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Bio Fungicidal Potential Of Plant Extracts In Controlling Fungal Diseases Of Oilseed Crops

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ABSTRACT

Plant fungal diseases significantly impact the yield and quality of oilseed crops in India, with Alternaria blight and related pathogens causing up to 70% yield losses. Chemical fungicides, though effective, are beset with issues such as resistance development, environmental persistence, and food safety concerns. In response, research has focused on the bio-fungicidal properties of locally available plant extracts—particularly garlic (Allium sativum), neem (Azadirachta indica), ginger (Zingiber officinale), NSKE (Neem Seed Kernel Extract), and Alstonia scholaris—aimed at sustainable disease management. This paper investigates their efficacy against fungal pathogens in Indian mustard and related oilseeds through in vitro and in vivo experiments, comparing findings to standard fungicides and biocontrol agents. The results indicate that garlic and neem extracts, especially when applied as combined seed and foliar treatments, offer disease suppression and yield improvements comparable to synthetic fungicides, presenting a viable option for integrated pest management.

Keywords: Biofungicides, plant extracts, fungal diseases, oilseed crops, disease management.

INTRODUCTION

Oilseed crops such as mustard (Brassica juncea), groundnut (Arachis hypogaea), and sesame (Sesamum indicum) play a vital role in Indian agriculture, serving as essential sources of edible oils and contributing significantly to the nation's nutritional and economic security. These crops collectively cover approximately 27 million hectares across the country and contribute around 10% to India's agricultural Gross Domestic Product (GDP). Despite their importance, oilseed production faces several challenges, with fungal diseases emerging as a major constraint to productivity and quality. Pathogens such as Alternaria brassicae and Sclerotinia sclerotiorum are among the most destructive, capable of causing substantial yield losses and deteriorating oil content and quality. Alternaria blight alone can result in yield reductions ranging from 35% to 70%, depending on climatic conditions and management practices.

Traditionally, chemical fungicides have been the primary method for managing these diseases. While effective in the short term, their long-term use raises several concerns, including the development of fungicide resistance in pathogen populations, accumulation of chemical residues in food and the environment, and negative impacts on non-target organisms and overall ecosystem health. These issues, coupled with increasing consumer awareness and demand for safer, residue-free agricultural products, have intensified the search for eco-friendly, sustainable disease management alternatives.

Among the promising solutions are plant-derived biopesticides, which utilize natural compounds with antifungal properties. Many plants are known to produce secondary metabolites—such as phenolics, alkaloids, and terpenoids—that exhibit strong antimicrobial activity. Extracts from commonly available plants like garlic (Allium sativum), neem (Azadirachta indica), and ginger (Zingiber officinale) have been widely reported for their broad-spectrum efficacy against various phytopathogenic fungi (Bhoshale et al., and Tripathi et al., 2008). Despite promising laboratory findings, there remains a gap in large-scale, field-based validation of these botanical extracts, particularly within the context of Indian oilseed farming systems (Sonali et al., 2022). Therefore, systematic evaluation of these natural treatments under real agricultural conditions is essential to assess their potential as viable alternatives to synthetic fungicides.

METHODOLOGY

Sample collection and study sites

The present study was conducted across two distinct research locations under varying field conditions. The first site comprised research plots situated within selected villages of the Bareilly district, Uttar Pradesh—a region known for its extensive cultivation of Indian mustard (Brassica juncea). The second site was located within the botanical research fields on the college campus, providing a controlled environment for comparative evaluation. Both sites fall within the agro-climatic zones favourable for oilseed crop production, allowing the study to assess the efficacy of treatments under both farmer-field conditions and semi-controlled research environments.

Disease samples were collected from symptomatic mustard plants displaying typical signs of foliar blight and pod infection. These samples were used for pathogen isolation and further study.

Control measure

A total of three intervention groups were evaluated: (1) plant extracts, including garlic bulb (15%, 10%, 5%), neem leaf and neem seed kernel extract (NSKE) (15%, 10%, 5%), and ginger rhizome and Alstonia leaf extracts (10%, 5%); (2) bio-agents, namely Trichoderma harzianum and Pseudomonas fluorescens, both at 1% concentration; and (3) standard chemical fungicides such as Mancozeb 75% WP (0.25%), Carbendazim 50% WP (0.2%), and Captan + Hexaconazole applied as per recommended doses (Singh et al., 2017). The experimental setup followed a randomized block design (RBD) with three to four replications in both laboratory and field conditions.

