



Exploring the potential of plant extracts in suppressing rice blast under field conditions

AAKASH¹, ASHWANI KUMAR^{2*}, ANIL KUMAR SAINI¹, MAHAVEER SINGH BOCHALYA²,
POOJA¹ and LOKESH YADAV¹

Regional Research Station (Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana),
Kaithal, Haryana 136 021, India

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ABSTRACT

Rice blast disease incited by *Pyricularia oryzae*, remains a substantial challenge in rice (*Oryza sativa* L.) cultivation, necessitating the exploration of management strategies. The present study was carried out during rainy (*kharif*) season of 2022–23 at Regional Research Station (Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana), Kaithal, Haryana to assess the efficacy of seven botanicals in controlling rice blast disease on two rice varieties, CSR 30 and PB 1121. The botanicals used for the study were, Neem leaf extract @ 20%; Garlic clove extract @10%; Ginger rhizome extract @10%; Turmeric powder extract @10%; Eucalyptus leaves extract @20% congress grass leaf extract @ 20% and Control. The experiment was laid out in randomized block design (RBD), replicated thrice with varied treatments. Among them, garlic clove extract followed by neem leaf extract found most effective reducing disease severity to 36.11% in PB 1121 and 37.96% in CSR 30 variety. On average, disease severity decreased to 41.11% in PB 1121 and 41.85% in CSR 30 variety with neem extract treatment. Eucalyptus leaves extract was found to be least effective in reducing leaf blast severity. Similar trend was observed in neck blast management. Garlic clove extract 31.11% in CSR 30 and 25.89% in PB 1121 proved most effective followed by neem leaf extract 35.56% in CSR 30 and 34.07% in PB 1121 and eucalyptus leaves extract (51.67%) found to be least effective. Similar trend was seen in terms yield for both the varieties. In conclusion, our study identifies garlic and neem extract as potent botanicals for effectively managing rice blast while simultaneously enhancing yield across varieties CSR 30 and PB 1121. These results signify the promising role of garlic and neem extract in sustainable rice cultivation, warranting further investigation and adoption in agricultural practices to promote disease resilience and productivity.

Keywords: Blast, Plant extract, Rice varieties, Severity

Rice (*Oryza sativa* L.) is the most important cereal crop of world, classified under the Poaceae family. The global rice production area is 164.34 million hectares with a production of 547.57 million tonnes and an average productivity of 4530 kg/ha. Similarly in India, rice is being grown in the area of 451.52 lakh ha with a production of 1238.15 lakh tonnes and productivity of 2742 kg/ha. The area of rice production of Haryana is 15.32 lakh ha with a production of 56.43 lakh tonnes and productivity of 3683 kg/ha (Anonymous 2023). It serves as main source of food for more than half population of earth (Fahad *et al.* 2019). Nearly 90% of the world's rice is mostly grown in China, India, Japan, Southeast Asia, Korea and the nearby Pacific islands (Poehlman 2013). Yield of rice is continuously threatened by various biotic

stresses. Amongst these, rice blast caused by *Pyricularia oryzae* is one of the major diseases of crop that results in significant yield losses (Zheng *et al.* 2013, Skolik *et al.* 2018, Yang *et al.* 2019, Kousik *et al.* 2024). The extent of damage caused by rice blast varies with environmental conditions, leading to losses of 10–30% of the global rice yield (Zhang *et al.* 2003) and may lead to 100% damage under congenial conditions (Divya *et al.* 2015)

P. oryzae damages the aerial parts of the rice plant, with the leaves and panicles being the most commonly affected areas (Sesma and Osbourn 2004). Infection with this pathogen reduces the plant's photosynthetic area and when it infects the panicles, it significantly reduces yield (Roumen 1992). The blast spores release a special adhesive that attaches them to the leaves, initiating the infection process (Hamer *et al.* 1988). Once attached to the leaf surface, the spore forms a specialized cell called the appressorium, which facilitates the infection. Pathogen affects all the development stages of crop and infects leaves, collars, necks and panicles. Initial symptoms are white to

