Harnessing Abiotic Defence Inducers for Effective Management of Pod Rot in Mung Bean

Abstract

Pod rot is a significant issue for mung bean plants, causing substantial reductions in yield and quality. In this study, several defence inducers, including salicylic acid (SA), nicotinic acid (NA), indole butyric acid (IBA), chitosan, and benzothiadiazole (BTH), were applied as foliar sprays to assess their effectiveness in enhancing resistance to pod rot in field conditions. The results indicated that benzothiadiazole -treated plants experienced a marked reduction in disease severity of 18.667% compared to untreated plants (control) with 36.177%. This indicatedthat benzothiadiazole has antifungal properties, decreases disease severity, and stimulates defence mechanisms in Mung bean against pod rot.

Keywords: Pod rot, mung bean, defence inducers

Introduction

Mung bean (*Vigna radiata* (L.) R. Wilczek var. *radiata*), also known as green gram or moong, is a vital crop in South and Southeast Asia's agricultural systems, with significant cultivation occurring globally (Mehandi et al.,2019). Its popularity among farmers is attributed to its short growth cycle, low input needs, compatibility with cereal crop rotations, and resilience to heat and drought conditions. In countries like India and Pakistan, mung bean is a crucial subsistence crop, supplying essential nutrients such as protein, iron, and zinc to farmer families. Meanwhile, in countries such as Myanmar, China, and Kenya, it serves as a significant income-generating crop (Nair and Schreinemachers, 2020).

The average production of mungbeans is 721 kg/ha, and there are around 7.3 million hectares planted worldwide. 30% of the 5.3 million tonnes of production produced globally is split between India and Myanmar. China, Indonesia, Thailand, Kenya, and Tanzania are other significant producers (Nair et al. 2020)**.**Mung bean is often cultivated after rice, wheat, and maize, and its demand and production are on the rise. This increasing trend is also seen in Australia, a key exporter of mung bean seeds, where the cultivation area grew from about 1,000 hectares in the 1970s to 125,000 hectares in 2015-2016 **(Clarry, 2016)**.

Despite its advantages, mung bean production is hindered by significant challenges from both abiotic and biotic stresses, with diseases and insect pests being primary causes of reduced yields. Mung bean plants are vulnerable to pathogens and pests at all growth stages, from emergence to reproduction, which can lead to severe damage and even crop failure **(Pandey *etal*., 2018)**. Common diseases affecting mung bean include powdery mildew, Cercospora leaf spot, yellow mosaic virus, anthracnose, Fusarium wilt, root rot, charcoal rot/dry root rot, and bacterial leaf blight, with fungal diseases alone responsible for yield losses of up to 40-60% **(Pandey et al., 2018)**. Among these, powdery mildew, Cercospora leaf spot, and yellow mosaic virus are the most widespread and economically impactful. Deployment of varieties for genetic resistance is the most effective and durable method for integrated disease management (**Nair *et al.*, 2020**). Traditional plant breedingplaysa vital role in preserving genetic resources and generating genetic variation through hybridization and induced mutations.

Pod rot disease has recently become a significant concern for mung bean production This disease causes seeds and pods to discolour and rot, with symptoms worsening due to intermittent rainfall during pod formation to crop maturity. Managing pod rot effectively is crucial to avoid substantial yield losses, as the disease results in mung bean seeds that are shrivelled, cracked, and discoloured, thereby reducing both yield quantity and quality. Because the disease can spread through contaminated seeds, using high-quality, disease-free seeds is critical. The use of resistant varieties and fungicide treatments has proven effective in controlling pod rot in mung bean cultivation**(Buttar *et al*., 2023)**.

Unlike conventional chemical fungicides, plant defense elicitors boost a plant's natural immunity by activating systemic acquired resistance, which prepares the plant to combat future pathogen infections **(Bektas and Eulgem, 2015)**. Chemical fungicides, on the other hand, can leave residues on crops for long durations **(Ragsdale and Sisler, 1994)**. Therefore, plant defence elicitors are regarded as a more environmentally friendly method of disease management than chemical fungicides **(Wang *et al*., 2015)**. Since plant defence elicitors are non-toxic to microorganisms, they are also likely to be less disruptive to the microbiome than chemical fungicides.This study aims to investigate the effect of defence inducers on the severity of pod rot in mungbean.

Material and methods

In *Kharif*2021, field experiment was conducted at the Crop Research Centre, GBPUA&T, Pantnagar (29.0222°N, 79.4908°E), Uttarakhand to evaluate the efficacy of defence inducers against pod rot in mung bean. Six treatments were tested: salicylic acid (SA), indole butyric acid (IBA), chitosan, nicotinic acid (NA), benzothiadiazole (BTH), and a control group. These treatments were arranged in a randomized block design with three replications. The defence inducers were applied as foliar sprays at a concentration of 0.1%, while the control group received nothing except water. Each treatment was applied three times at seven-day intervals, beginning with maturing of pods.

