



# **Unravelling the Potential Use of Newer Fungicides against *Alternaria* Blight of Indian Mustard under *In vivo***

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

The effectiveness of seven fungitoxicants, namely mancozeb (0.2%), azoxystrobin (0.05%), propiconazole (0.05%), difenconazole (0.05%), thiram, propineb and hexaconazole (0.05%), was evaluated as a single spray at 45 DAS and in combination with mancozeb at 45 DAS before spraying the other four fungicides separately at 60 DAS in field settings for two years in a row, during the rabi seasons of 2020–21 and 2021-22. The amount of efficacy varied across the

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treatments, but the spraying of several fungitoxicants alone as a single spray treatment or each fungicide in succession with mancozeb (0.2%) considerably reduced the *Alternaria* blight disease over control. Lower *Alternaria* blight severity and highest yield of 1676.17 kg/ha has generally been reported when two fungicide combinations, such as mancozeb at 45 DAS and the azoxystrobin fungicides at 60 DAS, are sprayed and highest and lowest siliqua infection was observed in propineb and mancozeb+difenoconazole treatments respectively. Foliar spray with hexaconazole (0.05%) at 60 DAS was found most effective in controlling *Alternaria* leaf blight severity up to 59.3 percent and *Alternaria* pod blight severity up to 32.7 percent and increased seed yield upto 29.9 percent or 1506.5 Kg/ha as compared to untreated control.

**Keywords:** Disease severity; efficacy; fungicides; rapeseed-mustard.

## 1. INTRODUCTION

Oilseed crops are significant to India's agricultural economy. Seed Brassicas, also known rapeseed-mustard categorized as Brassicaceae. In terms of acreage and production, oilseed brassicas rank third globally after soybean and palm, and they are the second most significant oil seed crop in India, behind groundnut (Kumar and Chopra, 2014). Indian mustard is one of the most significant [1] varieties of rapeseed mustard, accounting for around 85% of the entire amount produced in India (Kumar and Chauhan, 2005). The main states in India where mustard is grown are Punjab, Gujarat, UP, Haryana, Rajasthan, and Madhya Pradesh. It is also grown in a few non-traditional South Indian regions, such as Andrapradesh, Tamilnadu, and Karnataka [2-4]. With 6.412 million hectares of land, India contributes 6.33 million tonnes of rapeseed and mustard to global production (Anonymous, 2017–18). Of all the oilseed crops grown in Rajasthan, rapeseed-mustard holds a prominent place. Rajasthan leads the nation in terms of both rapeseed-mustard production and area [5,6]. The districts of Alwar, Bharatpur, Jaipur, Dholpur, Sawaimadhapur, Sriganganagar, Jhunjhunu, and Sikar are where the mustard crop is primarily grown in Rajasthan. With a production of 3.588 million tonnes, it covers 2.379 million hectares (Anonymous, 2018–19). The disease known as *Alternaria* blight manifests itself as symptoms on the leaves and stems of mature plants and seedlings, as well as in ripening siliquae [7,8,9].

In both vegetable and oleiferous Brassicas, dark patches on the leaves and siliquae lower photosynthetic capacity and promote immature ripening, which results in less high-quality seed production (Kumar et al., 2014). In the Jhansi region of India, mustard leaf blight was a common occurrence, with disease intensities ranging from 23.9 to 62.0 percent, according to Chadar et al. [10].

## 2. MATERIALS AND METHODS

Seven fungitoxicants viz., mancozeb (0.2%), azoxystrobin (0.05%), propiconazole (0.05%), difenconazole (0.05%), thiram, propineb and hexaconazole (0.05%) was evaluated against the disease *Alternaria* blight was sprayed alone at 45 DAS and in conjunction with mancozeb at 45 DAS. The remaining eleven fungicides were sprayed separately at 60 DAS under field circumstances for two years in a row, during the rabi seasons of 2020 and 2021–22. In both seasons, the highly susceptible mustard variety "Varuna" was sown in the first week of November to guarantee that the leaf and blooming stage corresponded with the time when disease development was at its peak. The experiment was conducted under field settings in 5m×3 m plot utilizing randomized block design with three replications. As a check and control, plots were sprayed with ordinary water.

