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Comparative Assessment of Yield Losses in Improved Varieties of Indian Mustard [*Brassica juncea* (L.) Czern Coss] due to White Rust and Alternaria Blight

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Abstract Mustard (Rai) is a very important oilseed crop. The production is highly affected by the fungal diseases. Downy mildew, Alternaria blight, White rust and Sclerotinia rot are the major diseases which can cause tremendous yield losses. The present investigations were therefore carried out with the objectives to estimate the yield losses due to white rust disease and alternaria blight diease in improved varieties of Mustard/Rai (*Brassica juncea*). All the varieties found susceptible to Alternaria blight disease except Divya which was found slightly tolerant to the disease. Mustard (*Brassica juncea*), varieties PR-2006-14 and NDRE-4 found susceptible to white rust while varieties PRB-2008-5, PRE-2009-12 and PRB-2004-3-4 found slightly tolerant to white rust disease. Yield loss (%) ranges from 3.16 to 31.87% and found maximum in variety PRB-2004-3-4 (25.10%) and (25.83%) during 2011-2012 and 2012-2013 respectively.

Keywords White rust, Alternaria blight disease, *Brassica juncea*, Yield losses.

Introduction

Mustard/Rai [*Brassica juncea* (L.) Czern Coss], an important edible oil seed crop which belongs to family Cruciferae (Brassicaceae). Rapeseed-mustard is group of crops contributes 32% of the total oilseed production in India and it is the second largest indigenous oilseed crop. Out of 75.55 m tones of estimated rapeseed-mustard produced over 30.51 m ha in the world, India produces 7.36 m tones from 6.18 m ha with 1190 kg/ha productivity [1]. It is a very good source of oil varying from 35–48%. Besides their importance in diet of Indian masses, the crop assumes tremendous importance in cropping system [2].

The area, production and yield of Mustard in India have been fluctuating due to various biotic and abiotic stresses. The major biotic stresses which are responsible for yield losses are Alternaria blight (*Alternaria brassicae* (Berk.) Sacc.), white rust (*Albugo candida* (Lev.) Kuntze), sclerotinia stem rot (*Sclerotinia sclerotiorum*) and downy mildew (*Hyaloperonospora parasitica* (Pers.) ex. Fr.). Economically significant yield loss due to foliar and staghead infection varies from 20 to 60% have been reported in severely infected field [3]. It is the important diseases of rapeseed-mustard causing severe yield losses with no proven source of transferable resistance in any of the hosts [4]. This disease adversely affected the seed quality by reducing seed size, causing seed discoloration and reduction in oil content [5]. Alternaria blight can cause 14.58% to 35.97% reduction in the oil content of mustard seed [6]. Spray of soil isolates of *Trichoderma viride* at 45 and 75 days after sowing could manage Alternaria

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Table 1. Comparative performance of plant height and branching of improved varieties of *Brassica juncea* under protected and unprotected condition.

	2011-12								
	Plant height (cm)			No. of primary branches			No. of secondary branches		
Varieties	S	US	Mean	S	US	Mean	S	US	Mean
PRB-2008-5	135.66	133.52	134.59	6.33	5.67	6.00	11.75	9.67	10.71
PRE-2009-12	154.43	147.10	150.77	7.17	6.17	6.67	10.42	5.67	8.04
PRB-2004-3-4	154.93	141.60	148.27	6.50	5.00	5.75	9.54	7.67	8.60
PRE-2007-6	144.77	136.10	140.43	5.75	5.50	5.63	8.67	7.50	8.08
PR-2008-13	136.10	126.77	131.43	6.83	6.33	6.58	6.33	4.67	5.50
PR-2006-14	129.43	126.43	127.93	6.67	6.50	6.58	8.00	6.75	7.37
Divya	118.10	112.10	115.10	6.83	5.83	6.33	13.83	11.67	12.75
NDRE-4	120.10	110.10	115.10	6.67	6.00	6.33	17.67	14.17	15.92
Kranti	149.27	133.93	141.60	7.17	5.67	6.42	11.84	9.17	10.50
Mean	138.09	129.74	133.91	6.66	5.85	6.25	10.89	8.55	9.72
CD (5%)	11.89			1.12			2.29		
CV	7.26			14.70			19.32		
Protection									
CD (5%)	1.43			0.23			0.31		
CV	1.87			6.53			5.61		
Varieties × Protection									
CD (5%)	4.29			0.70			0.93		
Protection × Varieties									
CD (5%)	12.27			1.23			2.39		

Table 1. Continued.

