

# Yield Loss Assessment due to Alternaria Blight Disease in Rapeseed and Mustard

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## ABSTRACT

An experiment was conducted to assess the yield losses due to Alternaria blight in different released cultivars of rapeseed-mustard during Rabi 2016-17 and 2017-18 planting 15 varieties of the rapeseed-mustard namely RH-749, Pusa gold, KBS-3, GSL-5, GSL-2, Pusa mustard-27, Jhumka, Anuradha, PT-30, T-27, PM-25, Pusa aditya, PT-303, Sheetal, TMLC-2 in six replications. The minimum disease severity on leaves and pods were recorded in protected and unprotected conditions in the variety GSL-5 (2.65% and 16.26%), (1.75% and 6.32%) followed by GSL-2 (3.20% and 19.72%), (1.89% and 6.75%) Pusa aditya (6.91% and 19.89%), (2.18% and 7.20%) and Sheetal (7.99% and 23.13%), (3.21% and 7.43%), respectively. On the basis of mean values the minimum infection rate on pods was recorded GSL-2 (0.083 and 0.042) followed by Pusa aditya (0.089 and 0.045), respectively. The minimum AUDPC on leaf under protected and unprotected was recorded on cultivar GSL-5 (76.40 and 496.20) followed by GSL-2 (88.80 and 596.85), Pusa aditya (205.35 and 588.25), Sheetal (241.70 and 717.30) and RH-749 (244.95 and 950.85), respectively. Whereas the minimum AUDPC on pod was recorded with variety GSL-5 (32.10) and Pusa aditya (200.25) followed by [GSL-2 (34.65) and Sheetal (206.65)], [Pusa aditya (39.35) and RH-749 (566.41)] and [Sheetal (60.95) and Pusa mustard-27 (741.75)], respectively. The maximum yield avoidable loss (%) was recorded T-27 (46.67%) followed by Jhumka (44.53%, Anuradha (40.00%), KBS-3 (38.77%) and Pusa gold (34.13%), respectively. Minimum avoidable loss (%) was recorded on cultivar GSL-5 (11.09%) followed by Anuradha (14.36%), GSL-2 (17.73%), RH-749 (17.90%) and Pusa aditya, respectively. In present investigation out of 15 genotypes examined for blight resistance, GSL-5, Pusa Aditya, Sheetal and GSL-2 exhibited good level of partial resistance i.e. moderately resistance. Other 11 varieties RH-749, Pusa gold, Pusa mustard-27, Jhumka, Anuradha, PT-30, PT-303, T-27, KBS-3, TMLC-2 and PM-25 were susceptible based on the mean basis severity (PDI), reduced apparent infection rate and lesser value of AUDPC.

## KEYWORDS

Rapeseedmustard, variety, yield loss, fungicides, Alternaria brassicae

## ARTICLE INFO

Received on	:	12/04/2021
Accepted on	:	05/07/2021
Published online	:	05/09/2021



## INTRODUCTION

Rapeseed-mustard is one of the major oilseed crops cultivated in India and around the world. It is extensively grown traditionally as a pure crop as well as intercrop (mixed crop) in marginal and sub-marginal soils in the eastern, northern and north-western States of India (Singh *et al*, 2017). Rapeseed and mustard belong to family Brassicaceae, Indian mustard commonly known as *rai* is the most important member of Cruciferous oil seeds occupying nearly 70 per cent of the total area under rapeseed-mustard (Singh *et al*, 2014b). The leaves of young plants are used as green vegetable and whole plants as green fodder. The seeds are highly nutritive containing 38 to 57 per cent erucic acid, 4.7 to 13 per cent linoleic acid and 27 per cent oleic acid (Singh *et al*, 2011). The rapeseed and mustard group dominates among oilseed crops in area and production on global level. India is one of the largest rapeseed-mustard growing countries in the world, occupying the third position in area and

