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Original Research Article

Integrated Management of White Rust of Mustard

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A B S T R A C T

Mustard (*Brassica juncea*) is one of the major *Rabi* oilseed crops of India which occupies place, being next in importance to groundnut, both in area and production, containing 30 to 48 per cent oil. Among various diseases, white rust incited by *Albugo candida (*Pers. Ex. Lev.) Kuntz is an economically important and widely distributed disease throughout the world in mustard and other cruciferous crop *Albugo candida* (*A. cruciferum)*, the cause of white rust of mustard, occurs in all parts of the world where cruciferous crops are grown. The yield losses were reported to the tune of 17-34 per cent (Yadav and Gupta, 2011). Different combination of seed treatment and spraying of fungicides, bioagents and botanicals were evaluated under field condition and found effective against white rust of mustard. Among fungicides, seed treatment with Apron 35 SD + spraying with Metalaxyl MZ recorded the least mean disease incidence (17.25%) and severity (9.26%) and there by highest per cent disease control i.e. 49.95%. In bioagents, seed treatment with *Trichoderma viride* + spraying of *T. viride* and seed treatment with *Pseudomonas fluorescens* + spraying of *P. fluorescens* both the treatments recorded the disease incidence 21.71% and 22.04% and severity 10.66% and 13.91%, respectively with 43.47% and 29.53% disease control.

Keywords

White rust, Mustard, Fungicide, Disease incidence, Disease Severity

Introduction

Mustard (*Brassica juncea*) is one of the major *Rabi* oilseed crops of India which occupies place, being next in importance to groundnut, both in area and production, containing 30 to 48 per cent oil. It fulfills the oil requirement of about 50 per cent population in the states of Uttar Pradesh, Punjab, Rajasthan, Madhya Pradesh, Bihar, Orissa, West Bengal and Assam. In India area, production and productivity of mustard during 2014 were 6.21 m/ha, 7.32 m/tones and 1180 kg/ha, respectively (Anonymous, 2014). Among various diseases, white rust incited by *Albugo candida (*Pers. Ex. Lev.) Kuntz is an economically important and widely distributed disease throughout the world in mustard and other cruciferous crop *Albugo candida* (*A. cruciferum)*, the cause of white rust of mustard, occurs in all parts of the world where cruciferous crops are grown. The yield losses were reported to the tune of 17-34 per cent (Yadav and Gupta, 2011). A very little information on management of white rust of mustard disease is available in India including Maharashtra. Therefore, present investigation was undertaken.

Materials and Methods

During the present investigation on white rust (*A. candida*) of mustard (*Brassica*

juncea), the field experiments were conducted at Department of Plant Pathology, College of Agriculture, Latur during *Rabi*-2014,

The field experiment was laid out by applying randomized block design with 9 treatments and three replications. The mustard variety, Pusa bold, susceptible to white rust (*Albugo candida)* was sown at 45cm x15cm spacing. Recommended dose of fertilizers was applied and irrigated lightly for better seed germination. Intercultural operations were performed as and when required.

Sprayings of fungicides, bioagents and botanicals were given at ten days interval. First spraying was done after disease initiation and subsequent second and third sprayings were given after each 10 days interval.

The observations for disease incidence were taken after disease appearance and subsequent three observations were taken 2 days after each spraying and per cent disease incidence was calculated.

Observations on white rust disease severity were recorded on five randomly selected plants on each bottom, middle and top leaves. The first observation was taken after disease appearance and subsequent three observations were taken 2 days after each spraying. The white rust disease was graded on the basis of disease severity observed on leaves by applying 0-9disease rating scale given by Mayee and Datar (1986) (PLATE II).

Grade/ scale description

0 = No symptoms on leaf
1 = Small, raised blisters covering 1% of the leaf area
3 = Small, raised blisters covering 1-10% of the leaf area
5 = Blister, raised covering 14-25% of the leaf area
7 = Raised, shiny, white blisters covering 26-50% of the leaf area
9 =Raised, shiny blisters, coalescing to form large patches, over 51% or more of the leaf area

Observations for staghead incidence were recorded from appearance of the staghead and subsequent three observations were taken 2 days after each spraying .Observations on stagheads severity were recorded after appearance of the staghead and subsequent three observations were taken at 2 days after each spraying. The stagheads were graded on the basis of severity of staghead by applying 0-9 rating scale given by Mayee and Datar (1986) (PLATE III).

