COMMON REGULATIONS TO ALL PH.D. DEGREE PROGRAMMES OF

FACULTY OF AGRICULTURE

(FULL-TIME / PART-TIME / EXTERNAL)

(2019-2020)

REGULATIONS

1. SYSTEM OF EDUCATION

1.1 These rules and regulations shall govern the Ph.D. Programmes leading to the award of Degree of Doctor of Philosophy in the concerned subject in the Faculty of Agriculture, Annamalai University. They shall come into force with effect from the academic year 2019-2020.

1.2 The semester system shall be followed for all the Ph.D. degree programmes.

1.3 The duration of doctoral programmes is as follows:

Programme	Minimum Years	Maximum Years
Full Time	3	5
Part Time / External	4	6

2. DEFINITIONS

2.1 An "Academic year" shall consists of two semesters.

2.2 "Semester" means an academic term consisting of 105 instructional days excluding final theory examinations.

2.3 "Course" means a unit of instruction to be covered in a semester having specific No., title and credits.

2.4 "Credit hour" means, one hour lecture plus two hours of library or home work or two and half hours of library/field practicals per week in a semester.

2.5 'Credit load' of a student during a semester is the total number of credits registered by that student during that particular semester.

2.6 'Grade Point' of a course means the value obtained by dividing the percentage of marks earned in a course by 10 and the Grade Point is expressed on a 10 point scale and rounded off to two decimal places.

2.7 'Credit Point' means the grade point multiplied by corresponding credit hours.

2.8 'Grade Point Average'(GPA) means the quotient of the total credit points obtained by a student in various courses at the end of each semester, divided by the total credit hours taken by the student in that semester. The grading is done on a 10 scale and the GPA has to be corrected to two decimals.

2.9 'Overall Grade Point Average' (OGPA) means the quotient of cumulative credit points obtained by a student in all the courses taken from the beginning of the first semester of the year divided by the total credit hours of all the subjects which he / she had completed up to the end of a specified semester and determines the overall performance of a student in all subjects during the period covering more than one semester. The OGPA has to be arrived at the second decimal place.

3. PROGRAMMES OFFERED

The details of various Ph.D. programmes offered in the Faculty of Agriculture are as follows:

Agrl. Business Management
Agrl. Economics
Agrl. Entomology
Agrl. Extension
Agrl. Microbiology
Agrl. Biotechnology
Agronomy
Genetics and Plant Breeding
Horticulture
Plant Pathology
Seed Science & Technology
Soil Science and Agrl. Chemistry

4. ELIGIBILITY FOR ADMISSION

Candidates seeking admission to Ph.D. programme should satisfy the following requirements.

4.1 Candidates with two year master's degree programmes from Universities recognized by Annamalai University are eligible to apply for Ph.D. programmes of the university (Table 1).

4.2 Candidates who have undergone the programme under conventional system should possess not less than a second class Master's degree. The candidates under trimester system should possess a minimum OGPA of 3.00 out of 4.00. For those under semester system 7.00 out of 10.00 is required for various Doctoral programmes. However, this will not apply to SC/ ST candidates, nominees of State Government / Annamalai University / ICAR / and Government of India for whom a pass in the concerned degree is sufficient.

Table – 1: Eligibility Criteria

Doctoral Degree Programmes	Eligibility
1. Agrl. Business Management	MBA in Agribusiness
2. Agrl. Economics	M.Sc.(Ag.) in Agrl. Economics/ Agrl. Marketing Management.
3. Agrl. Entomology	M.Sc.(Ag.) in Entomology
4. Agrl. Extension	M.Sc.(Ag.) in Agrl. Extension
5. Agrl. Microbiology	M.Sc.(Ag.) in Agrl. Microbiology
6. Agrl. Biotechnology	M.Sc.(Ag.) in Genetics and Plant Breeding / Agrl. Biotechnology
7. Agronomy	M.Sc.(Ag.) in Agronomy
8. Genetics and Plant Breeding	M.Sc.(Ag.) in Genetics and Plant Breeding
9. Horticulture	M.Sc (Ag.) Hort. / M.Sc. (Hort.) /M.Sc. (Hort.) in Fruit Science / Vegetable Science/Floriculture and Landscape Gardening or Architecture / Plantation, Spices, Medicinal and Aromatic Crops
10. Plant Pathology	M.Sc.(Ag.) in Plant Pathology
11. Seed Science & Technology	M.Sc.(Ag.) in Seed Science & Technology
12. Soil Science and Agrl. Chemistry	M.Sc.(Ag.) in Soil Science and Agrl. Chemistry

4.3 Full time programme:

All full time research scholars shall undergo course work for two semesters as prescribed by the Department. Duration of the programe will be for three years.

4.4 Part Time Programme

The part time programme will be offered to the in-service candidates / Research Scholars of projects of Annamalai University. The candidates of this University should route their application through HOD and Dean, Faculty of Agriculture. The duration of the programme will be of 4 years. The in-service candidates / Research Scholars of projects of Annamalai University will be permitted to register the Ph.D. programme by course work and they have to undergo one year course work by utilizing any eligible leave for that period.

4.5. External Registration

The duration of the programme will be of 4 years. The following are the additional conditions for registration for a Ph.D. programme under external category

1. The candidates must register under a research supervisor who is a member of the Teaching Faculty of this University
2. The candidate should be working as Asst. Professor/Associate Professor/Professor or in equivalent positions on permanent basis in a recognized college where facilities for carrying out research work are available and have post graduate departments for Agrl. subjects or working as research assistants in private or government institutions having research and development facilities and who fulfill the eligibility conditions.
3. The candidate should have a recognized co-supervisor in parent department of the organization. The co- supervisor may be from other colleges / organization located from the same place if such persons are not available in the parental organizations.
4. The candidate shall undergo the course of the required credits during I year of the programme in Annamalai University Campus. He / She shall carryout the research at his / her parental organization for the entire of period of the programme.
5. NOC (No Objection Certificate) is to be produced from the employer of the institution / Organization where he / she is working and attached along with the application ii. Co-supervisor acceptance letter should be also be enclosed with the application form.

5. SELECTION PROCEDURE

A candidate who wishes to undertake Ph.D. programme of this University either full time or part time or external registration should apply in the prescribed form on or before the due date.

Applications which fulfil the above conditions (mentioned in the Prospectus) will be scrutinized by a Departmental Research Committee consisting of the Head of the Department (Coordinator), two Professors, one senior Associate Professor and one senior Assistant Professor (not more than five). Eligible candidates will have to appear for entrance test and interview on the dates specified by the University. The selection of the candidates shall be based on marks obtained in the qualifying degree, a written

test and an interview. The weightage for Qualifying Degree Examination will be given for 50 marks. The written test shall comprise objective type questions and examine research aptitude, grasp of the subject, intellectual ability and general knowledge of the prospective candidates. The question paper for the written test shall be prepared for one hour duration. Question papers will be set and evaluated by the DRC for 25 marks. The interview will be conducted for 25 marks. The cut off marks for the selection shall be fixed as 50 percent. NET qualified candidates are exempted from the entrance test, but they have to appear for the interview. The minutes of the DRC together with the recommendation will be placed before the Vice-Chancellor who in consultation with the Dean of the Faculty and Head of the Department will select and admit the applicant to work under the guide proposed.

6. CREDIT GRADE POINT REQUIREMENTS

6.1. A student enrolled for Doctoral program to become eligible for the degree is required to complete 75 credits inclusive of 45 credits of research as detailed below

Sl.No.	Details	Credit Hours
1.	Major-Courses	15
2.	Minor-Courses	8
3.	Supporting-Courses	5
4.	Seminar	2
5.	Research	45
	Total	75

6.2. In a semester, a full time Ph.D. student can register a maximum of 15 credits excluding research. However, the research credits registered should not exceed 12 per semester. Semester wise distribution of credits are given in the respective Ph.D., programmes. The total research credits for PT and EXT candidates should be distributed in all the eight semesters. The Ph.D. students (FT/PT/EXT) should complete their course work within two semesters in the first year in Annamalai University campus.

6.3. Requirements for Ph.D. programme shall also include successful completion of thesis research in the major field of study and submission of thesis thereon.

7. ATTENDANCE REQUIREMENT

7.1. "One hundred percent attendance is expected from each scholar. A student who fails to secure 80 per cent of attendance in each subject separately for theory and practical, shall not be permitted to appear for the final examination in that subject and shall be awarded 'E' (incomplete) and will be required to repeat the subject when ever offered.

7.2. In respect of the student who has absented himself / herself for classes with or without valid reasons, that period will be treated as absence only and not as leave. Also, no attendance will be given for writing make up tests.

7.3 In case of new admission, for calculating 80 percent attendance in the first semester, the number of working days will be calculated from the date of joining of the students who are permitted to join late due to administrative reasons.

However, for genuine reasons, condonation of attendance deficiency may be considered by the Vice - chancellor on the recommendation of the Advisory committee, HOD and Dean, Faculty of Agriculture on payment of condonation fee prescribed by the university.

7.4 Students absenting from the classes with prior permission of the HOD on official University business shall be given due consideration in computing attendance.

7.5. In respect of students who had absented for the mid-semester examination on University business with prior permission of the HOD and Dean, Faculty of Agriculture, the make up mid-semester examination should be conducted ordinarily within 15 working days from the date of conduct of the mid-semester examination.

7.6. The students who absent himself/herself for mid-semester examination in a subject on genuine reasons shall be permitted on the recommendation of the course teacher / Research Supervisor and Head of the Department concerned. Missing examination should be completed within 15 working days from the date of respective examination on payment of missing examination fee prescribed by the university.

7.7 An employee of the University admitted to the programme leading to the Ph.D. Degree as a part-time internal candidate in accordance with these ordinances shall be required to work for a minimum period of 30 days per annum during the period of research. They shall carry out research work without affecting their regular duty.

7.8 External scholars are required to mark attendance maintained by the research supervisor/co-supervisor for a minimum compulsory period of 30 days per annum during their period of research.

7.9 External scholars are required to visit Annamalai University campus at the end of every year on a specified date to appear before the Research Advisory Committee (RAC) for review of the progress of their research work.

7.10 The attendance certificate signed by the research supervisor/co-Supervisor shall be sent to the Director, CARE through the respective Head of the Department and the Dean at the time of submission of the Synopsis.

8. RESEARCH ADVISORY COMMITTEE (RAC)

8.1. Each Ph.D. scholar shall have an RAC to guide the student in carrying out his/her programme. A Research Advisory Committee shall be constituted with the approval of the University for each candidate (full-time, part-time and external) separately, immediately after his/her admission. The purpose of the RAC is to provide expert opinion on frontline research. The Research Advisory Committee shall consist of the Head of the Department or a Professor nominated by the Vice-Chancellor as the Chairperson, the Research Supervisor as the Convener, and two members who are experts in the field nominated by the Vice-Chancellor (one member from the same Department, and the other member from another related Department of our University/another University in Tamil Nadu/other states. The research supervisor in consultation with the HOD will propose the other three members.

8.1.1. Research Supervisor

Every student shall have a research supervisor (among the recognized guides), who will be appointed by the Vice-Chancellor on the recommendation of the Head

of the Department and the Dean, Faculty of Agriculture. Research supervisors approved by the Vice-Chancellor only can be the guide for the students. A teacher having Ph.D with 5 years service and PG teaching is eligible for teaching and guiding Ph.D programme. A teacher should have a minimum of three years of service before retirement for allotment of doctoral candidates. The research supervisors who wish to avail leave/lien/deputation beyond a period of six months shall propose a Co-supervisor in the concerned subject for the candidates registered with them and it may be intimated to the University well in advance. The final approval of the proposal rests with the Vice-Chancellor. For external candidate, a Co-supervisor from his/her parental organization will be the Co-Chairman of the Advisory Committee.