¹Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana; ²Regional Research Station (Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana), Kaithal, Haryana. *Corresponding author email: dahiya.ashwani@gmail.com

grey spot with dark green border on leaves; older leaf lesions have an oval or spindle-shaped shape, with red to brownish border. As these lesions develop, they become elliptical or spindle-shaped, with red to brownish or necrotic margins and pale to grey centers. Certain lesions are diamond-shaped, tapering toward each end and wide in the middle. These lesions grow and combine, eventually causing the leaves as a whole to die. Under favourable condition it can cause a 30–80% loss in paddy yield depending upon the factor like variety, location and disease severity (Balgude and Gaikwad 2019) whereas while in severe epidemic, the grain loss can be observed between 70 and 80%. Under Haryana conditions losses ranging from 1.49–59.80%, depending on the severity of the disease. The injudicious and indiscriminate use of chemical pesticides as a conventional management practice results in residual toxicity. Consequently, there is a growing shift towards eco-friendly and biodegradable bio pesticides (Saini *et al.* 2024). In recent years, plant-based products have gained significant traction in the development of novel chemotherapeutants for plant protection (Saini *et al.* 2024). Plant extracts are a rich source of eco-friendly bioactive metabolites. These compounds possess antagonistic effect against plant pathogens (Moloudizargari *et al.* 2013). In view of this, the use of plant-based products to manage blast is now considered not only as an eco-friendly approach but also a sustainable agriculture. This study sought to delve into the potential of utilizing extracts derived from various plant sources to suppress rice blast disease, a prevalent and economically significant fungal disease affecting rice crops worldwide.

MATERIALS AND METHODS

Preparation of plant extracts: The present study was carried out during rainy (*kharif*) season of 2022–23 at Regional Research Station (Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana), Kaithal, Haryana. The plant materials, including neem leaves (*Azadirachta indica*), congress grass leaves (*Parthenium hysterophorus*), eucalyptus leaves (*Eucalyptus teretracornis*), cloves of garlic (*Allium sativum*), rhizome of ginger (*Zingiber officinale*) and turmeric powder (*Curcuma longa*) were sourced from various locations within College of Agriculture, Kaul, Kaithal, Haryana. Additionally, turmeric powder was procured from the market. Aqueous extracts of the plant extracts were meticulously prepared in accordance with methodology outlined by Shekhawat and Prasad (1971), albeit with certain modifications. The plant parts were washed in sterile distilled water and subsequently pulverized using a grinder, with the addition of an equal volume (100 ml) of sterilized distilled water (1:1 w/v). Following the grinding process, the resultant extract underwent filtration through muslin cloth and ultimately, the extracts were subjected to centrifugation at 10,000 rpm for 20 min in centrifuge at room temperature. The resulting supernatant was designated as the standard plant extract solution, constituting 100% concentration and thereafter diluted with water to the desired concentration.

Crop raising: Seeds of rice cultivars PB 1121 and CSR 30 (blast susceptible) underwent pre-sowing treatments involving a 24 h immersion in water followed by a 48 h incubation period to promote accelerated germination. Subsequently, pre-germinated seeds were uniformly broadcasted @60 g/m² within the nursery. Seedlings attaining age of 25 days of were transplanted in 5 m × 3 m plots with spacing of 20 cm × 15 cm. Experiment was laid out in randomized block design, replicated thrice with varied treatments.

Plant extract application: Two sprays of aforementioned plant extracts were given, first spray after the first appearance of the disease followed by one more spray at 15 days interval. The plant extracts and concentrations were neem leaf extract @20%, garlic clove extract @10%, ginger rhizome extract @10%, turmeric powder extract @10%, eucalyptus leaves extract @20% and congress grass leaf extract @20%. Two sprays of the plant extracts were administered during the growing season. The first spray was applied immediately after the 1st appearance of rice blast symptoms, as identified by the characteristic lesions on leaves. The 2nd spray was administered 15 days after the first application to reinforce the initial treatment and inhibit further disease progression. The timing of these applications was chosen based on the disease development stages to maximize the impact of the extracts.

