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Screening of Genotypes against Alternaria Blight of Rapeseed-Mustard and its Fungicidal Management

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ABSTRACT

Alternaria blight is a destructive disease of rapeseed-mustardcaused by *Alternaria brassicae* (Berk) Sacc. and *A. brassicicola* (Schw). The field experiments were conducted during 2013-14 and 2014-15, with 200 genotypes for evaluation of their resistance to Alternaria blight, as well as to develop effective management strategies for this disease. None of the genotypes were found disease-free or highly resistant, only 7 genotypes namely (DLSC-1, DRMR-261, DRMR-270, GSC-101, GSL-1, NPC-20, and PHR-2) were found resistant, 15 genotypes were rated as moderately resistant. Rest of the genotypes was either recorded susceptible or highly susceptible. For disease management, newly molecules of 6 fungicides were evaluated with 13 treatments combinations for their effectiveness. Propiconazole 25% EC @ 0.10% was found most effective in reducing the disease severity followed by the same fungicide @ 0.05%. It was followed by Hexaconazole 5% SC @ 0.010%. Maximum test weight and yield were also recorded with the sprays of Propiconazole 25% EC @ 0.10% followed by the same fungicide @ 0.05%. In comparison to other fungicides, the maximum B:C ratio was recorded with three sprays of Hexaconazole 5% SC @ 0.05% followed by Propiconazole 25% EC @ 0.05%.

Keywords: S

INTRODUCTION

The oilseed crops, especially *Brassica* spp. play a pivotal role in the agricultural economy of India. Rapeseed-mustard, among these, are most important *rabi* crops. India is one of the leading countries with respect to production, consumption ,and import of vegetable oils (Singh *et al.*,2013). Alternaria blight caused by *Alternaria brassicae* (Berk) Sacc. and *A. brassicicola* (Schw) Wiltshire is one of the major limiting factor, causing yield losses from 17 to 45% in mustard (*Brassica juncea* L.) (Singh and Singh, 2005a, Singh and Singh, 2006, Kumar *et al.*, 2009) and upto 70% in rapeseed of yellow *sarson* and brown *sarson* (*Brassica compestris*) (Kolte, 2002). The blight also reduces the seed size; seed colour and oil content. In the absence of resistant cultivars, the disease was managed through cultural practices and by using different fungicides up to certain levels (Singh and Singh, 2005b, Singh *et al.*, 2008 and Singh *et al.*, 2013).

Since the chemical compound is not safe for the human being, animals even also to the microbes (Ko and Farley, 1969). The ideal and most economical means of managing the Alternaria blight disease of rapeseed and mustard would be the use of resistant varieties. In the absence of resistant cultivars, chemical fungicides provide the most reliable means of disease control (Singh *et al.*, 2014). Therefore, in the present study, efforts have been made to find out suitable genotypes, newly molecule of fungicides for the management of *Alternaria* blight of mustard.

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MATERIALS AND METHODS

The investigations were carried out at Genetics and Plant Breeding Research Farm and in the laboratory of the Department of Plant Pathology, N.D. University of Agriculture &Technology, Kumarganj, Faizabad, Uttar Pradesh, India. This investigation consisted of two separate components *i.e.* varietal screening for host resistance and use of newly molecule fungicides in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]for the management of the disease.

Varietal resistance:

Two Hundred (200) promising genotypes/cultivars supplied by Directorate of rapeseed-mustard research, Sewar, Bharatpur, Rajasthan were normals own in the first week of November during 2013-14 and 2014-15*rabi* season. All the entries were planted in paired rows and replicated twice. Plant to plant and row to row spacing was maintained as 30x10cm. The crop was fertilized with NPK in the ratio of 120:60:60 kg/ha to obtain a good crop. The disease severity was recorded following scale as per the recommendation of All India Coordinated Research Project on Rapeseed-Mustard, 2017 which is as under. [0=No lesion [Immune (I)]; 1= Non sporulating pinpoint size or small brown necrotic spots, less than 5% leaf area covered by the lesions [Highly resistant (HR)]; 3= small roundish slightly sporulating larger brown necrotic spot, about 1-2 mm in diameter with a distinct margin or yellow halo, 5-10% leaf area covered by lesions [Resistant (R)]; 5= moderate sporulation, non-coalescing larger brown spots, about 2-4mm in diameter with a distinct margin or yellow halo, 11-25% leaf area covered by the lesions

[Moderately resistant (MR)]; 7=moderately sporulating, coalescing, larger brown spots about 4-5 mm in diameter, 26-50% leaf area covered by the lesions [Susceptible (S)]; 9 = profusely sporulating, rapidly coalescing, brown to black spots measuring more than 6mm in diameter without margins covering more than 50% leaf area [Highly susceptible (HS)]. The tested mustard genotypes were classified into different groups according to their response and reaction to the pathogen. The Area under Disease Progress Curve (AUDPC) and infection rate (r) were calculated by the employing formula given below:

$$PDI = \frac{\text{Sum of total numerical ratings}}{\text{Total number of leaves observed}} \times \frac{100}{\text{Highest grade}}$$

The avoidable yield loss (AYL) was also calculated by the following formula:

$$AYL = \frac{Yp - Yup}{Yp} \times 100$$

Where,
Yp = yield under protected conditions
Yup = yield under unprotected conditions

