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RESEARCH ARTICLE

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Evaluating the Effectiveness of Various Fungitoxicants and Botanical Extracts against Alternaria Leaf Blight in Faba bean (*Vicia faba*), Caused by *Alternaria alternata* in *In-vivo* Condition

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ABSTRACT

Background: A field study was conducted over three consecutive crop seasons (2022-2025) to evaluate the effectiveness of various fungitoxicants and botanical extracts against *Alternaria* leaf blight in faba bean, caused by *Alternaria alternata*. Thirteen treatments, including chemical fungicides, botanicals and their integrated applications, were assessed for their impact.

Methods: The study employed a randomized block design with 13 treatments replicated thrice. Treatments included seed treatment with Azoxystrobin, foliar sprays of Chlorothalonil, NSKE, garlic extract and their combinations. Disease intensity, percent disease control, yield and test weight were recorded and statistically analyzed over pooled data from 2022 to 2025.

Result: The results revealed that the combination of Azoxystrobin seed treatment (10 ml/kg) with Chlorothalonil 75 WP foliar spray (0.15%) was the most effective, recording the lowest PDI (12.45%), highest PDC (74.08%), maximum yield (24.23 q/ha) and highest test weight (91.73 g). Other effective treatments included Carbendazim 12% + Mancozeb 63% WP and combinations of Azoxystrobin with NSKE or Garlic Extract. Standalone botanical treatments were comparatively less effective. The untreated control showed the highest disease severity (PDI: 47.06%) and the lowest yield (19.40 q/ha), emphasizing the importance of effective disease management.

Key words: Blight, Garlic extract, NSKE, PDC, PDI.

INTRODUCTION

The faba bean, scientifically called *Vicia faba*, is among the earliest domesticated dietary legumes (Sahile *et al*., 2011). It is frequently known by different names, including tic bean, horse bean, field bean, broad bean, and fava bean. The crops are considered highly significant from a scientific perspective due to their rich nutritional composition and their role in improving soil health through biological nitrogen fixation and organic matter enhancement (Bhardwaj *et al*., 2024). The Neolithic era is thought to have been when it was domesticated (Metayer, 2004). It is extensively cultivated in Asia and Africa (Soysal, 2021). Although it may also be effectively produced in hilly and mountainous places during the *kharif* season, the faba bean is mostly farmed in India's plains as a *rabi* pulse (Singh and Bhatt, 2012b). Another common garden produce is faba beans. They are the fourth most significant food legume in the world, after garden peas (Valente *et al*., 2018). Furthermore, faba beans are a great option for crop rotation with cereals and other plants since they fix nitrogen, which is essential for increasing soil fertility (Al-Abdalall, 2010; Teshome and Tagegn, 2013). Several scientific studies have demonstrated that the cultivation of crops following faba bean can lead to substantial reductions in nitrogen fertilizer requirements ranging from 100 to 200 kg N/ha without compromising maximum yield (Adak and

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Mehmet Kibritci, 2016). North Africa and Southwest Asia are the native habitats of the faba bean. According to Alshameri *et al.* (2021) and Crépon *et al.* (2010), the protein content of faba beans ranges from 24 to 35%. Faba beans are vital contributors to global food security and provide essential nutrients to human and livestock diets (Jeong and Na, 2024). They are an excellent complement to a balanced diet because they are also a great source of vitamins, minerals, and dietary fibre (Ouraji *et al*., 2020; Xiao *et al*., 2021; Rosa-Sibakov *et al.,* 2018). Fresh or dried, faba beans can be used to make flour, hummus, and falafel, among other things. They can be used in salads, soups, stews, and side dishes due to their versatility in the kitchen (Zhang *et al*., 2020).

