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Revised Curricula & Syllabi as per the Recommendation of ICAR – Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020

of

Master of Science in Agriculture

Complied and Prepared

By

Board of Studies (BoS) under The Chairmanship of Dean, Faculty of Agriculture,
Approved by Academic Council and published by Registrar

Bundelkhand University, Jhansi (INDIA)

Foreword

The quality of human resource is the greatest treasure of a nation and the main driver of comprehensive development. Drucker (1994) said "Instead of traditional factors of production land, labor and capital – knowledge and technology will become the critical factors. The winners will be the economies with necessary skills and the losers will be nations who lack them". Therefore our human capital has to respond to emerging challenges. But, fundamental question is that ***"What kind of Agricultural education is needed for what kind of Society of tomorrow"*** *In this regard the aim, process and goal of agriculture education would have to be identified while preparing educational program as per NEP-2020. Agriculture education is a profession oriented complex built on knowledge from basic sciences, applied sciences most relevant to agriculture production, related insight from the social & behavioral sciences and the problem solving field like natural resources management also.*

The emerging scenarios and diverse employment opportunities warrant curricular reform through better course integration. The urgent need to Post Graduate Agricultural education is to enhance the research, skills, problems solving abilities and employbility. There is a need for a few balances between breadth of discipline oriented studies and the depth of specialized skills & abilities. Therefore, the efforts are taken to involve the industries with academia. The specialized and integrated two year curriculum an appropriate balance between major area of specialization along with minor and breadth and specialization, discipline courses v/s multidisciplinary courses, core courses v/s choice of specialization and class room study v/s field/factory study. Conferring professionalism in a chosen area should be the mail consideration. Since education and training are powerful tools for agriculture development and training should find a higher place in higher educational agenda. The training with education should focus on practical and problem solving abilities and acquisition of skills for entrepreneurship and self employment.

Hence, toward enhancing human values & ethics, personality & leadership attributes, employability and entrepreneurial ability of the Agriculture graduates we decides to upgrade/revised curriculum of Agricultural education at graduate levels accordingly.

Contents

Definitions of Academic Terms:

Chairperson means a teacher of the major discipline proposed by the Head of Department.

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

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

Credit load of a student refers to the total number of credits of all the courses he/ she registers during a particular semester.

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

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

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

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

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

बुन्देलखण्ड विश्वविद्यालय, झाँसी

विश्वविद्यालय के पत्र पत्रांक बु०वि०/एके०/2022/7590 दिनांक 16.07.2022 में सन्दर्भित एजेंडा -2 जोकि विश्वविद्यालय के कृषि संकाय के अन्तर्गत संचालित परास्नातक (M.Sc. Ag.) के समस्त विषयों के पाठ्यक्रमों को ICAR के राष्ट्रीय कोर समूह एवं 19वें ब्रॉड सब्जेक्ट मैटर एरिया (BSMA) द्वारा संस्तुत पाठ्यक्रमों को दृष्टिगत रखते हुए संकायाध्यक्ष, कृषि की अध्यक्षता में पाठयक्रम संरचना समिति का गठन किया जाता है। जो विश्वविद्यालय में कृषि संकाय के अंतर्गत संचालित समस्त पाठ्यक्रमों का विस्तृत प्रारूप (Draft) तैयार कर दिनांक 20.07.2022 को संकायाध्यक्ष को सोंपेगी । जिससे उसे दिनांक 21.07.2022 को कृषि संकाय के अध्ययन बोर्ड की बैठक में अनुमोदनार्थ प्रस्तुत किया जा सके।

समिति के अध्यक्ष	:	प्रोफे. (डॉ.) एस.एल. पाल (संकायाध्यक्ष, कृषि)
समिति के समन्यवक	:	डॉ. नरेश कुमार सिंह
समिति के सचिव	:	डॉ. एस.जी. राजपूत
समिति के संयुक्त सचिव	:	डॉ. जितेन्द्र सिंह,
समिति के सदस्य	:	समस्त संयोजक, अध्ययन बोर्ड (कृषि संकाय)

Ordinances-2022-23

माननीय कुलपति जी के आदेशानुसार पत्रांक संख्या बु० वि०/एके०/2022/**7590** दिनांक 16.07.2022 के अनुपालन में दिनांक 21/07/2022 को पूर्वाह्न 11:00 बजे विश्वविद्यालय सभागार में कृषि संकाय की समस्त पाठ्यक्रम समितियों की बैठक आहूत की गई, जिसमे एजेंडा संख्या -2 के अन्तर्गत लिखित "पाठ्यक्रम संरचना" - विश्वविद्यालय अनुदान आयोग की गाइड लाइन के अनुरूप पाठक्रमों का अधुनातन किया जाना सहित पाठ्यक्रम की गुणवत्ता पर विशेष ध्यान दे पाठ्यक्रम को तैयार करना था।

बैठक की कार्यवाही –

"कृषि संकाय" की समस्त पाठ्यक्रम समितियों के समन्वयक एवं सदस्य आज दिनांक 21/07/2022 को अधुनातित कृषि परास्नातक विषयवार पाठ्यक्रम की संरचना का विस्तृत ड्राफ्ट अपनी संस्तुति सहित सत्र 2022-23 से लागू करने हेतु तैयार आगे की कार्यवाही के लिए "कृषि संकाय अध्यक्ष", बुन्देलखंड विश्वविद्यालय, झाँसी को सौंपती है।

समस्त पाठ्यक्रम समितियों के समन्वयकों एवं सदस्यों के हस्ताक्षर-

सस्य विज्ञान पाठ्यक्रम समिति भूमि संरक्षण एवं ,कृषि अभियांत्रिकी)कृषि-वानिकी संयुक्त समिति(

डा ,(वरुण कुमार सिंह) .सहप्राध्यापक-
एवं संयोजक अध्ययन बोर्ड

डा ,(पाण्डेय .के.की) .सहप्राध्यापक-
सदस्य अध्ययन बोर्ड

डा ,(शैलेन्द्र कुमार) .सहा. प्राध्यापक एवं
सदस्य अध्ययन बोर्ड

डा ,(सुनील कुमार) .विभागाध्यक्ष
एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डा ,(मनोज कुमार सिंह).प्राध्यापक
एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डा(कुलदीप देशवाल) .
इंडस्ट्रीयल सदस्य

डा ,(संतोष पाण्डेय) .सहायक आचार्य एवं
विशेष आमंत्री सदस्य

मृदा विज्ञान एवं कृषि रसायन पाठ्यक्रम समिति

डा) .एस.जी. राजपूत ,(सहा. प्राध्यापक एवं
संयोजक अध्ययन बोर्ड

डा ,(दशरथ सिंह) .सहप्राध्यापक एवं -
सदस्य अध्ययन बोर्ड

डा ,(अनिल कुमार सचान) .प्राध्यापक एवं
बाह्य विशेषज्ञ अध्ययन बोर्ड

डा ,(चमन सिंह) .सहप्राध्यापक एवं -
शेषज्ञ अध्ययनबाह्य वि

डा(राजेश कुमार सिंह) .
इंडस्ट्रीयल सदस्य

डा ,(सत्यवीर सिंह) .सहायक आचार्य एवं
विशेष आमंत्री सदस्य

उद्यान विज्ञान पाठ्यक्रम समिति

प्रोफेप्राध्यापक ,पाल.एल.एस (.डा) .
एवं संयोजक अध्ययन बोर्ड

21/7/22

डा ,(उमराव .के.वी) .प्राध्यापक
एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

21/7/22

डा विपिन) .कुमार ,(सहप्राध्यापक-
एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डाप्राध्यापक एवं -सह (सिंह .के.जी) .
सदस्य अध्ययन बोर्ड

डा(योगेश मिश्रा) .
इंडस्ट्रीयल सदस्य

डा ,(हरपाल सिंह) .सहायक आचार्य एवं
विशेष आमंत्री सदस्य

आनुवंशिकी एवं पादप प्रजनन पाठ्यक्रम समिति

डा ,(सुरेन्द्र सिंह) .सहप्राध्यापक एवं -
संयोजक अध्ययन बोर्ड

डा ,(बलवंत सिंह) .सहप्राध्यापक एवं -
सदस्य अध्ययन बोर्ड

डा ,(मनोज श्रीवास्तव) .प्राध्यापक एवं
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एवं बाह्य विशेषज्ञ अध्ययन बोर्ड
अध्ययन बोर्ड

डा(कुलदीप देशवाल) .
इंडस्ट्रीयल सदस्य

पशुपालन एवं दुग्ध विज्ञान पाठ्यक्रम समिति

डा(नरेश कुमार सिंह) . 21/07/2022
सहप्राध्यापक- एवं संयोजक अध्ययन बोर्ड

डा(कुशवाहा .पी.वी) .
प्रधान वैज्ञानिक
एवं बाह्य विशेषज्ञअध्ययन बोर्ड ,

डा(रामजी गुप्ता) .
प्राध्यापक -पशुपालन एवं दुग्ध विज्ञान
एवं बाह्य विशेषज्ञअध्ययन बोर्ड ,

डा(भीमसेन) . सहप्राध्यापक -
पशुपालन एवं दुग्ध विज्ञान
एवं सदस्य अध्ययन बोर्ड

P.K. Singh

डा(प्रवीण शिदु) .
इंडस्ट्रीयल सदस्य

डासहायक आचार्य एवं (~~सिंह.के.पी~~) .
विशेष आमंत्री सदस्य

कीट विज्ञान पाठ्यक्रम समिति

डा ,(राम सुभग सिंह) .सहप्राध्यापक एवं - संयोजक अध्ययन बोर्ड

डा ,(हरिकेश सिंह) .प्राचार्य एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डा ,(सिंह वी.बी) .प्राध्यापक एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डा ,(मनोज कुमार त्रिपाठी) .प्राध्यापक एवं सदस्य अध्ययन बोर्ड

डा(वीरेश मिश्रा) . इंडस्ट्रीयल सदस्य

पादप रोग विज्ञान पाठ्यक्रम समिति

डा ,(राम .के) .सहप्राध्यापक एवं - संयोजक अध्ययन बोर्ड

डा ,(धर्मेन्द्र कुमार) .सहप्राध्यापक एवं - सदस्य अध्ययन बोर्ड

डा ,(रामचंद्र) .प्राध्यापकएवं बाह्य , विशेषज्ञ अध्ययन बोर्ड

डा ,(रमेश सिंह) .प्राध्यापक एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डा(कुलदीप देशवाल) . इंडस्ट्रीयल सदस्य

डा ,(बबेले .के.जी) .सहायक आचार्य एवं विशेष आमंत्री सदस्य

कृषि अर्थशास्त्र पाठ्यक्रम समिति (की की संयुक्त समितिकृषि अर्थशास्त्र एवं कृषि सांख्यि)

डा ,(जितेन्द्र सिंह) .सहायक प्राध्यापक एवं संयोजक अध्ययन बोर्ड

डा ,(अवधेश नारायण शुक्ला) .सहायक प्राध्यापक

डा ,(उमेश चन्द्र त्रिपाठी) .सहायक प्राध्यापक एवं सदस्य अध्ययन बोर्ड

डा ,(एल सिंह एच) .प्राध्यापक एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डा राहुल कुमार) .राय ,(सहायक प्राध्यापक एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डा(प्रवीण शिद्धू) . इंडस्ट्रीयल सदस्य

डा ,(शिशिर कुमार सिंह) .सहायक आचार्य एवं विशेष आमंत्री सदस्य

कृषि प्रसार पाठ्यक्रम समिति

डा ,(सरजू नामदेव) .सहायक प्राध्यापक एवं संयोजक अध्ययन बोर्ड

डाभान) .ु प्रकाश मिश्रा ,(प्राध्यापक एवं सदस्य अध्ययन बोर्ड

डासेवानिवृत (कुशवाहा .के.आर) . प्राध्यापक एवं बाह्य विशेषज्ञ अध्ययन

डा ,(बी पाल.एस) .सहायक प्राध्यापक एवं बाह्य विशेषज्ञ अध्ययन बोर्ड

डा(राजेश कुमार सिंह) . इंडस्ट्रीयल सदस्य

डा ,(भारती .के.ए) .सहायक आचार्य एवं विशेष आमंत्री सदस्य

This ordinance shall be called ***"The Bundelkhand University, Jhansi, Master of Science in Agriculture degree Ordinance 2022-23"***. This ordinance shall replace the existing ordinance and effective from the Academic Session 2022-23. The ordinance has been grouped into following parts:

1. Nomenclature of the degree
2. Academic year and fees
3. Admission eligibility and procedures
4. Program duration
5. Examination & evaluation.

1. Nomenclature of the degree:

The name of the degree shall be ***Master of Science in Agriculture*** and abbreviated in short as ***M. Sc. (Ag.)*** *along with name of the subject of specialization.*

2. Academic year and fees:

Academic year will be divided into two semesters, each semester having duration of approximately 90 teaching and learning days. Students will have to pay required fee as prescribed under rules and regulations of the Bundelkhand University, Jhansi and/or Colleges for the program at the time of admission.

3. Admission procedure and eligibility:

3.1 Procedure of admission:

Admission in the first year program **shall be based on the single merit of entrance examination conducted by** the University/College under the supervision of the Dean faculty of Agriculture, Bundelkhand University, Jhansi.

3.2 Eligibility of admission:

All residents of India and NRI's shall be eligible for admission in this program provided that candidate must be physically fit and passed / appeared in the qualifying graduation examination in Agricultural Science stream from any university/institution recognized by UGC/ICAR. The admitted students have to submit/show all original documents related to their admission eligibility before on dated 30th September of that academic session or as per university notification whichever earlier. If fail to submit, their admission liable to cancel without pre-notice to the candidate.

3.3 Number of seats and reservation:

Total number of seat available for admission in each subject of specialization in the university/colleges shall be notifying by the University every year before initiation of admission process. The reservation in the admission shall be applicable as per the rules & regulation of reservation formulated by university and/or state Government of Uttar Pradesh / Government of India.

4. Program duration:

The minimum duration of the programm shall be a two academic years (four semesters) and extended to a maximum of consecutive up to five academic years (10 semesters). In case a

student fails to complete the programme within the maximum duration of requirement, his/ her admission shall stand cancelled

5. Medium of instruction and examination:

Medium of instruction in the class room shall be in the English or in hybrid mode (Hindi and English). The examination papers shall be in English only while student may answer the question in English/Hindi.

6. Promotion of online Learning:

In line with the suggestion in new education policy (NEP), the various courses are available in the form of e-courses, MOOCs, SWAYAM, etc. The student are advised to explore the benefit of learning of common stared (*) courses through online resources as well as other courses also.

5.2: Evaluation method-

The student's achievements shall be evaluated on the basis of their performance in different tests in the form of written and practical examinations, and thesis and viva-voce examination where applicable. The various tests, their number and relative weightage in each semester shall be as follows:

	Name of Test and evaluation	No.	Exam-weight
(A)	**Theory with Practical Course:**		
	(a) Mid-semester Examination(Written internal)	One	20%
	(b) End-semester Examination		
	(i) Theory (University Exam)	One	50%
	(ii) Practical (University External)	One	30%
(B)	**Theory Courses only:**		
	(a) Mid-semester examination (Written internal)	One	50%
	(b) End-Semester Examination (University Exam)	One	50%
	(c) Assignment internal evaluation (only for * courses)	One	50%
(C)	**Practical Courses only:**		
	(a) End-Semester Examination (University external)	One	100%

- The mid-semester examination shall be of one hour's duration and generally cover 50% of the total course.
- End semester examination covering the entire subject matter of a course, shall be held at the end of each semester. The duration of the examination shall be as per university norm.

Calculation of GPA / CGPA / OGPA :-

Point Score of the paper = Marks obtained out of 100 x Credit Hours / 10

GPA = Total Point Score in all papers / Total Credits (for one semester)

CGPA = ∑ Total Point Score / Course Credits

OGPA = ∑ Total Point Score (after excluding failure Points) / Course Credits

% of Marks = OGPA X 100 / 10

Significance of grade For M.Sc. (Ag.)	EXPRESSION
8.00 and above	Excellent
6.5 - < 7.99	Good
5.5 - < 6.5	Fair
< 5.5	FAIL

Equivalence of grade in percent and as division:

Grade X 10.0 = % marks

70% and above = First Division;
Above 65% but below 70% = Second Division;
Below 60% = Fail

Calculation of GP, GPA, and OGPA and Mark sheet (A model) :

Grade point and overall grade point average shall be calculated as illustrated here under-

Credits	Marks				Grade		OGPA
(Theory + practical)	Mid-term **Or** *(Mid + Assignment)	End-term	Practical	Total	Grade	Grade Point(GP)	53.6 ÷ 7 = 7.657
3 (2+1)	25	33	22	80	8.0	24.0	
2 (2+0)	28	50	-	78	7.8	15.6	
2 (0+2)	18	-	52	70	7.0	14.0	
7 (4+3)						53.6	

Note :-

Grade Point (GP) : Grade X Credit

Grade Point Average : GP/Credit

Over All Grade Point Average (OGPA) : Total GP/Total Credits

Grade : Total Marks in a Course / 10

MINIMUM GRADE POINT REQUIREMENT FOR PASSING A COURSE / SEMESTER / DEGREE PROGRAMME

Minimum grade points required are given below :

Passing requirement of-	M.Sc. (Ag.)
A course	4.0
A semester	5.5
An academic year	5.5
Degree Programme	5.5

Advisory Committee (Advisor/ Co-guide/ Member) and thesis evaluation work will be done on the basis of research ordinance of the University.

5.1 Research Advisory Committee:

There shall be an Advisory Committee for every student consisting of at least two members with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and/or minor fields amongst the members of the faculty.

Internship for Development of Entrepreneurship in Agriculture (IDEA):

By this ordinance, a provision of 25 credits for dissertation work (IDEA) in M.Sc. (Ag) in all discipline in lieu of thesis/ research work is recommended. This program helps practically only those students who aspire to pursue their career as in entrepreneurship. It will give the students an opportunity to have a real-time hands-on experience in the industry. It is envisaged that the internship/ in-plant training would enhance the interactions between academic organizations and the relevant industry. It would not only enable the development of highly learned and skilled manpower to start their-own enterprises but also the industry would also be benefitted through this process. This pragmatic approach would definitely result in enhanced partnerships between academia and industry in the future.

The main objectives of the program:

- To promote the linkages between academia and industry
- To establish newer University – Cooperative R&D together with industry for knowledge creation, research and commercialization
- Collaboration between Universities and industries through pilot projects
- To develop methods for knowledge transfer, innovation and networking potential
- To enhance skill, career development and employability

The criteria for IDEA will be taken into consideration will be follows:

- At any point of time there will not be more than 50% of students who can opt under IDEA
- Major Advisor will be from Academia and Co-advisor (or Advisory Committee member) from industry
- Total credits (25) will be divided into 15 for internship/ in-plant training and10 for writing the report followed by viva-voce similar to dissertation
- Work place will be industry; however, academic/ research support would be provided by the University or both and MoU may be developed accordingly
- The IPR, if any, would be as per the University policy

Department Wise Syllabus of Major Courses

1. **Agronomy (AGR)**
2. **Soil Science & Agricultural Chemistry (SAC)**
3. **Horticulture (HOR)**
4. **Genetics & Plant Breeding (GPB)**
5. **Animal Husbandary & Dairying (AHD)**
6. **Agricultural Entomology (ENT)**
7. **Plant Pathology (PPA)**
8. **Agricultural Economics (AEC)**
9. **Agricultural Extension (EXT)**
10. **Seed Science & Technology (SST)**
11. **Agroforestry (AGF)**

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Agronomy

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1: Conservation Agriculture		AGR-1101	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Principles and practices of soil fertility and nutrient management		AGR-1102	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3: Agronomy of major Cereals and Pulses		AGR-1103	*2 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Agronomy of fodder and forage crops		AGR-1104	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5: Management of Problematic soils and water		SAC1204	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST-3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Intellectual Property and its Management in Agriculture**		*COM-5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM-5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1: Principles and Practices of Water Mangt.		AGR-1105	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2. Principles and Practices of Organic Farming		AGR-1106	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Principles and Practices of Weed Mangt.		AGR-1107	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Modern Concepts in Crop Production		AGR-1108	*2 (2+0)*	*100 (20 M + 30 P + 50 T)*
	5: Disease of field and medicinal crops		PPA-1708	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs		*AST-3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM- 5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM-5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	1: Agronomy of oilseed, fibre and sugar crops		AGR-1109	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Agronomy of medicinal, aromatic & underutilized crops		AGR-1110	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Dryland Farming and Watershed Management		AGR-1111	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Cropping System and Sustainable Agriculture (As Minor)		AGR 1112	*2 (2+0)*	*100 (20 M + 30 P + 50 T)*
	*6: Agricultural Research, Research Ethics and Rural Development Programs**		*COM-5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	1: Seminar		*AGR-1213*	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	*AGR-1114*	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	*AGR-1115*	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Syllabus
M.Sc. (Ag.) Agronomy
SEMESTER I
1. Course Title : Conservation Agriculture
Course Code : AGR-1101
Credit Hours : 3(2+1)

Theory

Unit I

Conventional and conservation agriculture systems, sustainability concerns, conservation agriculture: Historical background and present concept, global experiences, present status in India.

Unit II

Nutrient management in CA, water management, weed management, energy use, insect-pest and disease management, farm machinery, crop residue management, cover crop management.

Unit III

Climate change mitigation and CA, soil health management, soil microbes and CA.

Unit IV

CA in agroforestry systems, rainfed / dryland regions

Unit V

Economic considerations in CA, adoption and constraints, CA: The future of agriculture

Practicals

- Study of long-term experiments on CA,
- Evaluation of soil health parameters,
- Machinery calibration for sowing different crops, weed seed bank estimation under CA, energy requirements, economic analysis of CA.

Suggested Reading

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

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

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

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

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

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

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

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

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

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

2. Course Title: Principal and Practices of Soil Fertility and Nutrient Management

Course Code : AGR-1102

Credit Hours :2(1+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Time, methods and doses of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management.

Practical

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

Suggested Readings

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

3. Course Title: Agronomy of Major Cereals and Pulses

Course Code: AGR-1103

Credit Hours : 3(2+1)

Theory

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

Unit I: *Rabi* cereals.

Unit II: *Kharif* cereals.

Unit III: *Rabi* pulses.

Unit IV: *Kharif* pulses.

Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR etc)
- Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient and Competition Ratio etc)
- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of seed production techniques in selected crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings

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

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

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

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

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

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

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

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

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

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

4. Title : Agronomy of Fodder and Forage Crops
Course Code: AGR-1104
Credit Hours : 3(2+1)

Theory

Unit I

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like sorghum, maize, *bajra*, *guar*, cowpea, oats, barley, berseem, *senji*, lucerne, etc.

Unit II

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops, Napier grass, *Panicum, Lasiuras, Cenchrus,* etc.

Unit III

Year-round fodder production and management, preservation and utilization of forage and pasture crops.

Unit IV

Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder. Fodder production through hydroponics. Azolla cultivation.

Unit V

Economics of forage cultivation uses and seed production techniques of important fodder crops.

Practical

- Practical training of farm operations in raising fodder crops;
- Canopy measurement and yield, Leaf: Stem ratio.
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation.

Suggested Reading

Chatterjee BN. 1989. *Forage Crop Production - Principles and Practices*. Oxford & IBH.

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

Narayanan TR and Dabadghao PM. 1972. *Forage Crops of India*. ICAR.

Singh P and Srivastava AK. 1990. *Forage Production Technology*. IGFRI, Jhansi.

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

Tejwani KG. 1994. *Agroforestry in India*. Oxford & IBH.

SEMESTER II

5. Course Title: Principles and Practices of Water Management

Course Code: AGR-1105

Credit Hours : 2(1+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

Water management of crops under climate change scenario.

Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
- Determination of maximum water holding capacity of soil
- Determination of soil-moisture characteristics curves
- Estimation of upward flux of water using tensiometer from depth of ground water table
- Determination of irrigation requirement of crops (calculations)
- Determination of effective rainfall (calculations)
- Determination of ET of crops by soil moisture depletion method Determination of water requirements of crops
- Measurement of irrigation water by volume and velocity-area method
- Measurement of irrigation water by measuring devices and calculation of irrigation efficiency

Suggested Reading

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

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

Lenka D. 1999. *Irrigation and Drainage*. Kalyani. Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.

Paliwal KV. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi. Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.

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

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

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

6. Course Title: Principles and Practices of Organic Farming
Course Code: AGR-1106
Credit Hours : 3(2+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

- Method of making compost by aerobic method
- Method of making compost by anaerobic method
- Method of making vermicompost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
- Visit to a biogas plant

- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farm

Suggested Readings

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

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

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

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

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

Rao BV Venkata. 1995. *Small Farmer Focused Integrated Rural Development: Socio-conomic Environment and Legal Perspective*: Publ.3, ParisaraprajnaParishtana, Bangalore.

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

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

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

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

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

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

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

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

7. Course Title: Principles and Practices of Weed Management
Course Code: AGR-1107
Credit Hours : 3(2+1)

Theory

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

Unit II

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

Unit III

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

Unit IV

Weed management in major crops and cropping systems; alien, invasive and parasitic.

Unit V

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

Practical

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

Suggested Reading

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

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

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

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

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

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

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

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

Walia US. 2006. *Weed Management*, Kalyani. Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub.*

8. Title: Modern Concepts in Crop Production
Course Code : AGR- 1108
Credit Hours : 2(2+0)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield

potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture.Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

Suggested Readings

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

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

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

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

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

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

Lal R. 1989. *Conservation tillage for sustainable agriculture: Tropics versus Temperate Environments. Advances in Agronomy* 42: 85-197. Wilsie CP. 1961. *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.

SEMESTER III

9. Course Title: Agronomy of Oilseed, Fibre and Sugar Crops

Course Code : AGR-1109

Credit Hours : 3(2+1)

Theory

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

Unit I

Rabi oilseeds – Rapeseed and mustard, Linseed and Niger

Unit II

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

Unit III

Fiber crops - Cotton, Jute and Mesta.

Unit IV

Sugar crops – Sugar-beet and Sugarcane.

Practical

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
- Intercultural operations in different crops
- Cotton seed treatment.
- Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio etc)
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fibre of different fibre crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Reading

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

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

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

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

10. Course Title : Agronomy of Medicinal, Aromatic and Under Utilized Crops
Course Code : AGR-1110
Credit Hours : 3(2+1)

Theory

Unit I

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.

Unit II

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, *Aloe vera*, Satavar, *Stevia*, Safed Musli, Kalmegh, Asaphoetida, *Nuxvomica*, Rosadle, etc).

Unit III

Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium).

Unit IV

Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice, Lathyrus, Sesbania, Clusterbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

Unit V

Post harvest handling –drawing, processing, grading, packing and storage, value addition and quality standards in herbal products.

Practical

- Identification of crops based on morphological and seed characteristics
- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants.

Suggested Reading

Chadha KL and Gupta R. 1995. *Advances in Horticulture*. Vol. II. *Medicinal and Aromatic plants*. Malhotra Publ.

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

Handa SS. 1984. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.

Hussain A. 1984. *Essential Oil Plants and their Cultivation*. CIMAP, Lucknow.

Hussain A. 1993. *Medicinal Plants and their Cultivation.* CIMAP, Lucknow.

ICAR 2006. *Hand Book of Agriculture.* ICAR, New Delhi.

Kumar N, Khader Md. Abdul, Rangaswami JBM & Irulappan 1997. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants.* Oxford & IBH.

Prajapati ND, Purohit SS, Sharma AK and Kumar T. 2003. *A Hand Book of Medicinal Plants: A Complete Source Book.* Agrobios.

Sharma R. 2004. *Agro-Techniques of Medicinal Plants*. Daya Publ. House.

11. Course Title : Dryland Farming and Watershed Management
Course Code. : AGR-1111
Credit Hours : 3(2+1)

Theory

Unit I

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

Unit II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

Unit III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid season correction contingent plan for aberrant weather conditions.

Unit IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

Unit V

Concept of watershed resource management, problems, approach and components.

Practical

- Method of Seed Priming
- Determination of moisture content of germination of important dryland crops
- Determination of Relative Water Content and Saturation Deficit of Leaf
- Moisture stress effects and recovery behaviour of important crops
- Estimation of Potential ET by Thornthwaite method
- Estimation of Reference ET ny Penman Monteith Method
- Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)
- Classification of climate by Koppen Method
- Estimation of water balance by Thornthwaite method
- Estimation of water balance by FAO method
- Assessment of drought
- Estimation of length of growing period
- Estimation of probability of rain and crop planning for different drought condition
- Spray of anti-transpirants and their effect on crops
- Water use efficiency
- Visit to dryland research stations and watershed projects

Suggested Reading

Reddy TY. 2018. *Dryland Agriculture Principles and Practices*, Kalyani publishers

Das NR. 2007. *Tillage and Crop Production*. Scientific Publ.

Dhopte AM. 2002. *Agrotechnology for Dryland Farming*. Scientific Publ.

Dhruv Narayan VV. 2002. *Soil and Water Conservation Research in India*. ICAR.

Gupta US. (Ed.). 1995. *Production and Improvements of Crops forDrylands*. Oxford & IBH.

Katyal JC and Farrington J. 1995. *Research for Rainfed Farming*. CRIDA.

Rao SC and Ryan J. 2007. *Challenges and Strategies of Dryland Agriculture*. Scientific Publ.

Singh P and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture.* Agrotech Publ. Company.

Singh RP. 1988. *Improved Agronomic Practices for Dryland Crops*. CRIDA.

Singh RP. 2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.

Singh SD. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publ.

Venkateshwarlu J. 2004. *Rainfed Agriculture in India. Research and Development Scenario*. ICAR.

12. Course Title : Cropping Systems and Sustainable Agriculture
Course Code : AGR-1112
Credit Hours : 2(2+0)

Theory

Unit I

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

Unit II

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

Unit III

Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture.

Unit IV

Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

Unit V

Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Suggested Reading

Panda SC. 2017. *Cropping Systems and Sustainable Agriculture*. Agrobios (India)

Panda SC. 2018. *Cropping and Farming Systems*. Agrobios.

Palaniappan SP and Sivaraman K. 1996. *Cropping Systems in the Tropics; Principles and Management.* New Age.

Panda SC. 2003. *Cropping and Farming Systems*. Agrobios.

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

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

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

Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1997. *Soil Fertility and Fertilizers*. Prentice Hall.

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Soil Science & Agricultural Chemistry

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1: Soil Physics		SAC-1201	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Analytical Technique and Instrumental Methods in Soil and Plant Analysis		SAC-1202	*2 (0+2)*	*100 (100P)*
	3: Soil, Water and Air Pollution		SAC-1203	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	4:Management of Problematic soils and water		SAC-1204	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5: Agriculture Conservation		AGR-1101	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST-3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Intellectual Property and its Management in Agriculture**		*COM-5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM-5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1: Remote Sensing and GIS Technique for Soil and Crop Studies		SAC-1205	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2.Soil Biology and Biochemistry		SAC-1206	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Soil Mineralogy, Genesis and Classification		SAC-1207	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Soil Survey and Land Use Planning		SAC-1208	*2 (2+0)*	*100 (50 M + 50 T)*
	5: Principles and Practices of Organic Farming		AGR-1106	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs		*AST-3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM-5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM-5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	1: Soil Chemistry		SAC-1209	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Soil Fertility and Fertilizer use		SAC-1210	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Soil Erosion and Conservation Land		SAC-1211	*3 (1+1)*	*100 (20 M + 30 P + 50 T)*
	4: Land Degradation and Restoration		SAC 1212	*2 (2+0)*	*100 (50 M + 50 T)*
	*6: Agricultural Research, Research Ethics and Rural Development Programs**		*COM-5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	1: Seminar		*SAC-1213*	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	*SAC-1214*	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(C) Internship for Development of Entrepreneurship in Agriculture (IDEA)	*SAC-1215*	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Syllabus
M.Sc. (Ag.) Soil Science & Agricultural Chemistry

SEMESTER I

1. Course Title : Soil Physics

Course Code : SAC-1201

Credit Hours: 3(2+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

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

Unit VIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management. Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

- Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,
- Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity

under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

Suggested Reading

- Baver LD, Gardner WH and Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
- Ghildyal BP and Tripathi RP. 2001. *Soil Physics*. New Age International.
- Hanks JR and Ashcroft GL. 1980. *Applied Soil Physics*. Springer Verlag.
- Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.
- Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
- Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.
- Hillel D. 1998. *Environmental Soil Physi*cs. Academic Press.
- Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.
- Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D and Powers WL. 1972. *Advanced Soil Physics*. Wiley-Inter science.
- Kohnke H. 1968. *Soil Physics*. McGraw Hill.
- Lal R and Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

2. Course Title : Analytical Technique and Instrumental Methods in Soil and Plant Analysis

Course Code: SAC- 1202

Credit Hours 2(0+2)

Practical

Unit I

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

Unit II

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

Unit III

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

Unit IV

Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Unit V

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

Unit VI

Drawing normalized exchange isotherms; measurement of redox potential.

Suggested Reading

- Hesse P. 971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons.
- Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.
- Keith A Smith 1991. *Soil Analysis; Modern Instrumental Techniques*. Marcel Dekker.
- Kenneth Helrich 1990. *Official Methods of Analysis*. Association of Official Analytical Chemists.
- Page AL, Miller RH and Keeney DR. 1982. *Methods of Soil Analysis*. Part II. SSSA, Madison.
- Piper CE. *Soil and Plant Analysis*. Hans Publ.
- Singh D, Chhonkar PK and Pandey RN. 1999. *Soil Plant Water Analysis - A Methods Manual*. IARI, New Delhi.
- Tan KH. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press/Taylor & Francis.
- Tandon HLS. 1993. *Methods of Analysis of Soils, Fertilizers and Wat*ers. FDCO, New Delhi.
- Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

3. Course Title: Soil, Water and Air Pollution
Course Code : SAC-1203
Credit Hours: 2(1+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Toxic elements–their sources, behaviour in soils, effect on nutrients availability, effect on

plant and human health.

Unit VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of green house gases–carbondioxide, methane and nitrous oxide.

Unit VII

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

Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safe guard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO_2 and O_2 conc**.** Visit to various industrial sites to study the impact of pollutants on soil and plants.

Suggested Reading

- Lal R, Kimble J, Levine E and Stewart BA. 1995. *Soil Management and Greenhouse Effect.* CRC Press.
- Middlebrooks EJ. 1979. *Industrial Pollution Control*. Vol. I. *Agro-Industries*. John Wiley Interscience.
- Ross SM. *Toxic Metals in Soil Plant Systems*. John Wiley & Sons.
- Vesilund PA and Pierce 1983. *Environmental Pollution and Control*. Ann Arbor Science Publ.

3. Course Title : Management of Problem Soils and Water
Course Code : SAC 1203
Credit Hours : 2+1

Theory

Unit I

Area and distribution of problem soils–acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

Unit II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils-soluble salts, ESP, pH; physical, chemical and microbiological properties.

Unit III

Management of salt-affected soils; salt tolerance of crops- mechanism and ratings; salt stress meaning and its effect on crop growth, monitoring of soils salinity in the field; management principles for sandy, clayey, red lateritic and dryland soils.

Unit IV

Acid soils-nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

Unit V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality. Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical

Characterization of acid, acid sulfate, salt-affected and calcareous soils, Determination of cations (Na^+, K^+, Ca^{++} and Mg^{++}) in groundwater and soil samples, Determination of an ions (Cl^-, SO_4^-, CO_3^- and HCO_{3-}) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils.

Suggested Reading

- Bear FE. 1964. *Chemistry of the Soil*. Oxford & IBH.
- Jurinak JJ. 1978. *Salt-affected Soils*. Department of Soil Science & Biometeorology. Utah State University
- USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*. Oxford & IBH.

SEMESTER II

5. Course Title: Remote Sensing and GIS Technique for Soil, Water and Crop Studies

Course Code : SAC-1205

Credit Hours: 2(1+1)

Theory

Unit I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

Unit II

Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyperspectral imaging, thermal imaging; image processing and interpretations.

Unit III

Application of remote sensing techniques-landuse soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, waste land identification and management.

Unit IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

Unit V

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photo graphs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geostatistical techniques, Creation of datafiles in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.
- Lillesand TM and Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.
- Nielsen DR and Wendroth O. 2003. *Spatial and Temporal Statis*tics. Catena Verloggmbh.
- Star J and Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

6. Course Title: Soil Biology and Biochemistry
Course Code : SAC-1206
Credit Hours : 3 (2+1)

Theory

Unit I

Soil biota, soil microbial ecology, types of organisms indifferent soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

Unit II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora; Root rhizosphere and PGPR.

