

About the Editors



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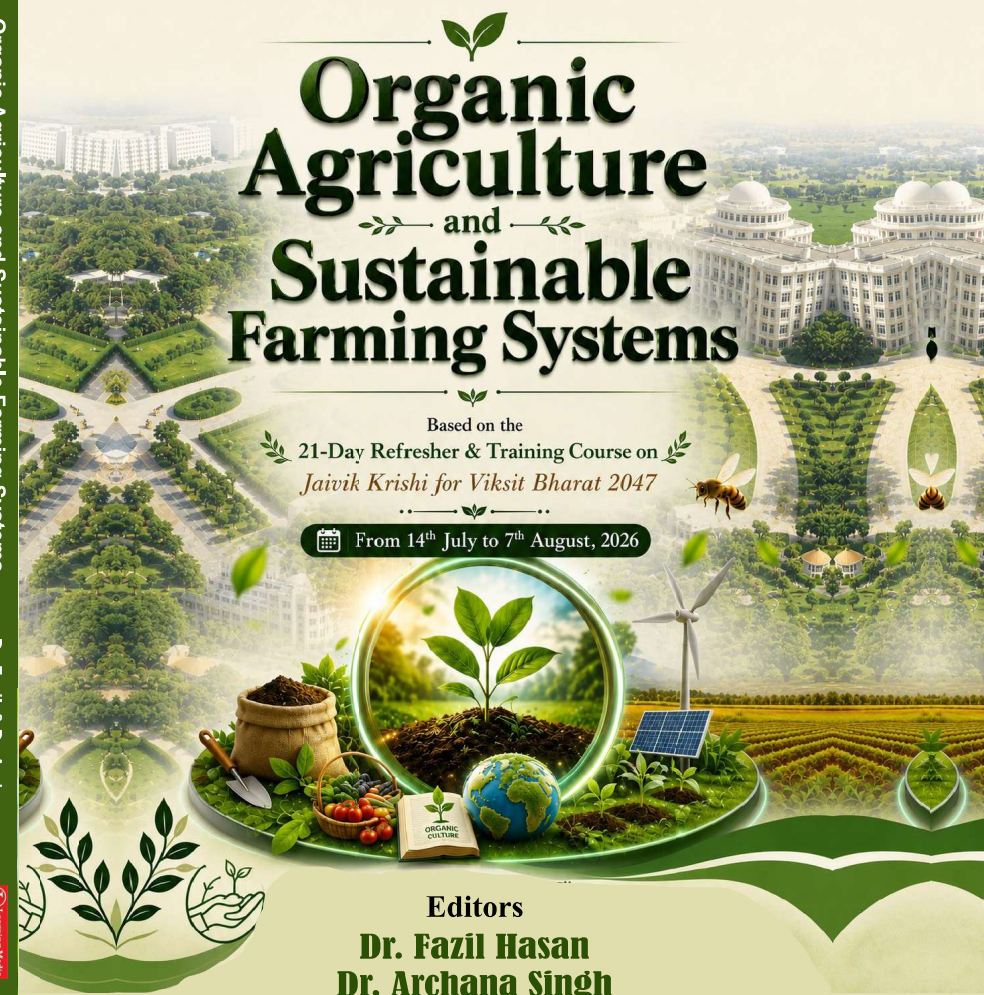
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Organic Agriculture and Sustainable Farming Systems

Dr. Fazil & Dr. Archana



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S. No.	CONTENTS	Page No.
1.	Physical and Cultural Control of Plant-Parasitic Nematodes Mohammad Mahamood	1-7
2.	Towards Sustainable Organic Litchi Production: Integrating Ecological Pest Management and Pollinator Conservation Ipsita Samal	8-14
3.	Next-Generation Biotechnology For Jaivik Kheti: Biofertilizers & Plant Growth Promoters Shilpy Singh * and Jayant M. Kushwaha	15-19
4.	Potential and applications of endophytic entomopathogenic fungi as eco-friendly biological control agents against insect pests Tanmaya Kumar Bhoi	20-25
5.	Towards Sustainable Organic Production of Medicinal & Aromatic Plants: Integrating Natural Farming for a Viksit Bharat 2047 Mahesh Mahadeo Kadam	26-31
6.	Biological Control Agents in Organic Farming Systems: Current Status, Ecological Engineering, and Future Perspectives Salman Ahmad and Fazil Hasan	32-38
7.	From Waste to Wealth: Decoding Composting & Vermicomposting Charu Gupta	39-45
8.	Food as Medicine or Food as a Source of Toxicants? The Importance of Jaivik Krishi Dharmasheel Shrivastav, Jyotsna Mishra Hamza Saleem and Saloni Jain	46-52
9.	Organic Production Technologies for Sustainable Tuber Crop Cultivation Surbhi Prithiani	53-58
10.	Seed Technology for Organic and Climate-Smart Agriculture: A Pathway towards Viksit Bharat 2047 Sagar Kumar Sharma , Pratiksha Singh, K K Singh and Fazil Hasan	59-66
11.	Azolla: A Sustainable Biofertilizer for Organic and Climate-Smart Agriculture Archana Singh , Neetu Singh, Fazil Hasan and Sonal Jain	67-70
12.	Role of Direct-Seeded Rice (DSR) in Climate-Smart Agriculture in India Vagish Mishra, Ranjana Tiwari, Sakshi Suchita, Shailesh Solanki and Pragya Mishra	70-75
13.	Organic Mushroom Production Gopal Singh, Rohit Kumar and Akshay Chaudhary	76-81
14.	Biotechnological tools to develop climate resilient varieties promoting organic agriculture Dr. Priyanka Dwivedi	82-86
15.	Role of agroforestry in ecological and economic security of farmers Ankita, Susmita Shil and Sakshi Suchita	87-91