Assessment of leaf and neck blast severity: Disease severity was recorded 15 days after 2nd spray following standard evaluation system for rice (IRRI) (Anonymous 2013). Five hills were randomly selected from each plot for recording observations. The severity of leaf blast was recorded using 0–9 as outlined by IRRI (0, Absence of observable symptoms; 1, Presence of small brown specks, ranging from pinhead size or larger, lacking a sporulating centre; 2, Manifestation of small, roundish to slightly elongated necrotic grey spots, measuring approximately 1–2 mm in diameter, accompanied by a distinct brown margin, predominantly localized on lower foliar surfaces; 3, Appearance of lesions akin to those described in level 2, albeit with a notable prevalence on upper leaf regions; 4, Occurrence of characteristic blast lesions indicative of susceptibility, measuring 3 mm or longer, affecting less than 4% of the leaf surface area; 5, Presence of typical blast lesions, encompassing 4–10% of the leaf surface area; 6, Manifestation of typical blast lesions covering 11–25% of the leaf surface area; 7, Presence of typical blast lesions covering 26–50% of the leaf surface area; 8, Presence of typical blast lesions covering 51–75% of the leaf surface area; 9, Extensive involvement of more than 75% of the leaf surface area (Anonymous 2013) (Fig. 1a). Similarly, panicle blast (Fig. 1b) was also assessed using a scale ranging from 0–9 as outlined by IRRI (0, Absence of visible lesions or lesions observed only on a few pedicels; 1, Presence of lesions on several pedicels or secondary branches; 3, Development of lesions on a few primary branches or the central portion of the panicle axis; 5, Formation of lesions partially encircling the base (node), the uppermost internode



Fig. 1 (A) 0–9 scale for leaf blast; (B) 0–9 scale for panicle blast.

or the lower section of the panicle axis near the base; 7, Complete encirclement of lesions around the panicle base, uppermost internode or panicle axis near the base, with more than 30% of filled grains affected; 9, Complete encirclement of lesions around the panicle base, uppermost internode, or the panicle axis near the base, with less than 30% of filled grains affected) (Anonymous 2013).

The percentage disease index (PDI) was calculated using formula (McKinney 1923):

$$\text{Per cent disease index} = \frac{\text{Sum of all numerical ratings}}{\frac{\text{No. of plant examined} \times \text{Maximum disease rating}}{2}} \times 100$$

The area under the disease progress curve (AUDPC) was computed following the methodology outlined by Wilcoxon *et al.* (1975).

$$\text{AUDPC} = \sum_{k=0}^n \frac{1}{2} (y_i - y_{i-1}) \times d$$

Where Y_1 , Disease severity following first spray; Y_{i-1} , Disease severity following second spray, and d , Time interval between the observations at time.

Infection rate was worked out following Van der Plank (1963):

$$\text{Apparent infection rate} = \frac{2.3}{t} \times \frac{\log_2 (1-x_1)}{x_1(1-x_2)}$$

Where x_1 and x_2 , Disease proportion following first and the second spray of botanicals; t , Time interval between two recorded observations.

Per cent disease over control was calculated by this formula:

$$\text{Per cent disease over control} = C - T \times 100, T$$

Where C , Control and T , Treatment.

Grain yield (q/ha) from each plot was recorded at the time of harvest.

Statistical analysis: The statistical analysis of data was performed after angular transformation with RBD design at 5% level of significance, as outlined by Panse and Sukhatme (1978), which provide a robust framework for analysing agricultural research data.

RESULTS AND DISCUSSION

Results indicated a significant reduction in disease severity across all treatments for both cultivars (Table 1 and Table 2). During *kharif* 2022, garlic cloves @10% showed the highest efficacy in managing the disease, exhibiting the lowest leaf blast severity (28.61%, 30.86%) and neck blast severity (24.78%, 26.55%) in PB 1121 and CSR 30 variety respectively, while the untreated plot exhibited highest leaf (44.34%, 46.19%) and neck blast severity (37.89%, 39.14%). Similarly, during *kharif* 2023, garlic cloves @10% surpassed in reducing disease severity with lowest leaf (26.85%, 29.22%) and neck blast severity (23.15%, 24.63%) in PB 1121 and CSR 30 variety respectively. In contrast, untreated plots showed significantly higher disease severity for both leaf blast (43.19%, 44.42%) and neck blast (36.38%, 38.88%) across both years and varieties.

Therefore, garlic cloves @10% was the most effective plant extract for managing leaf blast (35.79%, 32.07%) and neck blast (34.12%, 34.18%) during both years in both PB 1121 and CSR 30 varieties, followed by neem leaves @20% exhibiting leaf blast management (29.55%, 24.37%) and neck blast management (26.82%, 26.45%) over control while eucalyptus leaves @20% was the least effective in managing leaf blast (7.71%, 6.26%) and neck blast (26.28%, 26.45%).