Unit III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials, cycles of important organic nutrients.

Unit IV

Organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

Unit V

Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

Unit VI

Biofertilizers–definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of biofertilizers.

Unit VII

Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms inpedogenesis – important mechanisms and controlling factors; soil genomics and bioprospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

Practical

- Determination of soil microbial population
- Soil microbial biomass carbon
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter 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 micronutrients

Suggested Reading

- Paul EA and Clark FE. *Soil Microbiology and Biochemistry.*
- Lynch JM. *Soil Biotechnology*
- Willey JM, Linda M. Sherwood and Woolverton CJ. *Prescott's Microbiology.*
  Subba Rao NS. *Advances In Agricultural Microbiology.*

7. Course Title: Soil Mineralogy, Genesis and Classification
Course Code : SAC-1207
Credit Hours : 3 (2+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Practical

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

Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu. Buol EW, Hole ED, MacCracken RJ and Southard RJ. 1997. *Soil Genesis*
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.
- USDA. 1999. *Soil Taxonomy*. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
- Wade FA and Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
- Wilding LP and Smeck NE. 1983. *Pedogenesis and Soil Taxonomy*: II. *The Soil Orders*. Elsevier.

8. Course Title: Soil Survey and Land Use Planning
Course Code : SAC-1208
Credit Hours : 2(2+0)

Theory

Unit I

Soil survey and its types; soil survey techniques- conventional and modern; soil series–characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; thematic soil maps, cartography, mapping units, techniques for gene ration of soil maps, application of remote sensing and GIS in soil survey and mapping of major soil group of India

Unit II

Landform–soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT)–concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Unit III

Concept and techniques of land use planning; factors governing present land use; Land evaluation method sand soil-site suitability evaluation for different crops; land capability classification and constraints in application.

Unit IV

Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Status of LUP in India.

Practical

- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in differentscales
- Land use planning exercises using conventional and RS tools

SEMESTER III

9. Course Title : Soil Chemistry
Course Code : SAC-1209
Credit Hours : 3 (2+1)

Theory

Unit I

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

Unit II

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

Unit III

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

Unit IV

Ion exchange processes in soil; cation exchange- theories based on law of massaction (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange–innersphere and outer-sphere surface complex formation, fixation of oxyan ions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

Unit V

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

Unit VI

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

Unit VII

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

Unit VIII

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

Practical

Preparation of saturation extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-

charge and associated surface charge characteristics by the serial potentio metric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E4/E6) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl2-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

Suggested Reading

- Bear RE. 1964. *Chemistry of the Soil*. Oxford and IBH.
- Bolt GH and Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.
- Greenland DJ and Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
- Greenland DJ and Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.
- McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford University Press.
- Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford University Press.
- Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford University Press.
- Sposito G. 1989. *The Chemistry of Soils*. Oxford University Press.
- Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.
- Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

10. Course Title: Soil Fertility and Fertilizer Use
Course Code : SAC-1210
Credit Hours : 3 (2 +1)

Theory

Unit I

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

Unit II

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

Unit III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid andalkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soilsand management under field conditions. Potassium - forms, equilibrium in soils and its agriculturalsignificance; mechanism of potassium fixation; management of

potassium fertilizers under fieldconditions.

Unit V

Sulphur - source, forms, fertilizers and their behavior in soils; roleincropsandhuman health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Unit VI

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

Unit VII

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

Unit VIII

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

Unit IX

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

Unit X

Definition and concepts of soil health and soil quality; Longterm effects of fertilizers and soil quality.

Practical

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

Suggested Reading

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

11. Course Title: Soil Erosion and Conservation
Course Code : SAC-1211
Credit Hours : 3(2+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Practical

- Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI30) using rain gauge data
- Land capability classification of a watershed
- Visits to a watersheds

Suggested Reading

- Biswas TD and Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.
- Doran JW and Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.
- Gurmal Singh, Venkataramanan C, Sastry G and Joshi BP. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.
- Hudson N. 1995. *Soil Conservation*. Iowa State University Press.

12. Course Title: Land Degradation and Restoration
Course Code: SAC-1212
Credit Hours: 2(2+0)

Theory

Unit I

Type, factors and processes of soil/land degradation and its impact on soil productivity including soil fauna, biodegradation and environment.

Unit II

Land restoration and conservation techniques-erosion control, reclamation of salt-affectedsoils; minelandreclamation, afforestation, organic products.

Unit III

Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Suggested Reading

- Biswas TD and Narayanasamy G. (Eds.). 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Soc. Soil Sci. 17, New Delhi.
- Doran JW and Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Madison.
- Greenland DJ and Szabolcs I. 1994. *Soil Resilience and Sustainable Land Use*. CABI.
- Lal R, Blum WEH, Vailentine C and Stewart BA. 1997. *Methods for Assessment of Soil Degradation.* CRC Press.
- Sehgal J and Abrol IP. 1994. *Soil Degradation in India - Status and Impact*. Oxford & IBH.

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Horticulture

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1: Production technology of fruit crop		HOR 1301	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Propagation and Orchard Management		HOR 1302	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3: Minor Fruit Production		HOR 1303	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	4: Postharvest Management of Horticultural Produce		HOR 1304	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5:Breeding of Fruit Crops- Minor		GPB-1404	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST 3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Intellectual Property and its management in Agriculture**		*COM 5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM 5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1: Production technology of vegetable crops.		HOR 1305	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2: Improvement of vegetable crops		HOR 1306	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Protected Cultivation of Vegetable Crops		HOR 1307	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Production of Spice Crops		HOR 1508	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	5: Breeding of Vegetable Crops		GPB-1407	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs		*AST-3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM-5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM-5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	*1: Commercial Production of Cut and Loose Flowers*		HOR-1309	*3 (2+1)*	*100 (20 M + 30 P + 50T)*
	2:Ornamental Gardening And Landscaping		HOR 1310	*3 (2+1)*	*100 (20 M + 30 P + 50T)*
	3:Protected Cultivation of Flower Crops		HOR 1311	*3 (2+1)*	*100 (20 M + 30 P + 50T)*
	4: Breeding of Ornamental crops- (As Minor)		HOR 1312	*2 (1+1)*	*100 (20 M + 30 P + 50T)*
	*5: Agricultural Research, Research Ethics and Rural Development Programs**		*COM 5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	*1: Seminar*		*HOR-1313*	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	*HOR-1314*	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	*HOR-1315*	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Syllabus
M.Sc. (Ag.) Horticulture

SEMESTER I

1. Course Title : Production Technology of Fruit Crop

Course Code : HOR-1301

Credit Hours : 3(2+1)

Theory :

Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements. Propagation, Planting and Orchard Floor Management planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production. Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders – causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management. Conventional and Non-Conventional Breeding: Approaches for crop improvement – direct introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrusts.

Crops

Mango, Banana, Guava, Pineapple, Papaya, , Jackfruit, Annonas, Aonla, Ber, Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Persimmon, Kiwifruit, Nuts- Walnut, Almond, Pecan, etc.

Suggested Reading

Bose TK, Mitra SK and Sanyal D. 2002. *Fruits of India – Tropical and Sub-Tropical*.3rd Edn. Naya Udyog, Kolkata.

Dhillon WS. 2013. *Fruit Production in India.* Narendra Publ. House, New Delhi.

Iyer CPA and Kurian RM. 2006. *High Density Planting in Tropical Fruits: Principlesand Practices.* IBDC Publishers, New Delhi.

Litz RE. 2009. *The Mango: Botany, Production and Uses*. CAB International. Madhawa Rao VN. 2013. *Banana.* ICAR, New Delhi.

Midmore D. 2015. *Principles of Tropical Horticulture*. CAB International. Mitra SK and Sanyal D. 2013. *Guava,* ICAR, New Delhi.

Chadha KL and Awasthi RP. 2005. *The Apple*. Malhotra Publishing House, New Delhi. Chadha TR. 2011. *A Text Book of Temperate Fruits*. ICAR, New Delhi

Kumar N. 2014. *Breeding of Horticultural Crops: Principles and Practices*. NIPA, N. Delhi. Peter KV. 2013. *Biotechnology in Horticulture: Methods and Applications*. NIPA, New Delhi.

2. Course Title: Propagation and Orchard Management

Course Code: HOR 1302

Credit Hours: 2(1+1)

Theory:

Unit I: Propagation

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

Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

Budding and grafting – principles and methods, establishment and management of bud wood bank. Stock, scion and inter stock relationship– graft incompatibility, physiology of rootstock and top working. Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques – *in-vitro*clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules. Management Practices and Regulation: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.

Unit II: Canopy Management of Fruit Crops

Introduction, Types and Classification: Canopy management – importance and factors affecting canopy development. Canopy types and structures, canopy manipulation for optimum utilization of light and its interception. Spacing and utilization of land area – Canopy classification. Physical Manipulation and Growth Regulation: Canopy management through rootstock and scion. Canopy management through plant growth regulators, training and pruning and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality.

Unit III: Nutritional Requirement of Fruit Crops

General Concepts and Principles: Importance and history of nutrition in fruit crops, essential plant nutrients, factors affecting plant nutrition; nutrient uptake and their removal from soil. Nutrient requirements, root distribution in fruit crops, soil and foliar application of nutrients in major fruit crops, fertilizer use efficiency. Integrated Nutrient Management (INM): Fertigation in fruit crops, bio- fertilizers and their use in INM systems.

Practical :

- Hands on practices on rooting of dormant and summer cuttings

- Anatomical studies in rooting of cutting and graft union
- Hands on practices on various methods of budding and grafting
- Propagation by layering and stooling Micro-propagation- explants preparation, media preparation, culturing meristem tip culture, axillary bud culture, micro-grafting, hardening.
- Visit to commercial tissue culture laboratories and accredited nurseries
- Training of plants for different canopy types
- Canopy development through pruning
- Understanding bearing behaviour and canopy management in different fruits
- Use of plant growth regulators
- Visual identification of nutrient deficiency symptoms in fruit crops
- Identification and application of organic, inorganic and bio-fertilizers
- Soil/ tissue collection and preparation for macro- and micro-nutrient analysis
- Analysis of soil physical and chemical properties- pH, EC, Organic carbon
- Determination of N,P,K and other macro- and micronutrients
- Fertigation in glasshouse and field grown horticultural crops
- Preparation of micro-nutrient solutions, their spray and soil applications

Suggested Reading

Bose TK, Mitra SK and Sadhu MK. 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash, Kolkatta.

Davies FT, Geneve RL and Wilson SB. 2018. *Hartmann and Kester's Plant Propagation- Principles and Practices.* Pearson, USA/ PrenticeHall of India. New Delhi.

Gill SS, Bal JS and Sandhu AS. 2016. *Raising Fruit Nursery*. Kalyani Publishers,New Delhi. Jain S and Ishil K. 2003. *Micropropagation of Woody Trees and Fruits*. Springer.

Sharma RR. 2014. *Propagation of Horticultural Crops.* Kalyani Publishers, New Delhi

Tyagi S. 2019. *Hi-Tech Horticulture.* Vol I: *Crop Improvement, Nursery and Rootstock Management.* NIPA, New Delhi.

Srivastava KK. 2012. *Canopy Management in Fruits*. ICAR, New Delhi

Yawalkar KS, Agarwal JP and Bokde S. 1972. *Manures and Fertilizers*. 3rd Ed. Agri Horticultural Publishing House, Nagpur.

3. Course Title : Minor Fruit Production

Course Code: HOR-1303

Credit Hours : 2(1+1)

Theory

Block 1: Introduction

Unit I: Occurrence, Adoption and General Account: Importance – occurrence and distribution, climate adaptation in fragile ecosystem and wastelands.

Block 2: Agro-Techniques

Unit I: Propagation and Cultural Practices: Traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality.

Block 3: Marketing and Utilization

Unit I: Post-Harvest Management: Post harvest management, marketing; minor fruit crops in terms of medicinal and antioxidant values; their uses for edible purpose and in processing industry

Crops

Bael, chironji, fig, passion fruit, jamun, phalsa, karonda, woodapple, cactus pear, khejri, kair, pilu, lasoda, loquat, tamarind, dragon fruit, monkey jack, mahua, khirni, amra, kokum, cape gooseberry, kaphal, persimmon, pistachio, seabuckthorn, hazel nut and other minor fruits of regional importance

Practical

- Visits to institutes located in the hot and cold arid regions of the country
- Identification of minor fruits plants/ cultivars
- Collection of leaves and preparation of herbarium
- Allelopathic studies
- Generating know-how on reproductive biology of minor fruits
- Fruit quality attributes and biochemical analysis
- Project formulation for establishing commercial orchards in fragile ecosystems

Suggested Reading

Ghosh SN, Singh A and Thakur A. 2017. *Underutilized Fruit Crops: Importance and Cultivation.*

Jaya Publication House, New Delhi.

Krishna H and Sharma RR, 2017. *Fruit Production: Minor Fruits*. Daya Publishing House, New Delhi.

Mazumdar BC. 2014. *Minor Fruit Crops of India: Tropical and Subtropical*. Daya Publication House, New Delhi.

Nath V, Kumar D, Pandey V and Pandey D. 2008. *Fruits for the Future*. Satish Serial Publishing House, New Delhi.

Pareek OP, Sharma S, and Arora RK. 2007. *Underutilised Edible Fruits and Nuts*, IPGRI, Rome.

Peter KV. 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, New Delhi. Rana JC and Verma VD. 2011. *Genetic Resources of Temperate Minor Fruit* (*Indigenous and*

Exotic). NBPGR, New Delhi.

Saroj PL and Awasthi OP. 2005. *Advances in Arid Horticulture*, Vol. II: *Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.

Saroj PL, Dhandar DG and Vashishta BB. 2004. *Advances in Arid Horticulture*, Vol.-1 *Present Status*. IBDC, Lucknow. Singh *et al*. 2011. *Jamun*. ICAR, New Delhi.

4. Course Title: Postharvest Management of Horticultural Produce

Course Code: HOR-1304

Credit Hours: 3(2+1)

Theory

Block 1: Postharvest Management of Horticultural Produce

Unit I:

History, Importance and scope of Postharvest technology of horticultural produce. Nature and structure of horticultural produce. Pre and Postharvest losses and their causes.

Unit II:

Climacteric and non-climacteric fruits. Regulation of ripening by use of chemicals and growth regulators. Control of sprouting, rooting anddiscoloration in vegetables.

Unit III:

Maturity indices for harvest. Harvesting and harvesting tools. Curing in roots and tubers. Prepackage Operation: Preecooling, washing, sorting, grading of horticultural perishables for local markets and export. Postharvest handling of spices, plantation crops, medicinal and aromatic plants. Equipments for washing, sizing, grading.

Unit IV:

Pre and Postharvest treatments for extending storage life/ vase life. VHT, irradiation treatment, skin coating, degreening, etc.Prepackaging, Packaging techniques for local market andStandardsand specifications for fresh produce.

Unit V:

Postharvest handling system for horticulture crops of regional importance. Principles of transport, modes of transportation, types of vehicles and transit requirements for different horticultural produce. Marketing: Factors influencing marketing of perishable crops, marketing systems and organizations.

Practical

- Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops;
- Protective skin coating with wax emulsion and pre and Postharvest treatment with fungicides, chemicals and growth regulators to extend the shelf life of fruits and vegetables;
- Prepackaging of perishables;
- Extension of vaselife of cut flowers by use of chemicals and growth regulators;
- Control of sprouting of potato and onion by using growth regulators;
- Study of modern harvesting, sorting and grading equipments;
- Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers;
- Visit to packaging centers;
- Visit to local markets, cooperative organizations, super markets dealing with marketing of Perishables.

Suggested Reading

Bhattacharjee SK and Dee LC. 2005. *Postharvest technology of flowers and ornamental plants*. Pointer publishers, Jaipur.

Chattopadhyay SK. 2007. *Handling, transportation and storage of fruit and vegetables*. Gene- Tech books, New Delhi.

FAO. 2007. *Handing and Preservation of Fruits and Vegetables by Combined methods for Rural Areas*-Technical Manual. FAO Agr. Ser. Bull., 149.

Kader AA. 1992. *Postharvest technology of horticultural crops*. 2nd ed university of California. Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest Biology and Technology of*

Fruits, Vegetables and Flowers, Wiley-Blackwell, ISBN: 9780813804088.

Pruthi JS. 2001 (Reprint). *Major spices of India crop management and Postharvest technology*. ICAR, NewDelhi

Stawley J Kays. 1998. *Postharvest physiology of perishable plant products*. CBS publishers. Sudheer KP, Indira V. 2007. *Postharvest Technology of Horticultural Crops*, Peter K.V. (Ed.),

New India Publishing Agency, ISBN 9788189422431.

Sunil Pareek (Ed.) 2016. *Postharvest Ripening Physiology of Crops*, CRC Press, ISBN 9781498703802.

Thompson AK. (Ed.) 2014. *Fruit and Vegetables: Harvesting, Handling and Storage* (Vol. 1 & 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.

Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.

Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.

Websites:

Horticulture-Post harvest management CSIR-NISTADS
http://www.nistads.res.in/indiasnt2008/t6rural/t6rur13.htm

Post harvest technology- MANAGE http://www.manage.gov.in/ftf-itt/prgReports/iihr.pdf
Role of post-harvest management http://www.fao.org/3/y5431e/y5431e02.htm

SEMESTER II

5. Course Title : Improvement of vegetable crops

Course Code : HOR-1305

Credit Hours : 2 (1+1)

Theory

Origin, botany, taxonomy, wild relatives, cytogenetics and genetics, types of pollination and fertilization mechanism, sterility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation and polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, breeding for protected environment and quality improvement, molecular markers and marker's assisted breeding; QTLs, PPV and FR Act. with reference to vegetable crops specially Tomato, eggplant, hot pepper, sweet pepper and okra. Garden peas, Gourds, melons, cucumber, Cauliflower, cabbage, kohlrabi, broccoli and brussels sprouts. Carrot, radish and onion.

Practical

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

Suggested Reading

Allard RW. 1960. *Principle of plant breeding*. John Willey and Sons, USA. Kalloo G. 1988. *Vegetable breeding* (Vol. I, II, III). CRC Press, Fl, USA.

Kole CR. 2007. *Genome mapping and molecular breeding in plants-vegetables*. Springer, USA. Peter KVand Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p.488.

Prohens J and Nuez F. 2007. *Handbook of plant breeding-vegetables* (Vol I and II). Springer, USA.

Singh BD. 2007. *Plant breeding- principles and methods* (8th edn.). Kalyani Publishers, New Delhi.

Singh Ram J. 2007. *Genetic resources, chromosome engineering, and crop improvement-vegetable crops* (Vol. 3). CRC Press, Fl, USA.

6. Course Title : Production technology of vegetable crop

Course Code: HOR-1306

Credit Hours: 3 (2+1)

Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery, sowing/ planting time and methods, hrydroponics and aeroponics,

precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops. *Cole crops*—Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale *Root crops*—Carrot, radish, turnip and beetroot. *Peas and beans*—Garden peas and broad bean. *Leafy vegetables*—Beet leaf, fenugreek, coriander and lettuce. *Fruit vegetables*—Tomato, brinjal, hot pepper, sweet pepper and okra. *Cucurbits*—Cucumber, melons, gourds, pumpkin, snake gourd, pointed gourd and squashes.

Practical

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

Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya udyog.

Bose TK, Som MG and Kabir J. (Eds.). 1993. *Vegetable crops*. Naya prokash.

Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture* Vols. V-X. Malhotra publ. house.

Chadha KL. (Ed.). 2002. *Hand book of horticulture*. ICAR.

Chauhan DVS. (Ed.). 1986. *Vegetable production in India*. Ram prasad and sons.

Fageria MS, Choudhary BR and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani publishers.

Gopalakrishanan TR. 2007. *Vegetable crops*. New India publ. agency.

Hazra P and Banerjee MK and Chattopadhyay A. 2012. *Varieties of vegetable crops in India*,(Second edition), Kalyani publishers, Ludhiana, 199 p.

Hazra P. 2016. *Vegetable Science*. 2nd edn, Kalyani publishers, Ludhiana.

Hazra P. 2019. *Vegetable production and technology*. New India publishing agency, New Delhi.

Hazra P, Chattopadhyay A, Karmakar K and Dutta S. 2011. *Modern technology for vegetable production*, New India publishing agency, New Delhi, 413p

Rana MK. 2008. *Olericulture in India*. Kalyani publishers, New Delhi.

Rana MK. 2008. *Scientific cultivation of vegetables*. Kalyani publishers, New Delhi. Rana MK. 2014. *Technology for vegetable production*. Kalyani publishers, New Delhi.

Rubatzky VE and Yamaguchi M. (Eds.). 1997. *World vegetables: principles, production and nutritive values*. Chapman and Hall.

Saini GS. 2001. *A text book of oleri and flori culture*. Aman publishing house.

Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker.

Shanmugavelu KG. 1989. *Production technology of vegetable crops*. OXford and IBH.

Singh DK. 2007. *Modern vegetable varieties and production technology*. International book distributing Co.

Singh SP. (Ed.). 1989. *Production technology of vegetable crops*. Agril. comm. res. centre. Thamburaj S and Singh N. (Eds.), 2004. *Vegetables, tuber crops and spices*. ICAR. Thompson HC and Kelly WC. (Eds.). 1978. *Vegetable crops*. Tata McGraw-Hill.

7. Course Title : Protected Cultivation of Vegetable Crops

Course Code : HOR-1307

Credit Hours : 3 (2+1)

Theory

Unit I

Scope and importance- Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high cost polyhouses/ greenhouse structures.

Unit II

Types of protected structure- Classification and types of protected structures- greenhouse/ polyhouses, plastic-non plastic low tunnels, plastic walk in tunnels, high roof tunnels with ventilation, insect proof net houses, shed net houses, rain shelters, NVP, climate control greenhouses, hydroponics and aeroponics; Soil and soilless media for bed preparation; Design and installation of drip irrigation and fertigation system.

Unit III

Abiotic factors- Effect of environmental factors and manipulation of temperature, light, carbon dioXide, humidity, etc. on growth and yield of different vegetables.

Unit IV

Nursery raising- High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation; Nursery problems and management technologies including fertigation.

Unit V

Cultivation of crops- Regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures.

Unit VI

Solutions to problems- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production.

Practical

- Study of various types of protected structure;
- Study of different methods to control temperature, carbon dioxide and light;
- Study of different types of growing media, training and pruning systems in greenhouse crops;
- Study of fertigation and nutrient management under protected structures;
- Study of insect pests and diseases in greenhouse and its control;
- Use of protected structures in hybrid seed production of vegetables;
- Economics of protected cultivation (Any one crop);
- Visit to established green/ polyhouses/ shade net houses in the region.

Suggested Reading

Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture*. Malhotra Pub. House. Chandra S and Som V. 2000. *Cultivating vegetables in green house*. Indian horticulture

Kalloo G and Singh K. (Eds.). 2000. *Emerging scenario in vegetable research and development*.Research periodicals and Book publ. house.

Parvatha RP. 2016. *Sustainable crop protection under protected cultivation*. E-Book Springer. Prasad S and Kumar U. 2005. *Greenhouse management for horticultural crops*. 2nd Ed.Agrobios. Resh HM. 2012. *Hydroponic food production*. 7thEdn. CRC Press.

Singh B. 2005. *Protected cultivation of vegetable crops*. Kalyani publishers, New Delhi

Singh DK and Peter KV. 2014. *Protected cultivation of horticultural crops* (1st Edition) New India publishing agency, New Delhi.

Singh S, Singh B and Sabir N. 2014. *Advances in protected cultivation*. New India publishing agency, New Delhi.

Tiwari GN. 2003. *Green house technology for controlled environment*. Narosa publ. house.

8. Course Title : Production of Spice Crops

Course Code : HOR-1308

Credit Hours : 2(1+1)

Theory

Introduction and importance of spice crops- historical accent, present status (national and international), future prospects, botany and taxonomy, climatic and soil requirement, commercial cultivars/ hybrids, site selection, layout, sowing/ planting time and methods, seed rate and seed treatment, nutritional and irrigation requirement, intercropping, mixed cropping, intercultural operations, weed control, mulching,

physiological disorders, harvesting, post-harvest management, plant protection measures, quality control and pharmaceutical significance of crops mentioned below:

Unit I

Fruit spices- Black pepper, small cardamom, large cardamom and allspice

Unit II

Bud and kernel- Clove and nutmeg

Unit III

Underground spices- Turmeric, ginger and garlic

Unit IV

Seed spices- Coriander, fenugreek, cumin, fennel, ajowain, dill and celery

Unit V

Tree spices- Cinnamon, tamarind, garcinia and vanilla

Practical

- Identification of seeds and plants;
- Botanical description of plant;
- Preparation of spice herbarium;
- Propagation;
- Nursery raising;
- Field layout and method of planting;
- Cultural practices;
- Harvesting, drying, storage, packaging and processing;
- Value addition;
- Short term experiments on spice crops.

Suggested Reading

Agarwal S, Sastry EVD and Sharma RK. 2001. *Seed spices: production, quality, export*. Pointer Publication.

Arya PS. 2003. *Spice crops of India*. Kalyani.

Bhattacharjee SK. 2000. *Hand book of aromatic plants*. Pointer publications.

Bose TK, Mitra SK, Farooqi SK and Sadhu MK. (Eds.). 1999. *Tropical horticulture*.Vol.I. Naya Prokash.

Chadha KL and Rethinam P. (Eds.). 1993. *Advances in horticulture*. Vols. IX-X. *Plantation crops and spices*. Malhotra Publ. House.

Pruthi JS. (Ed.). 1998. *Spices and condiments*. National Book Trust

Pruthi JS. 2001. *Minor spices and condiments- crop management and post harvest technology*. ICAR.

Purseglove JW, Brown EG, Green CL and Robbins SRJ. (Eds.). 1981. *Spices*. Vols. I, II. Longman.

Shanmugavelu KG, Kumar N and Peter KV. 2002. *Production technology of spices and plantation crops*. Agrobios.

Thamburaj S and Singh N. (Eds.). 2004. *Vegetables, tuber crops and spices*. ICAR.

Tiwari RS and Agarwal A. 2004. *Production technology of spices*. International Book Distr. Co. Varmudy V. 2001. *Marketing of spices*. Daya Publ. House.

SEMESTER III

Course Title : Commercial Production of Cut and Loose Flowers

Course Code : HOR-1309

Credit Hours: 3 (2+1)

Theory

Block 1: Production management

Unit I: Scope and scenario: National and International scenario, importance and scope of cut flower trade, constraints for cut flower production in India.

Unit II: Growing environment: Soli analysis, soil health card, Growing environment, open cultivation, protected cultivation, soil/ media requirements, land preparation, planting methods, influence of light, temperature, moisture, humidity and microclimate management ongrowth and flowering.

Unit III: Crop management: Commercial Flower production – Commercial varieties, water and nutrient management, fertigation, weed management, crop specific practices, ratooning, training and pruning, pinching, deshooting, bending, desuckering, disbudding. Use of growthregulators, physiological disorders and remedies, IPM and IDM.

Unit IV: Flower regulation: Flower forcing and year round/ offseason flower production through physiological interventions, chemical regulation, environmental manipulation and improvement techniques (Breeding and Biotechnological tools)

Block 2: Post-harvest management and marketing

Unit I: Post harvest management: Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, storage andtransportation.

Unit II: Marketing: Marketing, export potential, institutional support, Agri export Zones, 100% Export Oriented units, Crop Insurance.

Crops

Rose, chrysanthemum, gladiolus, tuberose, carnation, gerbera, orchids, lilium, anthurium, china aster, bird of paradise, dahlia, gypsophila, P stock, marigold, jasmine cut greens and fillers.

Practical

- Identification of Plants/varieties
- Propagation
- Microclimate management
- Training and pruning techniques
- Pinching, deshooting, disbudding, desuckering
- Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application
- Harvesting techniques, post-harvest handling, cold chain
- Economics, Project preparation for regionally important cut flowers, crop specificguidelines for project financing (NHB guidelines)

- Visit to commercial cut flower units
- Case studies

Suggested Reading

Arora JS. 2010. *Introductory Ornamental Horticulture*. Kalyani Publi. 6th Edition, pp. 230. Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Reprint, pp. 2065.

Bose T K, Maiti RG, Dhua RS and Das P. 1999. *Floriculture and landscaping*. Naya Prokash, Kolkata, India.

Bose TK and Yadav LP. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.

Chadha KL and Bhattacharjee S K. 1995. *Advances in Horticulture: Ornamental Plants.* Vol.

XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.

Chadha KL and Chaudhury B.1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India. Laurie A and Rees VH. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.

Prasad S and Kumar U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur. Randhawa GS and Mukhopadhyay A. 2001. *Floriculture in India*. Allied Publ. pp 660.

Sheela VL. 2008. *Flowers for Trade*. Horticulture Science Series, vol.10, pp. 392. New India Publ. Agency, New Delhi, India.

10. Course Title: Ornamental Gardening and Landscaping

Course Code : HOR-1310

Credit Hours: 3(2+1)

Theory

Block 1: Gardens and components

Unit I: Styles and types of gardens: Historical background of gardening, Importance and scope of ornamental gardening, styles and types of gardens, formal and informal style gardens. English, Mughal, Japanese, Persian, Spanish, Italian, French, Hindu and Buddhist gardens. Special gardens: Special gardens including miniature gardens and plant stand. Presentations like dish, terrarium, bottle gardens, Vertical gardens, hanging baskets, window boxes and Bonsai.

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

Unit III: Specialized gardens: Specialised gardens such as vertical garden, roof garden,

terrace garden, water garden, sunken garden, rock garden, shade garden, temple garden, sacred gardens (with emphasis on native plants), Zen garden.

Block 2: Landscape planning

Unit I: Principles and elements of landscaping: Basic drawing skills, use of drawing instruments garden symbols, steps in preparation of garden design, programmes phase, design, phase, etc.

Elements and principles of landscape design. Organization of spaces, visual aspects of plan arrangement- view, vista and axis. Principles of circulation, site analysis and landscape, water requirement, use of recycled water.

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

Practical

Identification of various types of ornamental plants for different gardens and occasions

- Preparation of land, planning, layout and planting, deviations from landscape principles Practice of propagation through specialized structures cuttings, layering, budding and grafting
- Case study
- Site analysis, interpretation of map of different sites, use of GIS for selection (1);
- Enlargement from blue print. Landscape design layout and drafting on paper as per the scale
- Preparation of garden models for home gardens, farm houses, industrial gardens, institutional gardens, corporate, avenue planting, practices in planning and planting of special types of gardens.
- Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubbery borders
- Project preparation on landscaping for different situations, creation of formal and informal gardens
- Visit to parks and botanical gardens

Suggested Reading

Bose TK, Chowdhury B and Sharma SP. 2011. *Tropical Garden Plants in Colour*. Hort. and Allied Publ.

Bose TK, Maiti RG, Dhua RS and Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.

Grewal HS and Singh P. 2014. *Landscape Designing and Ornamental Plants*. Kalyani Publishers, New Delhi.

Lauria A and Victor HR. 2001. *Floriculture-Fundamentals and Practices.* Agrobios Publ., Jodhpur.

Misra RL and Misra S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi, India. Nambisan KMP. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co., New Delhi, India.

Randhawa GS and Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Sabina GT and Peter KV. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency, New Delhi, India.

Singh A and Dhaduk BK. 2015. *A Colour Handbook: Landscape Gardening*. New India Publ. Agency, New Delhi, India.

11. Course Title Protected Cultivation of Flower Crops

Course Code : HOR-1311

Credit Hours : 3(2+1)

Theory

Block 1: Principles and types

Unit I: Prospects and types of protected structures: Prospects of protected floriculture in India; Types of protected structures – Glasshouse/ polyhouse, shadenet houses, mist chambers, lath houses, orchidarium, fernery, rain shelters, etc.

Unit II: Principles and design: Principles of designing and erection of protected structures; Low cost/ Medium cost/ High cost structures; Location specific designs; Structural components; Suitable flower and foliage plants for protected cultivation.

Block 2: Growing environment

Unit I: Control of environment: Microclimate management and manipulation of temperature, light, humidity, air and CO_2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation, water harvesting.

Unit II: Intercultural operations and crop regulation: Containers and substrates, media, soil decontamination, layout of drip and fertigation system, water and nutrient management, IPM and IDM, Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

Unit III: Automation and standards: Automation in greenhouses, sensors, solar greenhouses and retractable greenhouses, GAP/ Flower labels, EXport export, on-tariff standards, EXIM policy, APEDA regulations for barriers.

Crops

Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Lilium, Limonium, Lisianthus, heliconia, Cala lily, Alstromeria, etc.

Practical

- Study of various protected structures
- Design, layout and erection of different types of structures
- Practices in preparatory operations, growing media, soil decontamination techniques
- Microclimate management
- Practices in drip and fertigation techniques, special horticultural practices
- Determination of harvest indices and harvesting methods
- Postharvest handling, packing methods
- Economics of cultivation, Project preparation
- Project Financing guidelines

- Visit to commercial greenhouse.

Suggested Reading

Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Reprint, pp. 2065.

Bose TK, Maiti RG, Dhua RS and Das P. 1999. *Floriculture and Landscaping*. Naya Prokash,

Kolkata, India.

Bose TK and Yadav LP. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.

Chadha KL and Bhattacharjee SK. 1995. *Advances in Horticulture: Ornamental Plants*. Vol.

XII, Parts 1 & 2. pp.533 and pp.574. Malhotra Publ. House, New Delhi, India.

Lauria A and Victor HR. 2001. *Floriculture-Fundamentals and Practices*.Agrobios Publ., Jodhpur.

Nelson PV. 2011. *Green House Operation and Management*. Pearson Publ. 7th edition, pp. 624.

Prasad S and Kumar U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur. Randhawa GS and Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Reddy S, Janakiram T, Balaji T, Kulkarni S and Misra RL. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India

12. Course Title : Breeding of Ornamental Crops
Course Code : GPB-3515
Credit Hours : 3 (2+1)

Theory

Unit I

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

Unit I I

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

Unit III

Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its exploitation, production of F_1 hybrids and utilization of male sterility.

Unit IV

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

Practical

- Study of floral biology and pollination in important species and cultivars of ornamental crops;

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

Suggested Reading

Alexander V. 2002. *Breeding for ornamentals: Classical and Molecular Approaches*. Kluwer Academic Publishers, London.

Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons. INC. New York. Bhattacharjee SK and De LC. 2003. *Advanced Commercial Floriculture* Vol. 1. Aavishkar

Publishers & Distributors, Jaipur.

Bose TK and Yadav LP. 2003. *Commercial Flowers*. Naya Prokash Publishers, Kolkata. Chadha KL and Bhattacharjee SK. *Advances in Horticulture* Vol. 12, Malhotra Publishing

House, New Delhi.

Mc Donald MB and Kwong FY. 2005. *Flower Seeds Biology and Technology*, CABI Publishing, Oxfordshire, UK.

Watts L.1980. *Flower and Vegetable Plant Breeding*. Grower Books.

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Genetics & Plant Breeding

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1: Principles of Genetics		GPB-1401	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Principles of Plant Breeding		GPB -1402	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3: Crop Breeding-I (Kharif Crops)		GPB -1403	*2 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Breeding of Fruit Crops		GPB-1404	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5: Seed Production Principles and Techniques in Field crops		SST-2004	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST 3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	7: *Intellectual Property and its Management in Agriculture**		*COM 5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM 5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1: Crop Breeding-II (Rabi Crops)		GPB 1405	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2. Hybrid Breeding		GPB 1406	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Breeding of Vegetable Crops		GPB 1407	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Germplasm Characterization and Evaluation		GPB 1408	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	5: Post Harvest Handling and Storage of Seed		SST-2008	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs		*AST 3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM 5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM 5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	1: Molecular Breeding and Bioinformatics		GPB-1409	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Breeding for Quality and Special Traits		GPB-1410	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Fundamentals of Quantitative Genetics		GPB-1411	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Principles of Cytogenetics		GPB-1412	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	*6: Agricultural Research, Research Ethics and Rural Development Programs**		*COM 5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	1: Seminar		GPB-1413	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	GPB -1414	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	GPB-1415	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Contents
M.Sc. (Ag) in Genetics and Plant Breeding (GPB)

SEMISTER I

1. Course Title: Principles of Genetics
Course Code: GPB-1401
Credit Hours : 3 (2+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

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

Suggested reading

Daniel LH and Maryellen R. 2011. *Genetics:* "*Analysis of Genes and Genomes*".

