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Induction of Host Resistance with Plant Defense Activators against White Rust of Mustard cv. DRMRIJ-31

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A B S T R A C T

Systemic resistance in plants can be induced through biotic or abiotic plant defense inducers. Efficacy of plant defense activators was tested against *Albugo candida* causing white rust on mustard cv. DRMRIJ-31 under artificial epiphytotic conditions during two consecutive cropping season. The maximum reduction of the size of pustules was found in Metalaxyl at 0.3 % was 56.61 % and minimum reduction over the check was recorded in check followed by $ZnSO_4$ at 0.50 % was 15.27 %. In non-conventional chemicals maximum reduction of size of pustules over the check was observed in salicylic acid at 0.25 % was 45.99 % followed by $CaSO_4$ at 1.00 % was 38.98 %. The significant minimum number of pustules was observed in Metalaxyl at 0.2% was 1.73 pustules/25 mm^2 area in *rabi* season (Table 3). Among non-conventional chemicals salicylic acid at 0.25% was found better over all the treatments and zinc sulphate at 0.50 % was recorded minimum reduction of the disease over the check. Among the bio control agents, both *Trichoderma viride* at 1.00 % and *Pseudomonas fluorescens* at 1.00 % were found significantly better over the check. The per cent disease index in all the treatments, Metalaxyl 0.3% found superior with 48.69 per cent disease reduction over the check. Among non-conventional chemicals salicylic acid at 0.25% was found best with 38.41 per cent reduction over the check followed by calcium sulphate at 1.00 % showed disease index (29.91 %), Borax at 0.50 % (23.93 %) and potassium sulphate at 1.00 % (18.88 %).

Introduction

In India, Rapeseed-mustard grown over an area of 6.02 mha, ranks 2nd most important oilseed crop (Sunayana *et al.*, 2021), yielding 9.34 million tones with an average productivity of 1499 kg per hectare (GOI, 2019-20). The prominent growing states are Rajasthan, Uttar Pradesh, Haryana, West Bengal, Madhya Pradesh, Gujarat and Assam accounting for 92 per cent of total production. As per USDA (2016), India has become the leading rapeseed-mustard growing country with 21.6 per cent production globally. Rajasthan is the leading state particularly in Indian mustard production contributing about 45 per cent of the country with an annual output of 3.40 million tonne and average productivity of 1558 kg/ha. It is grown on 2.18 million hectare (Anonymous, 2019-20). Indian

mustard being an important source of edible oil in India, possesses the capacity to reduce the import of edible oil, which is currently 70 per cent of total edible oil demand (Priyamedha, 2021).

The mustard disease management opportunities available to farmers include resistant and tolerant cultivars, biological control, tillage and chemicals (Jayant and Sinha, 1981; Dhyani *et al.*, 1990; Gupta *et al.*, 1990). Among the fungicides, numerous combinations are available to the farmers but nearly all possess direct fungitoxicity to human. A second potential principle for chemically mediated disease management could be based on compounds that would induce systemic acquired resistance response in the plants. Recently established concept of systemic acquired resistance for plant disease management provides an exciting vision for prevention and control. The availability of permanent, broad spectrum stable resolution to disease management would indisputably have massive positive influence on crop yield.

Induced resistance in host-pathogen system was well-documented phenomenon (Kloepper *et al.*, 1992; Kuc, 1982). Induction of resistance can be accomplished by chemical and biological agents.

The extent of defense may vary among plant species. The agents involved induction of host responses which produce not only localized resistance as well as systemic resistance to plants depending upon the treatment (Tuzun and Kuc, 1985). In several plant species pathogen induced tissue necrosis results to the systemic activation of a broad spectrum permanent disease resistance called systemic acquired resistance. Present investigation was carried out to explore the possibility of utilizing induced host resistance as an authentic substitute to classical fungicides.

