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Effect of plant defense activators on white rust of mustard cv. RH- 749 under artificial epiphytotic conditions

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Abstract

Experiment was conducted to study the effect of plant defense activators on white rust of Indian mustard cultivar RH-749 under artificial epiphytotic conditions. The size of pustule of white rust was recorded minimum in Metalaxyl 0.3% (0.32 mm) followed by Metalaxyl 0.2% (0.33 mm) during 2015-16, although, the 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 among all the treatments. The number of pustules were recorded maximum in check was 7.47 and 7.53 followed by zinc sulphate at 0.50 % was 7.1 and 7.3 during 2015-16 and 2016-17, respectively. Salicylic acid 0.25% reduces 31.5% white rust disease over the control followed by calcium sulphate at 1.0% which reduces disease 24.0%. Zinc sulphate at 0.50% was found least effective abiotic chemical which reduce 6.1% disease.

Keywords : *Epiphytotic, Indian mustard, plant defense activators, white rust*

Introduction

Plants undergo several stresses throughout their life span and respond them through numerous chemical and physical stimuli (Omidi, 2010). Plants are prepared through pre-formed or constitutive mechanical and chemical barriers as well as with inducible defense systems to protect themselves from the attack of different pathogens such as bacteria, virus, fungi, nematodes and parasitic plants in their environment. Induction of defensive system in plants can be achieved or enhanced by pretreatment of plants with avirulent pathogen (biotic inducers) or chemical compounds (abiotic inducers). These biotic and abiotic inducers are known as elicitors. Elicitors are low molecular weight compounds which induces a systemic defense response in plants. These elicitors are synthesized by itself or released from polymeric precursors through infection by pathogen (Ozeretskovskaya and Vasyukova, 2002; Zhao *et al.,* 2005, Holopainen *et al.,* 2009).

Induced resistance has been exploited extensively for the management of many plant diseases (Gorlach *et al.,* 1996). Several compounds such as salicylic acid (Yalpani and Raskin, 1993), benzothiadiazoles (Narusaka *et al.,* 1999), fatty acids and oligosaccharides (Kobayashi, *et al.,* 1993), harpin protein (Wei *et al.,* 1992, De *et al.,* 1990) are effective inducers of plant defense in the host plant system. 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 several types of organisms such as fungi, bacteria and even parasitic plants (Matheron and Porchas, 2002).

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 known as "plant defense activators" or "plant activators" (Romero *et al*., 2001). Salicylic acid mimics compounds such as acibenzolar s methyl, bion, phosphorous salts and micronutrient potassium salts have been used as commercial plant activators (Becot *et al*., 2000; Macmillan *et al*., 2000; Pajot *et al*., 2001; Graham and Leite, 2004).

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). *Trichoderma viride* is known as one of the most important bio-control agent that has been used extensively in agriculture. Biological plant defense inducers provide systemic resistance to plants infested by various fungal and bacterial phytopathogens. Biocontrol activity of *Trichoderma* based biocontrol agents inheres in their ability to orchestrate several biochemical pathways in diseased plants (Surekha *et al.,* 2014). Although studies explaining

biocontrol activity of *Trichoderma* against fungal pathogens are recognized, there is need for imparting the biochemical basis of disease resistance being induced by *Trichoderma.* Therefore, research investigations pertaining to induction of such systemic resistance and associated biochemical responses is necessary to understand the mechanism of biological control activity of *T. viride* and *Pseudomonas fluorescens*.

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) and amino butyric acid (Cohen, 1994; Kaur and Kolte, 2001). Host resistance is considered to be the most effective and economical method in plant disease management. Evaluation of new germplasm helps to identify some good sources of resistance that may be exploited for commercial production or for breeding of new disease resistant lines. The resistant sources help to slow down the rate of epidemic buildup. Therefore, the development of disease resistant varieties is the most effective and economical approach of integrated disease management programme.

In plants systemic resistant can be induced through biotic or abiotic plant defense inducers. Resistance to diseases can be induced sys-tematically in plants by biological and chemical means (Ryals *et al*., 1994; Spletzer and Enyedi, 1999). Most commonly used chemicals inducers are salicylic acid, which appears to mimic the systemic effects of localized infection in plant system (Safari *et al.,* 2013). 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). External application of salicylic acid can induce systemic acquired resistance (Hammerschmidt, 1999).

The potential of chemical inducers of systemic acquired resistance to reduce white rust disease on mustard was evaluated to explore the possibility of utilizing induced host resistance as a realistic alternative to classical fungicides in disease management.

Materials and Methods

First spray plant defense activators in the mustard variety RH-749 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 were 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 ($ZnSO4.7H_2O$)	0.50
T_{12}	Check	-

Observations recorded

Size of pustule on leaves

Diameter of randomly selected five leaves was 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 were 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).