	2012-13								
	Plant height (cm)			No. of primary branches			No. of secondary branches		
Varieties	S	US	Mean	S	US	Mean	S	US	Mean
PRB-2008-5	134.89	132.75	133.82	6.00	5.33	5.67	11.75	9.67	10.71
PRE-2009-12	153.67	146.33	150.00	6.83	5.83	6.33	10.42	5.67	8.04
PRB-2004-3-4	154.17	140.83	147.50	6.17	4.67	5.42	9.54	7.67	8.60
PRE-2007-6	144.00	135.33	139.67	5.42	5.17	5.29	8.67	7.50	8.08
PR-2008-13	135.33	126.00	130.67	6.50	6.00	6.25	6.33	4.67	5.50
PR-2006-14	128.67	125.67	127.17	6.33	6.17	6.25	8.00	6.75	7.37
Divya	117.33	111.33	114.33	6.50	5.50	6.00	13.83	11.67	12.75
NDRE-4	119.33	109.33	114.33	6.33	5.67	6.00	17.67	14.17	15.92
Kranti	148.50	133.17	140.83	6.83	5.33	6.08	11.84	9.17	10.50
Mean	137.32	128.97	133.15	6.32	5.52	5.92	10.89	8.55	9.72
CD (5%)	11.89			1.12			2.29		
CV	7.30			15.53			19.32		
Protection									
CD (5%)	1.42			0.23			0.31		
CV	1.87			6.90			5.67		
Varieties × Protection									
CD (5%)	4.28			0.70			0.93		
Protection × Varieties									
CD (5%)	12.27			1.23			2.39		

blight of Indian mustard (*Brassica juncea*) as effectively as mancozeb [7], which have been confirmed later in multilocation trials [8]. The present study was conducted to estimate the comparative yield losses caused due to white rust and Alternaria blight diseases in improved varieties of Mustard for consecutive two years during 2011-2012 and 2012-2013 at the GB Plant University of Agriculture and Technology, Pantnagar, Uttarakhand.

Table 2. Comparative performance of raceme length and siliqua of improved varieties of *Brassica juncea* under protected and unprotected condition.

	2011-12								
	Main raceme length (cm)			No. of siliqua per main raceme			Siliqua length (cm)		
Varieties	S	US	Mean	S	US	Mean	S	US	Mean
PRB-2008-5	49.00	44.58	46.79	35.00	31.00	33.00	5.55	5.38	5.47
PRE-2009-12	46.33	41.33	43.83	36.33	28.17	32.25	4.38	4.38	4.38
PRB-2004-3-4	44.67	37.66	41.17	26.17	23.00	24.58	5.05	5.05	5.05
PRE-2007-6	45.83	41.50	43.67	36.67	28.17	32.42	4.88	3.72	4.30
PR-2008-13	48.00	41.83	44.92	34.17	31.67	32.92	4.88	4.55	4.72
PR-2006-14	36.00	34.50	35.25	27.83	26.17	27.00	3.88	3.55	3.72
Divya	43.17	41.33	42.25	31.17	27.17	29.17	4.88	3.88	4.38
NDRE-4	42.00	40.16	41.08	33.50	28.50	31.00	4.30	4.05	4.18
Kranti	50.83	37.00	43.92	35.33	30.67	33.00	4.44	3.72	4.08
Mean	45.09	39.99	42.54	32.91	28.28	30.59	4.69	4.25	4.47
CD (5%)	1.87			4.89			0.44		
CV	3.59			13.06			8.21		
Protection									
CD (5%)	0.70			0.78			0.14		
CV	2.89			4.50			5.60		
Varieties × Protection									
CD (5%)	2.11			2.36			0.42		
Protection × Varieties									
CD (5%)	2.39			5.16			0.54		

Table 2. Continued.

	2012-13								
	Main raceme length (cm)			No. of siliqua per main raceme			Siliqua length (cm)		
Varieties	S	US	Mean	S	US	Mean	S	US	Mean
PRB-2008-5	48.67	44.25	46.46	33.00	29.00	31.00	5.50	5.33	5.42
PRE-2009-12	46.00	41.00	43.50	34.33	26.17	30.25	4.33	4.33	4.33
PRB-2004-3-4	44.33	37.33	40.83	24.17	21.00	22.58	5.00	5.00	5.00
PRE-2007-6	45.50	41.17	43.33	34.67	26.17	30.42	4.83	3.67	4.25
PR-2008-13	47.67	41.50	44.58	32.17	29.67	30.92	4.83	4.50	4.67
PR-2006-14	35.67	34.17	34.92	25.83	24.17	25.00	3.83	3.50	3.67
Divya	42.83	41.00	41.92	29.17	25.17	27.17	4.83	3.83	4.33
NDRE-4	41.67	39.83	40.75	31.50	26.50	29.00	4.25	4.00	4.13
Kranti	50.50	36.67	43.58	33.33	28.67	31.00	4.39	3.67	4.03
Mean	44.76	39.66	42.21	30.91	26.28	28.59	4.64	4.20	4.42
CD (5%)	1.87			4.89			0.44		
CV	3.62			13.97			8.30		
Protection									
CD (5%)	0.70			0.78			0.14		
CV	2.91			4.82			5.66		
Varieties × Protection									
CD (5%)	2.11			2.36			0.42		
Protection × Varieties									
CD (5%)	2.39			5.16			0.54		

