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Screening of Mustard Germplasm against Powdery Mildew (*Erysiphe cruciferarum*) and Analysis of Yield Contributing Characters

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The current experiment was carried out at the Regional Agricultural Research Station (RARS) Polasa, Jagtial during *rabi* 2020-21, with the goals of (1) assessing the resistance of Indian mustard germplasm lines to powdery mildew disease and (2) analysing the yield and its contributing traits,

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days to 50% flowering, days to maturity, plant height in centimetres, primary branch number, secondary branch number, siliqua number and siliqua length in centimetres. The results of the analysis of variance showed that there were statistically significant differences between the genotypes and their characteristics. The genotypes *viz*., DRMR-150-35, Black gold, and RH-9304 performed best on average out of 50 different varieties for twelve different characteristics, including high seed yield per plant, high 1000-seed weight and high harvest index.Two resistant genotypes (GM-3 and Swarna Jyothi) and nine genotypes (Pusa mahak, PM-25, PM-26, PDZM-31, Pusa tarak, Pusa bahar, Ashirwad, DRMR-601, and JM-2) demonstrated considerable resistance reaction to the powdery mildew disease after being screened against the illness. We can solve the disease effect problem by utilizing these germplasm lines as donors in future breeding programme to develop powdery mildew resistant lines.

Keywords: Brassica juncea; Indian mustard; Erysiphe cruciferarum and powdery mildew.

1. INTRODUCTION

The oilseed sector plays a significant role in India's agricultural economy, as the country is the world's largest producer of oilseeds. Outside of grains, oilseeds are one of the country's most important agricultural exports. India is a global player in edible oil arena, being the 2nd largest importer, and 3rd largest consumer of edible oil as well as 4th largest oilseed producer [1].

Soybean (34%), Groundnut (27%), Rapeseed & Mustard (27%) contributes to more than 88% of total oilseeds production and >80% of vegetable oil with major share of mustard (35%), soybean (23%) and groundnut (25%) (NMOOP 2018). Rapeseed and mustard, Soybean and groundnut contribute 82% of total inland oilseed production. Two of the most perishable necessities are oilseeds and edible oils. Crops like these are second only to food grains in terms of total acreage, total production and total economic worth. According to the 3rd Advance Estimates published by the Ministry of Agriculture on 25.05.2021, India is expected to produce 36.56 million tonnes of nine cultivated oilseeds in 2020-21 (November-October). This sector occupies an important place in the agricultural economy (GOI, Department of Food and Public Distribution, Ministry of Consumer affairs, Food & Public Distribution (https://dfpd.gov.in/oil-division.htm).

Relay cropping of mustard can be taken up on at least 2 million hectares of paddy land in India, which remains fallow after the monsoon season of paddy farming, using residual moisture to produce an additional 3.5 to 4 million tonnes of rapeseed-mustard, according to mustard experts. In non-traditional mustard-growing regions, the proof of concept is already in place.

In 2018-2019, it was predicted that global rapeseed-mustard plantings would cover 36.59 million hectares (mha), produce 72.37 million tonnes (mt), and yield 1980 kilo grammes per hectare (kg ha^{-1}) as shown in Fig. 1. India accounts for 17.19% of the world's total land and 8.54% of global production (USDA) represented in Figs. 2 and 3. “Production has increased from 61.64 mt in 2010-11 to 72.42 mt in 2018-19, and productivity has increased significantly from 1840 kg ha^{-1} in 2010-11 to 1980 kg ha^{-1} in 2018-19” as shown in Fig. 1.