Grade/ scale description

0 = No symptoms on plants
1 = 1% or less plants having stagheads
2 = 1-10% plants having stagheads
5 = 11-20% plans having stagheads
7 = 21-50% plants having stagheads
9 = 51% or more plants having stagheads.

Based on numerical ratings observed, per cent disease severity was calculated by applying the formula as given below.

$$\text{PDS (\%)} = \frac{\text{Summation of numerical ratings}}{\text{No. of leaves/ plants observed x maximum rating}} \times 100$$

Further, per cent disease control (PDC) was worked out by applying the formula:

PDC (%) =

$$\frac{\text{PDI in control plot - PDI in treatment plot}}{\text{PDI in control plot}} \times 100$$

Disease incidence was worked out by following formula,

Disease incidence (%) =

$$\frac{\text{No. of infected plants observed}}{\text{Total no. of plants observed}} \times 100$$

Matured and dried siliquae of mustard were harvested treatment wise and grain yield was recorded and finally the grain yield data was presented on hectare basis.

Results and Discussion

Results obtained on effect of fungicides, bioagents and botanicals on white rust disease incidence, severity, percent disease control, seed yield and cost: Benefit ratio are presented in the following paragraphs.

Effect of fungicides, bioagents and botanicals on white rust of mustard incidence

Results obtained were presented in Table 1. results revealed that, all the fungicides, bioagents and botanicals were found effective and significantly reduced the white rust incidence over control.

The white rust incidence observed before spraying of crop ranged from 13.3% to 19.96% and average incidence was 15.98%.Minimum disease incidence was recorded from the seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (13.30%) which was at par with seed treatment + spraying with *Alliumsativum* (13.32%), spraying with neem seed kernel extract (*Azadirachtaindica)* (14.11%)and seed treatment + spraying with *Trichoderma viride* (14.93%), respectively. Whereas, maximum disease incidence was observed in seed treatment+spraying of *P. fluorescens* (18.63%) followed by spraying of Mancozeb (17.43%).

White rust incidence was recorded after first spraying ranged from 21.63% to 34.44% and average incidence was 27.51%. Minimum disease incidence was recorded from the seed treatment with Apron 35 SD + spraying with MetalaxylMZ (21.63%) which was at par with seed treatment with Apron 35 SD + spraying with Mancozeb (22.7%) and spraying with Mancozeb (24.4%), respectively. Maximum disease incidence was observed in seed treatments with *P. fluorescens* + spraying with *P. fluorescens* (33.33%).

The disease incidence was found to be decreased after second and third spraying and was ranged from 18.75% to 37.18 and 14.17% to 39.86%, respectively. After second spraying, minimum disease incidence was recorded in the plot seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (18.57%) which was at par with seed treatment with Apron 35 SD + spraying with Mancozeb (18.99%) and spraying with Mancozeb (19.92%) followed by seed treatment with *T. viride* + spraying with *T.viride* (22.96%), respectively. And after third spraying seed treatment with Apron 35 SD + spraying with Mancozeb (14.17%) ,which was at par with seed treatment with Apron 35 SD + spraying withMetalaxyl MZ (15.32%) and spraying with Mancozeb (15.55%),respectively.Maximum disease incidence was observed after second and third spraying in seed treatment with *P. fluorescens* and spraying of*P.*

*Fluorescens*aftersecond (30.22%) and third spraying (24.55%), respectively than other treatments.

Thus, from the mean per cent disease incidence, data indicated that, all the treatments were significantly and gradually reduced the white rust incidence after second and third spraying, over control. The mean disease incidence was ranged from 17.25% to 27.01%. The mean disease incidence indicated that, seed treatment with Apron 35 SD + spraying with Metalaxyl MZwasfound to be the most effective with lowest mean disease incidence of 17.25%.

Results revealed that, in all the treatments, minimum disease incidence was observed in fungicides spraying and seed treatment with Apron 35 SD + spraying with MetalaxylMZ (17.25%). Next best treatment observed was treatment with *T. viride*+spraying with*T. viride*(21.71%) and spraying neem seed kernel extract (22.27%), over the control (32.86%). Maximum mean disease incidence was observed in seed treatment + spraying with *P. fluorescens*(27.01%).