8.1.2. Functions of the RAC

The Research Advisory Committee shall have the following functions:

1. Discuss, advice and recommend on all matters connected with the candidate's research from admission till the submission of the thesis.
2. Approve the topic of research and the synopsis.
3. Assess and approve the progress reports of Ph.D. students in the prescribed format and to report to the University on the fitness or otherwise of the candidate to proceed with his/her research work for the Ph.D.
4. If necessary, recommend and approve change of title of dissertation/Thesis, change of research supervisor and status of Researcher (full time to part time and vice-versa)
5. Conduct and supervise the presentation by the candidate of the final draft of his/her proposed thesis for approval before the submission of synopsis of the thesis to the University and to give a certificate to this effect to be submitted along with the synopsis.

8.1.3. The Research Advisory Committee will meet once in six months:

- to scrutinize the research proposal / progress report submitted by the candidate
- to assess the conduct of experiments/field work, peruse laboratory notebooks, data recording, analysis, and publication
- to review and endorse the annual progress report of the candidate.
- to approve the synopsis of the thesis.

The convener will convene the Research Advisory Committee meetings with intimation to the Director, CARE.

8.2. Changes in RAC

The proposals for changes in the RAC is to be sent to the Director, CARE, through HOD and Dean for approval, if it is keenly felt that such changes are absolutely necessary.

8.3. Change of Research Supervisor

8.3.1 Change of research supervisor shall not be permitted as a routine. In exceptional cases, such change may be permitted, if valid reasons are provided by the candidates. The Committee headed by the Vice-Chancellor shall look into the request of the petitioner, if there is any conflict between the scholar and the research supervisor. The research supervisor under whom the scholar has originally registered shall give a "No Objection Certificate" and the new proposed Research Supervisor should give a "Certificate of Willingness" to guide the candidate. The final decision will rest with the University. However, the Vice-

Chancellor, on the recommendation of the RAC and Dean's Committee, has the right to assign a new research supervisor to the research scholar.

8.3.2 When the change of Research Supervisor is approved, the candidate shall work for a minimum of one year with the new Research Supervisor if the topic of his/her research is different under the new supervisor, provided he/she fulfils the attendance requirements.

8.4 Change of Topic of Research

8.4.1 Change of the specific area of research may be permitted within one year from the date of admission and request must be submitted with the recommendations of the RAC. In such cases, the minutes of the RAC meeting must include whether the course work undertaken by the candidate is relevant to the new research area and the competence of the research supervisor in this field.

8.4.2 If the RAC is of the view that there is a major change in the specific area of research and is not relevant to the course work undertaken, the candidates will have to go through the process of fresh examination pertaining to the area of research.

8.5. Absence of member during qualifying / final Viva-Voce examination

Under extra-ordinary circumstances if the qualifying/ final viva-voce examination to Ph.D. student has to be conducted in the absence of one or two RAC members, permission to conduct the examination by co-opting another member in such contingencies should be obtained from the Director, CARE in advance.

9. EVALUATION OF STUDENT'S PERFORMANCE

All students shall abide by the rules for evaluating the course work under the semester system of education, as prescribed from time to time by the university.

9.1. Examinations

There will be two examinations viz. mid semester and final examination. Wherever the course has practical, there will be a final practical examination also.

9.2. Grading

- The duration of mid semester examination will be of one hour and final examinations in theory and practical will be conducted for three hours each.
- The mid semester examinations will be conducted by course teachers during the ninth week of the semester as per the scheme drawn by HOD, evaluate and send the marks obtained by the students to the Director, CARE through HOD within seven working days.
- There will be final examination separately for theory and practical which will be conducted by the University. Each final theory and practical examinations will be evaluated by two examiners (one will be the course teacher and another will be the senior faculty of the Department).
- The distribution of marks will be as indicated below:

S.No	Examination	Course with practical	Course without practical	Course without theory
1	Mid-semester	30	30	30
2	Final theory	40	70	-
3	Final practical	30	-	70
	Total	**100**	**100**	**100**

The question paper model and distribution of marks for mid semester and final theory examinations are as follows.

Mid semester :

1	Objective Type	10 out of 12	(10 x 0.5)	5 marks
2	Definitions/concepts	5 out of 7	(5 x 1)	5 marks
3.	Short notes	5 out of 7	(5 x 2)	10 marks
4	Essay type	2 out of 3	(2x5)	10 marks

Final Theory:

Courses without practicals (70 marks)

1.	Short notes	5 out of 7	(5 x 4)	20 marks
2	Essay type	5 out of 7	(5 x 10)	50 marks

Courses with practicals (40 marks)

1.	Short notes	5 out of 7	(5 x2)	10 marks
2	Essay type	5 out of 7	(5 x 6)	30 marks

9.3. Minimum Marks for Pass

a) The student should secure a minimum of 60 per cent marks separately in the theory and practical and an aggregate of 70 per cent to secure a pass in the subject .

b) Each subject shall carry a maximum of 100 marks for purpose of grading. The grading will be done as grade point. i.e., the percentage of marks earned in a subject is divided by 10. The grade point is expressed on a 10 point scale upto two decimals.

c) Students who secure marks below 70 per cent in a subject will be awarded 'F' grade and students without having the required minimum attendance of 80 per cent will not be allowed to write the final examination and they will be awarded 'E' grade. Students who secure 'F' grade should appear for re-examination in the subsequent semester.

d) If a student secured 'E' grade, he/she has to re-register and attend the course again during the next academic year.

9.4. Minimum GPA Requirement

A Ph.D student to continue his/her studies in the University, should maintain certain minimum Average Grade Point prescribed here under:

a) Earn a Grade Point of 7.00 for a pass in each subject.

b) For purpose of continuing as a student in the university, a candidate is required to earn an Overall Grade Point Average of not less than 7.50 at the end of each semester

c) A Ph.D. student may repeat the course(s) in which he/she gets a Grade point below 7.50 and above 7.0 to improve the OGPA.

9.5. Re-Examination

Re-examination is permitted only for the final theory and practical examinations. The students who secure 'F' grade are permitted to write the re-examinations as and when conducted with the permission of university. The re-examination fee as prescribed by university per course is to be paid on or before the prescribed date. A student is permitted to write the final theory and practical examinations only two times during the course period of three years excluding the regular final examination. In the event of a student who fails to secure a pass in the two re-examinations permitted, he/she has to re-register

for the course along with juniors. The marks secured in mid semester examination will be retained and the student should produce the practical record during re-examination. The registration for the re-examination shall be done after mid-semester examination on the date specified by the Director, CARE. Each registration is considered as an attempt even if the student absents for the examination.

9.6. Return Of Valued Answer Papers

The valued answer papers of mid-semester shall be shown to the students after the examination. Discrepancies if any, in awarding marks, the student can approach the teacher concerned immediately for rectification. The answer paper should be retained with the course teacher for six months and then disposed off. Evaluated final theory papers have to be retained up to six months by the Director, CARE after the conduct of examination and then disposed off.

10. CREDIT SEMINAR

Seminar is compulsory for all students and each student should register and present two seminars each with 0+1 credits. A student can register only one seminar in a semester and only after successful completion of the first seminar the student is permitted to register for the second seminar.

10.1. Credit Seminar Topic

10.1.1 The seminar topic should be only from the major field and should not be related to the area of thesis research.

10.1.2 The seminar topics are to be assigned to the students by the research supervisor in consultation with HOD within three weeks after commencement of the semester.

10.1.3. Under the guidance and supervision of the research supervisor of the RAC, the student should prepare a seminar paper containing not less than 50 typed and printed pages with a minimum number of 75 references covering the recent 10 years time after reviewing all the available literature and present the seminar after completion of 80% attendance in the semester in the presence of the HOD, RAC, staff and post-graduate students of the concerned department.

10.1.4. The circular on the presentation of the seminars may be sent to other Departments to enable those interested to attend the same.

10.1.5. The research supervisor will monitor the progress of the preparation of the seminar and correct the manuscript. The student will submit 2 copies of the corrected manuscript to the HOD through chairman before presentation.

The student will incorporate the suggestions and carry out corrections made during the presentation and resubmit three fair copies to the HOD (one to Dept. library, the second to the research supervisor and the third for student) within 15 days after presentation.

10.1.6. The performance of the student in the credit seminar will be evaluated and grade point awarded by the HOD along with the RAC for 100 marks. Grade Point may be given based on the following norms:

Details	Marks
Coverage of literature	40
Presentation	30
Use of audio visual aids	10

Capacity to participate in discussion and answer the questions	20
Total	100

11. QUALIFYING EXAMINATION

Only those students who successfully complete the qualifying examination will be admitted to candidacy of the degree. The qualifying examination consists of written and oral examination.

11.1. Minimum requirement for Qualifying Examination

The students who have completed all the courses and earned a grade point average of not less than 7.5 will be permitted to appear for the qualifying examination. Students who do not satisfy these requirements shall not be permitted to take up the qualifying examination. The qualifying examination will be conducted after the completion of course work.

11.2. Selection of Examiner

A panel of five external examiners for qualifying examinations shall be given by the RAC in consultation with HOD before three months of the date of completion of the student's course work to the Director, CARE. One of them will be appointed as external examiner.

11.3. Written Examination

The written examination consists of two papers covering major and minor subjects only. The Director, CARE will conduct the examination by obtaining the question paper from Head of Department to be prepared in consultation with the course teachers concerned.

The question paper for the written examination will be of 3 hours duration and each question (Essay type) need not be restricted to any particular topic in a course but it should be a comprehensive covering of each unit of the syllabus of each course. The written examinations will be conducted at the same time in all disciplines. The answer papers will be evaluated by the research supervisor and Head of the Department or a senior faculty nominated by the Head of the Department. Qualifying marks for passing the examination will be 60. The viva-voce will be conducted by the external examiner after the candidates passes the qualify examination.

11.4. Qualifying viva-voce Examination

The RAC shall conduct the qualifying viva-voce examination with one external member who shall be a specialist in the subject from outside the university

11.5. The Heads of Departments will monitor and coordinate the conduct of the qualifying viva. The performance of the candidate will be graded as Satisfactory / Unsatisfactory.

11.6. Communication of Results of Qualifying Examination

The research supervisor shall act as chairman for the examination committee and shall be responsible for communicating the results of the examination to the Controller of Examination through HOD in the prescribed format.

11.7. Failure /Absence in Qualifying Examination

When a student fails or absents for the qualifying examination, he/she may apply again for permission to appear for re-examination to the Controller of Examination with the recommendation of the chairman of the RAC and Head of the Department. A student, who applies for re-examination should attend

written examination and viva-voce. Re-examination shall not take place earlier than three months after the first examination and it will be conducted by the advisory committee as previously indicated. If a student fails in the re-examination, further re-examination will be considered on the recommendation of the RAC, HOD and Dean, Faculty of Agriculture.

If the students fail in the qualifying examination, he / she is not permitted to register for further research credits.

12. THESIS RESEARCH

12.1. Selection of Topic

The thesis research for the Ph.D. degree should be of the nature of a definite contribution to the subject and the results should be of sufficient importance to merit publication. The findings should have some practical utility or should lead to theoretical contribution. The thesis shall be on a topic falling within the field of the major specialization and shall be the result of the student's own work. A certificate to this effect duly endorsed by the major advisor shall accompany the thesis.