production after China and Canada sharing 12 per cent of world's total production. At global level, rapeseed-mustard is cultivated on 5.96 million hectares with production of 8.32 million tonnes and productivity of 1397 kg/ha (Anonymous, 2018). Rapeseed-mustard is the second most important oilseed crop after groundnut and accounts for nearly 30.7 per cent of the total oilseed production in the country. There are several diseases known to affect the mustard crop but foliar diseases like Alternaria leaf spot, white rust (blister), downy and powdery mildews cause heavy yield losses to the crop. Alternaria blight caused by *Alternaria brassicae* (Berk.) Sacc and *Alternaria brassicicola* (Schw) Wiltshere is a world-widely distributed and economically important disease on rapeseed (*Brassica napus*), mustard (*Brassica campestris*) and other brassicas (Singh *et al*, 2014a), Tewari and Conn (1993), Kumar (1997), Meah *et al* (2002), Meena *et al* (2010). The characteristic symptom is the development of circular spots on leaves and pods with concentric ring. Later on spots coa-

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lesce and ultimately the leaves become blighted. This disease is severe yield destabilizing factor causing reduction from 35 to 45 per cent and inflicts very severe losses up to 70 per cent in Indian mustard (Chattopadhyay, 2008). The disease also adversely affects quality by reducing seed size, impairing seed colour and oil content (Kaushik *et al*, 1984). There is no information available on the resistance sources. Chemicals are being successfully used in controlling the disease (Meah *et al*, 2002). However, chemicals pollute our environment so much which is not desirable, so the present study was conducted to assess the yield losses due to *Alternaria* blight in different cultivars.

## MATERIALS AND METHODS

The experiment was conducted during Rabi 2016-17 and 2017-18 at Student's Instructional Farm of the Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (located at 26° 47'N, 82° 12'E) by planting 15 varieties of the rapeseed- mustard namely RH-749, Pusa gold, KBS-3, GSL-5, GSL-2, Pusa mustard-27, Jhumka, Anuradha, PT-30, T-27, PM-25, Pusa aditya, PT-303, Sheetal, TMLC-2 in six replications in Randomized Block Design having plot size of 4.0 m x 3.0 m with an spacing of 30 cm x 15 cm row to row and plant to plant, respectively. Fertilizers NPK were applied at the rate of 120 N, 60 P, 60 K, kg/ha, respectively. Half dose of nitrogen, full dose of phosphorus and potash were applied as basal and remaining half dose of nitrogen was top dressed at first irrigation. Three replications were protected and three replications were unprotected. Half seeds of each variety were treated with Apron @ 6g/kg seed separately before sowing and were sown only in protected plots. Unprotected plots were sown by untreated seeds of each cultivar separately. The three sprays of Trifloxystrobin 25% + Tebuconazol 50% (Nativo) @ 0.08% were given starting from first appearance of disease followed by 15 days intervals in the protected plots. Disease severities in protected and unprotected plots were recorded separately on lower, middle and upper leaves of randomly selected 10 plants in each treatment and replication after 10 days of last spray and on pods at 15 days before harvest through 0-9 rating scale as per recommendation of Proceedings of All India Coordinated Research Project on Rapeseed- Mustard, 2017, Sewar, Bharatpur, Rajasthan 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)] and genotypes were classified based on the highest of the two years disease score. The per cent disease index (PDI) was calculated by employing formula mentioned below:

$$PDI = \frac{\text{Sum of all numerical rating} \times 100}{\text{Total no. of leaves observed} \times \text{Maximum rating}}$$

### Infection rate (r)

The period from the initial appearance of symptoms and the final incidence of the disease was also considered and the apparent infection rate of the disease spread was calculated according to the following formula (der Plank, 1963).

$$\text{Infection Rate (r)} = \frac{2.3}{t_2 - t_1} \log_e \frac{x_2(1 - x_1)}{x_1(1 - x_2)}$$

Where,

$t_1$  = time during first observation

$t_2$  = time (days) during second observations

$t_2 - t_1$  = time intervals between two observations

$x_1$  = percent disease intensity value in decimal at corresponding  $t_1$  time

$x_2$  = percent disease intensity value in decimal at corresponding  $t_2$  time

