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Comparative Assessment of White Rust Disease in Improved Varieties of Indian Mustard

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A B S T R A C T

Indian mustard (*Brassica juncea*) is the most important and major edible oil seed crop. White rust [Albugo *candida* (Pers. Ex.Lev.) Kuntze] is the important disease which can cause major yield losses in Indian Mustard. This study shows comparative assessment of white rust disease index (%), white rust disease severity and white rust disease incidence on leaves as well as on the inflorescence in the improved varieties of Indian Mustard. The experiment was conducted in RBD in split plot arrangement with three replications. Nine different improved varieties of Indian Mustard (*Brassica juncea*) were used as main plots, while protected and unprotected treatments were considered in sub-plots separately. Per cent disease index (PDI) of white rust on leaves of different genotypes of *Brassica juncea* was recorded at four stages of plant growth i.e. 80 DAS, 90 DAS, 100 DAS and 110 DAS while staghead severity and staghead incidence were recorded one week before maturity. *Brassica juncea*, varieties PR-2006-14 and NDRE-4 found susceptible to white rust which shows maximum PDI (74.97) and 56.31 respectively while varieties PRB-2008-5, PRE-2009-12, and PRB-2004-3-4 found slightly tolerant to White rust disease and shows minimum PDI (52.15), (49.98) and (49.98) respectively.

Introduction

Indian mustard is the most important and major edible oil seed crop after soybean. It is a very good source of oil varying from 35-48 per cent which has several anti-nutritional factors like erucic acid (22:1) and eusinic acid (20:1). It is also used as a spice or condiment in preparation, seasoning and stuffing of foods and pickles in India.

Apart from this, its oil is also used for treating medicinal remedies like stomach aches, bone aches, muscle pains, skin disorders etc.

The estimated area, production and productivity of rapeseed-mustard in the world was 30.74 million hectares (m ha), 59.93 million tonnes (m t) and 1,950 kg/ha, respectively, during 2009-10. Globally, India produces 7.565 million tonnes (m t) from 6.583 million hectares (m ha) with productivity of 11.74 kg/ha (GOI, 2011-12).

Despite considerable increase in the productivity and production under Technology Mission, huge amount of money is spent on the import of edible oil. A wide gap exists between the potential yield and the yield

realized at the farmer's field, which is largely because of number of biotic and abiotic stresses to which the rapeseed-mustard crop is exposed. Major biotic stresses are Alternaria blight disease [*Alternaria brassicae* (Berk.) Sacc.], white rust [*Albugo candida* (Lev.) Kuntze], and downy mildew [*Hyaloperonospora parasitica* (Pers.) ex. Fr.].

Mixed infection of white rust and downy mildew in inflorescence of *Brassica* crop showed 37-47 per cent less pods with reduction of 17-32 per cent grain yield (Bains and Jhooty, 1979). Petrie and Vanterpool (1974) from Canada reported that systemic infection causes average reduction of 60 percent in seed yield on individual plants. Saharan (1992) reported 23-55 per cent yield loss in *B. juncea* and Bisht *et al.,* (1994) reported 17-37 per cent yield loss in Rapeseed-Mustard due to mixed infection of white rust and downy mildew. Yield losses ranging between 23 to 54.5% due to white rust have been reported from India (Saharan *et al.,* 1984). Sangeetha and Siddaramaiah (2007) have reported that a maximum temperature of 26 to 29°C, a minimum temperature of 14 to 15°C and average relative humidity of more than 65% favour the development of these diseases. The pustules of white rust developed at a faster rate when the average relative humidity was more than 65% and average temperature was between 10 to 18°C (Lakhra and Saharan, 1991).

This study shows comparative assessment of white rust disease severity, incidence and Percent Disease Index (PDI) in improved varieties of Indian Mustard (*Brassica juncea*) for consecutive two years during 2011-12 and 2012-13.