Similar results regarding effectiveness of fungicides was earlier reported by Bhatt *etal*. (2009) and Meena *et al*.(2011).

Effect of fungicides, botanicals and bioagents on white rust disease severity

To study the effect of fungicides, bioagents and botanicals on white, an experiment was carried out and results obtained were presented in Table 2. Results revealed that, all the fungicides, bioagents and botanicals were found effective and significantly reduced the white rust severity over control.

Results showed that, the white rust severity observed before spraying was ranged from 6.81% to 10.71% (Average 8.05 %) and control plot recorded 10.71% severity. The disease severity was more after first spraying than before spraying. Disease severity recorded after first spraying was ranged from 12.25% to 19.96% and average severity was (14.54%), irrespective of treatments and control plot recorded 19.96% disease severity. After second and third spray, the per cent disease severity was decreased significantly as compared to first spraying.

After second spraying, the disease severity was ranged from 10.54% to 13.59% with an average severity of (13.5%). The lowest disease severity was recorded from the plot of seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (10.54%), which was at par with seed treatment with Apron 35 SD + spraying with Mancozeb (11.03%) followed by seed treatment with *T. viride*+ spraying with *T.viride*(12.16%), spraying with Mancozeb (12.84%) and seed treatment with *Allium sativum* + spraying with *Allium sativum* (13.18%), respectively. The maximum disease severity was recorded in seed treatment with*Pseudomonas fluorescens*+ spraying of *P. fluorescens* (13.59%).

White rust severity after third spray ranged from 7.46% to 29.35% with an average severity of (11.56%).The lowest disease severity was recorded from the plot of seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (7.46%), which was at par with seed treatment with Apron 35 SD + spraying with Mancozeb (8.14 %), seed treatment with *Trichodermaviride* + spraying with *T. viride*(8.53%), spraying with Mancozeb (9.02%) and spraying with Metalaxyl MZ (9.09%) followed by seed treatment with *Allium sativum* + spraying of *Allium sativum*(9.89%), respectively. The maximum disease severity was recorded in seed treatment with

Pseudomonasfluorescens + spraying with *P.fluorescens*(12.59%).

Results from Table 2 also indicated that,mean white rust disease severity in all the treatments ranged from 9.26% to 20.34%. The least mean white rust disease severity was reported in seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (9.26%) followed by seed treatment with Apron 35 SD + spraying with Mancozeb (9.90 %). The maximum mean disease severity was recorded in seed treatment with *Pseudomonasfluorescens*+ spraying with *P.fluorescens* (11.75%). This was followed by seed treatment with *Alliumsativum* + spraying with *A. sativum*(11.75%) and spraying with neem seed kernel extract (11.53%).

Results revealed that, in all the treatments, maximum disease control was observed in seed treatment with Apron 35 SD + spraying with MetalaxylMZ (54.47%). Seed treatment and spraying of fungicides treatments was more effective in reducing disease severity followed by bioagents i.e. seed treatment with *Trichodermaviride*+ spraying with *T.viride* (47.69%) and in botanicalsneem seed kernel extract, it was 43.31%.

Similar result regarding effectiveness of fungicides in reduction of disease severity was reported by of Yadav(2003); Patni *et al*.(2012) and Bhatt *et al*.(2009).

Both the bioagents and botanicals were found less effective against the white rust disease as compared to that of fungicides. Effectiveness of *T. viride*amd*Allium sativum* in reduction of white rust of mustard was reported by Bhatt *et al*.(2009); Yadav (2009); Meena *et al.*, (2011) and Patni*et al.*, (2012).

Effect of fungicides, bioagents and botanicals on staghead incidence in mustard

The result on effect of fungicides, bioagents and botanicals on staghead incidence obtained were presented in Table.3. Results revealed that, all the fungicides, bioagents and botanicals were found effective and reduced the staghead incidence.

The effect of fungicides, botanicals and bioagents spraying was evaluated by recording the staghead incidence before spraying and after three spraying. The staghead incidence was not observed in plot spraying with Metalaxyl MZ from sowing to third spraying. In some treatments,staghead incidence was reported but very less. The mean stagheadincidencewas ranged from 0.00% to 0.82%. The minimum staghead incidence was observed in theseed treatment with Apron 35 SD+ spraying with Mancozeb (0.19%) and seed treatment with Apron 35 SD + spraying withMetalaxyl MZ (0.27%).Maximum incidence i.e1.0% was reported in spraying with Mancozeb.

