DEPARTMENT OF BOTANY

UNIVERSITY OF JAMMU

CURRICULUM FRAMEWORK FOR

FOUR-YEAR UNDER GRADUATE (FYUG) PROGRAM IN BOTANY

UNDER **CBCS**

AS PER

National Education Policy–2020

WITH EFFECT FROM THE ACADEMIC YEAR 2022–23

Approved By

Board of Studies in Botany

DEPARTMENT OF BOTANY, UNIVERSITY OF JAMMU, JAMMU

Following courses of study are prescribed for **1st and 2nd semesters** **FYUG** program in the subject of **BOTANY**

under **CBCS** as per **NEP-2020**

SEMESTER	TYPE OF THE COURSE	TITLE OF THE COURSE	COURSE NO.	CREDITS (T-Teaching P- Practical)
FIRST	MAJOR	INTRODUCTION TO MICROBES AND PLANT KINGDOM	UMJBOT101	4 (3T + 1P)
	MINOR	PLANT AND MICROBIAL WORLD	UMIBOT102	4 (3T + 1P)
	MULTIDISCIPLINARY	PLANTS-IMPORTANCE AND PROPAGATION	UMDBOT103	4 (T)
	SKILL ENHANCEMENT	NURSERY AND GARDENING	USEBOT104	2 (1T + 1P)
SECOND	MAJOR	ECONOMIC BOTANY AND PLANT CONSERVATION	UMJBOT201	4 (3T + 1P)
	MINOR	UTILIZATION AND CONSERVATION OF PLANTS	UMIBOT202	4 (3T + 1P)
	MULTIDISCIPLINARY	ENTREPRENEURSHIP IN BOTANY	UMDBOT203	4 (T)
	SKILL ENHANCEMENT	BIOFERTILIZERS	USEBOT204	2 (1T + 1P)

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

INTRODUCTION TO MICROBES AND PLANT KINGDOM
(MAJOR COURSE)

Course No. UMJBOT101 **Max. Marks: 100 (Theory-75, Practical-25)**

	Credits	Contact Hours	Units	Examination			
				Duration (hours)		Weightage (Marks)	
Theory	03	45	I to IV	1½	03	15	60
Practical	01	30	V	1½	3½	10	15

Objectives:

This paper will give an overview of the plant and microbial world to the students and help them understand the interrelationships and evolutionary pathways among them.

Learning outcomes:

The course will acquaint the students with the diversity of microbial and plant kingdom. General life cycle, reproduction and economic importance of most of the groups will be covered. The knowledge will help the students appreciate and tap the economic significance of the major microbial and plant groups.

Unit I: Microbial Diversity

1.1 Microbes-Introduction and significance; hierarchical organization of microbes in living world.

1.2 Microbes-Whittaker's Five Kingdom concept; distribution in soil, air, water and food; economic importance.

1.3 Viruses-Discovery, structure, general account of plant and animal viruses and bacteriophages, concept of lytic and lysogenic cycles.

1.4 Bacteria-Discovery, general characteristics, cell structure and modes of reproduction.

Unit-II: Algal, Fungal and Lichen Diversity

2.1 Algae-Distribution, habitat, thallus organization, cell structure, pigments and reserve food, general reproduction, life cycle and economic importance (in brief).

2.2 Fungi- Occurrence, general characteristics, cell structure, reproduction, life cycle and economic importance (in brief).

2.3 Lichen-Morphology, types and reproduction; economic importance.

2.4 Mycorrhiza-General account, types and significance.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

INTRODUCTION TO MICROBES AND PLANT KINGDOM
(MAJOR COURSE)

Course No. UMJBOT101 **Max. Marks: 100 (Theory-75, Practical-25)**

Unit-III: Cryptogam Diversity

3.1 Bryophytes- Origin, occurrence, thallus structure and general features.
3.2 Bryophytes-Alternation of generations; reproduction and life cycle; ecological and economic importance (in brief).
3.3 Pteridophytes-General features, affinity with bryophytes, occurrence and alternation of generations.
3.4 Pteridophytes-Reproduction, life cycle and economic importance.

Unit-IV: Phanerogam Diversity

4.1 Gymnosperms-Distribution, general characters, reproduction and life cycle.
4.2 Gymnosperms-Affinities and evolutionary significance; economic importance.
4.3 Angiosperms-Occurrence and general features; reproduction and life cycle.
4.4 Angiosperms-Categorization into monocots and dicots; economic and evolutionary significance (in brief).

Unit-V: Practicals

5.1 Study of diversity in thallus forms of algae: Cyanophyceae, Chlorophyceae, Xanthophyceae, Phaeophyceae and Rhodophyceae through temporary mounts, specimens or permanent slides.
5.2 Study of various types of fungi and lichens through temporary mounts or locally available specimens.
5.3 Study of various types of Bryophytes and Pteridophytes using live/ preserved specimens.
5.4 Study of various types of Gymnosperms and monocots and dicots with the help of specimens collected from local areas during field trips.
5.5 Electron micrographs/Models of viruses.
5.6 Gram staining in bacteria.
5.7 Types of Bacteria from temporary/permanent slides/photographs and by Gram staining technique; electron micrographs of bacterial reproduction, Binary Fission and Conjugation.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

INTRODUCTION TO MICROBES AND PLANT KINGDOM
(MAJOR COURSE)

Course No. UMJBOT101 **Max. Marks: 100 (Theory-75, Practical-25)**

Note for paper setters

End Semester University Examination (Total Marks: 60; syllabus to be covered: 100%)

The question paper will have 2 sections. Section 'I' will be compulsory having four questions of 3 marks each and spread over the entire theory syllabus (one from each unit i.e., Units I to IV). The questions will be short answer type having answers not exceeding 50 to 70 words. Section 'II' will have eight long answer type questions, two from each unit. Each question will be of 12 marks. The candidates will be required to answer one question from each unit.

Mid Semester Assessment Test (Total Marks: 15; syllabus to be covered: up to 50%)

Fifteen (15) marks for theory paper in a subject reserved for internal assessment shall have one long answer type question of 7 marks and four short answer type questions of 2 marks each.

Note for distribution of 25 Marks in Practical Examination (based on Unit V).