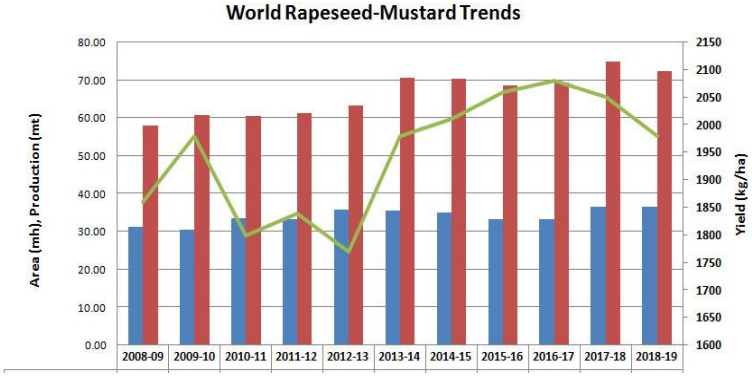

Fig. 1. Rapeseed-Mustard Production trends in World

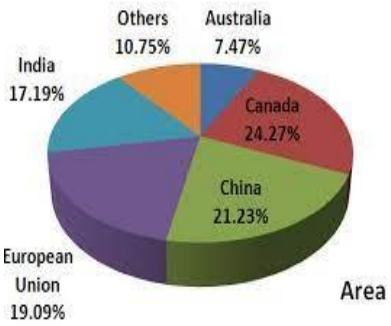

Fig. 2. Contribution of different countries in R&M acreage Average (2013-14 to 2018-19)

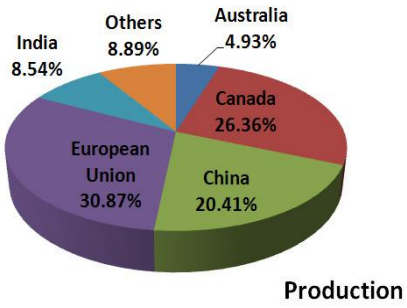

Fig. 3. Contribution of different countries in R&M production Average (2013-14 to 2018-19)

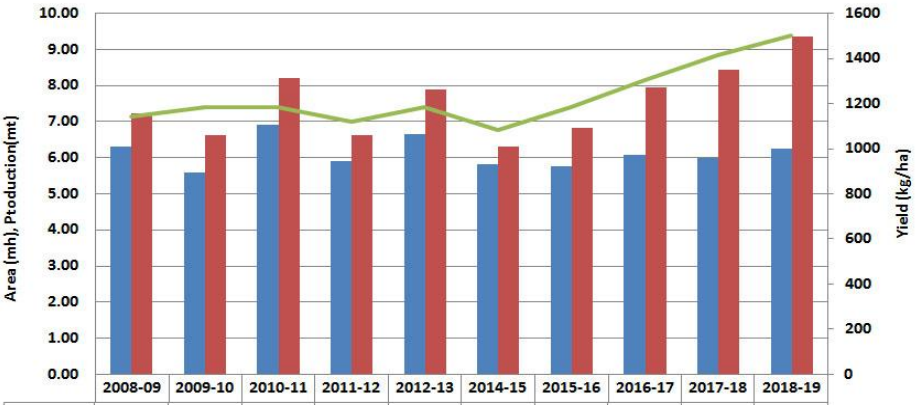

Fig. 4. Rapeseed-Mustard Production trends in India

In India, rapeseed and mustard are cultivated in a wide variety of agro-climatic settings, from the cool, wet and windy north-east to the hot, dry and humid south. When it comes to mustard, India has the biggest area at 5.96 million hectares, with output and productivity of 8.4 million tonnes and 1,410 kg ha^{-1}, respectively [2] as shown in Fig. 4. It is cultivated on an area of 3,000 ha in Telangana, yielding 4,780 tonnes per year with a productivity of 1,594 kg ha^{-1}. The districts of Adilabad, Jagtial, Karimnagar and Nizamabad in Northern Telangana are the areas where you'll find this as a summer crop [3].

The Solvent Extractor's Association (SEA) reports that between July 2018 and 2019, the import of vegetable oils increased by 26%, from 11.19 to 14.12 lakh tonnes. Reducing reliance on imported vegetable oils requires more land to be devoted to oil seed production. Only by breeding high-yielding variants (HYV) of oil seed crops can we increase our chances of getting the highest potential yield and oil content.

Mustard is primarily a rainfed crop in India, where it is subjected to a variety of biotic and abiotic stresses that reduce its output. One of the most damaging fungal disease is powdery mildew (*Erysiphe cruciferarum*), which causes significant losses in crops yield. Small, scattered, almost round colonies emerge first on the upper surface of the lowest leaves (old leaves) and under ideal conditions they spread until they cover the entire leaf surface. Powdery mildew not only stunts mustard's growth, but it also kills the plant's leaves [4].

Brassica juncea (43.2%) had the worst disease severity of all the Brassica species comparatively [5]. Growers currently rely heavily on chemical fungicides for the incomplete treatment of the disease, which is both costly and harmful to the environment. Though several fungicides have been tried for controlling powdery mildew, spraying them on a crop when it's still standing and in full bloom is challenging, costly, and unsustainable. The best, most reliable and cost-effective way to safeguard crops and guarantee

their good yield is through the use of genetic techniques, such as the exploitation of disease resistance. The only other solution to generate high-yielding mustard varieties that are resistant to the disease reaction by identifying resistant sources within the existing mustard germplasm. In this experiment the authors made an attempt to identify high-yielding mustard genotypes with resistance to powdery mildew disease.