Preparation of extract

Plant extracts were prepared by washing and homogenizing fresh plant materials in a 1:1 weight-to-volume ratio with sterile distilled water, followed by filtration and centrifugation to obtain stock solutions. These were further diluted to desired working concentrations. Treatments included both seed and foliar applications: seeds were soaked in the respective solutions and dried before sowing, while foliar sprays were applied at 50 and 65 days after sowing (DAS).

Assessment of disease

Assessment parameters included disease metrics such as percent disease intensity (PDI) on leaves at 75 DAS and on pods at 90 DAS. Growth and yield attributes—plant height, test weight (g/1000 seeds), and grain yield (quintals per hectare)—were also recorded. Laboratory evaluations involved in vitro mycelial growth inhibition using the poisoned food technique and seed germination/vigour assessment through the standard blotter method. Data were statistically analyzed using ANOVA, with treatment means compared by Duncan's Multiple Range Test (DMRT) at a 5% significance level ($P = 0.05$).

RESULTS AND DISCUSSION

Garlic and neem extracts applied at a 15% concentration significantly reduced disease intensity in oilseed crops, with percent disease index (PDI) values only 2–4% higher than those observed in mancozeb-treated plots, and substantially lower than the untreated controls. Among the treatments, garlic extract exhibited the highest inhibition of fungal mycelial growth, achieving over 90% suppression at a 10% concentration in vitro, thereby confirming its strong antifungal efficacy. Furthermore, the application of garlic extracts enhanced seed germination rates, reaching 85% compared to just 56.5% in the control group. This improvement, along with increased seedling vigor, suggests that garlic extract not only offers protective benefits against fungal pathogens but also contributes to overall plant growth and development.

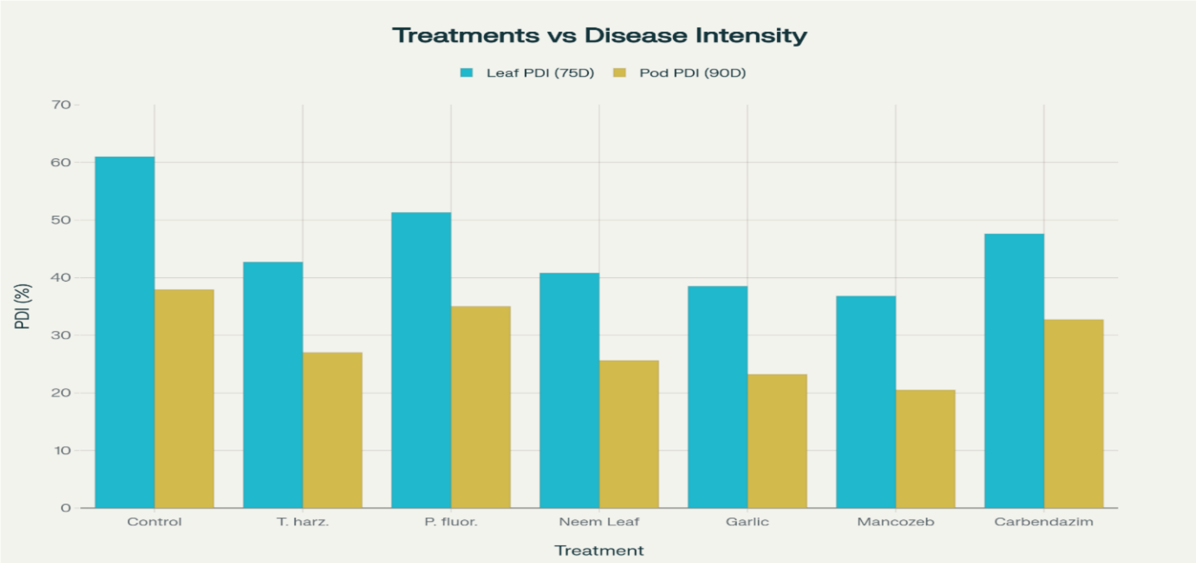
Table 1: Effect of treatments on disease and yield in mustard