16.	Emerging and Invasive Fungal Pathogens Associated with <i>Allium</i> Crops: Biosecurity Challenges and Sustainable Management Meenu Gupta and Dixit Sharma	92-98
17.	Seed Health and Disease-Free Seed in Organic Agriculture Sakshi Suchita, Ranjana Tiwari and Vagish Mishra	99-106
18.	Urban Organic Farming: Sustainable Approach For Greener Tomorrow Neha Kumari* , Sakshi Suchita and Ranjana Tiwari	107-112
19.	Sucking Insect Pests: Identification and Organic Management Mogili Ramaiah and Snehasish Routray	113-119
20.	Reframing Host Plant Resistance to Major Insect Pests of Pulses Under Climate Change: Challenges, Opportunities, and Future Directions Jagdish Jaba	120-128
21.	Role of Natural Farming in Insect Pest Management Rohit Rana ¹ and Fazil Hasan	129-134
22.	Artificial Intelligence Technology in the Agricultural Sector For Plant Disease Detection Praveen Malik, Bhawna Kaushik, Poonam Kumari and Ravina Gupta	135-141
23.	Natural Farming in Integrated Pest Management (IPM): A sustainable approach towards eco-friendly crop protection Hurditay Gupta, Ranjana Tiwari, Sakshi Suchita and Piyush Srivastava	142-147
24.	Indigenous IPM Package for the Management of Soil-Borne Root-Knot Nematodes and Wilt/Rot Diseases of Horticultural Crops Neetu Singh, Archana Singh and Fazil Hasan	148-153
25.	From Farms to Buildings: The Hidden Journey of Bioaerosols and Their Impact on Environmental Sustainability and Human Health Juhi Mishra	154-157
26.	Environmental Biotechnology for Sustainable Agriculture: From Waste Management to Resource Recovery Ravi Shankar Yadav	158-162
27.	Organic approaches for Insect pest management in Cruciferous Vegetables Ramesh K. B , Gangaraj R, Viveka Nand Singh and Pushpendra Pratap Singh	163-171

Biological Control Agents in Organic Farming Systems: Current Status, Ecological Engineering, and Future Perspectives

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Abstract

The increasing demand for residue-free food, coupled with the adverse environmental impacts of synthetic pesticides has accelerated the global transition toward organic farming systems. Biological control has emerged as a cornerstone of organic agriculture by utilizing living organisms and their products to suppress insect pests, plant pathogens, and weeds while maintaining ecological balance. This chapter provides a comprehensive synthesis of the principles, evolution, and current status of biological control in organic farming, with particular emphasis on predators, parasitoids, entomopathogenic microorganisms, and entomopathogenic nematodes. Recent advances in microbial biopesticides, particularly *Bacillus thuringiensis*, *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii*, insect-specific viruses, and beneficial nematodes, have substantially expanded the scope of environmentally benign pest management. The chapter further highlights conservation biological control through ecological engineering practices such as flowering strips, banker plants, habitat diversification, cover crops, and reduced pesticide use, which enhance natural enemy abundance and ecosystem resilience. Commercialization, quality assurance, and successful implementation of biological control programs are discussed with reference to notable case studies from India and other countries. The challenges associated with environmental variability, host specificity, mass production, formulation stability, regulatory constraints, and farmer adoption are critically examined. Emerging technologies including molecular biology, microbiome engineering, artificial intelligence, precision agriculture, remote sensing, and RNA interference are reshaping the future of biological control and improving its integration into sustainable crop production systems.

1. Introduction

Agriculture is confronted with the formidable challenge of producing sufficient, safe, and nutritious food for a rapidly expanding global population while minimizing environmental degradation and conserving natural resources (Vos & Bellù, 2019). During the past six decades, remarkable increases in agricultural productivity have largely been achieved through the intensive use of synthetic pesticides and fertilizers. Although these inputs have significantly contributed to crop protection and food security, their indiscriminate and prolonged use has resulted in several unintended consequences, including the development of pesticide resistance, resurgence of secondary pests, contamination of soil and water resources, destruction of beneficial organisms, biodiversity loss, and the accumulation of pesticide residues in agricultural commodities (Sonkar et al. 2025; Ahmad et al. 2025a; Hasan et al.