Keeping in view of the economic importance of mustard and effect of powdery mildew disease in yield reduction, the present study was carried out to identify the resistant genotypes against powdery mildew disease.

2. MATERIALS AND METHODS

The current experiment was conducted with 50 genotypes of mustard during *rabi* 2020-21 at the Regional Agricultural Research Station (RARS) Polasa, Jagtial under the title "Screening of mustard germplasm against powdery mildew disease caused by *Erysiphe cruciferarum*. The study was set up utilising a Randomized Block Design (RBD) and two independent replicates. Two rows, each three metres in length were planted with each genotype, with 45 centimetres between rows and 10 centimetres inside each row. The seed was sown by dibbling it into the soil at a depth of two to three centimetres. During the time when the crops were actively growing, the full suite of recommended procedures was applied. The numbers were crunched using INDOSTAT Services' WINDOW STAT, version 8.6 on a PC.

The experimental material used in the present investigation comprised of 50 genotypes of mustard including two checks *viz.,* Black gold and NRCHB-101. The resistant genotypes were identified based on the natural screening against the mustard powdery mildew *Erysiphe cruciferarum*. Details of the genotypes evaluated are mentioned in the Table 1.

The data was recorded on yield and its contributing characters viz., days to 50% flowering, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of siliquae plant^{-1}, length of siliqua (cm), number of seed siliqua^{-1}, 1000 seed-weight (g), seed yield plant^{-1} (g), harvest index (%) and oil content (%) from five randomly selected plants in each replication.

Table 1. Details of fifty genotypes of mustard under investigation

S. No.	Name of the genotype	Source
1	Pusa Mahak	IARI, New Delhi
2	PM-25	IARI, New Delhi
3	PM-26	IARI, New Delhi
4	PM-27	IARI, New Delhi
5	PM-28	IARI, New Delhi
6	PM-29	IARI, New Delhi
7	PDZM-31	IARI, New Delhi
8	Pusa Jagannath	IARI, New Delhi
9	Pusa Jaikisan	IARI, New Delhi
10	Pusa Vijay	IARI, New Delhi
11	Pusa Tarak	IARI, New Delhi
12	Pusa Agrani	IARI, New Delhi
13	Varuna	DRMR, Bharatpur
14	Giriraj	DRMR, Bharatpur
15	GM-1	DRMR, Bharatpur
16	GM-2	DRMR, Bharatpur
17	GM-3	DRMR, Bharatpur
18	RB-50	DRMR, Bharatpur
19	RH-0406	DRMR, Bharatpur
20	RH-0119	DRMR, Bharatpur
21	RH-8812	DRMR, Bharatpur
22	RH-0725	DRMR, Bharatpur
23	RH-0749	DRMR, Bharatpur
24	RH-30	DRMR, Bharatpur
25	RH-9304	DRMR, Bharatpur

S. No.	Name of the genotype	Source
26	RH-9801	DRMR, Bharatpur
27	GDM-4	DRMR, Bharatpur
28	GDM-5	DRMR, Bharatpur
29	RSK-1328	DRMR, Bharatpur
30	RSK-1746	DRMR, Bharatpur
31	RSK-1620	DRMR, Bharatpur
32	RSK-1626	DRMR, Bharatpur
33	RSK-1712	DRMR, Bharatpur
34	RSK-1630	DRMR, Bharatpur
35	RGN-73	DRMR, Bharatpur
36	PBR-91	DRMR, Bharatpur
37	CS-52	DRMR, Bharatpur
38	RH-781	DRMR, Bharatpur
39	Vaibhav	DRMR, Bharatpur
40	Pusa Bahar	DRMR, Bharatpur
41	Urvashi	DRMR, Bharatpur
42	Satabdi	DRMR, Bharatpur
43	Vasundara	DRMR, Bharatpur
44	Ashirwad	DRMR, Bharatpur
45	DRMR-601	DRMR, Bharatpur
46	JM-2	DRMR, Bharatpur
47	Maya	DRMR, Bharatpur
48	Swarna Jyothi	DRMR, Bharatpur
49	Black gold (Susceptible check)	DRMR, Bharatpur
50	NRCHB-101 (Moderately resistant check)	DRMR, Bharatpur

2.1 Natural Screening for Powdery Mildew Resistance

A total of 50 different mustard genotypes were planted in a specially prepared plot in order to test their resistance disease reaction to powdery mildew in a realistic field setting during *rabi* 2020-21. The moderately resistant check, NRCHB-101, were planted in a single row of two metres length with a spacing of 30X10 cm. Screening was done using the infector row technique, in which two rows of susceptible check variety i.e., Black gold was sown across the field and in between the test entries after every 10 test entries to ensure consistent inoculum availability and it establishes the strong disease pressure.