Materials and Methods

Field experiment was conducted in randomized block design in split plot arrangement. Nine different varieties of *Brassica juncea* were used as main plot and each main plot was divided into two sub plots as protected and unprotected. In protected plot alternate sprays of fungicides viz. Mancozeb @ 0.2% and

Table 3. Comparative performance of seeds per siliqua and 1000 seed weight of improved varieties of *Brassica juncea* under protected and unprotected condition.

	2011-12						2012-13					
	Seeds per siliqua			Test weight (gm)			Seeds per siliqua			Test weight (gm)		
Varieties	S	US	Mean	S	US	Mean	S	US	Mean	S	US	Mean
PRB-2008-5	11.23	9.03	10.13	4.217	3.239	3.728	11.10	8.90	10.00	4.214	3.236	3.725
PRE-2009-12	11.33	10.03	10.68	3.488	3.058	3.273	11.20	9.90	10.55	3.485	3.055	3.270
PRB-2004-3-4	11.53	10.73	11.13	3.058	2.948	3.003	10.90	10.60	10.75	3.055	2.945	3.000
PRE-2007-6	11.03	10.23	10.63	2.938	2.598	2.768	11.40	10.10	10.75	2.935	2.595	2.765
PR-2008-13	10.33	9.13	9.73	2.898	2.558	2.728	10.20	9.00	9.60	2.895	2.555	2.725
PR-2006-14	10.53	9.33	9.93	3.058	2.958	3.008	10.40	9.20	9.80	3.055	2.955	3.005
Divya	10.83	9.43	10.13	2.951	2.631	2.791	10.70	9.30	10.00	4.055	3.825	3.940
NDRE-4	10.53	9.33	9.93	3.728	3.468	3.598	10.40	9.20	9.80	3.725	3.465	3.595
Kranti	10.53	10.03	10.28	4.058	3.828	3.943	10.40	9.90	10.15	2.948	2.628	2.788
Mean	10.88	9.70	10.29	3.377	3.032	3.205	10.74	9.57	10.16	3.374	3.029	3.201
CD (5%)	0.69			0.0015			0.51			0.0015		
CV	5.55			0.04			4.12			0.04		
Protection												
CD (5%)	0.29			0.0014			0.36			0.0014		
CV	5.05			0.08			6.26			0.08		
Varieties × Protection												
CD (5%)	8.89			0.0044			1.09			0.0044		
Protection × Varieties												
CD (5%)	0.94			0.0035			0.92			0.0035		

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.

Statistical analysis

Harvest weight was recorded from each and every plots of protected as well as unprotected plots of all the nine improved varieties and then average of three replication was calculated separately. The data collected from above field experiment at different growth stages were subjected to statistical analysis.

$$\text{Percent yield loss} = \frac{\text{Yield of protected plot–Yield of unprotected plot}}{\text{Yield of protected plot}} \times 100$$

Results and Discussion

Plant height and branching

The variety PRB-2004-3-4 obtained significantly higher plant height (154.93 cm) and (154.17 cm) during 2011-12 and 2012-13 respectively in protected plots. The number of primary branches were found significantly higher in variety PRE-2009-12 (7.17) and (6.83) during 2011-2012 and 2012-2013 respectively. The number of secondary branches was found significantly higher in variety NDRE-4 (17.67) during 2011-2012 and 2012-2013 (Table 1).

Main raceme length and siliqua

The observations on length of main raceme, number of siliqua on main raceme and siliqua length were taken at the time of crop maturity during 2011-2012 and 2012-2013. The length of main raceme, number of siliqua on main raceme and siliqua length were found statistically superior in variety Divya over the rest of the varieties in protected as well as in unprotected plots during 2011-2012 and 2012-2013. On an average length of main raceme, number of siliqua on main raceme and siliqua length in protected plots were found significantly higher than unprotected plots (Table 2).