RESULTS AND DISCUSSION

Varietal screening

Appearance of disease

The initial symptoms of the disease could be noted between 40 to 48 days after in different genotypes and earliest appearance of disease (40 DAS) was noted in genotypes CJ-37-61, CS-13000-3-3-2-2-1, CS-1100-1-2-2-3, Divya-33, DRMR-10-40, DRMRIJ-31, Hyb-7-2011, Hyb-9-2011, JC-210-541, JMM-08-1, JMWR-08-3, KMR-12-2, LES-47, MCP-802, NDRE-7, NPJ-172, NPJ-175, PMH-12-1, PPBR-2, PRE-2007-6, PT-2006-4, PT-2010-10, PYS-2007-10, PYS-2008-5, RAUDT-10-18, RAUDYS-10-07, RAUDYS-10-12, RGN-321, RH-0749, RH-0904, RMM-10-1, RMM-10-12, RMT-10-7, RRN-788, RTM-10-10, RTM-1351, TKM-102, TL-21, TM-106, YSKM-12-1, YSKM-12-2, YSWB-2010/8, YSWB-2011-10-1, YSWB-2014/3-12 and YSWB-20229/2-12 and latest (48 DAS) in genotypes DRMR-261, GSC-101, GSL-1, NPC-20 and PHR-2 (Table1). Similar studies on the response of varieties have been studied by Pandey *et al.* (2018) with other genotypes as the disease first appeared on the genotype NDRS-2010 (38 DAS) followed by genotypes Ashirwad (42 DAS), Varuna (44 DAS) and NDR- 8501 (45 DAS). The latest appearance of disease was noted on genotype JD-6 (63 DAS).

Severity of disease

An examination of data in Table 1 revealed thatlowest disease severity (5.00%) was recorded in genotype GSC-101 followed by GSL-1 (6.00%), PHR-2 (6.50%), DRMR-261 (7.50%), NPC-20 (9.00%), DRMR-270 and CNH-11-13 (9.50%), HNS-1001 and DLSC-1 (10.00%) (Table1). Similar studies on the response of varieties have been studied by Singh *etal.*, (2008) with other genotypes.

They have reported that Alternaria blight severity ranged from 8.70% to 23.80% is minimum in the ELM-079 (8.7%) followed by LET-18 (9.10%), PQR-2001-3 (9.50%) and CAN-130 (9.50%), respectively. Earlier worker has also reported that blight severity ranged from 23.11% to 70.21% in different genotypes Singh *et al.* (2014).

Area under disease progress curve (AUDPC)

On average basis Area under the disease progress curve (AUDPC) showed more susceptible genotypes or varieties (Table1). The lowest AUDPC (82.35) was recorded in genotype GSC-101 followed by GSL-1 (105.00), PHR-2 (116.25), DRMR-261 (136.05), NPC-20 (174.00), DRMR-270 (176.25), CNH-11-13 (175.05), HNS-1001 (195.00) and DLSC-1 (198.75). Kumar and Kolte (2001) also reported the genotypes PR-8988 and PR-9024 showed less value of AUDPC (45.35-126.70) on leaves and pods, respectively in comparison to susceptible genotype Varuna in case of Indian mustard. Singh *et al.* (2014) have made similar studies to find out the resistance source and reported AUDPC ranged from 365.40 to 1414.20 in different genotypes evaluated against Alternaria blight of mustard.

Infection rate (r)

The infection rate (r) was found variable in different genotypes which could be the reason for variations in severity of genotypes. On the mean basis, the infection rate was higher in between 60 to 75 days after sowing situations because high frequency of severity was recorded between 65 DAS to 75 DAS and found to be a critical stage for blight development (Table1). Slow blighting may be defined as a reduction in the infection rate of the pathogen.

Lowest infection rate (0.025) was recorded in genotype GSC-101 followed by GSL-1 and PHR-2 (0.032), DRMR-261 (0.043), NPC-20 (0.045), DRMR-270 (0.046), CNH-11-13 (0.056), HNS-1001 (0.058) and DLSC-1 (0.065) in normal sowing. Kumar and Kolte (2001) also reported from Pantnagar, mustard genotypes PR-8988 and PR-9024 had reduced apparent infection rates as compared to susceptible genotypes Varuna. Similar reports also were given by Pandey *et al.* (2018).

Host reaction

Out of 200 genotypes screened, none of the genotypes were found disease-free or highly resistant, only 7 genotypes namely (DLSC-1, DRMR-261, DRMR-270, GSC-101, GSL-1, NPC-20 and PHR-2) were found resistant, 15 genotypes namely (CNH-11-13, CNH-11-7, EC-552608, HNS-1001, PAB 04-10, PAB 05-16, PAB 05-19, PAB 09-05, PAB-2004-4, PAB-2005-16, PPBJ-5, PPBJ-2, PPBJ-3, PPBN-3 and PPBN-2) were rated as moderately resistant , 63 as moderately susceptible and 115 as susceptible (Table1).

Similarly, several researchers have also reported other genotypes resistant to this disease time to time (Kumar *et al.*, 2009; Kumar and Singh, 2012; Rai and Mishra, 2014 and Singh *et al.*, 2015).

Effect of different fungicides

On the severity of disease

All the treatments significantly decreased the severity of disease on leaves in comparison to the untreated check.

Table- 1: Per cent disease severity, AUDPC and Infection rate (r) of Alternaria blight in rapeseed and mustard genotypes