Materials and Methods

Field experiment was conducted for consecutive two crop season during 2011-2012 and 2012-2013 at the NEB Crop Research Centre, G.B Pant University of Agriculture and Technology, Pantnagarfor comparative assessment of white rust disease severity in the improved varieties of Indian Mustard.

The experiment was conducted in RBD in split plot arrangement with three replications. Nine different improved varieties of Indian Mustard (*Brassica juncea*) were used as main plots, while protected and unprotected treatments were considered in sub-plots separately. In protected plot alternate spray of fungicides viz. Mancozeb @ 0.2% and Ridomil MZ @ 0.25% at weekly intervals were done as much as possible to completely control the diseases. In case of unprotected plot no fungicide was applied as to provide the natural conditions as much as possible to create maximum disease pressure. Mancozeb was used to manage the Alternaria blight disease and also to overcome the development of resistance among the pathogens.

White rust disease severity at leaf stage

Average disease index on true leaves due to white rust was taken at 80,90,100 and 110 days after sowing (DAS) by using 0-6 disease rating scale (Conn *et al.,* 1990) as follows: Fifteen leaves were randomly collected from each treatment and rated as per the above rating scale and disease index was calculated separately for each treatment. The formula given by Wheeler (1969) was used to calculate the per cent disease index as follows:

$$\text{Disease index (\%)} = \frac{\text{Sum of all numerical ratings}}{\text{No. of leaves examined (15)} \times \text{Maximum grade of scale (6)}} \times 100$$

Staghead incidence

Total number of plants, and plants affected by staghead symptoms were counted in each treatment. The staghead incidence was calculated with the help of following formula:

$$\text{Staghead incidence (\%)} = \frac{\text{Number of plants showing staghead}}{\text{Total number of plants}} \times 100$$

Staghead severity

Total racemes of five staghead affected plants and number of racemes showing staghead symptoms per plant was counted and staghead severity was calculated as per the formula given below:

$$\text{Staghead severity (\%)} = \frac{\text{Number of racemes showing staghead/plant}}{\text{Total number of racemes/plant}} \times 100$$

Per cent Disease Control (PDC)

Per cent disease control was calculated at different plant growth stages with the help of following formula:

$$\text{Per cent disease control} = \frac{\text{Disease incidence or severity in unprotected plot} - \text{Disease incidence or severity in protected plot}}{\text{Disease incidence or severity in unprotected plot}} \times 100$$

Results and Discussion

White rust disease index (%)

Percent disease index of white rust on leaves of different genotypes of *Brassica juncea* was recorded at four stages of plant growth i.e. 80 DAS, 90 DAS, 100 DAS and 110 DAS during 2011-12 and 2012-13.

At 80 DAS, maximum white rust index was recorded in genotype PR-2006-14(49.78%) followed by PRB-2008-5 (47.38%) and PRE-2009-12 (47.38%) in unprotected plots during 2011-12. Genotype PRB-2008-5, PRE-2009-12, PRB-2004-3-4, Divya, NDRE-4 and Kranti showed the minimum white rust index on leaf (24.09%) followed by PRE-2007-6, PR-2008-13, and PR-2006-14(25.33%) in protected plots. Similarly NDRE-4 showed the maximum white rust index on leaf (37.73 %) followed by PR-2006-14, Divya and Kranti (35.26%) in unprotected plots during 2012-13. (Table 1).

At 90 DAS, during 2011-12, maximum white rust index was recorded in genotype PR-2006-14(57.33%) followed by PRB-2008-5 and PRE-2007-6 (52.24%) in unprotected plots. White rust index was significantly less in genotype PRB-2008-5 and PRE-2007-6(0.00) as compared to rest of the genotypes (13.62 %) in protected plots.During 2012-13, white rust disease index on leaves was significantly less in genotype PRB-2008-5, PRE-2009-12, PRB-2004-3-4, Divya, NDRE-4 and Kranti (24.09%) as compared to PRE-2007-6, PR-2008-13, and PR-2006-14(25.33%) in protected plots. Maximum white rust index was recorded in genotype NDRE-4(37.73%) followed by PR-2006-14, Divya and Kranti (35.26%) in unprotected plots (Table 1).

