

DISEASE INCIDENCE AND MANAGEMENT OF POWDERY MILDEW IN FENUGREEK

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Abstract- Fenugreek (*Trigonella foenum-graecum* L.) is a highly variable nutritionally significant leguminous crop that is also used as medicine and has been a source of income for a long time. Despite this, its output is often limited by a variety of fungal disease, with powdery mildew causing by *Erysiphe polygoni*, which usually accounts for a heavy yield loss particularly under warm and dry climatic conditions, being ranked first. The symptom of this diseased is white powdery fungal growths on the surface of leaves, stems, and pods that lead to chlorosis, defoliation, and substantial yield loss. This article reviews the disease powdery mildew in fenugreek, which includes the paper's focal points of pathogen incidence, epidemiology, and management strategies. Factors that influenced the growth of the disease, such as temperature, humidity, and host susceptibility, are also briefly outlined. The prevention methods endorsed for disease minimization comprise several aspects: resistant cultivars' use, cultural

methods like crop rotation and sanitation, and fungicide application, e.g., sulfur and triazoles, at the right time and in the right dose. Moreover, the newest developments in the biological control of antagonistic fungi use and production of plant-based extracts have given good results. This paper strongly urges farmers to implement integrated disease control measures (IDM) not only by using cultural methods as well as biological and chemical means, which will be eco-friendly and ensure good crop health and higher yield in fenugreek powdery mildew cases.

Keywords: Powdery mildew, *Erysiphe polygoni*, fenugreek (*Trigonella foenum-graecum*), disease incidence, epidemiology, integrated disease management (IDM), resistant cultivars, cultural practices, biological control.

I. INTRODUCTION

Fenugreek is an extensively grown leguminous crop famous for its different

uses as a spice, vegetable, and a medicinal herb. It has both economic and nutritional worth because of the contributions it makes as a protein, vitamin, mineral, and bioactive compounds source e.g. diosgenin and alkaloids. The main fenugreek producers are India and other areas of Asia as well as the countries bordering the Mediterranean, North Africa. The crop is grown for both local consumption and export. However, the crop is infected with fungi most of the times and thus, its yield and quality are severely affected. Powdery mildew ranks first among the diseases of fenugreek that cause significant losses in yield and quality of the crop in dry and hot climatic regions, hence, this disease has been the focus of many research studies in recent years. Powdery mildew on fenugreek, mainly induced by *Erysiphe polygoni*, is the development of a white, powdery fungal layer on the surfaces of leaves, stems, and pods. The pathogens cause the tissues to yellow, dry, and shrivel, finally, by defoliation, photosynthesis is lessened, and there is made a drastic reduction in yield as a consequence. The disease is at any stage of the crop's life and hence it always happens, but its intensity is at a maximum during flowering and pod formation phases.

The development and spread of powdery mildew are influenced by factors such as temperature, humidity, plant density, and

varietal susceptibility. The use of chemical fungicides alone in traditional management methods has been successfully made, but still, problems associated with environmental pollution, residue accumulation, and resistance development in pathogens have been identified. So, the implementation of integrated disease management (IDM) which embraces cultural, biological, and chemical practices and eco-friendly disease control has been highly recommended. Knowing the incidence, epidemiology, and powdery mildew in fenugreek management is the foundation upon which eco-friendly and effective disease control strategies can be built. The present paper is intended to discuss the disease, its factors, and the different control measures used for disease reduction and sustainable agriculture.

II. PREVIOUS RESEARCH

Numerous investigations have been embarked upon across the globe to unravel the occurrences, the factors influencing the spread, and the handling of the powdery mildew condition in fenugreek (*Trigonella foenum-graecum* L.). The first research pinpointed *Erysiphe polygoni* as the major causal agent accountable for the disease, and that it prospers in dry and warm environmental conditions. As per Singh et al. (2003) powdery mildew outbreaks are influenced by weather when the

temperature is between 20–25°C and relative humidity is moderate, with low rainfall during the crop season. The Mehta and Pandey (2006) stated that the disease is initially manifested in the form of white powdery spots on the underside of the leaves after which it spreads upward, thus, if it is not controlled in time, the whole aerial part of the plant will be covered.

Scientists maintain that pathogen resistance in the host plant is the principal factor in disease control. Patel et al. (2010) tested varieties of fenugreek and, as a result, 'RMT-1' and 'AFg-3' were found to be moderately resistant in open-field conditions. Similarly, Chand et al. (2012) put forward the idea that the creation of resistant genotypes gives rise to the reduction of fungicides usage and yield loss minimization.