Following the common bean, pea, chickpea, cowpea and lentil in terms of total production, faba beans came in sixth place worldwide in 2018-19 with 4.5 million tons produced from 2.5 million hectares. China is the world's largest producer and planter of faba beans (Khazaei and Vandenberg, 2020). Since faba beans are a traditional legume crop in Bihar, the state possesses the biggest area in India allocated to their cultivation. Madhya Pradesh, Odisha, Jharkhand and Uttar Pradesh are other Indian states that cultivate faba beans, especially in the eastern part of the country (Singh *et al.,* 2012a). Influences including disease outbreaks and climate change have caused changes in recent production patterns (Mínguez and Rubiales, 2021). Numerous biotic and abiotic stresses have an effect on faba beans, resulting in a considerable decrease in their total yields (El-Hendawy *et al.,* 2010). Numerous harmful viruses and pathogens target the crop, particularly in the Mediterranean region. Regarding faba beans, fungi are one of the most prevalent and possibly dangerous groups (Honda *et al.,* 2001; Reis *et al.,* 2007; Juroszek and von Tiedemann, 2011). Faba beans are vulnerable to a variety of illnesses brought on by bacteria, nematodes, viruses and fungi, just like other pulse crops. The fungus *Alternaria alternata* is the main cause of Alternaria leaf spot, one of the fungal diseases that poses a serious risk to faba beans. This disease is marked by the development of dark, necrotic lesions on the leaves, which can significantly reduce yield by impairing photosynthesis and causing early leaf drop (Kamble *et al.,* 2000; El-Metwally *et al.,* 2010). It is particularly harmful in humid regions, where the environmental conditions are conductive to the growth of the pathogen (Abdel, 2008).

MATERIALS AND METHODS

Study area

The present investigation entitled "Evaluating the effectiveness of various fungitoxicants and botanical extracts against Alternaria leaf blight in faba bean (*Vicia faba*), caused by *Alternaria alternata* in *in-vivo* condition" was carried out in the Department of Plant Pathology's laboratory and performed in the field at the Genetics and Plant Breeding Farm, which is a part of the Department of Plant Pathology, College of Agriculture ANDUAT, Ayodhya (U.P.) during 2022-25.

Efficacy of fungi-toxicants against the pathogen in *in vivo* for the control of the disease

To find out the efficacy of thirteen fungi-toxicant including fungicides and botanicals (T_1-Seed treatment with azoxystrobin @ 10 ml/kg seed, T_2-Chlorothalonil 75 WP @ 0.15% spray, T_3-NSKE @ 5% spray, T_4-NSKE @ 10% spray, T_5-Garlic extract 5% spray, T_6-Garlic extract 10% spray, T_7-Seed treatment with azoxystrobin @ 10 ml/kg seed + Chlorothalonil 75 WP 0.15% spray, T_8-Seed treatment with azoxystrobin @ 10 ml/kg seed + NSKE @ 5% spray, T_9-Seed treatment with azoxystrobin @ 10 ml/kg seed + NSKE @ 10% spray, T_{10}-Seed Treatment with Azoxystrobin @ 10 ml/kg seed + Garlic Extract 5% spray, T_{11}-Seed treatment with azoxystrobin @ 10 ml/kg seed + Garlic extract 10% spray, T_{12}- Carbendazim 12% + Mancozeb 63% WP and T_{13}-Untreated control) were tested *in vivo* condition against the pathogen.

For botanical testing, fresh parts of the test plants were collected and washed thoroughly in tap water. 50 g of each sample were grinded in mortar and pestle by adding 500 ml of sterilized water (1:1 w/v) and boiled them at 80°C for 10 minutes in water bath. The grinded material was filtered through muslin cloth followed by filtering through sterilized Whatman No 1 filter paper and treated as standard plant extract (100 per cent) (Bhat and Sivaprakasan, 1994).

Effectiveness of various fungitoxicants and botanical extracts

The present investigation aimed to assess the effectiveness of different fungitoxicants and botanical formulations against Alternaria leaf blight of faba bean, incited by *Alternaria alternata*, under *in vivo* conditions using the susceptible genotype 'Vikram'. All evaluated treatments, including fungicides and botanicals, exhibited varying levels of efficacy in managing the disease.

A susceptible faba bean germplasm (Vikram) was sown on 2nd week of November, 2022-2025. Efficacy of fungicides along with botanicals were evaluated against Alternaria leaf blight of faba bean by spraying on naturally infected plants.

List of fungi-toxicants and botanical extract.