The severity of powdery mildew disease was recorded 90 days after sowing when disease was recorded 9 score on susceptible check following 0-9 scale [6] as described below in Table 2. By selecting five plants randomly. The percent disease incidence [7] was recorded using the formula given below.

$$\text{Percent disease index (PDI)} = \frac{\text{Sum total of all the numerical ratings X 100}}{\text{Total number of plants observed X Maximum grade}}$$

Table 2. Disease scoring method for evaluation of mustard genotypes for resistance against powdery mildew

Score	Description	Type of reaction
0	No infection	Immune
1	1-10% leaf area infected	Resistance
3	11-25% leaf area infected	Moderate resistance
5	26-50% leaf area infected	Moderate susceptible
7	51-70% leaf area infected	Susceptible
9	71-100% leaf area infected	Highly susceptible

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance (ANOVA)

The mean sum of squares for yield and its contributing characters such as days to 50% flowering, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of siliqua plant^{-1}, siliqua length (cm), number of seeds siliqua^{-1}, 1000 seed-weight (g), seed yield plant^{-1}(g), harvest index (%) and oil content (%). The genotypes exhibited statistically significant variation for the mean performance across all characters studied and showing the presence of genetic diversity as shown in the Table 3.

The range of days to 50% flowering was 17 days wide from 33 to 50, with an average of 43 days. RSK-1746 flowers in 33 days, but Rajat blooms much later (50 days). Pusa Agrani (34 days) and Pusa Bold (21 days) are two other early-flowering genotypes (35 days). Averaging out at 90 days, the maturation periods ranged from 82 (Black gold) to 95 (Silver king) (PDZM-31). Out of 50 genotypes studied, PDZM-31 was the only one to mature 95 days after sowing, making it a late-maturing genotype. In contrast, Black gold matured at 82 days after sowing, making it an early-maturing genotype followed by RSK-1746 (84 days) and Pusa Agrani are two further early-maturing genotypes (86 days). Individual plant heights ranged from 103.35 cm (PDZM-31) to 206.20 cm (PDZM-2). The average plant height was 163.66 cm (RCC-4). The RCC-4 genotype was recorded to be the tallest, whereas PDZM-31 genotype was the shortest. RSK-1621 (123.45 cm) and Black gold (123.45 cm) are two other short genotypes (113.90 cm).

Primary branches per plant were found to have a mean value of 4.22, it ranging from a low of 2.50 (PDZM-31) to a high of 5.30 (RGN-298). Primary branches on the main stem are more numerous in the RGN-298 genotype than in the dwarfed PDZM-31 variety. Secondary branch variance plant^{-1} ranged from 2.70 (RSK-1630) to 17.00 (RB-50), with a mean value of 9.34. The RB-50 genotype was recorded the most secondary branches plant^{-1} to the other genotypes studied, whereas RSK-1630 genotype recorded the fewest.

An average of 235.36 siliquae were produced by each plant, with a range of 108.04 (PDZM-31) to 394.00 (RCC-4). The PDZM-31 genotype generated the fewest siliquae per plant, while the RCC-4 genotype produced the most followed by GDM-4 (373.39) and RH-0406 which showed higher siliquae yields per plant (368.87). A siliqua's length can be anywhere from 4.18 centimetres (PDZM-31) to 7.08 centimetres (PDZM-33) (Rajat). Among the 50 genotypes studied, Rajat showed longest siliqua of having 7.08 cm, while the shortest was PDZM-31 at 4.18 cm. Number of seeds per siliqua varied from 10.20 (RH-8812) to 17.00 (Rajat), with a mean value of 13.43. It was shown that genotypes Rajat and NDRE-4 produce more seeds per siliqua than genotype RH-8812 (17.00).