Gardner EJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley and Sons. 8th ed. 2006 Klug WS and Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education

India; Tenth edition

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

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

Snustad DP and Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition Stansfield WD.1991. *Genetics.*Schaum Outline Series Mc Graw Hill

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

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

2. Course Title : Principles of Plant Breeding

Course Code: GPB-1402

Credit Hours : 2 (1+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S_1 and S_2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

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

Unit VI

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

Unit VII

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

Practical

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

Suggested Reading

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

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

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

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

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

Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House. Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi. Simmonds NW.1990. *Principles of Crop Improvement*. English Language Book Society. Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.

Singh S and Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

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

Course Code: GPB-1403

Credit Hours : 2(1+1)

Theory

Unit I

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

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

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

Unit II

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

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

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

Unit III

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

Unit IV

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

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

Unit V

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

Forage crops: Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance, etc. **Seed spices**: Origin, evolution, mode of reproduction, chromosome number; Genetics

Practical:

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

Suggested Reading

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

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

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

Chopra VL and Prakash S. 2002. *Evolution and Adaptation of Cereal Crops*. Oxford & IBH.

Gill KS. 1991. *Pearl Millet and its Improvement*. ICAR.

IRRI. 1964. *Rice Genetics and Cytogenetics*. Elsevier.

IRRI. 1986. *Rice Genetics*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.

IRRI. 1991. *Rice Genetics II*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.

IRRI. 1996. *Rice Genetics III*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.

IRRI. 2000. *Rice Genetics IV*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.

Jennings PR, Coffman WR and Kauffman HE. 1979. *Rice Improvement*. IRRI, Los Banos, Manila, Philippines.

Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.

4. Course Title: Breeding of Fruit Crops
Course Code: GPB-1404
Credit Hours: 3(2+1)

Theory

Unit I

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

Unit II

Issues in fruit crop breeding – heterozygosity, polyploidy, polyembryony,

parthenocarpy and seed lessness, incompatibility and sterility systems.

Unit III

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

Unit IV

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

Practical

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

Suggested Reading

Bhojwani SS and Razdan MK. 2006. *Plant Tissue Culture -Theory and Practice*. Elsevier Publication, Amesterdam.

Chadha KL and Pareek, OP. 1996. (Eds.). *Advances in Horticulture.* Vol. I to IV. Malhotra Publ. House, New Delhi.

Chadha KL and Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House, New Delhi.

Janick and Moore JN. 1996. *Advances in Fruit Breeding*, AVI Pub., USA. Janick J and Moore JN. 1996. *Fruit Breeding*. Vols. I to III. John Wiley & Sons.

Kumar N. 2006. *Breeding of Horticultural Crops - Principles and Practices*. New India Publishing Agency, New Delhi.

Moore JN and Janick Jules. 1996. *Methods in Fruit Breeding*. Purdue University Press, South Campus Court D., USA.

Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK. and Mohanadas S. 2001. *Biotechnology of Horticultural Crops.* Vols. I-III. Naya Prokash, Kolkata.

Ray PK. 2002. *Breeding of Tropical and Sub-tropical Fruits*. Narosa Publishing House, New Delhi.

Simmonds NW. 1976. *Evolution of Crop Plants*, Orient Longman, London.

SEMESTER II

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

Course Code: GPB-1405

Credit Hours: 2(1+1)

Theory

Unit I

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

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

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

Unit II

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

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

Unit III

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

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

Unit IV

Mesta and minor fibre crops: Origin, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required),

biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Unit V

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

Practical

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

Suggested Reading

Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.

Bahl PN and Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I.

Pulses and Oilseeds. Oxford & IBH.

Gupta SK. 2012. *Technological Innovations in Major World Oil crops*. Vol. I. Springer, USA. Gupta SK. 2012. *Technological Innovations in Major World Oil crops*. Vol. II. Springer, USA. Gupta SK. 2016. *Breeding of Oilseed Crops for Sustainable Production*. Academic Press, USA. Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. *New Dimensions and*

Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU, Coimbatore.

Parthasarathy VA. 2017. *Spices and Plantation Crops* Vol.1 (Part A) *Breeding of Breeding and Genetics*. John Wiley & Sons.

6. Course Title : Hybrid Breeding
Course Code : GPB-1406
Credit Hours : 3(2+1)

VI. Theory

Unit I

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic Consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops, problems and prospects; Pre-Mendelian and Post-Mendelian ideas – Evolutionary concepts and causes of heterosis; inbreeding depression, coefficient

of inbreeding and its estimation, residual heterosis in F_2 and segregating populations, importance of inbreeding in exploitation of heterosis.

Unit II

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

Unit III

Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreeds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Apomixis in fixing heterosis-concept of single line hybrid; Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

Practical

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

7. Course Title : Breeding of Vegetable Crops
Course Code : GPB-1407
Credit Hours: 3(2+1)

Theory

Unit I

Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II

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

Unit III

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

Unit IV

Breeding for Cole crops: Cabbage, cauliflower, broccoli and knolkhol. Breeding for Root vegetables: Carrot, beetroot, radish, sweet potato and tapioca.

Unit V

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

Practical

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

Suggested Reading

Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons.

Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani Publishers, New Delhi.

Kalloo G. 1988. *Vegetable Breeding*. Vols. I-III. CRC Press.

Kalloo G. 1998. *Vegetable Breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency. Peter KV and Pradeep KT. 2008. *Genetics and Breeding of Vegetables.* ICAR.

Rai N and Rai M. 2006. *Heterosis Breeding in Vegetable Crops*. New India Publication Agency. Ram HH. 2005. *Vegetable Breeding-Principles and Practices*. Kalyani Publishers

Sharma JP. 2010. *Principles of Vegetable Breeding*. Kalyani Publishers, New Delhi. Singh BD. 1983. *Plant Breeding*. Kalyani Publishers

Course Title: Germplasm Characterization and Evaluation
Course Code: GPB-1408
Credit Hours: 2(1+1)

Theory

Unit I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit II

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

Unit III

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

Practical

- Field layout and experimental designs;
- Recording field data on germplasm evaluation in different agri-horticultural crops,

- post harvest handling;
- Evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing;
- Documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.
- Lectures
- Power point presentations
- assignments, quiz
- Group tasks, student's presentations

Suggested Reading

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

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

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

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

Utilizing Multimedia Database. NBPGR, New Delhi.

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

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

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

Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. *Plant Genetic Resources Evaluation: Principles and Procedures*, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. vi+50 p.

SEMESTER III

9. Course Title : Molecular Breeding and Bioinformatics
Course Code : GPB-1409
Credit Hours: 3(2+1)

Theory

Unit I

Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, etc.), Functional markers; Mapping populations (F_2s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

Unit II

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

Unit III

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

Unit IV

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

Practical

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

Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder;

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

Suggested Reading

Azuaje F and Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics.*

John Wiley and Sons.

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

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

Ltd.

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

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

Hackett PB, Fuchs JA and Messing JW. 1988. *An Introduction to Recombinant DNA Technology*

- *Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.

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

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

Robert NT and Dennis JG. 2010. *Plant Tissue Culture, Development, and Biotechnology*. CRC Press.

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

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

10. Course Title: Breeding for Quality and Special Traits
Course Code: GPB-1410
Credit Hours: 3(2+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Classification and importance, Nutritional genomics and Second generation transgenics.

Practical

- Grain quality evaluation in rice; Correlating ageing and quality improvement inrice;
- Quality analysis in millets;
- Estimation of anti-nutritional factors like tannins in different varieties/ hybrids: A comparison;
- Quality parameters evaluation in wheat, pulses and oilseeds;
- Evaluation of quality parameters in cotton, sugarcane and potato;
- Value addition in crop plants;
- Post-harvest processing of major field crops;
- Quality improvement in crops through tissue culture techniques;
- Evaluating the available populations like RIL, NIL, etc. for quality improvement using MAS procedures;
- Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

Suggested Reading

Chahal GS and SS Ghosal. 2002. *Principles and procedures of plant breeding - Biotechnological and Conventional approaches***,** Narosa Publications Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. 2018.

FAO 2001. *SpecialityRices of the World - Breeding, Production and Marketing*. Oxford & IBH,1 Nov 2001.

Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.

Gupta SK. 2007. *Advances in Botanical Research* Vol. 45 Academic Press USA. Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.

Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH. Singh BD. 1997. *Plant Breeding*. Kalyani Publishers, New Delhi.

Singh RK, Singh UK and Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

11. Course Title: Fundamentals of Quantitative Genetics
Course Code: GPB-1411
Credit Hours:3 (2+1)

Theory

Unit I

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

Unit II

Designs for plant breeding experiments- principles and applications; Variability parameters,

concept of selection, simultaneous selection modes and selection of parents, MANOVA.

Unit III

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

Unit IV

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

Unit V

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

Practical

- Analysis and interpretation of variability parameters;
- Analysis and interpretation of Index score and Metroglyph;
- Clustering and interpretation of D^2 analysis;
- Genotypic and phenotypic correlation analysis and interpretation;
- Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation;
- A, B and C Scaling test;
- L × T analysis and interpretation, QTL analysis;
- Use of computer packages;
- Diallel analysis;
- G × E interaction and stability analysis.

Suggested Reading

Bos I and Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.

Falconer DS and Mackay J. 1998. *Introduction to Quantitative Genetics* (3rd Ed.).ELBS/ Longman, London.

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

Naryanan SS and Singh P. 2007. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.

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

Sharma JR. 2006. *Statistical and Biometrical Techniques in Plant Breeding*. New Age International Pvt. Ltd.

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

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

Kalyani Publishers, New Delhi.

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

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

e-Suggested Reading

www.iasri.icar.gov.in www.hau.ac.in/OPstat

12. Course Title: Principles of Cytogenetics
Course Code : GPB-1412
Credit Hours: 2(1+1)

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

a. Learning the cytogenetical laboratory techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning, etc.;
b. Microscopy: various types of microscopes;
c. Preparing specimen for observation;
d. Fixative preparation and fixing specimen for light microscopy studies in cereals;
e. Studies on mitosis and meiosis in crop plants;
f. Using micrometres and studying the pollen grain size in various crops. Pollen germination *in vivo* and *in-vitro*;
g. Demonstration of polyploidy.

Suggested Reading

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

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

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

Elgin SCR. 1995. *Chromatin Structure and Gene Expression*. IRLPress,Oxford.

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

Gupta PK. 2010. *Cytogenetics*. Rastogi Pubishers. Johannson DA. 1975. *Plant Micro technique*. McGraw Hill.

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

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

Schulz SJ.1980. *Cytogenetics- Plant, animals and Humans*. Springer.

Sharma AK and Sharma A. 1988. *Chromosome Techniques: Theory and Practice*. Butterworth- Heinemann publisher 2014.3rd edition

Singh RJ. 2016. Plant *Cytogenetics* 3rd Edition. CRC Press.

Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ. 1 edition, Springer pub. Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Animal Husbandry & Dairying

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	*1:* Dairy Chemistry		AHD-1501	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2:Animal Genetics and Breeding		AHD-1502	*2 (0+2)*	*100 (20 M + 30 P + 50 T)*
	3: Introductory AH & Dairying		AHD-1503	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	4: Dairy Microbiology		AHD-1504	*3(2+1)*	*100 (20 M + 30 P + 50 T)*
	5: Agronomy of fodder & Forage Production		AGR-1104	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST -3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	7: *Intellectual Property and its management in Agriculture**		*COM-5001*	*1(1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM-5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	*1:* Principles of Nutrition and Feed Technology		AHD-1505	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2: Production and Management of Swine		AHD-1506	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Liquid milk processing and quality control		AHD-1507	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Dairy products Manufacturing Technolog-1		AHD-1508	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	5: Soil Biology and Plant Biochemistry		SAC -1206	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs		*AST-3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM-5003*	*1(1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM-5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	*1:* Production and Management of poultry		AHD-1509	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Production and Management of Cattle & Buffalo		AHD-1510	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
			AHD-1511	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Production and Management Sheep & Goat		AHD-1512	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	4: Dairy Products Manufacturing Technology-2				
	*6: Agricultural Research, Research Ethics and Rural Development Programs**		*COM-5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	*1: Seminar*		*AHD-1513*	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	*AHD-1514*	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	*AHD-1515*	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
		Total credits = 74			

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

AHD 1501: Dairy Chemistry Semester- I: 3(2+1)

Unit-1: Milk synthesis and secretion in mammary glands. Chemical composition, physico-chemical and nutritional properties of milk and colostrum, Detail chemistry of milk major constituents- milk fat, proteins, lactose, minerals, vitamins, enzymes and pigments. Factors associate with variation in milk composition.

Unit- 2: Physico-chemical Changes in different milk constituents on processing and storage. Bio-active component of milk, Anti-bacterial component of milk. Adultration of milk and milk products and their identification methods. Use of milk preservatives. Test for the quality of milk, butter, ghee, milk powder etc., adulterants, neutralizers and preservatives, their detection, heat stability of milk.

Unit-3: Spoilage of dairy products and control measures. Use of antioxidants, chemistry of milk fermentation, chemistry of rennin coagulation of milk and changes occurring during ripening of cheese, physico-chemical changes in the manufacture and storage of milk powder, lactose. Crystallization and its significance, physicochemical changes during the manufacture of indigenous milk products, quality standards of dairy products. Use of bio-protective factors for preservation of raw milk: effects on physico-chemical, micro-bial and nutritional properties of milk and milk products; Present status of preservation of raw milk.

Unit- 4: Bacteriological aspects of milk processing - Thermization, pasteurization, boiling, sterilization, UHT, bactofugation, and membrane filtration; Microbiological quality of cream, butter, ice-cream, concentrated dairy products, dried milks, infants milk foods, indigenous dairy products

Practical

Specific gravity of milk by lactometer. Determination of freezing point depression. Determination of fat by gravimetric and volumetric method in milk and milk products. Estimation of lactose by lodimetric and fehling solution method in milk and milk products. Detection common adulteration milk and Ghee.

Book Resources:

1. Dairy Chemistry and Biochemistry P.F. FOX and P.L.H. McSWEENEY Department of Food Chemistry University College Cork, Ireland BLACKIE
2. A TEXTBOOK OBDAIRY CHEMISTRY *By* EDGAR R. LING M.Sc.(LoND.), F.R.I.C, A.R.C.S. LONDON CHAPMAN & HALL LTD 37 ESSEX STREET, W.C.2
3. FUNDAMENTALS OF DAIRY CHEMISTRYTHIRD EDITION Editor Noble P. Wong Agricultural Research Service U.S. Department of Agriculture Associate Editors Robert Jennes formerly Department of Biochemistry University of Minnesota Mark Keeney Department of Chemistry and Biochemistry University of Maryland Elmer H. Marth Department of Food Science University of Wisconsin
4. De S.2020. Outline of Dairy technology. *2020. Oxford university press*

AHD 1502: Animal Genetics and Breeding Semester- I: 2(1+1)

Unit- 1: Principles of animal genetics, cell structure and multiplication. Principles of population genetics, concept of heredity, heterosis and mutation, principles of evolution, Evaluation cattle and buffalo breeds and their characteristics.

Unit- 2: Reproduction in animals and poultry Breeding records & their maintenance. Artificial management. Artificial Breeding and its economic importance, post A.I. Management pregnancy development and diagnosis. Management of down calves post-mortem care, factors influencing reproductive efficiency in buffaloes and crossbreed cattle and measures for improvement. Breeding methods in livestock and poultry. Population / quantitative genetics of livestock.

Unit- 3: Male and female reproduction physiology of livestock and poultry. Endocrine control of reproduction. Artificial reproduction assisted technologies- artificial insemination, protocol for embryo- transfer technology, in-vitro fertilization, cryo-preservation etc..

Unit- 4: Different mating system: assertive system: assertive mating, inbreeding, out breeding; genetic and phenotypic consequence and applications of various mating system in animal improvement

Practical:

Visit near veterinary hospital and be aware for A.I method. Examination of reproductive organs at various stages of reproductive cycle. Heat detection in cattle buffalo. Heat cycle of various animals, preparation of heat expectancy chart. Artificial insemination by recto vaginal and spectrum method. Pregnancy diagnosis. Evaluation of semen and dilution use for preservation.

Books

1. Principle of Genetics, This eCourse Developed By TNAU (ICAR), Agrimoon publishing.
2. BrahGS.2016. *Animal Breeding: Principal and Applications.* KalyaniPublication
3. TomarSS.2010. *A Textbook of animal Breeding.* Universal Publisher
4. Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
5. ICAR. 2014. *Handbook of Animal Husbandry,* 3rd ed. ICAR.

AHD 1503: Introductory AH & Dairying Semester I: 2 (1+1)

Unit- 1: General concepts of livestock production and management, livestock in different production/farming systems in India. Present status of livestock and poultry industry and impact on livestock farming in Indian agriculture.

Unit- 2: Diversity of livestock in India, important breed of different category of livestock and theirs characteristics. Management of livestock in livestock housing, production and reproduction management, lactation management, breeding programs for livestock and poultry. General behavior of livestock and their control methods.

Unit- 3: General idea of livestock products, composition, quality control and general principle of preservation & storage of livestock products, methods of processing. International Trade/WTO/IPR issues related to the livestock and its products.

Unit-4: Status of dairy processing industry in India and abroad; Prospects and constraints in development of Indian dairy industry. Brief history of dairy development, role of dairy cooperatives and its structure, operation flood program

Practical:

Practice of restrains and control of livestock, Identification of livestock, Identification of different livestock breeds, Practice of dehorning, castration, milking methods, judging of livestock. Visit of livestock rearing farms and milk processing plant, chilling and collection centers.

Books resource:

1. **A guide to dairy herd management Author:** John House, The University of Sydney, New South Wales, Australia **Editor:** Ian Partridge Published by: Meat & Livestock Australia Limited ABN: 39 081 678 364 October 2011
2. ICAR. 2014. *Handbook of Animal Husbandry*, 3rd ed. ICAR.
3. Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
4. Banerjee G.C. 2012. *A text book of Animal Husbandry*. Oxford & IBH Publicing Company Pvt. Ltd.

AHD 1504: Dairy Microbiology Semester-I: 3(2+1)

Unit- 1: Introduction to dairy microbiology – Milk production hygiene and critical risk factors affecting microbiological quality on-farm; Microorganisms associated with milk and their classification based on growth temperature – psychrotrophs, mesophiles, thermodurics and thermophiles;

Unit- 2: Microscopy, methods of enumeration, isolation and identification of bacteria and emerging dairy pathogens, detection of microbial toxins, drug residues in milk and their public health importance;
Bacteriological aspects of milk processing - Thermization, pasteurization, boiling, sterilization, UHT,
bactofugation, and membrane filtration.

Unit-3: Microbial metabolites and their role in spoilages - souring, curdling, gassiness, ropiness, proteolysis, lipolysis, abnormal flavour and colour; Antimicrobial systems in raw milk; Microbiological grading of raw milk; Microflora of mastitic milk and its importance in dairy industry; Food poisoning, food infections, toxi-infections and other milk borne diseases and their control. Microbiological quality of cream, butter, ice-cream, concentrated dairy products, dried milks, infants milk foods, indigenous dairy products; Factors affecting the microbiological quality of these products during production, processing, handling, storage and distribution

Unit-4: Basic principles involved in fermentation. Microbiology of dairy starters; Classification, genetic aspects and carbohydrate metabolism of Lactic Acid Bacteria (LAB); Preservation, propagation and quality control of dairy starters and their inhibition by antibiotic residues, detergents, sanitizers, bacteriophages etc.; Microbiology of fermented milks, cheeses and application of probiotic concept in dahi, yoghurt, Kefir, Kumiss, Bulgarian milk, cultured buttermilk, leben, yakult, cheddar and processed cheese; Dairy plant hygiene and sanitation - Microbiological standards for milk and milk products.

Practical:

Practical microscopy, Laboratory enumeration, isolation and identification of bacteria and emerging dairy pathogens, detection of microbial toxins, drug residues in milk and their public health importance. Staining method: Simple, Gram's spore and acid fast staining. Enumeration of bacteria in milk and milk products as cream, butter, Khoa, Chhana and ice-cream by S.P.C. and D.M.C. and judging bacteriological qualityby dye reduction test.

Book:

1. MICROBIOLOGY HANDBOOK DAIRY PRODUCTS Edited by RheaPieter Walstra Jan T. M. Wouters Tom J. Geurts
2. Microbiology in action CAMBRIDGE UNIVERSITY PRESS *J. Heritage, E. G. V. Evans and R. A. Killington* CAMBRIDGE UNIVERSITY PRESS
3. De S.2020. Outline of Dairy technology. *2020. Oxford university press*

AHD 1505: Principles of Nutrition and Feed Technology Semester- II: 2(1+1)

Unit-1: General nutrition- Importance of nutrients in animal health and production, composition & comparison of animal body and plants, Digestion- control motility and secretion of alimentary tract. Proximate principles and cell wall constituents,

Unit-2: Metabolism- carbohydrates, proteins and fats their digestion and metabolism in ruminants and non-ruminants. Evaluation of energy value of feed. Energy partition- measures of protein quality. Role of Water, minerals, vitamins and additives,

Unit-3: Feeds and fodders and their classification. Different types of rations and unconventional feeds. Processing method of animal feeing stuffs. Methods of improving the nutritive value of inferior quality roughages.

Unit-4: Feed and Forage conservation and processing-Hay and silage making, Grinding, chaffing, pelleting, roasting, feed block. Feed formulation principles. Common harmful natural and toxic substances in animal feed and fodders.. Quality control of feed ingredients and finished feeds

Practical

Visit of field and identified of seasonal feed and fodder. Quality evaluation of silage and hay, Laboratory preparation of silage. Symptoms and disease control by nutrients deficiency. Storage feed stuffs during. Liquid feed ingredients. Storage losses; insect pests and rodents control measures. Ration computation and formulation.

Book Resources

1. Dryden G. 2008. *Animal Nutrition Science*. CAB International.
2. Kundu SS, Mahanta SK, Singh S & Pathak PS. 2016. *Animal Feed Technology*. Satish Publishers
3. ICAR. 2014. *Hand Book of Animal Husbandry*, 3rd ed. ICAR.
4. Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
5. Banerjee G.C. 2012. *A text book of Animal Husbandry.* Oxford & IBH Publicing Company Pvt. Ltd.
6. Prashad J. 2018. *Animal Husbandry and Dairying.* Kalyani Publication

AHD 1506: Production and Management of Swine Semester- II: 2(1+1)

Unit-1: Breeds of Swine. Population dynamic, Economic contribution of pigs, Advantages and limitations of swine rearing, Systems of management of swine. Housing and rearing systems. Housing and equipment requirements for different classes of swine, layout plans and construction for different sized farms. Wallowing practices.

Unit-2: Feeding principles and nutritional requirement of different classes of swine. Feeding and watering schedule for different classes of swine. Traditional and scientific methods of swine feeding. Digestive system of pig.

Unit -3: Traits of economic importance and their interrelationship. Selection of breeding stock. Reproductive parameters of swine. Methods for detection of heat. Mating systems. Care and management of pregnant sows, piglets, growers and boar. Summer management in swine.

Unit -4: Health Management, major disease control of swine. Prevention and control measures including sanitation, vaccination, deworming, etc. FMD, swine dysentery, Swine fever, Piglet anaemia and its management.

Practical:-

Visit modern piggeries and critical analysis of various types of management practices. Practical feeding and breeding management, disease control measures, Judging. Record-keeping. Economics of pig production. Formulation of economic rations for different classes of swine. Reproductive management in sow.

Resources:-

1. Acharya RM & Puneet Kumar. 2017. *Pig Production*. Satish Serial Publishing, Delhi
2. ICAR. 2014. *Hand Book of Animal Husbandry*, 3rd ed. ICAR.
3. Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
4. Sharda DP. 2000. Swine Production. ICAR publication
5. *Selected articles from journals.*.
6. Banerjee G.C. 2012. *A text book of Animal Husbandry.* Oxford & IBH Publicing Company Pvt. Ltd.
7. Prashad J. 2018. *Animal Husbandry and Dairying.* Kalyani Publication

AHD 1507: Liquid milk processing and quality control Semester-III: 2(1+1)

Unit- 1: Principles and processes of food preservation, processing of fluid milk, HACCP Concepts in Fluid Milk Processing. Manufacture of various types of liquid dairy products.

UNIT- 2: Centrifugal Separation and Bactofugation, homogenization- Theory of Homogenization and process, pasteurization- pasteurizer construction & principles and methods of pasteurization from of various type of milk (Toned milk, double toned milk, Full cream milk, Organic milk, skim milk, flavor milk, soy milk and culture milk).

UNIT- 3: Membrane techniques- applications of ultra-filtration (UF), reverse osmosis, nanofiltration and microfiltration in the dairy industry. Cleaning and sanitization of different types of membranes Irradiation and high frequency heating (Microwave and Radio frequency processing): Principles, merits and demerits; Applications in dairy processing; Safety aspects,

sources and properties of ionizing radiation; UV pasteurization of milk; Safety aspects in radiation processing; National and international regulations in relation to radiation processing.

Unit- 4: Sensory evaluation and judging of milk and milk products, types of packaging materials and their properties, packing forms and operations, problems in food packaging, recent advances in packaging dairy and food products.

Practical

Study of instruments commonly used in dairy rheology. Assessment of microbial quality of various dairy products. Collection of different types of packaging used in the packaging of various milk products. Preparation of dairy scheme. Calculation on economy of machines used in dairy plant. Visit to dairy plants and factories and submission of visit reports.

Book Resources:

1. Dairy Science and Technology Second Edition A CRC title, part of the Taylor & Francis imprint, a member of the Taylor & Francis Group, the academic division of T&F Informa plc. Boca Raton London New York. By Pieter Walstra Jan T. M. Wouters Tom J. Geurts
2. Dairy processing Hand Bookhandbook Tetra Pak Processing Systems AB S-221 86 Lund, Sweden
3. De S.2020. *Outline of Dairy technology. 2020. Oxford university press*

AHD 1508: Dairy products Manufacturing Technolog-1 Semester-II: 2(1+1)

Unit- 1: Definition, classification and manufacturing technologies of indigenous milk products- khoa/mawa, khurchan, rabri, kulfi, kheer, dahi, misti dahi, shrikhand, paneer, chhana, makkhan, ghee, lassi, ghee residue

Unit- 2: Definition, classification and manufacturing technologies of special milk products- sterilized milk, homogenized milk, fermented milks, standardized milk, reconstituted milk recombined milk, tonned milk, humanized milk.

Unit-3: Definition, classification and manufacturing technologies of fat rich milk products- cream, butter, butter oil. Ice-cream.

Unit-4: Definition, classification and manufacturing technologies of cheese- cheddar, cottage cheese, processed chese, mozerella cheese.

Practical:-

fatrich milk product- cream, butter, butter oil, ghee. Frozen milk product, ice cream, kulfi, Filled and imitation ice cream. Fermented milk product- different varieties of cheese- Cheddar, Gouda, Mozerella, swiss, processed cheese, cheese spread, processed cheese food, shrikhand, lassi, dahi, mishit dahi. Concentrated and dry milk products- condensed milk, milk powder, instant milk powder, infants food, weaning food, cream powder , butter powder, cheese powder, ice cream mix powder and malted milk powder

Resources

De S. 2020. *Outline of Dairy technology.* *2020. Oxford university press*

AHD 1509: Production and Management of poultry Semester-III: 3(2+1)

Unit-1: Breeds of poultry. Poultry housing systems - cage v/s floor system, litter management and lighting for poultry, backyard poultry, Housing equipments and housing requirement. Precaution at the time of construction of poultry house.

Unit-2: Types of poultry rearing. Management of different type of poultry house. Management of chicks, growing, laying and breeding flocks, broiler production, selection and culling of laying flocks. Poultry feeding management and preparation of feed. Method of feeding. Digestive and reproductive system of poultry.

Unit- 3: Procuring, care and pre-incubation storage of hatching eggs - Method of incubation, sanitation disinfection and management of hatchery. Struucture and nutritive value of egg. Factors affecting egg size. Breeding and rearing management chicks in brooder.

Unit- 4: Management of replacement pullet. Heath and sanitation problem and their control. Major disease of poultry (Ranikhet, Fowl pox, Gumbaro, new castle, Coccidiosis). Health management and vaccination schedule. Management of birds during disease outbreaks.

Practical

Observation and recording of Poultry Farm management - Brooding of chicks; selection of laying flocks - Disease preventive measures - Selection and care of hatching eggs; incubator operation, fumigation and candling setting and hatching. Reproductive system of Poultry. Debeaking and vaccination of poultry. Economical analysis of poultry. Dressing percent of Poultry. Ration formulation for poultry.

Resources

1. Powell-Owen W. 2008. *Poultry Farming and Keeping*. Daya Books.
2. Prasad J. 2018. *Poultry Production and Management*. Kalyani Publication
3. Singh RA. 1996. *Poultry Production*. 3rd ed. Kalyani Publication
4. ICAR. 2014. *Handbook of Animal Husbandry*, 3rd ed. ICAR.
5. Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.
6. Banerjee G.C. 2012. *A text book of Animal Husbandry.* Oxford & IBH Publicing Company Pvt. Ltd.

AHD 15010: Production and Management of Cattle & Buffaloes Semester-III 3(2+1)

Unit- 1: Important breed of cattle and buffalo. Housing /Shelter management, Housing and equipment requirement for different classes of cattle and buffaloes. Type of house and construction details of various houses.

Unit- 2: Feeding management Feed and fodder resources used for feeding cattle and buffaloes. Feed and fodder requirement of different categories of cow and buffaloes (dry animals, milking animals, for calf, for bull), enrichment of poor quality roughages. Care and management of dams. Care and feeding management of different categories of cow and buffaloes (dry animals, milking animals, for calves, for bull), Precaution and maintenance for shelter house. Improving breeding efficiency of Dairy animals.

Unit- 3: Farm management practices and farm labour management. Milking management practices. Clean milk production practices and transportation. Summer and winter management of animals. Digestive and Reproductive system of ruminant animal.

Unit- 4: Health management of Dairy animals, Draughtability and management of draught animals. Management of different diseases FMD, BQ, HS, Brucellosis, Rabies, Tetanus and Pica disease and metabolic disorders..

Practical-

Visit to different size dairy farm and assessment of routine managemental practices. Analysis of various farm records for economic evaluation- computation of practical and economical rations. Layout plans and housing details. Housing, milking, calf heifer, and adult management. Dairy cattle and Buffalo judging and body condition scoring (BCS).

Book Resources-

1. Arora SP. 1997. *Feeding of Dairy Cattle and Buffaloes.* Kalyani Publication.
2. Gupta PR. 2018. *Dairy India- 2017*, 7th Dairy India yearbook, Thomas Press Ltd.
3. ICAR. Livestock Production and Management- ICAR eCourse PDF eBook (online)
4. Sastry NSR. 2016. *Livestock Production under Diverse Constraints- Indian Experience in its Management.* ISAPM Publication
5. Thomas CK, Sastry NSR & Ravikiran G. 2012. Dairy Bovine Production, 2en ed. Kalyani Publishers.
6. *Selected articles from journals.*
7. Banerjee G.C. 2012. *A text book of Animal Husbandry.* Oxford & IBH Publicing Company Pvt. Ltd.
8. Prashad J. 2018. *Animal Husbandry and Dairying.* Kalyani Publication

AHD 15011: Production and Management Sheep & Goat Semester- III: 3(2+1)

Uni- 1: Population structure and importance. Breeds of Goat and Sheep. Type of Goat & Sheep farming. Advantages and limitation of farming. Shelter management. Housing and equipment requirement for goat and sheep. Layout plan of house. Precaution use before and after construction of house.

Unit- 2: Feed and fodder resources for small ruminants. Principles and system of feeding and watering different categories of sheep and goat. Pasture utilization and improvement. Digestive system of Goat and sheep.

Unit- 3: Breeding management, Breeding season. Selection of breeding animals. Method of detection of heat, use of teaser, flushing, tupping. Estrous synchronization. Breeding in goat and sheep. Care and management of pregnant animals and breeding stock. Culling.

Unit 4:- Disease management. Prevention and control measures including vaccination, deworming, dipping and spraying etc. Transportation of small ruminants. Meat, method of slaughter, dressing percentage. Wool shearing methods. Importance of wool, wool quality. Goat fiber: Mohair, pashmina- Marketing of goat fiber/ wool. Clean milk production and its odor.

Practical

Visit to modern sheep and goat farm and critical analysis of various managerial practices under different conditions. Study of practical housing management. Disease control management. Shearing management. Record keeping and economics of sheep and goat farming.

Book Resources

ICAR. 2014. *Handbook of Animal Husbandry,* 3rd ed. ICAR.

Jindal SK. 2013. *Goat Production and Health Management*. New India Publishing Agency.

Kaushik SK. 2017. *Sheep Production*. ICAR Publ.

Sastry NSR. 2016. *Livestock Production Under Diverse Constraints - Indian Experience in its Management*. ISAPM Publication.

ICAR. 2014. *Hand Book of Animal Husbandry*, 3rd ed. ICAR

Banerjee G.C. 2012. *A text book of Animal Husbandry*. Oxford & IBH Publicing Company Pvt. Ltd.

AHD 15012: Dairy Products Manufacturing Technology-2 Semester-III: 3(2+1)

Unit- 1: Introduction, Definition, classification and detailed manufacturing technologies of different kinds of condensed milk

Unit- 1: Introduction, definition, classification and detailed manufacturing technologies of different kinds of condensed milk- SCM, EM

Unit-3: Introduction, definition, classification and detailed manufacturing technologies of different kinds of condensed milk dried milk and milk products- WMP, SMP, butter milk powder, ice cream mix powder, cheese powder, infants milk food, chhana powder, khoa powder, shrikhand powder.

Unit-4: Introduction, definition, classification and detailed manufacturing technologies of dairy by-products- industrial and edible casein, lactose, ghee residue

Practical:

Laboratory preparation practice of milk product- ghee, paneer, chhena and its based sweets, khoa and it based sweets, cottege cheese, ice-cream, kulfi, cream, butter and their quality evaluation & economics. Manufaturing of Dahi, Yoghurt, Shrikhand, Lassi, Misti Dahi, and judging for their market quality. General study evaporators. Preparation of whey drink.

Book Resources:

1. Advanced Dairy Science and Technology, *Edited by Trevor J. BritzUniversity of Stellenbosch South Africa Richard K. Robinson Consultant in Food Science and Technology Reading UK* by Blackwell Publishing Ltd**.**
2. De S.2020. *Outline of Dairy technology. 2020. Oxford university press*

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Agricultural Entomology

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1: Insect Taxonomy		ENT-1601	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Insect Morphology		ENT -1602	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3:Insect Ecology		ENT -1603	*2 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Biological Control of Insect pests and Weeds		ENT-1604	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5:Plant Nematology		PPA-1704	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture *7: Intellectual Property and its management in Agriculture** *8: Library and Information Service**		*AST 3001* *COM 5001* *COM 5002*	*3 (2+1)* *1 (1+0)* *1(1+0)*	*100 (20 M + 30 P + 50 T)* *100 T (50 M + 50 A)** *100 T (50 M + 50 A)**
2nd Semester	1:Toxicology of Insecticides		ENT 1605	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2: Insect Anatomy and Physiology		ENT 1606	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3:Pests of Field Crops		ENT 1607	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4:Concept of Integrated Pest Management		ENT 1608	*2 (2+0)*	*100 (50 M +50 T)*
	5: Disease of Crops and Medicinal Crops		PPA-1608	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs *7: Basic Concepts in Laboratory Techniques** *8: Technical Writing and Communications Skills**		*AST 3002* *COM 5003* *COM 5004*	*3 (2+1)* *1 (1+0)* *1 (1+0)*	*100 (20 M + 30 P + 50 T)* *100 T (50 M + 50 A)** *100 T (50 M + 50 A)**
3rd Semester	1:Pests of Horticultural and Plantation Crops		ENT-1609	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2:Apiculture		ENT-1610	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3:Sericulture		ENT-1611	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4:Post Harvest Entomology		ENT-1612	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	*5: Agricultural Research, Research Ethics and Rural Development Programs**		*COM 5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	*1: Seminar*		ENT-1613	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	*ENT-1614*	*25*	*100* *The evaluation of thesis shall be:* *(50 Internal + 50 External)*
		(B) Internship for Development of Enterpeneurship in Agriculture (IDEA)	*ENT-1615*	*25 Internship based dissertation*	*100* *The evaluation of IDEA shall be:* *(50 Internal + 50 External)*
	Total credits = 72				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Contents
M.Sc. (Ag) in Entomology
SEMESTER - I

1. Course Title : Insect Taxonomy
Course Code : ENT- 1601
Credit Hours : 3 (2 + 1)

Theory

Unit I

History of insect classification; principles of systematics and its importance. Descriptions subjects of descriptions, characters, nature of characters, analogy *v/s* homology, parallel *v/s* convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects introduction to phylogeny of insects and Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Insect labeling protocols and procedures.