Treatment	Fungi-toxicants
T_1	Seed treatment with azoxystrobin @ 10 ml/kg seed
T_2	Chlorothalonil 75 WP @ 0.15% spray
T_3	NSKE @ 5% spray
T_4	NSKE @ 5% spray
T_5	Garlic extract 5% spray
T_6	Garlic extract 10% spray
T_7	Seed treatment with azoxystrobin @ 10 ml/kg seed + Chlorothalonil 75 WP 0.15% spray
T_8	Seed treatment with azoxystrobin @ 10 ml/kg seed + NSKE @ 5% spray
T_9	Seed treatment with azoxystrobin @ 10 ml/kg seed + NSKE @ 10% spray
T_{10}	Seed treatment with azoxystrobin @ 10 ml/kg seed + Garlic extract 5% spray
T_{11}	Seed treatment with azoxystrobin @ 10 ml/kg seed + Garlic extract 10% spray
T_{12}	Carbendazim 12% + Mancozeb 63%WP @ 0.2% spray
T_{13}	Untreated control

After attaining the age of 60 days, the plants were inoculated with mycelium cum spore suspension of the pathogen and the field was irrigated from time to time to maintain proper humidity. The first spraying of fungi-toxicant using recommended doses was given 72 hours after inoculation followed by two more applications at an interval of 10 days. The plots of faba bean plants, sprayed with water served as control. Final observations on percent disease intensity (PDI) were recorded 15 days after the last spraying on the basis of percentage leaf area affected. The yields of leaves per plot were also recorded after harvest of the crop. The percentages of disease controls over check were calculated by the fallowing formula (McKinney, 1923).

$$\text{Disease control (\%)} = \frac{\text{Disease intensity in control - Disease intensity treatment}}{\text{Disease intensity in control}} \times 100$$

Disease scale	Leaf area infected (%)	Reaction
0	No infection	Immune (I)
1	Less than 1% infection	Highly resistant (HR)
3	5-10% infection	Resistant (R)
5	11-25% infection	Moderately resistant (MR)
7	26-50% infection	Moderately susceptible (MS)
9	> 51% infection	Susceptible (S)

Per cent disease intensity (PDI) =

$$\frac{\text{Sum of numarical rating}}{\text{Total number of leaves examinded} \times \text{Maximum rating}} \times 100$$

Rating scale 0-9 (Mayee and Datar, 1986) for Alternaria leaf blight disease.

Statistical analysis

The data of the experiments conducted in fields was subjected to statistical analysis. The critical differences were worked out at 5% probability level to find the difference between the treatments. The data were transformed whenever required.

RESULTS AND DISCUSSION

Effect of fungitoxicants against alternaria leaf blight of during 2022-23 to 2024-25

A field study conducted from 2022 to 2025 to assess the effectiveness of various fungi-toxicants and bio-extracts in managing Alternaria leaf blight of faba bean, caused by *Alternaria alternata.* The treatments were evaluated based on per cent disease index (PDI), per cent disease control (PDC), total yield (q/ha), percentage yield increase, test weight (g) and percentage increase in test weight. The results indicated considerable variation among treatments in their ability to control disease and improve yield-related traits (Table 1).

Disease management (PDI and PDC)

The data revealed that seed treatment with Azoxystrobin + Chlorothalonil 75 WP was the most effective, showing the lowest PDI of 12.45% and the highest PDC of 74.08%, significantly outperforming all other treatments. This was followed closely by Carbendazim 12% + Mancozeb 63% WP (PDI: 13.94%, PDC: 71.28%) and seed treatment with azoxystrobin + Garlic extract 10% (PDI: 17.22%, PDC: 64.00%). In contrast, the untreated control plot recorded the highest PDI of 47.06%, with no disease control, indicating the high susceptibility of faba bean to Alternaria leaf blight under unmanaged conditions (Table 2).

Effect on yield and yield components

The disease control achieved through effective treatments translated into improved yield performance. The highest yield (24.23 q/ha) was recorded in plots treated with Azoxystrobin + Chlorothalonil, with a yield increase of 24.91% over the untreated control. This was closely followed by Carbendazim + Mancozeb (24.03 q/ha, 23.89% increase) and Azoxystrobin + Garlic Extract 10% (23.42 q/ha, 20.72% increase). On the other hand, NSKE 5% recorded the lowest yield (20.63 q/ha) among treatments, with only a 6.36% increase over the control, highlighting its relatively lower efficacy (Table 2).