Materials and Methods

First spray plant defense activators in the mustard cultivar, DRMRIJ-31was given when plants shows first symptom of the disease in each treatment with their respective concentration using a randomized block design. One standard chemical check, Metalaxyl at 0.10, 0.20 and 0.30 per cent and one sterile distilled water check was also maintained in three replications.

Observations recorded

Size of pustule on leaves

Diameter of randomly selected five leaves were measured in mm with the help of plastic scale and average size of pustule was calculated and recorded at ten days interval.

Number of pustules

Numbers of pustules recorded by counting the pustules per 25 mm^2 leaf area of randomly selected five leaves of plant. The observations were recorded on five leaves and average number of pustules was then calculated per 25 mm^2 leaf area.

Per cent disease index on leaf

The per cent disease index on leaf due to white rust was recorded at 10 days interval up to 90 days after sowing (DAS) by using of 0-5 rating scale given by Biswas *et al.*, (2011); Tirmali and Kolte (2012).

Ratings were given as per above mentioned rating scale and white rust per cent disease index was calculated by using formula given by Wheeler (1969) and Mathur *et al.*, (2013). Observations were recorded by randomly selecting twenty five leaves from each replication and were rated as per the above rating scale and per cent disease index was calculated and statistically analyzed as described by Panse and Sukhatme (1985) for analysis of variance of randomized block design in order to test the significance of experimental results.

$$\text{White rust index (\%)} = \frac{\text{Sum of all numerical ratings}}{\text{Number of leaves examined X maximum grade of scale}} \text{ x } 100$$

Results and Discussion

The size of the pustules was increased from 70 days after sowing to 90 days after sowing in cv. DRMRIJ-31 during *rabi* season 2015-16. The significant differences were observed among the different treatments (Table 2). The significant minimum size of pustule was found in Metalaxyl at 0.3 % was 0.30 mm at 70 days after sowing in 2015-16. The maximum reduction of the size of pustules was found in Metalaxyl at 0.3 % was 56.61 % and minimum reduction over the check was recorded in check followed by $ZnSO_4$ at 0.50 % was 15.27 %. In non-conventional chemicals maximum reduction of size of pustules over the check was observed in salicylic acid at 0.25 % was 45.99 % followed by $CaSO_4$ at 1.00 % was 38.98 %.

The average number of pustule was increased from 70 days after sowing to 90 days after sowing in cv. DRMRIJ-31 during 2016-17. The significant minimum number of pustules was observed in Metalaxyl at 0.2% was 1.73pustules/25 mm^2 area in *rabi* season (Table 3). Among non-conventional chemicals salicylic acid at 0.25% was found better over all the treatments and zinc sulphate at 0.50 % was recorded minimum reduction of the disease over the check. Among the bio control agents, both *Trichoderma viride* at 1.00 % and *Pseudomonas fluorescens* at 1.00 % were found significantly better over the check.

The per cent disease index due to white rust on leaf of the mustard at 70, 80 and 90 days after sowing was found significantly better then in all the treatments over the check in cv. DRMRIJ-31(Table 4). Among all the treatments Metalaxyl 0.3% found superior with 48.69 per cent disease reduction over the check. However it was found at par with the Metalaxyl 0.1 and Metalaxyl 0.2 at 70, 80 and 90 Days after sowing during 2015-16 and 2016-17. Among non-conventional chemicals salicylic acid at 0.25% was found best with 38.41 per cent reduction over the check followed by calcium sulphateat 1.00 % showed disease index (29.91 %), Borax at 0.50 % (23.93 %) and potassium sulphate at 1.00 % (18.88 %). The maximum percent disease index was observed in check (77.60) during the year 2015-16 and minimum disease index was recorded in Metalaxyl 0.3% (7.73) during 2015-16.