Unit II

Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

Unit III

Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

- Study of Orders of insects and their identification using taxonomic keys.
- Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera.
- Field visits to collect insects of different orders.

Suggested Reading

CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.

Freeman S and Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Gullan PJ and Cranston PS. 2010. *The Insects: An outline of Entomology*. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK.

Mayr E. 1971. *Principles of Systematic Zoology*. Tata McGraw Hill, New Delhi.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology.* 10th Ed. Chapman and Hall, London.

Ross HH.1974. *Biological Systematics.* Addison Wesley Publ. Company.

Triplehorn CA and Johnson NF. 1998. *Borror and DeLong's Introduction to the Study of Insects.*7th Ed. Thomson/ Brooks/ Cole, USA/ Australia.

Course Title : Insect Morphology
Course Code : ENT- 1602
Credit Hours : 2 (1+1)

Theory

Unit I-

External Morphology: Insect body wall structure, cuticular outgrowths in insects, body tagmata, sclerites and segmentation.

Head- Structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites.

Unit II- Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation and wing coupling apparatus ; legs: structure and modifications.

Abdomen- Segmentation and appendages; genitalia and their modifications;.

Unit III- Insect sense organs (mechano, photo and chemorecepters). Post-embryonic development, types of metamorphosis, Types of immature stages in insect orders, structure of egg, nymph/ larva and pupa, identification of different immature stages of crop pests and stored product insects. significance of immature stages for pest management

Practical

- Study on insect head, antennae, mouth parts, legs and wings. Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia;
- Types of immature stages in insects; their collection, rearing and preservation;
- Identification of immature insects to orders and families, in endopterygote orders, viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera.

Suggested Reading

Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.

Chu HF. 1992. *How to Know Immature Insects*. William Brown Publication, Iowa.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.

Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.

Gillott C. 1995. *Entomology*, 2nd Ed. Plenum Press, New York, London.

Gullan PJ and Cranston PS. 2000. *The Insects, An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.

Peterson A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman and Hall, London.

Snodgross RE. 1993. *Principles of Insect Morphology.* Cornell Univ. Press, Ithaca.

3. Course Title : Insect Ecology
Course Code : ENT- 1603
Credit Hours : 2 (1+1)

Theory

Unit I

History and definition. Basic Concepts. Organization of the Biological world. Plato's Natural Balance *vs* Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalized action on insects.

Unit II

Basic concepts of abundance. Population growth basic models – Exponential *vs* Logistic models. Discrete *vs* Continuous growth models. Environmental Resistance. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) – aestivation, hibernation.

Unit III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions – The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive exclusion.

Unit IV

Community ecology- Concept and Organization of communities- Hutchinson Ratio, May's *d/w*, Relation between the two. Relative distribution of organisms, Concept of diversity- Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology. Climate change and insect pest/ natural enemy population.

Practical

- Types of distributions of organisms
- Methods of insects sampling, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution;
- Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit;
- Assessment of prey-predator densities from natural systems and understanding the correlation between the two;
- Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values;
- Field visits to understand different ecosystems and to study insect occurrence in these systems.

Suggested Reading

Begon M, Townsend CR and Harper JL. 2006. *Ecology: From Individuals to Ecosystems*. 4th Ed. Blackwell Publishing, USA/ UK/ Australia.

Chapman JL and Reiss MJ. 2006. *Ecology: Principles and Applications*. 2nd Ed. Cambridge Univ. Press, Cambridge.

Fowler J, Cohen L and Jarvis P. 1998. Practical Statistics for Field Biology. 2nd Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.

Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics.* Sinauer Associates, Inc., Sunderland, MA.

Gotelli NJ. 2001. *A Primer of Ecology.* 3rd Ed. Sinauer Associates, Inc., Sunderland, MA

Gupta RK. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.

Krebs CJ. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York.

Krebs CJ. 2001. *Ecology: The Experimental Analysis of Distribution and Abundance.* 5th Ed. Benjamin-Cummings Publ. Co., New York.

Magurran AE. 1988. *Ecological Diversity and its Measurement.* Princeton Univ. Press, Princeton.

Price PW. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.

Real LA and Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.

Schowalter Timothy D. 2011. *Insect Ecology – An Ecosystem Approach*. 3rd Ed. Academic Press, London, UK/ CA, USA.

Southwood TRE and Henderson PA. 2000. *Ecological Methods.* 3rd Ed. Methuen and Co. Ltd., London.

Speight MR, Hunta MD and Watt AD. 2006. *Ecology of Insects: Concepts and Application*. Elsevier Science Publ., The Netherlands.

Townsend Colin R, Begon Michael and Harper John L. 2008. *Essentials of Ecology*. 3rd Ed. Blackwell Publishing, USA/ UK/ Australia.

Wilson EO, William H and Bossert WH. 1971. *A Primer of Population Biology*. Harvard University, USA.

Wratten SD and Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold, London.

4. Course Title : Biological Control of Insect Pests And Weeds
Course Code : ENT- 1604
Credit Hours : 3 (2+1)

Theory

Unit I

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.

Unit II

Biology, adaptation, host seeking behaviour of major predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, their mode of action. Biological control of weeds using insects. Symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

Unit III

Mass production of quality bio-control agents- techniques, formulations, economics, field release/ application and evaluation. Development of insectaries and their maintenance.

Unit IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations. Role of biotechnology in biological control. Semiochemicals in biological control.

Practical

- Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers;
- Visits to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds;
- Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Suggested Reading

Burges HD and Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites.* Academic Press, London.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds.* Chapman and Hall, New York.

Dhaliwal GS and Arora R. 2001. *Integrated Pest Management: Concepts and Approaches.* Kalyani Publishers, New Delhi.

Gerson H and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual.* Chapman and Hall, New York.

Huffaker CB and Messenger PS. 1976. *Theory and Practices of Biological Control.* Academic Press, London.

Ignacimuthu SS and Jayaraj S. 2003. *Biological Control of Insect Pests*. Phoenix Publ., New Delhi.

Saxena AB. 2003. *Biological Control of Insect Pests*. Anmol Publ., New Delhi.

Van Driesche and Bellows TS. Jr. 1996. *Biological Control*. Chapman and Hall, New York.

SEMESTER - II

Course Title : Toxicology of Insecticides
Course Code : ENT 1605
Credit Hours : 2 (1+1)

Theory

Unit I

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

Unit II

Classification of insecticides based on mode of entry, mode of action and chemical nature; categorization of insecticides on the basis of toxicity; structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds/ new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.

Unit III

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. bioassay definition, objectives, criteria, factors, problems and solutions.

Unit IV

Insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management, pest resurgence. safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

- Insecticide formulations and mixtures;
- Laboratory and field evaluation of bio-efficacy of insecticides;
- Bioassay techniques and Probit analysis;
- Pesticide appliances;
- Working out doses and concentrations of pesticides;

Suggested Reading

Chattopadhyay SB. 1985. *Principles and Procedures of Plant Protection.* Oxford and IBH, New Delhi.

Dodia DA, Petel IS and Petal GM. 2008. *Botanical Pesticides for Pest Management*. Scientific Publisher (India), Jodhpur.

Dovener RA, Mueninghoff JC and Volgar GC. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA

Gupta HCL.1999. *Insecticides: Toxicology and Uses.* Agrotech Publ., Udaipur.

Ishaaya I and Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action.* Narosa Publ. House, New Delhi.

Ishaaya I and Degheele D. 1998. *Insecticides with Novel Modes of Action: Mechanism and Application*. Norosa Publishing House, New Delhi.

Krieger RI. 2001. *Handbook of Pesticide Toxicology*. Vol-II. Academic Press. Orlando Florida.

Mathews GA. 2002. *Pesticide Application Methods*. 4th Ed. Intercept. UK.

Matsumura F. 1985. *Toxicology of Insecticides.* Plenum Press, New York.

Otto D and Weber B. 1991. *Insecticides: Mechanism of Action and Resistance*. Intercept Ltd., UK.

Pedigo LP and Marlin ER. 2009. *Entomology and Pest Management*, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.

Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. *Insecticides in Agriculture and Environment.* Narosa Publ. House, New Delhi.

Prakash A and Rao J. 1997. *Botanical Pesticides in Agriculture.* Lewis Publication, New York.

Roy NK. 2006. *Chemistry of Pesticides*. Asia Printograph Shahdara Delhi.

6. Course Title : Insect Anatomy and Physiology
Course Code : ENT- 1606
Credit Hours : 3 (2+1)
Theory

Unit I

Scope and importance of insect physiology; physiology of integument, moulting, chemistry of cuticle, growth, hormonal control, metamorphosis and diapause; pheromone secretion, transmission, perception and reception.

Unit II

Physiology and mechanism of digestion, circulation, respiration, excretion, reproduction, secretion (exocrine and endocrine glands) and nerve impulse transmission in insects.

Unit III

Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

Practical

- Dissection of alimentary canal, reproductive organs and nervous system of different insects.
- Latest analytical techniques for analysis of free amino acids of haemolymph;
- Determination of chitin in insect cuticle;
- Examination and count of insect haemocytes; preparation and evaluation of various diets;
- Preparation of digestion of natural and artificial diets.

Suggested Reading

Chapman RF. 1998. *Insects: Structure and Function*. ELBS Ed., London.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.

Gullan PJ and Cranston PS. 2000. *The Insects*: *An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.

Kerkut GA and Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology.* Vols. I-XIII. Pergamon Press, New York.

Patnaik BD. 2002. *Physiology of Insects*. Dominant Publishers, New Delhi.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology.* 10th Ed. Vol. 1.

7. Course Title : Pests of Field Crops
Course Code : ENT- 1607
Credit Hours : 3 (2+1)

Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pest scenario in relation to climate change.

Unit I

Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs, etc.). Insect pests of cereals and millets and their management.

Unit II

Insect pests of pulses, tobacco, oilseeds and their management.

Unit III

Insect pests of fibre crops, forage crops, sugarcane and their management.

Practical

- Field visits, collection and identification of important pests and their natural enemies;
- Detection and estimation of infestation and losses in different crops;
- Study of life history of important insect pests.

Suggested Reading

David, BV and Ramamurthy, VV. 2001. *Elements of Economic Entomology.* Popular Book Depot, Chennai.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publishers, New Delhi

Evans JW. 2005. *Insect Pests and their Control*. Asiatic Publ., New Delhi.

Nair MRGK. 1986. *Insect and Mites of Crops in India.* ICAR, New Delhi.

Prakash I and Mathur RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.

Saxena RC and Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Udaipur.

8. Course Title : Concepts of Integrated Pest Management
Course Code : ENT- 1608
Credit Hours : 2 (2+0)

Theory

Unit I

History, origin, definition and evolution of various terminologies. Importance of resistance, principles, classification, components, types and mechanisms of resistance. National and international level crop protection organizations; insecticide regulatory bodies; synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides – the pros and cons.

Unit II

Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

Unit III

Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming.

Unit IV

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system.

Suggested Reading

Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches.* Kalyani Publishers, New Delhi.

Horowitz AR and Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.

Ignacimuthu SS and Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.

Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management.* Prentice Hall, New Delhi.

Pedigo RL. 2002. *Entomology and Pest Management.* 4th Ed. Prentice Hall, New Delhi.

Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products.* Marcel Dekker, New York.

SEMESTER III

9. Course Title : Pests of Horticultural and Plantation Crops
Course Code : ENT- 1609
Credit Hours : 3 (2+1)

Theory

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of major insect pests of various crops.

Unit I

Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.

Unit II

Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, drumstick, leafy vegetables, etc.

Unit III

Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa, etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine, etc.

Unit IV

Ornamental, medicinal and aromatic plants and pests in polyhouses/ protected cultivation.

Practical

• Collection and identification of important pests and their natural enemies on different crops;

• Study of life history of important insect pests and non-insect pests.

Suggested Reading

Atwal AS and Dhaliwal GS. 2002. *Agricultural Pests of South Asia and theirManagement.* Kalyani Publishers, New Delhi.

Butani DK and Jotwani MG. 1984. *Insects and Vegetables.* Periodical Expert Book Agency, New Delhi.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Srivastava RP. 1997. *Mango Insect Pest Management.* International Book Distr., Dehra Dun.

Verma LR, Verma AK and Goutham DC. 2004. *Pest Management in Horticulture Crops*: *Principles and Practices*. Asiatech Publ., New Delhi.

10. Course Title : Apiculture
Course Code : ENT- 1610
Credit Hours : 3 (2+1)

Theory

Unit I

Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus *Apis* and races; Morphology and anatomy of honey bee;

Honey bee biology, ecology, adaptations; Honey bee behaviour – nest founding, comb construction, brood care, defense, other in-house and foraging activities; Bee pheromones; Honey bee communication.

Unit II

Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment; Seasonal bee husbandry; Honey bee nutrition and artificial diets; Absconding, swarming, drifting – causes and management; Curbing drone rearing; Laying worker menace – causes, signs and management.

Unit III

Ectoparasitic and endoparasitic bee mites –nature and symptoms of damage, management tactics; Wax moths, wasps and ants – nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; Pesticide poisoning to honey bees, signs and protection.

Unit IV

Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and bees wax and their post-harvest handling; Development of apiculture project.

Unit V

Non-*Apis* pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.

Practical

- Morphological characteristics of honey bee;
- Mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees;
- Recording of colony performance;
- Seasonal bee husbandry practices;
- Swarming, queenlessness, laying workers menaces, etc. and their remedies;
- Formulation of artificial diets and their feeding;
- Production technologies for various hive products;
- Bee enemies and diseases and their management;
- Recording pollination efficiency;
- Developing a beekeeping project.

Suggested Reading

Abrol DP and Sharma D. 2009. *Honey Bee Mites and Their Management.* Kalyani Publishers, New Delhi, India.

Abrol DP. 2009. *Honey bee Diseases and Their Management*. Kalyani Publishers, New Delhi, India.

Abrol DP. 2010. *Beekeeping: A Compressive Guide to Bees and Beekeeping*. Scientific Publishers, India.

Abrol DP. 2010. *Bees and Beekeeping in India*. Kalyani Publishers, New Delhi, India.

Atwal AS. 2001. *World of Honey Bees.* Kalyani Publishers, New Delhi- Ludhiana, India.

Atwal AS. 2000. *Essentials of Beekeeping and Pollination*. Kalyani Publishers, New Delhi-Ludhiana, India.

Bailey L and Ball BV. 1991. *Honey Bee Pathology*. Academic Press, London.

Crane Eva and Walker Penelope. 1983. *The Impact of Pest Management on Bees and Pollination.* Tropical Development and Research Institute, London.

Free JB. 1987. *Pheromones of Social Bees.* Chapman and Hall, London.

Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. *Mass Multiplication of Honey Bee Colonies.* ICAR, New Delhi, India.

Grahm Joe M. 1992. *Hive and the Honey Bee.* Dadant & Sons, Hamilton, Illinois, USA.

Grout RA. 1975. *Hive and the Honey Bee.* Dadant & Sons, Hamilton, Illinois, USA.

Holm E. 1995. *Queen Rearing Genetics and Breeding of Honey Bees.* Gedved, Denmark.

Laidlaw HH Jr and Eckert JE. 1962. *Queen Rearing*. Berkeley, University of California Press.

Mishra RC. 2002. *Perspectives in Indian Apiculture*. Agro-Botanica, Jodhpur, India.

Mishra RC. 1995. *Honey Bees and their Management in India.* I.C.A.R., New Delhi, India.

Morse AA. 1978. *Honey Bee Pests, Predators and Diseases*. Cornell University Press, Ithaca and London.

Rahman, A. 2017. *Apiculture in India*, ICAR, New Delhi

11. Course Title : Sericulture
Course Code : ENT- 1611
Credit Hours : 3 (2+1)

Theory

Unit I

History of Sericulture, importance, organizations involved in sericulture activities, silkworm types, distribution, area and silk production.

Unit II

Mulberry species, ecological requirements, cultivation (Moriculture)- improved varieties, propagation methods, sapling production, planting and pruning techniques; pest and diseases management strategies. Food plants of eri silkworm, Tasar and Muga silkworm.

Unit III

Silkworm origin – classification based on voltinism, moultinism, geographical distribution and genetic nature – pure races –multivoltine and bivoltine races – cross breeds – bivoltine hybrids –Races and hybrids of mulberry. Morphology and biology of silkworm, structure and function of silk glands.

Unit IV

Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods, Chawki rearing, feeding, cleaning and spacing; rearing of late age worms, feeding, cleaning, spacing and moulting care; mountages, cocoon harvesting and marketing; pests and diseases of silkworms and their management.

Unit V

Post cocoon technology, stifling, cocoon cooking, reeling, value addition in sericulture; economics of sericulture.

Practical

- Morphology of mulberry plants;
- Identification of silk worm species
- Nursery bed and main field preparation;
- Planting methods;

- Pruning technique and harvesting methods
- Morphology of silkworm – Identification of races – Dissection of mouth parts and silk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – hyperparasitoids and mass multiplication techniques – silkworm egg production technology, Visit to grainage, cocoon market and silk reeling centre – Economics of silkworm rearing.

Suggested Reading

Dandin SB and K Giridhar. 2014. Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.

Govindaiah G, VP, Sharma DD, Rajadurai S and Nishita V Naik. 2005. A text book on mulberry crop protection. Central Silk Board, Bangalore.450 p.

Jolly MS, Sen SK, Sonwalkar TN and Prasad GK. 1980. Non–mulberry Silks. FAO Agicultural Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.

Mahadevappa D, Halliyal VG, Shankar DG and Ravindra Bhandiwad. 2000. Mulberry Silk Reeling Technology. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi. 234 p.

Mohanty PK. 2003. Tropical wild cocoons of India. Daya Publications, Tri Nagar, New Delhi, 197 p.

Nataraju B, Sathyaprasad K, Manjunath D and Kumar A. 2005. Silkworm crop protection. CSB, Bangalore. 412 pp.

Rangaswami G, Narasimhanna MN, Kasiviswanathan K, Sastry CR and Jolly MS. 1976. Food Plants of non-mulberry silkworms. In: *Mulberry cultivation*. FAO Agricultural Services Bulletin. Vol.1, Chapter-13. Rome, Italy. 96 p.

Tribhuvan Singh and Saratchandra B. 2004. Principles and Techniques of silkworm seed production. Discovery publishing House, New Delhi, 360 pp.

E-resources

www.silkwormgenomics.org; www.silkboard.com; ww.silkgermplasm.com; www.csrtimys.res.in**.**

12. Course Title : Post Harvest Entomology
Course Code : ENT- 1612
Credit Hours : 2 (1+1)

Theory

Unit I

Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto vis-à-vis* total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault.

Unit II

Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross

infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

Unit III

Ecology of insect pests of stored commodities/ grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage.

Unit IV

Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/ sanitation, disinfestations of stores/ receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological. Chemical control prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Insecticide resistance in stored product pests and its management; integrated approaches to stored grain pest management.

Practical

- Collection, identification and familiarization with the stored grains/ seed insect pests and nature of damage caused by them;
- Detection of hidden insect infestation in stored food grains;
- Determination of moisture content in stored food grains;
- Familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques;
- Treatment of packing materials and their effect on seed quality;
- Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, Mysore; IGSMRI, Hapur, etc. (only where logistically feasible).

Suggesting Reading

Hall DW. 1970. *Handling and Storage of Food Grains in Tropical and Subtropical Areas.* FAO.

Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.

Jayas DV, White NDG and Muir WE. 1995. *Stored Grain Ecosystem.* Marcel Dekker, New York.

Khader V. 2004. *Textbook on Food Storage and Preservation*. Kalyani Publishers, New Delhi.

Khare BP. 1994. *Stored Grain Pests and Their Management.* Kalyani Publishers, New Delhi.

Subramanyam B and Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products.* Marcel Dekker, New York.

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Plant Pathology

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1:Mycology		PPA-1701	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2:Plant Virology		PPA -1702	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3:Plant Pathogenic Prokaryotes		PPA -1703	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	4:Plant Nematology		PPA-1704	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5: Biological control of Insect Pests and Weeds		ENT-1603	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST 3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	7: *Intellectual Property and its Management in Agriculture**		*COM 5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM 5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1: Principles of Plant Pathology		PPA 1705	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2:Techniques in Detection and Diagnosis of Plant Diseases		PPA 1706	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Principles of Plant Disease Management		PPA 1707	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Diseases of Field and Medicinal Crops		PPA 1708	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	5: Soil Biology and Biochemistry		SAC-1202	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs		*AST 3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM 5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM 5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	1:Chemicals and Botanicals in Plant Disease Management		PPA-1709	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Diseases of Fruits, Plantation and Ornamental Crops		PPA-1710	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3:Diseases of Vegetable and Spices Crops		PPA-1711	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Biological Control of Plant Diseases (Minor)		PPA-1712	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	*6: Agricultural Research, Research Ethics and Rural Development Programs**		*COM 5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	1: Seminar		PPA- 1713	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	PPA -1714	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	PPA-1715	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Contents

M.Sc. in Plant Pathology

SEMESTER I

Course Title : Mycology
Course Code : PPA 1701
Credit Hours : 3 (2+1)

Theory

Unit I

Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi. Modern concept of nomenclature and classification, Classification of kingdom fungi: Stramenopila and Protists.

Unit II

The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

Unit III

Kingdom fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.

Unit IV

Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes. Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts. Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

Practical

- Detailed comparative study of different groups of fungi;
- Collection of cultures and live specimens;
- Saccardoan classification and classification based on conidiogenesis;
- Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi;
- Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia. Oomycota; Plant Protection–Plant Pathology
- Somatic and reproductory structures of *Pythium*, *Phytophthora*, downy mildews and *Albugo*, Zygomycetes: Sexual and asexual structures of *Mucor*, *Rhizopus*, General characters of VAM fungi. Ascomycetes; fruiting structures, Erysiphales, and Eurotiales;
- General identification characters of Pyrenomycetes, Discomycetes, Loculoascomycetes and Laboulbenio-mycetes, Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes;
- Characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states, Collection, preservation, culturing and identification of plant parasitic fungi;
- Application of molecular approaches and techniques for identification of fungal pathogens.

Suggested Reading

Ainsworth GC, Sparrow FK and Susman HS. 1973. *The Fungi – An Advanced Treatise*. Vol. IV

(A & B). Academic Press, New York.

Alexopoulos CJ, Mims CW and Blackwell M.2000. *Introductory Mycology*. 5th Ed. John Wiley & Sons, New York.

Maheshwari R. 2016. *Fungi: Experimental Methods in Biology* 2nd edn. CRC Press, US.

Mehrotra RS and Arneja KR. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi.

Sarbhoy AK. 2000. *Text book of Mycology*. ICAR, New Delhi.

Singh RS. 1982. *Plant Pathogens – The Fungi*. Oxford & IBH, New Delhi.

Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

Course Title : Plant Virology
Course Code : PPA- 1702
Credit Hours : 2(1+1)

Theory

Unit I

History and economic significances of plant viruses. General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids and prions. Origin and evolution of viruses and their nomenclature and classification.

Unit II

Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatical changes. Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.

Unit III

Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.

Unit IV

Virus epidemiology ecology (spread plant viruses in fields host range and survival). Management of diseases caused by plant viruses.

Practical

- Study of symptoms caused by plant viruses (followed by field visit);
- Isolation and biological purification of plant virus cultures;
- Bioassay of virus cultures on indicator plants and host differentials;
- Transmission of plant viruses (Mechanical, graft and vector and study of disease development);
- Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology;
- Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP, Later flow micro array and PCR based techniques);
- Exposure to basic bio-informatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Claustal X/W, MEGA Software).

Suggested Reading

Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.

Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ and Watson L. 1995. *Virus of Plants: Descriptions*

and Lists from VIDE Database. CABI, Wallington.

Gibbs A and Harrison B. 1976. *Plant Virology – The Principles*. Edward Arnold, London. Hull

R. 2002. *Mathew's Plant Virology*. 4th Ed. Academic Press, New York.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Oxford & IBH, New Delhi.

Wilson C. 2014. *Applied Plant Virology.* CABI Publishing England.

Course Title : Plant Pathogenic Prokaryotes
Course Code : PPA- 1703
Credit Hours : 2(1+1)

Theory

Unit I

Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell. Structure and composition of gram negative and gram positive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccaride structure; Membrane transport; fimbrae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (Slayer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.

Unit II

Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes.

Unit III

Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

Unit IV

Variability among phytopathogenic prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteriaconjugation; transformation; transduction); and horizontal gene transfer.

Unit V

Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, Use of phages in plant pathology/ bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes.Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

Practical

- Study of symptoms produced by phytopathogenic prokaryotes;
- Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria;
- Stains and staining methods;

- Biochemical and serological characterization;
- Isolation of genomic DNA plasmid;
- Use of antibacterial chemicals/ antibiotics;
- Isolation of fluorescent *Pseudomonas*;
- Preservation of bacterial cultures;
- Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences;
- Diagnosis and management of important diseases caused by bacteria and mollicutes.

Suggested Reading

Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.

Jayaraman J and Verma JP. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publishers, Ludhiana.

Mount MS and Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II Academic Press, New York.

Salle AJ. 1979. *Fundamental Principles of Bacteriology 7th edn.*

Verma JP, Varma A and Kumar D. (Eds). 1995. *Detection of Plant Pathogens and their Management*. Angkor Publ., New Delhi.

Course Title : Plant Nematology
Course Code : PPA- 1704
Credit Hours : 3(2+1)

Theory

Unit I

Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

Unit II

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

Unit III

Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

Unit V

Principles and practices of nematode management; integrated nematode management.

Unit VI

Emerging nematode problems, Importance of nematodes in international trade and quarantine.

Practical

- Studies on kinds of nematodes- free-living, animal, insect and plant parasites;
- Nematode extraction from soil;
- Extraction of migratory endoparasites, staining for sedentary endoparasites;
- Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

Suggested Reading

Dropkin VH. 1980. *An Introduction to Plant Nematology*. John Wiley & Sons, New York.

Maggenti AR. 1981. *General Nematology*. Springer-Verlag, New York.

Perry RN and Moens M. 2013. *Plant Nematology*. 2nd Ed. CABI Publishing: Wallingford, UK.

Perry RN, Moens M, and Starr JL. 2009. *Root-knot nematodes*, CABI Publishing: Wallingford, UK.

Sikora RA, Coyne D, Hallman J and Timper P. 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture.*3rd edn. CABI Publishing, England.

Thorne G. 1961. *Principles of Nematology*. McGraw Hill, New Delhi.

SEMESTER-II

Course Title : Principles of Plant Pathology
Course Code : PPA- 1705
Credit Hours : 2(1+1)

Theory

Unit I

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

Unit II

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Unit III

Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

Unit IV

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

Practical

- Basic plant pathological techniques;
- Isolation, inoculation and purification of plant pathogens and proving Koch's postulates;
- Techniques to study variability in different plant pathogens;
- Purification of enzymes, toxins and their bioassay;
- Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.

Suggested Reading

Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.

Heitefuss R and Williams PH. 1976. *Physiological Plant Pathology.* Springer Verlag, Berlin, New York.

Mehrotra RS and Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi.

Singh RP. 2012. *Plant Pathology* 2nd edn. Kalyani Publishers, New Delhi.

Singh RS. 2017. *Introduction to Principles of Plant Pathology*. 5th edn. MedTech, New Delhi.

Singh DP and Singh A. 2007. *Disease and Insect Resistance in Plants.* Oxford & IBH, New Delhi.

Upadhyay RK. and Mukherjee KG. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology.* Oxford & IBH, New Delhi.

Course Title : Techniques for Detection and Diagnosis of Plant Diseases
Course Code : PPA- 1706
Credit Hours : 3(2+1)

Theory

- Detection of plant pathogens 1. Based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological

assays 7. Nucleic acid based techniques (Non-PCR–LAMP, Later flow microarray and PCR based- multiplex, nested, qPCR, immune capture PCR, etc.);

- Phenotypic and genotypic tests for identification of plant pathogens;
- Molecular identification (16S rDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing;
- Volatile compounds profiling by using GC-MS and LC-MS;
- FAME analysis, Fluorescence *in-situ* Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens;
- Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

Practical: Related to theory

Suggested Reading

Baudoin ABAM, Hooper GR, Mathre DE and Carroll RB. 1990. *Laboratory Exercises in Plant*

Pathology: An Instructional Kit. Scientific Publ., Jodhpur.

Dhingra OD and Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.

Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology*, CABI Wallington.

Forster D and Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic*

Resistance. *Methods in Molecular Biology*. Humana Press, Totowa, New Jersey.

Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.

Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agic. Pub.

Doc. Wageningen.

Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi.

Trigiano RN, Windham MT and Windham AS. 2004. *Plant Pathology-Concepts and Laboratory*

Exercises. CRC Press, Florida.Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

Course Title : Principles of Plant Disease Management
Course Code : PPA- 1707
Credit Hours : 3(2+1)

Theory

Unit I

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

Unit II

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides.

Unit III

Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health *vis-a-vis* environmental hazards, residual effects and safety measures Plant Protection–Plant Pathology

Practical

- Phytopathometry;
- Methods of *in-vitro* evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Field evaluation of chemicals, antibiotics, bio agents against plant pathogens;
- Soil solarisation, methods of soil fumigation under protected cultivation;
- Methods of application of chemicals and bio control agents;
- ED and MIC values, study of structural details of sprayers and dusters;
- Artificial epiphytotic and screening of resistance.

Suggested Reading

Fry WE. 1982. *Principles of Plant Disease Management.* Academic Press, New York.

Hewitt HG. 1998. *Fungicides in Crop Protection*. CABI, Wallington. Marsh RW. 1972. Systemic

Fungicides. Longman, New York.

Nene YL and Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. Oxford & IBH, New Delhi.

Palti J. 1981. *Cultural Practices and Infectious Crop Diseases*. Springer Verlag, New York.

Vyas SC. 1993 *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

Course Title : Diseases of Field and Medicinal Crops
Course Code : PPA- 1708
Credit Hours : 2(1+1)

Theory

Unit I

Diseases of Cereal crops- Rice, wheat, barley, pearl millet, sorghum and maize.

Unit II

Diseases of Pulse crops- Gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

Unit III

Diseases of Oilseed crops- Rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

Unit IV

Diseases of Cash crops- Cotton, sugarcane.

Unit V

Diseases of Fodder legume crops- Berseem, oats, guar, lucerne.

Unit VI

Medicinal crops- *Plantago*, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, *Aloe vera*.

Practical

- Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops;
- Collection and dry preservation of diseased specimens of important crops.

Suggested Reading

Joshi LM, Singh DV and Srivastava KD. 1984. *Problems and Progress of Wheat Pathology in South Asia*. Malhotra Publ. House, New Delhi.

Rangaswami G. 1999. *Diseases of Crop Plants in India*. 4th Ed. Prentice Hall of India, New Delhi.

Ricanel C, Egan BT, Gillaspie Jr AG and Hughes CG. 1989. *Diseases of Sugarcane, Major Diseases*. Academic Press, New York.

Singh RS. 2017. *Plant Diseases*. 10th Ed. Medtech, New Delhi.

Singh US, Mukhopadhyay AN, Kumar J and Chaube HS. 1992. *Plant Diseases of Internatiobnal*

Importance. Vol. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

SEMESTER-III

Course Title : Chemicals and Botanicals in Plant Disease Management
Course Code : PPA- 1709
Credit Hours : 3(2+1)

Theory

Unit I

History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals.

Unit II

Classification of chemicals used in plant disease management and their characteristics.

Unit III

Chemicals in plant disease control, viz., fungicides, bactericides, nematicides, antiviral chemicals and botanicals. Issues related to label claim.

Unit IV

Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

Unit V

Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. New generation fungicides and composite formulations of pesticides.

Unit VI

Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases. General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practical

- Acquaintance with formulation of different fungicides and plant protection appliances;
- Formulation of fungicides, bactericides and nematicides;
- *In-vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens;
- Persistence, compatibility with other agro-chemicals;
- Detection of naturally occurring fungicide resistant mutants of pathogen;
- Methods of application of chemicals.

Suggested Reading

Bindra OS and Singh H. 1977. *Pesticides – And Application Equipment*. Oxford & IBH, New Delhi.

Torgeson DC. (Ed.). 1969. *Fungicides.* Vol. II. An Advanced Treatise. Academic Press, New York.

Vyas SC. 1993. *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

Course Title : Diseases of Fruits, Plantation and Ornamental Crops
Course Code : PPA- 1710
Credit Hours : 3(2+1)

Theory

Unit I

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm, custard apple and their management.

Unit II

Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.

Unit III

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, gerbera orchids, marigold, chrysanthemum and their management.

Practical

- Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops;
- Collection and dry preservation of diseased specimens of important crops.

Suggested Reading

Gupta VK and Sharma SK. 2000. *Diseases of Fruit Crops*. Kalyani Publishers, New Delhi.
Pathak VN. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.
Singh RS. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.
Walker JC. 2004. *Diseases of Vegetable Crops*. TTPP, India.

Course Title : Diseases of Vegetable and Spices Crops
Course Code : PPA- 1711
Credit Hours : 3(2+1)

Theory

Unit I

Nature, prevalence, factors affecting disease development of tuber, bulb, leafy vegetable, crucifers, cucurbits and solanaceaous vegetables. Diseases of crops under protected cultivation.

Unit II

Symptoms and management of diseases of different root, tuber, bulb, leafy vegetables, crucifers, cucurbits and solanaceaous vegetable crops.

Unit III

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, nutmeg, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger. Biotechnological approaches in developing disease resistant transgenics.

Practical

• Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

Suggested Reading

Chaube HS, Singh US, Mukhopadhyay AN and Kumar J. 1992. *Plant Diseases of International*

Importance. Vol. II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs, New Jersey.

Gupta VK and Paul YS. 2001. *Diseases of Vegetable Crops*. Kalyani Publishers, New Delhi

Gupta SK and Thind TS. 2006. *Disease Problem in Vegetable Production*. Scientific Publ., Jodhpur.

Sherf AF and Mcnab AA. 1986. *Vegetable Diseases and their Control*. Wiley Inter Science, Columbia.

Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New Delhi.

Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

Course Title : Biological Control of Plant Pathogens
Course Code : PPA-1712
Credit Hours : 2(1+1)

Theory

Unit I

Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.

Unit II

Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

Unit III

Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of bioagents with agrochemicals and other antagonistic microbes.

Unit IV

Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

Practical

• Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in-vitro and in vivo* conditions;

• Preparation of different formulations of selected bioagents and their mass production; • Quality parameters of biocontrol agents;

• One week exposure visit to commercial biocontrol agents production unit.

Suggested Reading

Campbell R. 1989. *Biological Control of Microbial Plant Pathogens*. Cambridge Univ. Press, Cambridge.

Cook RJ and Baker KF. 1983. *Nature and Practice of Biological Control of Plant Pathogens*. APS, St. Paul, Minnesota.

Fokkemma MJ. 1986. *Microbiology of the Phyllosphere*. Cambridge Univ. Press, Cambridge.

Gnanamanickam SS (Eds). 2002. *Biological Control of Crop Diseases*. CRC Press, Florida.

Heikki MT and Hokkanen James M. (Eds.). 1996. *Biological Control – Benefits and Risks*. Cambridge Univ. Press, Cambridge.

Mukerji KG, Tewari JP, Arora DK and Saxena G. 1992. *Recent Developments in Biocontrol of Plant Diseases*. Aditya Books, New Delhi.

