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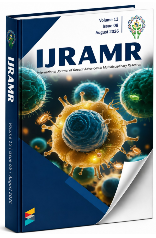

REVIEW ARTICLE

STUDIES ON MANAGEMENT OF SOME FUNGAL DISEASES IN PULSES IN MAHARASHTRA – A REVIEW

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ABSTRACT

Pulses are an important component of the agricultural system and a major source of dietary protein in Maharashtra. However, their productivity is significantly affected by various fungal diseases such as Fusarium wilt, dry root rot, powdery mildew, rust, and *Cercospora* leaf spot. The present review aims to compile and analyze existing research on the occurrence and management of major fungal diseases in pulse crops. The study is based on secondary data collected from peer-reviewed journals, books, and institutional publications. The reviewed literature indicates that fungal pathogens cause considerable yield losses, especially under favorable environmental conditions. Various management strategies including cultural practices, use of resistant varieties, chemical control, and biological control have been evaluated by different researchers. Among these, biological control using beneficial microorganisms and the development of resistant varieties are gaining importance due to their eco-friendly nature. The findings emphasize that Integrated Disease Management (IDM), which combines cultural, biological, and chemical methods, is the most effective and sustainable approach for managing fungal diseases in pulses. The review also highlights the influence of environmental factors and the need for climate-resilient disease management strategies. Adoption of improved practices and increased farmer awareness are essential for enhancing pulse productivity and ensuring sustainable agriculture.

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INTRODUCTION

Pulses are an integral component of the agricultural economy and dietary system in Maharashtra, where they are cultivated across a wide range of agro-climatic zones, from semi-arid to sub-humid regions. Major pulse crops such as chickpea (*Cicer arietinum* L.), pigeon pea (*Cajanus cajan* (L.) Millsp.), mung bean (*Vigna radiata* (L.) R. Wilczek.), and urd bean (*Vigna mungo* (L.) Hepper) occupy a prominent place in the state's cropping systems due to their adaptability to marginal lands and low input requirements. Apart from being rich sources of protein, vitamins, and minerals, pulses contribute significantly to soil health through symbiotic nitrogen fixation, thereby enhancing soil fertility and reducing dependence on synthetic fertilizers (Ali and Gupta, 2012). This makes pulses a key component in sustainable and climate-resilient agriculture. Despite their importance, pulse productivity in Maharashtra remains relatively low compared to global standards. One of the major constraints responsible for this yield gap is the widespread occurrence of fungal diseases, which cause severe qualitative and quantitative losses. These diseases not only reduce yield but also affect seed quality, market value, and storage life. Among the various biotic stresses, fungal pathogens are particularly destructive due to their rapid spread, survival ability in soil and crop residues, and favorable interaction with environmental conditions (Nene *et al*., 1996). Several fungal diseases have been reported to affect pulse crops in Maharashtra, including Fusarium wilt, dry root rot, powdery mildew, anthracnose, *Cercospora* leaf spot, and rust. The intensity and distribution of these diseases vary depending on crop species, cultivar susceptibility, and prevailing environmental conditions such as temperature, humidity, and rainfall patterns. Yield losses due to these diseases can range from 10% to complete crop failure under severe epidemic conditions (Pande *et al*., 2005). The situation becomes more critical under rainfed conditions, where moisture stress predisposes plants to infection by soil-borne pathogens.

Fusarium wilt, caused by *Fusarium oxysporum* f. sp. *Cicero* (Padwick) Matuo & K. Sato, is one of the most devastating diseases of chickpea and is widely prevalent in major chickpea-growing regions of Maharashtra. The pathogen invades the vascular system of the plant, leading to wilting and eventual plant death. Similarly, dry root rot caused by *Rhizoctonia bataticola* (Taubenh.) E.J. Butler, is an emerging threat, particularly under high temperature and low soil moisture conditions. Foliar diseases such as powdery mildew

(*Erysiphe polygoni* DC.) and rust (*Uromyces* spp.) also significantly reduce photosynthetic efficiency and crop yield in pulses like mung bean and urd bean (Ghosh *et al*., 2013).