Log e = natural log

### Area under disease progress curve (AUDPC)

The Area Under Disease Progress Curve (AUDPC) was calculated by the formula as under:

$$AUPDC = \sum_{i=1}^n [Y_{i+1} + Y_i] \times 0.5 [T_{i+1} + T_i]$$

Where

$Y_i$  = Alternaria blight severity (%) at the  $I^{st}$  observation

$T_i$  = Time (days) of the  $I^{st}$  observation

$n$  = Total number of observations

### Avoidable Yield loss

Yield (kg/plot) and test weight (g/1000 seed) was recorded in each treatment separately to know the difference in yield between unprotected and protected condition and yield kg/ha was calculated. Test weight of seed of each treatment was recorded as g/1000 seed weight. The avoidable Yield loss was calculated by employing formula mentioned below:

$$\text{Avoidable yield loss} = \frac{Y_p - Y_{up}}{Y_p} \times 100$$

Where,

$Y_p$  = Yield under protection condition

$Y_{up}$  = Yield under unprotected condition

## RESULTS AND DISCUSSION

Yield losses due to *Alternaria* blight disease in different 15 varieties of rapeseed-mustard perusal of the Table 6 indicates the less disease severity on leaves and pods were recorded in protected plots in comparison to unprotected plots in each cultivar (Table 1 and Table 3). The minimum disease severity on leaves and pods were recorded in protected and unprotected conditions in the variety GSL-5 (2.65% and 16.26%), (1.75% and 6.32%) followed by GSL-2 (3.20% and 19.72%),

(1.89% and 6.75%) Pusa aditya (6.91% and 19.89%), (2.18% and 7.20%) and Sheetal (7.99% and 23.13%), (3.21% and 7.43%), respectively (Table 1 and 3). Varied per cent disease severity in rapeseed-mustard has been recorded under protected and unprotected conditions by several workers (Gupta *et al*, 2018). Infection rate recorded on leaves under protected and unprotected conditions varied from 0.031 to 0.070 and 0.048 to

0.092, respectively and minimum infection rate on leaves was recorded on cultivar [Sheetal (0.031) and T-27 (0.048)] followed by [Pusa aditya (0.035) and GSL-2 (0.052)], [TMLC-2 (0.035) and GSL-5 (0.052)] and GSL-5 (0.037) and Sheetal (0.056)], respectively (Table 2 and Table 4).

**Table 1:** Disease severity of Alternaria blight on leaves under protected and unprotected conditions in different rapeseed-mustard varieties during 2016-2017 and 2017-18 (Pooled data)