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Agricultural Economics

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1: Micro Economic Theory and Applications		AEC-1801	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Macro Economics and Policy		AEC-1802	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3: Agricultural Production Economics		AEC-1803	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	4: Agricultural Marketing and Price Analysis		AEC-1804	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5: Managing Extension organization (as Minor)		EXT-1904	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST 3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Intellectual Property and its Management in Agriculture**		*COM 5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM 5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1: Agricultural Development and Policy Analysis		AEC 1805	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2: Econometrics		AEC 1806	*3(2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Agricultural Finance and Project Management		AEC 1807	*3(2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Commodity Future Trading		AEC 1808	*2(1+1)*	*100 (20 M + 30 P + 50 T)*
	5: Natural Resource and Environmental Economics (as Minor)		AEC 1809	*3(2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Mathematics for Agricultural Economics		*SUP 4001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM 5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM 5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	1: Linear Programming		AEC-1810	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Research Methodology for Social Sciences		AEC-1811	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: International Economics		AEC-1812	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Development Economics credit (as Minor)		AEC-1813	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	*5: Agricultural Research, Research Ethics and Rural Development Programs**		*COM 5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	1: Seminar		AEC-1814	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	AEC -1815	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	AEC -1816	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Contents
M.Sc. (Ag) in Agricultural Economics

1. Course Title: Micro Economic Theory and Applications

Course Code: AEC-1801

Credit Hrs 3 (2+1)

THEORY

Unit 1: Basic Concepts: A review

Scarcity and Choice; Production possibility frontier, Positive and normative economics; concepts of opportunity cost, Demand and Supply: determinants of individual demand/supply; demand/ supply schedule and demand/ supply curve; market versus individual demand/ supply; shifts in the demand/ supply curve

Unit 2: Consumer Choice

Cardinal Utility Approach – Ordinal Utility Approach -Budget sets and Preferences under different situations – Hicks and Slutsky income and substitution effects. Applications of Indifference curve approach – Revealed Preference Hypothesis – Consumer surplus – Derivation of Demand curve – Elasticity of demand – Demand and supply together; how prices allocate resources; controls on prices – price floor and price ceiling – applications in agriculture.

Unit 3: Production and Cost

Production functions: single variable - average and marginal product, variable proportions, stages of production. Two variables - isoquants, returns to scale and to a factor; factor prices; Technical progress; cost minimization and output maximization; Elasticity of substitution. Expansion path and the cost function. Concept of economic cost; Short run and long run cost curves; increasing and decreasing cost industries; envelope curve; L-shaped cost curves; economies of scale; revenue and expenditure, elasticity and marginal revenue; Firm equilibrium and profit.

Unit 4: Market Forms

Behaviour of profit maximizing firms and the production process- Perfect competition: Equilibrium of the market. Long run industry supply, applications: effects of taxes and subsidies; Monopoly: Equilibrium; supply; multiplant firm; monopoly power; deadweight loss; price discrimination; Monopolistic Competition: Product differentiation; equilibrium of the firm in the industry-with entry of new firms and with price competition. Comparison with pure competition. Duoploy: Cournot model and reaction curves; Stackelberg's model, Bertrand model; Oligopoly.

Unit 2: Factor Markets

Labour and land markets - basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product); demand for labour; input demand curves; shifts in input demand curves; competitive labour markets; Economic rent and quasi rent.

Practical: Related to the Course

Suggested Reading

- Koutsoyiannis A. *Modern Micro Economics.* Macmillan Press Ltd
- Ferguson and Gould. *Micro Economic Theory.* Richard D Erwin Inc., USA
- Richard A. Bilas, *Micro Economic Theory.*
- Leftwich Richard H. *The Price System and Resources Allocation*
- Allen CL. *A Frame Work of Price Theory.*

2. Course Title: Macro Economics and Policy

Course Code: AEC-1802
Credit Hrs 2 (1+1)

Theory

Unit 1: Introduction: Measurement and Concepts

Basic concepts and scope of Macro-economics, National Income Accounting: Methods of measurement of key macro-economic aggregates, relationship of national income and other aggregates (with numerical exercises), real and nominal income

Unit 2: Theories of macroeconomics

Say's Law, Quantity Theory of Money, aggregate labour supply and demand of labour, Classical theory of determining output, wages and prices. Income And Spending: Keynesian Framework. Simple Keynesian model of income determination; Keynesian Multiplier- aggregate spending, taxation, transfer payments, foreign spending, balanced budget; budget surplus (with numerical exercises).

Unit 3: Money, Interest and Income

Goods market equilibrium-IS curve; Demand for Money, the Liquidity Preference Theory – Liquidity Trap; asset market equilibrium- LM curve; simultaneous equilibrium in goods and asset market- effect of fiscal and monetary policy

Unit 4: Theories of Aggregarte Consumption and Investment

Absolute Income Hypothesis, Relative Income Hypothesis, Fisher's Inter-temporal Choice Model, Life-Cycle and Permanent Income Hypotheses; Profits and Accelerator Theory.

Unit 5: Inflation and Unemployment

Inflation: Nature, Effects and control; Types of inflation – demand pull, cost push-stagflation, core inflation, hyperinflation; Phillips curve.

Practical: Related to the Course

Suggested Reading

- Stonier & Hegue. *A Text Book of Economic Theory*
- Samuelson PA. 1948. *Foundation of Economic Analysis*. Harvard University Press
- MC Vaish Allid. 1983. *Macro–Economics Theory*
- Gardner Ackley. 1961. *Macro–Economics Theory*: Macmillan, New York.
- TF Dernburg & DM Mcdougali-*Macro Economics*
- G. Sirkin – *Introduction to Macro–Economics Theory*
- RL Heibroker-*Understanding Macro–Economics*

3. Course Title: Agricultural Production Economics

Course Code: AEC-1803

Credit Hrs 2 (1+1)

Theory

Unit 1: Concepts of production economics

Nature, scope and significance of agricultural production economics- Agricultural Production processes, character and dimensions-spatial, temporal - Centrality of production functions, assumptions of production functions, commonly used forms - Properties, limitations, specification, estimation and interpretation of commonly used production functions.

Unit 2: Factors and theory of production

Factors of production, classification, interdependence, and factor substitution - Determination of optimal levels of production and factor application -Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination.

Unit 3: Concepts of cost

Cost functions and cost curves, components, and cost minimization -Duality theory – cost and production functions and its applications -Derivation of firm's input demand and output supply functions -Economies and diseconomies of scale.

Unit 4: Dynamics of economic assessment

Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis-concepts-types and measurement - Nature and sources of risk, modeling and coping strategies.

PRACTICAL

- Different forms of production functions
- Specification, estimation and interpretation of production functions
- Returns to scale, factor shares, elasticity of production
- Physical optima-economic optima
- Least cost combination
- Optimal product choice
- Cost function estimation, interpretation
- Estimation of yield gap
- Incorporation of technology in production functions
- Measuring returns to scale-risk analysis.

Suggested Reading

- EO Heady. *Economics of Agricultural Production and resources use.*
- John P Doll and Frank Orazem. *Production Economics: Theory with application*
- Heady EO & Dillon JL. 1961. *Agricultural Production functions.* Kalyani Publishers, Ludhiana, India. 667 p.
- Baumol WG. 1973. *Economic theory and operations analysis*. Practice Hall of India Private, Limited, New Dehli.626 p.

4. Course Title: Agricultural Marketing and Price Analysis

Course Code: AEC 1804

Credit hrs 3 (2+1)

Theory

Unit 1: Introduction to agricultural marketing

New Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production – Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis - Vertical and Horizontal integration - Integration over space, time and form-Vertical co-ordination.

Unit 2: Aspects of agricultural marketing

Different Forms of marketing: Co-operatives Marketing – APMC Regulated Marketing - Direct marketing, Farmer Producer Companies, e-NAM and marketing under e-NAM, e-marketing Contract farming and Retailing, Organized retailing - Supply Chain Management - State trading, Warehousing and other Government agencies -Performance and Strategies -Market infrastructure needs, performance and Government role - Value Chain Finance.

Unit 3: Future marketing and government

Introduction to Commodities markets and future trading - Basics of commodity futures - Operation Mechanism of Commodity markets – Price discovery - Hedging and Basis - Fundamental analysis - Technical Analysis – Role of Government/SEBI in promoting commodity trading and regulatory measures.

Unit 4: Use of Information Technology & Dynamics of price

Role of Information Technology and Market Intelligence in marketing of agricultural commodities, -electronic auctions (e-bay), e-Chaupals, Agmarknet and Domestic and Export market Intelligence Cell (DEMIC). Price forecasting – time series analysis – time series models – spectral analysis. Price policy and economic development – non-price instruments.

Practical

- Supply and demand elasticities in relation to problems in agricultural marketing.
- Price spread and marketing efficiency analysis.
- Marketing structure analysis through concentration ratios.
- Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products.
- Supply Chain Analysis - quantitative estimation of supply chain efficiency.
- Market Intelligence – Characters, Accessibility, and Availability Price forecasting.
- Online searches for market information sources and interpretation of market intelligence reports – commodity outlook.
- Technical Analysis for important agricultural commodities.
- Fundamental Analysis for important agricultural commodities.
- Presentation of the survey results and wrap-up discussion.

Suggested Reading

- Acharya SS & Agarawal NL. 2004. *Agricultural Marketing in India*. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
- Acharya SS & Agarawal NL. 1994. *Agricultural Prices-Analysis and Policy*. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
- Richard H Kohls and Joseph N. Uhl: *Marketing of Agricultural products* by Collier MacMillan, International.

5. Course Title: Agricultural Development and Policy Analysis

Course Code: AEC-1805

Credit Hrs. 2 (1+1)

Theory

Unit 1: Introduction

Role of agriculture in economic/ rural development – Evolution of thinking on agriculture and development; Agricultural development – meaning, stages and determinants – Population and food supply – need for sound agricultural policies

Unit 2: Theories of Agricultural Development

Resource exploitation model- Conservation model- Location (Urban impact) model- Diffusion model- High pay-off input model-Induced Innovation Model- Agricultural R&D and Linkages.

Unit 3: Performance of Indian Agriculture

Agrarian structure and land relations; trends in performance and productivity; agrarian structure and technology; credit, commerce and technology; capital formation; subsidies; pricing and procurement; Post Green Revolution agriculture; Production and productivity crisis in agriculture; Regional differences; Food Security, PDS system and Malnutrition.

Unit 4: Agricultural Policy: Process and Implementation

Instruments of Agricultural Policy; Process of agricultural policy formulation, implementation, Monitoring and Evaluation in India; Global experiences in participatory approach to Agricultural policy process; critical review of various elements of Indian agricultural policy-resource policies – credit policies – input and product marketing policies – price policies; WTO – Agreement on Agriculture; Planning models. Planning for utilization of resources and Indian Five Year Plans.

Practical: Related to the Course

Suggested Reading

- Albert O. Hirschman 1958. *Strategy of Economic Development.* New Man Yale University
- Simon Kuznets 1965. *Economic Growth and Structures.* Oxford New Delhi.
- Das Gupta AK. 1965. *Planning and Economic Growth.* George Allen and Unwin London
- Robert E. Baldwin 1966. *Economic Development and Growth*. John Willey, New York

6. Course Title: Econometrics

Course Code: AEC- 1806

Credit Hrs 3 (2+1)

Theory

Unit 1: Introduction

Relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics-regression analysis.

Unit 2: Classical Linear Regression

Basic two variable regression – assumptions estimation and interpretation approaches to estimation – OLS and their properties – extensions to multi-variable models-multiple regression estimation and interpretation.

Unit 3: Breaking down of Classical assumptions

Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification.

Unit 4: Qualitative variables and simultaneous equation models

Use of dummy variables- Introduction to simultaneous equations- identification problem

Practical

- Single equation two variable model specification and estimation
- Hypothesis testing transformations of functional forms and OLS application
- Estimation of multiple regression model
- Testing and correcting specification errors
- Testing and managing Multicollinearity
- Estimation of regressions with dummy variables

Suggested Reading

Dorfman R. 1996. *Linear Programming and Economic Analysis*. McGraw Hill.

Greene WH. 2002. *Econometric Analysis*. Pearson Education.

Johnston J and Dinardo J. 2000. *Econometric Methods*. Mc Graw-Hill.

Koutseyianis, A. 1997. *Theory of Econometrics*. Barner & Noble.

Maddala GS. 2002. *Econometrics*. Mc Graw-Hill.

Pinndyck RS and Rubinfeld DL. 1990. *Econometric Models and Econometric Forecasts*. McGraw Hill.

7. Course Title: Agricultural Finance and Project Management

Course Code: AEC-1807

Credit Hrs 3 (2+1)

Theory

Unit 1: Introduction to Agricultural Finance

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit

Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's.

Unit 2: Credit and Financial Analysis

Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening. Financial Decisions – Investment, Financing, Liquidity and Solvency. Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/ firm.

Unit 3: Project and Risk Management

Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures. Time value of money – Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Net work Techniques – PERT and CPM. Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes - yield loss and weather based insurance and their applications.

Practical

- Development of Rural Institutional Lending;
- Branch expansion, demand and supply of institutional agricultural credit and Over dues and Loan waiving;
- An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme;
- Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions;
- Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements;
- Performance of Micro Financing Institutions;
- NGO's and Self-Help Groups, Identification and formulation of investment projects;
- Project appraisal techniques – Undiscounted Measures and their limitations;
- Project appraisal techniques – Discounted Measures;
- Network techniques – PERT and CPM for project management;
- Case Study Analysis of an Agricultural project;
- Financial Risk and risk management strategies – crop insurance schemes;
- Financial instruments and methods – E banking, Kisan Cards and core banking.

Suggested Reading

- E Die Sollem H and Heady EO. (Ed.). *Capital and Credit Needs in Changing Agriculture*, Bauman.
- Hopkins A Barry, Peter Jo and Baker CB. *Financial Management in Agriculture.*
- Murray WG and Nelson AG. 1960. *Agricultural Finance*. Iowa State University

- Chanona C. 1969. *Agricultural Finance in India: Role of Commercial Banks*. Marketing and Economics Research Bureau, New Delhi.
- Gittinger JP. 1972. *Economic analysis of agricultural projects*, John Hopkins Univ. Press, Baltimore.
- Little IMD and JA Mirrless. 1974, *Project appraisal and planning for developing countries,* Oxford and IBH publishing Co. New Delhi.
- Arnold CH. 1972. *Project Evaluation, collected papers,* Macmillan.

8. Course Title: Commodity Future Trading

Course Code: AEC-1808
Credit Hrs 2 (1+1)

THEORY

Unit 1: Concepts of commodity future trading

History and Evolution of commodity markets – Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets. Speculatory mechanism in commodity futures.

Unit 2: Technical aspects

Transaction and settlement – delivery mechanism - role of different agents - trading strategies -potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets.

Unit 3: Risk and its Management

Risk in commodity trading, importance and need for risk management measures - managing market price risk: hedging, speculation, arbitrage, swaps - pricing and their features.

Unit 4: Commodity Exchange – A review

Important global and Indian commodity exchanges - contracts traded – special features - Regulation of Indian commodity exchanges - FMC and its role.

Unit 5: Analysis of commodity market

Fundamental Vs Technical analysis – construction and interpretation of charts and chart patterns for analyzing the market trend – Market indicators – back testing. Introduction to technical analysis software – analyzing trading pattern of different commodity groups.

Practical: Related to the Course

Suggested Reading

• Kaufman PJ. The Concise Handbook of Futures Markets: Jhon Wiley & Sons • Purcell WD. Agricultural Futures and Options: Principles and Strategies: MacMillan Publications

• Wasendorf RR & McCaffery All About Commodities from the Inside Out. McGraw Hill

9. Course Title: Natural Resource and Environmental Economics

Course Code: AEC- 1809
Credit Hrs 3 (2+1)

Theory

Unit 1: Basic Foundation

Concepts, Classification and Problems of Natural Resource Economics – Economy Environment interaction – The Material Balance principle, Entropy law-Resources Scarcity - Limits to Growth - Measuring and mitigating natural resource scarcity – Malthusian and Recardian scarcity – scarcity indices - Resource Scarcity and Technical Change.

Unit 2: Theories and economics of natural resources

Theory of optimal extraction renewable resources –economic models of oil extraction-efficiency - time path of prices and extraction - Hotelling's rule, Solow-Harwick's Rule. Theory of optimal extractio resources– economic models of forestry and fishery.

Unit 3: Environmental Issues and regulation

Environmental perspectives - biocentrism, sustainability, anthropocentrism - Environmental problems and quality of environment - Sources and types of pollution -air, water, solid waste, land degradation – environmental and economic impacts - Economics of pollution control - efficient reduction in environmental pollution. Environmental regulation – economic instruments - pollution charges – Pigovian tax - tradable permits – indirect instruments – environmental legislations in India.

Unit 4: Sustainability aspects

Concept of sustainable development – Economic Perspective – Indicators of sustainability Relation between development and environment stress-Environmental Kuznet's curve Environmental Accounting – resource accounting methods – International Environmental Issues – climate change – likely impacts – mitigation efforts and international treaties.

Practical

- Exhaustible resource management – optimum rate of oil extraction.
- Renewable resource management – optimum harvest of Forestry/fishery.
- Exercise on pollution abatement-I.
- Exercise on pollution abatement-II.
- Concepts in valuing the environment.
- Taxonomy of valuation techniques.
- Productivity change method – substitute cost method – Hedonic price method –Travel cost method – Contingent valuation methods.
- Discount rate in natural resource management.
- Environment impact assessment
- Visit to Pollution Control Board.

Suggested Reading

- Pearce DW and Turner RK. *Economics of Natural Resource and Environment*
- Kwak J. *Economism: Bad Economics and the Rise of Inequality*

10. Course Title: Mathematics for Agricultural Economics

Course Code: SUP-4001

Credit Hrs 3 (2+1)

Theory

Unit 1: Preliminaries

Logic and proof techniques; sets and set operations; relations; functions and their properties; number systems

Unit 2: Variables and functions

Specific functions is economic theory. Elementary analytical geometry-gradient and equation of straight line. Standard equations and simple properties of circle, parabola and rectangular hyperbola.

Unit 3: Differentiation of functions

Limit and continuity. Differentiation, theorems of differentiation, differentiation of logarithmic and exponential functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives to determine average and marginal values in economic analysis; determination of elasticities; points of inflexion; linear homogenous production functions; derivation of average and marginal curves.

Unit 4: Linear Algebra

Determinants, evaluation and properties of determinants, Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Solution of linear and quadratic equations involving one variable, simultaneous equations, application of determinants and matrices in solution of equation for economic analysis.

Unit 5: Optimization of functions

Optimization- unconstrained, maxima and minima, constrained optimization, Lagrange multiplier and their economic applications for optimization problems of cost, production, demand and supply.

Unit 6: Integration of functions

Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral, use of integration to determine relation between average and marginal value. Capitalization over time, estimation of returns from capital goods over time. Pareto distribution.

Practical: Related to the Course

11. Course Title: Linear Programming
Course Code: AEC-1810
Credit Hrs 3 (2+1)

Theory

Unit I: Decision Making

Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

Unit II: Simplex Method

Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and non farm problems as linear programming models and solutions.

Unit III

Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

Unit IV: Game Theory

Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game asprogramming.

Practical

- Graphical and algebraic formulation of linear programming models.
- Solving of maximization and minimization problems by simplex method.
- Formulation of the simplex matrices for typical farm situations.

12. Course Title: Research Methodology for Social Sciences
Course Code AEC-1811
Credit Hrs 3 (2+1)

Theory

Unit 1: Concepts of research methodology

Importance and scope of research in agricultural economics. Types of research – Fundamental vs. Applied. Concept of researchable problem – research prioritization – selection of research problem. Approach to research – research process.

Unit 2: Hypothesis: Framing & Testing and Sampling

Hypothesis – meaning – characteristics – types of hypothesis – review of literature setting of Course Objective and hypotheses – testing of hypothesis.

Unit 2: Sampling

Sampling theory and sampling design – sampling error - methods of sampling – probability and non-probability sampling methods - criteria to choose. Project proposals – contents and scope – different types of projects to meet different needs trade-off between scope and cost of the study. Research design and techniques. Types of research design.

Unit 3: Data Collection and Data Analysis

Data collection – assessment of data needs – sources of data collection – discussion of different situations. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule – problems in measurement of variables in agriculture. Interviewing techniques and field problems - methods of conducting survey – Reconnaissance survey and Pre testing.

Data coding, tabulation, cleaning. –Multivariate analysis –factor analysis' PCA' cluster analysis. Universal procedures for preparation of bibliography – writing of research articles.

Practical

- Exercises in problem identification.
- Project proposals – contents and scope.
- Formulation of Objective and hypotheses.
- Assessment of data needs – sources of data – methods of collection of data.
- Methods of sampling – criteria to choose – discussion on sampling under different situations.
- Scaling Techniques – measurement of scales.
- Preparation of interview schedule.
- Field testing. Method of conducting survey.
- Exercise on coding, editing, tabulation and validation of data.
- Preparing for data entry into computer.
- Hypothesis testing – Parametric and Non-Parametric Tests.
- Exercises on format for Thesis/ Report writing.
- Presentation of the results.

Suggested Reading

- Baker CB. *Research Methodology in Agricultural Economics*
- Cohen MR and Nagel R. *An Introduction to Logic and Scientific Method*
- Devey J Logic. *The Theory of Enquiry*
- Dhondhyal SP. *Social Science Research and Thesis Writing*
- Ezekiel M. *Correlation Analysis*
- Heady EO. *Linear Programming Methods*
- Willson ER. *An Introduction to Scientific Research*
- Kumar A. 2008. *Research Methodology: A Survey.* Alts, New Delhi,

13. Course Title: International Economics

Course Code: AEC-1812
Credit Hrs 3 (2+1)

Theory

Unit 1: Concepts of International Economics

Scope and Significance of International Economics – The role of trade- General Equilibrium in a Closed Economy (Autarky Equilibrium) – Equilibrium in a Simple Open Economy - Possibility of World Trade - Trade gains and Trade Equilibrium.

Unit 2: Models, Rate and Terms of Trade

Barriers to trade: Tariff, Producer Subsidy, EXport Subsidy, Import Quota and EXport Voluntary Restraints- The Case of Small Country and Large Country Case.

Models of trade: Ricardian Model of Trade- Specific Factors Model- Heckscher - Ohlin Model - Trade Creation and Trade Diversion – Offer Curve - Export Supply Elasticity and Import Demand Elasticity – Comparative Advantage and Absolute Advantage.

Rates and Terms of trade: Official Exchange Rate and Shadow Exchange Rate - Walra's Law and Terms of Trade – Trade Blocks.

Unit 3: Trades Institutions

IMF, World Bank, IDA, IFC, ADB – International Trade agreements – Uruguay Round – GATT – WTO.

Practical

- Producer's Surplus, Consumer's Surplus, National Welfare under Autarky and Free Trade Equilibrium with small and large country assumption.
- Estimation of Trade Gains
- Estimation of competitive and comparative measures like NPC, EPC, ERP and DRC
- Estimation of Offer Curve Elasticity
- Estimation of Effect of Tariff, EXport Subsidy, Producer Subsidy, Import Quotaand EXport Voluntary Restraints on National Welfare
- Estimation of Ricardian Model
- Estimation of Effect of Trade under Specific Factor Model
- Estimation of trade Equilibrium under Heckscher -Ohlin model
- Trade Creation and Diversion.

Suggested Reading

- Kindelberger and Joshi PK. 2016. *International Economics* AITBS Delhi-110051
- Brouwer F. *International Trade and Food Security*. LEI - Wageningen UR, The Netherlands.

14. Course Title: Development Economics Credit

Course Code: AEC-1813
Credit Hrs 2 (1+1)

Theory

Unit 1: Conceptions of Development

Development Economics – Scope and Importance - Economic development and economic growth - divergence in concept and approach - Indicators and Measurement of Economic Development –GNP as a measure of economic growth – New Measures of Welfare – NEW and MEW – PQLI – HDI – Green GNP - Criteria for under development – Obstacles to economic development –Economic and Non-Economic

factors of economic growth- Development issues, poverty, inequality, unemployment and environmental degradation.

Unit 2: Theories of Economic growth and development

Classical theories- Adam smith - Ricardo- Malthus, Marx's theory of economic development; Schumpeter's theory, Approaches to development- low income equilibrium trap - critical minimum effort- The Strategy of economic development- Balanced vs. Unbalanced growth, choice of technique, investment criteria, big push theory, Rostow's stages of Economic Growth, unlimited supply of labour; social and technological dualisms; roles of capital accumulation, human capital and technological change in economic development, Models of economic growth Harrod-Domar, Kaldor, Mahalanobis, Lewis, FeiRanis, Input-Output, multisectoral models.

Comparative Economic Development: Countries selected for case studies -USA, Japan, China and India; Overview of economic development is selected countries; agrarian surplus and the role of the peasantry in economic development; industrial revolution; division of labour, organisation of work and industrial production, the role of the State in developmental transition.

Practical: Related to the Course

Suggested Reading

- Blaug M. 1986. *Economic History and the History of Economic Thought*
- Chenery HB and TN Srinivasan. *Handbook of Development Economics*
- Baldwin RE. *Economic Development and Growth*. John Willey, New York

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Agricultural Extension

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1.Introductory Agricultural Extension		EXT-1901	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2. Extension Landscape-I		EXT -1902	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3.Extension Landscape-II		EXT -1903	*3(2+1)*	*100 (20 M + 30 P + 50 T)*
	4. Managing Extension Organizations		EXT-1904	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5.Development Economics credit (Minor I)		AEC- 1813	*2 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST-3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Intellectual Property and its Management in Agriculture**		*COM-5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM-5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1.Capacity Development-I		EXT-1905	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2.ICTs for Agricultural Extension and Advisory Services		EXT-1906	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3.Organisational Behaviour and Development		EXT-1907	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4. Applied Behaviour Change		EXT-1908	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	5. Entrepreneurial Dimensions (As Minor II)		EXT-1909	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs		*AST-3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM-5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM-5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	1. Research Methodology in Extension		EXT-1910	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2. Evaluation and Impact Assessment		EXT-1911	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3. Capacity Development- II		EXT-1912	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4. Enabling Innovation (Minor-3)		EXT-1913	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	*6: Agricultural Research, Research Ethics and Rural Development Programs**		*COM 5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	1: Seminar		EXT-1914	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	EXT -1915	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	EXT-1916	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Contents of M.Sc. (Ag) in Agricultural Extension Education

1. EXT-1901	1.Introductory Agricultural Extension	Semester-1st	3(2+1)

Unit-I

Education: Meaning, definitions & Types; Extension Education- meaning, definitions, scope process; objectives and principles; Agricultural Extension, Extension efforts-Program of pre-independence era and post-independence era; Various extension/ agriculture development programmes launched by ICAR/ Govt. of India (IADP, IAAP, HYVP, KVK, IVLP, ORP, ND,NATP, NAIP, etc.).

Unit-II

Extension teaching methods: meaning, classification, individual, group and mass contact methods, media mix strategies; communication: meaning and definition; models and barriers to communication,Concept relating to communication. diffusion and adoption of innovation: concept and meaning, process and stages of adoption, adopter categories. Agricultural journalism-history,efforts of ICAR,News-concept,forms,types;News story,feature story;Art of Interviewing;Ethical issues in Journalism.

Unit-III

Rural Development: concept, meaning, definition; principles,importance and problems.various rural development programmes launched by Govt. of India. Community Development Program-meaning, definition, concept,objective,philosophy & principles, Rural Leadership: concept and definition, types of leaders in rural context; Panchayti Raj Institutions in India.

Practical:

1. Preparation and use of AV aids including extension literature – leaflet, booklet, folder, pamphlet, news stories and success stories.
2. A visit to village to understand the problems being encountered by the villagers/ farmers;
3. To visit to NGO and learning from their experience in rural development;
4. To study the organization and functioning of DRDA and other development departments at district level.

Suggested Books:

Sagar Mondal (2021) Fundamentals of Agricultural Extension,Kalyani Publication,New Delhi.

Sarju Narain,RK Kushwaha and Sagar Mondal (2021) Fundamentals of Agricultural Extension (Hindi),Kalyani Publication,New Delhi.

2. EXT-1902	2.Extension Landscape-I Semester-1st	2(1+1)

Unit 1: Pluralism in Extension and Advisory Services (EAS)

Pluralism in Extension Delivery: Role of private sector (input firms, agri-business companies, consultant firms and individual consultants)- Trends in the development of private extension and advisory services in India and other countries; challenges faced by private extension providers; Role of Non-Governmental Organizations (National/international)/ Civil Society Organizations (CSOs) in providing extension-Experiences from India and other countries; Producer Organizations- Role in strengthening demand and supply of extension services; their strength and weaknesses-experiences from different sectors; Role of Media and ICT advisory service providers; global experiences with use of media and ICTs in advisory services provision.

Unit 1: From the Linear Paradigm to Systems Paradigm

Diffusion of Innovations paradigm- strengths and limitations; multiple sources of innovation-farmer innovation, institutional innovation; farmer participation in technology generation and promotion; strength and limitations; Agricultural Knowledge and Information Systems (AKIS); strength and limitations; Agricultural Innovation Systems (AIS); Redefining Innovation- Role of Extension and Advisory Services in AIS-From information delivery to intermediation across multiple nodes; Role of brokering; Innovation Platforms, Innovation Management; Strength and weaknesses of AIS. Rethinking Communication in the Innovation Process – Network building, support social learning, dealing with dynamics of power and conflict.

Unit 3: Evolving Extension Approaches

Evolution and features of extension approaches: Transfer of technology approach; educational approach, farmer participatory extension approach, demand-driven extension, market led extension (value chain extension), extension for climate smart agriculture, gender sensitive extension, extension for entrepreneurship, Extension systems in different regions: Asia-Pacific, Europe, Latin America, Australia, North America Networking for Strengthening EAS: GFRAS (Global Forum for Rural Advisory Services) and its regional networks.

Practical:

1. To identify the Pluralism in EAS at ground level.

2.To know the Ground reality of Agro-advisory services.

3. To study the various Transfer of technology approach.

4. To know the various Extension system in different regions.

Suggested Readings: As in Extension Landscape-II course.

3. EXT-1903	3.Extension Landscape-II Semester-1st	3(2+1)

Block 1: Globally, What Is New In Extension?

Unit 1: Challenges before Extension and Advisory Services (EAS)

Extension and Advisory Services (EAS)- Meaning (embracing pluralism and new functions) New Challenges before farmers and extension professionals: Natural Resource Management-Supporting farmers to manage the declining/deteriorating water and soil for farming; Gender Mainstreaming- How extension can enhance access to new knowledge among women farmers; Nutrition- Role of extension in supporting communities with growing nutritious crop and eating healthy food; Linking farmers to markets- Value chain extension including organizing farmers, strengthen value chain and supporting farmers to respond to new standards and regulations in agri-food systems; Adaptation to climate changes-How extension can contribute to up-scaling Climate Smart Agriculture; Supporting family farms-strengthening the capacities of family farms; Migration-Advising farmers to better respond to opportunities that emerge from increasing mobility and also supporting migrants in enhancing their knowledge and skills; Attracting and Retaining Youth in Agriculture including promotion of agripreneurship and agri-tourism; Urban and peri-urban farming- How to support and address issues associated with urban and peri-urban agriculture; Farmer distress, suicides- Supporting farmers in tackling farm distress.

Unit 2: New Functions and New Capacities

Beyond transfer of technology: Performing new functions to deal with new challenges; Organising producers into groups-dealing with problems that need collective decision making such as Natural Resource Management (NRM) and access to markets; Mediating conflicts and building consensus to strengthen collective decision making; Facilitating access to credit, inputs and services-including development of service providers;

New Capacities needed by extension and advisory services at different levels –at the individual (lower, middle management and senior management levels), organizational and enabling environment levels; –Core competencies at the individual level; Varied mechanisms for capacity development (beyond training).

Block 2: Extension Reforms and Policy Challenges

Unit 1: Changes in Governance, Funding and Delivery

Reduction in public funding: public withdrawal from extension provision (partial/ full); Examples/Cases; Privatization: Public funding and private delivery; cost sharing and cost recovery; Examples/Cases; Decentralisation of extension services; Examples/ Cases; Lessons from extension reforms in different countries; Extension and Sustainable Development Goals (SDGs).

Unit 2: Challenges in Managing Pluralistic Extension Systems

Pluralism: Managing pluralism and Co-ordination of pluralistic extension provision; Public private partnerships in extension (including the role of local governments/ panchayats and producer organisations); Examples, challenges in co-ordination; Achieving convergence in extension planning and delivery, Financing Extension: Mobilising resources for extension: public investments, donor support (grants/loans); Monitoring and Evaluation of Extension: Generating appropriate data for Assessment and Evaluation of pluralistic extension; Strengthening extension policy interface; generating evidence on impact of extension and policy relevant communication.

Practical:

1. To study the Challenges before Extension and Advisory Services (EAS).
2. To study the New Functions and New Capacities of Extension system
3. To study the Extension Reforms and Policy Challenges in India and at global level.
4. To study the Funding and Delivery mechanism for extension services.

Suggested Readings:

Ashok G, Sharma P, Anisha S and Prerna T. 2018. *Agriculture Extension System in India Review of Current Status, Trends and the Way Forward.* Indian Council for Research on International Economic Relations (ICRIER). http://icrier.org/pdf/Agriculture-Extension-System-in-India-2018.pdf

FAO.2017. *Climate-Smart Agriculture Sourcebook.* Available at: http://www.fao.org/3/a-i3325e.pdf

Saravanan R and Suchiradipta B. 2015. *mExtension – Mobile Phones for Agricultural Advisory Services.* Note 17. Gfras good practice note for extension and advisory services. GFRAS: Lindau, Switzerland.

Sulaiman RV and Davis K. 2012. *The New Extensionist: Roles, strategies, and capacities to strengthen extension and advisory services.* In Lindau, Switzerland: Global Forum for Rural Advisory Services. http://www.g-fras.org/en/157-thenew-extensionist

Swanson BE. 2008. *Global Review of Good Agricultural Extension and Advisory Service Practices.* Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/ pdf/011/i0261e/i0261e00.pdf

Websites

- **AESA**- Agricultural Extension in South Asia http://www.aesanetwork.org/
- **FAO**- Food and Agricultural Organisation (Research and Extension) http://www.fao.org/ research-and-extension/en/
- **GFRAS**- Global Forum for Rural Advisory Services http://www.g-fras.org/en/
- **INGENEAS**- Integrating Gender and Nutrition within Agricultural Extension Services https://ingenaes.illinois.edu/
- **IFPRI**- International Food Policy Research Institute (Extension) http://www.ifpri.org/topic/ agricultural-extension

EXT-1904	4. **Managing Extension Organizations** Semester-1st	3(2+1)

Block 1: Basics of Management

Unit 1: Management- An Over view

Management and Extension management – Meaning, concept, nature and importance;and theories of management. Management, administration and supervision -meaning, definition and scope; Approaches to management, Principles, functions and levels of management; Qualities and skills of a manager.

Block 2: Management in different types of Extension Organizations

Unit 1: Extension Management in public, private sector and other sectors

Extension management (POSDCORB) in public sector, Department of Agriculture, Agricultural Technology Management Agency (ATMA), Krishi Vigyan Kendra (KVK), SAUs, ICAR Institutes, Private sector, Cooperatives, NGOs, FPOs etc. Organisational Structure, Relations between different units- Challenges in management

Unit 2: Concepts in Management

Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions; Human Resource Management: Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development; Dealing with fund and staff shortages in different extension organizations (KVK, ATMA etc.); Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles; Authority and responsibility, Delegation and decentralization, line and staff relations; Challenges of co-ordination in extension organizations; Managing interdepartmental coordination and convergence between KVK, ATMA and line departments; Coordinating pluralism in extension services; Challenges in managing public-private partnerships (PPPs) at different levels in agricultural development in general and extension in particular.

Block 3: Motivation and Organizational Communication

Unit 1: Motivation and Communication

Managing work motivation – Concept, Motivation and Performance, Approaches to motivation, team building; Organizational Communication – Concept, Process, Types, Networks, Barriers to Communication; Mentoring, Time management, Team work and team-building strategies.

Unit 2: Supervision and Control

Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision; Managerial Control – Nature, Process, Types, Techniques of Control, Observation, PERT and CPM, Management Information Systems (MIS): Concept, tools and techniques, MIS in extension organizations.

Practicals

- Study the structure and function of agro-enterprises, Designing organizational

structure/ organograms.

- Group activity on leadership development skills
- Field visit to extension organizations (ATARI, KVKs, NGOs), FPOs, dairy cooperatives to understand the functions of management
- Group exercise on development of short term and long term plans for agro-enterprises
- Developing model agriculture-based projects including feasibility study, financial planning and cost-benefit analysis.

Suggested Reading

Chand S. 2017. *Modern Management Theory: Quantitative, System and Contingency Approachesto Management.* http://www.yourarticlelibrary.com/management/modern-management-theory-quantitative-system-and-contingency-approaches-to-management/25621

https://www.idosi.org/aejaes/jaes5(3)/3.pdf

http://www.g-fras.org/fr/component/phocadownload/category/70-new-extensionist-learning-kit-nelk.html?download=564:nelk-module-3-agricultural-extension-programme-management-textbook

Gupta CB. 2001. *Management Theory and Practice*. Sultan Chand &Sons. New Delhi Hoffmann V, Gerster BM, Christnick A, Lemma M. 2009. *Rural Extension Volume 1- Chapter7***.** MargrafPublishesrs, Kanalstr.