Management of fungal diseases in pulses is complex and requires a multi-pronged approach. Traditional methods such as crop rotation, timely sowing, and sanitation practices help reduce disease inoculum in the field. The use of disease-resistant or tolerant varieties is considered one of the most economical and effective strategies; however, resistance is often overcome by evolving pathogen races. Chemical control using fungicides provides quick results but poses concerns related to environmental safety, residual toxicity, and development of fungicide resistance (Sharma *et al*., 2016). In recent years, there has been increasing emphasis on eco-friendly and sustainable disease management strategies. Biological control using antagonistic microorganisms such as *Trichoderma* spp., *Pseudomonas fluorescens*, and *Bacillus* spp. has shown promising results in suppressing soil-borne pathogens and enhancing plant growth. These bio-agents act through mechanisms such as competition, antibiosis, parasitism, and induction of systemic resistance in host plants (Singh *et al*., 2017). Additionally, integrated disease management (IDM) approaches that combine cultural, biological, and chemical methods are being promoted for effective and long-term disease control. The changing climate scenario, characterized by erratic rainfall, rising temperatures, and increased frequency of extreme weather events, is further influencing the epidemiology of fungal diseases in pulses. Such changes may alter pathogen distribution, survival, and virulence, thereby posing new challenges for disease management. Therefore, it is essential to continuously monitor disease dynamics and develop adaptive management strategies tailored to regional conditions. In this context, a comprehensive review of studies on the management of fungal diseases in pulses in Maharashtra is of great significance. It will help consolidate existing knowledge, evaluate the effectiveness of different management practices, identify research gaps, and provide direction for future research aimed at improving pulse productivity and sustainability in the region.

LITERATURE REVIEW

Fungal diseases are among the most significant biotic constraints affecting pulse production worldwide, including in Maharashtra. Extensive research has been carried out on the occurrence, epidemiology, and management of major fungal pathogens affecting pulse crops such as chickpea, pigeon pea, mung bean, and urd bean.

Major Fungal Diseases in Pulses: Among soil-borne diseases, Fusarium wilt caused by *Fusarium oxysporum* f. sp. *ciceri* is one of the most extensively studied diseases in chickpea. Studies have reported that the pathogen can survive in soil for several years and cause severe yield losses under favorable conditions (Nene *et al*., 1996). Similarly, dry root rot caused by *Rhizoctonia bataticola* has emerged as a major threat in rainfed regions, particularly under moisture stress and high temperature conditions (Ghosh *et al*., 2013). Foliar fungal diseases also contribute significantly to yield reduction. Powdery mildew caused by *Erysiphe polygoni* is commonly observed in mung bean and urd bean, especially during late crop stages. *Cercospora* leaf spot (*Cercospora canescens*) and rust (*Uromyces* spp.) are also widely distributed and affect photosynthetic activity, leading to reduced grain yield (Pande *et al*., 2005). The occurrence and severity of these diseases are largely influenced by environmental factors such as humidity, temperature, and rainfall patterns (Kaur *et al*., 2018).

Cultural and Agronomic Management Practices: Cultural practices have been widely recommended as the first line of defense against fungal diseases in pulses. Crop rotation, deep summer ploughing, use of healthy seeds, and timely sowing have been shown to reduce soil-borne inoculum and disease incidence (Sharma *et al*., 2016). Intercropping systems, particularly chickpea with cereals, have also been reported to suppress disease spread by altering the microclimate and reducing pathogen buildup (Singh and Singh, 2014). Adjusting sowing dates has been found effective in avoiding peak disease periods. For instance, early sowing of chickpea can reduce the incidence of Fusarium wilt, while delayed sowing may help escape powdery mildew infection in mung bean (Pande *et al*., 2005). Proper field sanitation and removal of infected plant debris are also important in minimizing the carryover of pathogens.

Host Plant Resistance: The development and use of resistant varieties is considered one of the most economical and eco-friendly approaches to managing fungal diseases. Several resistant or moderately resistant varieties of chickpea and pigeon pea have been identified against Fusarium wilt and other diseases (Nene *et al*., 1996). However, the durability of resistance is often challenged by the existence of multiple pathogenic races and variability within pathogen populations.