	I. Internal Assessment (Total Marks: 10)	**Marks**
1.	Attendance	2
2.	Practical Test	5
3.	Daily performance based on practical work done	3
	II. External Assessment (Total Marks: 15)	
1.	External practical examination	10
2.	Viva-voce	5

INTRODUCTION TO MICROBES AND PLANT KINGDOM
(MAJOR COURSE)

Course No. UMJBOT101 **Max. Marks: 100 (Theory-75, Practical-25)**

Suggested Readings

1. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
2. Campbell, N.A., Reece J.B., Urry, L.A., Cain, M.L., Wasserman, S.A. Minorsky, P.V. and Jackson, R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
3. Coulter, J.M. (1851). Morphology of Angiosperms (Morphology of Spermatophytes. Part-II). Nebu press, pp 376.
4. Khan, A.S. (2017). Flowering Plants: Structure and Industrial Products. Wiley; 1st edition, United Kingdom, pp 344.
5. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
6. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
7. Pelczar, M.J. (2001). Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
8. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition.
9. Rashid, A. (1998). An Introduction to Bryophytes. Vikas publishing House, pp 308.
10. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
11. Vanderpoorten, A. and Goffinet, B. (2009). Introduction to Bryophytes. Cambridge University Press, pp 303.
12. Vashistha, P.C., Sinha, A.K. and Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

PLANT AND MICROBIAL WORLD
(MINOR COURSE)

Course No. UMIBOT102 **Max. Marks: 100 (Theory-75, Practical-25)**

	Credits	Contact Hours	Units	Examination			
				Duration (hours)		Weightage (Marks)	
				Mid-semester	End semester	Mid-semester	End semester
Theory	03	45	I to IV	1½	03	15	60
Practical	01	30	V	1½	3½	10	15

Objectives:

This paper will give an overview of the plant and microbial world to the students and help them understand the interrelationships and evolutionary pathways among them.

Learning outcomes:

The course will acquaint the students with the diversity of microbial and plant kingdom. General life cycle, reproduction and economic importance of most of the groups will be covered. The knowledge will help the students appreciate and tap the economic significance of the major microbial and plant groups.

Unit I: Microbial Diversity

1.1 Microbes-Introduction and significance; hierarchical organization of microbes in living world.

1.2 Microbes-Whittaker's Five Kingdom concept; distribution in soil, air, water and food; economic importance.

1.3 Viruses-Discovery, structure, general account of plant and animal viruses and bacteriophages, concept of lytic and lysogenic cycles.

1.4 Bacteria-Discovery, general characteristics, cell structure and modes of reproduction.

Unit-II: Algal, Fungal and Lichen Diversity

2.1 Algae-Distribution, habitat, thallus organization, cell structure, pigments and reserve food, general reproduction, life cycle and economic importance (in brief).

PLANT AND MICROBIAL WORLD
(MINOR COURSE)

Course No. UMIBOT102 **Max. Marks: 100 (Theory-75, Practical-25)**

2.2 Fungi- Occurrence, general characteristics, cell structure, reproduction, life cycle and economic importance (in brief).
2.3 Lichen-Morphology, types and reproduction; economic importance.
2.4 Mycorrhiza-General account, types and significance.

Unit-III: Cryptogam Diversity

3.1 Bryophytes- Origin, occurrence, thallus structure and general features.
3.2 Bryophytes-Alternation of generations; reproduction and life cycle; ecological and economic importance (in brief).
3.3 Pteridophytes-General features, affinity with bryophytes, occurrence and alternation of generations.
3.4 Pteridophytes-Reproduction, life cycle and economic importance.

Unit-IV: Phanerogam Diversity

4.1 Gymnosperms-Distribution, general characters, reproduction and life cycle.
4.2 Gymnosperms-Affinities and evolutionary significance; economic importance.
4.3 Angiosperms-Occurrence and general features; reproduction and life cycle.
4.4 Angiosperms-Categorization into monocots and dicots; economic and evolutionary significance (in brief).

Unit-V: Practicals

5.1 Study of diversity in thallus forms of algae: Cyanophyceae, Chlorophyceae, Xanthophyceae, Phaeophyceae and Rhodophyceae through temporary mounts, specimens or permanent slides.
5.2 Study of various types of fungi and lichens through temporary mounts or locally available specimens.
5.3 Study of various types of Bryophytes and Pteridophytes using live/ preserved specimens.

PLANT AND MICROBIAL WORLD
(MINOR COURSE)

Course No. UMIBOT102 **Max. Marks: 100 (Theory-75, Practical-25)**

5.4 Study of various types of Gymnosperms and monocots and dicots with the help of specimens collected from local areas during field trips.

5.5 Electron micrographs/Models of viruses.

5.6 Gram staining in bacteria.

5.7 Types of Bacteria from temporary/permanent slides/photographs and by Gram staining technique; electron micrographs of bacterial reproduction, Binary Fission and Conjugation.

Note for paper setters

End Semester University Examination (Total Marks: 60; syllabus to be covered: 100%)

The question paper will have 2 sections. Section 'I' will be compulsory having four questions of 3 marks each and spread over the entire theory syllabus (one from each unit i.e., Units I to IV). The questions will be short answer type having answers not exceeding 50 to 70 words. Section 'II' will have eight long answer type questions, two from each unit. Each question will be of 12 marks. The candidates will be required to answer one question from each unit.

Mid Semester Assessment Test (Total Marks: 15; syllabus to be covered: up to 50%)

Fifteen (15) marks for theory paper in a subject reserved for internal assessment shall have one long answer type question of 7 marks and four short answer type questions of 2 marks each.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

PLANT AND MICROBIAL WORLD
(MINOR COURSE)

Course No. UMIBOT102 **Max. Marks: 100 (Theory-75, Practical-25)**

Note for distribution of 25 Marks in Practical Examination (based on Unit V).