Genotypes	First appearance of disease (DAS)	Percent disease severity on leaves under unprotected conditions (DAS)					AUDPC	Percent disease severity on leaves under protected conditions (days after sowing)					AUDPC
		65	75	85	95	Mean		65	75	85	95	Mean	
RH-749	50	12.10 (20.36)	26.76 (31.18)	34.40 (35.91)	55.75 (48.33)	32.25 (33.95)	950.85	2.44 (8.91)	4.45 (12.11)	10.85 (19.19)	15.95 (23.50)	8.42 (15.93)	244.95
Pusa gold	52	20.20 (26.71)	43.40 (41.21)	51.80 (46.03)	75.08 (60.07)	47.62 (43.51)	1428.40	7.33 (15.68)	16.07 (23.66)	22.35 (28.25)	34.67 (36.09)	20.10 (25.92)	594.20
KBS-3	51	22.46 (28.32)	53.66 (47.12)	66.83 (54.82)	72.06 (58.12)	53.75 (47.10)	1677.50	5.75 (13.81)	16.00 (23.56)	20.74 (27.06)	32.20 (34.57)	18.67 (24.75)	557.15
GSL-5	60	6.36 (4.65)	12.47 (20.70)	21.72 (27.76)	24.50 (29.67)	16.26 (20.69)	496.20	1.51 (7.04)	2.31 (8.72)	2.37 (8.91)	4.41 (12.11)	2.65 (9.19)	76.40
GSL-2	59	7.33 (15.68)	15.13 (22.07)	25.36 (32.66)	31.06 (33.89)	19.72 (25.67)	596.85	1.75 (7.49)	2.16 (8.53)	2.78 (9.63)	6.13 (14.30)	3.20 (9.99)	88.80
Pusa mustard-27	50	13.33 (21.39)	34.26 (35.85)	45.88 (42.65)	56.10 (48.50)	37.39 (37.09)	1148.55	3.21 (10.31)	11.71 (20.00)	16.20 (23.73)	18.20 (25.25)	12.33 (19.82)	386.15
Jhumka	50	17.33 (24.58)	35.83 (36.51)	66.05 (54.39)	74.66 (59.80)	48.46 (43.82)	1478.75	12.56 (20.79)	21.93 (27.90)	28.36 (32.20)	38.53 (38.35)	25.34 (29.81)	758.35
Anuradha	49	17.30 (24.58)	42.60 (40.74)	53.70 (47.12)	79.55 (63.15)	48.29 (43.89)	1447.25	16.01 (33.66)	24.41 (29.80)	35.87 (36.81)	43.33 (41.15)	29.90 (35.35)	899.50
PT-30	50	25.30 (30.20)	40.35 (39.37)	56.00 (48.45)	84.50 (66.81)	51.53 (46.23)	1512.50	14.31 (22.22)	23.30 (28.86)	28.03 (31.95)	41.50 (40.11)	26.78 (30.78)	729.35
T-27	50	30.50 (32.52)	41.93 (40.34)	53.53 (47.01)	65.16 (53.85)	47.73 (43.68)	1432.9	15.13 (22.87)	24.68 (29.80)	30.30 (33.40)	42.50 (40.69)	28.15 (31.69)	837.95
PM-25	54	13.26 (21.32)	30.38 (33.77)	46.18 (42.82)	57.02 (49.02)	36.71 (36.75)	1117.00	7.64 (16.00)	12.71 (20.80)	19.73 (26.35)	24.60 (29.73)	16.17 (23.24)	485.60
Pusa aditya	60	9.16 (17.66)	14.50 (22.38)	23.58 (29.06)	32.33 (34.63)	19.89 (25.93)	588.25	3.86 (11.39)	5.33 (13.31)	8.10 (16.54)	10.35 (18.72)	6.91 (14.99)	205.35
PT-303	47	25.76 (30.53)	35.64 (26.63)	50.80 (45.46)	74.66 (59.80)	46.71 (43.11)	1366.50	12.70 (20.88)	19.26 (26.06)	27.37 (31.56)	32.66 (34.88)	22.99 (22.34)	693.10
Sheetal	50	8.34 (16.74)	18.63 (25.55)	32.30 (34.63)	33.26 (35.24)	23.13 (28.04)	717.30	4.10 (11.68)	7.12 (15.45)	9.25 (17.66)	11.50 (19.82)	7.99 (16.15)	241.70
TMLC-2	52	32.24 (34.57)	55.32 (48.04)	66.36 (54.57)	86.75 (68.61)	60.16 (51.45)	1811.75	17.10 (24.43)	30.71 (33.65)	38.10 (38.12)	45.71 (42.53)	32.91 (34.68)	1002.15
<b>Mean</b>		17.33 (23.19)	33.29 (34.57)	46.23 (42.73)	60.10 (51.30)			8.37 (16.85)	14.80 (22.63)	20.00 (26.56)	26.81 (31.18)		
<b>SEm±</b>		<b>0.64</b>	<b>0.56</b>	<b>0.61</b>	<b>0.40</b>			<b>0.86</b>	<b>0.83</b>	<b>0.7</b>	<b>0.51</b>		
<b>C.V</b>		<b>13.2</b>	<b>6.6</b>	<b>5.3</b>	<b>2.6</b>			<b>8.4</b>	<b>4.4</b>	<b>2.7</b>	<b>1.5</b>		
<b>C.D at 5%</b>		<b>1.85</b>	<b>1.63</b>	<b>1.77</b>	<b>1.15</b>			<b>2.49</b>	<b>2.41</b>	<b>2.08</b>	<b>1.48</b>		

**Table 2:** Apparent infection rate (R) of Alternaria blight on leaves under protected and unprotected conditions of rapeseed mustard varieties during 2016-2017 and 2017-18 (Pooled data)