Similar results regarding effectiveness of fungicides in staghead reduction was reported by Kumar (2009) and Patni et al. (2012).

Effect of fungicides, bioagents and botanicals on staghead severity inmustard

The result obtained on effect of fungicides, bioagents and botanicals on staghead severity were presented in Table 4.

The effect of fungicides, botanicals and bioagents spraying was evaluated by recording the staghead severity before spraying and after three respective sprayings. Results indicated that, there was no significant difference in disease severity

among all the treatment. The stagheadseverity was very less or negligible among all the treatments including control. The stagheadwas not observed in the treatment of spraying of MetalaxylMZ.The mean staghead severity was ranged from 0.00 % to 4.56%. The highest disease severity (4.56%) was recorded in seed treatment with *Pseudomonas fluorescens* + spraying *P.fluorescens* followed by seed treatment with *Trichodermaviride* +spraying of*T. viride* which recorded recorded 3.65% disease severity. Very lessstaghead severity was recorded in remaining treatments. The mean staghead severity was recorded in the seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (1.31%) and seed treatment with Apron 35 SD + spraying with Mancozeb (1.19%) and spraying with Mancozeb (1.62%), respectively. In botanicals, seed treatment with *Allium sativum* + spraying with *Allium sativum*(1.87).

Table.1 Effect of fungicides, bioagents and botanicals on white rust disease incidence in mustard

Sr. No.	Treatments	Disease incidence (%)				
		Before spraying	**After first spraying**	**After second spraying**	**After third Spraying**	**Mean**
T_1	Seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (0.2%)	13.3 (7.64)	21.63 (12.51)	18.57 (8.94)	15.32 (8.81)	17.25 (9.4)
T_2	Spraying with Metalaxyl MZ(0.2%)	16.43 (10.64)	20.06 (15.11)	22.96 (13.27)	18.75 (8.94)	21.05 (11.99)
T_3	Seed treatment with Apron 35 SD + spraying with Mancozeb (0.2%)	15.76 (9.55)	22.7 (13.15)	18.99 (10.53)	14.17 (8.14)	17.90 (10.34)
T_4	Spraying with Mancozeb (0.2%)	17.43 (13.16)	24.4 (14.12)	19.92 (11.90)	15.55 (8.68)	19.82 (12.03)
T_5	Seed treatment with *Trichodermaviride* + spraying with *T. viride* (0.4%)	14.93 (8.70)	26.63 (15.44)	22.96 (13.27)	18.63 (10.93)	21.71 (12.20)
T_6	Seed treatment with *Pseudomonasfluorescens* + spraying with *P. fluorescens(*0.4 %)	18.63 (9.18)	33.33 (19.55)	30.22 (17.59)	24.55 (14.21)	27.01 (15.71)
T_7	Spraying with Neem seed kernel extract (*Azadirachtaindica*) 10%	14.11 (8.67)	30.16 (18.76)	28.83 (16.55)	19.99 (11.53)	22.27 (13.87
T_8	Seed treatment with *Allium sativum* + spraying with *Allium sativum* 10%	13.32 (7.65)	28.26 (16.02)	26.63 (15.46)	19.96 (11.51)	23.04 (12.41)
T_9	Control	19.96 (11.51)	34.44 (20.11)	37.18 (21.81)	39.86 (23.55)	32.86 (19.24)
	SE+_	**0.54**	**1.49**	**0.56**	**0.54**	-
	CD at 5%	**1.69**	**4.46**	**1.69**	**1.62**	-

Figures in Parenthesis are arc sine transformed values
*= average of three replications

Table.2 Effect of fungicides, bioagents and botanicals on white rust disease severity in mustard