At 100 DAS, during 2011-12, maximum white rust index was recorded in genotype PR-2006-14(59.98%) followed by PRB-2008-5 and Kranti (57.33%) in unprotected plots. White rust index was significantly less in genotype PR-2008-13 and NDRE-4(0.00) as compared to rest of the genotypes (13.62 %) in protected plots.

During 2012-13, white rust disease index on leaves was significantly less in genotypePRB-2004-3-4(24.09%) as compared to PRB-2008-5 and PRE-2009-12(28.58%) in protected plots. Maximum white rust index was recorded in genotype PR-2006-14and NDRE-4(43.80%) followed by Divya (40.19%) in unprotected plots (Table 2).

At 110 DAS, during 2011-12, maximum white rust index was recorded in genotype PR-2006-14(65.88%) followed by PRB-2008-5 and PRE-2007-6 (62.89%) in unprotected plots. White rust disease was completely checked in all the genotypes in protected plots.

Table.1 Effect of alternate spraying of Ridomil MZ and Mancozeb on White rust disease of *Brassica juncea*

	White rust disease index (%)															
Varieties	**2011-12**								**2012-13**							
	80 DAS				**90 DAS**				**80 DAS**				**90 DAS**			
	S	**US**	**Mean**	**DC**	**S**	**US**	**Mean**	**DC**	**S**	**US**	**Mean**	**DC**	**S**	**US**	**Mean**	**DC**
PRB-2008-5	8.33	54.15	31.32	84.62	8.33	62.48	35.49	86.67	0.00	16.66	8.33	100.00	16.66	22.49	19.66	25.93
	(13.62)	(47.38)	(30.50)	(71.25)	(13.62)	(52.24)	(32.93)	(73.93)	(0.00)	(24.09)	(12.04)	(100.00)	(24.09)	(28.29)	(26.19)	(14.84)
PRE-2009-12	8.33	54.15	31.32	84.62	8.33	58.31	33.32	85.71	0.00	16.66	8.33	100.00	16.66	29.16	22.99	42.86
	(13.62)	(47.38)	(30.50)	(71.25)	(13.62)	(49.78)	(31.70)	(72.64)	(0.00)	(24.09)	(12.04)	(100.00)	(24.09)	(32.64)	(28.37)	(26.21)
PRB-2004-3-4	8.33	49.98	29.16	83.33	8.33	49.98	29.16	83.33	0.00	16.66	8.33	100.00	16.66	24.99	20.83	33.33
	(13.62)	(44.99)	(29.31)	(69.72)	(13.62)	(44.99)	(29.31)	(69.72)	(0.00)	(24.09)	(12.04)	(100.00)	(24.09)	(29.99)	(27.04)	(19.68)
PRE-2007-6	8.33	54.15	31.32	84.62	8.33	62.48	35.49	86.67	6.33	16.66	11.50	62.50	18.33	20.83	19.66	12.00