Genotypes	Infection rate on leaf under unprotected conditions after 10 days intervals				Infection rate on leaf under protected conditions after 10 days intervals			
	65-75	75-85	85-95	Mean	65-75	75-85	85-95	Mean
RH-749	0.098	0.036	0.088	0.074	0.062	0.096	0.044	0.067
Pusa gold	0.111	0.034	0.103	0.082	0.088	0.041	0.061	0.063
KBS-3	0.138	0.055	0.024	0.072	0.114	0.032	0.064	0.070
GSL-5	0.074	0.067	0.015	0.052	0.043	0.003	0.064	0.037
GSL-2	0.065	0.064	0.028	0.052	0.021	0.026	0.082	0.043
Pusa mustard-27	0.122	0.049	0.041	0.071	0.138	0.038	0.014	0.063
Jhumka	0.098	0.125	0.041	0.088	0.067	0.034	0.046	0.049
Anuradha	0.126	0.045	0.093	0.088	0.053	0.055	0.031	0.046
PT-30	0.069	0.063	0.145	0.092	0.060	0.025	0.060	0.048
T-27	0.050	0.047	0.048	0.048	0.061	0.028	0.053	0.047
PM-25	0.105	0.068	0.044	0.072	0.056	0.052	0.028	0.045
Pusa aditya	0.052	0.060	0.044	0.052	0.034	0.045	0.027	0.035
PT-303	0.047	0.062	0.105	0.071	0.049	0.046	0.025	0.040
Sheetal	0.092	0.073	0.004	0.056	0.050	0.023	0.021	0.031
TMLC-2	0.096	0.047	0.120	0.088	0.076	0.033	0.025	0.035

On the basis of mean values infection rate was recorded on pods under protected and unprotected conditions varied from 0.083 to 0.121 and 0.042 to 0.122, respectively. Minimum infection rate on pods was recorded GSL-2 (0.083 and 0.042) followed by Pusa aditya (0.089 and 0.045), [PT-303 (0.095) and GSL-5 (0.044)] and Sheetal (0.107 and 0.046), respectively (Table 2 and Table 4). Kumar and Kolte (2001), Kumar and Kolte (2001) also reported from Pantnagar, mustard genotypes PR-8988 and PR-9024 exhibited reduced apparent infection rates as compared to susceptible genotypes Varuna.

The Area Under Disease Progress Curve (AUDPC) on leaves under protected and unprotected conditions ranged from 76.40 to 1002.15 and 496.20 to 1811.75, respectively. The minimum AUDPC was recorded on cultivar GSL-5 (76.40 and 496.20) followed by GSL-2 (88.80 and 596.85), Pusa aditya (205.35 and 588.25), Sheetal (241.70 and 717.30) and RH-749 (244.95 and 950.85), respectively. Whereas the AUDPC on pods under protected and unprotected conditions ranged from 32.10 to 356.0 and 200.25 to 2190.50, respectively. The minimum AUDPC was recorded on cultivars [GSL-5 (32.10) and Pusa aditya (200.25) followed by [GSL-2 (34.65) and Sheetal (206.65)], [Pusa aditya (39.35) and RH-749 (566.41)] and [Sheetal (60.95) and Pusa mustard-27 (741.75)], respectively

(Table 1 and Table 3).

The maximum yield avoidable loss (%) was recorded T-27 (46.67%) followed by Jhumka (44.53%), Anuradha (40.00%), KBS-3 (38.77%) and Pusa gold (34.13%), respectively. Minimum avoidable loss (%) was recorded on cultivar GSL-5 (11.09%) followed by Anuradha (14.36%), GSL-2 (17.73%), RH-749 (17.90%) and Pusa aditya, respectively (Table 6).