I.	**Internal Assessment (Total Marks: 10)**	**Marks**
1.	Attendance	2
2.	Practical Test	5
3.	Daily performance based on practical work done	3
II.	**External Assessment (Total Marks: 15)**	
1.	External practical examination	10
2.	Viva-voce	5

Suggested Readings

1. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
2. Campbell, N.A., Reece J.B., Urry, L.A., Cain, M.L., Wasserman, S.A. Minorsky, P.V. and Jackson, R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
3. Coulter, J.M. (1851). Morphology of Angiosperms (Morphology of Spermatophytes. Part-II). Nebu press, pp 376.
4. Khan, A.S. (2017). Flowering Plants: Structure and Industrial Products. Wiley; 1st edition, United Kingdom, pp 344.
5. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
6. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
7. Pelczar, M.J. (2001). Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
8. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition.
9. Rashid, A. (1998). An Introduction to Bryophytes. Vikas publishing House, pp 308.
10. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali

PLANT AND MICROBIAL WORLD
(MINOR COURSE)

Course No. UMIBOT102 **Max. Marks: 100 (Theory-75, Practical-25)**

International, New Delhi.
11. Vanderpoorten, A. and Goffinet, B. (2009). Introduction to Bryophytes. Cambridge University Press, pp 303.
12. Vashistha, P.C., Sinha, A.K. and Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.

UNIVERSITY OF JAMMU
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BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

PLANTS–IMPORTANCE AND PROPAGATION
(MULTIDISCIPLINARY COURSE)

Course No. UMDBOT103 **Max. Marks: 75**

	Credits	Contact Hours	Units	Examination			
				Duration (hours)		Weightage	
				Mid semester	End semester	Mid semester	End semester
Theory	03	45	I to IV	1½	03	15	60

Objectives:

The course has been framed to familiarize students with the importance of plants for sustenance of our planet in general and mankind in particular. It also aims to educate them about different modes of plant reproduction.

Learning outcomes:

The course will teach the students importance of plants and the diversity of their methods of propagation. Insights gained therein will help them to bring the economically important taxa under effective cultivation.

Unit–I: Plants–An Overview

1.1 Diversity in habit (herb, shrub and tree) and habitat (terrestrial and aquatic) with respect to altitude (temperate, tropical, sub-tropical and alpine).
1.2 Diversity in forms and body organisation.
1.3 Diversity of plant adaptation.
1.4 Concept of evolution and speciation.

Unit–II: Importance of Plants

2.1 Plants and their role in climate stability (soil fertility, prevention of soil erosion, availability of Oxygen, Carbon sequestration, pollution control).
2.2 Plants as source of food (Wheat, Maize, Rice, Mango, Jamun, Rajmah, Apple, Bottlegourd and Fenugreek) – general description, botanical names and parts used.
2.3 Plants as source of fodder (Clover, Oak, Bhimal) and timber (Pine, Deodar, Shisham and Teak) – general description, botanical names and parts used.

PLANTS–IMPORTANCE AND PROPAGATION
(MULTIDISCIPLINARY COURSE)

Course No. UMDBOT103 **Max. Marks: 75**

2.4 Plants as source of medicine (Quinine, Belladona, Sarpgandha and Foxglove), essential oils (Lemon-grass and Lavender) and beverages (Tea and Coffee) **–** general description, botanical names and parts used.

Unit–III: Modes of Vegetative Propagation

3.1 General account of asexual means of reproduction; Concept of Apomixis and its main types.
3.2 Natural and artificial means of vegetative propagation; advantages and limitations.
3.3 Propagation by bulbs, corms, tubers, rhizomes, runners, stolons and suckers – general account.
3.4 Propagation by cutting, layering, grafting and budding **–** basic concepts.

Unit –IV: Modes of Sexual Reproduction

4.1 General account of sexual means of reproduction.
4.2 Structure of flower and its various forms; types of pollination (self-versus cross) mechanisms.
4.3 Fertilization, basic concept of seed and fruit development.
4.4 Seed germination and dormancy; types and methods to break dormancy.

Note for paper setters

End Semester University Examination (Total Marks: 60; syllabus to be covered: 100%)

The question paper will have 2 sections. Section 'I' will be compulsory having four questions of 3 marks each and spread over the entire theory syllabus (one from each unit i.e., Units I to IV). The questions will be short answer type having answers not exceeding 50 to 70 words. Section 'II' will have eight long answer type questions, two from each unit. Each question will be of 12 marks. The candidates will be required to answer one question from each unit.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

PLANTS–IMPORTANCE AND PROPAGATION
(MULTIDISCIPLINARY COURSE)

Course No. UMDBOT103 **Max. Marks: 75**

Mid Semester assessment Test (Total Marks: 15; syllabus to be covered: up to 50%)

Fifteen (15) marks for theory paper in a subject reserved for internal assessment shall have one long answer type question of 7 marks and four short answer type questions of 2 marks each.

Suggested readings

1. Bhojwani, S.S., Bhatnagar, S.P. and Dantu, P.K. (2018). The embryology of angiosperms. (6th edition). Vikas Publishing House, Noida.
2. Coulter, J.M. (1851). Morphology of Angiosperms (Morphology of Spermatophytes. Part-II). Nebu press, pp 376.
3. Johri, B.M. and Srivastava, P.S. (2013). Reproductive Biology of Plants. Springer Science and Business Media, pp 320.
4. Khan, A.S. (2017). Flowering Plants: Structure and Industrial Products. Wiley; 1st edition, United Kingdom, pp 344.
5. Kochhar, S.L. (2016). Economic Botany. Cambridge University Press, pp 680.
6. Nanda, K.K. and Kochar V.K. (1985). Vegetative Propagation of Plants. Kalyani Publishers, New Delhi.
7. Ramawat, K.G. et al. (2014). Reproductive Biology of Plants. CRC Press, Boca Raton.
8. Sadhu, M.K. (1999). Plant Propagation. New Age International (P) Limited Publishers, New Delhi.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

NURSERY AND GARDENING
(SKILL ENHANCEMENT COURSE)

Course No. USEBOT104 **Max. Marks: 50 (Theory-25, Practical-25)**

	Credits	Contact Hours	Units	Examination			
				Duration (hours)		Weightage (Marks)	
				Mid semester	End semester	Mid semester	End semester
Theory	01	15	I to II	½	2½	05	20
Practical	01	30	III	01	2½	05	20

Objectives:

The course aims to make students understand the theoretical and practical details of nursery and gardening. Knowledge so gained will provide them with the means for their self-employment and also of others.

Learning outcomes:

The students will be able to distinguish and choose the plant species amenable for nursery and gardening. They can develop their own nursery for livelihood and marketing purposes. The course will also equip the students with the basic skill needed to design and lay gardens.