Tirmali and Kolte (2012) reported the efficacy of several plant defense activators in the management of *Albugo candida* pathogen during 2003-04. They used varuna cultivar to study induction of host resistance in mustard against the pathogen. They found calcium sulphate, potassium chloride, potassium sulphate, zinc sulphate and borax significantly superior effective in reduction the pustules size of white rust on the mustard leaves with comparison to control.

Sharma and Kolte (1994) reported that potassium fertilized plants exhibited 30 to 45 per cent less disease severity of Alternaria blight based on the number and size of the spots, average disease index on leaf and pods. Tewari (1991) found that foliar application of the calcium reduce the per cent disease severity of Alternaria blight in rapeseed. Antonova *et al.,* (1984) and Dixon *et al.,* (1987) reported that boron application in the cabbage increase resistance to club root. Singh *et al.,* (2020) reported that the size of pustule of white rust was recorded minimum in Metalaxyl 0.3% was 0.32 mm followed by Metalaxyl 0.2% (0.33 mm) in cv. RH-749 during 2015-16 while maximum size of pustules were observed in check was 6.55 mm followed by zinc sulphate at 0.50% (5.88 mm) during 2016-17.

Among the abiotic chemicals, salicylic acid was recorded significantly better over all the treatments. The number of pustules were recorded maximum in the check was 7.47 and 7.53 followed by zinc sulphate at 0.50 % was 7.13 and 7.27 during 2015-16 and 2016-17, respectively. Salicylic acid 0.25% reduce 31.50% white rust disease over the control followed by calcium sulphate at 1.00% which reduce disease 23.99%. Zinc sulphate at 0.50% was found least effective abiotic chemical which reduce 6.14% disease.

Singh and Ratnoo (2021) reported similar finding in

their study in mustard cultivar RH-406. They found maximum average size of pustules were recorded in check (3.92 mm) followed by zinc sulphate (3.27 mm), *Trichoderma viride* (3.14 mm). Among the abiotic agents, maximum reduction in the size of the pustules were recorded in salicylic acid (47.01 %) followed by calcium sulphate (41.28 %) and potassium chloride (40.06 %).Overall number of pustules were recorded maximum in check (5.78), followed by zinc sulphate (5.39) and *Trichoderma viride* (5.16). Among the bio agents, *Pseudomonas fluorescens* reduced number of pustules by 25.96% over the check. Among the abiotic agents, salicylic acid recoded superior in all treatments over the control which reduced number of pustules 38.65% over the check followed by calcium sulphate (32.50%). Among the abiotic agents, salicylic acid reduce the percent disease index by 30.11% over the check followed by calcium sulphate (22.54%) and minimum percent disease index reduction was recorded in zinc sulphate was 5.93%.

Table.1 Biotic and abiotic activators and their concentration under field study

Treatments	Biotic and abiotic agents	Concentration (%)
T_1	*Trichoderma viride*	1.00
T_2	*Pseudomonas fluorescens*	1.00
T_3	Salicylic acid	0.25
T_4	Borax ($Na_2B_4O_7.10H_2O$)	0.50
T_5	Potassium sulphate (K_2SO_4)	1.00
T_6	Calcium sulphate ($CaSO_4$)	1.00
T_7	Metalaxyl	0.10
T_8	Metalaxyl	0.20
T_9	Metalaxyl	0.30
T_{10}	Potassium chloride (KCl)	1.00
T_{11}	Zinc sulphate ($ZnSO4.7H_2O$)	0.50
T_{12}	Check	-

Table.2 Per cent disease index on leaf

Numerical rating	Leaf area covered by the pustules (%)
0	No symptoms
1	1-10
2	11-25
3	26-50
4	51-75
5	>75

Table.3 Effect of biotic and non-conventional chemicals on size of pustule on mustard cv. DRMRIJ-31 under field conditions