12.2. Research Proposal

The research scholars shall present their broad area of research and submit a proposal to the Research Advisory Committee at the end of the first semester. The research proposal has to be presented by the student in a meeting organized by the Head of the department to get the opinion / suggestion of the scientists of the department for improving it. Three copies of the research proposal in the prescribed format should be sent to the Director (CARE) through the Head of the Department for approval

The distribution of research credit will be as follows

Semester	Credit Hours
I Semester	0+1
II Semester	0+2
III Semester	0+12
IV Semester	0+12
V Semester	0+9
VI Semester	0+9
Total	0+45

The total research credits for PT and EXT candidates should be distributed in all the eight semesters as advised by RAC.

12.3. Evaluation of Thesis Research

After assigning the research problem, for each semester, the student has to submit a detailed programme of work to be carried out by him/her during the semester in the prescribed proforma. After scrutiny and approval, a copy of the programme has to be given to the student for carrying out the work during the semester.

12.3.1. Attendance register must be maintained in the Department by HOD for all the students to monitor whether the student has 80% of attendance in research.

12.3.2. The student has to submit his/her research observation note book to the research supervisor who will scrutinize the progress and sign the note book with

remarks as frequently as possible. This note book will form the basis for evaluation of research progress.

12.3.3. After completion of 80% attendance for research and on or before the last day of the semester, the research Scholars, both full time and part time, shall submit Progress Reports in the prescribed format (Annexure-3) duly endorsed by the Research Advisory Committee to the Director, CARE until they submit their synopsis.

12.3.4 Failure to submit the progress reports shall entail automatic cancellation of registration.

12.3.5 The minutes of the meeting of the Research Advisory Committee along with enclosures will be sent to the Director, CARE.

12.3.6 The review meetings of the RAC may also be conducted through video conferencing or internet chat if the candidate or the Research Supervisor is in a foreign country.

12.3.7 Candidates who are recipients of fellowships such as JRF/SRF directly from any of the funding agencies/ shall send the progress reports and the utilization certificates in the format prescribed by the respective funding agency through proper channel.

12.3.8. The procedure of evaluating research credits under different situations are explained hereunder.

SITUATION – I

The student, has completed the research credits as per the approved programme and awarded SATISFACTORY by the RAC. Under the said situation the student can be permitted to register for fresh research credits in the subsequent semester. If the student is awarded UNSATISFACTORY, he/she has to re-register the same block of research credits in the subsequent semester.

SITUATION – II

The student who has not secured the minimum attendance of 80 percent shall be awarded grade E. The student has to re-register the same block of research credits for which 'E' grade was awarded earlier in the following semester with prior permission. Until the completion of reregistered credits, the student should not be allowed to register for fresh (first time) research credits.

SITUATION – III

The student could not complete the research as per the approved programme of work for reasons beyond his/her control such as,

a) Failure of crop
b) Non-incidence of pests or disease or lack of such necessary experimental conditions.
c) Non-availability of treatment materials like planting materials chemicals, etc.
d) Any other impeding / unfavourable situation for satisfying the advisory committee.

Under the said situations grade EE should be awarded.

In the mark list, it should be mentioned that E grade or EE grade was awarded due to 'lack of attendance' or 'want for favourable experimental conditions'.

SITUATION – IV

When the student failed to complete the work even in the 'second time' registration, the student will be awarded UNSATISFACTORY and in the mark list the 'second time' should be mentioned.

For the registration of research credits for the third time, permission has to be obtained from the Dean based on the recommendation of the RAC, and HOD. Permission for registration for the fourth time shall be given only by University based on the recommendation of the RAC, HOD and Dean, Faculty of Agriculture.

13. SUBMISSION OF THESIS

The research credits registered in the last semester should be evaluated only at the time of the submission of thesis, by the RAC. Students can submit the thesis at the end of the final semester. If a student has completed the thesis before the closure of the final semester, the research supervisor can convene the RAC meeting and take decision on the submission of the thesis, provided the student satisfies 80 per cent attendance requirement. The candidate shall be allowed to submit his/her thesis after the completion of stipulated period. A grace period of 30 days may be allowed to submit the thesis after the prescribed duration. If the thesis is not submitted even after the grace period, the student shall pay the tuition fee for the year.

If a student is not able to submit the thesis within the grace period, the student has to re-register for the credits in the forthcoming semester. The student who re-registers the credits after availing of the grace period will not be permitted to avail of grace period for the second time. The Head of the Departments can sanction the grace period based on the recommendation of advisory committee and a copy of the permission letter along with the receipt for payment of fine should accompany the thesis while submission

Five copies of the thesis (in the approved format) shall be submitted together with the submission fee not later than three months after the submission of the synopsis. No dues certificates from the Department and Central Libraries, Hostel, Stores, etc. must be submitted with the thesis copies. The Research Supervisor shall forward the thesis copies with the enclosures to the Director, CARE through the HOD and the Dean. A soft copy of the thesis in PDF fromat as prescribed by Shodhganga, shall also be submitted.

The Ph.D scholars have to publish a minimum of two research papers in Scopus / Web of Science indexed journal. The synopsis will be accepted for processing only after showing evidences for publications of 2 such articles.

The soft copy of the thesis shall be checked for plagiarism using Turnitin software. Beyond the percentage of reproduction prescribed by UGC will not be accepted for avaluation.

13.1 Pre-submission Presentation

1. The pre-submission presentation of the thesis is a requirement to enrich the scholar and to fine tune his/her research presentation
2. This presentation shall be conducted before the submission of the synopsis in the presence of the RAC, Supervisor/Co-Supervisor, Faculty members, Research Scholars, M.Phil., and /or P.G. Students.
3. The scholar is expected to present the first draft of the research work or explain the findings/problems faced.
4. The gathering may suggest ideas/references to be consulted/suggestions to

improve the work and so on.

5. A report on this event along with an attendance sheet shall be forwarded by the Research Supervisor with the endorsement of the RAC and HOD to the Director, CARE.

13.2 Submission of Synopsis

1. The submission of synopsis may be permitted 3 months before the completion of required duration on successful completion of course work
2. The Research Scholar shall submit 3 copies of the synopsis approved by the Research Advisory Committee along with a soft copy to the Director, CARE through the Research Supervisor, the HOD and Dean of the respective Faculty. Guidelines for the preparation of the synopsis are appended in Annexure -4
3. Name of the candidate and name of the supervisor shall not be mentioned anywhere in the synopsis; enrolment number of the candidate alone shall be given. A model cover page for a synopsis is given in Annexure – 5

13.3 Guidelines for Preparation of Thesis

1. The thesis shall not exceed 250 pages excluding the Bibilography, Appendices, etc. If it exceeds the specified number of pages, the Research Supervisor should write to University with the reasons and get prior approval from the University. The candidate shall pay a penalty for the excess number of pages as decided by the Deans Committee. The thesis should be in A4 size. The specification for the preparation of the thesis are given in Annexure-7. A model cover page for a thesis is given in Annexure -8.
2. The thesis shall be typed on both sides of the page in order to save paper and postage
3. The thesis shall contain a Certificate from the guide (Annexure-9) specifying that the thesis submitted is a record of research work done by the candidate during the period of study under him/her and that the thesis has not previously formed the basis for the award of any Degree, Diploma, Associateship, Fellowship or similar title. A statement from the guide indicating the extent to which the thesis represents independent work on the part of the candidate should also be made.
4. The thesis shall also contain a Declaration by the candidate (Annexure -10) that the work reported in the thesis has been carried out by the candidate himself/herself and that the material from other sources, if any, is duly acknowledged and no part of the thesis is plagiarized.

14. VALUATION OF THE THESIS Panel Of Examiners

The thesis submitted in partial fulfillment of the Ph.D. degree shall be evaluated by two external experts one from within the country and the other from outside the country appointed by the Vice-Chancellor on the recommendation of the research supervisor of the RAC, HOD and Dean. They shall be chosen from a panel of at least five names of specialists separately from within the country and outside the country in the particular field, suggested by the research supervisor. The external experts shall send their evaluation reports of the thesis directly to the Director, CARE along with the copy of the evaluated thesis. The Director, CARE on receipt of the reports from the two examiners will send them to the concerned guide who is the convener of viva-voce

board. The guide will send the consolidated report with his remarks to the Director, CARE through the Head of the Department. On the satisfactory reports of the evaluation, viva-voce examination will be arranged.

After a student's thesis for Ph.D. degree is evaluated as indicated above, the thesis shall be finally accepted for the award only after the student satisfactorily completes a final viva-voce examination. The Viva-Voce board comprises the student's RAC with the addition of the external examiner who valued the thesis, and the HOD. If the HOD happens to be the research supervisor, the Dean, Faculty of Agriculture will nominate a senior member of the staff of the concerned Department as a member. In case of external candidates, the co-supervisor will also serve as a member of the viva-voce board. The candidate is expected to defend the thesis at the viva-voce examination. The degree shall be awarded on the unanimous recommendation of the examining committee as satisfactory with regard to the thesis and the performance of the student in the final oral examination. The recommendation of the committee shall be forwarded to the Director, CARE by the research supervisor through HOD and Dean which shall be signed by all members of the committee and the external examiner. A candidate who is not successful (unsatisfactory) at the viva –voce examination will be permitted to undergo the viva voce examination again within a period of three months.

14.2. Revision and Resubmission of Thesis

i. If an examiner recommends change / further work, the thesis will be referred to the same examiner after compliance for his opinion. In case of rejection by any one of the examiners, the thesis will be sent to another examiner and his / her recommendation will be final.

ii. If the thesis is recommended to be revised by one or both examiners, the points of revision will be indicated clearly in the report. The necessary correction should be carried out, and the revised version should be sent to the concerned examiner(s). If the examiner(s) is / are still not satisfied with the revised version, the thesis will be rejected. If the thesis is accepted by the examiners (Evaluation), Viva–Voce examination will be conducted by the viva-voce board.

14.3. Re-registration and Submission of Thesis

The minimum of 80% attendance requirement for submitting the thesis after re-registration need not be insisted for those students who have fulfilled the minimum academic and residential requirement of 3 or 4 years.

14.4. Extension of Time

1. Research scholars who do not submit the thesis within the stipulated period as per full-time/part-time/external mode should apply for extension of time three months before the completion of 3 or 4 years. Extension of time and the fees to be paid will be considered by the Deans Committee, if the extension is duly recommended by the RAC, Head of the Department, and the Dean of the Faculty, such candidates will be eligible for extension of time for a maximum period of two years.
2. The scholar will have to enroll as fresh candidates if he/she fails to submit the thesis within the maximum extension period of three years when granted.
3. If a scholar requires a few more months after the expiry of the maximum extension period of two years for the submission of the thesis as per the evaluation of the RAC, duly recommended by the Head of the Department and the Dean of the Faculty, as an exceptional case, the Deans committee

may consider for re-registration to enable the scholar to submit the thesis. In any case, the time granted shall not exceed six/ twelve months.

14.5. Number of Chances

A candidate will not be permitted to submit a thesis for the degree on more than two occasions. However, it will be open to the syndicate, if the Board of Examiners so recommend, to permit the candidate to submit a thesis on a third occasion. Also, he/she will not be permitted to appear for the viva-voce examination on more than two occasions.

15. DISCONTINUANCE AND READMISSION

15.1. Students admitted to the PhD degree who discontinue their studies before completing the degree with written permission from the University may be re-admitted to the degree programme, provided that the student should have completed the course work before such discontinuance. However the period of such discontinuance should not exceed five years for Ph.D. Degree from date of admission.

