

THE PRESENT SCENARIO OF INTEGRATED DISEASE MANAGEMENT OF CUMIN BLIGHT DISEASE IN RAJASTHAN

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Abstract- Cumin is an important seed spice crop that is grown on a large scale in the arid and semi-arid regions of Rajasthan, India, and it is one of the key contributors to the country's spice production and export revenue. Even though cumin has a high economic value, productivity is affected severely by cumin blight disease as a result of *Alternaria burnsii* and *Fusarium oxysporum* f. sp. *cumini*, which pose a two-fold threat to yield and quality of the crop. Cumin blight disease occurs in almost all cumin-growing districts in Rajasthan and can cause substantial losses under favorable environmental conditions. Consequently, researchers and farmers have taken refuge in Integrated Disease Management (IDM), which is a holistic and sustainable approach to disease management that combines cultural, biological, chemical and host resistant strategies, which aims to minimize the impact of diseases in farming systems. Disease

Management promotes crop diversity (crop rotation), seed treatment (bioagents), fungicides (pesticides), and breeds of slightly resistance varieties to sustainably maintain the crop over a long period of time. However, challenges such as climatic conditions and variabilities, diversity of pathogens, low farmer awareness keeps the successful implementation of IDM from taking place. Ultimately, gaining farmer training, developing a disease forecasting system, and cost effective biological control, would assist with more sustainable production of cumin and other cropping systems.

Keywords: Cumin (*Cuminum cyminum* L.), Cumin blight, *Alternaria burnsii*, *Fusarium oxysporum* f. sp. *cumini*, Integrated Disease Management (IDM), Cultural practices, Biological control, Chemical management, Disease-resistant varieties.

I. INTRODUCTION

Cumin (*Cuminum cyminum* L.) is one of the most important and extensively planted seed spice crops in arid and semi-arid areas of Rajasthan, especially in the principal districts of Jodhpur, Barmer, Jaisalmer, and Nagaur. The state accounts for more than 60 percent of total cumin production in India, with cumin being a major part of the agricultural economy of the region, and a major component of the country's spice exports. Cumin has no value for farmers as a cash crop, as well as India's global trade, due to its unique fragrance and medicinal qualities. Cumin has difficulties due to biotic and abiotic stresses, with cumin blight disease as a major destructive limiting and considered most important.

Cumin blight, resulting mainly from *Alternaria burnsii* and *Fusarium oxysporum* f.sp. *cumini*, represents a serious threat to cumin production in Rajasthan. The pathogen can infect the cumin crop at any point in the crop cycle, often resulting in wilting, leaf blight, damping-off in seedlings, as well as discoloration of the seed. Damage correlated with these pathogens can be severe enough that cumulative yield loss can exceed 50 percent, affecting the quality and quantity of production. Losses not only reduce the potential profits for the producer, but also represent a threat to the viability of the spice export system. Environmental parameters

including cool temperatures, high humidity and prolonged dew have also caused the rapid onset and spread of cumin blight which is a continuous and troublesome crop production limitation for farmers in Rajasthan.

A realistic and sustainable method to combat this issue is Integrated Disease Management (IDM), which relies on the coordinated use of a range of strategies, including cultural practices, biological control agents, and judicious use of chemicals, to reduce disease incidence and improve crop health in the long run. For example, cultural practices such as crop rotation, timely sowing, and the sowing of clean seeds can help minimize primary infection sources, biological control using antagonistic fungi such as *Trichoderma harzianum* and *Pseudomonas fluorescens* can enhance plant defense mechanisms, and an appropriate and limited use of fungicides can help to prevent serious outbreak of the disease without causing significant impact to the environment. Although the IDM approach provides reduced incidence of cumin blight, it also benefits ecological balance, improves soil health, and enable sustainable cumin farming systems in Rajasthan's challenging agro-climatic conditions.

