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Research Article

INDUCTION OF HOST RESISTANCE WITH PLANT DEFENSE ACTIVATORS AGAINST WHITE RUST OF MUSTARD *CV.* PM-28

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Abstract: The size of pustule, number of pustules and per cent disease index due to white rust was recorded in mustard variety PM-28 in two consecutive crop seasons during 2015-16 and 2016-17 at 70, 80 and 90 days after sowing of the crop. The maximum average size of pustules was recorded in check (3.97 mm) followed by zinc sulphate (3.31 mm), *Trichoderma viride* (3.19 mm). The maximum reduction of the size of the pustules were found in Metalaxyl 0.3% followed by Metalaxyl 0.2% was 57.36 mm and 56.18 mm, respectively. Among the abiotic agents, maximum reduction in the size of the pustules were recorded in salicylic acid (46.48) followed by calcium sulphate (40.82 %) and Potassium chloride (39.59 %). The number of pustules were observed minimum in Metalaxyl 0.2% and Metalaxyl 0.3% was 2.07 and 2.07, respectively. Among the abiotic agents, salicylic acid recoded superior in all treatments over the control which reduced disease 36.27% over the check followed by calcium sulphate (30.88%). Salicylic acid 0.25% reduce 28.66 % white rust disease over the control followed by calcium sulphate at 1.00 % which reduce disease 21.20 %, zinc sulphate at 0.50 % was found least effective abiotic chemical which reduce 5.73 % disease.

Keywords: *White rust, PM-28, Mustard, Albugo candida, Activator, Salicylic acid, Host Resistance*

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Introduction

India is the fifth largest vegetable oil economy in the world accounting 7.4 per cent world`s oilseeds, 5.8 per cent oil and 6.1 per cent oil meal production and accounts 9.3 per cent of world`s edible oil consumption [1]. Despite being the largest cultivator of oilseeds in the world, India imports about 50 per cent of the domestic oil requirement and become the biggest importer of the vegetable oils with 11.2 per cent share in the total world import worth of about Rs. 68000 crores in 2016-17 [2]. Mustard is the second most important oilseed crop of India after groundnut in terms of area and production. Rajasthan state ranks first both in area and production [3]. 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 hectares [4].

Plant adopts a variety of biochemical defense towards microbial attack. Plant activators are chemicals compounds that induce plant defense responses to several pathogens causing disease. Disease control is largely based on the use of fungicides, bactericides and chemical compounds which are toxic to plant invaders, pathogens and vectors of plant diseases. However, the harmful effect of these chemicals on the environment and human health strongly requires the search for new, harmless means of disease management practices. There must be some usual phenomenon of induced resistance to defend plants from disease. Various biosynthetic pathways are activated in treated plants depending on the compound used.

Commonly tested chemical activators are salicylic acid, methyl salicylate and chitosan which affect production of phenolic compounds and activation of various defense-related enzymes in plants [5]. All biotic and abiotic activators either act as a signal or operate by inducing signal molecule within the plant. 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, PM-28 was given when plants show 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.

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 ($ZnSO_4.7H_2O$)	0.50
T_{12}	Control	-

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 mm² 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 mm² leaf area.

Table-2 Effect of bio-stimulators and non-conventional chemicals on size of pustule on mustard cv. PM-28 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	0.93	3.05	5.53	3.17	0.94	3.09	5.58	3.20	3.19	19.67
Pseudomonas fluorescens	1.00	0.60	2.25	4.69	2.51	0.61	2.29	4.72	2.54	2.53	36.28
Salicylic Acid	0.25	0.45	1.85	4.01	2.10	0.47	1.89	4.07	2.14	2.12	46.48
Borax	0.50	0.82	2.61	5.17	2.87	0.83	2.65	5.23	2.90	2.89	27.21
K_2SO_4	1.00	0.67	2.51	4.99	2.72	0.68	2.55	5.03	2.75	2.74	30.96
$CaSO_4$	1.00	0.51	2.10	4.37	2.33	0.53	2.14	4.43	2.36	2.35	40.82
Metalaxyl 0.1%	0.10	0.37	1.64	3.37	1.79	0.38	1.68	3.43	1.83	1.81	54.33
Metalaxyl 0.2%	0.20	0.35	1.57	3.25	1.72	0.36	1.61	3.30	1.76	1.74	56.18
Metalaxyl 0.3%	0.30	0.36	1.50	3.16	1.67	0.37	1.54	3.21	1.71	1.69	57.36
KCl	1.00	0.54	2.14	4.45	2.38	0.55	2.18	4.51	2.41	2.40	39.59
$ZnSO_4$	0.50	0.96	3.13	5.78	3.29	0.97	3.17	5.83	3.32	3.31	16.64
Check	-	1.39	4.03	6.43	3.95	1.40	4.06	6.49	3.98	3.97	0.00
SEm±	-	0.02	0.06	0.08	-	0.01	0.03	0.03	-	-	-
CD 5%	-	0.07	0.17	0.23	-	0.04	0.08	0.08	-	-	-

