scientific community.	1
3.	Discusses the title page, authorship details, certification, declaration, acknowledgments, contents page, and formatting standards used in thesis writing.	1
4.	Explains major thesis components such as the introduction, review of literature, materials and methods, results, discussion, summary, references, and appendices.	1
5.	Covers the format of research papers including the title, abstract, keywords, introduction, methodology, results, discussion, conclusion, references, and author contributions.	1
6.	Explains how to write effective abstracts, concise summaries, and well-structured précis, including length, style, purpose, and evaluation criteria.	1
7.	Covers citation styles (APA, MLA, Chicago, JRF, ICAR), in-text citations, reference lists, footnotes, and commonly used abbreviations in theses and research articles.	1
8.	Explains how to use photographs, graphs, charts, maps, and scientific drawings with appropriate captions, legends, resolutions, and placement guidelines.	1
9.	Describes rules for table numbering, figure numbering, page numbering (Roman & Arabic), table titles, footnotes, and alignment in scientific documents.	1
10	Covers rules for writing numeric data, units (SI units), measurements, formulas, equations, and scientific dates following international writing standards.	1

11	Teaches proofreading marks, identifying typographical, grammatical, logical, and formatting errors, and using checklists for editing scientific content.	1
12	Explains how to choose a topic, search literature, structure sections, synthesize findings, compare studies, and write high-quality review papers.	1
13	Covers basic grammar essentials including tense forms, verb agreement, noun forms, pronouns, adverbs, clauses, and correct sentence structure.	1
14	Explains punctuation marks, subject–verb agreement (concord), commonly misused word combinations (collocations), and how they affect scientific writing.	1
15	Focuses on spelling errors, redundancy, run-on sentences, misplaced modifiers, incorrect prepositions, and other frequently occurring writing problems.	1
16	Introduces phonetic symbols (IPA), stress patterns, weak forms in connected speech, and pronunciation techniques important for oral scientific communication.	1
17	Covers participation techniques for group discussions, confidence building, questioning strategies, and handling academic or job interviews effectively.	1
18	Explains preparing PPTs, slide design, sequence of presentation, verbal and non-verbal communication, answering audience questions, and professional presentation ethics.	1

Suggested Readings

- Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
- Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
- Collins' Cobuild English Dictionary. 1995.
- Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.
- Holt, Rinehart, and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
- James HS. 1994. Handbook for Technical Writing. NTC Business Books.
- Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
- Mohan K. 2005. Speaking English Effectively. MacMillan India.
- Richard WS. 1969. Technical Writing.
- Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
- Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

Course Title: Intellectual Property and Its Management in Agriculture
Course Code: PGS 503
Credit Hours: 1 (1+0)

Theory

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

THEORY SCHEDULE

S. No.	Name of Topic	No. of Lectures
1	Intellectual property concepts and definitions	2
2	Patents: types and filing procedures	2
3	Plant varieties protection	2
4	Trade secrets and confidential information	1
5	Copyright and trademark in agriculture	2
6	Licensing and technology transfer	2
7	IPR in biotechnology and agriculture	2
8	Management of research outputs	2
9	Agricultural policies and regulations	1

Suggested Readings

- Erbisch, F. H. and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli, P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
- Rothschild, M. and Scott, N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- Saha, R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

Course Title: Basic Concepts in Laboratory Techniques
Course Code: PGS 504
Credit Hours: 1 (0+1)

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, sand bath, water bath, oil bath; 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.

PRACTICAL SCHEDULE

S. No.	Name of Topic	No. of Practicals
1	Laboratory safety and hazard management	2
2	Personal protective equipment (PPE)	2
3	Laboratory equipment identification and use	2
4	Measurement and precision techniques	2
5	Weighing and volumetric glassware	2
6	Solution preparation and standardization	2
7	Basic chemistry and biochemistry techniques	2
8	Microscopy and observation techniques	2
9	Laboratory record keeping and documentation	2

Suggested Readings

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

Course Title: Agriculture Research, Research Ethics and Rural Development Program
Course Code: PGS 505
Credit Hours: 1 (1+0)

Theory

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

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

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

THEORY SCHEDULE

S. No.	Name of Topic	No. of Lectures
1	Research ethics principles and guidelines	2
2	Informed consent and research participant rights	2
3	Research misconduct and plagiarism	2
4	Ethical issues in genetic research	2
5	Institutional Review Board (IRB) procedures	1
6	Data management and confidentiality	2
7	Rural development and agriculture	2
8	Sustainable agriculture practices	2
9	Community engagement and extension services	1

Suggested Readings

- Bhalla, G.S. and Singh, G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
- Punia, M.S. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.
- Rao, B.S.V. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations, and Initiatives. Mittal Publ.
- Singh, K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.