Treatment	Concentration (%)	Size of pustules (mm)									
		2015-16				2016-17				Over all Mean	Reduction over check (%)
		70 DAS	80 DAS	90 DAS	Mean	70 DAS	80 DAS	90 DAS	Mean		
Trichoderma viride	1.00	0.88	3.07	5.47	3.14	0.89	3.02	5.49	3.13	3.14	17.58
Pseudomonas fluorescens	1.00	0.54	2.20	4.67	2.47	0.57	2.29	4.70	2.52	2.50	34.42
Salicylic Acid	0.25	0.39	1.80	3.93	2.04	0.42	1.82	3.97	2.07	2.06	45.99
Borax	0.50	0.79	2.60	5.20	2.86	0.86	2.63	5.17	2.89	2.88	24.44
K_2SO_4	1.00	0.64	2.53	4.93	2.70	0.64	2.54	4.96	2.71	2.71	28.85
$CaSO_4$	1.00	0.48	2.07	4.40	2.32	0.49	2.14	4.36	2.33	2.32	38.98
Metalaxyl 0.1%	0.10	0.34	1.67	3.47	1.83	0.34	1.69	3.37	1.80	1.81	52.32
Metalaxyl 0.2%	0.20	0.32	1.60	3.20	1.71	0.32	1.56	3.27	1.72	1.71	55.04
Metalaxyl 0.3%	0.30	0.30	1.47	3.13	1.63	0.31	1.52	3.17	1.67	1.65	56.61
KCl	1.00	0.49	2.09	4.33	2.31	0.49	2.11	4.37	2.32	2.32	39.15
$ZnSO_4$	0.50	0.89	3.13	5.60	3.20	0.91	3.18	5.65	3.24	3.22	15.27
Check	-	1.22	3.93	6.20	3.78	1.25	4.00	6.23	3.83	3.81	0.00
SEm±	-	0.02	0.08	0.15	-	0.03	0.08	0.16	-	-	-
CD 5%	-	0.06	0.23	0.42	-	0.07	0.24	0.46	-	-	-

DAS = Days after sowing

Table.4 Effect of biotic and abiotic agents on number of white rust pustule on mustard cv. DRMRIJ-31 under field condition

Treatment	Concentration (%)	Number of pustules/25 mm^2 area									
		2015-16				2016-17				Over all Mean	Reduction over check (%)
		70 DAS	80 DAS	90 DAS	Mean	70 DAS	80 DAS	90 DAS	Mean		
Trichoderma viride	1.00	5.20	7.07	5.22	8.20	3.67	5.13	6.93	5.24	5.23	8.01
Pseudomonas fluorescens	1.00	4.00	6.07	4.22	25.78	3.13	4.07	6.07	4.42	4.32	24.02
Salicylic Acid	0.25	3.27	5.07	3.58	37.11	2.60	3.33	4.87	3.60	3.59	36.91
Borax	0.50	4.73	6.60	4.84	14.84	3.27	4.80	6.80	4.96	4.90	13.87
K_2SO_4	1.00	4.53	6.20	4.67	17.97	3.27	4.60	6.33	4.73	4.70	17.38
$CaSO_4$	1.00	3.67	5.40	3.96	30.47	2.67	3.73	5.60	4.00	3.98	30.08
Metalaxyl 0.1%	0.10	3.00	4.40	3.16	44.53	2.20	3.07	4.27	3.18	3.17	44.34
Metalaxyl 0.2%	0.20	2.87	4.33	3.02	46.88	1.73	2.93	4.20	2.96	2.99	47.46
Metalaxyl 0.3%	0.30	2.73	4.27	2.98	47.66	1.80	2.80	4.27	2.96	2.97	47.85
KCl	1.00	3.73	5.60	4.00	29.69	2.73	3.80	5.27	3.93	3.97	30.27
$ZnSO_4$	0.50	5.13	7.13	5.24	7.81	3.53	5.20	6.93	5.22	5.23	8.01
Check	-	5.73	7.47	5.69	0.00	3.93	5.80	7.33	5.69	5.69	0.00
SEm±	-	0.13	0.15	0.21	-	0.15	0.15	0.20	-	-	-
CD 5%	-	0.38	0.42	0.61	-	0.42	0.42	0.58	-	-	-