Table-3 Effect of bio-stimulators and non-conventional chemicals on number of white rust pustule on mustard cv. PM-28 under field conditions

Treatment	Concentration (%)	Number of pustules/25 mm² 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	3.87	5.53	7.33	5.58	3.93	5.60	7.40	5.64	5.61	9.34
Pseudomonas fluorescens	1.00	3.13	4.53	6.27	4.64	3.20	4.60	6.33	4.71	4.68	24.42
Salicylic Acid	0.25	2.73	3.73	5.27	3.91	2.80	3.80	5.33	3.98	3.94	36.27
Borax	0.50	3.53	5.20	6.93	5.22	3.60	5.27	7.00	5.29	5.26	15.08
K_2SO_4	1.00	3.47	5.00	6.53	5.00	3.53	5.07	6.60	5.07	5.03	18.67
$CaSO_4$	1.00	2.93	4.13	5.67	4.24	3.00	4.20	5.73	4.31	4.28	30.88
Metalaxyl 0.1%	0.10	2.27	3.47	4.67	3.47	2.33	3.53	4.73	3.53	3.50	43.45
Metalaxyl 0.2%	0.20	2.07	3.33	4.60	3.33	2.13	3.40	4.67	3.40	3.37	45.60
Metalaxyl 0.3%	0.30	2.07	3.20	4.60	3.29	2.13	3.27	4.67	3.36	3.32	46.32
KCl	1.00	3.27	4.33	5.80	4.47	3.33	4.40	5.87	4.53	4.50	27.29
$ZnSO_4$	0.50	4.20	5.60	7.47	5.76	4.27	5.67	7.53	5.82	5.79	6.46
Check	-	4.47	6.20	7.80	6.16	4.53	6.27	7.87	6.22	6.19	0.00
SEm±	-	0.07	0.08	0.05	-	0.06	0.05	0.06	-	-	-
CD 5%	-	0.20	0.23	0.15	-	0.16	0.14	0.18	-	-	-

Table-4 Effect of bio-stimulators and non-conventional chemicals on disease index of white rust on leaf of mustard cv. PM-28 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	25.33 (30.22)	42.13 (40.47)	77.33 (61.57)	48.27 (44.01)	26.67 (31.09)	43.73 (41.40)	76.27 (60.85)	26.67 (44.36)	48.58	0.55
Pseudomonas Fluorescens	1.00	25.07 (30.04)	41.87 (40.32)	77.07 (61.39)	48.00 (43.85)	26.40 (30.92)	43.47 (41.25)	76.00 (60.67)	26.40 (44.21)	48.31	1.09
Salicylic Acid	0.25	15.20 (22.95)	28.80 (32.46)	65.60 (54.09)	36.53 (37.19)	12.80 (20.96)	27.47 (31.61)	59.20 (50.30)	12.80 (35.16)	34.84	28.66
Borax	0.50	20.00 (26.57)	34.40 (35.91)	72.27 (58.22)	42.22 (40.53)	18.93 (25.79)	35.20 (36.39)	65.60 (54.09)	18.93 (39.18)	41.07	15.92
K_2SO_4	1.00	20.80 (27.13)	35.73 (36.71)	73.60 (59.08)	43.38 (41.19)	20.53 (26.95)	36.80 (37.35)	68.80 (56.04)	20.53 (40.42)	42.71	12.56
$CaSO_4$	1.00	18.40 (25.40)	32.00 (34.45)	70.67 (57.21)	40.36 (39.44)	16.53 (23.99)	31.20 (33.96)	62.13 (52.02)	16.53 (37.24)	38.49	21.20
Metalaxyl 0.1%	0.10	13.33 (21.42)	24.80 (29.87)	58.40 (49.84)	32.18 (34.56)	8.80 (17.26)	24.27 (29.51)	54.67 (47.68)	8.80 (32.74)	30.71	37.12
Metalaxyl 0.2%	0.20	13.07 (21.19)	24.53 (29.69)	58.13 (49.68)	31.91 (34.40)	8.53 (16.98)	24.00 (29.33)	54.40 (47.52)	8.53 (32.57)	30.44	37.67
Metalaxyl 0.3%	0.30	12.80 (20.96)	24.27 (29.51)	57.87 (49.53)	31.64 (34.23)	8.27 (16.71)	23.73 (29.15)	54.13 (47.37)	8.27 (32.40)	30.18	38.22
KCl	1.00	22.13 (28.06)	37.60 (37.82)	75.20 (60.13)	44.98 (42.12)	22.93 (28.61)	38.67 (38.45)	71.20 (57.54)	22.93 (41.71)	44.62	8.64
$ZnSO_4$	0.50	22.40 (28.25)	38.93 (38.61)	76.00 (60.67)	45.78 (42.58)	24.80 (29.87)	40.80 (39.70)	73.33 (58.91)	24.80 (42.88)	46.04	5.73
Check	-	25.60 (30.40)	42.40 (40.63)	77.60 (61.75)	48.53 (44.16)	26.93 (31.26)	44.00 (41.55)	76.53 (61.03)	26.93 (44.52)	48.84	0.00
SEm±		0.47	0.80	0.77	-	0.79	0.67	0.80	-	-	-
CD 5%	-	1.36	2.29	2.20	-	2.25	1.91	2.30	-	-	-

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) [6], Tirmali and Kolte (2012) [7].