HRM 2013. *Current Trends in Human Resource Management* https://corehr.wordpress.com/ 2013/08/21/current-trends-in-human-resource-management/

MANAGE. 2008. *Project Management in Agricultural Extension*, AEM-203, Post Graduate Diploma in Agricultural Extension Management (PGDAEM), National Institute of Agricultural Extension Management, Hyderabad http://www.manage.gov.in/pgdaem/ studymaterial/aem203.pdf

Van den Ban AW and Hawkins HS. 1998. *Agricultural extension- Chapter 10*, BSL, CBS Publishers and Distributors.

	II[nd] Semester		18
EXT-1905	1.Capacity Development- I	Semester-2[nd]	2(1+1)

Block 1: Introduction to Capacity Development

Unit 1: Capacity Development–An Overview

Training, capacity building, capacity development and HRD-Meaning and differences; Need and principles of capacity development; Types of capacity building - Based on structure (structured, semi-structured &unstructured), Based on context (orientation, induction and refresher), and other categories (online, Webinar, distance etc.). Components of capacity development; Capacity development cycle.

Unit 2: Planning and Organization of Capacity Development Programmes

Steps in Designing and Planning of Capacity Development- Step 1. Select the participants, Step 2. Determine the participants' needs, Step 3. Formulate goal and objectives, Step 4. Outline the content, Step 5. Develop instructional activities, Step 6. Prepare the design, Step 7. Prepare evaluation form, Step 8. Determine follow-up activities; Organising capacity development programme; Operational arrangements at different stages- Before the programme, During the programme, Middle of the programme, At the end of the programme, After the programme, Follow up; Stakeholders' responsibilities.

Block 2: Capacity Development Needs Assessment

Unit 1: Planning and Organization of Capacity Development Programmes Concept of Need Assessment; Approaches in Need Analysis- Performance Analysis, Task Analysis, Competency Study; Needs Survey.

Unit 2: Capacity Development Needs Assessment Methods

Data Collection Methods in Identifying Needs - Rational Methods (Observation, Informal talks, Complaints, Comparison, Analysis of report, Opinion poll, Buzz session, Analysis of the new programme), Empirical Methods (Job analysis, Performance evaluation, Checklist or Questionnaire Method, Tests, Critical Incident Technique, Card Sort Method, Focus Group Discussion, Interview, SWOT Analysis); Information and Skills required in Need Analysis; Identification of Needs through Task Analysis - Task identification, Task Analysis, Gap Analysis.

Block 3: Capacity Development Institutions and Management

Capacity Developer (Trainer): Meaning and concept; Types of Capacity Developers (regular, *ad-hoc*, part time, guest and consultants); Roles of Capacity Developer (explainer, clarifier, supporter, confronter, role model, linker, motivator, translator/ interpreter, change agent); Good Capacity Developer – Qualities, skills and roles Qualities, Skills (Intrapersonal & Inter personal), Roles (Manager, Strategist, Task Analyst, Media Specialist, Instructional Writer, Marketer, Facilitator, Instructor, Counsellor, Transfer Agent, Evaluator); Capacity Development Centres and Locations; Organisation's Role in Capacity Development.

Practicals

- Capacity development needs assessment exercise
- Planning organizing and conducting an extension capacity development programme
- Designing a programme
- Developing objectives into curriculum
- Training plan
- Organizing capacity development workshop

Suggested Reading

ADB. 2009. *Training Needs Assessment and Strategic Training Plan.*

FAO .2013. *Capacity Development: Learning Module 4*. Organization Analysis and Development Food and Agriculture Organisation of the United Nations

Mittal N, Sulaiman RV and Prasad R M. 2016. *Assessing Capacity Needs of Extension and Advisory Services a Guide for Facilitators*. Agricultural Extension in South Asia. http://

www.aesanetwork.org/assessing-capacity-needs-of-extension-and-advisory-services-a-guide-for-facilitators/

Mishra DC. 1990. *New Directions in Extension Training*. Directorate of Extension, Ministry of Agriculture, Govt. of India, New Delhi.

Swanson BE and Rajalahti R. 2010. *Strengthening Agricultural Extension and Advisory Services* A Guide for Facilitators.

Websites

TAP–Tropical Agriculture Platform for Capacity Development– https://www.tapipedia.org/
FAO–FAO Capacity Development– http://www.fao.org/capacity-development/en/
GFRAS–Global Forum for Rural Advisory Services– http://www.g-fras.org/en/
AESA–Agricultural Extension

EXT-1906	2. ICTs for Agricultural Extension and Advisory Services Semester-2nd	3(2+1)

Block 1: Introduction to Information and Communication Technologies (ICTs) and E-extension

Unit 1: ICTs- Concepts, Status and Knowledge Management

ICTs- meaning, concepts, basics of ICTs, global and national status, types and functions of ICTs, innovations, meaning of e-Governance, e-learning, mLearning, advantages and limitations of ICTs. Knowledge management-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.

Unit 2: e-Extension initiatives in Agriculture and allied sectors

e-Extension, overview on Global and national e-extension initiatives, Inventory of e-Extension initiatives in Agriculture and allied sectors from Central and State governments, ICAR, SAUs, private sector and NGO initiatives in India.

Block 2: Application of ICTs in Extension and Advisory Services

Unit 1: ICT Applications and Expert Systems

Knowledge centres (tele centres), digital kiosks, websites and web portals, community radio, farmers call centres, mobile phone based advisory services and mobile applications (mExtension, mLearning), Self-learning CDs on Package of practices, social media, digital videos, Market Intelligence and Information Systems- ICT enabled Supply-Chains and Value-Chains/ e-Marketing (e-NAM, Agmarknet, *etc*.). Expert System/ Decision Support System/ Management Information Systems,

Unit 2: ICT Networks

Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCS, Course CCRA, EduEx, *etc*), e-Governance Systems; digital networks among extension personnel, Farmer Producers Organisations (FPOs)/ SHGs/ Farmers Groups.

Unit 2: Social Media Applications to engage audience

Video conference, live streaming and webinars, types and functions of social media applications, guidelines for preparing social media content, engaging audience and data-analytics.

Block 3: Smart and Disruptive Technologies for Agricultural Extension

Open technology computing facilities, System for data analytics/ mining/ modelling/ Development of Agricultural simulations; Remote Sensing, GIS, GPS, Information Utility (AIU); disruptive technologies- Analysis; Internet of Things (IoTs), Drones, Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.

Practicals

- Designing extension content for ICTs
- Creating and designing web portals, blogs, social media pages
- Developing digital videos
- Live streaming extension programmes and organising webinars
- Working with Farmers call centres

Suggested Reading

Sagar Mondal (2021) Fundamentals of Agricultural Extension,Kalyani Publication,New Delhi.

Sarju Narain,RK Kushwaha and Sagar Mondal (2021) Fundamentals of Agricultural Extension (Hindi),Kalyani Publication,New Delhi.

FAO 2011. *E-learning methodologies a guide for designing and developing e-learning courses.*Food and Agriculture Organization of the United Natihttp://www.fao.org/docrep/015/i2516e/i26e.pdf

Saravanan R and Suchiradipta B. 2016. *Social media policy guidelines for agricultural extension and advisory services,* GFRAS interest group on ICT4RAS, GFRAS: Lindau, Switzerland.

SaravananR. 2010. (Ed.) *ICTs for Agricultural Extension: Global Experiments, Innovations and Experiences,* New India Publishing Agency (NIPA), New Delhi. http://www.saravananraj.net/wp-content/uploads/2014/12/32_India_ICTs-for-Agricultural-Extension_Saravanan.pdf

Saravanan R, Suchiradipta B, Chowdhury A, Hambly OH and Hall K. 2015. *Social Media for Rural Advisory Services.* Note 15. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.

Saravanan R, Suchiradipta B, Meera SN, Kathiresan C and Anandaraja N. 2015. *Web Portals for Agricultural Extension and Advisory Services.* Note 16. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.

Saravanan R.2014. (Ed.). *Mobile Phones for Agricultural Extension: Worldwide mAgri Innovations and Promise for Future,* New India Publishing Agency, New Delhi.

Websites

FAO–Food and Agricultural Organisation (Research and Extension) http://www.fao.org/research-and-extension/en/

CTA–The Technical Centre for Agricultural and Rural Cooperation: Digitalization– https://www.cta.int/en/channel/digitalisation-sid05951b8c7-e611-4f34-9ae6-8c0fc0c822bc

GFRAS–Global Forum for Rural Advisory Services–http://www.g-fras.org/en/

AESA–Agricultural Extension in South Asia–http://www.aesanetwork.org/

EXT-1907	3.Organisational Behaviour and Development	Semester-2nd	3(2+1)

Block 1: Organizational Behavior

Unit1: Basics of Organization

Introduction to organizations-concept and characteristics of organizations; Typology of organizations.Concepts of Organisational Behaviour, Scope, Importance, Models of OB.

Unit 2: Individual Behaviour in Organizations

Introduction, Self-awareness, Perception and Attribution, Learning, Systems approach to studying organization needs and motives – attitude, values and ethical behavior, Personality, **Motivation**-Concept & Theories, Managing motivation in organizations.

Unit 3: Group Behaviour in Organization

Foundations of group, group behaviour and group dynamics, Group Development and Cohesiveness, Group Performance and Decision Making, Intergroup Relations; Teams in Organizations-Team building experiential exercises, Interpersonal Communication and Group; Leadership: Meaning, types, Theories and Perspectives on Effective Leadership, Power and Influence, managing Conflict and Negotiation skills, Job/ stress management, decision-making, problem-solving techniques.

Unit 4: Productive Behaviour and Occupational Stress

Productive behaviour - Meaning, dimension; Job analysis and Job performance – meaning, determinants and measurement; Job satisfaction and organizational

commitment - meaning, dimensions and measures roles and role clarity; Occupational stress – meaning, sources, effects, coping mechanism, effects and management; Occupational stress in farming, farmer groups/ organizations, research and extension organizations.

Unit 5: Organizational System

Organizations Structure- Need and Types, Line & staff, functional, committee, project structure organizations, centralization &decentralization, Organization and Environment, Power and Conflicts in Organizations, Organizational Decision-Making; Organizational Culture vs Climate; Organizational Change; Organizational Learning and Transformation.

Block 2: Organisational Development

Unit 1: Overview of Organizational Development and Managing Process

Concept of OD, Importance and Characteristics, Objectives of OD, History and Evolution of OD, Implications of OD Values. Basic Component of OD Program-Diagnosis-contracting and diagnosing the problem, Diagnostic models, Management- entering OD relationship, contracting, diagnosis, feedback, planned change, intervention, evaluation.

Unit 2: Organizational Development Interventions and Practitioner or Consultant

Meaning, Importance, Characteristics of Organization development Interventions, , Team Interventions, Structural Interventions, Comprehensive Interventions. Who is OD consultant? Types of OD consultants and their advantages, Organizational Development process by the practitioners skills and activities.

Practicals

- Simulation exercises on problem-solving – study of organizational climate in different organizations.
- Study of organizational structure of development departments, study of departmentalization, span of control, delegation of authority, decision-making patterns.
- Study of individual and group behaviour at work in an organization.

Suggested Reading

Pradip NK. 1992. *Organizational Designs for Excellence*. Tata McGraw Hill, New Delhi. Shukla, Madhukar. 1996. *Understanding Organizations*. Prentice Hall of India, New Delhi. Stephens PR and Timothy AJ. 2006. *Organizational Behaviour*, 12th Edition. Prentice Hall Pub.

EXT-1908	4.Applied Behaviour Change	Semester-2nd	2(1+1)

Block 1: Foundations of Behaviour Change

Unit 1: Foundations of Human Behaviour

Human behaviour – Meaning, importance and factors influencing human behaviour; Biological bases of human behaviour – Nervous system, brain, endocrine system and genes; Individual variations – intelligence, ability and creativity– foundations

and theories, personality and temperament - foundations, approaches, theories of personality, measuring personality (traits, locus of control, self-efficacy; Personal, social and moral development – meaning, concepts – self-concept, self-esteem and self-worth and theories. Motivation – foundations, approaches, theories, managing human needs and motivations; perceiving others – impression, attitude, opinions; Emotions - foundations, types and functions, measuring emotional intelligence.

Block 2: Cognitive Processes And Learning

Unit 1: Cognitive Processes affecting Human Behaviour

Sensory organs and their role cognition; Cognitive processes – Attention, perception, remembering and forgetting, knowledge and expertise – foundations and theories; Principles and processes of perception; Consciousness – meaning, types, sleep and dreams; Learning and Memory – Memory - meaning, types and mechanisms of storage and retrieval of memories in the Human brain; Complex cognitive processes- Concept formation, Thinking, Problem solving and transfer – foundations, theories and approaches.

Unit 2: Learning

Learning – foundations, approaches and theories; Cognitive approaches of learning – meaning, principles theories and models; Memory – foundations, types; Behavioural approaches of learning – foundations and theories - classical conditioning, operant conditioning, applied behaviour analysis; Social cognitive and constructivist approaches to learning – foundations and theories – social cognitive theory, Self-regulated learning; learning styles – meaning, types and applications in learning.

Block 3: Human Behaviour in the Society

Unit 1: Attitudes and Influence

Attitudes - meaning, assumptions, types, theories and models of attitude formation; methods of changing attitudes, Relating to others - liking, attraction, helping behaviour, prejudice, discrimination and aggression; Liking/ affect – meaning, types and theories; Attraction – meaning, types and theories; Persuasion – meaning, theories and techniques; Social influence and groups – conformity, compliance and obedience.

Unit 2: Social Judgement, Social Identity and Inter-Group Relations

Social judgement – meaning, frame of reference, stereotyping; The judgement of attitude models; Attribution – meaning, theories; Rational decision making; Social identify – meaning, types; assessment; Groups – meaning, types, group processes; sustainability of groups; Inter group processes and theories social learning.

Practicals

- Hands-on experience in the techniques for assessing creative thinking – divergent and convergent thinking
- Lab exercise in applying Maslow's need hierarchy to assess motivation
- Learning - Classical conditioning and operant conditioning
- Exercises in problem solving

- Experiment on factors influencing information processing
- Hands on experience in methods of persuasion
- Simulation exercise to understand decision-making under different situations

Suggested Reading

Eiser J, Richard. 2011. *Social Psychology: Attitudes, Cognition and Social Behaviour*. Cambridge: Cambridge University Press.(First Edition, 1986))

Eysenck MW and Keane M T. 2010. *Cognitive psychology: A student's handbook.* Sixth Edition, Hove: Psychology Press.

Feldman RS. 2008. *Essentials of understanding psychology* (7th ed.). Boston: McGraw-Hill. Gilovich T, Keltner D, and Nisbett RE. 2011. *Social psychology*. New York: W.W. Norton & Co. Moreno R. 2010. *Educational Psychology*. Hoboken, NJ: John Wiley & Sons Inc.

EXT-1909	5.Enterpreneurial Dimensions (Minor II) Semester-2nd	3(2+1)

Unit-I

Entrepreneurship-definition, theories, factors, characteristics, functions, types, models,Scope, phases of entrepreneurial venture, Entrepreneureship development process and stages, Entrepreneureship development program (EDP)-objective and types. Rural entrepreneurship, Agripreneureship, Women entrepreneurship.

Unit-II

Economic reforms and Agribussines, Government institutions for entrepreneurship development-NSTEDB, EDII, WCED, MANAGE, NIESBUD, SIDO,etc. Government policies and program for entrepreneurship development; SEZ, Food Park, Government financing for entrepreneurship development,Venture,Start-up.

Unit-III

Contract Farming: Contract Farming-definition,history, areas, models, advantages, limitations. Public Private Partnership**:** definition, rational, benefits, phases, examples, corporate social responsibility.Processing industries in Agriculture and allied sector**:** Essential conditions for processing industry,An overview of processing industry;post harvest value addition,food industry,Indian dairy industry,fish processing,food processing,Mga food park,farm machinery industry.

Practical:

1. Assessing entrepreneurial Potential@Skills@Characteristicsfor successful entrepreneur.
2. To practice relating to Creativity
3. SWOT analysis for preparation of business plan.
4. Project formulation/preparation of business plan for establishment of a agro based industry

Suggested Reading

1.Sagar Mondal (2021).Enterpreneurship development and Business Communication,Kalyani Publication,New Delhi

2. Sarju Narain and Sagar Mondal (2021).Enterpreneurship development and Business Communication (Hindi), Kalyani Publication, New Delhi

	III[rd] Semester	12
EXT-1910	1.Research Methodology in Extension Semester-3[rd]	3(2+1)

Block 1: Introduction To Behavioural Research

Unit 1: Nature of Behavioural Research

Methods of knowing; Science and scientific method; Behavioural research – Concept, aim, goals and objectives; Characteristic; Types of behavioural research based on applications, objectives and inquiry; prior research studies, reviews and academic debate; Role of behavioural research in extension; Careers in behavioural research.

Unit 2: The Behavioural Research Process

Basic steps in behavioural research – Formulating a Research Problem; Reviewing the Literature; Identifying the variables and hypotheses; Formulating research designs, methods and tools; Selecting sample; Collecting data; Analyzing and Interpreting the Data; Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals.

Block 2: Steps in Behavioural Research Process

Unit 1: Formulating a Research Problem

The research problem and research topic - definitions; Importance of formulating a research problem; Sources of research problems; Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research problem; Research questions – Types, Criteria for selecting research questions, techniques for narrowing a problem into a research question; Objectives - Meaning, types and criteria for judging the objectives.

Unit 2: Reviewing the Literature

Review-meaning and importance; Types of literature; Literature review for quantitative and qualitative studies; Steps in conducting literature review – Identify key terms, locate literature, critical evaluation and selection; organising literature and writing literature review.

Unit 3: Identifying Variables and Hypotheses

Developing theoretical, conceptual, empirical frameworks; Approaches for identifying concepts, constructs and variables; Role of theory in behavioural research; Steps in identifying variables – Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypotheses; Techniques of identifying concepts, constructs and variables - Types of concepts; Types of variables–causal relationship, the study design; and the unit of measurement; Types of definitions-Types of propositions and hypotheses. Characteristics of good hypotheses; Measurement – Meaning, levels of measurement – nominal, ordinal, interval and ratio; Criteria for choosing measurement levels for variables.

Unit 4: Formulating Research Designs, Methods and Tools

Research designs – Definition, purpose and functions; Research Design as Variance Control - MAXMINCON Principle; Classification of research designs: Quantitative designs - experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis; Qualitative designs - ethnographic, grounded theory, Mixed method designs – Action research design; Triangulation - Importance in behavioural research, Research methods: Designing research Instruments – questionnaires, interview schedules; tests – knowledge tests, behaviour performance tests; scales-scales and indexes, checklists, focus groups; Steps in developing and using research methods and tools; participatory rural appraisal.

Unit 5: Selecting Sample

Sampling - population, element, sample, sampling unit, and subject; Sampling strategies for quantitative and qualitative research; Principles of sampling; Factors affecting the inferences drawn from a sample; Types of sampling, Methods of drawing a random sample, Types of sampling- Probability Sampling - Simple random sampling, Cluster sampling, Systematic sampling, Stratified random sampling and Unequal probability Sampling; Non-probability Sampling - Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling; Sample size requirements for quantitative and qualitative studies.

Unit 6: Collecting Data

The process of collecting data – Selection, training, supervision, and evaluation of field investigators; Online data collection; Errors and biases during data collection. Testing goodness of measures through item analysis - Reliability and validity; Factors affecting the validity and reliability of research instruments, Strategies for enhancing validity and reliability of measures. Validity and reliability in qualitative research.

Unit 7: Analyzing and Interpreting the Data

Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; Quantitative data analysis - parametric and non-parametric statistical analyses; Parametric analysis – Descriptive and inferential statistics, Hypothesis testing - Type I and Type II errors. Concepts in hypothesis testing - Effect Size,Multivariate data analysis – regression, factor analysis, cluster analysis, logistic regression and structural equation modelling. Guidelines for choosing appropriate statistical analysis; Statistical packages for data analysis; Methods of interpreting data and drawing inferences -The Ladder of Inference; Methods of communicating and displaying analysed data.

Unit 8: Reporting and Evaluating Research

Writing reports and research publications; Evaluation Methodology

Practicals

- Selecting a research problem and writing problem statement
- Choosing right sampling method and estimating sample size

- Developing research methods and tools – questionnaires, interview schedule, check lists and focus group guides
- Field data collection using research methods and tools
- Testing reliability and validity of research instruments
- Hands on experience in using SPSS for coding, data exploration, editing, analysis and interpretation Formulation of secondary tables based on objectives of research
- Writing report, writing of thesis and research articles
- Presentation of reports

Suggested Reading

Kerlinger FN and Lee HB. 2000. *Foundations of Behavioral Research*. Orlando, FL: Harcourt College Publishers.

Kumar R. 2014. *Research Methodology: A Step- by- Step Guide for Beginners*. Fourth. Edition.Thousand Oaks, California: Sage Publications.

Sivakumar PS and Sulaiman RV. 2015. *Extension Research in India-Current Status and Future Strategies*. AESA Working Paper 2. Agricultural Extension in South Asia.http:// www.aesanetwork.org/aesa-working-paper-2-on-extension-research-in-india-current- status-and-future-strategies-p-sethurman-sivakumar-and-rasheed-sulaiman-v-december-2015/

EXT-1911	2. Evaluation and Impact Assessment	Semester-3rd	3(2+1)

Theory

Block 1: Programme Evaluation

Unit 1: Introduction to Evaluation

Concept of Evaluation: Meaning and concept in different contexts; Why Evaluation is Done and When? Programme planning, accountability, impact assessment, criteria and approaches of programme evaluation, evaluation principles; Role and Credibility of Evaluator.

Unit 2: Evaluation Theories

Evaluation theory vs. practice – synergistic role between practice and theory in evaluation; Evaluation theories - Three broad categories of theories that evaluators use in their works - programme theory, social science theory, and evaluation theory (other theories/ approaches - Utilization-Focused Evaluation & Utilization-Focused Evaluation (U-FE) Checklist, Values Engaged Evaluation, Empowerment Evaluation, Theory-Driven Evaluation).

Block 2: Evaluation Process

Unit 1: How to Conduct Evaluation

Ten Steps in programme evaluation: (1) Identify and describe programme you want to evaluate (2) Identify the phase of the programme(design, start-up, ongoing, wrap-up, follow-up) and type of evaluation study needed (needs assessment, baseline,

formative, summative, follow-up) (3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches to data collection (quantitative, qualitative, mixed) (6) Select data collection techniques (survey interviews and questionnaires with different types) (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques

(8) Collect, analyse and interpret data (qualitative and quantitative evaluation data analysis) (9) Communicate findings (reporting plan, evaluation report types, reporting results, reporting tips, reporting negative findings (10) Apply and use findings (programme continuation/ discontinuation, improve on-going programme, plan future programmes and inform programme stakeholders).

Block 3: Programme Management Techniques and Evaluation Tools

Unit 1: SWOT Analysis and Bar Charts

SWOT Analysis – Concept, origin and evolution; SWOT As a Programme Management Tool; Advantages and Disadvantages of SWOT; Bar Charts (Gantt Charts and Milestone Charts) - Characteristics, advantages and limitations.

Unit 2: Networks

Networks – Introduction, Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages. Critical Path, Critical Activity.

Unit 3: Bennett's Hierarchy of Evaluation

Introduction to Bennett's hierarchy – Background and description; Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy – Inputs, activities, participation, reactions, KASA changes, practice and behaviour changes, end results. Advantages and Disadvantages of Bennett's hierarchy

Block 4: Impact Assessment

Unit 1: Introduction to Impact Assessment

Concept of Impact Assessment: Meaning, concept and purpose in different contexts; Impact Assessment Framework: Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment.

Unit 2: Impact Assessment Indicators

Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and extension advisory services.

Unit 3: Approaches for Impact Assessment

Impact assessment approaches – Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages; Quantitative Impact Assessment Types – Based on Time of Assessment (Ex-ante and ex-post), Qualitative and Participatory Impact Assessment Methods.

Practicals

- Visit Directorate of Extension in your university and enquire about extension programmes being implemented / coordinated by Directorate. Develop an evaluation

proposal of any one programme using 'Ten Steps in Programme Evaluation' discussed in the theory class.

- Identify at least four agriculture development programmes and their objectives being implemented in your state. Write two attributes each on Strengths, Weaknesses, Opportunities and Threats related to the identified programme objectives in the SWOT grid.
- Identify an on-going development programme and make-out 6 activities from the programme.
- Visit a nearby KVKs / ATIC. Select any agriculture technology with package of practices and extension advisory services promoted by KVK / ATIC. Identify impact assessment indicators for social and behavioral indicators, socio-cultural indicators,technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.

Suggested Reading

GFRAS. 2012. *Guide to evaluating rural extension.* Lindau, Switzerland: Global Forum for Rural Advisory Services (GFRAS).

Hall A, Sulaiman VR, Clark N and Yoganand B. 2003. *From measuring impact to learning*

institutional lessons: An innovation systems perspective on improving the management of international agricultural research. Agricultural Systems, 78(2): 213–241.

Karthikeyan, C., Vijayaraghavan, K. and Lavanya, P. 2007. *Formative evaluation of Kisan Call Centres.* Tamil Nadu. Indian Journal of Extension Education, 43(1 &2): 20-25 (For LFA Example).

Sasidhar, P.V.K. and Suvedi, M. 2015. *Integrated contract broiler farming: An evaluation case study in India.* Urbana, IL: USAID-MEAS. www.meas.illinois.edu (For Bennett's Hierarchy Example).

Shadish, W. R. Jr., Cook, T. D., and Leviton, L. C. 1991. *Chapter 2: Good theory for social program evaluation. Foundations of Program Evaluation: Theories of Practice* (pp. 36-67). Newbury Park, CA: Sage.

Srinath, L.S. 1975. *PERT and CPM Principles and Applications,* East-West Press, New Delhi. Suvedi M, Heinze K and Ruonavaara D. 1999. *How to Conduct Evaluation of Extension Programs.* ANRECS Center for Evaluative Studies, Dept of ANR Education and Communication

Websites

Better Evaluation– www.betterevaluation.org

TAP– Tropical Agriculture Platform: Monitoring and Evaluation - www.tapipedia.org GFRAS– Global Forum for Rural Advisory Services http://www.g-fras.org/en/

AESA– Agricultural Extension in South Asia http://www.aesanetwork.org/ USAID– United States Agency for International Development: Evaluation

https://www.usaid.gov/evaluation https://education.illinois.edu/faculty/jennifer-greene

EXT-1912	3.Capacity Development- II	Semester-3rd	3(2+1)

Unit 1: Capacity Development Methods and Tools

Capacity Development Methods –Lecture, Discussion, Syndicate, Seminars, Conference, Symposium, Role Play, Case study, Programmed Instruction, T - group/ Laboratory methods; Factors Determining Selection of Methods - Capacity development objectives, subject matter, categories of participants, and the available resources like time, location, budget; Capacity Development Aids.

Unit 2: Capacity Development Project Formulation

Project Proposal: Concept and Meaning; Steps in Project Formulation- Review of past proposals, Consulting experts, consultants, and previous organizers, Review past project evaluation reports, Interact with the prospective beneficiaries; Format for Writing Project Proposal (LFA).

Unit 3: Evaluation

Capacity Development Programme Evaluation - Meaning & Importance; Purpose of Evaluation; Principles of Evaluation; Types of Evaluation – Formative, Summative, Process of Evaluation- Evaluation at the beginning, Evaluation during the programme, Evaluation at the end; Use of evaluation findings; Statistical Tools for evaluation.

Unit 4: Impact Assessment

Impact Assessment- Meaning, Need, Features, Benefits, Concepts; Indicators for Impact Assessment - Direct indicators, Indirect or proxy indicators, Quantitative indicators, Qualitative indicators, Methods of Impact Evaluation- Learning retention of participants (KOSA), Impact on the job performance, Impact on organizational effectiveness.

Unit 5: Human Resource Development

HRD: Meaning, Importance and Benefits; Types of HRD Systems & Sub-systems Career system (Manpower planning, Recruitment, Career planning, Succession planning, Retention), Development system (Induction, Training, Job enrichment, Self-learning mechanisms, Potential appraisal, Succession development, Counselling, Mentor system), Self-renewal system (Survey, Action research, Organisational development interventions), Culture system (Vision, mission and goals, Values, Communication, Get together and celebrations, Task force, Small groups); Components of HRD System - Performance Appraisal, Potential Appraisal, Task System, Development System, Socialisation System, Governance; Functions of HRD-Organisational Development, Career Development, Capacity Development.

Practicals

- Capacity development project formulation exercise
- Evaluation with pre- and post-training tests
- Training methods – Practicing each method mentioned in contents as group exercise

Suggested Reading –Books as in Capacity Development-I

EXT-1913	4.Enabling Innovation (Minor-3) Semester-3rd	2(1+1)

Block 1: Agricultural Innovation Systems

Unit 1: Agricultural Innovation Systems: Concepts and Elements

Innovation concept -Innovation vs Invention; Agricultural Innovation System (AIS) - ToT, FSR, AKIS and AIS compared, Key insights from AIS: Role of Communication in Innovation Process; Role of Extension in AIS.

Unit 2: Enabling Innovation

Role of enabling environment: Policies and institutions in enabling innovation; Role of Government-Innovation Policy: Achieving coordination and policy coherence; Innovation Platforms; Assessing Extension and Advisory Services within AIS; Capacity Development in AIS.

Block 2: Scaling Up Knowledge for Innovation

Scaling Up: Definitions; Changing views on scaling up: Approaches to Scaling Up: Push, pull, plant, probe: Scaling up pathways: Drivers and spaces for scaling up; Framework and Tools for Scaling up: Planning and implementing a scaling up pathways; Role of policies in scaling up: Influencing policies for scaling up; Innovation Management for scaling up knowledge and implications for Extension and Advisory Services.

Practical

- Identify one crop/commodity sector and use AIS framework to diagnose actors and their roles, patterns of interaction, institutions determining interaction and the enabling policy environment and develop a AIS Diagnosis Report (Review and Key informant interviews)
- Undertake a case study on a successful case of scaling up knowledge and identify factors that contributed to its success
- Identify one specific knowledge (a technology, an approach) that has been recently introduced and develop an Up scaling Strategy

I. Suggested Reading

Hall A, Sulaiman RV, Beshah T, Madzudzo E. and R Puskur. 2009. *Agricultural innovation system capacity development: Tools, principles or policies?* Capacity.org (37): 16-17 http://www.capacity.org/en/journal/practice_reports/tools_principles_or_policies

Saravanan R and Suchiradipta B. 2017. *Agricultural Innovation Systems: Fostering Convergence for Extension.* Bulletin 2, Extension Next. MANAGE. http://www.manage.gov.in/publications/extnnext/June2017.pdf

Sulaiman R V, Chuluunbaatar D and Vishnu S. 2018. *Up scaling Climate Smart Agriculture Lessons for Extension and Advisory Services.* Food and Agriculture Organization of the United Nations.

Sulaiman RV 2015. *Agricultural Innovation Systems.* Note 13. GFRAS Good Practice Notes for

Websites

AESA- Agricultural Extension in South Asia– http://www.aesanetwork.org/

FAO- Food and Agricultural Organisation (Research and Extension)– http://www.fao.org/research-and-extension/en/

GFRAS- Global Forum for Rural Advisory Services– http://www.g-fras.org/en/

KIT- Royal Tropical Institute (KIT)-Sustainable Economic Development– https://www.kit.nl/sed/

TAPipedia - Tropical Agriculture Platform– https://www.tapipedia.org/ **WUR**- Wageningen University and Research Research [Knowledge, Technology and Innovation Group (KTI)]–https://www.wur.nl/en/Research-Results/Chair-groups/Social-Sciences/ KnowledgeTechnology-and-Innovation-Group.htm

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Seed Science & Technology

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1: Seed Developmental Biology		SST-2001	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Seed Dormancy and Germination		SST -2002	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3: Seed Legislation and Certification		SST -2003	*2 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Seed Production Principles and Techniques in Field Crops		SST-2004	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5: Breeding Vegetable Crops		GPB-1404	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST 3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Intellectual Property and its Management in Agriculture**		*COM 5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM 5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1: Seed Quality Testing and Enhancement		SST-2005	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2: Seed Industry and Marketing Management		SST-2006	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops		SST-2007	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Post Harvest Handling and Storage of Seeds		SST-2008	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	5: Hybrid Breeding		GPB-1406	*3 (2+1)*	
	6: Experimental Designs		*AST 3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM 5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications Skills**		*COM 5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	1: Seed Production Techniques in Forage, Pasture and Green Manure Crops		SST-2009	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Seed Production Principles and Techniques in Vegetable Crops		SST-2010	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Seed Health Testing and Management		SST-2011	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Seed Technology of Tree Species (as Minor)		SST-2012	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	*6: Agricultural Research, Research Ethics and Rural Development Programs**		*COM 5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	1: Seminar		SST-2013	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	SST -2014	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	SST-2015	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

M.Sc. (Ag) in Seed Science and Technology (SST)

SEMESTER I

1. Course Title : Seed Developmental Biology

Course Code : SST- 2001

Credit Hours : 3 (2+1)

Theory

Unit I

Floral biology – types of pollination, mechanisms; sporogenesis – micro and mega sporogenesis; gametogenesis – development of male and female gametes and their structures; pollination and fertilization – mode of pollination, double fertilization, factors affecting pollination, fertilization; self-incompatibility and male sterility.

Unit II

Embryogenesis – development of monocot and dicot embryos – embryo plane formation – development of endosperm, cotyledons and seed coat – hard seed; apomixis – identification, classification, significance and its utilization; polyembryony – types and significance; haplontic and diplontic sterility system, causes of embryo abortion, embryo rescue technique; somatic embryogenesis.

Unit III

Seed development – source of assimilates – mechanism of translocation; chemical composition – synthesis and deposition of storage reserves – starch, protein, fat and secondary metabolites – hormonal regulation.

Unit IV

Maturation drying – orthodox and recalcitrant seeds – desiccation tolerance – mechanism – structural changes during desiccation – role of LEA protein.

Unit V

Seed maturity indices – physiological and harvestable maturity; biotic and abiotic factors influencing seed development – development of hard seeds.

Practical

- Study on floral biology of monocot; • Study on floral biology of dicot plants.
- Study on pollen morphology of different crops;
- Pollen germination and viability test in major crops;
- Seed embryo and endosperm development in monocots;
- Seed embryo and cotyledon development in dicots;
- Anatomy and morphology of seed coat during development;
- Hard seed coat development;
- Study on external and internal structures;
- Seed development and maturation in agricultural crops – physical and physiological changes;
- Seed development and maturation in horticultural crops – physical and physiological changes;
- Study of biochemical changes during seed development and maturation in agricultural crops;
- Study of biochemical changes during seed development and maturation in horticultural crops;

Suggested Reading

Adkins SW, Ashmore SE and Navi SC. 2007. Seeds: Biology, Development and Ecology. CAB International, Oxfordshire, UK.

Bewley JD and Black M. 1994. Seeds: Physiology of Development and Germination. Springer, New York.

Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. Seeds: Physiology of Development, Germination and Dormancy. Springer, New York.

Black M, Bewley JD and Halmer P. 2006. The Encyclopedia of Seeds: Science, Technology and Uses. CAB International publications, UK.

Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Department of Plant Breeding, CCSHAU, Hisar.

Copeland, LO and McDonald MB. 2001. Principles of Seed Science and Technology. 4th Ed. Kluwer Academic publishers, USA.

Suggested e-books

https://www.springer.com/in/book/9783642810619
https://www.springer.com/in/book/9780792373223
https://www.springer.com/gp/book/9780792346456
https://www.cabi.org/bookshop/book/9780851997230

Suggested websites

sbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/
https://courses.lumenlearning.com/wm-biology2/chapter/development-seeds-fruit
www.iari.res.in/index.php?option=com_content&view=article&id=449& Itemid=137

2. Course Title : Seed Dormancy and Germination
Course Code : SST - 2002
Credit Hours : 2 (1+1)

Theory

Unit I

Seed dormancy – definition, concept and theories – significance – evolution; classification and mechanism of dormancy – ecological singnificance.

