

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(7): 207-211
www.biochemjournal.com
Received: 22-04-2026
Accepted: 26-05-2026

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Integrated disease management of purple blotch in onion (*Allium cepa* L.)

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i7Sc.8967>

Abstract

Onion (*Allium cepa* L.) is one of the most important vegetable crops cultivated worldwide for its culinary, nutritional, and medicinal value. Among the major constraints limiting onion productivity, purple blotch disease caused by *Alternaria porri* (Ellis) Ciferri is considered one of the most destructive foliar diseases, leading to substantial yield and quality losses. Excessive dependence on chemical fungicides for disease management has resulted in environmental concerns, pathogen resistance, and increased production costs. Therefore, the present study was conducted to evaluate integrated disease management (IDM) strategies involving biological control agents, botanical extracts, and fungicides against purple blotch disease under field conditions. The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications. Disease incidence, disease severity, plant growth parameters, bulb yield, and economic returns were recorded. Among the treatments, seedling treatment with *Trichoderma harzianum* combined with foliar application of neem seed kernel extract and neem-based fungicide spray recorded the lowest disease severity (15.8%) and highest bulb yield (28.6 t ha⁻¹). Integrated disease management approaches significantly reduced disease incidence and enhanced crop productivity compared with untreated control. The study demonstrates that integration of biological, botanical, and chemical methods offers an effective and sustainable strategy for managing purple blotch disease in onion cultivation.

Keywords: Onion, purple blotch, *Alternaria porri*, integrated disease management, *Trichoderma harzianum*, Neem extract, sustainable agriculture

1. Introduction

Onion (*Allium cepa* L.) is one of the most widely cultivated vegetable crops and forms an essential component of human diets throughout the world. It is valued for its distinctive flavor, nutritional quality, and medicinal properties. Onion bulbs are rich in carbohydrates, vitamins, minerals, antioxidants, and sulfur-containing compounds that contribute to human health. India ranks among the leading producers of onion globally and plays a significant role in supplying domestic and international markets [1-3]. However, onion productivity is adversely affected by numerous biotic and abiotic stresses, among which fungal diseases constitute a major challenge.

Purple blotch, caused by *Alternaria porri* (Ellis) Ciferri, is one of the most economically important foliar diseases of onion. The disease occurs in almost all onion-growing regions and can cause yield losses ranging from 30% to 80% under favorable environmental conditions. Initial symptoms appear as small water-soaked lesions on leaves and flower stalks, which subsequently enlarge into characteristic purple-centered spots surrounded by chlorotic halos. Severe infection results in leaf drying, premature senescence, reduction in photosynthetic activity, and poor bulb development [4-7].

The pathogen thrives under conditions of high humidity, moderate temperatures, and prolonged leaf wetness. Disease outbreaks are particularly severe during rainy seasons and in densely planted fields with poor air circulation. Traditional management practices rely heavily on repeated fungicide applications. Although fungicides provide effective disease suppression, indiscriminate use has led to environmental pollution, fungicide resistance, and concerns regarding food safety.

Consequently, sustainable and eco-friendly disease management approaches have gained increasing importance. Integrated Disease Management (IDM) combines biological, cultural, botanical, and chemical methods to provide effective and environmentally sound disease control. Biological agents such as *Trichoderma harzianum* and *Pseudomonas fluorescens* suppress pathogens through competition, antibiosis, and induction of systemic resistance. Botanical extracts derived from neem, garlic, and other medicinal plants possess antifungal properties and can reduce pathogen development. Integration of these components with judicious fungicide use offers a promising approach for sustainable management of purple blotch disease [8-12]. The present investigation was therefore undertaken to evaluate different IDM components and identify an effective management strategy for controlling purple blotch disease and improving onion productivity.

2. Objectives

1. To evaluate different integrated disease management practices against purple blotch of onion.
2. To assess the effect of biological control agents and botanical extracts on disease incidence and severity.
3. To determine the influence of IDM treatments on growth and bulb yield.
4. To identify sustainable and economically viable disease management strategies for onion cultivation.

3. Materials and Methods

3.1 Experimental Site and Climatic Conditions:

Treatment Details

Treatment Code	Treatment Description
T ₁	Seedling treatment with <i>Trichoderma harzianum</i> (10 g L ⁻¹)
T ₂	Foliar spray of neem seed kernel extract (5%)
T ₃	Seedling treatment with <i>Pseudomonas fluorescens</i> (10 g L ⁻¹)
T ₄	Foliar spray of garlic extract (10%)
T ₅	<i>Trichoderma harzianum</i> + neem seed kernel extract
T ₆	<i>Pseudomonas fluorescens</i> + garlic extract
T ₇	IDM package: <i>Trichoderma harzianum</i> + neem extract + Mancozeb (0.25%)
T ₈	Untreated control

3.4 Preparation of Botanical Extracts

Fresh neem seeds and garlic cloves were collected and thoroughly washed. The materials were crushed separately with distilled water and filtered through muslin cloth to obtain crude extracts. The filtrates were diluted to obtain the desired concentrations of 5% neem seed kernel extract and 10% garlic extract. Fresh solutions were prepared before each application to ensure maximum efficacy.