The experimental treatments using garlic clove and neem leaf extracts consistently demonstrated superior efficacy in minimizing the Area Under Disease Progress Curve (AUDPC) for both rice varieties, PBW 1121 and CSR 30, over two consecutive years (Fig. 2). This consistent performance indicates that these plant extracts effectively reduced the overall disease burden throughout the growing season. Specifically, garlic clove extract emerged as particularly potent, consistently achieving one of the lowest infection rates across both years and both rice varieties (Fig. 3). The reduced infection rates associated with garlic clove extract highlight its robust antifungal properties and its potential role in inhibiting the progression of rice leaf blast disease. These findings underscore the practical utility

Table 1 Effect of foliar application of plant extracts on leaf blast on two susceptible varieties

Treatment	PB 1121			Per cent over control	CSR 30			Per cent over control
	2022	2023	Mean A		2022	2023	Mean A	
Neem leaf extract @20%	31.38 (34.05)	29.48 (32.87)	30.43 (33.46)	29.55	33.74 (35.49)	33.15 (35.13)	33.45 (35.31)	24.37
Garlic clove extract @10%	28.61 (32.31)	26.85 (31.19)	27.73 (31.75)	35.79	30.86 (33.73)	29.22 (32.70)	30.04 (33.21)	32.07
Ginger rhizome extract @10%	37.26 (37.60)	35.21 (36.37)	36.23 (36.99)	16.11	40.50 (39.50)	38.19 (38.15)	39.35 (38.83)	11.02
Turmeric powder extract @10%	33.56 (35.37)	30.52 (33.51)	32.04 (34.44)	25.81	36.88 (37.38)	35.19 (36.36)	36.04 (36.87)	18.51
Eucalyptus leaves extract @20%	40.27 (39.37)	39.45 (38.89)	39.86 (39.13)	7.71	42.71 (40.79)	40.19 (39.32)	41.45 (40.06)	6.26
Congress grass leaf extract @20%	39.77 (39.08)	38.78 (38.49)	39.28 (38.79)	9.06	41.66 (40.18)	39.97 (39.19)	40.82 (39.69)	7.70
Control	44.34 (41.73)	42.04 (40.40)	43.19 (41.06)		46.19 (42.79)	42.25 (40.63)	44.22 (41.71)	
Mean B	36.46 (37.07)	34.62 (35.96)			38.94 (38.55)	36.88 (37.36)		
CD ($P=0.05$)	Treatment		0.93				0.71	
	Variety		0.50				0.38	
	Treatment × Variety		1.63				1.47	

*Figures in parentheses represent angular transformed values; CD, Critical difference.

Table 2 Effect of foliar application of plant extracts on neck blast on two susceptible varieties

Treatment	PB 1121			Per cent over control	CSR 30			Per cent over control
	2022	2023	Mean A		2022	2023	Mean A	
Neem leaf extract @20%	27.41 (31.55)	26.23 (30.79)	26.82 (31.17)	26.28	29.73 (33.02)	27.46 (31.58)	28.60 (32.30)	26.45
Garlic clove extract @10%	24.78 (29.84)	23.15 (28.74)	23.97 (29.29)	34.12	26.55 (30.99)	24.63 (29.73)	25.59 (30.36)	34.18
Ginger rhizome extract @10%	31.37 (34.04)	30.54 (33.52)	30.95 (33.78)	14.92	34.33 (35.85)	33.52 (35.36)	33.93 (35.60)	12.74
Turmeric powder extract @10%	28.85 (32.47)	27.52 (31.62)	28.19 (32.05)	22.53	31.18 (33.93)	30.22 (33.33)	30.70 (33.63)	21.03
Eucalyptus leaves extract @20%	35.47 (36.54)	32.12 (34.50)	33.80 (35.52)	7.11	36.82 (37.43)	36.30 (37.03)	36.56 (37.18)	5.96
Congress grass leaf extract @20%	34.41 (35.89)	31.15 (33.90)	32.78 (34.90)	9.90	35.48 (36.54)	34.26 (35.80)	34.87 (36.17)	10.32
Control	37.89 (37.97)	34.86 (36.16)	36.38 (37.07)		39.14 (38.71)	38.62 (38.40)	38.88 (38.55)	
Mean B	31.36 (34.04)	29.36 (32.75)			33.31 (35.20)	32.14 (34.46)		
CD ($P=0.05$)	Treatment		0.66				0.78	
	Variety		0.34				0.42	
	Treatment × Variety		1.39				1.49	