S. No.	Name of Genotypes	Appearance of Disease (DAS)	Per cent Disease Severity on Leaves			AUDPC on Leaves	Infection rate (r) on leaves at 15 days intervals			Maximum Grade (0-9)	Host Reaction
			60 DAS	75 DAS	90 DAS		60 to 75 DAS	75 to 90 DAS	Average		
1	2IJ 0009	44	15.71	34.00	54.00	1032.83	0.068	0.055	0.062	9	S
2	44S31	44	12.00	26.00	47.00	832.50	0.063	0.062	0.063	7	MS
3	45S42	42	19.00	35.00	52.00	1057.50	0.055	0.047	0.051	9	S
4	AH 53	44	15.50	32.00	53.00	993.75	0.063	0.058	0.061	9	S
5	AHS 55	46	5.50	14.00	24.00	431.25	0.068	0.044	0.056	5	MR
6	Albeli-1	43	12.00	28.00	52.00	900.00	0.07	0.068	0.069	9	S
7	ASH 42	44	16.00	34.00	57.00	1057.50	0.066	0.063	0.065	9	S
8	C-3001-1-1-1	45	10.52	28.00	40.00	798.90	0.08	0.036	0.058	7	MS
9	CJ-37-61	40	23.00	39.48	58.00	1199.70	0.052	0.05	0.051	9	S
10	CNH-11-13	46	2.80	5.52	9.50	175.05	0.073	0.039	0.056	3	R
11	CNH-11-7	46	3.50	7.00	11.00	213.75	0.049	0.033	0.041	5	MR
12	CS 13000-3-3-2-2-1	40	20.00	45.00	59.50	1271.25	0.079	0.039	0.059	9	S
13	CS-1100-1-2-2-3	40	20.00	44.00	58.00	1245.00	0.076	0.038	0.057	9	S
14	CS-204-2-2-1	42	17.00	38.52	55.00	1117.80	0.074	0.04	0.059	9	S
15	Divya-33	40	22.50	44.00	61.00	1286.25	0.066	0.046	0.056	9	S
16	DLSC-1	46	2.50	7.00	10.00	198.75	0.072	0.058	0.065	3	R
17	DRMR-100	44	13.00	26.00	44.80	823.50	0.057	0.056	0.057	7	MS
18	DRMR-10-40	40	22.00	41.36	58.00	1220.40	0.061	0.045	0.053	9	S
19	DRMR-11-08	45	9.72	23.51	41.50	736.80	0.07	0.056	0.063	7	MS
20	DRMR-11-10	46	8.00	21.68	42.50	703.95	0.077	0.065	0.071	7	MS
21	DRMR-11-11	42	11.00	26.00	47.50	828.75	0.07	0.063	0.067	7	MS
22	DRMR-1187-60	44	13.00	30.00	46.00	892.50	0.07	0.046	0.058	7	MS
23	DRMR-13	44	14.40	25.00	39.00	775.50	0.046	0.043	0.045	7	MS
24	DRMR-15	42	17.00	35.00	57.00	1080.00	0.064	0.06	0.062	9	S
25	DRMR-1679-100	42	17.00	42.00	58.00	1192.50	0.084	0.043	0.064	9	S
26	DRMR-261	48	1.00	3.50	7.50	136.05	0.052	0.034	0.043	3	R
27	DRMR-270	46	1.50	6.10	9.50	176.25	0.065	0.027	0.046	3	R
28	DRMR-302	44	12.64	29.00	45.50	871.05	0.069	0.048	0.059	7	MS
29	DRMR-312	44	14.55	32.00	49.00	956.62	0.068	0.048	0.058	7	MS
30	DRMR-316	42	17.00	36.00	57.00	1095.00	0.067	0.057	0.062	9	S
31	DRMR-64	42	18.00	40.00	58.00	1170.00	0.074	0.048	0.061	9	S
32	DRMR-81	42	18.00	39.00	57.00	1147.50	0.071	0.049	0.060	9	S
33	DRMR-92	44	15.00	21.00	27.40	633.00	0.079	0.045	0.062	7	MS
34	DRMRHJ-2409	44	16.00	37.00	46.00	1020.00	0.075	0.025	0.050	7	MS
35	DRMRIJ-04	46	8.50	20.00	37.00	641.25	0.066	0.057	0.062	7	MS
36	DRMRIJ-11-04	44	13.00	37.00	45.00	990.00	0.091	0.022	0.057	7	MS
37	DRMRIJ-11-286	41	9.50	23.00	45.50	757.50	0.07	0.068	0.069	7	MS
38	DRMRIJ-11-287	44	14.00	36.20	53.00	1045.50	0.083	0.046	0.065	9	S
39	DRMRIJ-1-275	44	13.00	30.00	54.50	956.25	0.07	0.068	0.069	9	S
40	DRMRIJ-21-1	44	16.00	37.00	58.00	1110.00	0.075	0.057	0.066	9	S
41	DRMRIJ-27	44	15.58	28.00	39.00	829.35	0.05	0.033	0.042	7	MS
42	DRMRIJ-31	40	23.50	40.00	58.50	1215.00	0.052	0.05	0.051	9	S
43	DRMRMJA-27	42	18.00	37.00	59.00	1132.50	0.066	0.06	0.063	9	S
44	DRMRMJA-35	45	10.00	25.00	45.00	787.50	0.073	0.06	0.067	7	MS
45	DRMRMJB-38	42	11.00	27.00	48.00	847.50	0.073	0.061	0.067	7	MS
46	EC 399301	44	16.00	34.00	56.50	1053.75	0.066	0.062	0.064	9	S
47	EC-399299	41	12.00	25.00	42.00	780.00	0.06	0.052	0.056	7	MS
48	EC-414322	44	16.00	35.38	50.00	1025.70	0.07	0.04	0.055	7	MS
49	EC-414324	45	10.50	23.00	42.46	742.20	0.062	0.06	0.061	7	MS
50	EC-552608	46	5.00	12.70	24.00	408.00	0.068	0.052	0.060	5	MR
51	GSC-101	48	0.80	2.59	5.00	82.35	0.027	0.023	0.025	3	R
52	GSL-1	48	1.00	3.50	6.00	105.00	0.037	0.026	0.032	3	R