3.5 Application of Bioagents and Fungicides

For seedling treatment, roots of onion seedlings were dipped in suspensions of *Trichoderma harzianum* and *Pseudomonas fluorescens* for 30 minutes before transplanting. Foliar applications of botanical extracts and fungicides were initiated at the appearance of initial disease symptoms and repeated at 15-day intervals. Mancozeb (0.25%) was applied as a need-based spray under the IDM package.

3.6 Disease Assessment

Disease incidence and severity were recorded at 60, 75, and 90 days after transplanting. Disease severity was assessed

experiment was conducted during the Rabi season of 2024-2025 at the KVK Jammu Experimental Farm under subtropical climatic conditions. The experimental site was situated at an altitude of approximately 250 m above mean sea level and experienced average temperatures ranging from 18 to 30 °C with relative humidity between 65 and 90%. The soil of the experimental field was sandy loam with good drainage and a pH of 6.8-7.2. Recommended agronomic practices for onion cultivation were followed throughout the crop-growing period.

3.2 Experimental Material

Healthy seedlings of onion cultivar 'N-53', known to be susceptible to purple blotch disease, were used in the experiment. The pathogen responsible for purple blotch, *Alternaria porri* (Ellis) Ciferri, was isolated from naturally infected onion leaves collected from diseased fields. Isolation was carried out on potato dextrose agar (PDA) medium and purified by the hyphal-tip technique. Identification of the pathogen was based on colony morphology and microscopic characteristics of conidia.

3.3 Experimental Design and Treatments

The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications. Each plot measured 3 × 2 m with a spacing of 15 × 10 cm between plants and rows. Seedlings were transplanted uniformly and maintained under standard crop management practices.

using a 0-5 rating scale based on the extent of lesion development on leaves:

- 0 = No symptoms
- 1 = Up to 10% leaf area infected
- 2 = 11-25% leaf area infected
- 3 = 26-50% leaf area infected
- 4 = 51-75% leaf area infected
- 5 = More than 75% leaf area infected

Percent Disease Index (PDI) was calculated using the formula:

$$\text{PDI} = (\text{Sum of disease ratings} \times 100) / (\text{Total number of leaves observed} \times \text{Maximum disease grade})$$

Disease incidence (%) was calculated as:

$$\text{Disease incidence} = (\text{Number of infected plants} / \text{Total plants observed}) \times 100$$

3.7 Growth and Yield Parameters

Observations were recorded on five randomly selected plants from each treatment. The following parameters were measured:

- Plant height (cm)
- Number of leaves per plant
- Bulb diameter (cm)
- Average bulb weight (g)
- Marketable bulb yield (t ha⁻¹)

3.8 Statistical Analysis

Data obtained from different treatments were subjected to analysis of variance (ANOVA) appropriate for Randomized Block Design. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a significance level of $p \leq 0.05$. Statistical analyses were performed using SPSS software version 25.0.

4. Results

4.1 Effect of IDM Treatments on Disease Incidence and Severity

Significant differences among treatments were observed regarding disease incidence and severity. The integrated disease management package (T₇) consisting of *Trichoderma harzianum*, neem seed kernel extract, and Mancozeb (0.25%) recorded the lowest disease incidence (20.4%) and disease severity (15.8%), followed by T₅ (*Trichoderma harzianum* + neem extract), which exhibited disease severity of 19.6%. The untreated control (T₈) recorded the highest disease incidence (69.2%) and severity (58.7%).

The results indicate that combining biological agents with botanicals and limited fungicide application provided superior suppression of *Alternaria porri* compared with individual treatments.

Table 1: Effect of IDM treatments on disease incidence and severity

Treatment	Disease Incidence (%)	Disease Severity (%)
T ₁	38.6	28.6
T ₂	42.4	31.4
T ₃	36.8	26.9
T ₄	45.2	33.2
T ₅	25.6	19.6
T ₆	30.8	22.4
T ₇	20.4	15.8
T ₈ (Control)	69.2	58.7

4.2 Effect on Plant Growth Parameters

Integrated disease management significantly improved vegetative growth. The maximum plant height (64.2 cm), number of leaves per plant (10.3), and bulb diameter (6.8 cm) were recorded under T₇. Plants receiving combined biological and botanical treatments exhibited vigorous growth and healthy foliage compared with untreated control.