	(13.62)	(47.38)	(30.50)	(71.25)	(13.62)	(52.24)	(32.93)	(73.93)	(14.35)	(24.09)	(19.22)	(40.45)	(25.33)	(27.08)	(26.21)	(6.45)
PR-2008-13	0.00	45.82	22.99	100.00	0.00	62.48	31.32	100.00	12.50	16.66	14.66	25.00	18.33	29.16	23.82	37.14
	(0.00)	(42.59)	(21.30)	(100.00)	(0.00)	(52.24)	(26.12)	(100.00)	(20.52)	(24.09)	(22.31)	(14.80)	(25.33)	(32.64)	(28.99)	(22.40)
PR-2006-14	8.33	58.31	33.32	85.71	8.33	70.81	39.65	88.24	0.00	16.66	8.33	100.00	18.33	33.32	25.82	45.00
	(13.62)	(49.78)	(31.70)	(72.64)	(13.62)	(57.33)	(35.48)	(76.24)	(0.00)	(24.09)	(12.04)	(100.00)	(25.33)	(35.26)	(30.29)	(28.15)
Divya	8.33	45.82	27.16	81.82	8.33	54.15	31.32	84.62	12.50	16.66	14.66	25.00	16.66	33.32	24.99	50.00
	(13.62)	(42.55)	(28.08)	(67.98)	(13.62)	(47.38)	(30.50)	(71.25)	(20.52)	(24.09)	(22.31)	(14.80)	(24.09)	(35.26)	(29.67)	(31.67)
NDRE-4	0.00	41.65	20.83	100.00	0.00	37.49	18.83	100.00	12.50	16.66	14.66	25.00	16.66	37.49	27.16	55.56
	(0.00)	(40.19)	(20.10)	(100.00)	(0.00)	(37.73)	(18.87)	(100.00)	(20.52)	(24.09)	(22.31)	(14.80)	(24.09)	(37.73)	(30.91)	(36.16)
Kranti	8.33	49.98	29.16	83.33	8.33	62.48	35.49	86.67	12.50	16.66	14.66	25.00	16.66	33.32	24.99	50.00
	(13.62)	(44.99)	(29.31)	(69.72)	(13.62)	(52.24)	(32.93)	(73.93)	(20.52)	(24.09)	(22.31)	(14.80)	(24.09)	(35.26)	(29.67)	(31.67)
Mean	6.50	50.48	28.49	87.16	6.50	57.81	32.15	88.80	6.33	16.66	11.50	62.50	17.16	29.32	23.32	41.32
	(10.59)	(45.25)	(27.92)	(76.59)	(10.59)	(49.58)	(30.09)	(78.63)	(10.72)	(24.09)	(17.40)	(55.52)	(24.50)	(32.68)	(28.59)	(25.03)
C.D. (5%)	8.83	10.69			6.53	8.86			1.80	1.60			1.78	1.15		
C.V.	25.35	31.27			16.58	24.05			12.85	7.49			6.25	3.27		
Protection																
C.D. (5%)	3.22	4.32			3.02	4.33			1.16	1.04			1.42	0.95		
C.V.	19.81	27.04			16.44	25.16			17.67	10.48			10.70	5.83		
Varieties X Protection																
C.D. (5%)	9.67	12.95			9.07	12.98			3.47	3.13			4.27	2.86		
Protection X Varieties																
C.D. (5%)	11.17	14.07			9.15	12.76			3.04	2.73			3.51	2.32		