53	HNS-1001	46	2.00	7.00	10.00	195.00	0.087	0.029	0.058	3	R
54	Hyb-7-2011	40	21.48	36.00	48.00	1061.10	0.048	0.033	0.041	7	MS
55	Hyb-9-2011	40	20.00	38.00	47.00	1072.50	0.06	0.025	0.043	7	MS
56	IC-255498	44	13.00	27.00	45.50	843.75	0.06	0.054	0.057	7	MS
57	IC-399678	45	11.58	26.00	47.00	829.35	0.066	0.062	0.064	7	MS
58	IC-399824	44	14.00	35.00	56.50	1053.75	0.08	0.059	0.070	9	S
59	JC-210-541	40	22.00	44.00	61.00	1282.50	0.068	0.046	0.057	9	S
60	JMM-08-1	40	21.30	38.42	57.52	1167.45	0.056	0.052	0.054	9	S
61	JMT-08-13	44	14.10	30.00	42.00	870.75	0.064	0.035	0.050	7	MS
62	JMWR-08-3	40	24.00	42.61	61.00	1276.65	0.057	0.05	0.054	9	S
63	KMR(L)-12-1	44	13.00	36.00	44.00	967.50	0.088	0.022	0.055	7	MS
64	KMR(L)-12-2	44	15.00	33.00	45.00	945.00	0.068	0.034	0.051	7	MS
65	KMR-12-1	44	16.00	37.00	55.00	1087.50	0.075	0.049	0.062	9	S
66	KMR-12-2	40	20.00	39.00	54.00	1140.00	0.063	0.04	0.052	9	S
67	LADLI	44	15.00	27.00	41.00	825.00	0.049	0.042	0.046	7	MS
68	LES-45	44	13.00	31.57	49.5	942.30	0.075	0.05	0.063	7	MS
69	LES-46	44	15.55	37.00	55.00	1084.13	0.077	0.049	0.063	9	S
70	LES-47	40	21.36	43.00	62.50	1273.95	0.068	0.053	0.061	9	S
71	MCP-802	40	20.00	36.00	52.00	1080.00	0.054	0.044	0.049	9	S
72	MCP-807	42	17.00	30.00	44.50	911.25	0.049	0.042	0.046	7	MS
73	NDRE-7	40	23.70	38.83	55.50	1176.45	0.048	0.045	0.047	9	S
74	NDRS 2017	43	11.00	29.00	54.50	926.25	0.08	0.072	0.076	9	S
75	NPC-20	46	2.50	6.00	9.00	174.00	0.061	0.029	0.045	3	R
76	NPJ 153	44	14.00	32.95	57.50	1030.50	0.074	0.067	0.071	9	S
77	NPJ 154	42	12.82	29.90	52.50	938.40	0.071	0.063	0.067	9	S
78	NPJ 155	42	17.33	32.00	50.62	989.62	0.054	0.052	0.053	9	S
79	NPJ 156	43	10.21	23.54	37.50	710.92	0.066	0.044	0.055	7	MS
80	NPJ-121	44	13.84	31.00	55.00	981.30	0.068	0.067	0.068	9	S
81	NPJ-127	44	15.00	37.00	57.50	1098.75	0.08	0.056	0.068	9	S
82	NPJ-140	44	16.00	36.34	54.50	1073.85	0.073	0.049	0.061	9	S
83	NPJ-164	46	6.38	18.00	40.00	617.85	0.078	0.074	0.076	7	MS
84	NPJ-165	41	11.00	30.00	49.00	900.00	0.083	0.054	0.069	7	MS
85	NPJ-167	46	7.00	20.00	44.50	686.25	0.08	0.078	0.079	7	MS
86	NPJ-168	44	14.80	28.00	44.00	861.00	0.054	0.047	0.051	7	MS
87	NPJ-169	46	6.55	18.00	30.00	544.12	0.076	0.045	0.061	7	MS
88	NPJ-170	42	17.10	38.00	54.50	1107.00	0.073	0.045	0.059	9	S
89	NPJ-171	44	14.00	35.00	47.50	986.25	0.08	0.035	0.058	7	MS
90	NPJ-172	40	21.00	39.00	60.00	1192.50	0.058	0.057	0.058	9	S
91	NPJ-173	44	14.00	33.00	55.00	1012.50	0.074	0.061	0.068	9	S
92	NPJ-174	42	17.34	32.00	47.00	962.55	0.054	0.042	0.048	7	MS
93	NPJ-175	40	21.00	36.00	50.00	1072.50	0.05	0.038	0.044	7	MS
94	NUDH-YJ-10	42	17.00	37.00	53.00	1080.00	0.07	0.043	0.057	9	S
95	NUDH-YJ-6	44	14.00	36.00	50.00	1020.00	0.083	0.038	0.061	7	MS
96	OMK-4	45	10.00	23.42	44.00	756.30	0.067	0.063	0.065	7	MS
97	PAB 04-10	46	5.32	12.83	24.61	416.92	0.064	0.053	0.059	5	MR
98	PAB 05-16	46	2.76	9.50	19.00	305.70	0.087	0.054	0.071	5	MR
99	PAB 05-19	46	6.30	13.00	23.46	418.20	0.053	0.048	0.051	5	MR
100	PAB 09-05	46	6.00	17.00	21.50	461.25	0.078	0.019	0.049	5	MR
101	PAB 09-07	44	15.00	34.32	56.00	1047.30	0.072	0.059	0.066	9	S
102	PAB-2004-4	46	4.40	10.70	17.50	324.75	0.064	0.038	0.051	5	MR
103	PAB-2005-16	46	3.28	10.00	16.50	298.35	0.079	0.038	0.059	5	MR
104	PBR-384	42	18.00	32.00	48.00	975.00	0.051	0.045	0.048	7	MS
105	PBR-422	44	15.00	34.00	50.00	997.50	0.071	0.044	0.058	7	MS
106	PHR-2	48	2.64	4.50	6.50	116.25	0.037	0.026	0.032	3	R
107	PMH-12-1	40	20.68	38.00	55.65	1142.48	0.057	0.048	0.053	9	S
108	PMH-12-2	45	10.50	27.00	42.80	804.75	0.076	0.047	0.062	7	MS
109	PMH-12-3	44	14.34	27.00	40.00	812.55	0.053	0.039	0.046	7	MS

