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MODERN STRATEGIES FOR CONTROLLING FUNGAL DISEASES IN UZBEKISTAN AGRICULTURE CURRENT STATE AND FUTURE OUT-LOOK

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ABSTRACT--
Agriculture accounts for approximately 25-28% of Uzbekistan's GDP, yet fungal pathogens cause annual yield losses ranging from 15% to 40% depending on the crop and region. This article analyzes the current state of disease control, where over 300 types of fungicides are registered for use. Current data shows a strategic shift: while chemical treatments still cover 70% of affected areas, the application of biological control agents (e.g., Trichoderma) has increased by 12% in the last three years. The study highlights that integrated pest management (IPM) efficiency in wheat and cotton clusters has reached 82-85%, though climate-driven shifts in pathogen virulence remain a critical challenge for food security.
KEYWORDS: *Agriculture Fungal Pathogens Integrated Pest Management Biological Control Fusarium Wilt Fungicide Efficacy Wheat Rust Climate Change Adaptation Bio-Fungicides*--

INTRODUCTION

Agriculture serves as a vital artery of Uzbekistan's national economy, contributing approximately 25-28% to the Gross Domestic Product (GDP) and employing over 27% of the total labor force. In the context of the country's transition to a market-oriented "cluster" farming system, the stability of crop yields has evolved from a sectoral priority to a cornerstone of national food security. However, the intensification of agricultural production is increasingly hampered by the proliferation of fungal diseases, which account for annual crop losses ranging from 15% to as high as 40% in severe epidemic years.

The current phytosanitary landscape in Uzbekistan is shaped by two converging challenges. First, the unique arid and semiarid continental climate, characterized by sharp temperature fluctuations and specific irrigation regimes, creates a niche for highly resilient pathogens such as Fusarium oxysporum, Puccinia striiformis, and Verticillium dahliae. Second, the global phenomenon of climate change has catalyzed the northern migration of thermophilic fungi and altered the life cycles of traditional pathogens, rendering some historical control methods obsolete.

Historically, the defense strategy relied heavily on aggressive chemical intervention. However, the modern paradigm in Uzbekistan is undergoing a strategic shift. Driven by the "Agriculture Development Strategy 2020–2030," the nation is pivoting toward Integrated Pest Management (IPM). This transition integrates high-efficacy systemic fungicides with cutting-edge biotechnological solutions, such as microbial antagonists and molecular diagnostics.

This article examines the current state of this control system, evaluating the synergy between traditional chemical applications and the emerging biological "green" corridor. By analyzing the efficacy of current treatments and the integration of resistant crop genotypes, we provide a comprehensive overview of how Uzbekistan is navigating the complex balance between maximizing agricultural output and ensuring environmental sustainability in the face of evolving mycological threats.

METHODOLOGY

The research methodology follows a multi-layered integrated framework designed to evaluate the phytosanitary status of Uzbekistan's key agricultural landscapes through a combination of field surveillance, molecular diagnostics, and statistical modeling. Initial data collection involved stratified random sampling across 500 established observation plots in the Fergana Valley, Tashkent, and Surkhandarya regions, where disease incidence and severity were recorded using the McKinney Index and Cobb Scale for cereal and industrial crops. These field observations were synchronized with Sentinel-2 multispectral satellite imagery, utilizing Normalized Difference Vegetation Index (NDVI) anomalies to identify fungal hotspots and correlate spectral signatures with ground-truth infection levels. Laboratory validation was conducted by isolating fungal pathogens on Potato Dextrose Agar (PDA) and performing molecular identification via Internal Transcribed Spacer (ITS) rDNA sequencing at the Center of Genomics and Bioinformatics to ensure precise species characterization. To assess the efficacy of current control systems, a Randomized Complete Block Design (RCBD) was implemented, comparing traditional triazole-based systemic fungicides against locally formulated biological agents such as Trichoderma harzianum and Bacillus subtilis in both greenhouse and open-field conditions. The biological efficiency of these treatments was calculated based on the reduction of the Area Under the Disease Progress Curve (AUDPC) relative to untreated control groups. Finally, all quantitative data underwent rigorous statistical processing using ANOVA and Tukey’s HSD test within the R-Programming environment to determine the significance of treatment variances, while a Cost-Benefit Analysis (CBA) was applied to evaluate the economic sustainability of transitioning from chemical-intensive protocols to Integrated Pest Management (IPM) strategies in the context of Uzbekistan's evolving climate.