The weight of one thousand seeds for each genotype varied from 3.25 g (PDZM-31 and Rajat) to 5.80 g (Pusa bold and RSK-1620), with a mean of 4.42 g. Two of the genotypes examined, Rajat and PDZM-31, exhibited low 1000 seed-weight (3.25 g), whereas Pusa bold and RSK-1620 showed highest value (5.80 g). The mean seed yield per plant was 6.83 g, with a wide range of values between 3.38 g (PDZM-31) and 12.29 g (DRMR-150-35). More than 10 g of seeds were harvested from each plant of the genotypes *viz.,* DRMR-150-35, Black Gold and RH-9304. These genotypes show promise as high-yielding genotypes for use in seed production.

The average harvest index was 14.77 percent, with the range being 8.89 (rlm-619) to 18.69 per cent (drmr-150-35). The drmr-150-35 genotype exhibited the greatest harvest index (18.69%), followed by the rlm-619 (8.89%). The oil content of the samples were ranged from 24.91 (rgn-298) to 32.72% (gm-1), with a mean of 28.81 %. The oil content ranged from rgn-298 (24.91%) to gm-1 (32.72%), with rgn-298 having the lowest oil content.

3.2 Disease Scoring and Classification of Genotypes

The susceptible check variety i.e., Black gold showed signs on the lower leaves (older leaves) after 72 DAS, with the powdery mildew eventually spreading to the upper surfaces of the leaves, stem, and siliqua. Due to the nature of the field environment, the infection from the diseased leaves quickly spread to the other leaves, stem, and siliqua. As time progressed, the spots merged into a powdery coating that eventually covered the entire plant. Between 85 and 87 DAS, the susceptible check variety (Black Gold) scored 9 for powdery mildew disease severity on a disease scoring scale of 0 - 9. [6].

Table 3. Analysis of variance (ANOVA) for yield and yield contributing characters in mustard

		Mean sum of squares											
Source of variation	**Df**	**DFF**	**DM**	**PH (cm)**	**NPB**	**NSB**	**NSP**	**SL (cm)**	**NSS**	**TSW (g)**	**SYP (g)**	**HI (%)**	**OC (%)**
Replications	1	7.29	1.69	453.26	1.14	7.64	226.47	0.173	0.102	0.019	1.871	0.131	2.712
Genotypes	49	42.45**	10.99**	763.52**	0.67**	18.27**	7876.66**	0.797**	5.336**	0.916**	8.198**	9.086**	5.020**
Error	49	3.65	3.40	38.34	0.184	0.574	59.07	0.050	0.538	0.007	0.524	1.821	2.105
Total	99	22.89	7.141	401.46	0.433	9.405	3930.07	0.421	2.908	0.457	4.336	5.40	3.554

** Significant at 5 per cent level, ** Significant at 1 per cent level*

DFF-days to 50% flowering, dm-days to maturity, ph-plant height (cm), npb-number of primary branches per plant, nsb- number of secondary branches per plant, nsp- number of siliquae per plant, sl- siliqua length (cm), nss- number of seeds per siliqua, tsw- 1000 seed weight (g), syp- seed yield per plant (g), hi- harvest index (%), oc- oil content (%).

Table 4. Mean performance of fifty mustard genotypes for yield and yield contributing characters

