Department of Plant Pathology
Faculty of Agricultural Sciences
University of the Punjab, Lahore
Course Outline

Programme	B.Sc. (Hons.) Agriculture (Plant Pathology) 4 Year program	**Course Code**	**PP-302**	**Credit Hours**	3(2-1)
Course Title	**Beneficial microorganisms for sustainable agriculture**				

Course Introduction

In this course, we will explore the pivotal role that microorganisms play in enhancing agricultural productivity while promoting environmental sustainability. Throughout our journey, we will delve into the diverse functions of beneficial microbes such as nitrogen fixation, nutrient cycling, disease suppression, and soil remediation. By understanding their mechanisms and interactions with plants, we will uncover how these tiny allies can significantly reduce the reliance on chemical inputs, mitigate environmental impact, and foster resilient agricultural systems. Through a combination of theoretical insights and practical applications, students will gain a comprehensive understanding of harnessing microbial power to address the challenges of modern agriculture sustainably.

Learning Outcomes

On the completion of the course, the students will:

1. Students will gain knowledge about the diversity of beneficial microorganisms such as bacteria, fungi, and protozoa that contribute to soil health and plant growth.
2. Students will explore the role of beneficial microorganisms in enhancing soil fertility, nutrient cycling, and overall ecosystem health in agricultural settings.
3. Students will learn about the methods and benefits of using microbial inoculants (such as biofertilizers and biopesticides) in agricultural practices to promote sustainable and environmentally friendly farming.
4. Students will gain practical skills in the application and management of beneficial microorganisms in agricultural systems, including techniques for inoculant production, application timing, and integration with conventional farming practices.
5. Students will develop critical thinking skills to assess the efficacy and limitations of using beneficial microorganisms in different agroecological contexts, considering factors such as soil type, climate, and crop species.

Course Content		Assignments/Readings
Week 1	**<u>THEORY</u>** **Unit-I** 1.1 Introduction to beneficial microorganisms	Kumar, A., M. Bilal, G. Santoya, J.S. Panwar, 2024. Biocontrol Agents for Improved Agriculture

	1.1.2 different classes/groups of beneficial microorganisms 1.1.3 General introduction of role of beneficial microorganisms in sustainable agriculture	(Plant and Soil Microbiome) 1st Edition. Academic Press.
	PRACTICAL Isolation techniques for beneficial microorganisms from diverse sources (media preparation, sterilization and inoculation)	**Reading** Internet PowerPoint slides And research articles
Week 2	**THEORY** **Unit-II** 2.1 Role of microorganisms in bioremediation and biodegradation of agricultural waste/byproducts 2.1.1 Introduction to Bioremediation and Biodegradation 2.1.2 Types and sources of agricultural waste and byproducts 2.1.3 Importance of managing agricultural waste 2.1.4 Microbial diversity, functionality and mechanisms and factors affecting bioremediation and biodegradation	Liong, M.T., 2015. Beneficial Microorganisms in Agriculture, Aquaculture and Other Areas (Vol. 29). Springer. Cham
	PRACTICAL Identification of beneficial fungi isolated from diverse sources	**Reading** Internet PowerPoint slides And research articles
Week 3	**THEORY** **Unit-III** 3.1 Role of microorganisms in bioremediation and biodegradation of industrial waste/byproducts 3.1.2 Types and sources of industrial waste and byproducts 2.1.3 Importance of managing industrial waste 2.1.4 Microbial diversity, functionality and mechanisms and factors affecting bioremediation	Liong, M.T., 2015. Beneficial Microorganisms in Agriculture, Aquaculture and Other Areas (Vol. 29). Springer. Cham

	and biodegradation	
	PRACTICAL Identification of beneficial bacteria including nitrogen fixing bacteria through various biochemical tests and stainings.	**Reading** Internet PowerPoint slides And research articles
Week 4	**THEORY** **Unit-IV** 4.1 Use of microorganisms (bacteria, cynobacteria, nematodes and fungi inclusive of mycorrhizae) in bio-geochemical cycling 4.1.1 Introduction to bio-geochemical cycling 4.1.2 Role of bacteria and cyanobacteria in bio-geochemical cycling 4.1.3 Fungi and mycorrhizae: Symbiotic relationships in ecosystems 4.1.4 Microbial contributions to carbon and nitrogen cycling	Elmerich, C. and W. Edward Newton. 2007. Associative and Endophytic Nitrogen-fixing Bacteria and Cyanobacterial. Springer. 322 pp.
	PRACTICAL Mass multiplication of beneficial microorganisms. Visit to any research organization possessing required equipment (fermenters)	**Reading** Internet PowerPoint slides And research articles
Week 5	**THEORY** **Unit-V** 5.1 Use of microorganisms (bacteria, cynobacteria, nematodes and fungi inclusive of mycorrhizae) in biocontrol of plant diseases 5.1.1 Definition and principles of biological control 5.1.2 Importance of sustainable disease management in agriculture 5.1.3 Examples of microbial species used in biocontrol	Elmerich, C. and W. Edward Newton. 2007. Associative and Endophytic Nitrogen-fixing Bacteria and Cyanobacterial. Springer. 322 pp. **Assignment** on case studies in Pakistan related to the use of beneficial organisms in agriculture