Unit II

Induction of dormancy during development – hormonal, physiological, molecular and genetic control of dormancy – maternal and paternal contribution; environmental factors influencing dormancy induction and release – seasonal influence – winter and summer annuals – secondary dormancy induction mechanism; artificial induction of dormancy and release; soil seed bank – natural release of dormancy and its mechanism; dormancy breaking – principles and methods.

Unit III

Seed germination – types and phases of germination; imbibition – pattern and water kinetics – events of germination – physical, physiological, biochemical changes -aerobic and anaerobic respiration quiescent.

Unit IV

Physiological and biochemical changes- Enzyme activation – mechanism – factors affecting enzyme activation – breakdown of stored materials – starch, protein and fat – energy generation – mobilization of storage reserves – changes in phenolic compounds.

Unit V

Molecular and genetic mechanisms- Molecular and genetic control of seed germination – auto tropism; factors affecting germination – media – temperature – light – gases; in-situ and viviparous germination – causes and mechanism – pattern of seed germination – tri-phasic curve.

Practical

- Seed dormancy – identification of dormancy;
- Estimation of ABA and GA in dormant and non-dormant seeds;
- Study on artificial induction of dormancy;
- Dormancy breaking methods – scarification and stratification;
- Dormancy breaking methods – hormonal and chemical treatments;
- Dormancy breaking methods – after ripening and leaching of inhibitors;
- Dormancy breaking methods – combined treatments;
- Assessing the period of natural release of seed dormancy;
- Seed germination – studying the pattern of imbibition;
- Studying the pattern of seed germination in different media;
- Study on influence of light and temperature on germination and seedling development;
- Estimation of hydrolytic enzyme – □ amylase in different species;
- Estimation of hydrolytic enzyme – protease;
- Estimation of hydrolytic enzyme – lipase;
- Estimation of dehydrogenase enzyme and respiratory quotient in seeds;
- Estimation of food reserve composition during seed germination.

Suggested Reading

Baskin C and Baskin JM. 2014. Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination. Academic Press, Cambridge, UK.

Bewley J and Black M. 1994. Physiology of Development and Germination. Springer, New York.

Bewley JD, Bradford KJ, Hilhorst HWM and Nanogaki H. 2013. Seeds: Physiology of Development, Germination and Dormancy. Springer, New York.

Bewley JD and Black M. 1982. Physiology and Biochemistry of Seeds in Relation to Germination. Volume 2: Viability, Dormancy and Environmental Control.Springerlink, New York, USA

Benech-Arnold R and Rodolfo S. 2004. Handbook of Seed Physiology: Applications to agriculture. CRC Press., Florida, USA.

Black M and Bewley JD. 2000. Seed Technology and its Biological Basis. CRC Press. Florida, USA.

Bradbeer JW. 1988. Seed Dormancy and Germination. Chapman and Hall, New York, USA.

David R. Murray. 1985. Seed Physiology. Volume 2: Germination and Reserve Mobilisation. Academic Press, London, UK.

Suggested e-books

https://www.springer.com/in/book/9780792373223
https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1756-1051.2000.tb01610.x
https://www.elsevier.com/books/seeds/baskin/978-0-12-416677-6

https://books.google.co.in/books/about/Physiology_and_Biochemistry_of_ Seeds_in.html?id= 91nsCAAAQBAJ&printsec=frontcover&source=kp_read_ button&redir_esc=y#v= onepage&q&f=false
https://books.google.co.in/books/about/The_Germination_of_Seeds.html? id=aV62AgAAQBAJ& printsec=frontcover&source=kp_ read_button&redir_ esc=y#v=onepage&q&f=false
https://books.google.co.in/books/about/Seed_Dormancy_and_Germination. html?id=18HeBw AAQBAJ&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=fa lse

Suggested websites

https://agriinfo.in/botany/18/
https:/sproutnet.com/seed-dormancy/
https://www.britannica.com/science/germination
http://www.biologyreference.com/Re-Se/Seed-Germination-and-Dormancy.html
https://www.intechopen.com/books/advances-in-seed-biology/seed-dormancy

3. Course Title: Seed Legislation and Certification
Course Code: SST- 2003
Credit Hours: 2 (1+1)

Theory

Unit I

Genesis of seed Industry in India; seed quality control – concept and objectives; regulatory mechanisms – Seed Act (1966) – Seed Rules (1968) – statutory bodies – Central Seed Committee – Central Seed Certification Board.

Unit II

Seed Control Order (1983) – New Policy on Seed Development (1988) – Exim Policy – National Seed Policy (2002) – Plant Quarantine Act.

Unit III

Introduction to WTO and IPR – UPOV and its role – OECD seed certification schemes – PPV & FR Act (2001) and Rules (2003) – Seed Bill (2004 and 2011): Seed certification system in SAARC countries, Europe, Canada, Australia and USA.

Unit IV

Seed certification – history and objectives; general and specific crop standards, field and seed standards; seed certification agency – role of certification agency/ department and seed certification officers, phases of seed certification; field inspection – counting procedures – liable for rejection (LFR) – downgrading and partial rejection – reporting.

Unit V

Post-harvest inspection – construction of seed lot number; seed sampling – testing – labeling, sealing and grant of certificate – types and specifications for tags and labels; seed lot validity and revalidation; appellate authority, stop sale order, penalties records and registers to be maintained by seed processing units and seed dealers – verification procedures, role of seed analyst and seed inspector in quality regulation.

Practical

- Preparation of sowing report – varieties – transplanted and direct sown crops and hybrids;
- Verification of sowing report – seed certification procedures;
- Field inspection – estimation of area and isolation distance, stages of inspection for varieties and hybrids – procedures;
- Practicing field counting procedures – methods for row planting, broadcasted – varieties;
- Practicing field counting procedures – direct sown and transplanted crops – varieties;
- Study on field counting procedures – hybrids – planting design, planting ratio and block method and double count;
- Identification of contaminants – genetic and physical contaminants, procedure to remove partials, pollen shedders and shedding tassels;
- Assessing and calculation of field standards for important crops;
- LFR, partial rejection and downgrading – reasons, procedures and preparation of reports;
- Yield estimation – single and multiple harvest crops;
- Post harvest inspection – groundnut, cotton, pulses;
- Inspection and maintenance (licence and renewal) of records in processing unit – float test, preparation of processing report and seed lot number construction;
- Visit to seed certification agency/ department;
- Visit to grow-out test field;
- Visit to seed retail shop – procedures followed by Seed Inspector, verification of records and reporting;
- Procedure to issue tag, specification, bagging, tagging, labelling and sealing.

Suggested Reading

Agarwal RL. 2012. Seed Technology. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.

Anon. 2016. Manual of Seed Certification Procedures. Directorate of Seed Certification, Coimbatore, Tamil Nadu.

Chakrabarthi SK. 2010. Seed Production and Quality Control. Kalyani Publishers, New Delhi.

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

Renugadevi J, Srimathi P, Renganayaki PR and Manonmani V. 2012. A Handbook of Seed Testing. Agrobios, Jodhpur, Rajasthan.

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Trivedi PC. 2011. Seed Technology and Quality Control. Pointer Publications, Jaipur, Rajasthan.

Tunwar NS and Singh SV. 2003. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, GOI, New Delhi.

Suggested e-books

http://cms.tn.gov.in/sites/default/files/documents/seed-certification-0.pdf

http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDIAN-MINIMUMSEED-
CERTIFICATION-STANDARDS.pdf
https://www.india.gov.in/my-government/documents/e-books
https://books.google.co.in/books/about/Principles_of_Seed_Certification_and_ Tes.html?id=SQWHAAAACAAJ&redir_esc=y
https://dl.sciencesocieties.org/publications/books/tocs/cssaspecialpubl/theroleofseedce

Suggested websites

www.fao.org
www.agri.nic.in
www.agricoop.nic.in
www.gov.mb.ca
http:/agritech.tnau.ac.in
www.betterseed.org
www.oecd.org/india/
http://www.tnagrisnet.tn.gov.in/
https://pir.sa.gov.au/_data/assets/pdf_file/0003/148134/SeedCertification Manual.pdf

4. Course Title : Seed Production Principles and Techniques in Field Crops

Course Code: SST- 2004

Credit Hours: 3 (2+1)

Theory

Unit I

Importance of seed – seed quality concept – factors influencing seed production; generation system of seed multiplication – classes of seed, stages of seed multiplication in varieties and hybrids – seed multiplication ratio (SMR) – seed replacement rate (SRR) – seed renewal period (SRP) – varietal replacement rate (VRR).

Unit II

Genetic and agronomic principles of variety and hybrid seed production; methods and techniques of seed production in varieties and hybrids of important cereals and millets – wheat, oat, rice, maize, sorghum and pearl millet; varietal seed production in small millets – finger millet, fox tail millet, little millet, kodo millet, proso millet and barnyard millet.

Unit III

Methods and techniques of varietal seed production in major pulses – black gram, green gram, cowpea, chickpea, horse gram, soybean and lentil – varietal and hybrid seed production in red gram.

Unit IV

Methods and techniques of seed production in major oil seed crops – groundnut, sesame – varietal and hybrid seed production in sunflower, castor and mustard; varietal seed production in minor oilseed crops (safflower, linseed, niger) – varietal and hybrid seed production in cotton – varietal seed production in jute.

Unit V

Seed production planning for varieties and hybrids of major crops; participatory seed production – seed hubs, seed village concept and community seed bank.

Practical

- Seed selection – quality of seed on field establishment;
- Sowing and nursery management techniques;
- Planting – age of seedling on crop establishment – rice and pearl millet;
- Isolation distance and border rows in hybrid seed production field – space and barrier isolation; modifying isolation based on border rows in maize;
- Planting design for hybrid seed production – rice, maize, pearl millet, cotton, red gram, sunflower;
- Practicing breeding tools for hybrid seed production – detasseling – emasculation and dusting;
- Study on methods of achieving synchronization – rice, bajra, sunflower;
- Practicing supplementary pollination – rice and sunflower;
- Study on foliar nutrition and influence on seed yield;
- Practicing roguing operation – identification of off-types, pollen shedders, shedding tassels, partials, selfed bolls;
- Pre and post harvest sanitation operations – cereals, millets and pulses;
- Estimation of shattering and shattering loss; study on insitu germination and loss;
- Visit to seed production fields;
- Visit to seed industry;
- Seed production planning and economics of seed production – varieties;
- Seed production planning and economics of seed production – hybrids.

Suggested Reading

Agrawal RL. 2019. Seed Technology. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.

Hebblethwaite PD. 1980. Seed Production. Butterworth Heinemann Ltd., London, UK.

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

Kulkarni GN. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi.

Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios, Jodhpur, Rajasthan.

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New Delhi.

Mondal SS, Saha M and Sengupta K. 2009. Seed Production of Field Crops. New India Publishing

Agency, New Delhi.

Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani Publications, New Delhi.Sen

S and Ghosh N. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Singhal NC. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Suggested e-books

https://www.springer.com/in/book/9780792373223

https://www.springer.com/in/book/9780412075513

https://www.nipabooks.com/info/9788190723763/seed-production-of-field-crops

https://www.amazon.in/Production-Field-Crops-Brajesh-Tiwari/dp/9380179405

https://www.cambridge.org/core/journals/journal-of-agricultural-science/article/seed-productionof-

agricultural-crops-by-kelly-a-f-227-pages-harlow-longman-1988-price-2500-hard-coversisbn-0-582-40410-x/8BE3C99DFDC0F02D48E CB53418504D10

Suggested websites

https://agriinfo.in/botany/18/

http://www.fao.org/3/a-e8935e.pdf

http://www.agriquest.info/seed_production.php

http://agritech.tnau.ac.in/seed_certification/seedtech_index.html

http://coin.fao.org/coinstatic/cms/media/16/13666518481740/seed_enterprises_

enhacement_and_development_project_in_sierra_leone_mission_1_report_.pdf

SEMESTER II

5. Course Title : Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops

Course Code : SST- 2005

Credit Hours : 2(1+1)

Theory

Unit I

Scope for seed production in fruits, flowers, spices, plantation and medicinal crops; factors influencing seed production and quality; propagation methods – seed and clonal propagation; seed and seedling standards; propagation and seed production techniques in major tropical, sub-tropical and temperate fruit crops; seed orchards – seed collection, extraction processing and storage techniques.

Unit II

Seed production techniques in commercially important flower crops – nursery management, clonal propagation, planting, seed crop management, post-harvest seed handling and storage techniques.

Unit III

Seed production techniques in commercially important seed spices and other spices – nursery management, sowing, seed crop management and post-harvest seed handling and storage techniques.

Unit IV

Seed production in commercially important plantation crops – mother tree selection – criteria – nursery management, elite seedling production, planting, plantation management, post-harvest handling and storage techniques.

Unit V

Methods of quality seed production in commercially important medicinal plants – nursery management, sowing, seed crop management, post-harvest handling and storage methods.

Practical

- Study on the floral biology and pollination mechanism;
- Identification of seeds of fruits, flowers, spices, plantation and medicinal crops;
- Selection of mother plants and trees – phenotypic characters and genotypic characters;
- Study on different types of clonal and vegetative propagules;
- Seed and clonal standards of vegetatively propagating crops;
- Germination improvement treatments for seeds and vegetative propagules;
- Study on selection of planting materials and sowing methods;
- Nursery management practices for elite seedling production;
- Seed extraction methods – wet method and dry method;
- Post harvest seed handling – seed grading, upgrading techniques
- Study of seed storage techniques;
- Practicing seed germination enhancement techniques in fruits, spices and plantation crops;
- Practicing seed germination enhancement techniques in flowers and medicinal crops;
- Planning for seed production – economics of seed production in flower crops;
- Visit to mother tree orchard;
- Visit to plantation and orchard.

Suggested Reading

Chadha KL. 1995. Advances in Horticulture. (Volume 1 to 13). Malhotra Publishing House, New Delhi.

Hartman HT and Kester DE. 2000. Plant Propagation: Principles and Practices. Prentice Hall, New Jersey, USA.

Singh SP. 2001. Seed Production of Commercial Vegetables. Agrotech, New Delhi.

Vanangamudi K and Natarajan K. 2008. Advances in Seed Science and Technology. Quality Seed Production in Spices, Plantation, Medicinal and Aromatic crops (Vol. 5). Agrobios. Jodhpur.

Vanangamudi KM Prabu and Lakshmi S. 2012. Advances in Seed Science and Technology Vol.

7. Flower Seed Production. Agrobios, Jodhpur.

Suggested e-books

http://www.worldseed.org/wpcontent/uploads/2017/01/Seed-Production-Good-practice-10.01.17-
final.pdf
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4233836/
https://www.academia.edu/35629702/Hybrid_Seed_Production_and_Flowers
http://www.agrimoon.com/horticulture-icar-ecourse-pdf-books/
https://cbp.icar.gov.in/EBook.aspx

Suggested websites

www.cimap.res.in/english/index.php
www.dmapr.org.in/amprs.kau.in/basic-page/publications
http://ecoursesonline.iasri.res.in/course/view.php?id=153
http://ecoursesonline.iasri.res.in/course/view.php?id=612
http://www.celkau.in/Crops/Plantation%20Crops/Rubber/production.aspx
http://sbc.ucdavis.edu/Courses/Seed_Production/

SEMESTER II

5. Course Title : Seed Quality Testing and Enhancement

Course Code : SST- 2005

Credit Hours : 2 (1+1)

Theory

Unit I

Seed testing – history and development; seed testing in India; ISTA and its role in seed testing; seed lot and size, types of seed and size, samples – sampling – intensity and methods, sampling devices, receipt and registration of submitted samples in the laboratory and sub sampling; purity analysis – components and procedure – determination of other distinguishable varieties (ODV) and test weight determination – application of heterogeneity test – method of testing coated and pelleted seeds; seed moisture estimation – principles and methods, application of tolerances.

Unit II

Seed germination test – requirements, media and methods – seedling evaluation, tolerance and reporting results; viability test (TZ test) – principle, procedure and evaluation; vigour tests – concept of seed vigour and vigour test – types of vigour tests – direct and indirect tests – physical, physiological and biochemical tests – principles and methods; seed health test – principles and methods.

Unit III

Genetic purity assessment – laboratory methods – physical, chemical, biochemical and molecular tests – growth chamber and field testing (Grow Out Test) methods; testing of GM seeds; storage of guard sample – referral test; application of tolerance in seed testing; advanced non destructive techniques of seed quality analysis – soft x-ray imaging – hyper spectral imaging, thermal imaging – spectroscopy – e-nose and machine vision techniques.

Unit IV

Seed quality enhancement techniques – history and development; classification – physical, physiological and protective seed treatments – special seed treatments; physical seed treatment – liquid floatation, specific gravity separation, irradiation, electric and electro-magnetic seed treatments – principles and methods – seed pelleting and coating principles, purpose and methods.

Unit V

Physiological seed enhancement treatments – seed infusion, seed priming – principles and methods – physiological, biochemical and molecular mechanisms; pre-germination and fluid drilling techniques; biological seed treatments – microbial inoculation; organic seed treatment – integrated seed treatment – concept and methods of designer seed.

Practical

- Seed testing – sampling and dividing methods;
- Determination of seed test weight and heterogeneity test;
- Physical purity analysis – components, procedure, reporting results;
- Seed moisture estimation – methods and equipments;
- Conduct of seed germination test and seedling evaluation;
- Conduct of quick viability (tetrazolium) test and evaluation;
- Conduct of vigour tests – direct, indirect test and special tests;
- Genetic purity assessment – laboratory and conventional methods – image analysisfor seed quality;

- Conducting different seed health tests to identify bacteria, fungi and insects;
- Visit to seed testing laboratory;
- Seed enhancement techniques – practicing physical treatments and water floatation techniques;
- Seed coating and pelleting – uses of adhesives and filler materials;
- Performing seed priming – hydro, halo and bio-priming – solid matrix priming;
- Practicing seed infusion and microbial inoculation treatments;
- Practicing pre-germination technique;
- Studying integrated seed treatment/ designer seed treatment.

Suggested Reading

Agrawal PK. 1993. Hand book of Seed Testing. Ministry of Agriculture, GOI, New Delhi

Agrawal RL. 1997. Seed Technology. Oxford & IBH.

Agrawal PK and Dadlani M. 1992. Techniques in Seed Science and Technology. 2nd Ed. South

Asian Publications.

Chakrabarthi SK. 2010. Seed Production and Quality Control. Kalyani Publishers. New Delhi.

Chalam GV Singh A and Douglas JE. 1967. Seed Testing Manual. ICAR and United States Agency for International Development, New Delhi.

Suggested e-books

http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDIAN MINIMUM SEED CERTIFICATION STANDARDS.pdf.

www.kopykitab.com/Seed-Testing-and-Quality-Control-by-Vasudevan-SN

https://www.jstor.org/stable/10.14321/j.ctt7zt51m

https://link.springer.com/chapter/10.1007/978-1-4615-1619-4_13

https://www.researchgate.net/publication/269694458_QUALITY_SEED_ PRODUCTION_ITS_ TESTING_AND_CERTIFICATION_STANDARD

https://www.seedtest.org/upload/cms/user/ISTAMethodValidationforSeed Testing-V1.01.pdf

https://www.intechopen.com/books/new-challenges-in-seed-biology-basic-and-translationalresearch-driving-seed-technology/recent-advances-in-seed-enhancements

Suggested websites

http://agritech.tnau.ac.in/seed/Seed_seedtesting.html

https://core.ac.uk/download/pdf/85210907.pdf

https://www.betterseed.org/resources/seed-testing-accreditation-schemes/

http://sbc.ucdavis.edu/About_US/Seed_Biotechnologies/Seed_Enhancement/

https://www.seedtest.org/en/international-rules-for-seed-testing-content-1-1083. html

6. Course Title : Seed Industry and Marketing Management
Course Code : SST -2006
Credit Hours : 2 (2+1)

Theory

Unit I

Introduction to seed industry – genesis, growth and structure of seed industry – mission and objectives – present status of Indian and global seed industry – role of seed

industry in Indian agriculture; government initiatives – seed hubs, seed villages and community seed production system.

Unit II

Seed industry – organization set up and functions – public, private, MNC's, seed corporations; structure of small, medium and large seed industries, components of seed industry – public private partnership – custom seed production – risk management – human resource – infrastructure – processing unit – storage go down.

Unit III

Seed production and distribution systems in state and central government; seed supply chain systems – seed production and distribution – planning, organization and coordination, staffing, assembling of resources; cost of seed production – overhead charges.

Unit IV

Seed marketing – definition – importance – role of marketing; type of markets – domestic and global market – problems and perspectives; marketing policies – seed marketing schemes – marketing channels, responsibilities of dealers – marketing mix.

Unit V

Seed demand forecasting – purpose – methods and techniques; indenting and seed dispatch procedures and forms – seed store records – maintenance – missing link in seed supply chain; market intelligence – SWOT analysis; seed cost analysis; seed pricing – policy – components of seed pricing – factors – local market rate (LMR) – fixation of procurement and sale price of seed.

Practical

- Data collection on status of Indian and global seed industry;
- Assessing the factors influencing farmers preference and assessment of seed demand and supply;
- Planning for establishment of small, medium and large seed industry;
- Planning for establishment of seed production and processing unit;
- Economics of seed production – varieties and hybrids;
- Seed pricings and cost analysis;
- Exercise on fixing seed procurement and sale price;
- Study of marketing channels – domestic and international;
- Maintenance of carryover seeds – Assessing risk factors in seed industry and their management; Survey and interaction with seed dealers and distributors;
- Visit to state seed corporations;
- Visit to MNCs and expert discussion;
- Case studies and SWOT analysis;
- Visit to modern seed processing unit and advanced seed storage complex;
- Custom seed production, contract farming and procurement – procedures;
- Planning and preparation of project proposal for setup of a seed industry;
- Final practical examination.

Suggested Reading

Acharya SS and Agarwal NL. 2004. *Agricultural Marketing in India*. 4th Ed. Oxford and IBH.

Broadway AC and Broadway A. 2003. *A Text Book of Agri-business Management*.

Kalyani Singh AK and Pandey S. 2005. *Rural Marketing*. New Age Publications.

Kugbei S. 2008. *Seed Economics*. Scientific Publishers, Jodhpur, Rajasthan.

Sharma P. 2008. *Marketing of Seeds*, Green-Tech Book Publishers, New Delhi.

Singh G and Asokan SR. 1991. *Seed Industry in India: A Management Perspective* Oxford & IBH Publishing Co Pvt. Ltd., New Delhi.

Singh S. 2004. *Rural Marketing – Focus on agricultural Inputs*. Vikas Publishing House.

Suggested e-books

https://link.springer.com/chapter/10.1007/978-1-4615-1783-2-15
http://www.fao.org/3/V4450E/V4450E00.htm
https://books.google.co.in/books?id=vPVlBos4WkYC
http://download.nos.org/srsec319new/319EL19.pdf
https://isengewant.de/Marketing-of-Seeds-By-Premjit-Sharma.pdf
https://www.kopykitab.com/A-Handbook-of-Seed-Processing-and-Marketing-by- Gaur-SC

Suggested websites

www.gov.mb.ca
www.agricoop.nic.in
www.agri.nic.in
https://sathguru.com/seed/
http://www.fao.org/3/V4450E/V4450E03.htm
https://www.seednet.gov.in/smis/SMIS-User%20Manual.pdf

7. Course Title : Seed Production Techniques in Forage, Pasture and Green Manure Crops

Course Code : SST- 2007

Credits Hours : 3 (2+1)

Theory

Unit I

Scope and importance of seed production in forage, pasture and green manure crops – factors influencing seed production – seasonal influence; problems and constraints in seed production – seed set, shattering and seed dormancy; vegetative and clonal propagules and apomictic seed.

Unit II

Quality seed production techniques in major fodder crops – lucerne, hedge lucerne, leucaena, fodder sorghum, fodder maize and oats.

Unit III

Seed and planting material production techniques of major forage grasses – bajra - napier grass, guinea grass, deenanath grass and Cenchrus sp.; forage legumes Stylosanthus, cowpea and berseem.

Unit IV

Seed production techniques in major green manure crops – Glyricidia, Sesbania sp., sunnhemp, daincha, jute and Tephrosia sp.

Unit V

Post-harvest seed handling – processing, threshing, grading and upgrading; dormancy breaking and germination improvement – quality standards for seed and vegetative propagules.

Practical

- Seed collection and identification of seeds;
- Estimation of seed setting and shattering loss;
- Maturity indices – determination of physiological and harvestable maturity;
- Seed extraction and threshing methods;
- Separation of ill filled seeds – practicing different methods;

- Study of seed and clonal materials – standards;
- Quality of planting material and vegetative propagules on crop establishment;
- Seed quality analysis in forage and fodder crops – tiller wise quality analysis;
- Seed quality analysis in determinate and indeterminate crops;
- Study on effect of ratooning on seed quality;
- Practicing seed quality enhancement techniques;
- Practicing different seed extraction and dormancy breaking treatments;
- Preparation of vegetative propagules and planting;
- Planning for seed production in fodder and green manure crops;
- Economics of seed production in fodder, forage crops and green manure crops;
- Visit to forage and fodder seed production farms.

Suggested Reading

FAO. 2007. Quality Declared Seed System. FAO Plant Production and Protection Publication, FAO, Rome.

Farity DT and Hampton JC. 1997. Forage Seed Production. Vol. I. Temperate Species. CAB International Publications. UK.

Froma J. 1997. Temperate Forage Legumes. CAB International Publications. UK.

Gutterridge RG. 1997. Forage Tree Legumes in Tropical Agriculture. CAB International Publications, UK.

Masilamani S and Sivasubramanian K. 2016. Seed Production in Green Manures. Kalyani Publications, New Delhi.

8. Course Title : Post Harvest Handling and Storage of Seeds
Course Code : SST- 2008
Credit Hours : 2(1+1)

Theory

Unit I

Seed processing – objectives and principles; processing sequence – threshing, shelling, ginning, extraction methods; drying – principles and methods; seed cleaning, grading, upgrading – methods – machineries and equipment – scalper, pre-cleaner, cleaner cum grader, specific gravity separator, indented cylinder, disc separator, spiral separator, velvet separator, magnetic separator, electronic colour sorter – working principles and functions.

Unit II

Online seed processing – elevators and conveyers – processing plant – specifications, design and layout; mechanical injury – causes and detection – management.

Unit III

Seed treatment – methods – pre and mid storage seed treatments, seed treating formulations and equipments; packaging materials – types – bagging and labeling; seed blending – principle and methods.

Unit IV

Seed storage – purpose and importance – factors affecting storage, optimum condition for storage of different seeds; storage principles – Harrington's thumb rule – concepts and significance of moisture equilibrium – maintenance of safe seed moisture – physical, physiological, biochemical and molecular changes during seed storage –

storage behaviour of orthodox and recalcitrant seeds – prediction of viability – viability nomograph.

Unit V

Methods of seed storage – modified atmospheric storage – ultra dry storage – vacuum storage – cryopreservation – germplasm storage – gene banks – NBPGR, IPGRI and National seed storage laboratory; seed storage godown – structure – maintenance – sanitation.

Practical

- Seed extraction – wet and dry methods;
- Seed processing sequence for different crops;
- Design of processing plant – equipments – estimation of processing efficiency;
- Seed drying methods – principle and methods;
- Practicing seed grading – upgrading techniques;
- Delinting methods – assessment of mechanical damage;
- Visit to seed processing unit;
- Seed packaging – effect of packaging materials on seed longevity;
- Prediction of viability during storage – viability nomograph and accelerated ageing test;
- Assessing physical changes during seed storage;
- Assessing physiological changes during seed storage;
- Assessing biochemical changes during seed storage;
- Storage behaviour of recalcitrant seeds;
- Pre-storage seed treatments – protectants – antioxidants – halogens;
- Practicing seed blending methods;
- Seed storage godown – sanitation, fumigation – visit to seed storage godown and cold storage unit.

Suggested Reading

Barton LV. 1961. Seed Preservation and Longevity, (Vol. 1). Leonard Hill, London.

Gregg BR, Law AG, Virdi SS and Balis JS. 1970. Seed Processing. Avion printers, New Delhi.

Gupta D. 2009. Seeds: their conservation principles and practices. Sathish serial publishing house. New Delhi.

Justice OL and Bass LN. 1978. Principles and Practices of Seed Storage. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.

Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios, Jodhpur, Rajasthan.

Padmavathi S, Prakash M, Ezhil Kumar S, Sathiyanarayanan G and Kamaraj A. 2012. A Text book of Seed Science and Technology, New India Publishing Agency, New Delhi.

Sen S and Ghosh N. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Singhal NC. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Suggested e-books

http://dfsc.dk/pdf/Handbook/chapter8_internet.pdf

https://naldc.nal.usda.gov/download/CAT87208646/PDF

https://www.springer.com/in/book/9780792373223

http://203.64.245.61/fulltext-pdf/EB/1900-2000/eb0021.pdf

https://www.kopykitab.com/ebooks/2016/05/6997/sample/sample_6997.pdf

SEMESTER III

9. Course Title : Seed Industry and Marketing Management

Course Code : SST - 2009

Credit Hours : 3(1+1)

Theory

Unit I

Introduction to seed industry – genesis, growth and structure of seed industry – mission and objectives – present status of Indian and global seed industry – role of seed industry in Indian agriculture; government initiatives – seed hubs, seed villages and community seed production system.

Unit II

Seed industry – organization set up and functions – public, private, MNC's, seed corporations; structure of small, medium and large seed industries, components of seed industry – public private partnership – custom seed production – risk management – human resource – infrastructure – processing unit – storage go down.

Unit III

Seed production and distribution systems in state and central government; seedsupply chain systems – seed production and distribution – planning, organization and coordination, staffing, assembling of resources; cost of seed production – overhead charges.

Unit IV

Seed marketing – definition – importance – role of marketing; type of markets – domestic and global market – problems and perspectives; marketing policies – seed marketing schemes – marketing channels, responsibilities of dealers – marketing mix.

Unit V

Seed demand forecasting – purpose – methods and techniques; indenting and seed dispatch procedures and forms – seed store records – maintenance – missing link in seed supply chain; market intelligence – SWOT analysis; seed cost analysis; seed pricing – policy – components of seed pricing – factors – local market rate (LMR) – fixation of procurement and sale price of seed.

Practical

- Data collection on status of Indian and global seed industry;
- Assessing the factors influencing farmers preference and assessment of seed demand and supply;
- Planning for establishment of small, medium and large seed industry;
- Planning for establishment of seed production and processing unit;
- Economics of seed production – varieties and hybrids;
- Seed pricings and cost analysis;
- Exercise on fixing seed procurement and sale price;
- Study of marketing channels – domestic and international;
- Maintenance of carryover seeds – Assessing risk factors in seed industry and their management;
- Survey and interaction with seed dealers and distributors;
- Visit to state seed corporations;
- Visit to MNCs and expert discussion;
- Case studies and SWOT analysis;
- Visit to modern seed processing unit and advanced seed storage complex;

- Custom seed production, contract farming and procurement – procedures;
- Planning and preparation of project proposal for setup of a seed industry;
- Final practical examination.

Suggested Reading

Acharya SS and Agarwal NL. 2004. Agricultural Marketing in India. 4th Ed. Oxford and IBH.

Broadway AC and Broadway A. 2003. A Text Book of Agri-business Management.

Kalyani Singh AK and Pandey S. 2005. Rural Marketing. New Age Publications.

Kugbei S. 2008. Seed Economics. Scientific Publishers, Jodhpur, Rajasthan.

Sharma P. 2008. Marketing of Seeds, Green-Tech Book Publishers, New Delhi.

Singh G and Asokan SR. 1991. Seed Industry in India: A Management Perspective Oxford &

IBH Publishing Co Pvt. Ltd., New Delhi.

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http://www.fao.org/3/V4450E/V4450E00.htm

https://books.google.co.in/books?id=vPVlBos4WkYC

http://download.nos.org/srsec319new/319EL19.pdf

https://isengewant.de/Marketing-of-Seeds-By-Premjit-Sharma.pdf

https://www.kopykitab.com/A-Handbook-of-Seed-Processing-and-Marketing-by- Gaur-SC

Suggested websites

www.gov.mb.ca

www.agricoop.nic.in

www.agri.nic.in

https://sathguru.com/seed/

http://www.fao.org/3/V4450E/V4450E03.htm

https://www.seednet.gov.in/smis/SMIS-User%20Manual.pdf

https://www.icrisat.org/seed-systems-models-lessons-learned/

https://www.bookdepository.com/Seed-Industry-India-Gurdev-Singh/

10. Course Title : Seed Production: Principles and Techniques in Vegetable Crops
Course Code : SST- 2010
Credit Hours : 3 (2+1)

Theory

Unit I

Importance and present status of vegetable seed industry – factors influencing vegetable seed production; varietal and hybrid seed production techniques in major solanaceous vegetable crops – tomato, brinjal, chilli; malvaceous vegetable crop – seed production techniques of bhendi.

Unit II

Varietal and hybrid seed production techniques in important cucurbitaceous vegetables – gourds and melons, cole crops – cauliflower, cabbage, knol-khol, root vegetables – carrot, beetroot, turnip, radish and other temperate/ hilly vegetable crops.

Unit III

Varietal seed production techniques in major leguminous vegetables – peas and beans; seed production techniques in leafy vegetables – amaranthus, palak, spinach, and lettuce.

Unit IV

Seed production techniques in tuber crops – potato, sweet potato, colocasia, tapioca and yam, seed-plot technique in potato – true potato seed (TPS) production techniques – seed production techniques in bulb crops – onion, garlic.

Unit V

Vegetative and clonal multiplication – methods, merits and demerits; clonal multiplication – potato, sweet potato, colocasia, tapioca and yam.

Practical

- Identification of vegetable seeds;
- Study on sowing and nursery management;
- Study on transplanting and age of seedling on crop establishment;
- Studying floral biology of solanceous, malvaceous and cucurbitaceous vegetable crops;
- Studying floral biology of other vegetable crops;
- Practicing planting design for hybrid seed production;
- Modification of sex ratio in cucurbits;
- Practicing emasculation and pollination methods;
- Practicing roguing operations – identification of off-types – selfed fruits;
- Harvesting methods – single and multiple harvesting method;
- Practicing seed extraction methods – wet methods – tomato, brinjal, other cucurbitaceous fruits;
- Seed extraction – dry methods – chillies, bhendi, cucurbitaceous;
- Visit to seed production fields;
- Visit to private seed industry;
- Planning and economics of varietal seed production;
- Planning and economics of hybrid seed production.

Suggested Reading

Agarwal RL. 2012. Seed Technology. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.

Chadha KL. 1995. Advances in Horticulture. Volume 1 to 13. Malhothra Publishing House, New Delhi.

George RAT. 1985. Vegetable Seed Production. Lonhman Inc., New York.

Hebblethwaite PD. 1980. Seed Production. Butterworth Heinemann Ltd, London, UK.

Kulkarni GN. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi.

Maiti RK, Sarkar NC and Singh VP. 2006. Principles of Post Harvest Seed Physiology and Technology. Agrobios, Jodhpur, Rajasthan.

McDonald MB and Copeland L. 1998. Seed Production: Principles and Practices. CBS Publishers,

New Delhi.

Sen S and Ghosh N. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Singhal NC. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Vanangamudi K, Natarajan N, Srimathi P, Natarajan K, Saravanan T, Bhaskaran M, Bharathi A, Natesan P and Malarkodi K. 2006. Advances in Seed Science and Technology. Vol. 2. Quality Seed Production in Vegetables. Agro bios, Jodhpur.

11. Course Title : Seed Health Testing and Management
Course Code : SST- 2011
Credit Hours : 2 (1+1)

Theory

Unit I

History and economic importance of seed health in seed industry and plant quarantine – important seed borne and seed transmitted pathogens – role of microorganisms in seed quality deterioration – storage and field fungi – effect of storage fungi on seeds – factors influencing storage fungi and management.

Unit II

Transmission of pathogens – mode and mechanism – seed certification standards; mycotoxins – types and its impact on plant, animal and human health; seed health testing methods – direct examination, incubation, serological and molecular methods.

Unit III

Production of disease free seeds in agricultural and horticultural crops; management of seed borne pathogens – plant quarantine – Indian system and networking, postentry quarantine and international systems – Pest Risk Analysis (PRA); Sanitary and Phytosanitary System (SPS) – certificates; International Seed Health Initiative (ISHI) on seed health standards.

Unit IV

Storage pests – insects, mites, rodents and their development – economic importance; insect infestation – factors influencing, sources and kinds, biochemical changes in stored seeds due to insect infestation; detection methods and estimation of storage losses; types of seed storage structures – domestic and commercial.