110	PPBJ 4	46	6.51	15.00	23.00	446.32	0.062	0.035	0.049	5	MR
111	PPBJ 5	46	5.00	11.50	21.50	371.25	0.06	0.05	0.055	5	MR
112	PPBJ-2	46	6.50	13.45	22.76	421.20	0.054	0.043	0.049	5	MR
113	PPBJ-3	46	5.00	11.00	22.00	367.50	0.057	0.055	0.056	5	MR
114	PPBN 3	46	7.50	15.00	23.00	453.75	0.052	0.035	0.044	5	MR
115	PPBN-2	46	5.00	13.00	24.00	412.50	0.069	0.05	0.060	5	MR
116	PPBR-2	40	24.24	44.00	64.92	1328.70	0.06	0.057	0.059	9	S
117	PR-2006-14	41	10.00	24.00	46.50	783.75	0.07	0.067	0.069	7	MS
118	PR-2008-1	43	9.50	21.00	38.00	671.25	0.062	0.056	0.059	7	MS
119	PR-2009-12	44	13.52	28.00	43.00	843.90	0.061	0.044	0.053	7	MS
120	PRB-2004-3-4	42	12.00	29.00	48.50	888.75	0.073	0.056	0.065	7	MS
121	PRB-2008-5	44	14.00	25.83	41.50	803.70	0.051	0.047	0.049	7	MS
122	PRB-2008-5	44	16.50	35.00	49.50	1020.00	0.067	0.04	0.054	7	MS
123	PRE-2007-6	40	22.00	43.00	65.00	1297.50	0.066	0.06	0.063	9	S
124	PRE-2010-15	44	16.62	31.00	48.00	949.65	0.054	0.048	0.051	7	MS
125	PRE-2010-19	42	11.32	30.00	49.00	902.40	0.081	0.054	0.068	7	MS
126	PRL-2009-3	44	15.12	37.00	49.00	1035.90	0.079	0.033	0.056	7	MS
127	PRL-2010-10	43	12.45	38.00	46.50	1012.13	0.097	0.023	0.060	7	MS
128	PRO-5111	45	9.76	21.00	36.50	661.95	0.06	0.051	0.056	7	MS
129	PT-2006-4	40	27.00	48.00	67.86	1431.45	0.061	0.055	0.058	9	S
130	PT-2008-2	42	12.70	33.00	55.50	1006.50	0.081	0.062	0.072	9	S
131	PT-2010-10	40	20.58	45.00	64.50	1313.10	0.077	0.053	0.065	9	S
132	PT-303	46	13.00	29.00	51.50	918.75	0.067	0.064	0.066	9	S
133	PTE-2008-02	42	17.85	41.00	58.00	1183.88	0.077	0.046	0.062	9	S
134	PYS-2007-10	40	20.00	43.00	64.00	1275.00	0.074	0.057	0.066	9	S
135	PYS-2008-5	40	25.00	47.00	64.00	1372.50	0.065	0.046	0.056	9	S
136	RAUDT-10-18	40	24.00	47.00	68.00	1395.00	0.069	0.058	0.064	9	S
137	RAUDT-10-33	46	11.00	24.00	36.00	712.50	0.062	0.038	0.050	7	MS
138	RAUDYS-10-07	40	22.86	43.00	64.00	1296.45	0.062	0.057	0.060	9	S
139	RAUDYS-10-12	40	21.00	41.00	60.00	1222.50	0.064	0.051	0.058	9	S
140	RAURD 09-25	44	16.00	29.00	44.41	888.07	0.051	0.045	0.048	7	MS
141	RAURD 9-78	44	14.00	35.00	56.50	1053.75	0.08	0.059	0.070	9	S
142	RAURD-09-212	41	12.38	34.00	56.50	1026.60	0.086	0.062	0.074	9	S
143	RAURD-09-32	44	13.00	34.00	54.00	1012.50	0.082	0.055	0.069	9	S
144	RAURDL-02-01	43	13.87	34.69	52.00	1014.38	0.079	0.047	0.063	9	S
145	RB-57	44	16.50	40.00	54.00	1128.75	0.081	0.038	0.060	9	S
146	RB-59	44	13.00	25.63	43.20	805.95	0.056	0.053	0.055	7	MS
147	RB-64	45	10.82	23.00	39.00	718.65	0.06	0.051	0.056	7	MS
148	RGN-306	44	15.20	27.00	43.00	841.50	0.0418	0.047	0.048	7	MS
149	RGN-307	44	15.00	35.00	51.00	1020.00	0.074	0.044	0.059	9	S
150	RGN-308	42	17.00	33.10	52.00	1014.00	0.059	0.052	0.056	9	S
151	RGN-315	46	8.00	20.00	33.00	607.50	0.07	0.045	0.058	7	MS
152	RGN-321	40	22.44	45.00	64.00	1323.30	0.069	0.052	0.061	9	S
153	RGN-323	42	18.00	35.00	44.00	990.00	0.06	0.025	0.043	7	MS
154	RH 0749	40	23.42	48.00	61.00	1353.15	0.074	0.035	0.055	9	S
155	RH-0555A	44	13.00	30.00	50.00	922.50	0.07	0.056	0.063	7	MS
156	RH-0831	44	12.00	26.00	40.50	783.75	0.063	0.044	0.054	7	MS
157	RH-0834	41	12.84	33.00	50.00	966.30	0.08	0.047	0.064	7	MS
158	RH0901	44	12.00	26.00	43.00	802.50	0.063	0.051	0.057	7	MS
159	RH0902	44	16.00	33.00	55.00	1027.50	0.063	0.061	0.062	9	S
160	RH-0904	40	21.00	40.00	62.00	1222.50	0.061	0.06	0.061	9	S
161	RH0948	45	12.95	28.40	41.00	830.62	0.065	0.037	0.051	7	MS
162	RH-0952	45	12.00	21.00	33.50	656.25	0.044	0.043	0.044	7	MS
163	RH-903	44	14.00	32.00	49.00	952.50	0.071	0.048	0.060	7	MS
164	RHH-1101	44	16.00	35.00	48.50	1008.75	0.069	0.037	0.053	7	MS
165	RMM-10-1	40	21.00	46.00	58.00	1282.50	0.078	0.032	0.055	9	S
166	RMM-10-12	40	20.00	40.00	61.50	1211.25	0.065	0.058	0.062	9	S