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 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.

$$\text{White Rust Index (\%)} = \frac{\text{Sum of all numerical ratings}}{\text{Number of leaves examined x maximu grade of scale}} \times 100$$

Results and Discussion

The size of pustule 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 (Table 2). However the different concentration of Metalaxyl was found at par with each other during 2015-16 at 70, 80 and 90 days after sowing of the crop. All the treatments were found significantly better in the comparison with the control. The 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. Both the biotic agents were found significantly better in comparison with the control. The size of the pustules was enlarged from 70 to 90 days after sowing the mustard.

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 (Table 3). The minimum number of pustules was found in Metalaxyl 0.2 % and Metalaxyl 0.3 % was 1.80. However, different concentrations of Metalaxyl were found at par in comparison with each other during 2015-16 and 2016-17 at 70, 80 and 90 days after sowing. Among the biotic agents, *T. viride* and *P. fluorescens* were found significantly better over the check except *T. viride* at 1:00 % was found at par at 80 days after sowing during 2016-

Table 2: Effect of biotic and non-conventional chemicals on size of pustule on mustard cv. RH-749 under field conditions

Treatment	Concentration	Size of pustules (mm)								Over	% reduction
	(%)	2015-16				2016-17				all	over
		70 DAS	80 DAS	90 DAS	Mean	70 DAS	80 DAS	90 DAS	Mean	Mean	check
Trichodermaviride	1.0	0.9	3.0	5.5	3.2	1.0	3.1	5.6	3.2	3.2	19.9
Pseudomonas fluorescens	1.0	0.6	2.2	4.7	2.5	0.7	2.27	4.8	2.6	2.6	36.0
Salicylic Acid	0.3	0.4	1.8	4.01	2.1	0.5	1.8	4.1	2.2	2.1	46.7
Borax	0.5	0.8	2.6	5.19	2.9	0.9	2.7	5.3	3.0	2.9	26.7
K_2SO_4	1.0	0.6	2.5	4.98	2.7	0.7	2.6	5.1	2.8	2.8	30.8
$CaSO_4$	1.0	0.5	2.1	4.39	2.3	0.6	2.2	4.5	2.4	2.4	40.6
Metalaxyl 0.1%	0.1	0.4	1.6	3.40	1.8	0.4	1.7	3.5	1.9	1.8	53.9
Metalaxyl 0.2%	0.2	0.3	1.6	3.23	1.7	0.4	1.6	3.4	1.8	1.8	55.9
Metalaxyl 0.3%	0.3	0.3	1.6	3.17	1.7	0.4	1.6	3.3	1.8	1.7	56.6
KCl	1.0	0.5	2.2	4.49	2.4	0.6	2.3	4.6	2.5	2.4	38.7
$ZnSO_4$	0.5	0.9	3.1	5.82	3.3	1.2	3.2	5.9	3.4	3.4	15.9
Check	-	1.4	4.0	6.46	3.9	1.5	4.1	6.6	4.0	4.0	0.0
SEm±	-	0.02	0.07	0.14	-	0.02	0.06	0.08	-	-	-
CD 5%	-	0.05	0.21	0.41	-	0.05	0.17	0.23	-	-	-

DAS = Days after sowing

Table 3: Effect of biotic and abiotic agents on number of white rust leaf pustule on mustard cv. RH-749 under field condition

Treatment	Concentration (%)	Number of pustules/25 mm^2 area								Over all Mean	% reduction over check
		2015-16				2016-17					
		70 DAS	80 DAS	90 DAS	Mean	70 DAS	80 DAS	90 DAS	Mean		
Trichodermaviride	1.00	3.53	5.20	7.00	5.2	3.6	5.5	7.1	5.4	5.3	9.1
Pseudomonasfluorescens	1.00	2.80	4.40	5.93	4.4	2.9	4.1	6.0	4.3	4.4	25.6
Salicylic Acid	0.25	2.40	3.40	4.93	3.6	2.	3.6	5.0	3.7	3.6	37.9
Borax	0.50	3.20	4.87	6.60	4.9	3.5	4.8	6.7	5.0	4.9	15.8
K_2SO_4	1.00	3.13	4.67	6.20	4.7	3.2	4.9	6.3	4.8	4.7	19.2
$CaSO_4$	1.00	2.67	3.80	5.33	3.9	2.7	3.9	5.4	4.0	4.0	32.1
Metalaxyl 0.1%	0.10	2.00	3.13	4.33	3.2	2.1	3.1	4.4	3.2	3.2	45.7
Metalaxyl 0.2%	0.20	1.80	3.00	4.27	3.0	1.9	3.1	4.3	3.1	3.1	47.8
Metalaxyl 0.3%	0.30	1.80	2.87	4.27	3.0	1.9	2.9	4.4	3.0	3.0	48.6
KCl	1.00	2.93	4.00	5.47	4.1	3.0	4.1	5.5	4.2	4.2	28.8
$ZnSO_4$	0.50	3.87	5.27	7.1	5.4	3.7	5.3	7.3	5.4	5.4	7.4
Check	-	4.13	5.87	7.5	5.8	4.2	5.9	7.5	5.9	5.9	0.0
SEm±	-	0.07	0.15	0.18	-	0.07	0.15	0.18	-	-	-
CD 5%	-	0.21	0.44	0.50	-	0.21	0.44	0.50	-	-	-