II. DISEASE ETIOLOGY AND EPIDEMIOLOGY

Cumin blight pathogens are adaptable and resilient in the agronomic landscape, which complicates management efforts. They can survive in the affected crop residue, contaminated seed, infested soil, etc., for long periods of time and always serve as a source of inoculums for subsequent cropping seasons. Among the pathogens, *Alternaria burnsii* infects primarily the aerial plant parts, including the leaves, stems, and umbels. It will produce unique dark brown to black necrotic lesions on the leaves, which will expand and coalesce on the infected plant, causing the leaves to blight and, in turn, dry the plant prematurely. In this more severe infection type, the pathogen can dry the entire plant and drastically reduce the amount and quality of seed produced. In contrast, *Fusarium oxysporum* f. sp. *cumini* is a soil-born fungus that infects the vascular system of the plant and disrupts water and nutrient distribution. Infections usually initiate in the lower leaves with a yellowing, followed by wilting, and root-rotting symptoms ultimately causing death loss of the plant.

Environmental and agronomic factors are important determinants for the incidence and spread of cumin blight disease. Research indicates that disease development is correlated with certain climatic conditions, notably temperatures within the 15 - 20 °C

range, along with prolonged periods of high relative humidity, and dew formation, during flowering. These environmental conditions support spore germination and promote a greater number of pathogens on the plant tissue surface. Furthermore, in spice-producing areas in Rajasthan, frequent monocropping of cumin in the same fields increases inoculum load in the soil. In addition, poor management of soil conditions, including drainage, nutrients, and miscellaneous stress factors increase plant susceptibility and thus infective potential.

III. CULTURAL AND AGRONOMIC MANAGEMENT

Cultural methods are fundamental to integrated disease management.

- **Crop Rotation:** Rotating crops once every 3-4 years with non-host crops (e.g., pearl millet - *Pennisetum glaucum*, mustards - *Brassica* spp.), can decrease soil inoculum levels, preventing the disease from advancing in the coming seasons.
- **Field Sanitation:** Removing and destroying infected crop residues from the field will reduce sources of primary inoculum.
- **Seed Selection and Seed Treatment:** Use certified disease-free seeds, or treat with a bioagent (e.g., *Trichoder-*

-ma harzianum or a fungicide like carbendazim - 0.2%) to suppress seed-borne inoculum.

- **Planting Time and Density:** Early planting (mid-November) in Rajasthan climatic conditions reduces the intensity of the disease occurrence. Correct spacing of plants helps in aerating soil and reducing humidity accumulation around plants.
- **Soil Management:** Using well-decomposed organic manure and balanced fertilization efforts improves soils' health and microbial diversity to help develop plants' natural resistance.

Cultural methods are key components of a comprehensive Integrated Disease Management (IDM) strategy for cumin blight. Implementing a 3-4 year crop rotation with non-host crops such as pearl millet or mustard helps suppress the accumulation of fungal soil-borne inoculum. Cleaning the field of and destroying infected plant residues contributes further towards limiting sources of primary infection. The use of seed that is certified and disease-free is combined with the application of inoculated bioagents (e.g., *Trichoderma harzianum*) or fungicides (0.2% carbendazim) to manage seed-borne pathogens. Sowing time (mid-November) and plant spacing also contribute to improved aeration and,

subsequently, a reduction in humidity around the crop canopy that will lower disease incidence. In addition, the use of well-decomposed organic manure to enrich the soil, and balancing fertilizer applications improves soil health and microbial diversity that increases the natural resistance of plants to diseases.

IV. BIOLOGICAL MANAGEMENT

Biological control plays an increasingly important role in IDM programs. Several bioagents such as *Trichoderma harzianum*, *T. viride*, and *Pseudomonas fluorescens* have shown significant antagonistic effects against cumin blight pathogens.