Note: Value in Parenthesis shows Angular transformation of real value

Table.2 Effect of alternate spraying of Ridomil MZ and Mancozeb on White rust disease of *Brassica juncea*

Varieties	White rust disease index (%)															
	2011-12								2012-13							
	100 DAS				110 DAS				100 DAS				110 DAS			
	S	US	Mean	DC	S	US	Mean	DC	S	US	Mean	DC	S	US	Mean	DC
PRB-2008-5	8.33	70.81	39.65	88.24	0.00	79.14	39.65	100.00	22.99	31.32	27.16	26.67	33.32	52.15	42.65	36.00
	(13.62)	(57.33)	(35.48)	(76.24)	(0.00)	(62.89)	(31.45)	(100.00)	(28.58)	(33.97)	(31.28)	(15.87)	(35.26)	(46.18)	(40.72)	(23.66)
PRE-2009-12	8.33	66.64	37.49	87.50	0.00	70.81	35.49	100.00	22.99	39.65	31.32	42.11	33.32	49.98	41.65	33.33
	(13.62)	(54.72)	(34.17)	(75.11)	(0.00)	(57.33)	(28.67)	(100.00)	(28.58)	(38.98)	(33.78)	(26.67)	(35.26)	(44.99)	(40.12)	(21.63)
PRB-2004-3-4	8.33	58.31	33.32	85.71	0.00	66.64	33.32	100.00	16.66	33.32	24.99	50.00	33.32	49.98	41.65	33.33
	(13.62)	(49.78)	(31.70)	(72.64)	(0.00)	(54.72)	(27.36)	(100.00)	(24.09)	(35.26)	(29.67)	(31.67)	(35.26)	(44.99)	(40.12)	(21.63)
PRE-2007-6	8.33	70.81	39.65	88.24	0.00	79.14	39.65	100.00	24.99	33.32	29.16	25.00	39.65	52.15	45.82	24.00
	(13.62)	(57.33)	(35.48)	(76.24)	(0.00)	(62.89)	(31.45)	(100.00)	(29.99)	(35.26)	(32.62)	(14.93)	(38.98)	(46.18)	(42.58)	(15.61)
PR-2008-13	0.00	70.81	35.49	100.00	0.00	74.97	37.49	100.00	24.99	39.65	32.32	36.84	39.65	52.15	45.82	24.00
	(0.00)	(57.33)	(28.67)	(100.00)	(0.00)	(59.98)	(29.99)	(100.00)	(29.99)	(38.98)	(34.48)	(23.05)	(38.98)	(46.18)	(42.58)	(15.61)
PR-2006-14	8.33	74.97	41.65	88.89	0.00	83.30	41.65	100.00	24.99	47.98	36.49	47.83	33.32	56.31	44.82	40.74
	(13.62)	(59.98)	(36.80)	(77.29)	(0.00)	(65.88)	(32.94)	(100.00)	(29.99)	(43.80)	(36.89)	(31.52)	(35.26)	(48.58)	(41.92)	(27.43)
Divya	8.33	62.48	35.49	86.67	0.00	70.81	35.49	100.00	24.99	41.65	33.32	40.00	33.32	52.15	42.65	36.00
	(13.62)	(52.24)	(32.93)	(73.93)	(0.00)	(57.33)	(28.67)	(100.00)	(29.99)	(40.19)	(35.09)	(25.38)	(35.26)	(46.18)	(40.72)	(23.66)
NDRE-4	0.00	45.82	22.99	100.00	0.00	54.15	27.16	100.00	24.99	47.98	36.49	47.83	33.32	56.31	44.82	40.74
	(0.00)	(42.59)	(21.30)	(100.00)	(0.00)	(47.38)	(23.69)	(100.00)	(29.99)	(43.80)	(36.89)	(31.52)	(35.26)	(48.58)	(41.92)	(27.43)
Kranti	8.33	70.81	39.65	88.24	0.00	74.97	37.49	100.00	20.83	37.49	29.16	44.44	33.32	41.65	37.49	20.00
	(13.62)	(57.33)	(35.48)	(76.24)	(0.00)	(59.98)	(29.99)	(100.00)	(27.08)	(37.73)	(32.41)	(28.24)	(35.26)	(40.19)	(37.72)	(12.28)
Mean	6.50	65.64	36.15	90.14	0.00	72.64	36.32	100.00	23.16	39.15	31.15	40.83	34.65	51.31	42.98	32.43
	(10.59)	(54.29)	(32.44)	(80.49)	(0.00)	(58.71)	(29.36)	(100.00)	(28.70)	(38.66)	(33.68)	(25.77)	(36.08)	(45.79)	(40.93)	(21.19)
C.D. (5%)	6.44	8.89			2.55	1.69			3.25	2.09			1.27	0.74		
C.V.	14.58	22.40			5.73	4.70			8.53	5.07			2.42	1.47		
Protection																
C.D. (5%)	3.07	4.35			1.25	0.82			0.49	0.29			0.97	0.56		
C.V.	14.90	23.46			6.04	4.88			2.73	1.50			3.95	2.40		
Varieties X Protection																
C.D. (5%)	9.22	13.06			3.76	2.46			1.46	0.87			2.99	1.69		
Protection X Varieties																
C.D. (5%)	9.17	12.82			3.69	2.42			3.41	2.18			2.42	1.40		

Note: Value in Parenthesis shows Angular transformation of real value

Table.3 Effect of alternate spraying of Ridomil MZ and Mancozeb on Staghead incidence and severity of *Brassica juncea*