DAS = Days after sowing

Table 4: Effect of biotic and non-conventional chemicals on disease index of white rust on mustard cv. RH-749 under field conditions

Treatment	Concentration (%)	Disease index (%)								Over all Mean	Reduction over check (%)
		2015-16				2016-17					
		70 DAS	80 DAS	90 DAS	Mean	70 DAS	80 DAS	90 DAS	Mean		
Trichoderma viride	1.00	24.3(29.5)	42.7(40.8)	76.5(61.0)	47.8(43.8)	25.1(30.0)	42.9(40.9)	77.3(61.6)	48.4(44.1)	48.1	0.8
Pseudomonasfluorescens	1.00	23.7(29.2)	42.1(40.5)	76.3(60.9)	47.4(43.5)	24.8(29.9)	42.7(40.8)	77.1(61.4)	48.2(44.0)	47.8	1.6
Salicylic Acid	0.25	13.9(21.9)	33.6(35.4)	57.3(49.2)	34.9(36.2)	11.2(19.6)	28.8(32.5)	54.7(47.7)	31.6(34.2)	33.2	31.5
Borax	0.50	16.3(23.8)	36.0(36.9)	69.1(56.2)	40.4(39.5)	16.8(24.2)	33.9(35.6)	63.7(53.0)	38.1(38.1)	39.3	19.1
K_2SO_4	1.00	18.1(25.2)	37.6(37.8)	71.2(57.5)	42.3(40.6)	18.9(25.8)	35.2(36.4)	67.7(55.4)	40.6(39.6)	41.5	14.6
$CaSO_4$	1.00	15.2(23.0)	35.2(36.4)	65.6(54.1)	38.7(38.5)	15.2(23.0)	31.2(34.0)	58.9(50.2)	35.1(36.3)	36.9	24.0
Metalaxyl 0.1%	0.10	12.8(21.0)	29.6(33.0)	52.0(46.2)	31.5(34.1)	9.6(18.1)	23.5(29.0)	46.9(43.2)	26.7(31.1)	29.1	40.1
Metalaxyl 0.2%	0.20	12.5(20.7)	29.3(32.8)	51.7(46.0)	31.2(34.0)	9.3(17.8)	23.2(28.8)	46.7(43.1)	26.4(30.9)	28.8	40.7
Metalaxyl 0.3%	0.30	12.3(20.5)	29.1(32.6)	51.5(45.8)	30.9(33.8)	9.1(17.5)	22.9(28.6)	46.4(42.9)	26.1(30.7)	28.5	41.2
KCl	1.00	20.0(26.6)	39.2(38.8)	72.0(58.1)	43.7(41.4)	20.0(26.6)	37.3(37.7)	71.5(57.7)	42.9(40.9)	43.3	10.7
$ZnSO_4$	0.50	21.3(27.5)	41.1(39.9)	73.9(59.3)	45.4(42.4)	22.4(28.3)	39.2(38.8)	75.5(60.3)	45.7(42.5)	45.6	6.1
Check	-	24.8(29.9)	43.2(41.1)	76.8(61.2)	48.3(44.0)	25.3(30.2)	43.5(41.3)	77.6(61.8)	48.8(44.3)	48.5	0.0
SEm±	-	0.48	0.86	0.65	-	0.73	0.86	1.70	-	-	-
CD 5%	-	1.39	2.47	1.87	-	2.10	2.48	4.89	-	-	-

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

17. In non-conventional chemicals, salicylic acid was found superior followed by calcium sulphate then others which reduce average number of pustules 37.95 % and 32.07 % in comparison with the control, respectively and minimum reduction in number of pustules were recorded in zinc sulphate at 0.50 % (7.4 %) followed by Borax 0.50 % (15.8%).

The per cent disease index in cv. RH-749 was recorded at 70, 80 and 90 days after sowing of the mustard. All the treatments were found significantly better over the check (Table 3). Among all the treatments Metalaxyl 0.3% found superior which reduce 41.21 per cent disease in comparison with the control. However, the 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 *T. viride* and *P. 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% reduces disease significantly in 2015-16 and 2016-17. Salicylic acid 0.25% reduces 31.5% white rust disease over the control followed by calcium sulphate at 1.0% which reduces disease 24.0%. Zinc sulphate at 0.50% was found least effective abiotic chemical which reduce 6.1% disease.

Several plant defense activators in the management of *A. candida* has been used in mustard (Tirmali and Kolte, 2012). 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.

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