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Induction of host resistance with plant defense activators against white rust [*Albugo candida*] of Indian mustard

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Abstract

In plants systemic resistant can be induced through biotic or abiotic plant defense inducers. Efficacy of biotic and abiotic plant activators was tested against *Albugo candida* causing white rust on Indian mustard cultvar RH 406 under artificial epiphytotic conditions during two consecutive cropping seasons. 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 *T.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%.

Keywords: *Albugo candida*, *Indian mustard, resistance, white rust*

Introduction

Plants exhibit numerous responses when challenged by pathogens. Some of these involve the activation of host defense genes that bring about physical and biochemical changes in the host (Jones and Dangle, 2006). It is well established that resistance can be induced in plants by biotic as well as by abiotic agents (Kessman *et al*., 1994; Kombrink and Sommsich, 1995; Sticher *et al.*, 1997). In recent years, a new group of compounds that activate host defense mechanism and protect the plant against pathogens has been developed to manage crop diseases. These chemicals are identified as “plant defense activators” or “plant activators” (Romero *et al*., 2001). Host plant defense can be induced by the application of non-pathogenic microorganisms (Vishwanath *et al*., 1999; Singh *et al*., 1999) and certain abiotic activators such as salicylic acid (Spletzer and Enyedi, 1999). Most commonly used chemicals inducers is salicylic acid, which appears to mimic the systemic effects of localized infection in plant system (Safari *et al.,* 2013). External application of salicylic acid can induce systemic acquired resistance (Hammerschmidt, 1999). One of the potential management methods is the use of systemic acquired resistance to trigger host defense mechanisms, which would not involve the application of hazardous compounds to plants (Durrant and Dong, 2004).

Induced resistance has been exploited widely for the management of plant diseases (Gorlach *et al.,* 1996). Salicylic acid reported effective inducers of plant defense in the host plant system (Yalpani and Raskin, 1993). In addition, numerous microorganisms applied to the leaves or roots of plants may induce systemic or local resistance (Liu *et al.,* 1995). Such resistance is reported to be active against many types of organisms (Matheron and Porchas, 2002).

Biological plant defense inducers provide systemic resistance to plants infested by various fungal and bacterial phytopathogens. Biological plant defense inducers such as *Trichoderma viride, Pseudomonas, Bacillus, Serratia*, nonpathogenic strains of *Fusarium* and yeast have been developed as commercial product to combat various plant diseases (Droly *et al.,* 2002; Benhamon and Garand, 2001; Verhagen*et al*., 2004; Howell *et al*., 2000). Biocontrol activity of *Trichoderma* based biocontrol agents inheres in their ability to orchestrate several biochemical pathways in diseased plants (Surekha *et al.,* 2014).

There are various options available for the farmers to protect their crop from the disease. Some options include development of resistant cultivars, biological control, crop rotation, tillage, and chemical pesticides. Disease control is largely based on the use of fungicides, bactericides, and insecticides. These chemical compounds toxic to plant invaders, causative agents, or vectors of plant diseases. However, the hazardous effect of these chemicals or their degradation products on the environment and human health strongly necessitates the search for new, harmless means of disease control. There must be some natural phenomenon of induced resistance to protect plants from disease. Elicitors are compounds, which activate chemical defense in plants. Various biosynthetic pathways are activated in treated plants depending on the compound used. Commonly tested chemical elicitors are salicylic acid, methyl salicylate, benzothiadiazole, benzoic acid, chitosan, and so forth which affect production of phenolic compounds and activation of various defense-related enzymes in plants (Thakur and Sohal, 2013). The present study was undertaken to explore the possibility of utilizing induced host resistance as a realistic alternative to classical fungicides in white rust management.

Materials and Methods

First spray plant defense activators in the mustard variety RH-406 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 @ 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	*Pseudomonasfluorescens*	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	-

Observations recorded

Size of pustule on leaves

Diameter of randomly selected five leaves was measured in millimeter 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 were counted as pustules per 25 mm^2 leaf areaof 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

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

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.

$$\text{White rust index (\%)} = \frac{\text{Sum of all numerical ratings}}{\text{No. of leaves examined x max. grade of scale}} \text{ x100}$$

Table 2: Effect of bio-stimulators and non-conventional chemicals on size of pustule on mustard cv. RH-406 under field conditions