Recent studies have emphasized the need for breeding programs that incorporate multiple resistance genes to enhance durability. Molecular approaches such as marker-assisted selection are increasingly being used to develop disease-resistant varieties with improved agronomic traits (Varshney *et al*., 2019).

Chemical Control: Chemical fungicides have been widely used for the management of fungal diseases in pulses due to their rapid and effective action. Seed treatment with fungicides such as carbendazim, thiram, and captan has been found effective in controlling seed- and soil-borne pathogens (Sharma *et al*., 2016). Foliar sprays of fungicides like hexaconazole and wettable sulfur are commonly used to manage powdery mildew and rust diseases. However, excessive and indiscriminate use of fungicides has raised concerns regarding environmental pollution, development of resistant pathogen strains, and health hazards. Therefore, reliance solely on chemical control is not considered sustainable in the long term (Singh *et al*., 2017).

Biological Control: Biological control has emerged as a promising and environmentally safe alternative for managing fungal diseases in pulses. Antagonistic microorganisms such as *Trichoderma harzianum*, *Trichoderma viride*, and *Pseudomonas fluorescens* have been extensively studied for their ability to suppress soil-borne pathogens through mechanisms such as competition, antibiosis, mycoparasitism, and induced systemic resistance (Singh *et al*., 2017). Seed treatment and soil application of these bio-agents have shown significant reduction in disease incidence and improvement in plant growth and yield. Integration of bio-control agents with organic amendments such as farmyard manure and compost further enhances their effectiveness by improving soil microbial activity (Ghosh *et al*., 2013).

Table 1. Major Fungal Diseases of Pulses and Their Management

Crop	Disease	Pathogen	Key Symptoms	Management Practices
Chickpea	Fusarium wilt	*Fusarium oxysporum* f. sp. *Cicero* (Padwick) Matuo & K. *Sato*	Yellowing, drooping of leaves, vascular browning, sudden wilting of plants	Use resistant varieties, seed treatment with carbendazim/thiram, crop rotation, soil solarization
Chickpea	Dry root rot	*Rhizoctonia bataticola* (Taubenh.) E.J. Butler	Sudden drying of plants, blackened roots, shredding of bark	Maintain soil moisture, crop rotation, application of *Trichoderma* spp., organic amendments
Chickpea	Ascochyta blight	*Ascochyta rabiei* (Pass.) Labrousse	Brown lesions on leaves, stems, pods with concentric rings	Use disease-free seeds, fungicidal sprays (chlorothalonil), resistant varieties
Pigeon pea	Wilt	*Fusarium udum* Butler	Partial or complete wilting, purple streaks on stem	Resistant varieties, crop rotation, seed treatment, field sanitation
Pigeon pea	Sterility mosaic (fungal-like, vector-borne)	Not fungal (virus via mite)	Bushy appearance, no flowering	Rogue infected plants, vector control
Mung bean	Powdery mildew	*Erysiphe polygoni* DC.	White powdery growth on leaves, premature leaf fall	Sulfur dusting, fungicide spray (hexaconazole), resistant varieties
Mung bean	*Cercospora* leaf spot	*Cercospora canescens* Ellis & G. Martin	Circular brown spots with yellow halo	Seed treatment, foliar sprays (carbendazim/mancozeb), crop rotation
Urd bean	Anthracnose	*Colletotrichum lindemuthianum* (Sacc. & Magnus) Briosi & Cavara	Dark sunken lesions on pods and stems	Disease-free seeds, fungicide sprays, resistant varieties
Urd bean	Rust	*Uromyces phaseoli* (Pers.) G. Winter	Reddish-brown pustules on leaves	Early sowing, fungicide spray, resistant cultivars

Table 2. Integrated Disease Management (IDM) Strategies for Major Fungal Diseases in Pulses