Disease severity was evaluated using the scale (0-5) defined by **Singh (2021)**. The percent disease index was determined according to the formula established by **Wheeler (1969)**.

$$\text{PDI (\%)} = \frac{\text{Sum of all ratings}}{\text{Number of ratings X Maximum grade}} \text{ X 100}$$

Further, the percent efficacy of disease control (PDC) was calculated by using the formula:

$$\text{PDC (\%)} = \frac{\text{Disease severity in control} - \text{Disease severity in treatment}}{\text{Disease severity in control}} \text{ X 100}$$

To measure the extent of disease development on the pods, disease severity grades and the area under the disease progress curve (AUDPC) were calculated using the formulas provided by Vanderplank (1963), Wheeler (1969), and Wilcoxson et al., (1975), respectively.

Where, ris the apparent infection rate, *t*1 is the time of the first measurement, *t*2 is the time of the second measurement, *x*1 is the proportion of infection measured at time *t1* and *x*2 is the proportion of infection measured at time *t2*.

$$\text{AUDPC} = \sum_{i=1}^{N-1} [(y_{i+1} + y_i) / 2[(x_{i+1} - x_i)]$$

Where y_i = severity at first observation; x_i = time (days) at first observation; N = total number of observations.

Result and Discussion

The results of the experiment evaluating the effectiveness of various treatments on the percent disease index (PDI) in mung bean, using the percent disease control (PDC) and the Area under Disease Progress Curve (AUDPC). Six treatments were assessed: Salicylic Acid (SA), Indole Butyric Acid (IBA), Chitosan, Nicotinic Acid (NA), Benzothiadiazole (BTH), and a control with water spray.Each treatment's PDI was measured at four stages: before spray, after the first spray, after the second spray, and after the third spray.

The PDI measures the severity of the disease as a percentage, with higher values indicating more severe disease symptoms. Percent disease index was recorded at four different stages: before spraying, after the first spray, after the second spray, and after the third spray. Benzothiadiazole (BTH) demonstrated the lowest initial PDI of 6.177%, increasing to 18.667% after the third spray, and it achieved the highest PDC of 48.40% and the lowest AUDPC of 206.11, indicating it was the most effective treatment for controlling disease progression.

Table 1: Evaluation of defence inducers under field condition to manage pod rot of mung bean

S. No.	Treatment	Percent disease index				PDC	AUDPC
		Before spray	After Ist Spray	After IInd Spray	After IIIrd Spray		
1.	**Salicylic Acid (SA)**	7.73	10.44	17.47	23.29	35.63	235.36
2.	**Nicotinic Acid (NA)**	9.16	13.29	19.29	27.55	23.83	284.98
3.	**Indole butyric Acid (IBA)**	8.98	11.56	17.73	26.22	16.09	336.78
4.	**Chitosan**	11.02	15.64	22.623	30.357	27.52	254.96
5.	**Benzothiadiazole (BTH)**	6.18	9.87	13.24	18.67	48.40	206.11
6.	**Control**	12.22	18.13	25.07	36.18	0.00	384.38
CD @ 5%		1.508	1.31	2.244	3.114	-	-
SEm±		0.47	0.41	0.70	0.98		