S.No	Genotype	DFF	DM	PH (cm)	NPB	NSB	NSP	SL (cm)	NSS	TSW (g)	SYP (g)	HI (%)	OC (%)
1	Pusa Mahak	38.00	87.00	157.60	4.10	7.57	187.28	4.55	13.90	4.00	8.40	16.38	31.02
2	PM-25	38.00	88.00	141.90	4.30	5.54	201.45	5.90	15.20	4.85	5.17	16.55	30.43
3	PM-26	42.00	89.00	158.75	3.70	11.54	172.85	5.58	12.80	3.70	9.41	18.17	27.89
4	PM-27	41.00	90.00	163.90	3.43	4.93	187.78	5.25	15.90	3.35	5.46	15.74	28.29
5	PM-28	37.00	89.00	159.10	4.05	9.02	169.36	5.40	13.90	3.90	5.22	13.59	29.96
6	PM-29	35.00	88.00	174.70	3.90	10.09	193.73	5.55	11.40	4.25	7.43	16.68	25.83
7	PM-30	40.00	89.00	159.50	3.90	13.70	224.63	5.45	15.20	3.45	6.24	15.11	29.78
8	PDZM-31	43.00	95.00	**103.35**	2.50	2.75	108.04	4.18	12.70	3.25	3.38	11.06	27.07
9	Pusa Jagannath	37.00	90.00	171.10	3.65	6.82	198.74	5.75	13.50	5.00	7.85	14.18	27.38
10	Pusa Vijay	37.00	87.00	154.20	4.10	10.19	176.67	4.85	11.00	4.15	5.15	14.32	27.09
11	Pusa Tarak	43.00	90.00	164.40	**5.20**	10.60	239.02	6.00	12.90	3.90	6.61	15.84	26.93
12	Pusa Agrani	**34.00**	**86.00**	163.40	3.20	11.06	213.42	5.35	13.90	4.10	8.49	17.60	28.56
13	Pusa Bold	**35.00**	87.00	171.00	4.70	8.58	176.13	**6.85**	15.00	**5.80**	6.59	14.54	28.74
14	Pusa Karishma	41.00	88.00	149.50	3.90	8.35	209.91	4.45	15.10	3.65	5.70	12.99	26.71
15	Varuna	40.00	91.00	167.70	4.10	10.77	281.71	4.90	11.60	5.20	7.92	15.85	28.15
16	GM-1	43.00	92.00	158.40	3.40	6.04	221.79	5.70	12.50	4.35	9.81	14.57	**32.72**
17	GM-2	40.00	89.00	182.00	4.90	10.61	259.68	5.65	14.30	**5.40**	6.35	12.52	28.37
18	GM-3	44.00	92.00	179.00	4.75	12.90	227.03	4.60	10.30	4.75	8.39	16.58	29.28
19	RB-50	37.00	90.00	203.15	4.85	**17.00**	264.27	6.11	15.10	3.70	9.94	14.05	28.77
20	RH-0406	38.00	89.00	198.45	4.30	9.08	**368.87**	5.75	12.80	4.65	5.42	11.59	27.64
21	RH-0119	41.00	91.00	182.70	3.55	9.00	213.66	6.60	13.80	4.50	5.94	13.30	27.64
22	RH-8812	41.00	92.00	168.90	4.80	10.13	304.10	5.30	10.20	3.80	6.44	14.08	28.44
23	RH-0725	46.00	92.00	183.00	3.80	9.61	210.40	6.10	13.40	3.80	7.06	16.87	28.65
24	RH-0749	42.00	92.00	170.20	3.90	4.60	183.07	6.40	13.80	4.80	6.75	15.43	29.62
25	RH-30	47.00	92.00	167.80	4.60	9.13	234.66	4.95	14.80	5.10	6.69	15.38	30.14
26	RH-9304	48.00	94.00	178.65	4.90	9.80	304.41	4.60	12.50	4.10	**10.03**	**17.77**	30.17
27	GDM-4	47.00	90.00	177.25	4.50	12.30	**373.39**	5.20	11.40	4.90	9.42	14.46	26.82
28	GDM-5	46.00	91.00	167.20	4.10	10.62	220.73	5.35	12.40	4.20	6.37	15.19	29.70
29	RSK-1328	48.00	89.00	160.90	4.80	9.40	315.79	4.92	15.70	5.25	4.35	13.75	30.76
30	RSK-1728	47.00	91.00	174.20	3.70	6.80	224.14	5.90	**16.00**	4.80	3.64	12.43	**31.16**
31	RSK-1746	**33.00**	**84.00**	176.00	4.60	12.48	309.80	5.25	12.30	4.25	5.59	16.14	30.59