Treatment	PDI Leaf 75 DAS (%)	PDI Pod 90 DAS (%)	Plant Height 90 DAS (cm)	Test Weight (g/1000)	Yield (q/ha)
Control	61.0	37.9	135.7	4.11	9.04
Trichoderma harzianum (1%)	42.7	27.0	151.0	4.49	11.95
Pseudomonas fluorescens (1%)	51.3	35.0	137.3	4.68	10.12
Neem leaf extract (15%)	40.8	25.6	158.0	4.89	12.68
Garlic bulb extract (15%)	38.5	23.2	167.0	4.91	12.91
Mancozeb 75% WP (0.25%)	36.8	20.5	162.6	5.04	13.38
Carbendazim 50% WP (0.2%)	47.6	32.7	144.4	4.72	10.57

Trichoderma harzianum treatment contributed to increased plant height, demonstrating its growth-promoting potential. However, its effectiveness in suppressing fungal diseases was slightly lower compared to the best-performing plant extracts such as garlic and neem. Notably, the combined approach of seed treatment and foliar application delivered the most promising results, effectively minimizing disease incidence while maximizing yield and test weight—an outcome that reinforces the principles of integrated pest management (IPM). Although detailed economic analysis was beyond the scope of this study, previous research indicates that garlic extract offers a favourable cost–benefit ratio, comparable to conventional fungicides, especially considering its local availability and residual protective effects (Ahmed et. al., 2018). The adoption of plant-based fungicides not only reduces chemical residue buildup in the environment but also helps slow the development of resistance in fungal populations, thereby supporting more sustainable and eco-friendly agricultural practices.

Figure 1: Percent disease intensity (PDI) in mustard under different treatments

The following bar chart visually represents the impact of different plant extracts, bioagents, and fungicides on reducing fungal disease intensity in mustard plants.



X-axis: Treatments (Control, T. harz., P. fluor., Neem Leaf, Garlic, Mancozeb, Carbendazim), **Y-axis:** Percent Disease Intensity (PDI %)
Skyblue bars: Leaf PDI at 75 Days After Sowing (DAS), **Gold bars:** Pod PDI at 90 DAS

In the present study, control plots showed the highest disease intensity on both leaves and pods, indicating severe fungal disease pressure when no treatment was applied. Among the treatments, garlic bulb extract and neem leaf extract were particularly effective, significantly reducing disease intensity and demonstrating efficacy comparable to the chemical fungicide Mancozeb. The bioagents Trichoderma harzianum and Pseudomonas fluorescens also contributed to disease management but offered only moderate suppression. Synthetic fungicides such as Mancozeb 75% WP and Carbendazim 50% WP recorded the lowest Percent Disease Index (PDI), although the performance of garlic extract, a plant-based treatment, was nearly equivalent, suggesting its potential as an eco-friendly alternative.

Table 2: In- vitro efficacy of plant extracts (Standard Blotter Test)

Plant Extract	Germination (%)	Pre-Em. Mortality (%)	Post-Em. Mortality (%)	Seedling Vigour
Garlic (10%)	85.0	4.5	5.0	1045.5
NSKE (10%)	80.0	5.5	4.5	900.0
Neem Leaf (10%)	78.0	6.8	5.0	819.0
Ginger (10%)	77.0	5.5	5.0	758.5
Alstonia (10%)	68.0	11.0	6.5	632.4
Control	56.5	42.0	15.8	350.3

Table 3: Percent inhibition of mycelial growth by plant extracts

Extract	5%	10%	Mean
Garlic	89.4	91.7	90.5
NSKE	85.6	89.1	87.4
Neem Leaf	83.5	87.5	85.5
Ginger	80.3	84.7	82.5
Alstonia	59.3	62.3	60.8
Control	0.0	0.0	0.0

CONCLUSIONS

The study concludes that plant extracts, particularly those derived from garlic and neem, are effective and environmentally friendly alternatives to synthetic fungicides for managing fungal diseases in Indian oilseed crops. These botanical treatments significantly reduce disease incidence, enhance seed germination and vigour, and offer yield benefits comparable to those achieved with chemical fungicides. Promoting the widespread adoption of such bio-fungicides, especially among smallholder farmers, could reduce reliance on agrochemicals and contribute to more sustainable and resilient oilseed production systems. However, further research is needed to optimize formulations, improve shelf life, and develop efficient delivery mechanisms to ensure broader adoption and long-term impact.

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