- Seed treatment and soil application with *Trichoderma* spp. at 5 g/kg seed can substantially reduce disease incidence.
- *Pseudomonas fluorescens* enhances plant vigor and induces systemic resistance.
- Incorporation of composts enriched with beneficial microorganisms can further improve soil microbial balance.
- These biocontrol strategies are eco-friendly and reduce dependence on chemical fungicides, contributing to sustainable cumin production in Rajasthan.

Biological control is one of the best approaches of Integrated Disease Management (IDM) for cumin blight so provides an environmentally and sustainable

disease management opportunity. Some beneficial agents, such as *Trichoderma harzianum*, *T. viride*, and *Pseudomonas fluorescens* (all apply labelled product rates), can be applied as agents providing strong antagonistic activity on the pathogens associated with blight. Seed treatment or soil applications can all be conducted on *Trichoderma* spp. at rates of about approximately 5 g/kg seed to reduce total disease incidence, and *Pseudomonas fluorescens* can be used to increase plant vigor and apply systemic resistance. The compost associated with beneficial microorganisms also helps improve the soil microbial balance and improves overall plant health. Beyond just decreasing the additional reliance rate on returning back to using chemical fungicides, these biological methodologies also promote sustainable production of cumin in the extreme environment conditions of Rajasthan.

V. CHEMICAL MANAGEMENT

Chemical fungicides remain an important part of integrated control when used judiciously. When used carefully and in combination with other management strategies, chemical fungicides will continue to have an important role in an integrated approach to managing cumin blight. Applications of mancozeb (0.25%), carbendazim (0.1%), and propiconazole (0.1%) at the first detection of

infection have been effective in reducing severity of cumin blight. Alternating between systemic and contact fungicides is a practice that prevents the development of resistant pathogens and increases longevity of control efforts. Fungicides must be used only when needed and based on monitoring and observation as well as logical means of verifying the potential impact that is based on experience. This need-based approach is the most environmentally-responsible means to control disease while developing and sustaining reduce inputs or allow for sustainable cropping of cumin.

- Spraying with **mancozeb (0.25%)**, **carbendazim (0.1%)**, or **propiconazole (0.1%)** at the early appearance of disease symptoms has been found effective.
- Alternating systemic and contact fungicides helps delay resistance development.
- Fungicide application should be integrated with cultural and biological measures to minimize environmental impacts and ensure long-term efficacy.

However, frequent and indiscriminate fungicide use poses ecological and health risks. Hence, integrated and need-based application is recommended rather than calendar spraying.

VI. HOST RESISTANCE AND BREEDING EFFORTS

Development of resistant cultivars remains the most sustainable approach for disease management. Research centers such as RARI (Durgapura) and CAZRI (Jodhpur) have been working on identifying and breeding cumin varieties resistant to blight.

Promising lines such as **RZ-19**, **GC-4**, and **RZC-136** have shown moderate resistance under field conditions. However, complete resistance has not yet been achieved due to pathogen variability and changing climatic conditions. Marker-assisted breeding and genetic screening are being explored to accelerate the development of resistant genotypes.



Figure1: Cumin Blight Rajasthan

The breeding and release of resistant cultivars is potentially the most sustainable and long-term option for managing cumin blight

disease. Institutions, notably the Rajasthan Agricultural Research Institute (RARI), Durgapura, and the Central Arid Zone Research Institute (CAZRI), Jodhpur, are conducting breeding programs for the purpose of screening and developing Indian varieties of cumin that can resist blight disease. Lines such as RZ-19, GC-4, and RZC-136 have been recognized and released based on their intermediate level of resistance expressed under field conditions which could serve as a foundation for further adoption of these lines, albeit modestly. However, full resistance is difficult to achieve in the face of variability of the pathogen and potentially changing climates. In order to mitigate these issues, additional methods are being used to breeding resistant genotypes, including marker-assisted selection and increased molecular genetic screening to help speed the process of development of more stable and resistant genotypes for the agro-climatic environments found in Rajasthan.