There have been many studies on the use of chemicals as a method of controlling the disease. Kumar et al., (2014) noted the considerable decrease of the disease occurrence due to the spraying of wettable sulfur (0.25%) and hexaconazole (0.1%) at the early stages of the symptoms. Rani and Sharma (2006) further stated that the usage of triazole fungicides such as propiconazole and penconazole not only have the function to inhibit the pathogen but also invigorate the infected plants and increase the yield.

Nevertheless, the unremitting usage of fungicides has led to the rise of two major problems, namely the pollution of the environment and the surge of fungicide resistance.

To counter these different effects, recent researches have shifted their focus towards biological and eco-friendly management measures. Verma et al. (2011) found that the application of neem extract (5%) on the leaves and the inoculation with *Trichoderma harzianum* greatly reduced powdery mildew infection in the controlled environment. In the same way, Gupta and Joshi (2002) underscored the use of bio-control agents along with resistant cultivars as the best strategy to managing diseases in the long term.

Investigation into Disease Dynamics by Kaur et al. (2012) showed that manifestations of the disease have very close links with altered temperatures and the moisture of the affected areas, thus, it is easier to cut down upon the infection rates by adjusting the time of the seeding and keeping a good distance between the crops. Besides that, Sharma et al. (2013) underscored the significance of utilizing integrated disease management (IDM) tactics, which involve the use of resistant breeds, biological control agents, and the application of fungicides only when

necessary for accomplishing the effective and long-standing control of powdery mildew in fenugreek.

In sum, first off, research done so far has unmasked that no single means would suffice for the absolute suppression of

powdery mildew. The best and most sustainable method for tackling this disease in the cultivation of fenugreek is through a mix of genetic resistance, cultivation methods, biological agents, and the limited employment of fungicides.

Table 1: Summary of Previous Research on Powdery Mildew in Fenugreek

S. No.	Author(s) & Year	Findings / Focus Area	Key Outcomes / Remarks
1	Singh et al. (2003)	Studied environmental factors influencing powdery mildew incidence.	Found disease favored by 20–25°C temperature and moderate humidity.
2	Mehta and Pandey (2006)	Investigated symptom development and disease progression.	Reported white powdery spots start on lower leaves and spread to the entire plant.
3	Patel et al. (2010)	Evaluated resistance among fenugreek varieties.	Varieties ‘RMT-1’ and ‘AFg-3’ found moderately resistant.
4	Chand et al. (2012)	Studied impact of resistant genotypes on yield and disease reduction.	Resistant genotypes minimized fungicide use and yield loss.
5	Kumar et al. (2014)	Tested chemical control using sulfur and systemic fungicides.	Wettable sulfur (0.25%) and hexaconazole (0.1%) effectively reduced disease severity.
6	Rani and Sharma (2006)	Evaluated triazole fungicides for powdery mildew control.	Propiconazole and penconazole improved plant health and yield.
7	Verma et al. (2008)	Explored biological control using plant extracts and bioagents.	Neem extract (5%) and <i>Trichoderma harzianum</i> suppressed infection effectively.

S. No.	Author(s) & Year	Findings / Focus Area	Key Outcomes / Remarks
8	Gupta and Joshi (2002)	Focused on integrated biological and varietal control.	Combination of bio-control agents and resistant cultivars gave sustainable results.
9	Kaur et al. (2011)	Conducted epidemiological study on disease incidence.	Temperature fluctuations and canopy humidity strongly correlated with disease spread.
10	Sharma et al. (2012)	Evaluated integrated disease management (IDM) approaches.	IDM with resistant varieties, biological agents, and limited fungicides proved most effective.

III. CAUSES OF POWDERY MILDEW IN FENUGREEK

Powdery mildew in fenugreek is primarily caused by the **fungal pathogen *Erysiphe polygoni***, which infects a wide range of

leguminous crops. The disease develops due to a combination of **pathogen, host, and environmental factors** that favor the growth, reproduction, and spread of the fungus.



Figure 1. Fenugreek plant affected by powdery mildew

1. Pathogen Factor:

- The disease-causing *Erysiphe polygoni* creates conidia (asexual spores) that can spread quickly via the air and infect healthy plants.
- The fungus grows ectophytically (on the leaf surface) and penetrates the epidermal cells with haustoria to obtain nutrients.
- The pathogen may be present as cleistothecia or mycelium on volunteer host plants or crop

residues, thus, it can be a source of primary infection.

2. Host Factor:

- Infected varieties of fenugreek are more likely to get the disease, especially those with dense canopies or poor air circulation.
- The young and tender leaves are more susceptible than mature ones.
- The nutritional imbalance, especially the excess of nitrogen, increases the susceptibility of the

plant to the disease by producing soft, lush tissue that is ideal for the growth of the fungus.