Disease	Cultural Practices	Biological Control	Chemical Control	Resistant Varieties
Fusarium wilt	Crop rotation, deep ploughing, well-drained soil	*Trichoderma harzianum* Rifai, *Pseudomonas fluorescens*	Carbendazim seed treatment	Improved wilt-resistant varieties
Dry root rot	Proper irrigation, avoid drought stress	*Trichoderma viride* Migula	Thiram/carbendazim seed treatment	Tolerant cultivars
Powdery mildew	Adjust sowing time, proper spacing	*Bacillus subtilis* (Ehrenberg) Cohn	Wettable sulfur, hexaconazole spray	Resistant lines
Cercospora leaf spot	Crop rotation, removal of debris	*Trichoderma* spp.	Mancozeb, carbendazim spray	Moderately resistant varieties
Rust	Early sowing, field sanitation	Limited use	Propiconazole spray	Resistant cultivars
Anthracnose	Use healthy seeds, proper drainage	*Pseudomonas fluorescens* Migula	Carbendazim spray	Resistant varieties

Table 3. Summary of Important Bio-agents Used in Management of Pulse Diseases

Bio-agent	Target Pathogens	Mode of Action	Application Method
Trichoderma harzianum	*Fusarium*, *Rhizoctonia*	Mycoparasitism, antibiosis, competition	Seed treatment, soil application
Trichoderma viride	Soil-borne fungi	Enzyme production, competition	Seed + soil application
Pseudomonas fluorescens	Multiple fungal pathogens	Induced systemic resistance, antibiosis	Seed treatment, foliar spray
Bacillus subtilis	Foliar pathogens	Antibiotic production	Foliar spray
Gliocladium virens	Soil pathogens	Parasitism, competition	Soil treatment

Integrated Disease Management (IDM): Integrated Disease Management (IDM) approaches that combine cultural, biological, and chemical methods have been found to be most effective in managing fungal diseases in pulses. Several studies have demonstrated that combining resistant varieties with seed treatment, bio-agents, and need-based fungicide application significantly reduces disease incidence and increases yield (Sharma *et al*., 2016). IDM not only ensures effective disease control but also minimizes environmental risks and promotes sustainable agriculture. In Maharashtra, location-specific IDM modules have been developed for major pulse crops, taking into account local agro-climatic conditions and disease prevalence.

Impact of Climate Change on Disease Dynamics: Recent research indicates that climate change is likely to influence the epidemiology of fungal diseases in pulses. Changes in temperature, rainfall patterns, and humidity can alter pathogen survival, reproduction, and distribution (Kaur *et al*., 2018). For instance, increased temperature and drought conditions may favor dry root rot, while high humidity promotes foliar diseases like powdery mildew and rust. This highlights the need for continuous monitoring and development of adaptive disease management strategies to cope with changing environmental conditions.

METHODOLOGY

The present study is based on secondary data analysis and involves a comprehensive review of published literature on the management of fungal diseases in pulse crops, with special reference to Maharashtra. Relevant research articles, review papers, books, institutional reports, and conference proceedings were collected from various scientific databases and sources, including Google Scholar, ResearchGate, Scopus-indexed journals. The literature search was conducted using keywords such as pulses diseases, fungal pathogens in pulses, Fusarium wilt, dry root rot, powdery mildew, and integrated disease management in pulses. The collected literature was carefully screened based on relevance, authenticity, and recency. Priority was given to peer-reviewed journal articles and region-specific studies related to Maharashtra and similar agro-climatic conditions. Selected studies were critically analyzed to extract information on major fungal diseases, their causal organisms, symptoms, epidemiology, and management practices. The data and findings from different sources were systematically compiled, compared, and synthesized to identify common trends, effective management strategies, and research gaps. The information was then organized into thematic sections such as disease occurrence, cultural practices, biological control, chemical control, and integrated disease management (IDM). This review approach enables a comprehensive understanding of the existing knowledge on fungal disease management in pulses and provides a basis for suggesting future research directions.

RESULTS AND DISCUSSION

The synthesis of reviewed studies indicates that fungal diseases are a major limiting factor for pulse productivity in Maharashtra. The compiled data (Table 1–3) reveal that both soil-borne and foliar pathogens significantly influence crop health, yield stability, and economic returns.