Unit-I: Introduction to Nursery and Gardening

1.1 Definition and types of nurseries; physical resources for nurseries.
1.2 Selection of nursery site, ecological conditions, important nursery operations.
1.3 Definition and components of gardens, types of gardening (landscape and home gardening).
1.4 Scope and objective of gardening; garden landscaping with specific reference to Kew Botanical garden, AJC Bose Indian Botanic Garden, Kolkata and Lal Bagh Botanical Garden, Bangalore.

Unit-II: Plant Propagation Methods

2.1 Seed dormancy – causes and methods of breaking it; seed germination, types and factors affecting it.
2.2 Vegetative propagation, artificial and natural methods; Concept of soilless cultivation with special reference to aeroponics and hydroponics.

NURSERY AND GARDENING
(SKILL ENHANCEMENT COURSE)

Course No. USEBOT104 **Max. Marks: 50 (Theory-25, Practical-25)**

2.3 Concept of micro-propagation, hardening, packaging, transport and marketing of nursery plants; Scope and importance of plant propagation in nurseries.
2.4 Propagation structures: Mist chambers, green houses, glass houses, polyhouses and shade houses.

Unit-III: Practicals

3.1 Equipments and implements used in nurseries and gardening.
3.2 Gardening operations – Soil structure, bed preparation, fertigation and irrigation.
3.3 Weed management, water management, drainage, trimming, pruning and thinning.
3.4 Sowing/ raising of seeds and seedlings; transplanting of seedlings.
3.5 Potting, repotting, depotting and mulching.
3.6 Demonstration of techniques of vegetative means of propagation.
3.7 Preparation of material for hydroponics and aeroponics.
3.8 Field trip to Botanical garden of University of Jammu and important locally available nurseries.
3.9 Demonstration of formation of vertical gardens.

Note for paper setters

End Semester University Examination (Total Marks: 20; syllabus to be covered: 100%)

The question paper will have 2 sections. Section 'I' will be compulsory having four questions of 2½ marks each and spread over the entire theory syllabus (two from each unit i.e., Units I and II). The questions will be short answer type having answers not exceeding 30 to 60 words. Section 'II' will have four long answer type questions, two from each unit. Each question will be of 5 marks. The candidates will be required to answer one question from each unit.

Mid Semester Assessment Test (Total Marks: 5; syllabus to be covered: up to 50%)

Five (5) marks for theory paper in a subject reserved for internal assessment shall have ten (10) questions distributed as 5 MCQs, 3 fill in the blanks and 2 one word answer type questions. All the questions are compulsory and each question carries ½ mark.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP–2020)
UG SEMESTER–I
(For the examinations to be held in the years December 2022, 2023, 2024)

NURSERY AND GARDENING
(SKILL ENHANCEMENT COURSE)

Course No. USEBOT104 **Max. Marks: 50 (Theory-25, Practical-25)**

Note for distribution of 25 Marks in Practical Examination (based on Unit III).

I.	**Internal Assessment (Total Marks: 5)**	**Marks**
1.	Attendance	1
2.	Practical Test	2
3.	Daily performance based on practical work done	2
II.	**External Assessment (Total Marks: 20)**	
1.	External practical examination	15
2.	Viva-voce	5

Suggested readings

1) Acquaah, G. (2009). Horticulture, Principles and Practices (4th edition). Pearson Publisher, PrenticeHall.
2) Bose, T.K and Mukerjee, D. (1977). Gardening in India. New Delhi Oxford & IBH Pub. Co. Pvt. Ltd.
3) Bose, T.K., Singh, L.J., Sandhu, M.K. and Maity, T.K. (2015). Ornamental plants and Garden design in Tropics and Subtropics (Vol 1 & 2). Daya Publishing House; A division of Astral International Pvt. Ltd.
4) Brukell, C. (2007). Encyclopedia of Gardening. Dorling Kindersley Ltd.
5) Hartman, H.T. (1959). Plant Propagation–Principles and Practices by Prentice. Hall International: London.
6) Kumar, N. (2010). Introduction to Horticulture (7th edition). Oxford & IBH Publishing Company Pvt.Ltd.
7) Rao, M.B. (2005). Textbook of Horticulture (2nd edition). Macmillan India Ltd.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

ECONOMIC BOTANY AND PLANT CONSERVATION
(MAJOR COURSE)

Course No. UMJBOT201 **Max. Marks: 100 (Theory-75, Practical-25)**

	Credits	Contact Hours	Units	Examination			
				Duration (hours)		Weightage (Marks)	
				Mid semester	End semester	Mid semester	End semester
Theory	03	45	I to IV	1½	03	15	60
Practical	01	30	V	1½	3½	10	15

Objectives:

This course has been framed for enhancing the knowledge of students about the important plant resources and their sustainable utilization. Understanding the origin and domestication of plants will help the students appreciate the need to conserve.

Learning outcome:

The course will familiarize students with origin and utilization of plants. The students will be able to understand and appreciate the value of plants as sources of food, fodder, spices and drugs. The students will become aware of the need to conserve, build confidence among them towards sustainable use of plants and enable them to design strategies for their effective conservation.

Unit-I: Plants and civilization

1.1 Origin of agriculture-time and places of origin.
1.2 Centre of origin and domestication of cultivated plants; Vavilov's and de Candolle's concept.
1.3 Forest Resources – sustainable utilization and development.
1.4 Ethnobotany-role of plants in migratory and settled tribes.

Unit- II: Utilization of plants-I

2.1 Food and fibre plants-Botany and utility of Wheat, Maize, Rice, Cotton and Jute.
2.2 Pulses (Black mung, Rajmash and Kulth) – distribution and cultivation in India and food value.

ECONOMIC BOTANY AND PLANT CONSERVATION
(MAJOR COURSE)

Course No. UMJBOT201 **Max. Marks: 100 (Theory-75, Practical-25)**

2.3 Spices and condiments – Botany and utility of Cumin, Asafoetida, Fennel, Coriander, Cloves, Cinnamon, Ginger, Turmeric and Cardamom.

2.4 Vegetables and fruits-Botany and utility of Turnip, Bitter gourd, Lady Finger, Apple Mango and Walnut.

Unit-III: Utilization of plants-II

3.1 Vegetable oils-Botany and utility of Sunflower and Mustard.

3.2 Source and utility of resins, tannins, gums, rubber and natural dyes.

3.3 Non-wood forest products: distribution and utility of bamboos and rattans, raw materials for paper making and the processing procedure involved.

