E CONF SERIES

International Conference on Scientific Research in Natural and Social Sciences
Hosted online from New York, USA
Website: econfseries.com 2nd June, 2025

MODERN STRATEGIES FOR ENHANCING WHEAT RESISTANCE TO BIOTIC STRESSES: GENETIC, BIOLOGICAL AND AGRONOMIC APPROACHES

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Abstract

This article analyzes the theory and practice of protecting wheat varieties from biotic stress factors. Protection of wheat from pests, diseases, and viruses is a significant issue in agriculture. The article examines the main biotic stresses affecting wheat and their impact on yield, as well as modern technologies and methods for managing them. Approaches such as molecular selection, CRISPR/Cas9 technology, biological control and Integrated Pest Management (IPM) are presented as effective tools for protecting wheat from biotic factors. This article will be useful for agronomists, breeders, and agricultural specialists.

Keywords: wheat varieties, biotic factors, pests, diseases, viruses, molecular selection, biological control, fungal diseases, pesticides, biotic stress, agronomists, breeders, ecological safety

Introduction

Wheat plays a pivotal role in ensuring global food security. However, various biotic factors such as fungi, bacteria, viruses, and insect pests pose serious threats to wheat productivity. The impact of these stressors includes reduced yield, delayed crop maturation, and compromised grain quality. Therefore, developing resistant wheat cultivars and employing integrated management strategies are critical to sustainable agriculture.

Major Biotic Stress Factors in Wheat Production

1 Fungal Pathogens. Fungi such as Puccinia spp. (causing black rust), Fusarium spp., and Alternaria spp. not only reduce yield but also produce mycotoxins that degrade grain quality.

2 Bacterial Infections. Species like Xanthomonas and Pseudomonas can cause systemic diseases in wheat, leading to significant reductions in plant vigor and grain output.

3 Viral Diseases.Viral infections are often spread by insect vectors and result in chlorosis, stunted growth, and eventual yield loss, posing major economic threats.

4 Insect Pests. Common pests include the wheat weevil (Sitophilus granarius) and spider mites (Tetranychus spp.), which damage plants directly and act as disease vectors.

Genetic Approaches to Improve Biotic Stress Resistance

1 Molecular Breeding and Marker-Assisted Selection. The use of molecular markers allows for efficient selection of disease-resistant genotypes. Marker-assisted selection (MAS) accelerates breeding programs by targeting specific genes linked to biotic stress resistance.

2 Polyploidy. Inducing polyploidy can increase genetic diversity and enhance tolerance to pests and diseases.

3 Genetic Engineering and Genome Editing. Technologies such as CRISPR/Cas9 allow for precise editing of resistance genes. This approach offers potential for developing wheat varieties with durable resistance to multiple stressors.

Biological Control Strategies

1 Beneficial Microorganisms. Microbes such as Trichoderma and Bacillus species are effective against fungal pathogens and promote plant growth through antagonistic interactions.

2 Biopesticides. Biopesticides derived from bacteria and fungi offer an environmentally friendly alternative to chemical pesticides. They can be integrated into sustainable crop protection programs.

Agronomic and Integrated Management Practices

1 Optimal Fertilization and Irrigation. Appropriate management of water and nutrients strengthens plant immunity and enhances resilience to biotic stress.

2 Chemical Pesticide Application. While synthetic pesticides remain crucial, their overuse leads to environmental damage and resistance development in pests. Therefore, they should be used judiciously and in conjunction with other methods.

3 Integrated Pest Management (IPM). IPM combines biological, chemical, and cultural practices to minimize pest pressure. This holistic approach improves pest control efficacy while ensuring eco

Conclusion

Managing biotic stress in wheat requires an integrated approach that combines advanced genetic technologies, biological control agents, and sound agronomic practices. While each method has its strengths and limitations, the synergy among them provides the most promising route toward sustainable wheat production. Continued research into resistance genes, microbial interactions, and precision agriculture will further strengthen global efforts to safeguard wheat yields.

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