	5.1.4 Case studies of biocontrol of pest and pathogens in agriculture	
	PRACTICAL Procedures to demonstrate demonstration of antagonism in laboratory conditions.	Related research papers **Assignment:** Isolation and identification of at least 10 beneficial fungal and bacterial cultures.
Week 6	**THEORY** **Unit-VI** 6.1 Cultivation of edible fungi and yeasts 6.1.1 Introduction to various types of edible mushrooms and their cultivation requirements 6.1.2 Steps in mushroom cultivation: substrate preparation, spawning, incubation, fruiting, harvesting 6.1.3 Commonly used yeast species and their cultivation through fermentation at large scale	Chang, S.T. and P.G. Miles. 2004. Mushroom Cultivation, Nutritional Value, Medicinal Effect and Environmental Impact. CRC Press, NYC, USA.
	PRACTICAL Procedures to demonstrate demonstration of competition and antibiosis in laboratory conditions.	Related research papers
Week 7	**THEORY** **Unit-VII** 7.1 Classification of soils based on their microbiological properties 7.1.1 Microbial diversity in soil and their impact on soil health 7.1.2 Soil classification based on their microbial properties	**Reading** Internet PowerPoint slides And research articles
	PRACTICAL Isolation and identification of mycorrhizal species from agricultural soils	Nasim, G. and R. Bajwa. 2010. Glomalean Spore Flora of Pakistan. HEC, Islamabad, Pakistan.

Week 8	**THEORY** **Unit-VIII** 8.1 Principles and strategies for controlling the soil microflora for optimum crop production and protection 8.1.1 Factors affecting soil microbial properties 8.1.2 Strategies for enhancing beneficial microflora in soil	**Reading** Internet PowerPoint slides And research articles
	PRACTICAL Mass culturing of mycorrhiza for agricultural application	Podila, K. and D.D. Douds. 2000. Current Advances in Mycorrhizae Research. APS Press, USA.
Week 9	**MID TERM EXAMS**	
Week 10	**THEORY** **Unit-IX** 9.1 Application of beneficial microorganisms 9.1.1 An overview of all the applications of beneficial microorganisms in agriculture	Javaid, A. 2010. Beneficial Microorganisms for Mungbean Production. VDM Publishing Company. 212 pp.
	PRACTICAL Experiments to produce biofertilizers using beneficial microorganisms like nitrogen-fixing bacteria or phosphate-solubilizing bacteria	Related research papers
Week 11	**THEORY** **Unit-X** 10.1 Functions of microorganisms: putrefaction, fermentation, and synthesis 10.1.1 Introduction to microbial functions 10.1.2 Putrefaction: Microbial decomposition 10.1.3 Fermentation: Microbial metabolic pathways 10.1.4 Microbial synthesis: Production of useful	**Reading** Internet PowerPoint slides And research articles **Assignment:** compiling report of a study tour to any related agro-industry or research organization

	compounds	
	PRACTICAL Experiments to evaluate impact of biofertilizers on plants grown under greenhouse conditions	Related research papers **Assignment:** report on group experiment related to the efficacy of biopesticides or biofertilizers in green house conditions
Week 12	**THEORY** **Unit-XI** 11.1 Introduction to use of cellulose decomposing fungi in paper and textile industry 11.1.1 Types of cellulose decomposing fungi 11.1.2 Mechanisms of cellulose degradation by fungi 11.1.3 Applications of fungal biotechnology in paper and textile production	**Reading** Internet PowerPoint slides And research articles
	PRACTICAL Experiments to produce biopesticides using beneficial microorganisms like bacilli, *Trichoderma* spp etc.	Related research papers
Week 13	**THEORY** **Unit-XII** 12.1 Use of fungi such as *Penicillium* and *Aspergillus* species in food processing including cheese ripening, pickle production etc 12.1.1 Biotechnological Applications of Fungi in Food Industry 12.1.2 Role of *Penicillium* species in cheese ripening 12.1.3 *Aspergillus* species in food fermentation 12.1.4 Utilization of fungi in pickle production	**Reading** Internet PowerPoint slides And research articles
	PRACTICAL	Related research papers

	Experiments to evaluate the potential of biocontrol microbial agents to manage plant diseases and their comparison with synthetic pesticides.	
Week 14	**<u>THEORY</u>** **Unit-XIII** 13.1 Organisms as experimental tools 13.1.1 Types of microorganisms used as experimental tools 13.1.2 Microorganisms in environmental and agricultural research (case studies) 13.1.3 Ethical considerations in microbial research	Eugene, R. and G. Uri. 2011. Beneficial Microorganisms in Multicellular Life Forms. Springer. 348 pp.
	<u>PRACTICAL</u> Experiments to evaluate the potential of biocontrol microbial agents to manage plant diseases and their comparison with synthetic pesticides.	Related research papers
Week 15	**<u>THEORY</u>** **Unit-XIV** 14.1 Microorganisms and supplements of human food and animal feed (single cell protein, fodder yeast etc.) 14.1.1 Types of microorganisms used in Single Cell Protein (SCP) production 14.1.2 Production methods for SCP and their application in human food and animal feed 14.1.3 Fodder yeast: Characteristics and benefits 14.1.4 Microbial enzymes in food and feed supplements	Eugene, R. and G. Uri. 2011. Beneficial Microorganisms in Multicellular Life Forms. Springer. 348 pp.
	<u>PRACTICAL</u> Experiments to evaluate the potential of biocontrol microbial agents to manage plant diseases and their comparison with synthetic pesticides.	Related research papers