Treatment	Concentration (%)	Size of pustules (mm)									
		2015-16				2016-17				Over all	Reduction over
		70 DAS	80 DAS	90 DAS	Mean	70 DAS	80 DAS	90 DAS	Mean	Mean	check (%)
Trichoderma viride	1.00	0.89	3.01	5.49	3.13	0.91	3.03	5.50	3.15	3.14	19.96
Pseudomonas fluorescens	1.00	0.56	2.21	4.65	2.47	0.59	2.23	4.67	2.50	2.49	36.59
Salicylic Acid	0.25	0.41	1.81	3.97	2.06	0.44	1.83	3.99	2.09	2.08	47.01
Borax	0.50	0.78	2.57	5.13	2.83	0.81	2.60	5.15	2.86	2.84	27.47
K_2SO_4	1.00	0.63	2.47	4.95	2.68	0.65	2.49	4.97	2.71	2.69	31.24
$CaSO_4$	1.00	0.47	2.06	4.33	2.29	0.50	2.09	4.35	2.31	2.30	41.28
Metalaxyl 0.1%	0.10	0.33	1.60	3.33	1.76	0.36	1.63	3.35	1.78	1.77	54.89
Metalaxyl 0.2%	0.20	0.31	1.53	3.21	1.68	0.34	1.55	3.23	1.71	1.69	56.76
Metalaxyl 0.3%	0.30	0.31	1.46	3.12	1.63	0.33	1.49	3.13	1.65	1.64	58.15
KCl	1.00	0.50	2.10	4.41	2.34	0.52	2.13	4.43	2.36	2.35	40.06
$ZnSO_4$	0.50	0.94	3.09	5.74	3.26	0.96	3.11	5.76	3.28	3.27	16.64
Check	-	1.35	3.99	6.39	3.91	1.36	4.01	6.41	3.93	3.92	0.00
SEm±	-	0.01	0.06	0.11	-	0.02	0.03	0.04	-	-	-
CD 5%	-	0.04	0.16	0.31	-	0.06	0.08	0.11	-	-	-

DAS = Days after sowing

Table 3: Effect of bio-stimulators and non-conventional chemicals on number of white rust pustule on mustard cv. RH-406 under field conditions

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	3.47	5.07	6.93	5.16	3.53	5.20	6.73	5.16	5.16	10.77
Pseudomonas fluorescens	1.00	2.73	4.13	5.87	4.24	2.80	4.20	5.93	4.31	4.28	25.96
Salicylic Acid	0.25	2.33	3.33	4.87	3.51	2.40	3.40	4.93	3.58	3.54	38.65
Borax	0.50	3.13	4.80	6.53	4.82	3.20	4.87	6.60	4.89	4.86	15.96
K_2SO_4	1.00	3.07	4.60	6.13	4.60	3.13	4.67	6.20	4.67	4.63	19.81
$CaSO_4$	1.00	2.60	3.73	5.27	3.87	2.67	3.80	5.33	3.93	3.90	32.50
Metalaxyl 0.1%	0.10	1.87	3.07	4.27	3.07	2.00	3.13	4.33	3.16	3.11	46.15
Metalaxyl 0.2%	0.20	1.73	2.93	4.20	2.96	1.80	3.00	4.27	3.02	2.99	48.27
Metalaxyl 0.3%	0.30	1.73	2.80	4.20	2.91	1.80	2.87	4.27	2.98	2.94	49.04
KCl	1.00	2.87	3.93	5.40	4.07	2.93	4.00	5.47	4.13	4.10	29.04
$ZnSO_4$	0.50	3.80	5.20	7.07	5.36	3.87	5.27	7.13	5.42	5.39	6.73
Check	-	4.07	5.80	7.40	5.76	4.13	5.87	7.40	5.80	5.78	0.00
SEm±	-	0.08	0.11	0.12	-	0.05	0.05	0.10	-	-	-
CD 5%	-	0.24	0.33	0.36	-	0.14	0.14	0.30	-	-	-