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

Ratings were given as per above mentioned rating scale and white rust per cent disease index was calculated by using formula given by [8,9]. 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 [10] for analysis of variance of randomized block design in order to test the significance of experimental results.

White rust index (%)=(Sum of all numerical ratings)/(Number of leaves examined X maximum grade of scale) x 100

Results and Discussion

The size of pustule was noted during 2015-16 and 2016-17 in cultivar PM-28 at 70, 80 and 90 days after sowing of the crop [Table-2]. The maximum average size of pustules was recorded in check (3.97 mm) followed by zinc sulphate (3.31 mm), *Trichoderma viride* (3.19 mm). The maximum reduction of the size of the pustules were found in Metalaxyl 0.3% followed by Metalaxyl 0.2% was 57.36 mm and 56.18 mm, respectively. However different concentrations of Metalaxyl were non-significant with each other at 70, 80 and 90 days after sowing in 2015-16. Among the abiotic agents, maximum reduction in the size of the pustules were recorded in salicylic acid (46.48) followed by calcium sulphate (40.82 %) and Potassium chloride (39.59 %). Among the bio agents, *Trichoderma viride* and *Pseudomonas fluorescens* reduce the size of the pustules significantly over the check.

The number of pustules were observed minimum in Metalaxyl 0.2% and Metalaxyl 0.3% was 2.07 and 2.07, respectively [Table-3]. However, the different concentrations of Metalaxyl were found at par with each other at 70, 80 and 90 days after sowing in 2015-16 and at 90 days after sowing in 2016-17. The reduction of the disease over the check in Metalaxyl 0.1%, 0.2% and 0.3% were found lowest with 43.45%, 45.60% and 46.32%, respectively. Overall number of pustules were recorded maximum in check (6.19), followed by zinc sulphate (5.79) and *Trichoderma viride* (5.61). Among the bio agents, *Pseudomonas fluorescens* reduced disease by 24.42% over the check. Among the abiotic agents, salicylic acid recoded superior in all treatments over the control which reduced disease 36.27% over the check followed by calcium sulphate (30.88%) and minimum reduction was observed in zinc sulphate (6.46%) followed by borax (15.08%).

The per cent disease index in *cv.* PM-28 was recorded at 70, 80 and 90 days after sowing of the mustard. All the treatments were found significantly better over the check [Table-4]. Among all the treatments Metalaxyl 0.3% found superior which reduce 38.22 per cent disease in comparison with the control. However, different concentrations of Metalaxyl were found at par with each other at 70, 80 and 90 days after sowing during 2015-16 and 2016-17. In bio agents, both *Trichoderma viride* and *Pseudomonas fluorescens* were found non-significant at 70, 80 and 90 days after sowing during 2015-16 and 2016-17 in comparison with the control. Among abiotic agents, salicylic acid at 0.25% reduce disease significantly in 2015-16 and 2016-17. salicylic acid 0.25% reduce 28.66 % white rust disease over the control followed by calcium sulphate at1.00 % which reduce disease 21.20 %, zinc sulphate at 0.50 % was found least effective abiotic chemical which reduce 5.73 % disease.

Singh and Ratnoo (2022) [11] reported similar finding in their finding on efficacy of plant defense activators was against *Albugo candida* causing white rust on mustard *cv.* DRMRIJ-31 under artificial epiphytotic conditions during two consecutive cropping seasons. 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 against white rust was observed in Metalaxyl at 0.2% was 1.73 pustules/25 mm^2 area during rabi season. 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 %). 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.

Tewari (1991) [12] found that foliar application of the calcium reduces the per cent disease severity of Alternaria blight in rapeseed. Antonova, *et al.,* (1984) [13], Dixon, *et al.,* (1987) [14] reported that boron application in the cabbage increase resistance to club root. Singh, *et al.,* (2020) [15] 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 was 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) [16] 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 reduces 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%.

Application of research: Study the possibility of utilizing induced host resistance as an authentic substitute to classical fungicides

Research Category: Plant Defense Activators

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Study area / Sample Collection: Rajasthan

Cultivar / Variety / Breed name: Mustard *cv.* PM-28

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