3.4 Medicinal plants-General account; concept of natural and synthetic drugs; roots and seeds as sources of drugs; psychoactive drugs from Hemp and poppy and their mode of action (in brief).

Unit –IV: Extinction and plant conservation

4.1 IUCN categories of plants, land races of crops, methods of categorization.

4.2 Plant extinction: causes and preventive measures.

4.3 Principles of conservation, in-situ and ex-situ conservation strategies, CBD, international agreement to protect species and habitat.

4.4 Habitat protection, sacred groves and indigenous knowledge (IK) for the conservation of the plant species.

Unit–V: Practicals

5.1 Determination of the percentage of conservation value of soil and water for herbaceous community.

5.2 Determination of seed viability of medicinal plants by tetrazolium chloride test and its correlation with threat status.

5.3 Comparison of the germplasm diversity in economic traits of locally available vegetables.

5.4 Determination of the percentage of species association using Jaccard's index.

ECONOMIC BOTANY AND PLANT CONSERVATION
(MAJOR COURSE)

Course No. UMJBOT201 **Max. Marks: 100 (Theory-75, Practical-25)**

5.5 Pharmacognostic details (morphology, anatomy and organoleptic characters) of the locally available crude drugs of Indian system of medicine.
5.6 Determination of the presence of tannins and flavonoids in tea samples locally available in the market.
5.7 Comparison of the percentage of protein bodies in the locally available pulses.
5.8 Preparation of temporary mount using iodine solution as stain and compare type, shape, structure, and size of starch granules in the locally available plant material.
5.9 Determination of the presence of phlobatannins, flavonoids, steroids and glycosides in the locally available drug samples.
5.10 Preparation of soap from vegetable oil.
5.11 Extraction and characterization of the plant fibres from provided plant material.

Note for paper setters

End Semester University Examination (Total Marks: 60; syllabus to be covered: 100%)

The question paper will have 2 sections. Section 'I' will be compulsory having four questions of 3 marks each and spread over the entire theory syllabus (one from each unit i.e. Units I to IV). The questions will be short answer type having answers not exceeding 50 to 70 words. Section 'II' will have eight long answer type questions, two from each unit. Each question will be of 12 marks. The candidates will be required to answer one question from each unit.

Mid Semester Assessment Test (Total Marks: 15; syllabus to be covered up to: 50%)

Fifteen (15) marks for theory paper in a subject reserved for internal assessment shall have one long answer type question of 7 marks and four short answer type questions of 2 marks each.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

ECONOMIC BOTANY AND PLANT CONSERVATION
(MAJOR COURSE)

Course No. UMJBOT201 **Max. Marks: 100 (Theory-75, Practical-25)**

Note for distribution of 25 Marks in Practical Examination (based on Unit V)

I.	**Internal Assessment (Total Marks: 10)**	**Marks**
1.	Attendance	2
2.	Practical Test	5
3.	Daily performance based on practical work done	3
II.	**External Assessment (Total Marks: 15)**	
1.	External practical examination	10
2.	Viva-voce	5

Suggested readings:

1. Akeroyd, J. and Jackson, P.W. (1995). A Handbook of Botanic Garden and Reintroduction of Plants to the Wild. Botanic garden conservation Union, UK.
2. Chowdhery, H.J. and Murty, S.K. (2000). Plant Diversity and Conservation in India – an overview. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Directory of Indian Wetlands (1993). W.W.F. India, New Delhi and AWB, Kuala Lumpur.
4. Gadgil, M. and Guha, R. (1996). Ecology and Equality: Use and Abuse of Nature in Contemporary India. Penguin, New Delhi.
5. Heywood, V. (1995). Global Biodiversity Assessment. United National Environment Programme. Cambridge University Press, Cambridge, U.K.
6. Haunter, M.L. and Gibbs, J. (2007). Fundamentals of Conservation Biology. 3rd Edn. Blackwell Publishing, U.K.
7. Kochhar, S.L. (2016). Economic Botany. Cambridge University Press, pp 680.
8. Kothari, A. (1997). Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.
9. Meffe, G.K. and Ronald, C.R. (1994). Principles of Conservation Biology. Sinauer Associates. INC Publishers, USA.
10. Primack, R.E. (2006). Essentials of Conservation Biology. 4th Edn. Sinauer Associates, U.S.A.
11. Rodgers, N.A. and Panwar, H.S. (1988). Planning a Wildlife Protected Area Network in India. Vol. I. The Report Wildlife Institute of India, Dehradun.

ECONOMIC BOTANY AND PLANT CONSERVATION
(MAJOR COURSE)

Course No. UMJBOT201 **Max. Marks: 100 (Theory-75, Practical-25)**

12. Swaminathan, M.S. and Kocchar, S.L. (1989). Plants and Society. MacMillan Publication Ltd., London.
13. Vardhana, R. (2009). Economic Botany. Sarup Book Publishers Pvt. Ltd., New Delhi.
14. Walter, K.S. and Gillett, H.J. (1998). 1997 IUCN Red List of Threatened Plants. IUCN, the World Conservation Union, IUCN, Gland. Switzerland and Cambridge, U.K.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

UTILIZATION AND CONSERVATION OF PLANTS
(MINOR COURSE)

Course No. UMIBOT202 **Max. Marks: 100 (Theory-75, Practical-25)**

	Credits	Contact Hours	Units	Examination			
				Duration (hours)		Weightage (Marks)	
				Mid semester	End semester	Mid semester	End semester
Theory	03	45	I to IV	1½	03	15	60
Practical	01	30	V	1½	3½	10	15

Objectives:

This course has been framed for enhancing the knowledge of students about the important plant resources and their sustainable utilization. Understanding the origin and domestication of plants will help the students appreciate the need to conserve.

Learning outcome:

The course will familiarize students with origin and utilization of plants. The students will be able to understand and appreciate the value of plants as sources of food, fodder, spices and drugs. The students will become aware of the need to conserve, build confidence among them towards sustainable use of plants and enable them to design strategies for their effective conservation.

Unit-I: Plants and civilization

1.1 Origin of agriculture-time and places of origin.
1.2 Centre of origin and domestication of cultivated plants; Vavilov's and de Candolle's concept.
1.3 Forest Resources – sustainable utilization and development.
1.4 Ethnobotany-role of plants in migratory and settled tribes.