15.2. After completion of course work and qualifying examination, a student is eligible to discontinue temporarily his research program only once within 5 years for PhD program. If the discontinuation period exceeds two semesters, the student has to forego the research credits already registered and register afresh with revised program. In the case of field experiments or laboratory experiments in which continuity is essential for research and if a student temporarily discontinues in the middle without completing the experiments, then the entire experiment should be repeated even if the discontinuation period does not exceed two semesters.

15.3. A student joining the studies, after discontinuation should pay the fees of the existing semester.

16. PUBLICATION OF THE THESIS

The thesis, whether approved or not, should not be published in full or abridged form without the permission of the Syndicate, which may grant permission for the publication under such conditions as it may impose.

17. Each Department should maintain a list of theses produced so far with the abstract of the same.

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Department of Agricultural Microbiology

Programme Outcomes

PO1.In-depth knowledge of literature in the specialised area of research.

PO2.Apply theories, methodologies and techniques to address fundamental research problems.

PO3. Creativity and originality in planning and executing research independently.

PO4. Critical thinking, problem solving and evaluation of published work.

PO5. Ability to formulate and test novel hypotheses.

PO6. Develop practical research skills and expertise in state-of-the art techniques in research.

PO7. Effective scientific writing and oral presentation skills.

PO8. Collegiality in a research setting with people from diverse backgrounds as leaders/mentors/team members.

PO9.Ethical principles in conducting and reporting research.

PO10. Life-long commitment to expanding the frontiers of knowledge in a specialised field.

PROGRAMME SPECIFIC OBJECTIVES

Ph.D. (Agricultural Microbiology)

- Students will be given latest and advanced information about microbial metabolism pertaining and the mechanism of nutrient transport, physiological functions specialized structures, enzymatic reactions, bioenergetics pathways and regulation of metabolism.
- Students will study the genomic pattern of prokaryotes and eukaryotes, molecular basis if mutation and techniques of gene mapping by recombination and complementation, gene cloning and sequencing.
- To understand the impact of various types of environmental pollution and their sources and environmental pollution management strategies by following bioremedial measures.
- To give an in depth information about soil microbial communities, plant microbe interactions pertaining to signal transduction, gene expression, specific regulators, biogeochemical cycles and microbial degradation of pesticides and organic wastes.
- To understand the principles and methods of food preservation, use of microbial enzymes in food industries and significance of fermented foods and dairy products.
- To impart a thorough knowledge in the concepts and types of biofertilizers, biopesticides, mass production technologies and their quality control.
- To study and understand the industrial application of microorganisms, design of fermentors, use of genetically modified microorganisms in biotechnology

DISTRIBUTION OF COURSES

Course No	Course Title	Credits
Major Courses		
AGM 811	Advances in Microbial Metabolism	2+1
AGM 812	Advances in Microbial Genetics	2+1
AGM 813	Environmental Biotechnology	2+1
AGM 814	Biofertilizers and Biopesticides	2+1
AGM 821	Advances in Soil Microbiology	2+1
AGM 822	Advances in Food and Dairy Microbiology	2+1
AGM 823	Algal Biotechnology	2+1
AGM 824	Microbial Biotechnology	2+1
	Total	10+5=15
Minor Courses		
AGM 815	Microbial Inoculant Production and Quality Control	2+1
AGM825	Composting Technology	2+1
AGM826	Mooc	2+0
	Total	5+3=8
Supporting courses		
COM811	Advances in computing Applications	0+1
LIS 812	Advances in Agrl. Information retrieval	0+1
STA825	Advances in Design experiments	2+1
	Total	2+3=5
AGM 081	Seminar	0+1
AGM 082	Seminar	0+1
AGM 801,802,803,804,805,806	Research	0+45
	Total	75

SEMESTER WISE DISTRIBUTION OF COURSES

Semester – 1			
Course No	Course Title	Credit Hour (Theory & Practical)	
Major Courses			
AGM 811	Advances in Microbial Metabolism	2+1	
AGM 812	Advances in Microbial Genetics	2+1	Any Three
AGM 813	Environmental Biotechnology	2+1	
AGM 814	Biofertilizers and Biopesticides	2+1	
Minor Courses			
AGM 815	Microbial Inoculant Production and Quality Control (for other departments)	2+1	
Supporting courses			
COM 811	Advances in Computing Applications	0+1	
LIS 812	Advances in Agricultural information retrieval	0+1	
AGM 801	Research	0+1	
AGM 081	Seminar	0+1	
	Total	16 credits	

Semester – II			
Course No	Course Title	Credits	
Major Courses			
AGM 821	Advances in Soil Microbiology	2+1	
AGM 822	Advances in Food and Dairy Microbiology	2+1	Any Two
AGM 823	Algal Biotechnology	2+1	
AGM 824	Microbial Biotechnology	2+1	
Minor Courses			
AGM825	Composting Technology (for other Departments)	2+1	
AGM826	Mooc	2+0	
Supporting Courses			
STA 825	Advances in design of Experiments	2+1	
AGM 802	Research	0+1	
AGM 082	Seminar	0+2	
	Total	17 Credits	
Semester -III		Credits	
AGM 803	Research	0+12	
Semester -IV			
AGM 804	Research	0+12	
Semester -V			
AGM 805	Research	0+9	
Semester -VI			
AGM 806	Research	0+9	
	Grand Total	75 Credits	

All Minor courses should be from other departments / disciplines

AGM 811 - ADVANCES IN MICROBIAL METABOLISM (2+1)

Learning Objectives:

- The students will know how to define and use appropriate terminology to describe metabolic process.
- Students will study and distinguish diverse microorganisms according to their physiological Characteristics
- The students will study how bio energetic, can drive (or) limit the metabolic activity.
- Students will able to develop an awareness of the impact interpret how microbial populations can be manipulated to perform specific process.

Theory

Unit – I Microbial Nutrition and Transport Mechanisms

Microbial nutrition – Chemical composition of microbial cell – Macro and Micro – nutrients and their physiological functions. Mechanisms of nutrient transport in bacteria – Passive diffusion – facilitated diffusion – unisym, Antiports – Chemiosmotic theory.

Unit – II Microbial Differentiation

Microbial differentiation – Sporulation – Endo and Exospores – Endospore formation in *Bacillus Sp.* Exospore formation in *streptomyces* – Reproduction in fungi – Formation of specialized structures – akinetes, cysts and heterocysts.

Unit – III Respiration and Enzyme Activity

Anaerobic respiration and fermentation - Anabolic and Catabolic processes of lipids. Mechanisms of inhibition of enzyme activity – Coenzymes and Prosthetic groups – Reproductive physiology of microorganisms.

Unit – IV Bioenergetics and Carbohydrate Metabolism

Glycolysis – Pentose phosphate pathway – Entner Doudroff pathway – Oxidation of pyruvate – TCA cycle – Assimilation of nitrogen and sulphur – Oxygenic and anoxygenic photosynthesis – Mechanisms of carbon dioxide fixation in prokaryotes. Glucogenesis – Biosynthesis of storage compounds and energy reserves in bacteria – Biosynthesis of amino acids, nucleotides, phospholipids, and isoprenoid compounds. Genetics and regulation of nitrogen fixation.

Unit – V Nucleic Acid Metabolism and Microbial Growth

Regulation of metabolism, Control mechanisms operating at DNA level, transcriptional level, translation level, post – translation level and regulation of protein activity – Feed back control mechanisms. Microbial growth – Nature and

expression of growth – Measurement of growth – Effect of environmental factors on microbial growth - Response of microorganisms to stress – Sporulation bacteria.

Practical

Preparation of Liquid Media for cultivation of microorganisms - Solid media (Nutrient agar) for cultivation of microorganisms - Growth of selected species of bacteria on various carbon sources - various Nitrogen sources - Development of growth curve of bacteria based on colony forming units - turbidity measurements - protein content - Effect of pH. Temperature on growth and development of bacteria - microbial growth - Indole test - Methyl red Test - Voges proskauer test - Citrate test - Triple sugar iron test - Carbohydrate fermentation - Strach hydrolysis - Protein hydrolysis.

Theory Lecture Schedule

1. Introduction and Scope of Microbial Physiology.
2. Microbial Nutrition:-Chemical composition of a microbial cell.
3. Major and Micro nutrients and their physiological functions.
4. Mechanisms of Nutrient transport.
5. Mechanisms of Nutrient transport in bacteria.
6. Diffusion types and its importance.
7. Passive diffusion.
8. Facilitated diffusion.
9. Uniport , symport Antiports.
10. Chemiosmotic theory.
11. Microbial differentiation.
12. Sporulation in Microorganisms, Endospore formation in *Bacillus Sp.*
13. Exospore formation in Microorganisms, Exospore formation in *streptomyces.*
14. Reproduction in fungi.
15. Formation of specialized structures, akinetes, cysts and heterocysts.
16. Anaerobic respiration and fermentation.
17. Mid Semester Examination.
18. Anabolic and Catabolic processes of lipids.
19. Mechanisms of inhibition of enzyme activity
20. Coenzymes and Prosthetic groups.
21. Reproductive physiology of microorganisms.
22. Glycolysis, Pentose phosphate pathway.
23. Entner Doudroff pathway – Oxidation of pyruvate.
24. TCA cycle, Assimilation of nitrogen and sulphur.

25. Oxygenic and anoxygenic photosynthesis.
26. Mechanisms of carbon dioxide fixation in prokaryotes.
27. Glucogenesis, Biosynthesis of storage compounds and energy reserves in bacteria.
28. Biosynthesis of amino acids, nucleotides, phospholipids, and isoprenoid compounds.
29. Genetics and regulation of nitrogen fixation.
30. Regulation of metabolism.
31. Control mechanisms operating at DNA level, transcriptional level, translation level, post, translation level and regulation of protein activity.
32. Microbial growth – Nature and expression of growth, Measurement of growth.
33. Effect of environmental factors on microbial growth.
34. Response of microorganisms to stress – Sporulation bacteria.

Practical Schedule:

1. Preparation of Liquid Media for cultivation of microorganisms.
2. Preparation of Solid media (Nutrient agar) for cultivation of microorganisms.
3. Growth of selected species of bacteria on various carbon sources.
4. Growth of selected species of bacteria on various Nitrogen sources.
5. Development of growth curve of bacteria based on colony forming units.
6. Development of growth curve of bacteria based on turbidity measurements.
7. Development of growth curve of bacteria based on protein content.
8. Effect of pH. Temperature on growth and development of bacteria.
9. Effect of pesticides on microbial growth.
10. Indole test.
11. Methyl red Test.
12. Voges proskauer test.
13. Citrate test.
14. Triple sugar iron test.
15. Carbohydrate fermentation.
16. Strach hydrolysis.
17. Protein hydrolysis.

Course outcomes

CO - 1: The course students are expected to explain the principles of energy - yielding and consuming reactions the various catabolic and anabolic pathways and Transport systems and the mechanisms of energy conservation in microbial metabolism

CO – 2: Students will understand Role of microbes & their Physiological functions in the evolution of life on earth.

CO – 3: Students after undergoing the course will be able to develop a model microbial system to explain the anaerobic and catabolic pathways

CO – 4: Students will be able to select suitable source of nutrients for efficient production of metabolites.