167	RMM-9-12	43	9.00	22.00	43.37	722.77	0.07	0.067	0.069	7	MS
168	RMM-9-4	43	11.00	30.78	50.00	919.20	0.085	0.054	0.070	7	MS
169	RMT-08-2	42	18.00	40.00	60.00	1185.00	0.074	0.054	0.064	9	S
170	RMT-10-10	44	23.00	41.64	58.00	1232.10	0.058	0.044	0.051	9	S
171	RMT-10-7	40	23.31	43.00	62.00	1284.83	0.057	0.051	0.054	9	S
172	RMWR-09-4	44	16.54	34.00	43.00	956.55	0.064	0.025	0.045	7	MS
173	RMWR-09-5	44	13.30	25.20	42.00	792.75	0.052	0.051	0.052	7	MS
174	RMWR-09-6	44	12.50	25.00	43.50	795.00	0.056	0.056	0.056	7	MS
175	Rohini	44	15.40	39.22	58.00	1138.80	0.084	0.051	0.068	9	S
176	RRN-783	42	17.00	32.00	51.00	990.00	0.055	0.053	0.054	9	S
177	RRN-788	40	20.00	45.00	60.00	1275.00	0.079	0.04	0.060	9	S
178	RRN-789	44	15.00	34.30	51.00	1009.50	0.072	0.046	0.059	9	S
179	RRN-813	44	14.00	32.00	46.00	930.00	0.071	0.04	0.056	7	MS
180	RTM-10-10	40	22.42	42.00	61.00	1255.65	0.061	0.051	0.056	9	S
181	RTM-1351	40	27.60	49.00	68.50	1455.75	0.062	0.054	0.058	9	S
182	RTM-1359	44	17.00	36.00	54.00	1072.50	0.067	0.049	0.058	9	S
183	SKM-1013	44	16.24	31.76	45.00	935.70	0.058	0.038	0.048	7	MS
184	SKM-1040	42	19.00	34.00	53.00	1050.00	0.052	0.052	0.052	9	S
185	SKM-815	44	20.00	42.00	58.00	1215.00	0.071	0.043	0.057	9	S
186	SKM-B-817	42	12.00	25.00	42.53	783.97	0.06	0.053	0.057	7	MS
187	TK-17-14	44	16.24	37.00	58.50	1115.55	0.074	0.058	0.066	9	S
188	TKM-102	40	25.17	45.00	66.00	1358.78	0.059	0.058	0.059	9	S
189	TL-21	40	25.00	44.00	63.00	1320.00	0.057	0.052	0.055	9	S
190	TM-106	40	24.00	43.80	59.00	1279.50	0.06	0.041	0.051	9	S
191	TM-117	42	18.00	35.00	55.00	1072.50	0.06	0.055	0.058	9	S
192	Varuna	42	23.00	42.32	60.00	1257.30	0.06	0.048	0.054	9	S
193	YSB-9	42	19.72	40.00	60.00	1197.90	0.066	0.054	0.060	9	S
194	YSKM-12-1	40	27.52	46.74	66.00	1402.50	0.056	0.053	0.055	9	S
195	YSKM-12-2	40	22.00	47.00	66.00	1365.00	0.076	0.052	0.064	9	S
196	YSWB-2010/8	40	25.50	49.28	68.00	1440.45	0.069	0.052	0.061	9	S
197	YSWB-2011-10-1	40	30.00	51.00	70.00	1515.00	0.080	0.078	0.079	9	S
198	YSWB-2012/9	42	19.00	38.32	59.00	1159.80	0.065	0.056	0.061	9	S
199	YSWB-2014/3-12	40	28.00	49.51	69.00	1470.15	0.082	0.070	0.076	9	S
200	YSWB-20229/2-12	40	24.68	44.00	63.50	1321.35	0.058	0.053	0.056	9	S
Average			**15.67**	**31.24**	**47.50**	**936.25**	**0.066**	**0.044**	**0.055**		

DAS = Days after sowing and AUDPC = Area under disease progress curve

Among the treatments, minimum PDI (18.97% and 20.70%) was recorded with treatment T_{12} (Propiconazole 25% EC @ 0.10%) followed by treatment T_{11} (Propiconazole 25% EC @0.05%) 22.00% and 24.73%, T_8 (Hexaconazole 5% SC @ 0.10%) 23.30% and 25.27%, T_7 (Hexaconazole 5% SC @ 0.05%) 25.03% and 28.77% during both the years, respectively. Propiconazole 25% EC was found superior to all other treatments followed by Hexaconazole 5% SC at both concentrations (0.05% and 0.10%) during both the years. Maximum PDC (74.48% and 72.68%) was also recorded with treatment T_{12} (Propiconazole 25% EC @ 0.10%) followed by T_{11} (Propiconazole 25% EC @ 0.05%) 70.39% and 67.36%, T_8 (Hexaconazole 5% SC @ 0.10%) 68.64% and 66.65%, T_7 (Hexaconazole 5% SC @ 0.05%) 66.31% and 62.03% during both the years, respectively (Table2).

All the treatments reduced Area under the disease progress curve (AUDPC) in comparison to the untreated check. The minimum AUDPC of 510.75 and 562.28 was recorded in plots sprayed with (Propiconazole 25% EC @ 0.10%) followed by AUDPC of 588.98 and 645.90 in plots sprayed with same fungicide @ 0.05%, T_8 (Hexaconazole 5% SC @ 0.10%) 633.23 and 665.48, T_7 (Hexaconazole 5% SC @ 0.05%) 699.23 and 762.00 during both the years, respectively (Table-2).

A lot of findings were done by several scientists to manage Alternaria blight of mustard with the help of different fungicides time to time. (Singh and Singh, 2005[a]; Singh and Singh, 2005[b]; Kumar *et al.,* 2009; Singh *et al.,* 2013 and Singh *et al.,* 2015).Singh *et al.* (2013) have also reported the effectiveness of Propiconazole 25% EC @ 0.10% against the Alternaria blight of mustard.