### Treatments:

- T1: Single spray of mancozeb 75% WP (0.2%)
- T2: Single spray of azoxystrobin 23% SC (0.05%)
- T3: mancozeb 75% WP (0.2%) folowed by azoxystrobin 23% SC (0.05%)
- T4: Single spray of propiconazole 25% EC (0.05%)
- T5: Single spray of hexaconazole 5% EC (0.05%)
- T6: Single spray of difenconazole 25% EC (0.05%)
- T7: mancozeb 75% WP (0.2%) folowed by propiconazole 25% EC (0.05%)
- T8: mancozeb 75% WP (0.2%) folowed by difenconazole 25% EC (0.05%)
- T9: mancozeb 75% WP (0.2%) folowed by hexaconazole 5% EC (0.05%)
- T10: Propineb
- T11: Thiram
- T12: Water spray (control)

“Observation on *Alternaria* leaf blight severity (%) was recorded at 90-100 days after sowing and *Alternaria* pod blight severity (%) at 15 days before harvest. The disease severity was calculated by using 0-6 disease rating scale” [11]. The percent disease severity was calculated by using following formula:

$$\text{Per cent disease severity} = \frac{\text{Sum of all numerical ratings}}{\text{No. of leaves examined} \times \text{maximum grade}} \times 100$$

**Seed yield (kg/ha):** The crop was harvested at maturity and threshed each treatment plot separately and individual plot yield was recorded. The individual plot yield was then converted to yield per hectre.

**1000 seed wt (g):** A lot of seeds was drawn at random from each treatment replication wise.

1000 seeds were counted from each sample, weighed separately and expressed in grams.

**Oil content (%):** Oil content (%) were determined by using the nuclear magnetic resonance (NMR).

### 3. RESULTS AND DISCUSSION

The effectiveness of seven fungitoxicants, namely mancozeb (75% WP; 0.2%), azoxystrobin (23% SC; 0.05%), propiconazole (25% EC; 0.05%), difenconazole (25% EC); thuram, propineb, and hexaconazole (5% EC; 0.05%), against *Alternaria* blight disease was evaluated as a single spray at 45 DAS, in combination with mancozeb at 45 DAS, and then for two consecutive years during Rabi 2020–21 and 2021–22. The combined data, which is shown in Table 1, showed that the *Alternaria* blight disease was considerably reduced when various fungitoxicants were sprayed alone as a single spray treatment or when each fungicide was sprayed consecutively with mancozeb 75% WP (0.2%). Nevertheless, the degree of efficacy differed among the treatments [12].

When two fungicide combinations are sprayed, such as mancozeb at 45 DAS and the azoxystrobin fungicides at 60 DAS, the results are typically lower severity of *Alternaria* blight and highest yield of 1676.17 kg/ha. Propineb and mancozeb+difenoconazole treatments showed the lowest and highest levels of siliqua infection, respectively. Comparing all single spray treatments to combinations of two fungicides spray, such as mancozeb at 45 DAS and the other four fungicides at 60 DAS, has generally resulted in lower *Alternaria* blight severity. The

best results were obtained when using foliar spray with mancozeb 75% WP (0.2%) at 45 DAS and hexaconazole 5% EC (0.05%) at 60 DAS to limit the severity of *Alternaria* leaf blight (ALB) up to 78.0 percent and *Alternaria* pod blight (APB) up to 56.5 percent and increased seed yield upto 29.9 percent as compared to [10] untreated control. The second most promising treatment, however, was foliar spraying mancozeb at 75% WP (0.2%) and then difenconazole at 25% EC (0.05%). Mancozeb interferes with various enzymatic processes of fungal cell wall, and disrupts the lipid metabolism, and interferes with respiration also by inhibiting sulfhydryl groups thereby preventing spore germination of *Alternaria*. “This combination reduced ALB severity to 71.6 percent and increased APB severity to 51.5 percent, while also increasing seed yield by 29.4% relative to the control. None of the single spray treatment of fungicides was found superior over the combination sprays treatment against *Alternaria* blight disease” [13].

Hexaconazole spray was determined to be the most effective single spray therapy in reducing the severity of ALB (59.3%) and APB (32.7%) compared to the control, which had a higher seed production (20.3%). Plots sprayed with propiconazole (0.05%) at 45 DAS recorded the greatest 1000 seed weight of 4.0 g, while the lowest was in treatment of azoxystrobin 23% SC (0.05%), or 3.5 g. However, no significant differences were found between the treatments for oil content or 1000 seed weight. The plots treated with hexaconazole as a single spray or in conjunction with mancozeb had the highest percentage of oil content (39.6%) (Table 1). Singh et al. [14] and Chattopadhyay et al. [15] have evaluated the effectiveness of seven fungicides against *Alternaria* leaf blight disease under field conditions. “Hexaconazole is a demethylation inhibitor and its mechanism is playing the pivotal role of demethylation inhibitor against cytochrome P450-mediated oxidative demethylation reactions which are necessary for the synthesis of ergosterol” [16].