Disease Spectrum and Severity: The results clearly show that soil-borne pathogens such as *Fusarium oxysporum* f. sp. *ciceri* and *Rhizoctonia bataticola* are highly persistent and destructive. These pathogens survive in soil and crop residues for extended periods, making their management difficult. Reports indicate that Fusarium wilt alone can cause up to complete crop failure under favorable conditions (Nene *et al.*, 1996; Dubey *et al.*, 2010). The increasing incidence of dry root rot in recent years is particularly alarming and is strongly associated with rising temperatures and moisture stress conditions (Ghosh *et al.*, 2013; Sharma and Pande, 2013). This suggests a clear linkage between disease prevalence and changing climatic conditions. Foliar diseases such as powdery mildew, *Cercospora* leaf spot, and rust also contribute significantly to yield reduction by impairing photosynthesis and accelerating senescence. Studies have reported yield losses ranging from 20–40% depending on disease severity and environmental conditions (Pande *et al.*, 2005; Kumar *et al.*, 2018).

Evaluation of Management Practices: The comparative analysis of different disease management strategies indicates that integrated approaches are more effective than individual methods. Cultural Practices: Cultural practices such as crop rotation, deep ploughing, and timely sowing reduce primary inoculum and disease incidence. However, their effectiveness is often limited under high disease pressure or unfavorable environmental conditions (Sharma *et al.*, 2016). Intercropping systems have shown moderate success by modifying the microclimate and reducing pathogen spread (Singh and Singh, 2014). Host Plant Resistance: Host resistance remains the most economical strategy. However, the review highlights that resistance is often not durable due to the emergence of new pathogenic races. Recent advances in molecular breeding and genomics have improved the efficiency of developing resistant cultivars (Varshney *et al.*, 2019; Jha *et al.*, 2020). Nevertheless, continuous screening and varietal replacement are necessary. Chemical Control: Chemical fungicides are effective for immediate disease suppression, particularly in seed treatment and foliar applications. However, excessive reliance leads to issues such as resistance development, environmental contamination, and increased production costs (Brent and Hollomon, 2007). Therefore, their role should be supportive rather than primary. Biological Control: Bio-control agents such as *Trichoderma harzianum* and *Pseudomonas fluorescens* have demonstrated significant potential in managing soil-borne pathogens. These agents improve plant health through multiple mechanisms including antibiosis and induced systemic resistance (Singh *et al*., 2017; Harman *et al*., 2004). However, variability in field performance remains a limitation.

Superiority of Integrated Disease Management (IDM)

The results strongly support that Integrated Disease Management (IDM) is the most effective approach. Studies show that combining resistant varieties, seed treatment, bio-agents, and need-based fungicide application can reduce disease incidence by more than 50% and significantly increase yield (Sharma *et al*., 2016; Pande *et al*., 2010). IDM not only ensures better disease control but also enhances sustainability by reducing chemical inputs and improving soil health.

Influence of Climate Change: An important outcome of this review is the increasing influence of climate change on disease dynamics. Rising temperatures, erratic rainfall, and prolonged dry spells are creating favorable conditions for diseases like dry root rot, while high humidity favors foliar pathogens (Kaur *et al*., 2018; Chakraborty and Newton, 2011).

This highlights the urgent need for

- Climate-resilient varieties
- Region-specific disease forecasting models
- Adaptive management strategies

Research Gaps and Future Directions

The review identifies several gaps

- Limited region-specific studies for Maharashtra
- Inconsistent field performance of bio-agents
- Lack of farmer-level adoption of IDM practices

These findings emphasize the need for continuous surveillance, development of climate-resilient varieties, and adaptive management strategies to address emerging challenges.

CONCLUSION

Fungal diseases are a major constraint to pulse production in Maharashtra, causing significant yield and quality losses. Important diseases such as Fusarium wilt, dry root rot, powdery mildew, and rust continue to affect major pulse crops under diverse agro-climatic conditions. The review indicates that individual management practices are not sufficient for effective disease control. Cultural practices and resistant varieties provide a strong foundation, while chemical control offers quick results but has environmental and sustainability concerns. Biological control using eco-friendly agents like *Trichoderma* and *Pseudomonas* shows promising potential. Overall, Integrated Disease Management (IDM) emerges as the most effective and sustainable approach, combining multiple strategies to reduce disease incidence and improve productivity. Future efforts should focus on developing resistant varieties, promoting bio-control methods, and enhancing farmer awareness to ensure sustainable pulse production.

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