VII. INTEGRATED DISEASE MANAGEMENT (IDM) APPROACH

The IDM approach combines multiple compatible strategies to reduce disease pressure effectively:

1. Use of disease-free seed and seed treatment with *Trichoderma* spp.

2. Crop rotation with non-host species.
3. Balanced fertilization and irrigation management.
4. Timely fungicide application based on disease forecasting.
5. Adoption of moderately resistant varieties.

6. Farmer training and awareness programs for early diagnosis and management.

Field demonstrations in Rajasthan have shown that integrating these components can reduce cumin blight incidence by 50–70% and improve yield stability significantly.

Table1: Summarize Data of integrated disease management of cumin blight DISEASE

IDM Component	Key Practices	Overall Impact
Cultural Measures	Crop rotation, field sanitation, early sowing, balanced fertilization	Reduces soil inoculum; lowers disease incidence; improves crop health
Biological Control	<i>Trichoderma</i> spp., <i>Pseudomonas fluorescens</i> , enriched compost	Suppresses pathogens; enhances plant resistance; eco-friendly
Chemical Control	Mancozeb, carbendazim, propiconazole; fungicide rotation	Effective early control; delays resistance; reduces yield loss
Host Resistance	Use of moderately resistant varieties (RZ-19, GC-4, RZC-136)	Provides partial protection; supports sustainable production
Environmental & Epidemiological Factors	Low temperature, high humidity,	Increases disease severity; favors

IDM Component	Key Practices	Overall Impact
	monocropping	pathogen spread
Challenges	Pathogen variability, limited farmer awareness, climate change	Leads to inconsistent management outcomes
Future Prospects	Forecasting models, new bioagents, remote sensing, farmer training	Improves early detection and enhances long-term sustainability

VIII. CHALLENGES AND FUTURE PROSPECTS

While integrated disease management has been developed, there are still challenges for farmers found in managing cumin blight in Rajasthan. An example of this would be the inconsistency in control due to the variability in pathogens, as well as other conditions for a farmer to be able to access biological

management, such as knowledge or the lack of resistant varieties. Other conditions of climate change and the effects on the disease also must be considered, as conditions are actually needed for the outbreak risk. Future research is needed, for example developing models of disease forecasting, exploring other bioagents and using remote sensing tools. On-farm training will be needed, even with the opportunity for access to quality seeds, to improve the uptake of the farmers for more sustainable agro-ecosystem practices to create a more appropriate management system for longevity or long-term management of the disease and sustainability of cumin production.

Despite progress in integrated management, several challenges remain:

- Pathogen variability leading to inconsistent control.
- Limited farmer awareness of biological control options.
- Climate change impacts altering disease dynamics.
- Lack of resistant varieties and insufficient quality seed supply.

Future research should focus on developing disease forecasting models, exploring new bioagents, and integrating remote sensing tools for real-time disease monitoring. Strengthening farmer capacity-building

programs and promoting sustainable agro-ecosystems are also essential for long-term management.

IX. CONCLUSION

Cumin blight disease is still one of the major limitations in the spice-based agricultural economy of Rajasthan contributing to a significant loss of yield and quality on a large annual basis. As the highest cumin producer in India, the constant risk of a blight disease puts the income of farmers in jeopardy and the entire spice export market in India at risk. Addressing this issue requires a complete ‘sustainable’ approach and integrated disease management (IDM) has been the most effective. IDM integrates cultural, biological, chemical, and genetic disease management strategies and thereby reduces dependency on either one time management and encourages ongoing management with minimal affect on the environment. Some examples of IDM practices include crop rotation with other diseases, disease-free seed, bioagents, balancing nutrient management, and selective fungicides. All of these can lead to either reduced blight incidence and/or enhance soil health. Breeding blight-resistant varieties represents additional sustainability in overall production. Successful adoption of integrated disease management involves cooperation of researchers, farmers, and policy makers.

Continued research support, capacity-building efforts, and government extension programs can facilitate adoption of integrated management by farmers.

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