Unit- II: Utilization of plants-I

2.1 Food and fibre plants-Botany and utility of Wheat, Maize, Rice, Cotton and Jute.
2.2 Pulses (Black mung, Rajmash and Kulth) – distribution and cultivation in India and food value.
2.3

UTILIZATION AND CONSERVATION OF PLANTS
(MINOR COURSE)

Course No. UMIBOT202 **Max. Marks: 100 (Theory-75, Practical-25)**

2.4 Spices and condiments – Botany and utility of Cumin, Asafoetida, Fennel, Coriander, Cloves, Cinnamon, Ginger, Turmeric and Cardamom.

2.5 Vegetables and fruits-Botany and utility of Turnip, Bitter gourd, Lady Finger, Apple Mango and Walnut.

Unit-III: Utilization of plants-II

3.1 Vegetable oils-Botany and utility of Sunflower and Mustard.

3.2 Source and utility of resins, tannins, gums, rubber and natural dyes.

3.3 Non-wood forest products: distribution and utility of bamboos and rattans, raw materials for paper making and the processing procedure involved.

3.4 Medicinal plants-General account; concept of natural and synthetic drugs; roots and seeds as sources of drugs; psychoactive drugs from Hemp and poppy and their mode of action (in brief).

Unit –IV: Extinction and plant conservation

4.1 IUCN categories of plants, land races of crops, methods of categorization.

4.2 Plant extinction: causes and preventive measures.

4.3 Principles of conservation, in-situ and ex-situ conservation strategies, CBD, international agreement to protect species and habitat.

4.4 Habitat protection, sacred groves and indigenous knowledge (IK) for the conservation of the plant species.

Unit–V: Practicals

5.1 Determination of the percentage of conservation value of soil and water for herbaceous community.

5.2 Determination of seed viability of medicinal plants by tetrazolium chloride test and its correlation with threat status.

5.3 Comparison of the germplasm diversity in economic traits of locally available vegetables.

5.4 Determination of the percentage of species association using Jaccard's index.

UTILIZATION AND CONSERVATION OF PLANTS
(MINOR COURSE)

Course No. UMIBOT202 **Max. Marks: 100 (Theory-75, Practical-25)**

5.5 Pharmacognostic details (morphology, anatomy and organoleptic characters) of the provided crude drugs of Indian system of medicine.
5.6 Determination of the presence of tannins and flavonoids in the provided tea samples.
5.7 Comparison of the percentage of protein bodies in the provided pulses.
5.8 Preparation of temporary mount using iodine solution as stain and compare type, shape, structure, and size of starch granules in the provided plant material.
5.9 Determination of the presence of phlobatannins, flavonoids, steroids and glycosides in the provided drug samples.
5.10 Preparation of soap from vegetable oil.
5.11 Extraction and characterization of the plant fibres from provided plant material.

Note for paper setters

End Semester Qualifying Examination (Total Marks: 60; syllabus to be covered: 100%)

The question paper will have 2 sections. Section 'I' will be compulsory having four questions of 3 marks each and spread over the entire theory syllabus (one from each unit i.e. Units I to IV). The questions will be short answer type having answers not exceeding 50 to 70 words. Section 'II' will have eight long answer type questions, two from each unit. Each question will be of 12 marks. The candidates will be required to answer one question from each unit.

Mid Semester Assessment Test (Total Marks: 15; syllabus to be covered up to: 50%)

Fifteen (15) marks for theory paper in a subject reserved for internal assessment shall have one long answer type question of 7 marks and four short answer type questions of 2 marks each.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

UTILIZATION AND CONSERVATION OF PLANTS
(MINOR COURSE)

Course No. UMIBOT202 **Max. Marks: 100 (Theory-75, Practical-25)**

Note for distribution of 25 Marks in Practical Examination (based on Unit V)

	I. Internal Assessment (Total Marks: 10)	**Marks**
1.	Attendance	2
2.	Practical Test	5
3.	Daily performance based on practical work done	3
	II. External Assessment (Total Marks: 15)	
1.	External practical examination	10
2.	Viva-voce	5

Suggested readings:

1. Akeroyd, J. and Jackson, P.W. (1995). A Handbook of Botanic Garden and Reintroduction of Plants to the Wild. Botanic garden conservation Union, UK.
2. Chowdhery, H.J. and Murty, S.K. (2000). Plant Diversity and Conservation in India – an overview. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Directory of Indian Wetlands (1993). W.W.F. India, New Delhi and AWB, Kuala Lumpur.
4. Gadgil, M. and Guha, R. (1996). Ecology and Equality: Use and Abuse of Nature in Contemporary India. Penguin, New Delhi.
5. Heywood, V. (1995). Global Biodiversity Assessment. United National Environment Programme. Cambridge University Press, Cambridge, U.K.
6. Haunter, M.L. and Gibbs, J. (2007). Fundamentals of Conservation Biology. 3rd Edn. Blackwell Publishing, U.K.
7. Kothari, A. (1997). Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.
8. Meffe, G.K. and Ronald, C.R. (1994). Principles of Conservation Biology. Sinauer Associates. INC Publishers, USA.
9. Primack, R.E. (2006). Essentials of Conservation Biology. 4th Edn. Sinauer Associates, U.S.A.
10. Rodgers, N.A. and Panwar, H.S. (1988). Planning a Wildlife Protected Area Network in India. Vol. I. The Report Wildlife Institute of India, Dehradun.

UTILIZATION AND CONSERVATION OF PLANTS
(MINOR COURSE)

Course No. UMIBOT202 **Max. Marks: 100 (Theory-75, Practical-25)**

11. Swaminathan, M.S. and Kocchar, S.L. (1989). Plants and Society. MacMillan Publication Ltd., London.
12. Walter, K.S. and Gillett, H.J. (1998). 1997 IUCN Red List of Threatened Plants. IUCN, the World Conservation Union, IUCN, Gland. Switzerland and Cambridge, U.K.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

ENTREPRENEURSHIP IN BOTANY
(MULTIDISCIPLINARY COURSE)

Course No. UMDBOT203 **Max. Marks: 75**

	Credits	Contact Hours	Units	Examination			
				Duration (hours)		Weightage (Marks)	
				Mid semester	End semester	Mid semester	End semester
Theory	03	45	I to IV	1½	03	15	60

Objectives:

The course has been designed to make students of different disciplines understand, appreciate and value the significance plant resources hold in our lives and welfare. It will also motivate them to process, propagate and value-add plant products and establish them into small scale industrial units.