DAS = Days after sowing

Table 4: Effect of bio-stimulators and non-conventional chemicals on disease index of white rust on mustard cv. RH-406 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	24.8(29.9)	42.1(40.5)	75.7(60.5)	47.6(43.6)	26.9(31.3)	43.5(41.3)	77.1(61.4)	49.2(44.5)	48.4	0.7
Pseudomonas fluorescens	1.00	24.5(29.7)	41.9(40.3)	75.5(60.3)	47.3(43.5)	26.7(31.1)	43.2(41.1)	76.8(61.2)	48.9(44.4)	48.2	1.3
Salicylic Acid	0.25	14.4(22.3)	27.2(31.4)	62.7(52.3)	34.8(36.1)	14.1(22.1)	26.7(31.1)	59.2(50.3)	33.3(35.3)	34.0	30.1
Borax	0.50	17.6(24.8)	34.7(36.1)	68.0(55.6)	40.1(39.3)	20.0(26.6)	33.6(35.4)	66.7(54.7)	40.1(39.3)	40.1	17.7
K_2SO_4	1.00	18.4(25.4)	36.5(37.2)	69.6(56.5)	41.5(40.1)	21.6(27.7)	34.9(36.2)	70.1(56.9)	42.2(40.5)	41.9	14.1
$CaSO_4$	1.00	16.5(24.0)	32.3(34.6)	66.7(54.7)	38.5(38.3)	18.7(25.6)	29.6(33.0)	62.7(52.3)	37.0(37.5)	37.7	22.5
Metalaxyl 0.1%	0.10	9.6(18.1)	24.5(29.7)	56.0(48.5)	30.0(33.2)	9.6(18.1)	24.8(29.9)	51.5(45.8)	28.6(32.3)	29.3	39.8
Metalaxyl 0.2%	0.20	9.3(17.8)	24.3(29.5)	55.7(48.3)	29.8(33.1)	9.3(17.8)	24.5(29.69)	51.2(45.7)	28.4(32.2)	29.1	40.3
Metalaxyl 0.3%	0.30	9.1(17.5)	24.0(29.3)	55.5(48.1)	29.5(32.9)	9.1(17.5)	24.3(29.51)	50.9(45.5)	28.1(32.0)	28.8	40.9
KCl	1.00	20.5(27.0)	38.1(38.1)	72.0(58.1)	43.6(41.3)	22.4(28.3)	37.1(37.50)	72.5(58.4)	44.0(41.6)	43.8	10.1
$ZnSO_4$	0.50	22.1(28.1)	40.5(39.5)	72.8(58.6)	45.2(42.2)	23.7(29.2)	40.0(39.23)	75.7(60.5)	46.5(43.0)	45.8	5.9
Check	-	25.6(30.4)	42.4(40.6)	76.0(60.7)	48.0(43.9)	27.2(31.4)	43.7(41.40)	77.3(61.6)	49.4(44.7)	48.7	0.0
SEm±	-	0.42	0.66	0.79	-	0.91	1.30	1.00	-	-	-
CD 5%	-	1.21	1.90	2.26	-	2.61	3.74	2.88	-	-	-

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

Results and Discussion

The size of the pustules were enlarged from 70 days after sowing to 90 days after sowing in cv. RH-406 during 2015-16 and 2016-17 (Table 2). The maximum average size of pustules were recorded in check (3.92 mm) followed by zinc sulphate (3.27 mm), *Trichoderma viride* (3.14 mm). The maximum reduction of the size of the pustules were found in Metalaxyl 0.3% followed by Metalaxyl 0.2% was 58.15 mm and 56.76 mm, respectively. However different concentration of Metalaxyl was non-significant with each other at 70, 80 and 90 days after sowing during *Rabi* season 2015-16. 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 %). Among the bio agents which reduce the size of the pustules significantly over the check.

Minimum number of pustule were observed in Metalaxyl 0.2% and Metalaxyl 0.3% was 1.73 and 1.73, 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% was found lowest were 46.15%, 48.27% and 49.04%, respectively. Overall number of pustules were recorded maximum in check (5.78), followed by zinc sulphate (5.39) and *T.viride* (5.16). Among the bio-agents, *P. fluorescens* reduced disease by 25.96% over the check. Among the abiotic agents, salicylic acid recoded superior in all treatments over the control which reduced disease 38.65% over the check followed by calcium sulphate (32.50%) and minimum reduction was observed in zinc sulphate (6.73%) followed by borax (15.96%).

The average percent disease index was observed minimum in Metalaxyl 0.3% was 28.80% having disease reduction 40.88% (Table 4). However, the different concentrations of Metalaxyl were found at par with each other. Maximum average disease index was recorded in check (48.71) followed by *T.viride* (48.36) and *P. fluorescens* (48.09). Among the abiotic agents, salicylic acid reduce the disease by 30.11% over the check followed by calcium sulphate (22.54%) and minimum disease reduction was recorded in zinc sulphate was 5.93%.

Tirmali and Kolte (2012) reported the efficacy of several plant defense activators in the management of *A. candida* pathogen including calcium sulphate, potassium chloride, potassium sulphate, zinc sulphate and borax significantly reduced the pustules size in 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.

Conclusion

Among abiotic agents, salicylic acid, calcium sulphate and potassium chloride were found effective in reduction of white rust disease in Indian mustard. While, *P. fluorescens* was found best among the bio agents inreducing the disease over the check. However, the number of pustule was observed minimum in Metalaxyl 0.2% and Metalaxyl 0.3% in comparison to abiotic agents and bio-agents.

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