Varieties	Staghead incidence & Severity															
	2011-12								2012-13							
	Disease incidence				Disease severity				Disease incidence				Disease severity			
	S	US	Mean	DC	S	US	Mean	DC	S	US	Mean	DC	S	US	Mean	DC
PRB-2008-5	0.00	8.33	4.17	100	0.00	8.30	4.15	100	0.00	8.30	4.15	100	0.00	16.69	8.35	100
	(0.00)	(16.78)	(8.39)	(100.00)	(0.00)	(24.07)	(12.03)	(100.00)	(0.00)	(16.74)	(8.37)	(100.00)	(0.00)	(26.91)	(13.46)	(100.00)
PRE-2009-12	0.00	12.84	6.42	100	0.00	13.11	6.55	100	0.00	13.11	6.55	100	0.00	37.37	18.69	100
	(0.00)	(20.99)	(10.50)	(100.00)	(0.00)	(37.68)	(18.84)	(100.00)	(0.00)	(21.22)	(10.61)	(100.00)	(0.00)	(42.42)	(21.21)	(100.00)
PRB-2004-3-4	0.00	3.67	1.83	100	0.00	3.74	1.87	100	0.00	3.74	1.87	100	0.00	28.10	14.05	100
	(0.00)	(11.03)	(5.52)	(100.00)	(0.00)	(31.96)	(15.98)	(100.00)	(0.00)	(11.15)	(5.57)	(100.00)	(0.00)	(34.27)	(17.14)	(100.00)
PRE-2007-6	0.00	14.42	7.21	100	0.00	15.05	7.52	100	0.00	15.05	7.52	100	0.00	22.34	11.17	100
	(0.00)	(22.32)	(11.16)	(100.00)	(0.00)	(28.12)	(14.06)	(100.00)	(0.00)	(22.82)	(11.41)	(100.00)	(0.00)	(27.34)	(13.67)	(100.00)
PR-2008-13	0.00	1.06	0.53	100	0.00	1.42	0.71	100	0.00	1.42	0.71	100	0.00	11.66	5.83	100
	(0.00)	(5.90)	(2.95)	(100.00)	(0.00)	(19.88)	(9.94)	(100.00)	(0.00)	(6.83)	(3.42)	(100.00)	(0.00)	(21.90)	(10.95)	(100.00)
PR-2006-14	0.00	7.44	3.72	100	0.00	7.50	3.75	100	0.00	7.50	3.75	100	0.00	14.77	7.38	100
	(0.00)	(15.83)	(7.91)	(100.00)	(0.00)	(22.58)	(11.29)	(100.00)	(0.00)	(15.89)	(7.94)	(100.00)	(0.00)	(23.38)	(11.69)	(100.00)
Divya	0.00	1.00	0.50	100	0.00	1.05	0.52	100	0.00	1.05	0.52	100	0.00	9.01	4.51	100
	(0.00)	(5.74)	(2.87)	(100.00)	(0.00)	(17.46)	(8.73)	(100.00)	(0.00)	(5.87)	(2.94)	(100.00)	(0.00)	(19.00)	(9.50)	(100.00)
NDRE-4	0.00	4.13	2.06	100	0.00	3.78	1.89	100	0.00	3.78	1.89	100	0.00	6.04	3.02	100
	(0.00)	(11.72)	(5.86)	(100.00)	(0.00)	(14.18)	(7.09)	(100.00)	(0.00)	(11.21)	(5.61)	(100.00)	(0.00)	(14.83)	(7.42)	(100.00)
Kranti	0.00	4.70	2.35	100	0.00	4.61	2.30	100	0.00	4.61	2.30	100	0.00	14.30	7.15	100
	(0.00)	(12.52)	(6.26)	(100.00)	(0.00)	(22.20)	(11.10)	(100.00)	(0.00)	(12.39)	(6.20)	(100.00)	(0.00)	(23.82)	(11.91)	(100.00)
Mean	0.00	6.40	3.20	100	0.00	6.50	3.25	100	0.00	6.50	3.25	100	0.00	17.81	8.90	100
	(0.00)	(13.65)	(6.82)	(100.00)	(0.00)	(24.24)	(12.12)	(100.00)	(0.00)	(13.79)	(6.90)	(100.00)	(0.00)	(25.99)	(12.99)	(100.00)
C.D. (5%)	0.15	0.22			2.50	1.81			0.15	0.17			2.44	1.70		
C.V.	3.92	2.59			22.94	12.18			3.68	1.99			19.66	10.69		
Protection																
C.D. (5%)	0.08	0.11			1.17	0.85			0.07	0.08			1.10	0.79		
C.V.	4.26	2.76			23.05	12.26			3.63	2.01			19.06	10.58		
Varieties X Protection																
C.D. (5%)	0.23	0.32			3.52	2.55			0.20	0.24			3.31	2.36		
Protection X Varieties																
C.D. (5%)	0.23	0.31			3.53	2.55			0.20	0.24			3.38	2.38		