Learning outcome:

This course exposes students to the practices used for growing, multiplying, value adding and maintaining economically important plant species. Knowledge acquired thereof will help them in setting up their own small business enterprises.

Unit–I: Food and fodder

1.1 Essential components of human nutrition; concept of human disorders due to nutritional deficiencies, concept of rabi (Wheat) and kharif (Rice) crops.

1.2 Cereals- Rice and Wheat, nutritional value, agro-technology, products and long term storage.

1.3 Legumes- Pea and Soybean, nutritional value, agro-technology, products and long term storage.

1.3.1 Fodder crops- types (conserved forage, compound feed, crop residues, freshly cut forage) and their storage.

Unit–II: Horticulture, floriculture and MAP industry

2.1 Fruits- types, nutritional value, preservation and storage; Agro-technology and market trends of Mango and Amla.

ENTREPRENEURSHIP IN BOTANY
(MULTIDISCIPLINARY COURSE)

Course No. UMDBOT203 **Max. Marks: 75**

2.2 Flowers - economic importance (decorative, medicinal, aromatic, food); Agro-technology and market trends of Gladiolus, Lavender and Marigold.
2.3 Medicinal and Aromatic Plants (MAPs)-general account; agro-technology, market trends and economics of Ashwagandha and Safed muesli.
2.4 Cultivation, agro-technology and economics of essential oils (Lemon grass and Rose).

Unit–III: Vegetable oil and sugar industry

3.1 Composition and uses of vegetable oils (edible and medicinal).
3.2 Sunflower and mustard- agro-technology, storage and uses.
3.3 Extraction and refining of vegetable oils (oil expeller, degumming, bleaching and hydrogenation).
3.4 Sugarcane and Sugarbeet- agro-technology, extraction and economic importance of sugar.

Unit–IV: Plant fibres, natural dyes and paper industry

5.1 Plant fibres-types; agro-technology (Cotton and Agave) and extraction of fibres.
5.2 Natural dyes- types, agro-technology (Henna and Safflower) and extraction of dye.
5.3 Dyeing with natural dyes (process, colour combinations), dye recipes- flower, leaves, bark, and roots.
5.4 Paper industry - sources and processes (mechanical and chemical).

Note for paper setters

End Semester University Examination (Total Marks: 60; syllabus to be covered: 100%)

The question paper will have 2 sections. Section 'I' will be compulsory having four questions of 3 marks each and spread over the entire theory syllabus (one from each unit i.e., Units I to IV). The questions will be short answer type having answers not exceeding 50 to 70 words. Section 'II' will have eight long answer type questions, two from each unit. Each question will be of 12 marks. The candidates will be required to answer one question from each unit.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

ENTREPRENEURSHIP IN BOTANY
(MULTIDISCIPLINARY COURSE)

Course No. UMDBOT203 **Max. Marks: 75**

Mid Semester Assessment Test (Total Marks: 15; syllabus to be covered up to: 50%)

Fifteen (15) marks for theory paper in a subject reserved for internal assessment shall have one long answer type question of 7 marks and four short answer type questions of 2 marks each.

Suggested readings

1. Bedi, Y.S., Dutt, H.C. and Kaur, H. (2011). Plants of Indian System of Medicine (Vol. I &II). Lambert Academic Publishing, Germany.
2. Bose, T.K. and Som, M.G.V. (1986). Vegetable crops in India. Naya Prokash, Calcutta
3. Bose, T.K. (1985). Fruits of India tropical and subtropical. Naya Prokash, Calcutta.
4. Chandel, K.P.S., Shukla, G. and Sharma, N. (1996). Biodiversity in Medicinal and Aromatic Plants in India- Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
5. Furry, S.M. and Viemont, V.M. (1935). Home Dyeing with Natural Dyes. Thresh Publications. California.
6. Hanson, H., Borlaug, N.E. and Anderson, R.G. (1982). Wheat in the Third World. Westbiew Press, Colorado.
7. Jadhav, D. (2009). Medicinal Plants of India. Vol. 1-3. Scientific Publishers, India.
8. NIIR Board (2004).Cultivation of Fruits, Vegetables and Floriculture. NIIR.
9. JindalKent, N.L. (1983). Technology of Cereals (3rd Edn). Pergamon Press, Oxford.
10. Kochar, S.L. (2009). Economic Botany in the Tropics. 3rd Edn. MacMillan Publishers Ltd.
11. Maiti, R.K. and Singh R.K. (2006). An Introduction to Modern Economic Botany. Agrobios (India).
12. Metcalfse, D.S. and Elkins, D.M. (1980). Crop Production: Principles and Practices (IV ed.). Macmillan Publishing Co. Inc. New York.
13. Pradhan, S. (1995). Economic Botany. Har Anand Publication, New Delhi.

ENTREPRENEURSHIP IN BOTANY
(MULTIDISCIPLINARY COURSE)

Course No. UMDBOT203 **Max. Marks: 75**

14. Radhakrishnan, T., Anandaraja, N., Ramasubramanian, M., Nirmala, L. and Israel, M.T. (2009). Traditional Agricultural Practices: Applications and Technical Implementations. New India Publishing Agency, India.
15. Sharma, O.P. (1996). Hill's Economic Botany. Tata McGraw Hill's, Noida.
16. Singh, R. (1969). Fruits. National Book Trust, India.
17. Vardhana, R. (2009). Economic Botany. Sarup Book Publishers Pvt. Ltd., New Delhi.
18. Verma, V. (2009). Textbook of Economic Botany. Ane Books Pvt. Ltd, India.
19. West, R.B. (1999). Practical Gardening in India. Discovery publishing House, New Delhi.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

BIO FERTILIZERS
(SKILL ENHANCEMENT COURSE)

Course No. USEBOT204 **Max. Marks: 50 (Theory-25, Practical-25)**

	Credits	Contact Hours	Units	Examination			
				Duration (hours)		Weightage (Marks)	
				Mid semester	End semester	Mid semester	End semester
Theory	01	30	I to IV	½	2½	5	20
Practical	01	15	V	1	2½	5	20

Objectives:

The course introduces the students to the world of bio fertilizers which is quite relevant in the face of chemical fertilizers ruining the fertility of our agricultural fields. Bio fertilizers are harmless, replenish the soils and maintain their fertility over long periods of time. Therefore, a course on their types, preparation, and importance is the need of the hour.