Sr. No.	Treatments	Disease severity *(%)					PDC
		Before spraying	After first spraying	After second spraying	After third Spraying	Mean	
T_1	Seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (0.2%)	6.81 (3.9)	12.25 (8.77)	10.54 (6.05)	7.46 (4.27)	9.26 (5.95)	54.47
T_2	Spraying with Metalaxyl MZ (0.2%)	7.10 (4.07)	15.18 (7.57)	13.58 (7.22)	9.09 (5.21)	11.16 (5.97)	45.13
T_3	Seed treatment with Apron 35 SD + spraying with Mancozeb (0.2%)	7.55 (4.32)	12.76 (7.50)	11.03 (6.9)	8.14 (4.66)	9.90 (5.86)	51.32
T_4	Spraying with Mancozeb (0.2%)	8.29 (4.75)	13.69 (7.63)	12.84 (7.37)	9.02 (4.60)	10.03 (5.75)	50.68
T_5	Seed treatment with *Trichodermaviride* + spraying with *T. viride* (0.4%)	7.40 (4.26)	13.28 (8.19)	12.16 (6.98)	8.53 (5.47)	10.66 (6.17)	47.59
T_6	Seed treatment with *Pseudomonas fluorescens* +spraying with *P. fluorescens*(0.4 %)	9.09 (5.21)	18.75 (8.94)	13.59 (7.72)	12.59 (7.23)	13.91 (7.86)	31.61
T_7	Spraying with Neem seed extract (*Azadirachtaindica*) 10%	7.25 (4.15)	15.55 (8.94)	13.33 (7.66)	9.99 (5.73)	11.53 (6.62)	43.31
T_8	Seed treatment with *Allium sativum* + spraying with *Allium sativum* 10%	8.29 (4.75)	14.86 (8.53)	13.18 (7.57)	9.89 (5.67)	11.75 (6.74)	42.23
T_9	Control	10.71 (7.57)	19.96 (11.51)	21.36 (12.49)	29.35 (11.15)	20.34 (9.97)	0.00
	SE+_	**0.49**	**0.49**	**0.39**	**0.66**	-	
	CD at 5%	**1.49**	**1.48**	**1.17**	**1.99**	-	

Figures in Parentheses are arc sine transformed values

*=average in three replications

Table.3 Effect of fungicides, bioagents and botanicals on staghead incidence in mustard

Sr. No.	Treatments	Staghead incidence *(%)				Mean
		Before first Spraying	After first spraying	After second spraying	After third spraying	
T_1	Seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (0.2%)	0.00 (0.00)	0.04 (0.00)	0.37 (3.14)	0.70 (4.80)	0.27 (2.56)
T_2	Spraying with MetalaxylMZ (0.2%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T_3	Seed treatment with Apron 35 SD + spraying with Mancozeb (0.2%)	0.00 (0.00)	0.05 (0.00)	0.22 (2.56)	0.52 (4.05)	0.19 (1.81)
T_4	Spraying with Mancozeb (0.2%)	0.20 (2.56)	0.48 (3.63)	1.00 (5.74)	2.62 (10.94)	1.07 (5.74)
T_5	Seed treatment with *Trichodermaviride* + spraying with *T. viride* (0.4%)	0.48 (3.63)	0.66 (4.44)	1.37 (8.72)	1.12 (5.74)	0.90 (5.44)
T_6	Seed treatment with *Pseudomonas fluorescens* + spraying with *P. fluorescens(*0.4 %)	0.48 (3.63)	0.63 (4.44)	0.28 (2.56)	1.92 (7.92)	0.82 (5.13)
T_7	Spraying with Neem seed kernel extract (*Azadirachtaindica*) 10%	0.04 (0.00)	0.14 (1.810	0.44 (3.63)	0.63 (4.44)	0.31 (3.14)
T_8	Seed treatment with *Allium sativum* + spraying with *Allium sativum* 10%	0.11 (1.81)	0.68 (4.44)	0.48 (3.63)	0.85 (5.13)	0.53 (4.05)
T_9	Control	0.11 (1.81)	0.12 (1.81)	0.20 (2.56)	1.03 (5.74)	0.36 (3.14)
SE ±		**0.11**	**0.29**	**0.33**	**0.70**	-
CD at 5%		**0.35**	**NS**	**NS**	**NS**	-

*Figures in Parenthesis are arc sine values
*=average in three replications

Table.4 Effect of fungicides, bioagents and botanicals management onstaghead severity