Note: Value in Parenthesis shows Angular transformation of real value

White rust disease severity at leaf stage

Rating score	Leaf area covered by the pustules (%)
0	No symptoms
1	1-5
2	6-10
3	11-20
4	21-30
5	31-50
6	>50

During 2012-13, white rust disease index on leaves was significantly less in genotype PRB-2008-5, PRE-2009-12 and PRB-2004-3-4 (35.26%) as compared to PRE-2007-6 and PR-2008-13 (38.98%) in protected plots. Maximum white rust index was recorded in genotype PR-2006-14 and NDRE-4 (48.58%) followed by Divya (46.18%) in unprotected plots. On an average the white rust severity on the leaves of protected plots was significantly less than that of unprotected plots (Table 2).

Staghead incidence

Staghead incidence (% plant infected) was recorded at one week before maturity of *Brassica juncea*. The data revealed that all the genotypes were found to be free from staghead incidence under protected condition. During 2011-12, maximum staghead incidence was showed by genotype PRE-2007-6 (22.32%) followed by PRE-2009-12 (20.99%).

Similarly, minimum staghead incidence was recorded in NDRE-4 (5.72%) which was significantly lower than PR-2008-13 (5.90%) under unprotected condition. During 2012-13, maximum staghead incidence was also found in genotype PRE-2007-6 (22.82%) followed by PRE-2009-12 (21.22%). Similarly, minimum staghead incidence was recorded in Divya (5.87%) which was significantly lower than PR-2008-13 (6.83%) under unprotected condition (Table 3).

Staghead severity

Staghead severity was also recorded one week before maturity of *Brassica juncea* for consecutive two years. The data revealed that all the genotypes were found to be free from staghead severity during 2011-12 and 2012-13 under protected condition. During 2011-12, genotype NDRE-4 showed minimum staghead severity (14.18%) followed by DIVYA (17.46%) under unprotected condition. Similarly, maximum staghead severity was observed in genotype PRE-2009-12 (37.68%) followed by PRB-2004-3-4 (31.96%) under unprotected condition (Table 3).

During 2012-13, genotype NDRE-4 showed minimum staghead severity (14.83%) followed by Divya (19.00%) under unprotected condition. Similarly, maximum staghead severity was observed in genotype PRE-2009-12 (42.42%) followed by PRB-2004-3-4 (34.27%) under unprotected condition (Table 3).

On an average White rust severity, staghead incidence and staghead severity was found significantly lower in protected plots as compare to unprotected plots hence there was significant reduction in disease severity have been noticed under protected plots. Maximum disease control (%) up to 100% have been noticed under protected plots hence alternate sprays of Ridomil MZ and Mancozeb were

found to be very effective in controlling White rust disease as well as staghead severity. Similar results were reported by Srivastava and Verma (1989), Mehta *et al.*, (1996) and Kumar (1996). The effect of Ridomil MZ in the control of White rust and Downy mildew disease was reported by Kolte (1985).

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