Learning outcome:

The students will learn about different microbial sources of bio fertilizers. They will understand the role of nitrogen fixing organisms in soil fertility and will be practically trained to make Bio fertilizers. This in turn will enable them to start their own enterprise of a bio fertilizer brand.

Unit–I: Introduction to bio fertilizers

1.1 Bio fertilizers: definition, different sources, importance and comparison with conventional fertilizers.
1.2 Biological nitrogen fixation, symbiotic and asymbiotic.
1.3 General account of the microbes commonly used as bio fertilizers.
1.4 Rhizobium- infection and nodulation, isolation and mass multiplication.

Unit–II: Common bio fertilizers and nitrogen fixers

2.1 Azospirillum and Azotobacter: isolation, important characteristics and mass multiplication.
2.2 Manures: definition, types and their importance with special reference to green manure.
2.3 Cyanobacteria: cell structure, forms and characteristic features.
2.4 Heterocyst as a site of nitrogen fixation and importance of Nitrogenase; role of Cyanobacteria and Azolla in rice cultivation.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

BIO FERTILIZERS
(SKILL ENHANCEMENT COURSE)

Course No. USEBOT204 **Max. Marks: 50 (Theory-25, Practical-25)**

Unit–III: Practicals

3.1 Study the root system of leguminous plants.
3.2 Isolation of Rhizobium from root nodules of legumes.
3.3 Collection of Cyanobacteria and Azolla from rice fields.
3.4 Study of cell structure of Cyanobacteria.
3.5 Study the morphology of Azolla.
3.6 Isolation of Anabaena from coralloid roots of Cycas.
3.7 Study of heterocyst from Anabaena and Nostoc.
3.8 Demonstration of bio fertilizer preparation.
3.9 Preparation of farmyard manure (FMY).
3.10 Vermi compost preparation.

Note for paper setters

End Semester University Examination (Total Marks: 20; syllabus to be covered: 100%)

The question paper will have 2 sections. Section 'I' will be compulsory having four questions of 2½ marks each and spread over the entire theory syllabus (i.e., Units I and II; two from each unit). The questions will be short answer type having answers not exceeding 30 to 60 words. Section 'II' will have four long answer type questions, two from each unit. Each question will be of 5 marks. The candidates will be required to answer one question from each unit.

Mid Semester Assessment Test (Total Marks: 5; syllabus to be covered: up to 50%)

Five (5) marks for theory paper in a subject reserved for internal assessment shall have ten (10) questions distributed as 5 MCQs, 3 fill in the blanks and 2 one word answer type questions. All the questions are compulsory and each question carries ½ marks.

UNIVERSITY OF JAMMU
Syllabus for FYUG Program in
BOTANY (under CBCS as per NEP-2020)
UG SEMESTER–II
(For the examinations to be held in the years May 2023, 2024, 2025)

BIO FERTILIZERS
(SKILL ENHANCEMENT COURSE)

Course No. USEBOT204 **Max. Marks: 50 (Theory-25, Practical-25)**

Note for distribution of 25 Marks in Practical Examination (based on Unit III)

	I. Internal Assessment (Total Marks: 5)	**Marks**
1.	Attendance	1
2.	Practical Test	2
3.	Daily performance based on practical work done	2
II.	**External Assessment (Total Marks: 20)**	
1.	External practical examination	15
2.	Viva-voce	5

Suggested Readings

1. Bartha, A. (1998). Microbial Ecology: Fundamentals and applications. Benjamin/ Cummings, (4th edition).
2. Bhojiya, A. A., Jain, D. and Joshi, A. (2019). Manual on Bio fertilizer Research (Laboratory to Commercial Production) Apex Publishing House.
3. Das, D.K. (2002). Introduction to Soil Science. Kalyani Publisher 3rd edition.
4. Diaz, L.F., Bertoldi, M. and de Bidlingmaier, W. (2007). Compost Science and Technology, Elsevier, New York.
5. Gaur, A.C. (1990). Phosphate Solubilities, Micro-organizms and Bio fertilizers.. Oxfordand IBH Publishing Co. New Delhi.
6. Kolay, A. K. (2007). Handbook of Manures and Fertilizers. Atlantic Publisher.
7. Mukerjee, N. and Ghosh, T.K. (1998). Agricultural Microbiology, Kalyani Publisher, NewDelhi.
8. Mukerjee, S.K. (2006). An Introduction to Soil Science. Tata Mc graw Hills ICAR.
9. NIIR Board (2012). The Complete Technology Book on Bio fertilizer and Organic Farming (2nd Revised Edition). NIIR Project Consultancy Services.
10. Russel, E. (2010). Soil Conditions and Plant Growth, Nabu Press Publisher.
11. Sathe, T.V. (2004). Vermiculture and organic Farming. Daya Publishers.

BIO FERTILIZERS
(SKILL ENHANCEMENT COURSE)

Course No. USEBOT204 **Max. Marks: 50 (Theory-25, Practical-25)**

12. Subbha Rao, W.S. (1982). Bio fertilizers in Agriculture and Forestry. Oxford and IBH Publishing Co., New Delhi.
13. Subha Rao, N.S. (2000). Soil Microbiology, Oxford & IBH Publishers, New Delhi.
14. Tandon, H.L.S. (1992). Fertilizers, Organic Manures, Recyclable Wastes and Biofertilizers. Fertilizer Development and Consultation Organization, New Delhi.
15. Tandon, H.L.S. (2011). Bio fertilizers and Organic Fertilizers. Fertilizer Development and Consultation Organization, New Delhi.
16. Tate, R.L. (2012). Soil Microbiology (Second edition). Wiley India Pvt Ltd; pp 532.
17. Vayas,S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming Akta Prakashan, Nadiad
18. Yadav, A.N. (2021). Production Technology for Bio agents and Bio fertilizers-A Laboratory Manual. Eternal University, Himachal Pradesh.
19. Rai M.K. (2005). Handbook of Microbial Bio fertilizers. The Haworth Press Inc., New York.