Kumar (2001) and Kumar and Kolte (2001) also assessed the field resistance to Alternaria blight (*Alternaria brassicae*) in nine genotypes of Brassica juncea genotypes under field conditions and reported three genotype viz., PR-8988, PR-9024 and Kranti resistance with lower per cent blight cover, apparent infection rate and AUDPC values. In present finding the lower AUDPC values clearly separated the mustard genotypes with high level of partial resistance. AUDPC has been used successfully to evaluate the progress of disease rate on different crops also (Kumar and Kolte, 2001; Kumar, 2008). Singh *et al* (2014c) 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. In present study, it is clear that genotypes with high level of resistance have good yield potential than susceptible ones.

**Table 3:** Disease severity of *Alternaria* blight on pods under protected and unprotected conditions in different rapeseed-mustard varieties during 2016-2017 and 2017-18 (Pooled data)

Genotypes	PDI on pods under unprotected conditions (Days after sowing)					AUDPC	PDI on pods under protected conditions (Days after sowing)					AUDPC
	85	95	105	115	Mean		85	95	105	115	Mean	
RH-749.	3.73 (11.09)	17.06 (24.43)	23.73 (29.13)	47.51 (43.57)	23.00 (27.05)	566.41	-	1.40 (6.80)	5.26 (13.31)	16.90 (24.27)	7.85 (14.79)	144.10
Pusa gold	7.46 (15.89)	22.26 (28.18)	43.12 (41.03)	58.16 (49.72)	32.7 (33.70)	981.90	-	4.45 (12.11)	10.26 (18.63)	31.23 (33.96)	15.31 (21.57)	281.00
KBS-3	3.83 (11.24)	17.43 (24.65)	35.47 (36.57)	51.25 (45.69)	26.99 (29.54)	804.40	-	3.80 (11.24)	8.32 (16.74)	25.82 (20.53)	12.65 (16.17)	231.30
GSL-5	3.68 (11.09)	3.65 (10.94)	5.89 (14.06)	12.09 (20.36)	6.32 (14.11)	1174.26	-	0.50 (4.05)	1.16 (6.29)	3.60 (10.94)	1.75 (7.09)	32.10
GSL-2	3.78 (11.24)	4.53 (12.25)	6.56 (14.89)	12.14 (20.36)	6.75 (14.68)	2190.50	-	0.76 (5.00)	1.25 (6.55)	3.67 (11.09)	1.89 (7.55)	34.65
Pusa mustard-27	3.90 (11.39)	13.53 (21.56)	34.26 (35.85)	48.87 (44.37)	25.14 (28.29)	741.75	-	2.70 (9.46)	6.60 (14.89)	19.03 (25.84)	9.44 (16.73)	174.65
Jhumka	5.23 (13.18)	22.10 (28.04)	41.83 (40.28)	66.40 (54.57)	33.89 (34.02)	997.45	-	5.22 (13.18)	15.46 (23.19)	35.16 (36.39)	18.61 (24.25)	356.50
Anuradha	4.40 (12.11)	20.56 (26.99)	31.19 (33.96)	64.26 (53.31)	30.10 (31.59)	860.80	-	4.81 (12.66)	14.04 (21.97)	33.61 (35.43)	17.49 (23.35)	332.50
PT-30	5.30 (13.31)	17.30 (24.58)	35.74 (36.69)	58.53 (49.89)	29.21 (31.12)	849.55	-	3.62 (10.94)	10.95 (19.28)	29.64 (32.96)	14.74 (21.06)	275.80
T-27	9.25 (11.25)	24.46 (29.67)	33.67 (35.49)	52.13 (46.20)	29.88 (32.15)	888.20	-	4.70 (12.52)	11.30 (12.64)	28.86 (32.46)	14.95 (21.54)	280.80
PM-25	3.66 (11.07)	19.53 (26.21)	34.16 (35.79)	60.10 (50.83)	29.36 (30.97)	855.70	-	6.45 (4.65)	14.96 (22.71)	32.66 (34.88)	18.02 (20.75)	345.15
Pusa aditiya	3.93 (11.39)	4.63 (12.39)	6.63 (14.89)	13.60 (21.64)	7.20 (15.08)	200.25	-	0.78 (5.07)	1.32 (6.55)	4.45 (12.11)	2.18 (7.19)	39.35
PT-303	4.43 (12.11)	32.00 (34.45)	33.65 (35.43)	53.63 (47.06)	30.93 (32.26)	946.80	-	5.44 (13.44)	13.59 (21.64)	27.95 (31.88)	15.66 (22.32)	302.85
Sheetal	3.98 (11.54)	4.78 (12.66)	6.83 (15.12)	14.13 (22.06)	7.43 (15.35)	206.65	-	0.79 (5.10)	2.56 (9.28)	6.28 (14.54)	3.21 (9.64)	60.95
TMLC-2	8.00 (16.43)	24.03 (29.33)	38.85 (38.53)	52.66 (46.55)	30.88 (32.71)	932.10	-	4.58 (12.39)	12.48 (20.70)	27.37 (31.56)	14.81 (21.55)	284.55
<b>Mean</b>	4.97 (12.69)	16.52 (23.09)	27.44 (30.51)	44.36 (39.72)				3.33 (9.24)	8.63 (16.09)	21.75 (25.92)		
<b>SEm±</b>	<b>0.43</b>	<b>0.71</b>	<b>0.53</b>	<b>0.51</b>				<b>0.32</b>	<b>0.50</b>	<b>0.60</b>		
<b>C.V</b>	<b>14.9</b>	<b>7.5</b>	<b>3.3</b>	<b>2.00</b>				<b>16.7</b>	<b>10.1</b>	<b>4.7</b>		
<b>C.D at 5%</b>	<b>1.23</b>	<b>2.05</b>	<b>1.52</b>	<b>1.47</b>				<b>0.72</b>	<b>1.46</b>	<b>1.73</b>		