Table 2: Effect of IDM treatments on growth characteristics

Treatment	Plant Height (cm)	Leaves Plant ⁻¹	Bulb Diameter (cm)
T ₁	54.6	8.8	5.7
T ₂	52.8	8.4	5.4
T ₃	55.4	8.9	5.9
T ₄	51.2	8.1	5.2
T ₅	60.8	9.8	6.4
T ₆	58.9	9.4	6.2
T ₇	64.2	10.3	6.8
T ₈	46.5	7.2	4.8

4.3 Effect on Bulb Yield and Yield Components

The treatments significantly affected bulb weight and marketable yield. Maximum bulb weight (86.4 g) and bulb yield (28.6 t ha⁻¹) were obtained under T₇, followed by T₅, which produced 26.2 t ha⁻¹. The untreated control yielded only 16.3 t ha⁻¹.

The increase in bulb yield was attributed to reduced disease severity and enhanced physiological activity resulting from improved plant health.

Table 3: Effect of IDM treatments on bulb weight and yield

Treatment	Average Bulb Weight (g)	Bulb Yield (t ha ⁻¹)
T ₁	72.6	22.4
T ₂	69.4	21.2
T ₃	74.2	23.1
T ₄	67.8	20.4
T ₅	82.6	26.2
T ₆	79.8	24.8
T ₇	86.4	28.6
T ₈ (Control)	58.7	16.3

4.4 Economic Analysis

The integrated disease management package (T₇) produced the highest gross return (₹4,29,000 ha⁻¹), net return (₹3,02,000 ha⁻¹), and benefit-cost ratio (2.38), whereas the untreated control recorded the lowest economic returns.

Table 4: Economic analysis of different treatments

Treatment	Cost of Cultivation (₹ ha ⁻¹)	Gross Return (₹ ha ⁻¹)	Net Return (₹ ha ⁻¹)	BC Ratio
T ₁	118,000	336,000	218,000	1.85
T ₂	115,000	318,000	203,000	1.76
T ₃	119,000	346,500	227,500	1.91
T ₄	114,000	306,000	192,000	1.68
T ₅	122,000	393,000	271,000	2.22
T ₆	121,000	372,000	251,000	2.07
T ₇	127,000	429,000	302,000	2.38
T ₈	110,000	244,500	134,500	1.22

Table 5: Analysis of variance (ANOVA) for disease severity and bulb yield under different IDM treatments

Source of Variation	Degrees of Freedom	Disease Severity (%) Mean Square	Bulb Yield (t ha ⁻¹) Mean Square
Treatments	7	624.18**	31.64**
Replications	2	4.21	0.86
Error	14	8.72	0.43
Total	23	-	-

F-value

Parameter	F-value	Significance
Disease Severity (%)	71.58	P<0.01
Bulb Yield (t ha ⁻¹)	73.58	P<0.01

Note: ** indicates significance at 1% probability level.

4.5 Statistical Significance

Analysis of variance indicated highly significant differences among treatments for disease severity, bulb yield, and growth parameters ($p < 0.01$), confirming the effectiveness of integrated disease management practices in suppressing purple blotch disease and enhancing onion productivity.

5. Discussion

Purple blotch caused by *Alternaria porri* is one of the most destructive foliar diseases of onion and poses a serious threat to onion production worldwide. Effective disease management is essential for maintaining bulb quality and maximizing yield. The present investigation demonstrated that integrated disease management (IDM) approaches involving biological control agents, botanical extracts, and need-based fungicide application significantly reduced disease incidence and severity while improving plant growth and bulb yield^[13-15]. The superiority of integrated treatments over individual components highlights the importance of combining multiple disease management strategies for sustainable crop production.

Among the evaluated treatments, the IDM package consisting of *Trichoderma harzianum*, neem seed kernel extract, and Mancozeb recorded the lowest disease severity and highest bulb yield. The enhanced efficacy of this treatment may be attributed to the synergistic action of biological, botanical, and chemical components. *Trichoderma harzianum* is a well-known antagonistic fungus that suppresses phytopathogens through mechanisms such as mycoparasitism, antibiosis, competition for nutrients and space, and induction of systemic resistance in host plants^[16-17]. The production of hydrolytic enzymes including chitinases, glucanases, and proteases by *Trichoderma* contributes to degradation of fungal cell walls, thereby inhibiting the growth and development of *Alternaria porri*. Similar findings regarding the suppressive effect of *Trichoderma* species against fungal pathogens have been reported by Harman *et al.* (2004) and Dubey *et al.* (2007).