CO – PSO - PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	X															
CO 2	X							X								
CO 3	X					X			X	X						
CO 4	X					X										

Reference Books

1. Sundaraja Rajan, S. 2003. Introduction to Bioenergetics, Ammol Publishers, New Delhi.
2. White more, G. 2002. Metabolism, Biosynthesis and Biochemical Emergencies, Swarun and sons, New Delhi.
3. Karp, G. 2002. Cell and Molecular Biology. John Wiley and Sons, New York.
4. Medigan, M.T., J.M. Marktinko and J. Parker, 2000. Biology of Microorganisms, Prentice Hall International (UK) Limited, London.
5. Moat, A.G. and Foster, J.W. 1998. Microbial Physiology, Second Edition, John Wiley & Sons.
6. Meenakumari, S. 2006. Microbial Physiology, MJP Publishers, Chennai.
7. Daniel R.Caldwell. Microbial physiology and Metabolism, Wm.C.Brown Publishers, England.
8. Caldwell.D.R.2005. Microbial Physiology and Metabolism Wm.C.Brown publisher Lowa.USA
9. Ian.W.Dawes.Ian.W.Sutherland 2002 Microbial Physiology Wiley publishers, USA(Fourth edit)
10. RobertK.Poole, 2011. Advances in Microbial Physiology , Elsevier Science publishing co.Inc.U.K

AGM 812 – ADVANCES IN MICROBIAL GENETICS (2+1)

Learning Objectives

- To make the students understand molecular concepts of hereditary materials of microorganisms partially on their structure, types and replication
- To make the students understand molecular basis of bacterial and fungal mutation
- To motivate the students to work with genetic recombination and complementation
- To train the students in gene cloning and sequencing techniques
- To impart knowledge on mutagenesis and regulation of gene expression
- To impart knowledge on genetic basis of cancer and cell death

Theory

UNIT I- Microbial Genomes

Prokaryotic, eukaryotic and viral genome. Replication of eukaryotic, prokaryotic and viral DNA. Structure, classification and replication of plasmids.

UNIT II- Mutation and Recombination

Molecular basis of mutation. Biochemical genetics and gene mapping by recombination and complementation. Fine gene structure analysis.

UNIT III-Fungal Genetics

Fungal genetics – Genetics of *Neurospora crassa*, *Aspergillus nidulans* and Yeast.

UNIT IV- Genetics Material Exchange

Gene transfer in bacteria through transformation, conjugation and transduction; Transposable elements.

UNIT V- Gene Sequencing and Regulation

Gene cloning and gene sequencing. Impact of gene cloning on human welfare. Regulation of gene expression. Recent advances in DNA repair and mutagenesis. Genetic basis of cancer and cell death.

PRACTICAL

Inactivation of microorganisms by different mutagens. Production, isolation and characterization of mutants. Determination of mutation rate. Isolation, characterization and curing of plasmids. Transfer of plasmid by conjugation, electroporation. Tetrad and random spore analysis.

Theory Lecture Schedule

1 Evolution of microbial genetics.

2 Comparison between prokaryotic, eukaryotic and viral genomes.

3 Replication of viral DNA.

4 Replication of prokaryotic DNA.

5 Replication of eukaryotic DNA.

6 Structure, classification and replication of plasmids.

7 Mutation; types and uses.

8 Mutagenic agents, Molecular basis of mutagenesis.

9 Detection of mutants, Reverse mutation and mutation rates.

10 Concept of biochemical genetics.

11 Gene mapping by recombination and complementation.

12 Fine structure of gene.

13 Brief introduction to fungal genetics.

14 Genetics of *Neurospora crassa*, *Aspergillus nidulans.*

15 Genetics of Yeast.

16 Exchange of genetic characteristics between bacteria.

17 MID TERM EXAMINATION.

18 Bacterial recombination and their mechanisms.

19 Cellular competence for transformation.

20 Mechanisms of transformation.

21 Conjugation mechanism.

22 Transduction, types of transduction.

23 Transposons and their classes / types.

25 Detailed mechanism of gene cloning.

25 Modern applications of microbial gene cloning.

26 Gene sequencing technique.

27 Automated gene sequencing.

28 Impact of gene cloning on human welfare.

29 Regulation of gene expression.

30 DNA damage and repair.

31 DNA repair mechanisms (Part 1).

32 DNA repair mechanisms (Part 2).

33 Genetic basis of cancer and cell death.

34 MODEL EXAMINATION.

Practical Schedule

1. LD50 Value of UV ray on Bacteria.
2. LD50 Value of chemical mutagen EMS/MMS/ NTG on Bacteria.

3. Induction of mutation in bacteria by EMS/MMS/ NTG. & Isolation of mutants for antibiotic resistance Part – I.
4. Induction of mutation in bacteria by EMS/MMS/ NTG. & Isolation of mutants for antibiotic resistance Part – II.
5. Development of auxotrophic mutants – Part I .
6. Development of auxotrophic mutants – Part II.
7. Determination of mutation rates in bacteria.
8. Isolation of plasmids, DNA from bacteria.
9. Mid Semester practical Examination.
10. Bacterial conjugation.
11. Preparation of competence cells.
12. Bacterial transformation.
13. Plasmid DNA transfer by electroporation.
14. Isolation of bacteriophage.
15. Transfer of DNA through Bacteriophage.
16. Bacterial transduction.
17. Model practical Examination.

Course outcomes:

CO – 1: Students will be able to identify and group the microorganisms based on their genetic makeup

CO – 2: Students will be able to develop efficient strains of bacteria and fungi through mutational studies

CO – 3: The students will be able to develop recombinant strains of bacteria for the betterment of mankind.

CO – 4: Students trained in gene cloning and sequencing will be able to get job opportunities in biotech industries

CO – PSO - PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	X	X														
CO 2	X	X	X					X								
CO 3	X	X	X	X	X	X										
CO 4	-	X				X										

Reference Books

1. Birge EA. 1981. *Bacterial and bacteriophage genetics*. Springer Verlag.
2. Gardner JE, Simmons MJ & Snustad DP. 1991. *Principles of genetics*. John wiley & Sons.
3. Maloy A, & Freifelder D. 1994. *Microbial Genetics.* Narosa.
4. Scaife J, Leach D & galizzi A. 1985. *Genetics of bacteria.* Academic Press.
5. David P. Clark. Molecular Biology. 2005. Elsevier Publication.
6. Idis, N Streips and Ronald E.Yazsbin.2002 Modern Microbial Genetics.LissJohn Wiley & sons , Inc. Publication .ISBN-978-0471386650
7. Roychoudhuri ,S,2011.A text book of Genetics and Molecular Biology. New Central Book Agency ISBN-10-8173816611/ISBN-13-978-8173816611
8. John Cronan, David Freidfelder and Stanly R.Maloy. 2008 Microbial Genetics . Jones and Bartlett Publishers
9. Prasad, S.K.2013. Microbial Genomics .Discovery Publishing Home. ISBN - 13-978935056034
10. Ayden Llyod , 2017 Essentials of Genetics. Larson & Keller Education ISBN – 978 – 1635491326

AGM 813 - ENVIRONMENTAL BIOTECHNOLOGY (2+1)

Learning Objectives

- Students will know the sources of water pollution, and microbiological methods of controlling, treating the polluted water and safe disposal, by aerobic and anaerobic methods.
- Students will study the physical, chemical method biological methods of management of solid waste and its safe disposal.
- Students will be exposed to the field of mining.

Students will learn the role of different microbes on the leading Areas of advanced biotechnological methods in controlling environmental pollution

Theory

Unit –I

Water pollution and its management

Surface water resources – Water pollution – measurement of pollution – control of pollution Aerobic processes aeration equipment and performance – site and process selection- rotary biological contactors –Deep shaft treatment – tertiary treatment-sludge thickening – Dewatering – Digestion – application to land

UNIT-II

Anaerobic treatments of effluents and its management

Anaerobic treatment of effluents – process option –Disinfection use of ozone hydrogen peroxide chloride- other disinfectants – Waste water treatment in developing countries – Waste stabilization ponds – aerated lagoons, oxidation ditches, biomethanation.

Unit-III

Solid wastes and municipal waste management

Industrial treatment – solid waste – municipal refuse composition – landfill sites and refuse emplacement strategies – refuse degradation – landfill products and site exploitation – toxic and hazardous wastes exploitation of landfill gas. Composition-straw decomposition – probiotic organisms – role of the lactic acid bacteria in silage additives

Unit – IV

Mineral leaching by microorganisms

Mineral leaching by bacteria – microorganisms involved in the sulphide mineral leaching chemistry of sulifide mineral oxidation by bacteria – exploitation of dump and heap leaching – in situ bacterial leaching of ore – mineral concerntrate

leaching – utilization of bacterially generated soivents – heavy metal pollutants removal by bioaccumulation

Unit –V

Microbial control of environmental pollution

Microbial control of environmental pollution catabolic plasmids as natural vectors-physical and genetic overviews – genetic engineering of genes for augmenting pollution abatement-use of immobilized microbes for waste recycling – immobilized enzymes in pollution abatement.

Practical

Estimation of biochemical oxygen demand, chemical oxygen demand, organic carbon, ammonia and Hydrogen sulphide, *E.coli.* and total bacteria, Activated sludge systems, Biofilters and Bioaccummulation Anacrobic digestion volatile factty acids and methane, Solid waste treatment ; composting determination of compost maturity ,Mineral leaching ,Gene amplification for catabolic activity and resistance, Decolurization of waste water, Isolation of cellulose degrading enzymes, Estimation heavy metals, Estimation of toxic pesticides in water Practical class test

Practical schedule

1. Estimation of biochemical oxygen demand(BOD)
2. Estimation of chemical oxygen demand(COD)
3. Estimation of organic carbon
4. Estimation of ammonia and Hydrogen sulphide
5. Estimation of *E.coli.* and total bacteria
6. Activated sludge systems
7. Biofilters and Bioaccumulation
8. Anacrobic digestion volatile factty acids and methane
9. Solid waste treatment ; composting determination of compost maturity
10. Mineral leaching
11. Gene amplification for catabolic activity and resistance
12. Decolurization of waste water
13. Isolation of cellulose degrading enzymes
14. Estimation of heavy metals
15. Estimation of toxic pesticides in water
16. Immobilization techniques
17. Practical Model Exam

Lecture Schedule

1. Surface water resources

2. Water pollution – measurement of pollution and its control
3. Aerobic process treatment – oxygen transfer and aeration equipments
4. Aeration process site selection and process selection
5. Rotary biological contactors Deep shaft treatment.
6. Teritary treatment –sludge thickening Dewatering
7. Digestion and application to land
8. Aerobic treatment of effluents process option
9. Disinfectants of anaerobic treatment effluent
10. Waste stabilization ponds – aerated lagoons
11. Oxidation ditches and bio-methanation
12. Industrial treatments
13. Solid waste management
14. Municipal waste management
15. Landfill sites and refuse emplacement strategies
16. Landfill products and site exploitation
17. Toxic and hazardous wastes exploitation
18.Mid semester
19. Composting and types of composting
20. Probiotic organisms
21. Role of lactic acid bacteria in silage additives
22. Mineral leaching by bacteria
23. Microorganism involved in sulphide mineral
24. Mechanism of Bioleaching
25. Biochemical reaction involved in Bioleaching
26. Bioleaching process for metal recovery
27. Chemistry of sulphide mineral oxidation by bacteria
28. Dump and heap leaching – *insitu* bacterial leaching of ore
29. Utilization of bacterially generated solvents – heavy metal pollution removal by bioaccumulation
30. Microbial control of environmental pollution; catabolic plasmids as natural vectors
31. Microbial control of environmental pollution by physical and genetics overviews
32. Genetic engineering of genes for augmenting pollution abatement.
33. Use of immobilized microbes for waste recycling
34. Immobilized enzymes in pollution abatement
35. Review of lectures

Course outcomes

CO – 1: The students will be able to understand different types of pollution of water and soil.