*PDC: Percent disease control; AUDPC: Area under disease progress curve

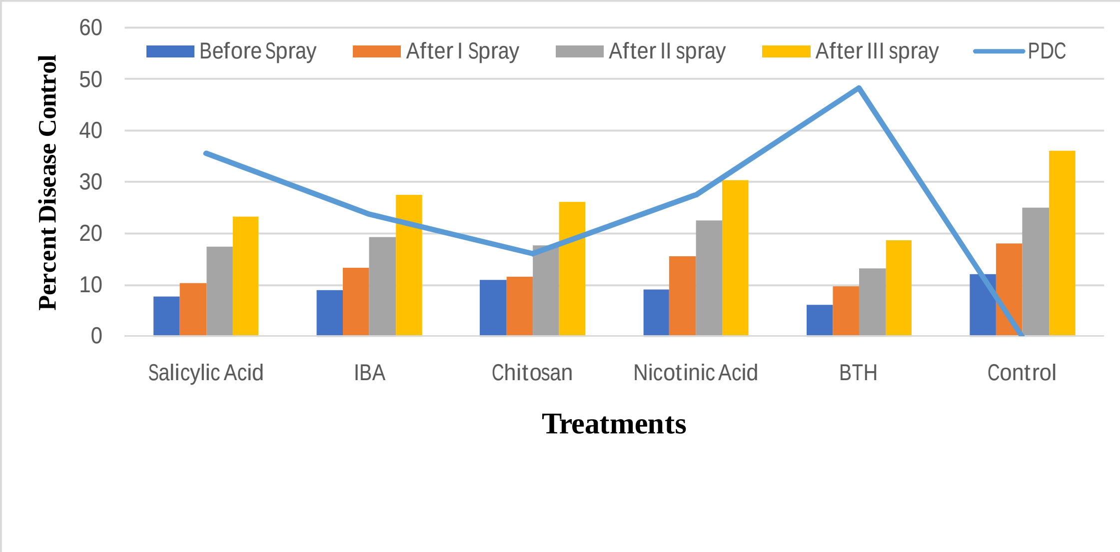

Fig 1. Variation in Disease control percentage with different treatments

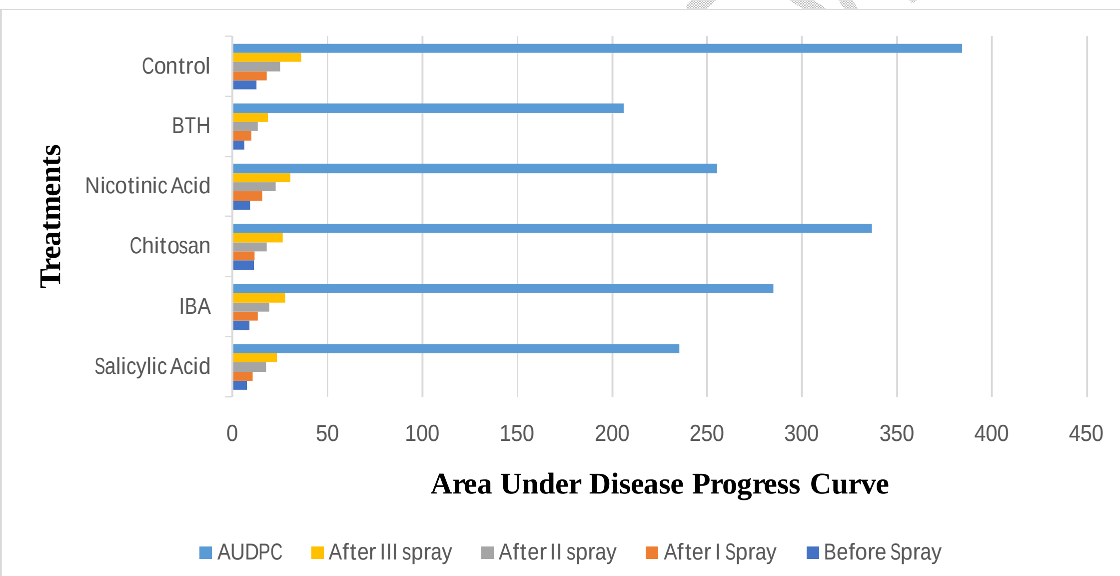

Fig 2. Disease progress curve in different treatments

Salicylic acid showed an increase in PDI from 7.733% before spraying to 23.290% after the third spray, with a PDC of 35.63% and an AUDPC of 235.36, indicating moderate disease control. In comparison, nicotinic acid (NA) exhibited a PDI increase from 9.157% to 27.553% with a PDC of 23.83% and an AUDPC of 284.98, suggesting lower effectiveness than salicylic acid. Indole butyric acid (IBA) showed a PDI increase from 8.980% to 26.223%, with a PDC of 16.09% and an AUDPC of 336.78, making it less effective than salicylic acid (SA) and nicotinic acid (NA).

Sangpueak*et al.*, (2021) explored the defence mechanisms in cassava triggered by salicylic acid, finding that SA was able to decrease anthracnose severity in cassava plants by up to 33.3%.Chitosan increased from 11.023% to 30.357% in PDI, achieving a PDC of 27.52% and an AUDPC of 254.96, which was more effective than nicotinic acid (NA) and indole butyric acid (IBA).**Jabnoun-Khiareddine*et al*., (2015)** demonstrated that salicylic acid and chitosan could serve as effective inducers of systemic acquired resistance for managing fungal diseases in tomatoes. Additionally, **Alnefaie*et al*., (2023)** found a positive correlation between reduced disease severity and the use of salicylic, nicotinic, and oxalic acids in faba bean.Incontrast, the untreated control experienced a significant increase in PDI from 12.220% to 36.177%, with no disease control (PDC of 0.00%) and the highest AUDPC of 384.38, reflecting the natural progression of the disease without any treatment. These findings suggest that Benzothiadiazole (BTH) is the most effective defence inducer for managing pod rot in mung bean, significantly reducing disease severity and spread compared to other treatments. Salicylic Acid (SA) and chitosan also demonstrated considerable effectiveness, while indole butyric acid (IBA) and nicotinic Acid (NA) showed moderate results.The study emphasizes the potential of BTH and SA as important elements in managing pod rot in mung bean, offering a promising and effective approach to controlling foliar fungal pathogens.

Conclusion

This research investigates how defence inducers can effectively manage pod rot disease in mung bean, potentially improving the performance and productivity of mung bean plants. Among the abiotic inducers tested, Benzothiadiazole and salicylic acid showed the greatest reduction in pod rot. Incorporating resistance inducers into plant disease management strategies can enhance the natural defence mechanisms of plants. By activating these innate defences, resistance inducers offer a sustainable approach to protecting crops from pathogens. When used in conjunction with other environmentally friendly control methods, such as biological control agents, cultural practices, and resistant crop varieties, they can contribute to an integrated disease management strategy that minimizes the reliance on chemical pesticides. This approach not only reduces the environmental impact but also supports long-term agricultural sustainability by promoting plant health and resilience.

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