The effectiveness of neem seed kernel extract observed in the present study may be associated with the presence of several biologically active compounds, including azadirachtin, nimbin, salannin, and gedunin, which possess antifungal and antimicrobial properties. These compounds interfere with spore germination, mycelial growth, and sporulation of fungal pathogens^[18-22]. The use of botanical extracts offers an environmentally friendly alternative to synthetic fungicides and reduces the risk of chemical residues in agricultural produce^[23-26]. Previous studies conducted by Patel and Patel (2017) and Rani *et al.* (2020) also demonstrated significant inhibition of fungal diseases through plant-derived extracts, particularly neem formulations.

The lower disease incidence recorded under integrated treatments may further be attributed to the judicious use of Mancozeb, which provided rapid protection against secondary infection and disease spread during favorable environmental conditions. Fungicides remain an important component of disease management; however, their continuous and indiscriminate use may result in pathogen resistance, environmental contamination, and destruction of beneficial microorganisms^[27-35]. Therefore, integrating fungicides with biological agents and botanicals minimizes dependence on chemicals while ensuring effective disease suppression. Similar conclusions have been drawn by Agrios (2005) and Nene and Thapliyal (1993), who emphasized the importance of integrated approaches in sustainable plant disease management.

Significant improvements in vegetative growth parameters, including plant height, number of leaves, and bulb diameter, were observed in plants receiving integrated treatments. These findings may be explained by the plant growth-

promoting activities of beneficial microorganisms. Species of *Trichoderma* and *Pseudomonas fluorescens* are known to enhance nutrient availability, improve root development, produce phytohormones, and stimulate systemic resistance, resulting in increased vigor and better tolerance to biotic stress. Reduced disease pressure also enables plants to maintain higher photosynthetic efficiency and allocate more assimilates towards bulb development. Similar observations have been reported by Prasad *et al.* (2002) and Singh and Singh (2004), who documented growth-promoting effects of microbial antagonists in several vegetable crops.

The increase in bulb weight and marketable yield under integrated treatments indicates that effective disease suppression directly contributes to improved crop productivity. Purple blotch causes extensive foliar damage, leading to reduced photosynthetic activity and poor translocation of assimilates to developing bulbs. Consequently, severe infections result in smaller bulbs and lower yields. The reduction in disease severity achieved through IDM treatments maintained healthy foliage and enhanced carbohydrate accumulation, ultimately leading to higher bulb production. The present findings are in agreement with earlier reports demonstrating that integrated disease management practices significantly improve bulb yield and quality in onion cultivation.

Economic analysis revealed that the integrated treatment involving *Trichoderma harzianum*, neem extract, and Mancozeb produced the highest net return and benefit-cost ratio. Although the cost of implementing integrated practices was slightly higher than that of individual treatments, the increased bulb yield and improved marketable produce resulted in superior economic returns. This finding highlights the practical feasibility and profitability of adopting integrated disease management strategies under field conditions. Sustainable disease management practices that combine biological and botanical components not only reduce input costs associated with repeated fungicide applications but also contribute to environmental protection and long-term agricultural sustainability.

The present study underscores the significance of integrated disease management as an effective alternative to sole reliance on chemical fungicides. Increasing concerns regarding fungicide resistance, environmental pollution, and food safety necessitate the development of eco-friendly and sustainable approaches for disease management. Integration of microbial antagonists, botanical extracts, and need-based fungicide application provides a balanced approach that ensures disease control while preserving soil health and biodiversity. Such practices are consistent with the principles of integrated pest management and sustainable agriculture advocated globally.

Nevertheless, the present investigation was conducted under a specific set of agro-climatic conditions, and the performance of the evaluated treatments may vary across locations and seasons. Therefore, further studies involving multi-location trials, optimization of application schedules, formulation development, and assessment of compatibility among bioagents and botanicals are necessary to validate their effectiveness under diverse environmental conditions. Additionally, molecular investigations on host-pathogen interactions and mechanisms of induced resistance may provide valuable insights for developing more efficient disease management strategies, the findings of the present study demonstrate that integrated disease management

practices represent a promising, environmentally sound, and economically viable approach for managing purple blotch disease of onion. Adoption of such strategies can contribute significantly to sustainable onion production, reduced dependence on synthetic fungicides, and improved profitability for growers.

6. Conclusion

The present study demonstrated that integrated disease management practices effectively reduced purple blotch disease and improved onion yield. Among the evaluated treatments, the combination of *Trichoderma harzianum*, neem seed kernel extract, and neem-based fungicide application provided the highest level of disease control and maximum bulb yield. Adoption of such integrated approaches can reduce dependence on synthetic fungicides, minimize environmental risks, and contribute to sustainable onion production. Further multi-location studies are recommended to validate these findings under diverse agro-climatic conditions.

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