3. Environmental Factors:

- **Temperature:** The microorganism survives well in warm and dry conditions, with an optimal temperature of 20–25°C for its development.
- **Humidity:** The moderate relative humidity of 50–70% is very favorable for the germination of conidia and the spread of the disease.
- **Rainfall:** Powdery mildew is preferred by zero or very low rain conditions, as the rain removes the spores from the surface and also inhibits spore germination.
- **Air Movement:** Lack of ventilation and overcrowding of plants cause an increase in the humidity of the air surrounding the leaves, thus providing the perfect conditions for fungal growth.

4. Agronomic and Management Factors:

- The practice of growing fenugreek continuously in the same field without rotation leads to an increase of the inoculum load.

- Late sowing enables the crop to encounter environmental conditions that are suitable for pathogen growth.
- The indifference to field sanitation, such as the leaving of infected residues, makes it easier for pathogens to survive and repeat the infection cycle.

IV. SYMPTOMS AND DISEASE DEVELOPMENT

Powdery mildew of fenugreek, caused by *Erysiphe polygoni*, is a highly recognizable disease due to its characteristic **white, powdery fungal growth** on aerial plant parts. The disease can affect fenugreek plants at **any stage of growth**, but symptoms are most severe during the **flowering and pod formation stages**, leading to significant yield reduction.

1. Initial Symptoms:

- The first signs usually appear as **small, circular, white or grayish spots** on the upper surface of lower leaves.
- These spots gradually enlarge and merge, forming a **continuous powdery coating** that resembles flour dust.
- The affected leaves may curl slightly and show signs of **chlorosis (yellowing)** around infected areas.

2. Progression of the Disease:

- As the infection advances, the powdery growth spreads to **stems, petioles, and pods**, covering a major portion of the plant.
- The fungal mycelium and conidia give the plant a **white, dusty appearance** that is easily visible in the field.
- Severely infected leaves **dry up, become brittle, and fall prematurely**, reducing the plant's photosynthetic capacity.
- In advanced stages, infection of **pods** can interfere with seed formation and quality.

3. **Disease Development and Epidemiology:**

- The pathogen primarily spreads through **airborne conidia**, which are produced in abundance on infected surfaces.
- Conidia germinate in the presence of **favorable temperature (20–25°C)** and **moderate relative humidity (50–70%)**, even in the absence of free moisture.
- The disease cycle continues as new conidia infect healthy tissues, leading to **secondary infections** throughout the growing season.

- In the off-season, the fungus survives as **cleistothecia (sexual fruiting bodies)** or as dormant mycelium on crop residues and alternate hosts.

4. **Impact on the Crop:**

- Severe infections lead to **reduced photosynthesis, stunted growth, and poor seed development**.
- Infected plants often produce **fewer and lighter seeds**, directly affecting yield and quality.
- Under epidemic conditions, yield losses may reach up to **40–60%**, depending on cultivar susceptibility and environmental conditions.

V. **MANAGEMENT AND CONTROL STRATEGIES**

Effective management of powdery mildew in fenugreek requires a **comprehensive and integrated approach** that combines cultural, biological, and chemical control methods. Since the disease can spread rapidly under favorable conditions, early detection and timely intervention are crucial to minimize yield losses and ensure sustainable crop production.