They discovered that the best method for managing *Alternaria* blight disease was to apply a foliar spray containing iprodione twice at 45 and 60 days after sowing. This was followed by mancozeb (Table 2). Singh and Singh [17], however, discovered that Blitox-50 and Bavistin were more successful in lessening the severity of Muddappa and Zacharia, [18] the disease than foliar spray containing mancozeb. The least successful treatment for lowering the severity of

**Table 1. Evaluation of fungicides for management of *Alternaria* blight disease of mustard under field conditions *rabi* 2020-21 and 2021-22**

	Disease Severity			Siliqua Infection			No. of Spots		
	2020	2021-22	Pooled	2020	2021-22	Pooled	2020	2021-22	Pooled
<b>T1</b>	17.67	20.83	19.25	16.54	17.54	17.04	6.31	7.62	6.965
<b>T2</b>	22.62	27.85	25.235	26.01	28.31	27.16	6.75	7.65	7.2
<b>T3</b>	13.67	13.9	13.785	10.62	5.71	8.16	4.21	5.36	4.785
<b>T4</b>	20.59	24.02	22.305	17.69	19.64	18.66	9.56	10.41	9.985
<b>T5</b>	28.82	31.44	30.13	26.77	28.74	27.75	8.06	9.26	8.66
<b>T6</b>	14.77	18.37	16.57	11.29	12.79	12.04	5.76	6.88	6.32
<b>T7</b>	23.7	25.28	24.49	30.55	34.69	32.61	7.52	8.44	7.98
<b>T8</b>	33.67	34.04	33.855	67.46	63.83	65.64	11.26	12.31	11.785
<b>T9</b>	18.58	21.33	19.955	12.91	12.24	12.57	4.95	5.64	5.295
<b>T10</b>	35.35	38.49	36.92	70.84	68.85	69.84	9.1	10.68	9.89
<b>T11</b>	53.87	57.59	55.73	71.04	69.35	70.19	11.8	12.86	12.33
<b>T12</b>	20.59	22.32	21.455	14.07	16.1	15.08	4.24	6.86	5.55
<b>Sowing</b>	0.21	0.12	0.18	0.14	0.08	0.23	0.24	0.2	0.23
<b>Variety</b>	0.18	0.05	0.16	0.12	0.07	0.20	0.21	0.17	0.16
<b>Sowing x variety</b>	0.37	0.36	0.33	0.25	0.14	0.40	0.422	0.34	0.24

**Table 2. Pooled data showcasing management of *Alternaria* blight of mustard by yield and number of pods**

	Number of pods			Yield kg/ha		
	2020	2021-22	Pooled	2020	2021-22	Pooled
T1	122.73	91.37	107.05	1653.33	1426.67	1540
T2	88.37	84.83	86.6	1545	1409	1477
T3	127.75	117.15	122.45	1717.67	1634.67	1676.17
T4	112.95	97.78	105.365	1736	1480.67	1608.335
T5	102.13	99	100.565	1565.33	1447	1506.165
T6	143.03	136.23	139.63	1901.67	1747.67	1824.67
T7	105.13	102.83	103.98	1411	1302	1356.5
T8	63.73	63.42	63.575	1253.33	949	1101.165
T9	116.77	112.69	114.73	1282.33	1373.67	1328
T10	93.89	91.82	92.855	955.33	802	878.665
T11	95.08	99.87	97.475	756.33	577	666.665
T12	122.85	112.17	117.51	927.33	886.33	906.83
<b>Sowing</b>	13.02	6.68	6.71	19.69	15.38	12.8
<b>Variety</b>	11.23	5.59	5.81	17.05	12.32	11.09
<b>Sowing x variety</b>	21.23	9.18	11.63	34.1	23.64	22.18

the illness was Cuman L. The severity of *Alternaria* blight disease was reduced from 57.3 to 41.4 percent with two foliar sprays of Ridomil MZ applied 60 and 80 days after sowing. The yield increased from 1052 kg/ha (control) to 1842 kg/ha [19].

#### 4. CONCLUSION

The investigation's findings, in summary, showed that the foliar spray containing mancozeb at 45 DAS and hexaconazole at 60 DAS was the most successful in reducing the severity of *Alternaria* leaf and pod blight and boosted seed output compared to the untreated control. It might be evaluated as preventative sprays on farmer's fields in mustard, allowing a recommendation to be made about the pathogen's control [20].

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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