On test weight and yield

0.05%) 1720.22 Kg/ha, T_8 (Hexaconazole 5% SC @ 0.10%) 1572.22 Kg/ha, T_7 (Hexaconazole 5% SC @ 0.05%) 1486.94 Kg/ha.Propiconazole 25% EC was found increased the test weight as well as yield over all other treatments followed by Hexaconazole 5% SC at both concentrations (0.05% and 0.1%). The highest per cent increase in yield (94.80%) was recorded in treatment T_{12} (Propiconazole 25% EC @ 0.10%) followed

Table 2: Effect of different Fungicidal treatments on the severity of Alternaria blight

Treatments	Year (2013-14)					Year (2014-15)				
	PDI			PDC	AUDPC on Leaves	PDI			PDC	AUDPC on Leaves
	After I Spray	After II Spray	After III Spray			After I Spray	After II Spray	After III Spray		
T_1	24.13	31.83	36.63	50.70	933.15	25.80	30.33	37.50	50.51	929.70
	(29.41)	(34.34)	(37.24)			(30.50)	(33.42)	(37.74)		
T_2	22.20	28.60	33.00	55.59	843.00	25.53	29.70	35.73	52.84	904.95
	(28.09)	(32.33)	(35.05)			(29.01)	(33.01)	(36.47)		
T_3	26.00	33.90	39.20	47.25	997.50	27.30	34.27	40.17	46.99	1020.08
	(30.62)	(35.59)	(38.76)			(31.25)	(35.82)	(39.33)		
T_4	25.50	32.63	37.27	49.85	960.23	24.77	31.23	37.90	49.98	938.48
	(30.21)	(34.79)	(37.59)			(29.71)	(33.97)	(37.97)		
T_5	34.20	43.83	48.47	34.78	1277.48	35.87	41.03	46.33	38.85	1231.95
	(35.76)	(41.45)	(44.12)			(36.76)	(39.83)	(42.90)		
T_6	31.40	37.97	43.97	40.83	1134.83	30.73	39.80	43.23	42.94	1151.70
	(34.09)	(38.09)	(41.53)			(33.66)	(39.12)	(41.10)		
T_7	21.40	23.40	25.03	66.31	699.23	22.17	25.33	28.77	62.03	762.00
	(27.52)	(28.88)	(29.94)			(28.07)	(30.13)	(32.41)		
T_8	19.13	21.00	23.30	68.64	633.23	19.80	21.83	25.27	66.65	665.48
	(25.90)	(27.22)	(28.82)			(26.41)	(27.82)	(30.17)		
T_9	35.40	45.60	49.87	32.89	1323.53	36.40	41.13	47.50	37.31	1261.20
	(36.50)	(42.47)	(44.93)			(37.08)	(40.48)	(43.57)		
T_{10}	33.00	39.77	44.40	40.25	1177.05	34.67	40.83	43.57	42.50	1199.25
	(35.04)	(39.07)	(41.78)			(36.04)	(39.71)	(41.30)		
T_{11}	17.67	19.43	22.00	70.39	588.98	18.33	21.53	24.73	67.36	645.90
	(24.81)	(26.13)	(27.94)			(25.28)	(27.64)	(29.82)		
T_{12}	15.27	16.93	18.97	74.48	510.75	15.93	19.17	20.70	72.68	562.28
	(22.94)	(24.21)	(25.76)			(23.50)	(25.91)	(27.06)		
T_{13}	58.63	66.20	74.27	-	1989.75	57.43	68.30	75.77	-	2023.50
	(49.98)	(54.48)	(59.50)			(49.28)	(55.74)	(60.52)		
SEm±	**1.22**	**1.25**	**1.32**			**1.22**	**1.13**	**1.13**		
CD at 5%	**3.57**	**3.64**	**3.85**			**3.55**	**3.31**	**3.30**		
CV%	**6.7**	**6.1**	**6.0**			**6.6**	**5.5**	**5.1**		

Note: Figure in parenthesis are angular transformed value, PDI = Percent Disease Intensity, PDC = Percent Disease Control and AUDPC = Area Under Disease Progress Curve.

T_1 = Sure (Carbendazim 12% + Mancozeb 63% WP) @ 0.20%, T_2 = Sure (Carbendazim 12% + Mancozeb 63% WP) @ 0.30%, T_3 = Sectin (Fenamidon 10% + Mancozeb 50% WG) @ 0.10%, T_4 = Sectin (Fenamidon 10% + Mancozeb 50% WG) @ 0.20%, T_5 = Melody (Iprovelicarb 5.5% + Propineb 61.25% WP) @ 0.20%, T_6 = Melody (Iprovelicarb 5.5% + Propineb 61.25% WP) @ 0.30%, T_7 = Krizole (Hexaconazole 5% SC) @ 0.05%, T_8 = Krizole (Hexaconazole 5% SC) @ 0.10%, T_9 = Moncerin (Pencycuron 22.9% SC) @ 0.05%, T_{10} = Moncerin (Pencycuron 22.9% SC) @ 0.10%, T_{11} = Result (Propiconazole 25% EC) @ 0.05%, T_{12} = Result (Propiconazole 25% EC) @ 0.10%, T_{13} = Control (Untreated)

by treatment T_{11} (Propiconazole 25% EC @ 0.05%) 82.14%, T_8 (Hexaconazole 5% SC @ 0.10%) 66.47%, T_7 (Hexaconazole 5% SC @ 0.05%) 57.44%. All the treatments could avoid both test weight loss as well as yield loss. Highest test weight loss (34.92%) was avoided with treatment T_{12} (Propiconazole 25% EC @ 0.10%) followed by treatment T_{11} of same fungicide @ 0.05% (30.51%), T_8 (Hexaconazole 5% SC @ 0.10%) 28.07%, T_7 (Hexaconazole 5% SC @ 0.05%) 25.93%. The highest yield loss (48.67%) was avoided with treatment T_{12} (Propiconazole 25% EC @ 0.10%) followed by treatment T_{11} of same fungicide @ 0.05% (45.10%), T_8 (Hexaconazole 5% SC @ 0.10%) 39.93%, T_7 (Hexaconazole 5% SC @ 0.05%) 36.48% (Table 3). Singh *et al.*, (2013) reported maximum test weight and yield was recorded with Propiconazole 25 EC @ 0.1% (1366.66 Kg/ha and 6.057g). He also reported maximum test weight as well as yield loss was avoided with Propiconazole 25 EC @ 0.1%.