Test weight and seed quality

The highest test weight (91.73 g) was also achieved with the Azoxystrobin + Chlorothalonil combination, with a 14.31% increase over the control (80.25 g). Similarly, Carbendazim + Mancozeb (90.53 gm) and Azoxystrobin + Garlic Extract 10% (89.72 g) significantly improved test weight, indicating better seed quality associated with effective disease management (Table 2).

Statistical significance

The differences among treatments were statistically significant as indicated by the C.D. at 5% for PDI (3.07), PDC (5.88) and total yield (1.90 q/ha). The coefficient of variation (C.V.) for yield parameters was within acceptable ranges (5.05% for total yield and 5.92% for test weight), ensuring data reliability. However, higher C.V. for test weight increase (71.48%) reflects variability in seed development due to environmental or biological factors (Table 2).

Integrated management approach

The findings clearly underscore the superiority of integrated treatment approaches especially those combining seed treatment with Azoxystrobin and foliar application of Chlorothalonil or botanical extracts in enhancing both disease resistance and crop productivity. Notably, these combinations were more effective than individual treatments, suggesting a synergistic effect.

Evaluation of the efficacy of different fungitoxicants and botanical extracts against Alternaria leaf blight of faba bean (*Vicia faba*), caused by *Alternaria alternata*, under *in vivo* conditions. Some related findings were reported in other

Table 1: Efficacy of fungi-toxicants and botanicals against Alternaria leaf blight of faba bean during 2022-23 to 2024-25.

Treatment	PDI			PDC			Yield (q/ha)			%Yield increase			Test Wight (g)			%Test weight increase		
	2022-23	2023-24	2024-25	2022-23	2023-24	2024-25	2022-23	2023-24	2024-25	2022-23	2023-24	2024-25	2022-23	2023-24	2024-25	2022-23	2023-24	2024-25
T_1	26.22	26.33	32.07	45.52	42.32	34.28	21.05	21.10	21.15	7.67	8.48	10.16	86.35	87.75	87.15	7.27	9.82	8.46
T_2	15.62	15.46	19.36	67.70	66.84	61.19	24.10	23.50	23.75	23.27	20.82	23.70	90.00	89.85	89.95	11.80	12.45	11.95
T_3	31.30	30.62	33.48	34.12	31.08	31.34	20.65	20.70	20.55	5.63	6.43	7.03	84.55	86.55	84.80	5.03	8.32	5.54
T_4	24.96	25.63	28.04	48.20	43.75	43.10	21.10	21.15	21.20	7.93	8.74	10.42	87.00	88.15	87.45	8.07	10.33	8.84
T_5	29.63	29.48	31.09	38.13	34.48	36.64	20.85	20.85	20.95	6.65	7.20	9.11	85.65	86.50	85.95	6.40	8.26	6.97
T_6	24.27	24.77	25.47	49.56	45.54	47.76	21.20	21.50	21.30	8.44	10.54	10.94	88.20	88.35	88.55	9.57	10.58	10.21
T_7	12.12	11.03	14.21	74.84	76.25	71.15	24.65	23.95	24.10	26.09	23.14	25.52	91.70	92.05	91.45	13.91	15.21	13.81
T_8	20.59	21.19	22.78	57.00	52.84	53.61	22.70	22.65	22.85	16.11	16.45	19.01	88.50	88.70	88.75	9.94	11.01	10.45
T_9	18.22	18.76	19.45	61.99	57.73	60.43	23.50	23.40	23.55	20.20	20.31	22.66	89.70	89.65	89.40	11.43	12.20	11.26
T_{10}	20.02	19.62	21.64	58.36	56.61	55.89	22.75	22.70	23.00	16.37	16.71	19.79	89.35	89.45	89.15	10.99	11.95	10.95
T_{11}	17.52	17.16	16.99	63.66	62.60	65.74	23.60	22.95	23.70	20.72	17.99	23.44	89.80	89.70	89.65	11.55	12.27	11.57
T_{12}	14.22	13.32	14.28	71.00	71.50	71.34	24.30	23.85	23.95	24.30	22.62	24.74	90.35	91.15	90.10	12.24	14.08	12.13
T_{13}	47.39	44.79	48.99	0.00	0.00	0.00	19.55	19.45	19.20	0.00	0.00	0.00	80.50	79.90	80.35	0.00	0.00	0.00
C.D. at 5%	3.08	2.95	3.18	5.81	5.89	5.94	1.91	1.89	1.90	10.06	9.93	10.17	N/A	N/A	N/A	N/A	N/A	N/A
SE(m)	1.05	1.00	1.08	1.98	2.01	2.02	0.65	0.64	0.65	3.42	3.38	3.46	3.29	3.26	2.43	4.15	4.13	3.06
C.V.	7.52	7.22	7.14	6.70	7.10	7.25	5.06	5.04	5.05	41.73	42.14	37.52	6.54	6.41	4.81	84.71	70.22	59.51