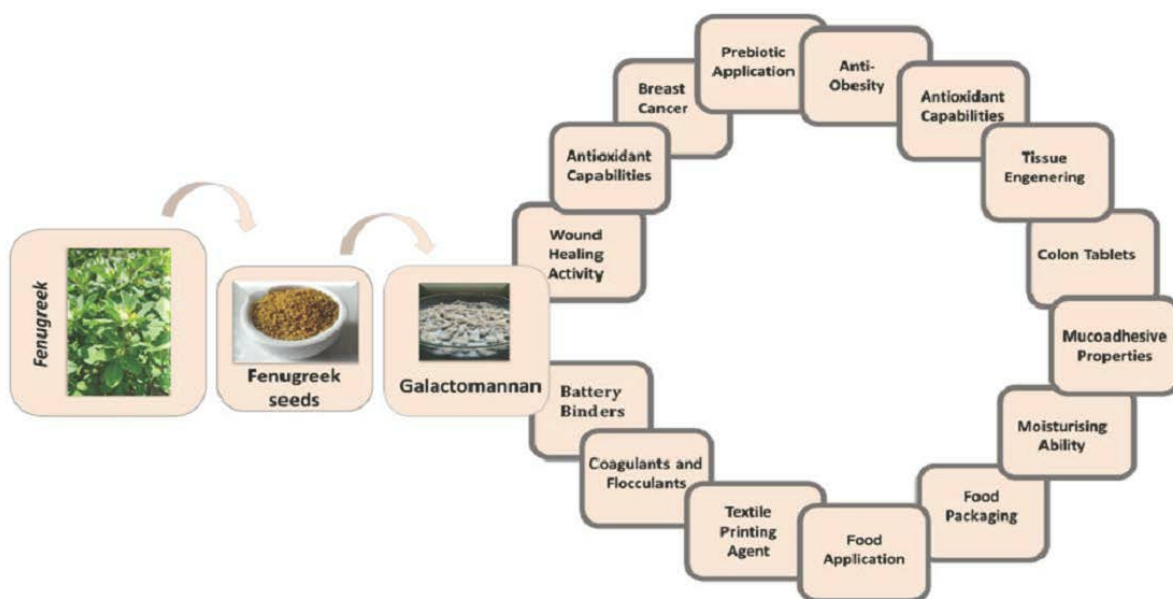


Figure 2. Management and Control Strategies

1. Cultural Management

- **Crop Rotation:** Avoid continuous cultivation of fenugreek or other leguminous crops in the same field. A **2–3-year crop rotation** with non-host crops like cereals helps in reducing pathogen inoculum.
- **Field Sanitation:** Remove and destroy infected crop residues and volunteer plants after harvest to prevent overwintering of the fungus.
- **Proper Spacing:** Maintain adequate plant spacing to ensure good air circulation and reduce humidity around the foliage.
- **Timely Sowing:** Early sowing helps the crop escape favorable conditions for powdery mildew development,

particularly during warm and dry late-season periods.

- **Balanced Fertilization:** Avoid excessive nitrogen fertilization, as it promotes dense foliage that favors fungal growth; instead, maintain a balanced NPK ratio.

2. Use of Resistant Varieties

- Growing **disease-resistant or tolerant varieties** is one of the most economical and eco-friendly methods.
- Varieties such as ‘**RMT-1**’, ‘**AFg-3**’, and ‘**HM-57**’ have shown moderate resistance to powdery mildew under field conditions.
- Continuous breeding efforts are ongoing to develop high-yielding, disease-resistant genotypes through

conventional and molecular approaches.

3. Chemical Control

- **Fungicidal Sprays:** Application of sulfur-based and systemic fungicides has proven effective against *Erysiphe polygoni*.
 - **Wettable sulfur (0.25%)**
 - **Hexaconazole (0.1%)**
 - **Propiconazole (0.1%)**
 - **Penconazole (0.05%)**
- Spraying should be initiated **at the first appearance of symptoms** and repeated at **10–15 day intervals** depending on disease severity and weather conditions.
- Alternating fungicides with different modes of action helps prevent **fungicide resistance** in the pathogen population.

4. Biological Control

- **Antagonistic fungi** such as *Trichoderma harzianum*, *Ampelomyces quisqualis*, and *Bacillus subtilis* have shown inhibitory effects against powdery mildew pathogens.
- Foliar application of **neem (Azadirachta indica) extract (5%)**, **garlic extract (2%)**, and other botanical formulations has reduced disease severity in field trials.

- These biological approaches are environmentally safe and can be integrated with chemical control for an **eco-friendly management program**.

5. Integrated Disease Management (IDM)

- Combining **cultural, biological, and chemical methods** provides the most sustainable solution for disease control.
- An IDM program typically includes:
 - Use of resistant varieties.
 - Timely sowing and balanced fertilization.
 - Application of bio-agents like *Trichoderma harzianum*.
 - Need-based fungicidal sprays at early infection stages.
 - This approach not only reduces chemical dependency but also enhances soil health and long-term disease suppression.

VI. CONCLUSION & RESULTS

Powdery mildew, caused by *Erysiphe polygoni*, is a significant problem that has spread widely and is a major cause of yield and quality losses in fenugreek (*Trigonella foenum-graecum* L.). The disease develops under warm and dry conditions, with moderate humidity, and is thus a problem that recurs in practically all fenugreek-growing areas. Proper understanding of disease etiology, epidemiology, and

favorable environmental conditions is the basis for effective management. Among the different options, integrated disease management (IDM) has been recognized as the most sustainable and effective method. The combination of cultural practices (such as timely sowing, crop rotation, and balanced fertilization), use of resistant varieties, biological control agents, and a careful fungicide application program provides economic viability as well as environmental safety. Chemical control alone is not sustainable or eco-friendly, so the use of IDM reduces the risk of fungicide resistance and maintains soil and ecological health. Breeding for resistance, biological control research, and environmental monitoring will continue to be the main factors in reducing the powdery mildew problem. Farmer education and the implementation of proper management practices at the field level can, therefore, be instrumental in increasing the productivity and profitability of fenugreek cultivation and at the same time contribute to sustainable agricultural development.

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