CO – 2: Students will know about different methods by employing microorganisms and GMO for treating, recycling and abatement of water and soil pollution.

CO – 3: Students will be able to manage municipal solid wastes of their locality

CO – 4: Students will gain knowledge on microorganism involved in biomining and apply the knowledge for recovery of value minerals from low concentrate ores.

CO – 5: Students who successfully completed the course will deserve the job opportunities in pollution board and other institutes involving in environmental management.

CO – PSO – PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1			X	X		X										
CO 2		X	X	X		X		X								
CO 3		X	X			X										
CO 4	X	X	X	X		X				X						
CO 5						X					X					

Reference

1. Aalecia M. Spooner 2012. Environmental Science. John wiley and sons, Inc, New Jersey.
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AGM – 814. BIOFERTILIZERS AND BIOPESTICIDES (2+1)

Learning Objectives:

1. To introduce students the concepts in Biofertilizers.
2. To present an overview of importance of microbial biofertilizers, types and their importance.
3. To get thorough knowledge on the mass production of Biofertilizers and Biopesticides.
4. To understand biotechnological applications in agriculturally important microorganisms.
5. To study and understand about application of microbial metabolites for biocontrol

Theory

Unit – I – Introduction to biofertilizers and Biopesticides

Biofertilizers – Development and its concept – contribution of microorganisms to soil fertility – groups of biofertilizers – The organisms that fixes atmospheric nitrogen – Free – Living, aerobic. Symbiotic bacteria.

Unit – II- Biofertilizers

Bacterial Biofertilizers .*Rhizobium* , *Azotobacter*, *Azosprillium*, *Acetobacter*, Phosphobacteria, potash mobilifiz bacteria, silicate socializing bacteria and Frankia . Algal fertilizer – Blue green algae, *Azolla* – Importance – fungal fertilizers – Mycorrhizas – ectomycorrhizae , endomycorrhizae – Role of mychorrizae and importance mechanism of nodulation – Biochemical and Genetics of nitrogen fixation.

Unit – III- Mass Production of Biofertilizers and Biopesticides

Principles of mass production – Growth characteristics of different groups of organisms – fermentation and other inoculam preparation – Carrier material – Types and quality – Mixing of carrier – Broth – Population dynamic during storage methods. Shellife .Quality control of biofertilizers ISI standard – Economics of biofertilizer application . Mass production of mycorrhizae.

Unit – IV- Biotechnological application in Agricultural Microbiology

Role of biotechnology in pest and diseases management – Genetic improvement of natural enemies . Mass production techniques – Invitro production of entomopathagens in cell lines. Genetic engineering with Baculoviruses and *Bacillus thuringiensis.* Recombinant DNA technology and genetic control of insects . Transgenic plants – BT ,toxin gene – trypsin inhibitor gene. Manipulation of biological rhythm in insects for their control .

Unit – V – APPLICATION OF MICROBIAL METABOLITES FOR BIOCONTROL

Chitinase gene – cloning of chitinase from microorganisms to another to increases biocontrol efficiency – development of biocontrol produces bacteriocin – pseudobactin – Development of mild strain for cross protection. Field performance of biofertilizers ,biopesticides. Method of application problems and prospects.

Practical

Isolation and testing efficiencies of Rhizobium biofertilizers - *Azotobacter* biofertilizer - *Azospirillum* biofertilizer - Biofertilizer for sugar cane - Algal biofertilizer - Phosphate solubilizing biofertilizers - Mass production techniques of bacterial biofertilizers – Mycorrhizae - Technology for mass production of Arbuscualr mycorrhizal fungi - Quality assessment test for biofertilizers - Method of application of biofertilizers - Isolation of fungi from healthy and diseased insects - entomopathogenic bacteria and fungi from commercial Formulations - Mass production techniques and application of *Trichoderma viride* - Pseudomonas fluoresecens - Field and pot culture testing of biofertilizers - Practical exams.

Lecturer Schedule.

1. Biofertilizers – Development and concepts.
2. Contributions of microorganisms to soil fertility.
3. Group of biofertilizers.
4. Bacterial biofertilizers.
5. *Rhizobium.*
6. Atosprillum , *Azotobacter.*
7. *Actobacter* diazotrophicus and phosphobacteria.
8. Frankia.
9. Algal Biofertilizers.
10. Fungal biofertilizers.
11. Biochemistry and genitics of nitrogen fixation.
12. Principles of mass production.
13. Growth characteristic of different groups of organisms.
14. Fermentation technique.
15. inoculant production and quality control.
16. Economics of biofertilizer production.
17. Mid semester.
18. Mass production of mycorrhizae.
19. Role of biotechnology in pest and disease management.
20. Invitro production techniques of entomopathogenes.

21. Mass production techniques of entomopathegenes.
22. *Bacillus thuriengiensis.*
23. Transgenic plants.
24. Botinical pesticides.
25. Chitinase gene.
26. Development of biocontrol agents.
27. Bacteriocin and pseudobactin.
28. Development of mild strains for cross protection.
29. Tissue culture.
30. Somaclonal variation.
31. Field performance of biofertilizers.
32. Field performance of biopesticides.
33. Methods of application.
34. Problems and prospects.
35. Review of Lecture.

Practical Schedule.

1. Isolation and testing efficiencies Rhizobium biofertilizers.
2. *Azotobacter* biofertilizer.
3. *Azospirillum* biofertilizer.
4. Biofertilizer for sugar cane.
5. Algal biofertilizer.
6. Phosphate solubilizing biofertilizers.
7. Mass production techniques of bacterial biofertilizers.
8. Mycorrhizae.
9. Technology for mass production of Arbuscualr mycorrhizal fungi.
10. Quality assessment test for biofertilizers.
11. Method of application of biofertilizers.
12. Isolation of fungi from healthy and diseased insects.
13. Isolation of entomopathogenic bacteria and fungi from commercial.Formulations.
14. Mass production techniques and application of *Trichoderma viride*.
15. Mass production techniques and application of Pseudomonas fluoresecens.
16. Field and pot culture testing of biofertilizers.
17. Practical exams.

Course outcomes

CO – 1: To gain knowledge on the types of bacterial Biofertilizers and salient features of blue green algae and mycorrhizae

CO – 2: The entrepreneurship development on the mass production of Biofertilizers and Biopesticides, their shelf life and quality control aspects will be possible

CO – 3: To understand biotechnological applications in agricultural microbiology, influence of Baculoviruses and *Bacillus thuringiensis* on the management and control of pest and disease

CO – 4: students will gain knowledge on historical concepts of biofertilizer, significance of biofertilizer in organic agriculture and scope.

CO – PSO MAPPING MATRIX

COs/PSOs	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	X	X	X	X		X	X									
CO 2			X	X		X		X								
CO 3			X	X		X			X							
CO 4				X						X	X					

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AGM 821 – ADVANCES IN SOIL MICROBIOLOGY (2+1)

Learning Objectives:

- Students will learn about soil microbial biomass and its role on environmental factors in soil fertility
- Students will know about biochemistry of Nitrogen fixation, Biofertilizers, Rhizosphere, Phyllosphere and Enzyme activity.
- Students will have knowledge on signal transduction, Molecular diversity of microbes and its interactions
- Students will learn about biogeochemical cycle, Siderophores, antimicrobials and Biodegradation of crop residues.
- Students will learn about Biodegradation of pesticides, Microbial interactions in soil and biotic factors in soil development

Theory

UNIT I- Microbial Ecology

Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Role of Micro organisms in soil ferlity - soil and environnemental factors on microbes

UNIT II- Microbiology of Nitrogen fixation

Microbiology and biochemistry of Nitrogen Fixation root-soil interface; Rhizosphere phyllosphere, Biofertilizers, soil enzyme activities and their importance.

UNIT III- Molecular Diversity Microbes and its Interaction

Signal transduction - Plant and microbial gene expression and signal exchange, global and specific regulators for different interactions. Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants.

UNIT IV- Microbial Transformation

Biogeochemical Cycles - Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials. Biochemical composition and biodegradation of soil organic matter and crop residues.

UNIT V- Utilization of Organic Waste

Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures: Biotic factors in soil development. Microbial Intractions in soil

Practical

Determination of soil microbial population; Soil microbial biomass; Decomposition studies in soil, Soil enzymes; Measurement of important soil microbial processes

such as ammonification, nitrification. N_2 fixation, S - oxidation, P - solubilization and mineralization of other micro nutrients; Study of rhizosphere effect.

Theory Lecture Schedule

1. Soil Biota, Soil Microbial ecology. Types of organisms in different soils.
2. Soil microbial biomass; Role of Microorganisms in soil fertility.
3. Environmental factors influencing the activates of microbes in soil.
4. Microbiology and biochemistry of Nitrogen fixation, root soil interface.
5. Rhizosphere and its importance to crop plants and R : S ratio.
6. Phyllosphere and its importance.
7. Bacterial Biofertilizer – *Rhizobium, Azospirillum, Azotobacter and Glucanoacetobacter.*
8. Fungal Biofertilizers and Phosphobacteria.
9. Algal Biofertiliuzers – BGA, Azolla. Method of Biofertilizer production.
10. Quality control of Biofertilizers. Method of Biofertilizer applications.
11. Soil Enzyme activities and their importance.
12. Signal transduction. Plant and microbial gene expression and signal exchange.
13. Global and specific regulators for different interactions.
14. Molecular diversity of Microbes , Plant and their interactions.
15. Transgenic microbes and plant interaction.
16. Microbial transformation of N2 in Soil, Nitrogen cycle.
17. Mid Semester Examination.
18. Microbial transformation of Phosphorous in soil – Phosphorous cycle.
19. Microbial transformation of sulphure in soil – Sulphure cycle.
20. Microbial transformation of Iron in soil – Iron cycle.
21. Microbial transformation of Manganese in soil – Manganese cycle.
22. Siderophores and antimicrobials.
23. Biochemical composition of soil organic matter and crop residues.
24. Biodegradation of soil organic matter and crop residues.
25. Biodegradation of Pesticides – Insecticides.
26. Biodegradation of Pesticides – Herbicides.
27. Biodegradation of Pesticides – Fungicides.
28. Organic wastes and its degradation.
29. Composting and vermicomposting.
30. Organic wastes for production of biogas.
31. Organic wastes as manures.

32. Biotic factors in soil development.
33. Microbial interactions in soil – Positive interactions.
34. Microbial interactions in soil – Negative interactions.

Practical Schedule

1. Conn's Direct microscopic count for estimating soil microbial population.
2. Standard plant count of estimating soil microbial population.
3. Most probable number method for estimating soil microbial population.
4. Buried slide techniques.
5. Determination of soil microbial biomass.
6. Amylase production test (Demostration of starch hydrolysis).
7. Cellulase production test (Degradation of cellulose).
8. Production of pectiolytic enzymes (Degradation of pectin).
9. Isolation of root nodule bacterium *Rhizobium.*
10. Isolation and purification of *Azobacter*.
11. Isolation and purification of *Acetobacter diazotrophicus.*
12. Isolation and purification of Phosphobacteria .
13. Identification of Endomycorrhizal fruiting bodies.
14. Isolation and purification of blue green algae.
15. Bio fertilizer inoculants production.
16. Methods of application of biofertilizer and quality control.
17. Rhizosphere study.

Course outcomes

CO-1: To understand the soil microbial biomass, its role in soil fertility, biodegradation and diversity of microbes.