Week 16	**THEORY** **Unit-XV** 15.1 bacteriophages 15.1.1 Structure and classification of bacteriophages 15.1.2 Life cycle of bacteriophages: Lytic and Lysogenic cycles 15.1.3 Host range and specificity of bacteriophages 15.1.4 Isolation and cultivation of bacteriophages 15.1.5 Application of bacteriophages in agriculture	**Reading** Internet PowerPoint slides And research articles
	PRACTICAL Compilation of report on effect of beneficial microorganisms on plant growth and disease management in greenhouse conditions	Related research papers
	FINAL TERM EXAM	

Textbooks and Reading Material

1. Textbooks.

In the detail course outline, one may mention chapters of the textbook with the content topics

2. Suggested Readings

2.1. Books

3. Bahl, N. 1988. Handbook on Mushroom. 2nd edition. Oxford and IBH Publishing Company New Delhi, India.

4. Burges, H.D. 1998. Formulation of Microbial Biopesticides: Beneficial Microorganisms, Nematodes and Seed Treatments. Kluwer Academic Press.

5. Carandang, G.A. 2011. Grow Your Own Beneficial Indigenous Microorganisms and Bionutrients in Natural Farming [Kindle Edition]. Bronze Age Media. pp. 30.

6. Chang, S.T. and P.G. Miles. 2004. Mushroom Cultivation, Nutritional Value, Medicinal Effect and Environmental Impact. CRC Press, NYC, USA.

7. Dinesh K. and D.K. Maheshwari. 2012. Bacteria in Agrobiology: Plant Probiotics. Springer. 371 pp.

8. Elmerich, C. and W. Edward Newton. 2007. Associative and Endophytic Nitrogen-fixing Bacteria and Cyanobacterial. Springer. 322 pp.

9. Eugene, R. and G. Uri. 2011. Beneficial Microorganisms in Multicellular Life Forms. Springer. 348 pp.

10. Javaid, A. 2010. Beneficial Microorganisms for Mungbean Production. VDM Publishing Company. 212 pp.

11. Kannan, V.R. and Bastas, K.K. eds., 2015. *Sustainable Approaches to Controlling Plant Pathogenic Bacteria*. CRC Press. Oakville, Canada

12. Kumar, A., M. Bilal, G. Santoya, J.S. Panwar, 2024. Biocontrol Agents for Improved Agriculture (Plant and Soil Microbiome) 1st Edition. Academic Press.

13. Liong, M.T., 2015. *Beneficial Microorganisms in Agriculture, Aquaculture and Other Areas* (Vol. 29). Springer. Cham

14. Maheshwari, D.K. 2010. Plant Growth and Health Promoting Bacteria. Springer. pp. 445

15. Nasim, G. and R. Bajwa. 2010. Glomalean Spore Flora of Pakistan. HEC, Islamabad, Pakistan.

16. Phillips, M., 2017. Mycorrhizal Planet: How Symbiotic Fungi Work with Roots to Support Plant Health and Build Soil Fertility. Chelsea Green Publishing.

17. Podila, K. and D.D. Douds. 2000. Current Advances in Mycorrhizae Research. APS Press, USA.

18. Prasad, R. and S.H. Zhang. 2022. Beneficial Microorganisms in Agriculture (Environmental and Microbial Biotechnology). Springer.

19. Samuel, S. and S.S. Gnanamanickam. 2007. Plant-Associated Bacteria. Springer. 712 pp.

20. Sundh, I., A. Wilcks and M.S. Goettel. 2013. Beneficial Microorganisms in Agriculture, Food and the Environment: Safety Assessment and Regulation. CABI. 360 pp.

20.1. Journal Articles/ Reports

21. It is preferable to use latest available editions of books. Mention the publisher & year of publication.

22. The References/ bibliography may be in accordance with the typing manual of the concerned faculty/subject. Preferably follow APA 7th Edition publication manual.

Teaching Learning Strategies

1. Provision of access to databases, research papers, and videos that showcase the latest developments in microbial agriculture.
2. Organizing visits to farms or research institutes where students can observe the application of microbial products in agriculture.
3. Assigning projects where students research specific beneficial microorganisms

(e.g., mycorrhizal fungi, nitrogen-fixing bacteria) and their applications.

4. Inviting experts from academia, industry, or government agencies to share their experiences and insights into the application of beneficial microorganisms in agriculture.

Assignments: Types and Number with Calendar

Mentioned in course content

Assessment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
3.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.