*Figures in parentheses represent angular transformed values; CD, Critical difference.

of botanical extracts, especially garlic clove extract, in mitigating disease progression. The consistent reduction in AUDPC and infection rates across different varieties and years suggested that these treatments are reliable and effective. This reliability is crucial for practical agricultural applications, where consistent performance across varying conditions is essential for sustainable disease management. For both PB 1121 and CSR 30 varieties, there are variations in disease severity across different treatments and observation years. The mean severity of leaf blast disease may differ between varieties, suggesting potential differences in susceptibility or resistance to the disease. Variations in disease severity between years may be influenced by environmental factors or changes in disease pressure. Amongst the various treatments, maximum yield was recorded upon foliar application of garlic clove extract (41.01 q/ha and 48.17 q/ha) followed by neem leaf extract (39.73 and 46.78 q/ha) in CSR 30 and PB 112, respectively during 2022 and 2023 (Table 3). While eucalyptus leaf extract was least influential in enhancing the average yield with 41.01 q/ha for PB 1121 and 33.68 t/ha for CSR 30. The untreated plots showed minimum yield 40.58 q/ha and 32.90 q/ha for PB 1121 and CSR 30, respectively (Table 3). It can be deduced that yield of rice is negatively correlated with disease severity.

Several studies have extensively documented the efficacy of garlic clove extract in mitigating various diseases, with a particular emphasis on its potent antifungal properties. Notably, *in vitro* investigations conducted by Hajano *et al.* (2012) demonstrated that garlic extract significantly impeded the mycelial growth of *Pyricularia oryzae*, the pathogen responsible for rice blast disease. Their findings

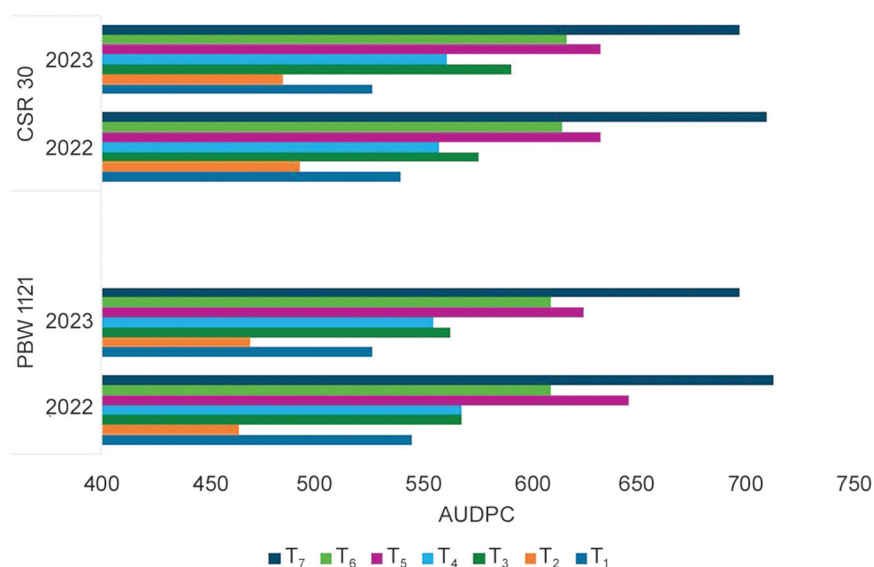


Fig. 2 Area under Disease Progress Curve (AUDPC) upon foliar application of plant extracts.