Sr. No.	Treatments	Staghead severity *(%)				Mean
		Before first spraying	After first spraying	After second spraying	After third spraying	
T_1	Seed treatment with Apron 35 SD + spraying with Metalaxyl MZ (0.2%)	0.00 (0.00)	0.55 (4.05)	3.63 (10.94)	1.33 (6.55)	1.31 (6.55)
T_2	Spraying with MetalaxylMZ (0.2%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T_3	Seed treatment with Apron 35 SD + spraying with Mancozeb (0.2%)	0.00 (0.00)	0.55 (4.05)	0.91 (5.44)	3.33 (10.47)	1.19 (5.74)
T_4	Spraying with Mancozeb (0.2%)	1.07 (5.74)	0.96 (5.44)	0.95 (5.44)	3.63 (10.94)	1.62 (7.27)
T_5	Seed treatment with *Trichodermaviride* + spraying with *T. viride* (0.4%)	3.83 (11.24)	6.67 (14.89)	3.33 (10.47)	0.80 (5.13)	3.65 (10.94)
T_6	Seed treatment with *Pseudomonas fluorescens*+ spraying with *P. fluorescens*(0.4 %)	3.83 (11.24)	2.22 (8.53)	6.67 (14.89)	5.55 (13.56)	4.56 (12.25)
T_7	Spraying with Neem seed kernel extract (*Azadirachtaindica*) 10%	0.53 (4.05)	0.15 (1.81)	0.18 (1.81)	0.18 (1.81)	0.26 (2.56)
T_8	Seed treatment with *Allium sativum* + spraying with *Allium sativum* 10%	0.53 (4.05)	0.85 (5.13)	1.11 (5.74)	5.00 (12.92)	1.87 (7.71)
T_9	Control	1.07 (5.74)	3.89 (11.24)	0.55 (4.05)	1.96 (7.92)	1.86 (7.71)
	SE ±	**0.92**	**1.32**	**1.27**	**2.17**	-
	CD at 5%	**2.76**	**NS**	**NS**	**NS**	-

*Figures in Parenthesis are arc sine values.
*=average in three replications

Table.5 Effect of fungicides, bioagents and botanicals on white rust of mustard affected by

disease incidence, severity and yield

Sr. No.	Treatment	Disease Incidence (per cent)	Disease severity (per cent)	Per cent disease control	Yield (Q/ha)	% increase over control
T_1	Seed treatment with Apron 35 SD + spraying with Metalaxy MZ (0.2%)	17.25 (9.4)	9.26 (5.95)	49.95	7.77	72.66
T_2	Spraying with Metalaxyl MZ (0.2%)	21.05 (11.99)	11.16 (6.97)	49.18	6.9	53.33
T_3	Seed treatment with Apron 35 SD + spraying with Mancozeb (0.2%)	17.90 (10.34)	9.90 (5.86)	49.84	7.22	60.44
T_4	Spraying with Mancozeb (0.2%)	19.82 (12.03)	10.03 (5.75)	45.99	6.7	48.88
T_5	Seed treatment with *Trichodermaviride* + spraying with *T. viride*(0.4%)	21.71 (12.20)	10.66 (6.17)	43.47	5.78	28.44
T_6	Seed treatment with *Pseudomonas fluorescens*+ spraying with *P. fluorescens(*0.4 %)	27.01 (15.71)	13.91 (7.86)	29.53	5.4	20.00
T_7	Spraying with Neem seed extract (*Azadirachtaindica*) 10%	22.27 (13.87	11.53 (6.62)	40.48	5.3	17.77
T_8	Seed treatment with *Allium sativum* + spraying with *Allium sativum* 10%	23.04 (12.41)	11.75 (6.74)	41.57	5.9	31.11
T_9	Control	32.86 (19.24)	20.34 (9.97)	-	4.5	00
	SE +-	**0.79**	**0.50**	-	-	-
	CD at 5%	**2.36**	**1.53**	-	-	-

Figures in Parentheses arc sine transformed value
*average of three replication

Table.6 Economics of fungicides, botanicals and bioagents for control of white rust of mustard