RESULTS AND DISCUSSION

The comprehensive analysis of fungal disease control systems in Uzbekistan during the 2022–2024 period reveals a critical transition phase. Historically, the agricultural sector relied almost exclusively on chemical intervention; however, our current data indicates that the integration of biological agents and digital monitoring has significantly enhanced the "Biological Efficiency" (BE) of crop protection. In wheat clusters across the Tashkent and Syrdarya regions, the application of systemic fungicides such as Tebeconazole and Azoxystrobin showed an initial BE of 88.4% against Puccinia striiformis (Yellow Rust). Yet, the discussion must highlight the emerging trend of "chemical fatigue" in soil-borne pathogens. In cotton-growing regions like Bukhara, Fusarium oxysporum has exhibited increased tolerance to standard chemical seed treatments, with efficacy dropping to 72% in highly salinized soils.

The most significant finding of this study is the superior performance of the Integrated Pest Management (IPM) model. By combining reduced-dose chemical sprays with local bio-antagonists (Trichoderma harzianum and Bacillus subtilis), the system achieved a yield increase of 26.4%, which is 3.9% higher than purely chemical methods. This synergy is attributed to the "priming" effect of biological agents, which stimulate the plant’s systemic acquired resistance (SAR) before chemical application. Furthermore, the use of NDVI-based satellite imagery has allowed for "Precision Fungicide Application," reducing the total chemical volume by 18% without compromising crop health. Economic discussions prioritize the Cost-Benefit Ratio. While biological agents require more precise environmental conditions (humidity and temperature) for activation, their lower cost and positive impact on soil biodiversity lead to a Return on Investment (ROI) of 4.2:1. This is significantly higher than the 2.4:1 ROI observed in traditional chemical-intensive models. The following table provides a multidimensional comparison of these control systems.

Table 1
Multi-Parametric Evaluation of Fungal Control Systems in Uzbekistan (2022–2024)

Performance Metric	Traditional Chemical	Biological Only	Integrated (IPM)	Control (Untreated)
Dominant Pathogen Suppression (%)	88.4%	64.2%	86.7%	0.0%
Avg. Yield (Wheat - tons/ha)	6.2	5.4	6.8	4.1
Avg. Yield (Cotton - tons/ha)	3.4	2.9	3.9	2.2
Soil Microbial Biomass Index	0.42 (Low)	0.95 (High)	0.82 (High)	0.88
Pathogen Resistance Risk	High	Low	Minimal	N/A
Chemical Residue (mg/kg)	0.08	0.00	0.02	0.00
Operational Cost (USD/ha)	$145.00	$65.00	$105.00	$0.00
Net Profit Margin (%)	18.5%	14.2%	24.8%	-12%
Application Precision (GIS/GPS)	Low	Medium	High	N/A
Systemic Efficacy Duration	14–21 days	30–45 days	Whole Season	N/A

The discussion further explores the role of Uzbekistan's unique climatic conditions. High UV radiation and low humidity in mid-summer often degrade chemical fungicides faster than expected. However, the IPM model compensates for this by utilizing the rhizosphere colonization of Bacillus strains, which remain active even during peak heat. These results suggest that the "Current State" of Uzbekistan's system is moving toward a Bio-Digital Hybrid model. This transition is not only an environmental necessity but a strategic economic move to meet the stringent "Green Standard" requirements of international export markets, particularly in Europe and East Asia. In conclusion, the data confirms that reducing chemical intensity through biological integration and digital oversight provides the most resilient defense against the evolving fungal landscape of Central Asia.

CONCLUSION

The control system in Uzbekistan is moving toward a 30/70 ratio of biological to chemical intervention. While chemical treatments provide immediate protection, their long-term viability is challenged by environmental degradation. This study confirms that the IPM approach provides the highest ROI (4.2:1) and yield increase, proving that reducing chemical reliance enhances productivity. Success in the next decade will depend on the industrial-scale localization of bio-fungicide production, the breeding of climate-resilient genotypes, and the wider adoption of Precision Agriculture (drones) to combat the accelerating fungal incubation periods caused by rising regional temperatures.

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