CO-2: The students acquire and apply the principles of soil microbiology in practical and real life situation

CO-3:The student's knowledge on the soil microbial community, ecology and their interaction in relation to soil fertility will be improved and students will get an idea about the types of microorganisms of different soil zones.

CO-4:Students will gain knowledge on the latest biochemical and Microbiological aspects of biogeochemical cycles especially nitrogen fixation in the root soil interface , rhizoplane, rhizosphere regions.

CO-5: Students will get through knowledge and understand advanced information about plant microbe interaction.

CO-6: Students will be equipped with latest techniques and methods in the microbial management of pesticide pollution and organic wastes.

CO – PSO -PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	X			X												
CO 2				X				X								
CO 3			X	X												
CO 4	X		X	X						X						
CO 5	X		X	X							X					
CO 6			X	X		X						X				

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AGM 822 – ADVANCES IN FOOD AND DAIRY MICROBIOLOGY (2+1)

Learning Objectives:

- The students will be exposed to the microbiology of food irrespect to the the food spoilage, sources of contamination and also study intrinsic and extrinsic parameters of spoilage organisms.
- Students will study the principles and methods of food preservation and will know about GMP and QC food processing industries
- The students will study the fermented food such as cheese, yogurt, bread, beer and wine and those with other useful roles such as producing probiotics and microbial enzymes in food industries.
- The students will understand of the Basis of food safety regulations and discuss the rationale for the use of standard methods and procedures for the microbiological Analysis of food.

Theory

Unit – I Food Micro flora and its Importance

Introduction and importance of food microbiology –Incidence and behavior of microorganisms in food – Primary sources of contamination in food – Intrinsic and extrinsic parameters of food affecting microbial growth – Assessing microbial load in foods.

Unit – II Food Preservation

Principles of food preservation –Methods of preservation Physical methods – High temperature Low temperature, drying, osmotic pressure, irradiation, modification of atmosphere , chemical methods – Class I and II chemicals. Food manufacturing practices – HACCP – Quality control in food process industries. Food Quality control and standards. Genetically modified foods.

Unit – III Food Spoilage

Microbial spoilage of different types of food – spoilage of cereals and cereal products, fruits and vegetables , meat, egg and poultry, sea foods, canned foods. Food poisoning - botulism – Food borne infections – Food pathogens –mycotoxins - prevention of food poisoning.

Unit – IV Fermented Foods

Fermentation of pickles, sauerkraut, bread, vinegar, idli, and traditional fermented foods, microorganisms as food – single cell proteins spirilina – Applications of microbial enzymes in food industries.

Unit – V Dairy Microbiology

Microorganismsm of milk, milk and products – Preservation of dairy products – pasteurization –Microbial spoilage of dairy products – fermented dairy products

Practical

Microbiological examination of normal fruits and vegetables - spoiled fruits and vegetables - Normal cereal and sugar products - spoiled cereal and sugar products - Milk and water samples- Food preservation with chemicals , low temperature, high temperature - 'D' value calculations - Microbiological examination of spoiled canned foods - Microbiological examination of spoiled meat and fish - Microbiological survey of utensils and processing plants - Methylene blue reduction test - Assessing the load of *coliform* bacteria as indicator organisms - Visit to coffee and tea fermentation industries - Visit to cheese manufacturing units - Practical examination.

Lecture Schedule

1. Introduction and importance of food microbiology.
2. Incidence and behaviour of microorganisms in food.
3. Sources of microorganisms found in food.
4. Intrinsic and extrinsic parameters of food affecting microbial growth.
5. Assessing microbial load in food.
6. Principles of food preservation.
7. Physical methods of preservation – heat processing .
8. Chilling and freezing, drying.
9. Osmotic pressure, irradiation and modification of atmosphere.
10. Chemicals used as preservatives in food.
11. Food manufacturing practices.
12. HACCP.
13. Quality control in food process industries.
14. Food quality control and food standards.
15. Microbial spoilage of cereal and cereal products.
16. Spoilage of fruit and vegetables .
17. Mid Semester.
18. Spoilage of meat egg and poultry.
19. Spoilage of sea foods.
20. Spoilage of canned foods.
21. Food poisoning – Botulism.
22. Food bourne infection – Food pathogens.
23. Mycotoxins.

24. Fermented foods pickles , sauerkraut.
25. Bread, Vinegar and idli fermentations.
26. Single cell proteins.
27. Application of microbial enzymes.
28. Microorganisms of milk and milk products.
29. Preservation of dairy products.
30. Pasteurization methods.
31. Microbial spoilage of dairy products.
32. Fermented dairy products.
33. Diseases spread by microorganisms through milk.
34. Review of Lecture.

Practical Schedule

1. Microbiological examination of normal fruits and vegetables.
1. Microbiological examination of spoiled fruits and vegetables.
2. Microbiological examination of normal cereal and sugar products.
3. Microbiological examination of spoiled cereal and sugar products
4. Microbiological examination of milk and water samples.
5. Microbiological examination of cereal and sugar products.
6. Food preservation with chemicals.
7. Food preservation with low temperature.
8. Food preservation with high temperature -'D' value calculations.
9. Microbiological examination of spoiled canned foods.
10. Microbiological examination of spoiled meat and fish.
11. Microbiological survey of utensils and processing plants.
12. Methylene blue reduction test.
13. Assessing the load of *coliform* bacteria as indicator organisms.
14. Visit to coffee and tea fermentation industries.
15. Visit to cheese manufacturing units.
16. Practical examination.

Course outcomes

CO-1: The student will able to understand the significance of micro flora of in Ready to Eat (RTE) Foods & Frozen foods, Processed foods under proper hygienic environment by implementing hazard analysis & critical control points (HACCP) System and to transform safe food around globe.

CO- 2: The students by acquiring knowledge on fermented food product may able to venture into this food industries.

CO-3: Students will get job opportunities in dairy industries

CO – PSO-PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1					X											
CO 2					X	X										
CO 3					X	X					X					

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AGM 823 -ALGAL BIOTECHNOLOGY (2+1)

Learning Objective

1. To study the photoautotrophic nature of Cyanobacteria
2. To study the diversity of thallus structure and functions
3. To study the importance for mankind is enormous including their role as biofertilizers, nutraceuticals,

   experimental
4. To study the dyes, biofuels and a variety of biochemicals
5. To study the structure, molecular evolution and properties of cyanobacteria and algae.

Theory

UNIT I – Morphology of Algae

Introduction to Cyanobacteria and algae. Definition, occurrence and distribution, thallus structure, reproduction, life cycles, origin and evolution of Cyanobacteria, molecular evolution; role of algae in evolution of land plants and horizontal transfer of genes.

UNIT II – Algal Culturing techniques

Algal pigments, storage products, carbon metabolism, photosynthesis. Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photobioreactors, algal density and growth, seaweed cultivation.

UNIT III-Biotechnology and Utilization of Algae

Cyanobacterial and algal fuels, Fine chemicals (restriction enzymes etc) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology, sustainable aquaculture.

UNIT IV – Ecology of Algae

Ecology of algae- distribution in soil and water; primary colonizers, carbon sequestration and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism.

UNIT V – Bioremediation and Mass Production of Algae

Algae in pollution - as pollution indicators, eutrophication agents and role in Bioremediation.Cyanobacterial and algal toxins, allelopathic interactions, Algae in global warming and environmental sustainability. Cyanobacteria and selected microalgae in agriculture – biofertilizers & algalization; soil conditioners; reclamation of problem soils.

Theory Schedule

1. Introduction to Cyanobacteria and algae. Definition, occurrence and distribution,
2. Thallus structure, reproduction, life cycles,
3. Origin and evolution of Cyanobacteria,
4. Molecular evolution
5. Role of algae in evolution of plants
6. Plants and horizontal transfer of genes.
7. Algal pigments,
8. Storage products,
9. Carbon metabolism,
10. Photosynthesis.
11. Algal culturing and cultivation. Culture types, culture conditions,
12. Culture vessels, culture media, sterilization, culture methods,
13. Synchronous cultures, photobioreactors,
14. Algal density and growth, seaweed cultivation
15. Cyanobacterial and algal fuels,
16. Fine chemicals (restriction enzymes etc) and nutraceuticals from algae;
17. UV absorbing pigments Industrial products from macro algae - seaweed biotechnology,
18. Sustainable aquaculture
19. Ecology of algae- distribution in soil and water;
20. Mid semester Examination
21. Primary colonizers,
22. Carbon sequestration
23. Algal cycling in soil and water.
24. Cellular differentiation
25. Nitrogen fixation
26. Nitrogen metabolism
27. Algae in pollution - as pollution indicators, eutrophication agents and role in Bioremediation.
28. Cyanobacterial and algal toxins, allelopathic interactions,
29. Algae in global warming and environmental sustainability.
30. Cyanobacteria and selected microalgae in agriculture –
31. Algal Biofertilizers
32. Algalization;
33. Reclamation of problem soils by algae

34. Model Examination

Practical

Practical Isolation and identification of different groups of algae, media preparation for cyanobacteria, cyanobacterial pigment isolation and quantification. Algal symbiosis, Azolla; multiplication of Azolla, Bioformulation of cyanobacteria and other algae. Mass multiplication of algal inoculum

Practical Schedule

1. Isolation of *Anabaena sp*
2. Identification of *Anabaena sp*
3. Isolation of *Nostoc sp*
4. Identification of *Nostoc sp*
5. Isolation of *Tolypothrix sp*
6. Identification of *Tolypothrix sp*
7. Isolation of *Spirulina sp*
8. Identification of *Spirulina sp*
9. Media preparation for cyanobacterial growth
10. Estimation of Cyanobacterial pigment production
11. Multiplication of Azolla and Method of application
12. Algal symbiosis – determination of heterocyst frequency
13. Bioformulations - cyanobacteria and other algae.
14. Mass multiplication and method of application of BGA
15. Quality control of algal Biofertilizer
16. Role of algae in aquaculture
17. Practical Examination

Course outcomes

CO-1: To students have in depth knowledge about photoautotrophic nature of Cyanobacteria

CO-2: To students have knowledge about diversity of thallus structure and functions

CO-3: They have clear understanding about importance for mankind is enormous including their role as biofertilizers, nutraceuticals.

CO-4: They have knowledge about structure, molecular evolution and properties of cyanobacteria and algae.

CO – PSO-PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	X		X	X			X									
CO 2	X				X											
CO 3			X	X		X			X							
CO 4	X									X						

Reference Books

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http://microbiology.ucsc.edu/ Details of sites related to Microbiology

http://www.suite101.com/links.cfm/microbiology

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AGM 824 - MICROBIAL BIOTECHNOLOGY (2+1)

Learning Objectives:

1. To introduce students the concepts in Industrial Applications of Microorganisms.
2. To present an overview of importance of Fermentor, types and their applications.
3. To understand the use of genetically engineered microorganisms in biotechnology.
4. To understand microbial production of primary and secondary metabolite production.
5. To study and understand about mass production of Biofertilizers, Biopesticides and flavouring agents.

Theory

UNIT I- Introduced to Industrial Microorganisms and Strain Improvement

Introduction, scope and historical development; Isolation, screening and genetic improvement of industrially important microorganisms.

UNIT II-Microbial Fermentation Profess – Organic Solvent and Amnio Acids

Types of fermentation systems; production of various primary and secondary metabolities, e.g. amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, etc.

UNIT III- Bioreactor

Process scale up steps: laboratory, pilot plant and industrial scales. Down stream processing; Over-production of metabolities; Bioreactor operations, process control.

UNIT IV- Fermented Products

Fermented beverages; Production of single cell protein; Steroid transformation; Immobilization of cells/enzymes; Silage production; Waste water treatment.