Table 2: Pooled data on efficacy of fungi-toxicants and botanicals against Alternaria leaf blight of faba bean and their effect on yield over 2022-23 to 2024-25.

Treatments	2022 to 2025: Pooled data					
	PDI	PDC	Total yield (q/ha)	%Yield increase	Test Wight (g)	%Test weight increase
T_1	28.21	40.71	21.10	8.77	87.08	8.52
T_2	16.81	65.24	23.78	22.60	89.93	12.07
T_3	31.80	32.18	20.63	6.36	85.30	6.30
T_4	26.21	45.02	21.15	9.03	87.53	9.08
T_5	30.07	36.42	20.88	7.65	86.03	7.21
T_6	24.84	47.62	21.33	9.97	88.37	10.12
T_7	12.45	74.08	24.23	24.91	91.73	14.31
T_8	21.52	54.49	22.73	17.19	88.65	10.47
T_9	18.81	60.05	23.48	21.06	89.58	11.63
T_{10}	20.43	56.95	22.82	17.62	89.32	11.30
T_{11}	17.22	64.00	23.42	20.72	89.72	11.80
T_{12}	13.94	71.28	24.03	23.89	90.53	12.82
T_{13}	47.06	0.00	19.40	0.00	80.25	0.00
SE(m)	1.04	2.00	0.65	3.42	3.02	3.81
C.D. at 5%	3.07	5.88	1.90	10.05	N/A	N/A
C.V.	7.30	7.02	5.05	40.52	5.97	72.22

crops by scientists and other workers such as Sharma *et al.* (2022), Choudhary *et al.* (2020) Kokare *et al.* (2020) Jackson and Kumar (2019), Rani *et al.* (2018) and Zade *et al.* (2018).

CONCLUSION

The pooled data from 2022 to 2025 demonstrated that the integrated application of Azoxystrobin seed treatment combined with Chlorothalonil 75 WP foliar spray was the most effective strategy for managing Alternaria leaf blight in faba bean. This treatment recorded the lowest Percent Disease Index (12.45%), highest disease control (74.08%) and resulted in the highest yield (24.23 q/ha) and test weight (91.73 g). Chemical treatments such as Carbendazim + Mancozeb and combinations with botanical extracts like Garlic and NSKE also showed promising results, particularly when used in combination with Azoxystrobin. Individual botanical treatments, while less effective on their own, provided moderate disease control and yield benefits. The untreated control recorded the highest disease incidence (47.06%), lowest yield (19.40 q/ha) and lowest seed weight (80.25 g), reinforcing the importance of effective disease management. Overall, the study concludes that integrated disease management especially combining systemic fungicide seed treatment with effective foliar sprays significantly improves disease suppression, yield and seed quality in faba bean crops.

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Disclaimers

Only the authors' opinions and conclusions are presented in this article and they may not be representative of those of their connected institutions. The writers disclaim any liability for any direct or indirect losses coming from the use of this content, however they are accountable for the completeness and accuracy of the information supplied.

Informed consent

The ANDUAT, Ayodhya of Animal Care Committee authorized the handling methods and all experimental procedures were approved by the Committee of Experimental Animal Care.

Conflict of interest

In relation to the publishing of this work, the authors declare that they have no conflicts of interest. The study design, data collection, analysis, publication decision and manuscript preparation were all independent of funding or support.

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