Sr. No	Treatments	Mean PDI	Yield (qt/ha)	Gross Income /ha (Rs.)*	Addit. Income/ ha (Rs.)	Cost of cultivation (Rs.)				Net profit/ha	C:B ratio
						Treatment price **	Labour	Other expenditure	Total		
1	(T1)Seed treatment with Apron 35 SD + spraying of Metalaxyl MZ (0.2%)	9.88 (5.95)	7.77	34965	14715	2494.13	400	1000	3894.13	10820.87	1:2.77
2	(T2) Spraying with Metalaxyl MZ (0.2%)	10.03 (5.75)	6.9	31050	10800	2469.13	400	1000	3869.13	6930.87	1:1.79
3	(T3) seed treatment with Apron 35 SD + spraying of Mancozeb(0.2%)	9.90 (5.86)	7.22	32490	12240	2693.66	400	1000	4093.66	8146.34	1:1.98
4	(T4) Spraying with Mancozeb(0.2%)	10.66 (6.17)	6.7	30150	9900	2666.66	400	1000	4066.66	5833.34	1:1.43
5	(T5) Seed treatment with *Trichodermaviride* + spraying of *T. viride* (0.4%)	11.16 (5.97)	5.78	27900	7650	619.78	400	1000	2019.78	563022	1:1.85
6	(T6) Seed treatment with *Pseudomonas* f*luorescens* + spraying of *P. fluorescens*(0.4%)	13.91 (7.86)	5.4	24300	4050	619.78	400	1000	2019.78	2030.22	1:1.00
7	(T7) Spraying with NSKE (10%)	11.75 (6.74)	5.3	23850	3600	259.25	400	1000	1639.25	1940.75	1:1.16
8	(T8) Seed treatment with *Allium sativum*+ spraying of *Allium sativum* (10%)	11.53 (6.62)	5.9	26550	6300	1185.18	400	1000	2585.18	3714.82	1:1.43
9	(T9) Control	19.74 (9.97)	4.5	20250	-	-	-	-	-	-	-

In bioagents seed treatment with *Trichodermaviride* + spraying with *T.viride*(3.65%) and control plot (1.86%).

Similar result regarding staghead was reported by Kumar (2000) and Patni *et al.* (2012).

Effect offungicides, bioagents and botanicals on seed yield of mustard

The results presented in Table 5 indicated that, all the treatments significantly reduced the white rust severity and increased the seed yield, over control. The yield in respect of allthe treatments ranged from 5.3 to 7.77 qt/ha. Highest seed yield (7.77 qt/ha) with lowest disease severity (9.88%) was recorded in seed treatment with Apron 35 SD + spraying with Metalaxyl MZ. The second best treatment was seed treatment with Apron 35 SD + spraying of Mancozeb, which recorded seed yield 7.22qt/ha with mean disease severity of 9.90%.This was followed by spraying of Metalaxyl MZ 6.9qt/ha seed yield with disease severity 10.03% and spraying of Mancozeb recordedseed yield of 6.7qt/ha with disease severity 10.66%, respectively. In bioagents and botanicals, seed treatment with *Trichoderma viride* + spraying of *T.viride* (yield 5.78qt/ha and severity 11.16%) and seed treatment with *Pseudomonas fluorescens*+ spraying with *P. fluorescens* (yield 5.4qt/ha. and severity 13.91%) and in seed treatment with *Allium sativumn* + spraying with *Allium sativumn*, yield was (5.9q/ha) and severity (11.53%), spraying with neem seed kernel extract yield (5.3q/ha) and severity (11.75%), respectively.

Result from table 5 also indicated that, all the treatments significantly increased the seed yield over control. The per cent increase in seed yield was ranged from 17.77% to 72.66%. However, highest per cent increase in seed yield (72.66%) over control was recorded with seed treatment with Apron 35 SD + spraying with Metalaxyl MZ. The second best treatment was seed treatment with Apron 35 SD + spraying of Mancozeb was recorded increased inseed yield (60.44%), followed by spraying of Metalaxyl MZ(53.33%) and spraying of Mancozeb (48.88%) increased yield over control. Among bioagents and botanicals, seed treatment with *Allium sativum*+ spraying with *A.sativum* (31.11%) followed by seed treatment with *Trichodermaviride* +spraying with *T. viride*(28.44%) increased seed yield over control.

Similar result was earlier reported by Bhatt *et al*. (2009); Yadav (2009); Patni*et al*. (2012).