Unit V

Fumigation – principles and techniques – type of fumigants; preservatives and seed protectants on seed quality – non-chemical methods for managing seed storage pests – controlled and modified atmospheric storage – trapping devices – IPM for seed storage.

Practical

- Detection of seed borne pathogens – direct examination;
- Detection of seed borne pathogens – incubation methods;
- Detection of seed borne pathogens – serological methods;
- Detection of seed borne pathogens – molecular methods;
- Study on seed transmission of seed borne fungi, bacteria and viruses;
- Identification of storage fungi;
- Management of seed borne pathogens – seed treatment methods;
- Identification of storage insects – internal and external feeders influencing insects;
- Study on the effect of pre harvest spray on field carryover storage pests;
- Estimation of storage losses due to pests;
- Methods of detection of insect infestation;
- Management of storage pests – pesticides, dose determination, preparation of solution and application;
- Management of storage pests – non-chemical management methods;
- Demonstration of controlled atmospheric storage;
- Safe handling and use of fumigants and insecticides;
- Visit to seed storage godowns.

Suggested Reading

Agarwal VK and Sinclair JB. 1996. Principles of Seed Pathology. Edition, CRC Press Inc. Boca Raton, FL.

Athanassiou CG and Arthur FH. 2018. Recent advances in stored product protection. Springer- Verlag, Germany

Cotton, RT. 2007. Insect Pests of Stored grain and Grain products. Burgess Publ. Co., Minneopolis, Minn., USA

Karuna V. 2007. Seed Health Testing. Kalyani Publishers, New Delhi.

Karuna V. 2009. Fundamentals of Seed Pathology. Kalyani Publishers, New Delhi.

Neergaard P. 1979. Seed Pathology. Vol. 1. The Macmillan Press Ltd.

Ranjeet K. 2017. Insect Pests of Stored grain – Biology, Behaviour and Management Strategies. Apple Academic Press, New York, USA.

Suggested e-books

https://link.springer.com/book/10.1007/978-1-349-02842-9

https://www.crcpress.com/Principles-of-Seed-Pathology/Agarwal-Sinclair/p/book/9780429152856

https://books.google.co.in/books/about/Seed_Pathology.html?id=lvVJAAAAYAAJ&redir_esc=y

https://www.taylorfrancis.com/books/9781315365695

https://www.ebooks.com/en-us/610606/insects-of-stored-products/david-rees/

https://www.elsevier.com/books/insects-and-seed-collection-storage-testing-and-certification/kozlowski/978-0-12-395605-7

Suggested websites

www.tnagrisnet.tn.gov.in/

www.storedgrain.com.au/

https://openlibrary.org/subjects/seed_pathology

http://ciat-library.ciat.cgiar.org/articulos_ciat/2015/12620.pdf

www.grainscanada.gc.ca/en/

https://entomology.ca.uky.edu/ef145

http://www.fao.org/3/t1838e/T1838E00.htm#Contents

https://www.agric.wa.gov.au/pest-insects/insect-pests-stored-grain

vBasic Concepts in Laboratory Techniques

12. Course Title : Seed Technology of Tree Species
Course Code : SST-2012
Credit Hours : 2 (1+1)

Theory

Unit I

Importance of tree seeds – seed quality in plantation establishment – scope of seed production in tree species; seed structure and its significance in natural regeneration of forest species.

Unit II

Reproductive biology – angiosperms and gymnosperms – reproductive age – seasonal influence on flowering – reproductive efficiency; factors influencing seed set –

pollination – pollinating agents – self incompatibility – seed dispersal – mode and mechanism of dispersal.

Unit III

Seed stand – selection and delineation – seed production area – seed zone – selection criteria for candidate, plus and elite tree; seed orchards – definition – types –seedling and clonal seed orchard – pollen dilution zone – seed orchard establishmen and management; OECD certification programmes for forest reproductive materials and seeds – ISTA certification standards for tree species.

Unit IV

Physiological maturity – maturity indices – determining optimum harvestable maturity; seed collection – methods – factors influencing seed collection – precautions in collection of recalcitrant seeds; seed extraction – methods – wet, dry and cone extraction; drying – critical moisture content – seed processing; dormancy – types of dormancy in tropical, sub tropical and temperate tree seeds – dormancy breaking treatments; recalcitrant seeds – mechanism.

Unit V

Seed production and handling techniques in important tree borne oil seeds (*Madhuca*, *Pongamia*, *Azadirachta*, *Simaruba*, *Callophyllum*), timber (teak, sandal, pine, cedar, red sanders, shisham), fuel wood (*Acacias*), pulp wood (Bambusa, *Ailanthus*, *Casuarina*, *Melia*, *Eucalyptus*), fodder (*Leucaena*, *Albizzia*) and ornamental (*Cassia*, *Delonix*) tree species.

Practical

- Study of tree seed structure – internal and external structures;
- Study on phenology of different tree species;
- Selection procedure of candidate and plus trees;
- Assessment of seed set, physiological and harvestable maturity;
- Assessing natural regeneration in different tree species;
- Study on seed dispersal methods and dispersal distance in different species;
- Seed collection techniques in important tree species – seed collection – orthodox and recalcitrant seeds – safety measures during collection;
- Seed extraction methods – wet and dry extractions – fruits, pods, cones, etc.;
- Study on different seed drying methods and precautions;
- Practicing seed grading and upgrading techniques;
- Practicing seed dormancy breaking methods;
- Germination improvement treatments for elite seedling production;
- Study on storage of recalcitrant seed;
- Estimation of critical moisture content for safe storage;
- Visit to seed production area and seed orchard;
- Visit to tree seed processing unit.

Suggested Reading

Dennis AJ, Schepp EN, Green RJ and West cott DA. 2007. *Seed Dispersal*. Agrobios, Jodhpur.

Khanna LS. 1993. *Principles and Practices of Silviculture*. Khanna Bandhu, Dehradun, India.

Lars Schmidt 2000. *Guide to Handling of Tropical and Sub Tropical Forest Seed*. Danida Forest Seed Centre, Denmark.

Negi SS. 1998. *Forest Tree Seed*. International Book Distributors, Dehradun, India.

Ram Prasad and Khandya AK. 1992. *Handling of Forestry Seeds in India*. Associated Publishers, New Delhi.

Sivasubramaniam K, Raja K and Geetha R. 2012. *Recalcitrant Seeds – Causes and Effects*. Sathish Serial Publishing House. Azadpur, New Delhi.

Umarani R and Vanangamudi K. 2004. *An Introduction to Tree Seed Technology*. International Book Distributors, Dehradun.

Vanangamudi K, Natarajan K, Saravanan J, Natarajan N, Umarani R, Bharathi A and Srimathi

P. 2007. *Advances in Seed Science and Technology: Forest Tree Seed Production* (Vol. 4). Agrobios, Jodhpur

Willan RL. 1985. *A guide to Forest Seed Handling*. FAO, Rome Zoebel B and Talbert TT. 1984. *Applied forest tree improvement*. Joh willey and Sons, New Yark.

Suggested e-books

http://www.fao.org/3/a-ah803e.pdf
http://www.fao.org/3/ad232e/AD232E01.htm
https://www.springer.com/gp/book/9783540490289
http://www.fao.org/docrep/006/ad232e/ad232e00.htm
http://envis.nic.in/ifgtb/pdfs/Tree%20Seed%20Management.pdf
https://www.forestry.gov.uk/PDF/FCBU054.pdf/$FILE/FCBU054.pdf
https://www.forestry.gov.uk/PDF/FCBU059.pdf/$FILE/FCBU059.pdf

Suggested websites

www.ista.org.in
ifgtb.icfre.org/index.php
http://www.kfri.res.in/research.asp
http://www.fao.org/3/ad232e/AD232E21.htm
https://www.srs.fs.usda.gov/pubs/gtr/gtr_so107.pdf

Course Curricula

Revised Curricula & Syllabi as per the Recommendation of ICAR-Natonal Core Group and 19th Broad Subject Matter Area (BSMA) Committee-2020 Based Syllabi

Name of program: M.Sc. (Ag): Agroforestry

Semester & Courses			Code	Credit Hours	Marks Distribution
1st Semester	1: Silviculture		AGF-2101	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Silvicultural Practices		AGF-2102	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	3: Agroforestry Systems		AGF-2103	*2 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Interactions in Agroforestry Systems		AGF-2104	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	5: Management of Problematic soils and water		SAC- 1204	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	6: Statistical Methods for Agriculture		*AST -3001*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	7: *Intellectual Property and its Management in Agriculture**		*COM-5001*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Library and Information Service**		*COM-5002*	*1(1+0)*	*100 T (50 M + 50 A)**
2nd Semester	1: Modern Nursery Technologies		AGF-2105	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	2: Plantation Forestry		AGF-2106	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Industrial Agroforestry		AGF-2107	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Climate Change and Conservation Silviculture		AGF-2108	*2 (1+1)*	*100 (20 M + 30 P + 50 T)*
	5: Seed Developmental Biology		SST-2006	*3 (3+0)*	*100 (20 M + 30 P + 50 T)*
	6: Experimental Designs		*AST-3002*	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	*7: Basic Concepts in Laboratory Techniques**		*COM-5003*	*1 (1+0)*	*100 T (50 M + 50 A)**
	*8: Technical Writing and Communications kills**		*COM-5004*	*1 (1+0)*	*100 T (50 M + 50 A)**
3rd Semester	1: Trees and Shrubs for Agroforestry		AGF-2109	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	2: Economics of Agroforestry Systems		AGF-2110	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	3: Nutrient and Weed Management in Production Forestry		AGF-2111	*3 (2+1)*	*100 (20 M + 30 P + 50 T)*
	4: Crops and Live Stock Management in Agroforestry (As Minor)		AGF-2112	*2 (2+0)*	*100 (20 M + 30 P + 50 T)*
	*6: Agricultural Research, Research Ethics and Rural Development Programs**		*COM-5005*	*1 (1+0)*	*100 T (50 M + 50 A)**
4th Semester	1: Seminar		AGF-2113	*1*	*100**
	2: Students shall be opt any one out of two options	*(A) Research (Thesis)*	AGF -2114	*25*	*100 The evaluation of thesis shall be: (50 Internal + 50 External)*
		(B) Internship for Development of Entrepreneurship in Agriculture (IDEA)	AGF-2115	*25 Internship based dissertation*	*100 The evaluation of IDEA shall be: (50 Internal + 50 External)*
	Total credits = 74				

M = Mid, P = Practical, T = Theory, A = assignment, *Courses = Total internal evaluation

Course Contents

M.Sc. (Ag.) Agroforestry

SEMESTER I

1. Course Title: Silviculture
Course Code: AGF-2101
Credit Hours :3 (2+1)

Theory

Unit I

Forest ecosystems- Introduction to tropical/ temperate silviculture. Role of silviculture in forest and wild land management, major forest formations- classification, distribution, composition and structure. Vegetation dynamics- species richness-diversity indices. Vegetation forms of India and their productivity.

Forest ecosystem- structure and functioning, community development, competitive interactions in forest communities, forest succession, concepts and models of succession-Connell-Slatyer models, climax theories, tolerance.

Unit II

Ecophysiology of tree growth- effect of radiation and water relationship, mineral nutrients and temperature. Forest stand development – stand development, even- aged and uneven-aged stands, age and site quality. Tree architecture and its role in stand management.

Unit III

Stand density determination-stand density indices-stand density management- density management diagram, silvicultural treatments involved- thinning as a stand management tool, objectives of thinning, effects on growth and yield, thinning effect on economic yield of stands. Forest site quality evaluation-direct and indirect methods.

Unit IV

Treatment analysis-silvicultural regimes- factors influencing choice of regimes, use of system analysis to determine regimes, models for evaluating silvicultural alternatives, development of silvicultural regimes to suit management objectives, optimum management strategies, silvicultural prescriptions for maximum production regime.

Practical

- Visit to forest areas to study forest composition, classification, factors of locality, site quality, form and growth of forest trees- study plant succession- study stand density, changes on productivity- thinning effects;

Sugessted Books

Daniel TW, Helms JA and Baker FS. 1979. Principles of Silviculture. McGraw-Hill Book Company.

Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press. Shepherd KR. 1986. *Plantation Silviculture.* Springer.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture-Applied Forest Ecology*. John Wiley & Sons.

2. Course Title : Silvicultural Practices
Course Code : AGF-2102
Credit Hours: 2(1+1)

Theory

Unit I

Sivilculture under changing context of forestry- sivilculture and ecosystem management, stand dynamics, silvicultural practices for pure and mixed stand, even aged and uneven aged stand – silvicultural practices for changing climatic conditions. Silvicultural practices for natural and artificial regeneration – Ecology of regeneration, forest site management- enrichment of site – quality classes and site index models – stand density – spacing and tree growth – forest vegetation management – techniques for early stand growth- tending operations. Biomass allocation: belowground and aboveground. Changing trends in adoption of silvicultural systems.

Unit III

Stand development – stages- crown dynamics, Crown Competition factor, Maximum crown area, thinning – pruning – response of trees and impact on wood quality, salvage cutting – improvement felling and enrichment planting – management of weeds, Invasive weeds in forests, Silvicultural practices for short rotation forestry-coppice forestry, Continuous cover forestry.

Unit IV

Site specific selection of tree species. Precision silviculture –silvicultural practices for important fast growing trees and bamboos of India- *Populus species, Neolamarkia cadamba, Eucalyptus* sp., *Casuarina* sp.,*Tectona grandis, Melia dubia, Dalbergia sissoo, Gmelina arborea, Leucaena leucocephala, Ailanthus excelsa, Azadirachta indica, Swietenia macrophylla, Dendrocalamus* sp., *Bambusa* sp., – Mechanization of silvicultural practices.

Practical

- Visit to different forest sites to study the influence of site factors on composition;
- Determination of site quality;
- Studies on stand structure and composition of different forest types;
- Practicing pruning and its impact on wood quality;
- Characterizing methods of thinning;
- Working out intensity of thinning;
- Study of stand densities in natural forest stand and plantation stand;
- Afforestation techniques, Wood management techniques for forest tree crops;
- Planning and designing a tree planting programme;
- Exercise on precision silviculture practices;
- Exercise on mechanized silvicultural practices.

Suggested Reading

Daniel TW, Helms JA and Baker FS. 1979. *Principles of Silviculture.* McGraw-Hill Book Company.

Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press.

Khanna LS. 1996. *Principle and Practice of Silviculture*. International Book Distributors. Khanna LS. 2015. *Theory and Practice of Indian Silviculture Systems.* Bio-Green Publisher. Lamprecht. 1986. *Silviculture in the Tropics*-Verlag Paul Parey, Hamburg und Berlin.

Nyland RD, Laura S, Kenefic, Kimberly K, Bohn and Susan LS.2016 *Silviculture: Concepts and Applications* (III edition), Kindle Edition, USA. Shepherd KR. 1986. *Plantation Silviculture*. Springer.

Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. *The Practices of Silviculture-Applied Forest Ecology*. John Wiley & Sons.

3. Course Title: Agroforestry Systems

Course Code: AGF-2103

Credit Hours: 2 (1 + 1)

Theory

Unit I

Agroforestry: objectives, importance, potentials and limitations for implementations. Land capability classification and land evaluation. Basis of classification of agroforestry systems and principles, indigenous vs. exotic, intraspecific variations, crown architecture of tropical/ temperate trees. Ideotype concept for selection of multipurpose trees. Nitrogen fixing trees. Overview and case studies of different agroforestry systems.

Unit II

Structural and functional attributes of agroforestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, silvopastoral systems, shelter-belts and windbreaks, energy plantations and home gardens.

Unit III

Role of trees in soil productivity and conservation– micro-site enrichment- litter and fine root dynamics, Nitrogen fixation and nutrient pumping. Soil productivity and management in agroforestry.

Unit IV

Community forestry and social forestry, linear strip plantations.

Unit V

Trends in agroforestry systems research and development, Diagnosis and Design –PRA-RRA tools in agroforestry problem diagnosis.

Unit VI

Climate Change mitigation and adaptation through agroforestry- climate negotiations- LULUCF- agroforestry options.

Practical

- Survey and analysis of land use systems in the adjoining areas;
- Study of tree crown architecture;
- Design and plan of suitable models for improvement;
- PRA-RRA tools in agroforestry problem diagnosis.

Suggested Reading

Buck LE, Lassoie, Fernandes ECM 1999. *Agroforestry in Sustainable Agri. Systems*. CRC Press. Kumar BM and Nair PKR. 2006. *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry.* Springer publication.

Kumar BM and Nair PKR. 2013. *Carbon Sequestration Potential of Agroforestry Systems: Opportunities and Challenges (Advances in Agroforestry*). Springer publication.

4. Course title: Interactions in Agroforestry Systems

Course Code : AGF-2104

Credit Hours: 3(2+1)

Theory

Unit I

Tree-crop interphase- biological factors affecting form and function in woody and non-woody plant mixtures. Nature and types of interactions- positive and negative, aboveground and belowground interactions- competition, complementarity in resource sharing.

Unit II

Method for quantifying interactions, principles of resource capture and utilization of light and water, nutrition and space. Tree-soil-crop interactions- nitrogen fixing trees interactions in agroforestry. Allelopathy. Use of radioisotopes in tree-crop interaction studies. Root distribution of trees and crops-competition and/ orcomplementarity. Animal-tree-crop interaction.

Unit III

Management options to neutralize negative (competitive) interactions, tree husbandry practices for alleviating competition- tree density manipulation, pruning,mixture of trees and herbaceous crops.

Practical

- Different methods for quantifying interactions;
- Studies on allelopathy;
- Effect, microclimate modifications, different plant mixtures, tree-soil-crop nteractions;
- Estimation of Land Equivalent Ratio, Estimation of competition indices;
- Measurement and interpretation of light interception in agroforestry systems;
- Interpretation of yield responses to shelter, soil water and drainage measurement, transpiration measurement, quantifying root distribution.

Suggested Reading

Avery MA, Cannel MGR and Ong CK. 2005. Biophysical Research for Asian Agroforestry. Oxford and IBH Publishing Co. Pvt. Ltd.

Mac Dicken, KG and Vergara NT. 1989. Agroforestry-classification and Management.

Nair PKR. 1993. An Introduction to Agroforestry. Kluwer Academic Pub.

SEMESTER II

5. Course Title : Modern Nursery Technologies

Course Code : AGF-2105

Credit Hours: 3 (2 + 1)

Theory

Unit I

Introduction and importance of nursery. Types of nurseries-temporary and permanent, bare root, containerized and clonal nursery. Bare root nursery- nursery soil and water management, bed preparation, pre-sowing seed treatments, seed sowing and intermediate operations, viz., pricking, watering, fertilization, weeding and hoeing.

Unit II

Physiology and nursery environment interaction affecting seedling growth. Root culturing techniques. Containerized nursery—type and size of containers including root trainers, selection of growing medium. Types of green house and mist chamber for propagation.

Vegetative propagation – importance, selection of superior genotypes, Advanced methods of propagation, containers, growing media, fertilizers, sanitation and management in vegetative propagation. Special requirement for clonal propagation. Propagation Structures and Management.

Unit IV

Clonal propagation: miniclonal and micro cuttings technology. Vegetative propagation of bamboos and canes. Factors affecting rooting of cuttings. Lifting windows. Important forest nursery pests and diseases and their management. Seedling quality assessment, grading, packaging, storing and transportation.

Practical

- Introduction and identification of modern equipments and tools used in nursery;
- Pre-sowing seed treatments;
- Preparation of nursery beds and growing media for containerized nursery;
- Sowing of seed and other intermediate operations;
- Preparation and planting of cuttings;
- Use of vegetative propagation methods such as budding, grafting and layering;
- Miniclonal and microcutting technology;
- Use of plant bio-regulators for rooting;
- Assessment of seedling quality;
- Maintenance of nursery records. Identification of nursery insects and diseases and their control measures;
- Visit to forest nurseries;
- Nursery practices of commercially important tree species.

Suggested Reading

Bhardwaj RL and Sarolia DK. 2011. *Modern Nursery Management.* Published by Agrobios Publishing. New Delhi (India).

Kumar GA and Gopikumar. 2003. *Forest Nursery and Tree Husbandry.*

Kumar V. 2012. *Nursery and Plantation Practices in Forestry.* Scientific Publishers (India). Saini RS, Kaushik N, Kaushik RA and Godara NR. 2012. *Practical Nursery Production*. Agrobios, New Delhi (India).

6. Course Title : Plantation Forestry

Course Code : AGF-2106

Credit Hours : 3(2+1)

Theory

Unit I

Role of plantation forestry in meeting the wood demand – status of plantation forestry in India and world. Purpose of plantation, factors determining scale and rate of plantation. Land suitability and choice of species. Preliminary site preparation for establishing plantation. Plantation planning, project formulation and appraisal. Planting programme, time of planting, spacing, pattern and planting methods.

Unit II

Nutritional dynamics and irrigation of plantation. Mechanization in plantation. Protection and after care of plantation. Pruning and thinning in plantations for quality wood production. Rotation in plantation. Failures of plantations. Impact of interaction and integration of plantation forestry.

Unit III

Protective afforestation, afforestation of inhospitable sites. Plantation forestry for climate change mitigation- carbon forestry. Ecological factors and long term productivity. Sustainable yield from plantations. Case studies in plantations of Eucalyptus, Casuarina, Poplars, Acacias, Pine, Silver Oak, Gmelina, Teak, Sandal, Bamboo, etc. Production technology of energy plantations, industrial plantations. Emerging concepts in plantation forestry: mixed plantation, continuous cover forests.

Practical

- Analysis of plantation problems in Asia and India;
- Preparation of plantation calendar –Preliminary arrangement for a plantation programme;
- Planting geometry and calculation of planting stock;
- Study of different cultural operations and site preparation for plantation;
- Studies on wood based industries – problems and prospects;
- Management of Eucalyptus, Casuarina, Teak, Sal, Poplar, Acacias and Bamboo plantations;
- Production technology for energy plantations. INM in plantations;
- Irrigation and plantations;
- Economics of pulpwood, timber and energy plantations. Study of mixed plantation model.

Suggested Reading

Dwivedi AP. 1993. *Forestry in Indi*a. Surya Publ.

Julius E. 1982. *Plantation Forestry in the Tropic*s. Clarendon Press, Oxford. Kumar V. 1999. *Nursery and Plantation Practices in Forestr*y. Scientific Publ. Luna RK. 1989. *Plantation Forestry in Indi*a. International Book Distributors.

Prakash R, Chaudhari DC and Negi SS. 1998. *Plantation and Nursery Techniques of Forest Tree*s. International Book Distributors.

7. Course Title : Industrial Agroforestry

Course Code : AGF-2107

Credit Hours : 3(2+1)

Theory

Unit I

Role of forests in industrial sector, industrial raw material, demand and supply, indigenous and exotic industrial resources, extent of area, policy and legal issues towards industrial wood plantation. Major wood based industries in India; timber, pulp wood, plywood, matches, etc. Raw material requirements and their procurements.

Unit II

Industrial wood plantations – status in India and different states, preferred species – current plantation management and establishment, propagation and plantation technique, economics of industrial agroforestry, pest and disease management for major industrial wood species, harvesting, reduced impact logging, mechanization.

Unit III

Supply chain; definition, concept, supply chain network, logistic activities, Marketing system; marketing type and channel, price patterns of various industrial wood agroforestry plantations. Contract farming: concept and methods, contract tree farming system in India. Industrial experiences– price support system – constraints. Corporates in industrial agroforestry: International and National corporate, success stories. Corporate social responsibilities. Tree insurance.

Unit IV

Impacts of industrial agroforestry – ecological impacts; climatic, edaphic and biotic– carbon sequestration. Carbon storage potential of industrial agroforestry and carbon trading mechanism of industrial agroforestry, socio-economic impacts–clean development mechanism. Certification of industrial plantations.

Practical

- Study of various wood based industries;
- Study on raw material requirement and sourcing of plywood, pulp and paper, matchwood, timber processing;
- Biomass power generation industries;
- Value addition technology of various wood products;
- Industrial wood plantations – economics and impact assessment.

Suggested Reading

Cosasalter C and C Pye-Smith. 2003. *Fast Wood Forestry – Myths and Realities*. CIFOR. Bogor, Indonesia. 50p.

Mehta T. 1981. *A Hand Book of Forest Utilization.* International Book Distributors, Dehradun. Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic publishers.

Parthiban KT, Umarani R, Umesh Kanna S, Sekar I, Rajendran P and Durairasu P. 2014.

Industrial Agroforestry: Perspectives and Prospectives. Scientific Publishers. Tejwani KG. 1994. *Agroforestry in India*. Oxford and IBH publishing Co., New Delhi.

SEMESTER III

8. Course Title : Climate Change and Conservation Silviculture

Course Code : AGF-2108

Credit Hours : 2(2+0)

Theory

Unit I

Global climate change-factors involved, green house gases, potential threats, global carbon cycle and C-budget, carbon sequestration. Forests and climate change: Forest responses and vulnerabilities to climate change mitigation.Status of forests in global climate change. Harnessing Forests for Climate Change Mitigation, International climate negotiation, UNFCCC, IPCC, CoP:LULUCF, REDD++ and CDM.

Unit II

Silviculture and sustainability-criteria and indicators for sustainable plantation forestry in India-CIFOR guidelines. Silvicultural and stand management strategies for carbon sink maximization and source minimization. Adaptive silviculture for climate change.

Unit III

Disturbance- natural and anthropogenic, short and long term impacts and their implications. Fire loss estimation in forests. Deforestation and degradation trends at global, national and regional levels. Mega development projects, Road widening projects and conservation of native and threatened species, management and rehabilitation plans.

Unit IV

Impacts of 'No Green Felling' on stand productivity and health. Restoration forestry- silvicultural treatments for habitat restoration, catchment area treatments, enrichment planting, Analog forestry for site productivity and carbon value. Expanding forest and tree cover area- TOF sector in India.

Unit V

Role of canopy in regulating functional inputs to stand: canopy and forest continuum, Continuous Cover Forestry. Silviculture of old growth stands and sacred grooves-their ecological significance and biodiversity values. Carbon sequestration potential of Trees Outside forests (TOFs), homegardens and urban forests.

Suggested Reading

Anderson P and Palik B. 2011. *Silviculture for Climate Change.* U.S. Department of Agriculture, Forest Service, Climate Change Resource Center.

SEMESTER III

9. Course Title: Trees and Shrubs for Agroforestry

Course Code: AGF-2109

Credit Hours: 3(2+1)

Theory

Unit I

Introduction, importance of woody elements in agroforestry systems, their role in biomass production. Suitability of species for different purposes. Multipurpose trees in agroforestry systems. Fodder from trees/ shrubs and their nutritive value, propagation techniques.

Unit II

Role of nitrogen fixing trees/ shrubs. Choice of species for various agro-climatic zones for the production of timber, fodder, fuel wood, fibre, fruits, medicinal and aromatic plants. Generic and specific characters of trees and shrubs for agroforestry.

Unit III

Fruit crop and small timber trees and their need and relevance in agroforestry, trees suitable for various assemblage and their planting plan in different agroclimatic zones and agroforestry system. Intercropping in fruit orchards like Apple, Walnut, Jack fruit, Mango, Sapota, Pomegranate, Orange, Citrus, Guava, etc. Modification in tending and pruning operations and canopy management. Fertility management, yield and quality improvement.

Practical

- Field survey and acquaintance with specialized features of trees, shrubs and fruit species and varieties for Agroforestry;
- Planting plans including wind breaks;
- Training and pruning of forest trees, shrubs and fruit trees for enhancing production in agroforestry system.

Suggested Reading

Dwivedi AP. 1992. *Agroforestry: Principles and Practice*s. Oxford & IBH. Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestr*y. Kluwer. Nair PKR. 1993. *An Introduction to Agroforestr*y. Kluwer.

Ong CK and Huxley PK. 199*6. Tree Crop Interactions – A Physiological Approac*h. ICRAF. Srivastava KK. 2007. *Canopy Management of Fruit Crops*, IBD.

Thampan PK. 1993. *Trees and Tree Farmin*g. Peekay Tree Crops Development Foundation.

10. Course Title: Economics of Agroforestry Systems

Course Code: AGF-2110

Credit Hours : 3 (2+1)

Theory

Unit I

Basic principles of economics applied to agroforestry. Financial measures.

Unit II

Optimization techniques-Planning, budgeting and functional analysis. Role of time, risk and uncertainty in decision making. Agroforestry budgeting. Risk analysis, re-assessment.

Unit III

Financial and socio-economic analysis of agroforestry projects. Principles of financial management and harvesting, post harvest handling, value addition, marketing of agroforestry products including benefit sharing.

Unit IV

Valuation of ecosystem services in agroforestry and payment for ecosystem systems. Bankable agroforestry projects, incentives, tree insurance, etc. Certification process in agroforestry based carbon projects, carbon finance, etc.

Practical

- Exercises on agroforestry production relationships;
- Preparation of agroforestry based enterprise, partial and complete budgets;
- Application of various methods in formulation and appraisal of agro-forestry projects;
- Case studies on harvesting, post harvest management and marketing of agro-forestry products;
- Valuation of ecosystem services in agroforestry and payment for ecosystem services.

Suggested Reading

Alavalapati JRR and Mercer D Evan. 2004 *Valuing Agroforestry Systems: Methods and Applications*. Kluwer Academic Publishers.

Kant S and Janaki A. 2014. *Handbook of Forest Resource Economics*. Publisher: Routledge Nair PKR, Rai MR and Buck LE. 2004. *New Vistas in Agroforestry*. Kluwer Academic Publishers. Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer Academic Publishers.

Ong CK and Huxley PK. 1996. *Tree Crop Interactions – A Physiological Approach*. ICRAF. Sullivan Gregory M, Susan Hoke M and Jefferson M. Fox (editors). 1992. *Financial and Economic*

Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu. Hawaii. USA. July 1991. Paia, Ill: Nitrogen Fixing Tree Association.

Thampan PK. 1993. *Trees and Tree Farming*. Peekay Tree Crops Development

11. Course Title: Nutrient and Weed Management in Oduction Forestry

Course Code: AGF-2111

Credit Hours: 3(2+1)

Theory

Unit I

History of nutrient management in forest nurseries and plantations. Essential nutrient elements and their deficiency. Mechanism of nutrient uptake by plants, functions and translocation/ interactions. Concept of nutrient availability.

Unit II

Climatic and soil conditions causing micronutrient deficiencies in plants. Occurrence and treatment of micronutrient disorders. Evaluation of soil for the supply of micronutrient. Rare and non-essential elements.

Unit III

Technology and use of complex liquid and suspension fertilizers. Fertilizer use efficiency. Biological nitrogen fixation and bio-fertilizers. Farm yard manure and other organic fertilizers. Mycorrhizal associations and their significance. Economic implications of nutrient management. Importance of renewable wastes and their recycling.

Unit IV

Principles of weed control. Methods of weed control-cultural, biological, mechanical and chemical. Herbicide/ weedicide classification, properties and their application.

Practical

- Methods of soil and plantanalysis.
- Preparation of nutrient solutions.
- Practical application of fertilizers;
- Study of fertilizer response and diagnosis of deficiency symptoms.
- Fertilizer testing and pot experiments;
- Nursery inoculation techniques of bio-fertilizers;
- Methods of application of formulated products-seed treatment, root dip, suckers treatment, soil application, foliar application and combination of different methods;
- Important weeds in forest nurseries and plantations. Control of weeds.

Suggested Reading

Allen V and Barker. 2007. *Handbook of Plant Nutrition*. Pilbeam London. Gupta OP. 2011. *Modern Weed Management*. Agrobios, New Delhi (India).

Kumar D, Chowdhary S and Sharma R. 2011. *Weed Management: Principles and Practices.* Narendra Publishing House.

Rajaram C. 2012. *Hand book of Plant Nutrition*. Neha Publishers and Distributors.

Rammoorthy and Subbian P. 2012. *Weed Management*. Agrotech Publishing Academy, Udaipur(India).

12. Course Title: Crops and Live Stock Management in Agroforestry

Course Code: AGF-2112

Credit Hours: 2(2+0)

Theory

Unit I

Choice of inter-crops for different tree species, sowing and planting techniques. Planting patterns, crop geometry, nutrient requirements, and weed management. Management of fodder tree species, thinning, lopping, pruning. Ecological and socio-economic interactions.

Unit II

Role of tree architecture and its management on system's productivity. Production potentials of fodder based agroforestry systems in different agro-climatic conditions and crop combinations. Importance of cattle, sheep and goat vis-à-vis agro-forestry systems. Feed and fodder resources in agro-forestry systems and live stock management.

Unit III

Nutrient analysis of forages derived from fodder trees/ shrubs. Nutrient requirement for various livestock and their ration computation with agroforestry forages and tree leaves. Forage and tree leaves preservation. Calendars for forage crop production in agro-forestry systems including lopping schedules. Optimization of animal production. Animal products technology andmarketing.

Unit V

Integrated Agroforestry Farming System.

Suggested Reading

Bran Powell. 2017. *Livestock Production and Management.* L & K Education.

Kundu SS, Dagar JC, Prakash O, Chaturvedi and Sirohi SK. 2008. *Environment, Agroforestryand Livestock Management.*

Course Syllabus

of

Saporting and Common Courses

AST-3001: Statistical Methods for Agriculture Semester-I 3(2+1)

Unit I

Descriptive statistics: probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, normal distribution and its properties.

Unit II

Concepts of compound, truncated and mixture distributions (definitions and examples). Sampling distributions of sample mean and sample chi-Square, *t, Z and F* distributions, their properties and inter relationships.

Unit III

Correlation, rank correlation, correlation ratio and intra-class correlation. Regression analysis, partial and multiple correlation

Unit IV

Sampling distribution of correlation coefficient, regression coefficient. Basic concept of probability and non probability sampling.

Practical

distribution; Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation; Regression coefficients and regression equations; chi-Square, *t* and *F* distributions numerical

Suggested Reading

- Rohatgi VK and Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.
- Gupta. S.P 2008. *Statistical Methods*. Sultan Chand & sons Educational Publisher

COM-5001: Intellectual Property and Its Management in Agriculture Semester I: (1+0)

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

Suggested Readings

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

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol.Technology Generation and IPR Issues. Academic Foundation.

Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other DevelopingCountries: A Compendium on Law and Policies*. Daya Publ. House.

COM-5002: Library and Information Services Semester- I 1(1+0)

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

AST-3002: Experimental Designs Semester-II 3(2+1)

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, missing plot techniques in randomized block and Latin square designs; Transformations,.

Practical

Uniformity trial data analysis, formation of plots and blocks, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,Analysis with missing data, Split plot and strip plot designs.

Suggested Reading

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

COM-5003: BASIC CONCEPTS IN LABORATORY TECHNIQUES Semester II: (0+1)

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

Suggested Readings

- Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
- Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

COM 5004: Technical Writing and Communications Skills

Semester II: (1+0)

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

Suggested Readings

- *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
- *Collins' Cobuild English Dictionary*. 1995.
- Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.
- Richard WS. 1969. *Technical Writing*.
- Wren PC and Martin H. 2006. *High School English Grammar and Composition*.S. Chand & Co.
- Sarju Narain and Sagar Mondal, 2021 Communication Skills and Personality Development, Kalyani Publication.

COM-5005: Agricultural Research, Research Ethics and Rural Development Programmes **Semester- III: (1+0)**

UNIT I

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

UNIT II

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

UNIT III

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

Suggested Readings

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

Research (Thesis) and IDEA: *For details see in ordinance*

Appendix-1 : Design of Mark Sheet

Papers code & title	***Credit Hours assigned to the paper***	***Point Scored=*** (Marks obtained x Credit Hours) 10
1.---------- **2.----------** **3.----------** **4.----------** **.** **.** **.**	**-----** **-----** **-----** **-----**	**-------** **-------** **-------** **-------**
Total Credit =	**------**	**Total Point Scored = ----------**

Grade Point Average(GPA) of the Semester = Total Point Scored/Total Credit Hours = --------

Result = Pass / Fail

Final Result (Summary)

Grade Point Average (GPA) of the 1st Semester = ……....
Grade Point Average (GPA) of the 2nd Semester = ……
Grade Point Average (GPA) of the 3rd Semester = ……
Grade Point Average (GPA) of the 4th Semester = ……
Grade Point Average (GPA) of the 5th Semester = ……
Grade Point Average (GPA) of the 6th Semester = ……
Grade Point Average (GPA) of the 7th Semester = ……
Grade Point Average (GPA) of the 8th Semester = ……

Overall Grade Point Average(OGPA) = …… Result = Pass/Fail
Overall Percentage = …….. Division = …….