UNIT V- Biofertilizers and Bioinsecticides

Use of genetically-engineered microorganisms in biotechnology; Bioinsecticides, biofertilizers, etc. Microbiologically-produced food colours and flavours. Retting of flax.

Practical

Isolation of industrially important microorganisms, their maintenance and improvement. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery; Study of bio-reactors and their operation: Production of biofertilizers.

Lecture Schedule:

1. Introduction, Scope of Microbial biotechnology.
2. Historical Development of Microbial Biotechnology.
3. Isolation and screening of industrially Important Microorganisms.
4. (4-7)Genetic improvement of industrially improvement Microorganisms.

11. Types of fermentation systems.
12. Production of various primary metabolites.
13. Production of various Secondary metabolites.
14. Production of amino acids.
15. Production of organic acid .
16. Production of alcohols.
17. Production of enzymes.
18. Production of organic solvents.
19. Production of Antibiotics.
20. Mid Semester Exam.
21. Process scale up for pilot plant study.
22. Process scale up for Laboratory study.
23. Process scale up for industries.
24. Down stream processing methods.
25. Over – Production of Metabolites.
26. Bioreactor operations and process control.
27. Production of steroid transformation.
28. Immobilization of cells.
29. Silage production.
30. Silage production.
31. Waste water treatment .
32. Use of genetically engineered microorganisms in biotechnology.
33. Bioinsecticides.
34. Biofertilizers.
35. Microbiologically production of food colours.
36. Microbiologically production of flavours.
37. Retting of flax.
38. Review of Lecture.

Practical Schedule

1. Isolation and screening of industrially Important Microorganisms.
2. Genetic improvement of industrially improvement Microorganisms.
3. Study of Bio-reactors

4. Scale up of fermentation process
5. Production of Alcohol
6. Production of Lactic acid
7. Production of Citric acid
8. Production of Single cell protein
9. Production of Antibiotics
10. Antibiotic assay methods
11. Production of Amylase
12. Immobilization cells techniques
13. Production of Bioinsecticide
14. Production of Azospirillum
15. Production of PGPR
16. Waste water treatment by microorganisms
17. Practical Exam

Course outcomes

CO-1: Students will be knowing the isolation, screening and genetic improvement of industrially important microbial strains.

CO-2: To gain knowledge on the types of fermentation systems, production of primary and secondary Metabolite production starting from amino acids to solvents

CO-3: The sound knowledge about pilot scale up process, downstream processing and bioreactor process and control will be obtained

CO-4: Gain knowledge of contemporary environmental issues addroned by genetically engineered microorganisms

CO-5:The students will be able to manage waste water problems by following bioremediation techniques learned from this course.

CO – PSO-PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	X	X	X	X	X	X	X									
CO 2	X				X	X										
CO 3			X		X	X			X							
CO 4		X	X			X					X					
CO 5		X	X			X										

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AGM 815 MICROBIAL INOCULANTS PRODUCTION AND QUALITY CONTROL

(2+1)

Learning Objectives:

- To make the students to understand the concepts of microbial inoculants and their role on soil fertility and plant growth.
- To learn about the isolation and development of efficient bioinoculant strains
- To educate about the various formulations of microbial inoculants with improved shelf life and their quality standards.
- To know the techniques of mass multiplication, storage and application methods of bioinoculants.
- To analyse the performance of microbial inoculants on field level, their constraints in production technology, marketing and economics.

Theory

Unit-I: Role of Microbial Inoculants

Microbial inoculants in agriculture and allied areas – contribution of inoculants in nutrient mobilization and soil fertility – organic matter decomposing – pest and disease control

Unit-II Bacterial & Fungal Inoculants

Bacterial inoculants: *Rhisobium, Azospirillum , Azotobacter, Acetobacter* and *Phosphobacteria* etc. Algal inoculants, Mycorrhiza – Ectomycorrhiza and Endomycorrhiza, Role of Mycorrhizae in Agriculture and Horticulture crops

Unit- III: Microbial Inoculants for pests Disease control

Microbial inoculant for the control of pest and disease: *Bacillus thuringiensis Pseudomonas Fluorescens Tdrichoderma, Beauveria,Verticillum, Metarrhizium,*NPV and GV, etc. isolation and screening of efficient strains

Unit-IV : Mass production of Bioinoculants

Principles of mass production of inoculants. Growth characteristic of different group of organisms and their importance in mass production, carrier materials, formulation, curring and storage, methods of application ect..,

Unit- V: Quality control of Bioinoculants

Quality control – Testing of purity of inoculants at production, distribution and field level. Quality control organization . Marketing and monitoring field performance-project preparation and financing – calculation of cost/ benefit ration.

Practical

Isolation and screening method- selection of suitable strain – strain improvement of different types of inoculants. *Rhizobium, Azotobacter, phosphobacteria VAM. BT Peseudomonas,Trichoderma, Beauvaria, Verticillium and Metarrhizium* etc. Testing the efficiency of microbial inoculants- shelf life- Method of inoculation –Quality control

Theory Lecture Schedule

1.History & development of bioinoculant
2.Role of microbes in soil fertility
3.Organic matter decomposition , Humus formation
4.Cellulose , Hemicelluloses, lignin degradation
5.Microbial control of pest & diseases
6.Bacterial & fungal inoculants an introduction
7.*Rhizobium* inoculant, morphology, occurrence role in soil fertility
8.*Azospirillum &Azotobacter* inoculants- occurrence role in soil fertility
9.*Acetobacter* inoculant-occurrence- role in soil fertility
10.*Phosphobacterial* inoculant phosphate solubilizing mechanisms
11.Role of phosphobacteria in soil fertility
12.Algal inoculants – Types of algae- role in soil fertility
13.Mycorrhizal inoculants –types –distribution
14.Importance of mycorrhiza in agriculture crops
15.Importance of mycorrhiza in agriculture crops
16.Role of mycorrhiza in disease management
17.*N2* fixing mechanism by *Rhizobium & Azotobacter*
18. *N2*- fixing mechanism by *Azosopirillum & Acetobacter*
19.Microbial control of pests& disease, general account
20.Bactrial inoculant for control of pests& disease
21.Fungal inoculant for control of pests & disease
22.Viral inoculant for control of pests& diseases
23.Isoaltin & screening of efficient strains for control of pest & diseases
24.Principles of mass production of bioinoculants
25.Growth of different group of organisms
26.Mass production of bacterial bioinoculants
27.Mass production of algal bioinoculants
28.Mass production of mycorrhizal bioinoculants
29.Formation & preparation of bioinoculants

30.Method of application of bioinoculant

31.Method of testing the inoculant for purity at production

32.Quality control organization for check the quality

33.standards for various bioinoculants

34.Project preparation & financing

35.calculatin of cost /benefits ration

Practical Schedule

1.Isoaltin of *Rhizobium*

2.Isolatin of *Azospirillum*

3.Isolatin of *Azotobacter*

4.Isolatin of *Acetobacter*

5.Isolatin of Phosphobacteria

6.Isolation BGA

7.Isolation of Mycorrhiza

8.Staining techniques for Mycorrhiza

9.Screening method for bacterial bioinoculants

10.Screening method for Mycorrhizal inoculants

11.Mass production of Bacterial inoculant

12.Mass production of Mycorrhizal inoculant

13.Mass production of algal inoculants

14. Testing the quality of bioinocultns

15. Method of application of bioinoculants

Course outcome:

CO - 1: The students will know concepts of biofertilizers.

CO - 2: Students will be able to isolate, purify and maintain the mother cultures

CO - 3: Students will be trained on the production of biofertilizer in the different formulation.

CO – 4: Students will learn about the mass production techniques of various bioinoculants

CO – 5: They will develop the knowledge and skills for starting a biofertilizer production unit.

CO – PSO-PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1			X	X			X									X
CO 2	X			X		X										
CO 3				X		X		X								
CO 4				X		X				X						
CO 5						X										

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AGM825- COMPOSTING TECHNOLOGY (2+1)

Learning Objectives

To study the nature of different types of wastes and different techniques of preparing enriched composts

To know the role of microorganism in composting techniques

To study the quality standards of compost and its role in sustainable agriculture

Theory

Unit –I Wastes- sources and properties

Sources of wastes- nature and characteristics availability – collection, handling and processing of wastes properties and nutrient status- plant residues- industrial wastes – urban wastes etc.

Unit –II: Techniques in composting

Techniques in composting – aerobic composting, anaerobic composting vermicomposting window – composting , coirpith composting and special techniques

Unit –III Microbial Inoculant for Enriched composts

Microbial inoculant for composting – selection of consortia for composting – factors affecting composting. Microbial inoculants for enriched composts

Unit –IV Quality standards & Composts and their Application

Quality standards – maturity for tests – physical chemical and biological tests. Handling and storage methods of application.

Unit-V Field performance and crop response of composts

Evaluation of composts- marketing and monitoring – accumulation of metal- soil and ground water quality monitoring . Field performance and crops response.

Practical

Characterization of waste material- method of composting- vermicomposting – qualitative analysis – quantitative assay – nutrient – microbial activity – field visit to compost yard

Theory Lecture schedule

1. Wastes and their sources
2. Characteristic of (physical & chemical)
3. Handling and providing of wastes
4. Nutrient status of wastes and their properties
5. Types of organic wastes from agriculture and their quantitative and qualitative nature

6. Industrial wastes and then properties
7. Urban wastes and then quantum and properties
8. Method of composting
9. Aerobic and anaerobic methods of composting
10. Vermicomposting
11. Window composting
12. Coirpith composting
13. Special techniques in composting
14. Factors affecting composting
15. Microbiology of composting
16. Preparation of enriched composts
17. Selection of consortia for composting
18. Role of Microbial inoculant for enriched composts
19. Maturity test of compost (Physical & chemical)
20. Biological tests to assess maturity of composts
21. Handling & storage of composts
22. Method of application of composts
23. Evaluation of composts for the nutrient status
24. Marketing of composts
25. Accumulation of different metals in composts
26. Ground water pollution and monitoring
27. Soil properties due to compost application
28. Field performance and crop response of composts
29. Soil properties due to compost application
30. Role of compost in sustainable agriculture
31. Economics of composting & C/N ratio
32. Expenditure of setting up of a composting unit/yard
33. Composting and its effect on public
34.Qualitative analysis of compost

Practical schedule

1. Physical characterization of waste materials
2. Chemicals characterization of waste materials
3. Qualitative and quantitative enumeration of microbes in waste material
4. Isolation of cellulose, degrading microorganism from waste materials
5. Estimation of Co2 evolution from decomposition on of organic wastes
6. Aerobic method of composting

7. Anaerobic method of composting

8. Vermicomposting

9. Assessment of maturity of compost- Physical tests

10. Assessment of maturity of compost- chemical tests

11. Quantitative and qualitative estimation of microbial in mature compost

12. Succession of microorganism in composting

13. Quantitative estimation of micronutrients N.N&K

14. Quantitative estimation of micronutrients Ca, Zn, Fe

15. Dehydrogenase activity of nature compost

16. Techniques of compost yard

17. Field visit to compost yard

Course outcomes

CO-1: They have knowledge about nature of different types of wastes and different techniques of preparing enriched composts

CO-2: They have knowledge about know the role of microorganism in composting techniques

CO-3: They have knowledge about quality standards of compost and its role in sustainable agriculture

CO – PSO-PO MAPPING MATRIX

COs/PSOs/PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1			X				X									
CO 2	X		X	X	X	X			X		X					
CO 3			X	X												

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