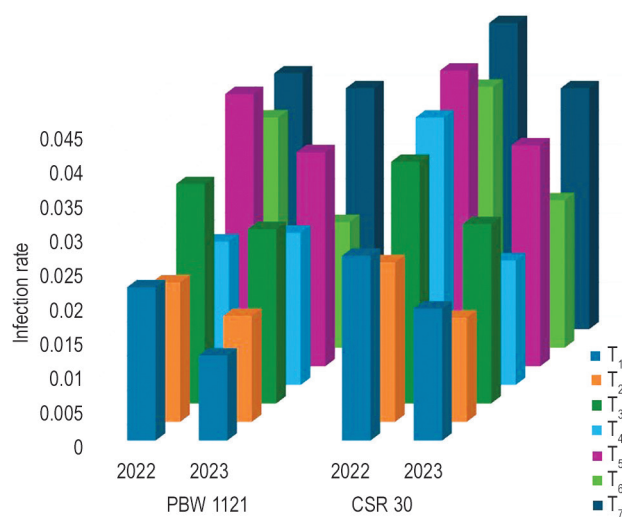


Fig. 3 Infection rate upon foliar application of plant extracts.

Table 3 Effect of foliar application of plant extracts on yield of two susceptible varieties

Treatment	CSR 30		Yield (q/ha)	PB 1121		Mean
	2022	2023		2022	2023	
Neem leaf extract @20%	39.45	40.01	39.73	46.04	47.52	46.78
Garlic clove extract @10%	39.45	40.01	39.73	46.04	47.52	46.78
Ginger rhizome extract @10%	40.23	41.78	41.01	47.43	48.91	48.17
Turmeric powder extract @10%	36.23	37.25	36.74	41.44	42.92	42.18
Eucalyptus leaves extract @20%	37.25	39.12	38.19	42.93	44.41	43.67
Congress grass leaf extract @20%	33.10	32.98	33.04	40.24	41.78	41.01
Neem leaf extract @20%	33.23	34.12	33.68	40.97	42.45	41.71
Control	32.56	33.23	32.90	39.84	41.32	40.58
CD ($P=0.05$)	0.79	0.93		1.73	1.83	
SEM±	0.25	0.42		0.79	0.98	

*Figures in parentheses represent angular transformed values; CD, Critical difference

underscored the potential of garlic extract as a potent antifungal agent, providing an eco-friendly alternative to conventional chemical fungicides. Similarly, Slusarenko *et al.* (2008) highlighted the potent antifungal efficacy of garlic juice and its active compound, allicin, against *P. oryzae*. Their study revealed that garlic juice, rich in allicin, effectively inhibited the growth of the rice blast pathogen, reinforcing the notion that garlic and its derivatives can serve as effective agents for managing rice blast. Fiona *et al.* (2005) further corroborated these findings, demonstrating that allicin not only suppressed the growth of *P. oryzae* but also inhibited its infection stages. Their work provided a comprehensive view of how allicin disrupts the life cycle of the pathogen, thereby reducing its capacity to cause disease. In contrast, Muralidharan *et al.* (2003) observed that the chemical fungicide tricyclazole exhibited more pronounced effects in managing rice blast disease compared to botanical and biocontrol agents. The study attributed tricyclazole's enhanced efficacy to its specific mode of action at the site of infection and its superior efficiency in targeting the blast pathogen. This indicates that while botanical extracts like garlic showed promise, chemical fungicides still play a crucial role in disease management due to their targeted action and reliability. Moreover, plant-derived products containing azadirachtin, such as Achook, Neemazal, Neemgold and Wanis, have shown promising results in managing rice leaf blast. Studies by Govindaraju and Somasekhara (2016) and Kumar *et al.* (2017) reported that these products reduced the severity of leaf blast by 40–44%. These findings highlight the potential of neem-based products as viable alternatives or supplements to traditional chemical fungicides. They offer an integrated approach to disease management that can potentially reduce the environmental impact of chemical usage. Muralidharan *et al.* (2003) also recognized the effectiveness of these plant-derived commercial products, underscoring their potential role in integrated disease management strategies. By combining the use of chemical fungicides with plant products, it is possible to achieve effective disease control while minimizing the negative environmental impacts associated with heavy reliance on chemical treatments.

In conclusion, while chemical fungicides like tricyclazole remain highly effective in managing rice blast disease, the integration of botanical or plant-derived products offers a promising, environmentally friendly alternative. Significant antifungal qualities have been shown by garlic clove extract and neem-based products, which could be used in integrated disease management plans to lessen dependency on chemical fungicides and support sustainable farming methods. Future research should focus on optimizing the use of these plant extract products, understanding their modes of action and integrating them effectively with conventional disease management approaches to enhance crop protection and sustainability.

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