DAS = Days after sowing

Table.5 Effect of biotic and non-conventional chemicals on disease index of white rust on leaf on mustard cv. DRMRIJ-31 under field conditions

Treatment	Concentration (%)	Disease index (%)									
		2015-16				2016-17				Over all Mean	Reduction over check (%)
		70 DAS	80 DAS	90 DAS	Mean	70 DAS	80 DAS	90 DAS	Mean		
Trichoderma viride	1.00	24.27 (29.51)	40.00 (39.23)	73.87 (59.26)	46.04 (42.73)	25.07 (30.04)	39.47 (38.92)	76.27 (60.85)	46.93 (43.24)	46.49	2.24
Pseudomonas fluorescens	1.00	22.93 (28.61)	39.47 (38.92)	72.80 (58.56)	45.07 (42.17)	24.80 (29.87)	39.20 (38.76)	76.00 (60.67)	46.67 (43.09)	45.87	3.55
Salicylic Acid	0.25	10.13 (18.56)	26.40 (30.92)	48.00 (43.85)	28.18 (32.06)	12.00 (20.27)	24.53 (29.69)	54.67 (47.68)	30.40 (33.46)	29.29	38.41
Borax	0.50	19.20 (25.99)	30.93 (33.79)	54.93 (47.83)	35.02 (36.28)	16.80 (24.20)	30.40 (33.46)	64.80 (53.61)	37.33 (37.66)	36.18	23.93
K_2SO_4	1.00	20.00 (26.57)	32.27 (34.61)	58.93 (50.15)	37.07 (37.50)	19.20 (25.99)	32.27 (34.61)	68.80 (56.04)	40.09 (39.28)	38.58	18.88
$CaSO_4$	1.00	16.53 (23.99)	28.80 (32.46)	50.93 (45.53)	32.09 (34.50)	15.20 (22.95)	27.73 (31.78)	60.80 (51.24)	34.58 (36.02)	33.33	29.91
Metalaxyl 0.1%	0.10	8.27 (16.71)	24.00 (29.33)	41.33 (40.01)	24.53 (29.69)	8.80 (17.26)	19.20 (25.99)	48.80 (44.31)	25.60 (30.40)	25.07	47.29
Metalaxyl 0.2%	0.20	8.00 (16.43)	23.73 (29.15)	40.53 (39.54)	24.09 (29.39)	8.53 (16.98)	18.93 (25.79)	48.53 (44.16)	25.33 (30.22)	24.71	48.04
Metalaxyl 0.3%	0.30	7.73 (16.15)	23.47 (28.97)	40.00 (39.23)	23.73 (29.15)	8.27 (16.71)	18.67 (25.60)	48.27 (44.01)	25.07 (30.04)	24.40	48.69
KCl	1.00	21.60 (27.69)	33.60 (35.43)	63.73 (52.97)	39.64 (39.02)	22.13 (28.06)	34.13 (35.75)	72.00 (58.05)	42.76 (40.83)	41.20	13.36
$ZnSO_4$	0.50	22.40 (28.25)	35.20 (36.39)	67.20 (55.06)	41.60 (40.16)	24.27 (29.51)	35.73 (36.71)	72.53 (58.39)	44.18 (41.66)	42.89	9.81
Check	-	25.60 (30.40)	40.53 (39.54)	77.60 (61.75)	47.91 (43.80)	25.33 (30.22)	39.73 (39.08)	76.53 (61.03)	47.20 (43.39)	47.56	0.00
SEm±	-	0.71	0.91	1.25	-	0.66	1.26	2.23	-	-	-
CD 5%	-	2.03	3.18	5.79	-	1.90	3.61	6.41	-	-	-

Values in parenthesis are angular transformed values
DAS = Days after sowing

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