**Table 4:** Apparent infection rate (R) of Alternaria blight on pods under protected and unprotected field conditions of rapeseed-mustard varieties during 2016-2017 and 2017-18 (Pooled data)

Genotypes	Infection rate on pods (10 days intervals) under unprotected conditions				Infection rate on pods (10 days intervals) under protected conditions			
	85-95	95-105	105-115	Mean	85-95	95-105	105-115	Mean
RH-749	0.167	0.041	0.107	0.105	-	0.136	0.130	0.113
Pusa gold	0.127	0.096	0.061	0.095	-	0.089	0.138	0.114
KBS-3	0.165	0.096	0.065	0.109	-	0.108	0.134	0.121
GSL-5	0.004	0.050	0.079	0.044	-	0.085	0.116	0.101
GSL-2	0.019	0.039	0.068	0.042	-	0.050	0.110	0.083
Pusa mustard-27	0.135	0.120	0.061	0.105	-	0.093	0.120	0.106
Jhumka	0.164	0.093	0.101	0.119	-	0.120	0.109	0.115
Anuradha	0.172	0.056	0.014	0.080	-	0.117	0.113	0.116
PT-30	0.132	0.098	0.093	0.108	-	0.118	0.123	0.121
T-27	0.115	0.045	0.076	0.079	-	0.095	0.116	0.106
PM-25	0.185	0.076	0.106	0.122	-	0.094	0.101	0.098
Pusa aditya	0.017	0.038	0.081	0.045	-	0.053	0.125	0.089
PT-303	0.232	0.007	0.082	0.107	-	0.100	0.090	0.095
Sheetal	0.019	0.038	0.081	0.046	-	0.119	0.094	0.107
TMLC-2	0.129	0.070	0.056	0.085	-	0.109	0.097	0.103

**Table 5:** Reaction of rapeseed-mustard genotypes against Alternaria blight under unprotected conditions on the mean basis

Rating scale (0-9)	Reactions	No. of entries	Genotypes
0	Highly resistant	NIL	-
3	Resistant	NIL	-
5	Moderately resistant	4	GSL-5, Pusa Aditya, Sheetal, GSL-2
7	Susceptible	11	TMLC-2, Anuradha, Pusa mustard-27, Pusa gold-45, Jhumka, KBS-3, PT-30, PT-303, T-27, PM-25, RH-749
9	Highly susceptible	NIL	-