Table 4. Comparative performance of yield potential of improved varieties of *Brassica juncea* under protected and unprotected condition.

	2011-12						
	Yield per plant (gm)			Yield (q/ha)			
Varieties	S	US	Mean	S	US	Mean	Yield loss (%)
PRB-2008-5	7.37	5.85	6.61	13.68	12.43	13.06	9.14
PRE-2009-12	6.81	5.66	6.24	17.57	17.01	17.29	3.16
PRB-2004-3-4	6.50	5.74	6.12	17.15	12.85	15.00	25.10
PRE-2007-6	6.92	5.09	6.01	19.24	17.99	18.61	6.50
PR-2008-13	5.93	5.02	5.47	15.21	14.10	14.65	7.31
PR-2006-14	6.37	5.31	5.84	14.38	12.85	13.61	10.63
Divya	8.83	7.66	8.25	22.01	17.71	19.86	19.56
NDRE-4	7.29	5.94	6.61	18.54	15.49	17.01	16.48
Kranti	5.80	5.18	5.49	17.43	11.88	14.65	31.87
Mean	6.87	5.72	6.29	17.25	14.70	15.97	14.77
CD (5%)	0.90			0.68			
CV	11.69			3.52			
Protection							
CD (5%)	0.16			0.30			
CV	4.58			3.33			
Varieties × Protection							
CD (5%)	0.49			0.91			
Protection × Varieties							
CD (5%)	0.96			0.94			

Table 4. Continued.

	2012-13						
	Yield per plant (gm)			Yield (q/ha)			
Varieties	S	US	Mean	S	US	Mean	Yield loss (%)
PRB-2008-5	7.34	5.82	6.58	11.85	10.74	11.30	9.38
PRE-2009-12	6.78	5.62	6.20	15.19	14.69	14.94	3.25
PRB-2004-3-4	6.46	5.71	6.08	14.81	10.99	12.90	25.83
PRE-2007-6	8.80	7.62	8.21	16.67	15.56	16.11	6.67
PR-2008-13	5.89	4.98	5.44	13.09	12.10	12.99	7.55
PR-2006-14	6.33	5.28	5.80	12.35	10.99	11.67	11.00
Divya	6.88	5.06	5.97	19.14	15.31	17.22	20.00
NDRE-4	7.26	5.90	6.58	16.05	13.33	14.69	16.92
Kranti	5.76	5.15	5.46	15.06	11.98	13.52	20.49
Mean	6.83	5.68	6.26	14.91	12.85	13.88	13.80
CD (5%)	0.90			0.53			
CV	11.76			3.14			
Protection							
CD (5%)	0.16			0.13			
CV	4.61			1.71			
Varieties × Protection							
CD (5%)	0.49			0.40			
Protection × Varieties							
CD (5%)	0.96			0.60			

Seeds per siliqua and 1000 seed weight

The number of seeds per siliqua and 1000 seed weight were found significantly higher in variety Divya in protected plots as well as in unprotected plots during 2011-2012 and 2012-2013 respectively. On an average the number of seeds per siliqua and 1000 seed weight

in protected plots were found significantly higher than unprotected plots (Table 3).

Yield per plant and yield (q ha^{-1})

The observations on yield per plant and yield (q ha^{-1}) were taken after the harvest of crop during 2011-2012 and 2012-2013. The yield per plant and yield (q ha^{-1}) were found significantly higher in variety Divya in protected plots as well as in unprotected plots during 2011-2012 and 2012-2013 respectively. On an average the yield per plant and yield (q ha^{-1}) in protected plots were found significantly higher than unprotected plots. Yield loss was found maximum in variety PRB-2004-3-4 (25.10%) and (25.83%) during 2011-2012 and 2012-2013 respectively. Similarly minimum yield loss (%) was found in variety PRE-2009–2012 (3.16%) and (3.25%) during 2011-2012 and 2012-2013 respectively (Table 4).

On the basis of present investigation, it can be concluded that, all the improved varieties of Indian Mustard was found susceptible to Alternaria blight disease except variety Divya which is found slightly tolerant to the disease. Yield losses in the field ranges from 3.16–25.83% as reported earlier (17–18%) by Prasad et al. [9]. Alternate sprays (5–6) of Ridomil MZ and Mancozeb is found most economical and highly effective for the management of White rust, Downy mildew and Alternaria blight diseases which ultimately reduces the yield loss at greater extent in all the varieties of Mustard (*Brassica juncea*) progress in sequencing pathogens or beneficial microflora and the combination of bioinformatics and functional genomics are likely to provide a better understanding of plant-pathogen networks and lead to increase resistance to crop pathogens [10].

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