S.No	Genotype	DFF	DM	PH (cm)	NPB	NSB	NSP	SL (cm)	NSS	TSW (g)	SYP (g)	HI (%)	OC (%)
32	RSK-1620	49.00	93.00	169.35	4.80	10.00	269.21	5.19	14.40	**5.80**	6.16	15.65	26.56
33	RSK-1621	47.00	90.00	**123.45**	4.70	6.50	257.25	5.25	14.60	4.30	4.20	13.45	29.81
34	RSK-1626	42.00	90.00	162.80	4.70	9.20	246.28	5.20	11.70	4.30	3.42	10.37	28.55
35	RSK-1712	42.00	90.00	162.80	4.60	8.21	232.86	4.93	12.60	4.55	6.27	15.46	29.58
36	RSK-1630	47.00	89.00	170.00	4.10	2.70	216.33	5.65	10.90	4.50	5.17	13.13	29.52
37	Kranti	44.00	91.00	169.75	3.70	6.34	309.58	5.30	12.40	4.85	8.35	12.91	28.52
38	NRCHB-101	42.00	90.00	144.90	**5.20**	**15.17**	357.15	6.60	13.50	5.20	9.58	17.46	**31.30**
39	DRMR-150-35	43.00	87.00	152.10	4.60	12.19	202.59	5.70	15.60	**5.40**	**12.29**	**18.69**	30.51
40	RCC-4	49.00	92.00	206.20	5.00	**15.05**	**394.01**	5.55	12.90	4.40	9.28	15.58	27.95
41	RLM-619	46.00	90.00	157.40	4.40	8.80	116.25	**6.65**	13.20	5.20	4.31	8.89	28.51
42	RGN-298	48.00	92.00	179.10	**5.30**	14.50	279.12	5.08	13.80	5.20	7.97	15.03	24.91
43	Laxmi	47.00	90.00	186.00	4.00	8.65	172.91	5.45	12.30	3.40	4.58	14.13	29.25
44	NDRE-4	48.00	89.00	138.45	3.50	6.69	219.43	5.45	16.90	4.10	6.96	15.90	29.77
45	Rajat	50.00	92.00	166.30	4.20	10.44	178.46	7.08	17.00	3.25	5.91	17.11	26.62
46	Black gold	36.00	82.00	113.90	4.50	10.65	263.87	4.40	13.10	4.80	10.38	18.57	30.27
47	JM-1	37.00	86.00	154.40	4.20	9.78	306.04	5.65	14.70	5.40	9.08	13.69	28.76
48	Geeta	46.00	90.00	142.75	3.80	5.70	216.04	5.45	13.00	3.70	5.91	15.62	30.01
49	RLM-1359	48.00	89.00	155.80	3.70	7.30	179.21	5.45	11.90	4.40	5.99	13.94	29.47
50	NRCDR-2	48.00	91.00	139.80	4.30	8.49	175.44	5.50	11.80	3.65	5.08	10.75	26.74
	Mean	42.85	89.99	163.66	4.22	9.34	235.36	5.47	13.43	4.42	6.83	14.77	28.81
	Mini.Range	33.00	82.00	103.35	2.50	2.69	108.04	4.18	10.20	3.25	3.38	8.89	24.91
	Max.Range	50.00	95.00	206.20	5.30	17.00	394.00	7.08	17.00	5.80	12.29	18.69	32.72
	C.V	4.46	2.05	3.78	10.16	8.11	3.26	4.11	5.46	1.93	10.58	9.13	5.03
	C.D	3.84	3.707	12.44	0.86	1.52	15.44	0.45	1.47	0.17	1.45	2.71	2.91

DFF-Days to 50% flowering, DM-Days to maturity, PH-Plant height (cm), NPB-Number of primary branches per plant, NSB- Number of secondary branches per plant, NSP- Number of siliquae per plant, SL- Siliqua length (cm), NSS- Number of seeds per siliqua, TSW- 1000 seed weight (g), SYP-Seed yield per plant (g), HI- Harvest index (%), OC- Oil content (%)

The disease reaction of genotypes to the powdery mildew illness are displayed in Table no.4 and a classification scheme based on the reaction to the disease is displayed in Fig. 5. Out of 50 genotypes, two test entries viz., GM-3 and Swarna Jyothi showed resistance disease reaction to powdery mildew which showed disease score -1, whereas nine genotypes viz., Ashirwad, DRMR-601, Pusa Mahak, PM-25, PM-26, PDZM-31, Pusa Tarak, Pusa Bahar, and JM-2 recorded moderately resistant disease reaction with score-3. A total of 15 genotypes including PM-27, PM-28, Pusa Vijay, Pusa Jaikisan, GM-1, RB-50, RH-0749, RH-30, RH-9801, RSK-1328, RSK-1620, RGN-73, PBR-91, Urvashi, and Vasundara, exhibited a moderately sensitive reactivity (score-5) to disease. The 16 genotypes that exhibited a susceptible reaction *viz.,* PM-29, Pusa Jagannath, Pusa Agrani, Giriraj, GM-2, RH-0406, RH-0119, RH-9304, GDM-4, GDM-5, RSK-1746, CS-52, RH-781, Satabdi, Maya, and NRCHB-101 (score-7). The moderately resistant check variety NRCHB-101 also shown susceptible reaction because of favourable weather conditions during the crop growth period. Eight of the present genotypes *viz.,* Varuna, RH-8812, RH-0725, RSK-1626, RSK-1712, RSK-1630, Vaibhav and Black gold were exhibited highly susceptibility reaction to the powdery mildew with disease score-9.