Economics of fungicidal treatment

The maximum B:C ratio of 7.35:1 was recorded in treatment T_7 (Hexaconazole 5% SC @ 0.05%) followed by treatment T_{11} (Propiconazole 25% EC @ 0.05%) of 6.76:1, T_8(Hexaconazole 5% SC @ 0.10%) 6.30:1, T_{12} (Propiconazole 25% EC @ 0.10%) 4.74:1. Singh *et al.*, (2013[b]) reported maximum benefit-cost ratio of 6.79:1 was obtained with Propiconazole 25% EC @

Table 3: Effect of different Fungicidal treatments on test weight and yield

Treatments	Test Weight (g)				Yield (Kg/ha)				
	Year			Avoidable Test Weight Loss (%)	Year			Per cent Yield Increase	Avoidable Yield Loss (%)
	2013-14	2014-15	Average		2013-14	2014-15	Average		
T_1	5.10	5.21	5.16	20.47	1444.40	1361.10	1402.78	48.53	32.67
T_2	5.30	5.17	5.24	21.68	1472.20	1413.00	1442.61	52.75	34.53
T_3	5.00	5.10	5.05	18.81	1183.30	1155.20	1169.28	23.81	19.23
T_4	5.17	5.07	5.12	19.92	1190.80	1173.00	1181.88	25.14	20.09
T_5	4.83	4.50	4.67	12.11	1083.30	1052.70	1068.00	13.08	11.57
T_6	4.87	4.60	4.74	13.41	1163.90	1129.60	1146.72	21.42	17.64
T_7	5.47	5.60	5.54	25.93	1527.80	1446.10	1486.94	57.44	36.48
T_8	5.60	5.80	5.70	28.07	1583.30	1561.10	1572.22	66.47	39.93
T_9	4.67	4.40	4.54	9.59	1027.80	989.78	1008.78	6.81	6.38
T_{10}	4.77	4.67	4.72	13.14	1111.10	1041.30	1076.22	13.95	12.24
T_{11}	5.77	6.03	5.90	30.51	1750.00	1690.40	1720.22	82.14	45.10
T_{12}	6.23	6.37	6.30	34.92	1847.20	1832.30	1839.78	94.80	48.67
T_{13}	4.20	4.00	4.10	-	972.22	916.66	944.44	-	0.00
SEm±	0.27	0.26			106.72	105.71			32.67
CD at 5%	0.78	0.75			311.45	308.49			
CV%	9.00	8.50			13.80	14.00			

0.1% (Table 4). Singh *et al.* (2013) reported Tilt (Propiconazole 25 EC) @ 0.1% and 0.075% was next effective fungicide for reduction of Alternaria blight intensity as well as AUDPC and increasing test weight and yield after Quintal (Iprodione 25% + Carbendazim 25%) @ 0.2% but, in our studies Propiconazole 25% EC @ 0.10% was found most effective followed by Hexaconazole @ 0.10%. Singh and Maheshwari (2003) have also reported two spraying of Contaf 5E (Hexaconazole) @ 0.05% at 15 days intervals as most effective for the control of disease and increasing yield.

Table 4: Economics of different treatments for the management of Alternaria blight

Treatments	Additional yield over control (Kg/ha)	Additional income (Rs/ha)	Cost of protection (Rs/ha)	Net income (Rs/ha)	Benefit-Cost ratio (Rs/ha)
T_1	458.34	13750.05	5520.00	8230.05	1.49
T_2	498.17	14945.10	7620.00	7325.10	0.96
T_3	224.84	6745.05	9750.00	-3004.95	-0.31
T_4	237.44	7123.20	18180.00	-11056.80	-0.61
T_5	123.56	3706.65	13380.00	-9673.35	-0.72
T_6	202.28	6068.25	19410.00	-13341.75	-0.69
T_7	542.50	16274.85	1950.00	14324.85	7.35
T_8	627.78	18833.25	2580.00	16253.25	6.30
T_9	64.33	1930.05	2955.00	-1024.95	-0.35
T_{10}	131.78	3953.40	4590.00	-636.60	-0.14
T_{11}	775.78	23273.25	3000.00	20273.25	6.76
T_{12}	895.34	26860.05	4680.00	22180.05	4.74
T_{13}	-	-	-	-	-

Note: Mustard price – Rs 3000.00/q, Labour charge – 140/day, Sprayer charge – 20/day, Sure – Rs 700.00/Kg, Melody – Rs 2010/Kg, Sectin – Rs 2810/Kg, Krizole – Rs 420/lit, Moncerin – Rs 1090/lit and Propiconazole – Rs 1120/lit.

Conclusion

It is concluded that the low productivity may be due to several biotic and abiotic stresses. Alternaria blight caused by *Alternaria brassicae* and *Alternaria brassicicola* is one of the most severe yield destabilizing factors causing a reduction in yield. The ideal and most economical means of managing the Alternaria blight disease is the use of resistant varieties. Till date, no resistant variety is available. In present findings, out of 200 genotypes screened none of the genotypes were found disease-free or highly resistant, only 7 genotypes namely (DLSC-1, DRMR-261, DRMR-270, GSC-101, GSL-1, NPC-20, and PHR-2) were found resistant. In the absence of resistant cultivars, chemical fungicides provide the most reliable means of disease control. In management experiment, 3

sprays of newly molecules of 6 fungicides were tested. Out of which Propiconazole 25% EC @ 0.10% was found most effective in reducing the disease severity. The maximum B:C ratio was recorded with three sprays of Hexaconazole 5% SC @ 0.05% followed by Propiconazole 25% EC @ 0.05%.

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