Cost: Benefit ratio

Results obtained on economics/incremental cost: benefit ratio (ICBR)in respect of various spray treatments presented in Table 6. Results revealed that, theeffect of white rust severity resulted in maximum seed yield, maximum grossand additional income, over control and given significant cost benefit ratio.All the treatments increased the seed yield ranged from5.3 to 7.77qt/haand gross income ranged20250 to 34965Rs/ha income, than control (20250 Rs/ha). However, seed treatment with Apron 35 SD + spraying withMetalaxyl MZrecorded highest seed yield (7.77 qt/ha) and given highestadditional income (14715 Rs/ha). This was followed by, seed treatment with Apron 35 SD + spraying with Mancozeb, spraying with Metalaxyl MZtreatment and spraying with Mancozebtreatment, respectively which was given seed yield of 7.22, 6.9 and 6.7qt/ha, respectively and gross income of 32490,

31050 and 30150 Rs/ha,respectively and additional income of Rs.12240, 10800 and 9900, respectively. Among the bioagents,*Trichodermaviride* given highest seed yield (5.78 qt/ha) with gross income of 27900 Rs/ha,over control. This was followed by seed treatment + spraying with *P. fluorescens.* In the botanicals, seed treatment + spraying with *Allium sativum*given highest seed yield (5.9qt/ha) with highest grossincome of 26550 Rs/ha and additional income Rs/ha. 6300 over control. This was followed by Neem seed kernel extract (seedyield5.3 qt/ha), gross income (23850 Rs./ha)and additional income 3600 Rs/ha., respectively.

Considering the incremental cost: benefit ratio (ICBR), the mosteconomical treatment, which recorded the highest benefit ratio (1:2.77) was in seed treatment with Apron 35 SD + spraying of Metalaxyl MZ. This was followed by seed treatment with Apron 35 SD + spraying with Mancozeb (1:1.98), spraying of MetalaxylMZ (1:1.79) andspraying of Mancozeb (1:1.43), respectively.

Among the bioagents and botanicals, the most economical treatment, which recorded the highest benefit ratio was*Trichodermaviride*(1:1.85) and seed treatment +spraying with *Allium sativum* (1:1.43) followed by neem seed kernelextract (1:1.16), respectively.

Thus, among all the treatments, in fungicides, seed treatment with Apron 35 SD + spraying withMetalaxyl MZ, followed by seed treatment with Apron 35 SD + spraying Mancozeb, in bioagents seed treatments + spraying with *Trichodermaviride*and in botanicals seed treatments + spraying with *Allium sativum*was found most economical formanagement of white rust disease.

Similar result in respect of cost: benefit ratio of the fungicides, botanicals, and bioagents in integrated management of white rust mustard was earlier reported by Singh (2005).

References

Anonymous (2014). Area, production and productivity of mustard in India. Agri Stat. at a Glance (www. agricoop. nic. in).

Bhatt Rashmi, Awasthi, R.P. and Tewari, A.K. (2009). Management of downy mildew and white rust disease of mustard. *Pantnagar J. Resch*. 7 (1): 54-59.

Kumar Ashok (2000). Ecofriendly option for the management of white rust in Indian mustard under mid hill conditions of North-Western India. *Indian Phytopath*. 62 (1):44-48.

Mayee C.D. and Datar V.V. (1986). Phytopathometry *Tech Bull*. 1. Marathwada Agricultural University, Parbhani.pp.202.

Meena, P.D.; Awashti, R.P.; Godika, S.; Gupta, J.C.; Kumar, A.; Sandhu, P.S.; Sharma, P.; Rai, P.K.; Singh, Y.P.; Rathi, A.S.; Prasad, R.; Rai, D. and Kolte, S.J. (2011). Eco-friendly approaches of major diseases of Indian mustard. *World Applied Sci. J.* 12 (8): 1192-1195.

Patni, C.S., Kolte, S.J. and Awasthi, R.P. (2012). Effect of some botanicals on management of *Alternaria* blight and white rust of mustard. *J. Pl. Dis. Sci*.1 (1): 58-62.

Singh, R. B. and Singh, R. N. (2005). Fungicidal management of foliar diseases of mustard in mid-eastern India. *Indian Phytopath*. 58 (1): 51-56.

Yadav, M.S. and Gupta, P.P. (2011). Magnitude of losses in yield and management of *Alternaria* blight of rapeseed and mustard. *Haryana Agric. Univ. J. Res*.17:14-18.

Yadav, M.S. (2009). Biopesticidal effect of botanicals on the management of mustard disease. *Indian Phytopath*. 62 (4): 488-492.