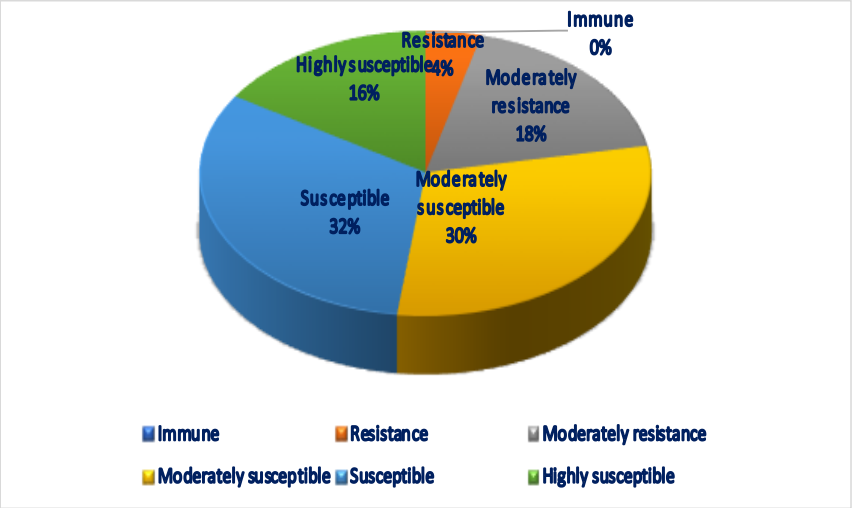

Fig. 5. Classification of mustard genotypes for powdery mildew disease reaction

Table 5. Classification of mustard genotypes according to disease scoring scale

S. No.	Type of reaction	Grade	No. of genotypes	Genotypes
1	Immune	0	0	-
2	Resistance	1	2	GM-3 and Swarna Jyoti
3	Moderately resistance	3	9	Pusa Mahak, PM-25, PM-26, PDZM-31, Pusa Tarak, Pusa Bahar, Ashirwad, DRMR-601 and JM-2
4	Moderately susceptible	5	15	PM-27, PM-28, Pusa Vijay, Pusa Jaikisan, GM-1, RB-50, RH-0749, RH-30, RH-9801, RSK-1328, RSK-1620, RGN-73, PBR-91, Urvashi and Vasundara.
5	Susceptible	7	16	PM-29, Pusa Jagannath, Pusa Agrani, Giriraj, GM-2, RH-0406, RH-0119, RH-9304, GDM-4, GDM-5, RSK-1746, CS-52, RH-781, Satabdi, Maya and NRCHB-101.
6	Highly susceptible	9	8	Varuna, RH-8812, RH-0725, RSK-1626, RSK-1712, RSK-1630, Vaibhav and Black gold

Kanzaria and Dhruj [8], Kumar et al. [9], and Nanjundan et al. [10] all claimed that none of the 50 genotypes screened showed any immunity to powdery mildew (2020). However, Chadar et al. [6] discovered few powdery mildew-resistant immune genotype sources in the mustard crop. Nanjundan et al. in 2020 pinpointed RDV-29 as the mustard powdery mildew resistance gene source. Based on above findings the genotypes GM-3 and Swarna Jyothi showed resistant reaction to powdery mildew. These genotypes can be used in breeding programme as donor parents for developing powdery mildew resistant lines [11,12].

4. CONCLUSION

Analysis of variance demonstrated that there were statistically significant differences between genotypes for all traits evaluated and that there was a considerable amount of volatility in the mean performance of all genotypes across all characters.

Out of the 50 genotypes screened, two test entries were found to be resistant to powdery mildew disease reaction (GM-3 and Swarna Jyothi), while nine genotypes (Pusa Mahak, PM-25, PM-26, PDZM-31, Pusa Tarak, Pusa Bahar, Ashirwad, DRMR-601, and JM-2) were showed moderately resistant reaction. The genotype PM-26 recorded high mean value for yield and its contributing traits and also showed moderate resistance reaction to powdery mildew disease. On considering the above points, the genotype PM-26, further utilised as a donor parent in a backcross breeding programme for development of disease resistant lines with high yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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