Concurrent with present findings Prasad *et al* (2003) also conducted experiment on Indian mustard genotypes and reported reduction in disease from 16.1 to 72.6 per cent in different genotypes and highest yield loss of 20.0 to 32.5 per cent and maximum in cultivar Varuna. Kumar (1997) reported maximum average yield loss due to Alternaria brassicae in yellow sarson (27.28%) followed by brown sarson (25.01%), Indian mustard (20.28%), gobhi sarson (17.16) and Brassica carinata (10.72%), respectively. Different workers have also

evaluated the yield loss in rapeseed-mustard crop due to Alternaria brassicae causing blight time to time and reported 35-45 per cent yield loss and even more upto 70% in different cultivars (Kolte *et al*, 1987; Saharan, 1992; Kolte, 2002; Gupta *et al*, 2018). In the present finding the losses in yield may be due to reduction in pod formation or pod size or number of seeds/pods or test weight or in all the parameters collectively. Losses in test weight in each cultivar under unprotected condition support this view.

**Table 6:** Test weight, under protected and unprotected conditions and yield loss (%) in different varieties of rapeseed-mustard during 2016-2017 and 2017-18 (Pooled data)

Genotypes	1000 Seed weight (g)		Increase in 1000 seed weight	Avoidable loss (%)	Yield (kg/ ha <sup>-1</sup> )		Increase in yield (Kg)	Avoidable loss (%)
	Unprotected	Protected			Unprotected	Protected		
RH-749	3.38	4.86	1.48	30.45	2333.33	2722.22	388.89	17.90
Pusa gold	2.79	3.38	0.59	17.45	1222.22	1855.56	633.34	34.13
KBS-3	2.96	3.16	0.20	6.32	1000.00	1633.33	633.33	38.77
GSL-5	4.59	4.63	0.04	0.86	2844.85	3200.00	255.15	11.09
GSL-2	3.22	3.64	0.42	11.53	1855.56	2255.55	299.99	17.73
Pusa mustard-27	3.18	3.43	0.25	7.29	1433.33	1877.78	344.45	23.67
Jhumka	3.33	3.40	0.07	2.05	733.33	1322.20	588.87	44.53
Anuradha	3.78	3.87	0.09	2.32	1655.56	1933.33	177.77	14.36
PT-30	2.90	3.23	0.33	10.21	700.00	1166.66	336.66	40.00
T-27	2.90	3.14	0.24	7.64	533.33	1000.00	466.67	46.67
PM-25	4.42	4.52	0.10	2.21	1800.00	2500.00	900.00	28.00
Pusa aditya	4.23	4.47	0.24	5.37	2567.05	3155.56	388.51	18.64
PT-303	3.36	3.54	0.18	5.08	755.56	1125.55	266.70	32.29
Sheetal	4.36	4.40	0.04	0.91	1600.22	2055.55	355.33	22.15
TMLC-2	2.74	2.91	0.17	7.76	722.22	1089.89	266.67	33.73

## CONCLUSION

In present investigation out of 15 genotypes examined for blight resistance, GSL-5, Pusa Aditya, Sheetal and GSL-2 exhibited good level of partial resistance i.e. moderately resistance. Other 11 varieties RH-749, Pusa gold, Pusa mustard-27, Jhumka, Anuradha, PT-30, PT-303, T-27, KBS-3, TMLC-2 and PM-25 were susceptible based on the mean basis severity (PDI), infection rate and AUDPC. Minimum avoidable loss (%) was recorded on cultivar GSL-5 (11.09%) followed by Anuradha (14.36%), GSL-2 (17.73%), RH-749 (17.90%) and Pusa aditya, respectively. The maximum yield avoidable loss

(%) was recorded T-27 (46.67%) followed by Jhumka (44.53%), Anuradha (40.00%), KBS-3 (38.77%) and Pusa gold (34.13%), respectively.

## ACKNOWLEDGEMENT

The author is thankful to Director, Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan and Director Research, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya for support to the present research work.

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**Citation:**

Singh HK, Kumar P and Singh SK. 2021. Yield Loss Assessment due to Alternaria Blight Disease in Rapeseed and Mustard. *Journal of AgriSearch* **8**(3):241-248