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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(3): 210-213

www.thepharmajournal.com
Received: 01-01-2020
Accepted: 05-02-2020

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Study on evaluation of Indian mustard germplasms for the quantitative traits

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Abstract
Among all the oilseed crops that are grown in India, Indian mustard is the most important one. Over the past years, there is a stagnant yield and productivity of Indian mustard in our country as we do not possess varieties which are high yielding. This is a major reason for the lack of acceleration in the production and productivity of this crop. For any of the breeding programme to come up with a high yielding variety for any crop, it is very crucial to choose an accurate and precise parental genotype which have superior traits as per the objective of a breeding programme. In this context, the present investigation was carried out using thirty-six germplasms of Indian mustard to study their ten quantitative characteristics in order to find out the germplasms which show promising characters. Out of them, six of them showed the very promising magnitude of quantitative characteristics and Jawahar Mustard-02 was the best of them all.

Keywords: evaluation, mustard germplasms, quantitative traits

Introduction
Brassica L. genus comes under the family Cruciferae or Brassicaceae which comprises of many diverse types of plant which have different economically important products ranging from roots to shoots to leaves to even seeds. The genera have more than 3200 species with contrasting morphological build-up and pollination types (Prasad and Patil, 2018) [8]. Main agricultural products that are obtained from *Brassica* L. or the most cultivated species are of seeds for extraction of oil and leaves for consumption as vegetables. The oilseed crops of this genera are altogether known as rapeseed/mustard which is grown globally and is also the main component of Indian rain-fed agricultural cycle. Among the oilseed brassicas, Indian mustard (*Brassica juncea* L. Czern and Coss) and rapeseed (*Brassica napus*) are the important ones with grown in an area of 5.96 million hectares in India (Directorate of Economics and Statistics, 2020). The current productivity of these is 1397 kg ha^{-1} (Directorate of Economics and Statistics, 2020) which is very far less than that in developed countries of 2500-3000 kg ha^{-1}. Even the current productivity is less than the average world productivity of 1900 kg ha^{-1} (Yadava *et al*., 2011) [11].

The productivity of any crop is dependent on both the genetical and environmental factors along with the interaction between the two. In the process of developing a better variety, we first need to have better parent materials which possess promising heritable characters. If the parental materials are genetically more variable, then a breeding programme stands a chance to develop superior varieties and/or hybrids. A similar approach is also needed for enhancing the production and productivity of Indian mustard in our country. Keeping the environmental factors at one end, our aim should be to develop varieties with traits/characters which can sustain those environmental conditions and perform well. Thus, a knowledge of genetic diversity in *Brassica juncea* would certainly be helpful to carry out the advanced breeding processes. A correlation of genetic diversity with the yield is also essential so that we can keep on improving the yield as well. If the genetic diversity of *Brassica juncea* is known to any plant breeder or plant geneticists, then it becomes easier for them to predict the combinations which would potentially be better genotype and additionally would ward-off the initial stages of any breeding programme. In this premise, the present investigation was carried out to study the genetic variability and yield of thirty-six Indian mustard germplasms in order to characterize them and find out the germplasm(s) which we can further utilize as per the objective of any breeding programme.

Table 1: List of *Brassica juncea* germplasm used in the present study

Serial Number	Name of the Germplasm	Procured Institution
1.	Rohini (IM)	ICAR-Directorate of Rapeseed-Mustard Research, Sewar, Bharatpur, Rajasthan
2.	Jagannath (IM)	
3.	Shivani (IM)	
4.	Swarna Jyoti (IM)	
5.	Pusa Bold (IM)	
6.	Pusa Agrami (IM)	
7.	Laxmi (IM)	
8.	Kanti (IM)	
9.	Pathan Mustard-67(IM)	
10.	Vasundhara (IM)	
11.	Pusa Jai Kisan (IM)	
12.	Durgamani (IM)	
13.	NRCHB-101(IM)	
14.	NRCDR-02 (IM)	
15.	Varuna–T59 (IM)	
16.	Saurabh (RH-8113) (IM)	
17.	Vaibhav (IM)	
18.	RH-30	
19.	Jawahar Mustard-01 (IM)	
20.	Jawahar Mustard-02 (IM)	
21.	Gujarat Mustard-01 (IM)	
22.	Gujarat Mustard-02 (IM)	
23.	Gujarat Mustard-03 (IM)	
24.	Pusa Mahak (IM)	
25.	Geeta (IM)	
26.	T-2	Bhabha Atomic Research Centre, Mumbai
27.	TPM	
28.	PM-21	Indian Agricultural Research Institute (IARI), New Delhi.
29.	PM-22	
30.	PM-25	
31.	PM-26	
32.	PM-27	
33.	PM-28	
34.	PM-29	
35.	PM-30	
36.	PV	

Materials and Methods

The present study was conducted at the research field of Department of Genetics and Plant Breeding, Palli Siksha Bhavana, Visva Bharati University during the consecutive *Rabi* seasons of 2017-2018 and 2018-2019.

Germplasms

During the investigation, thirty-six germplasms *Brassica juncea* were used studying of their genetic variability and yield. The list of germplasm name along with their procured institution is given below in Table 1.

Experimental soil

The detailed physicochemical characteristics of the soil on which the investigation was carried out is provided in Table 2. The soil was sandy loam (ultisol) in texture with acidic nature.

Table 2: Physiochemical characteristics of the experimental soil

Texture	Sandy-Loam
pH	5.83
EC (dS m^{-1})	0.43
Available nitrogen (kg ha^{-1})	158.1
Available organic carbon (%)	0.47
Available phosphorus (kg ha^{-1})	18.23
Available potassium (kg ha^{-1})	138.5

Design and agronomic practices

The thirty-six germplasms of Indian mustard were grown in a randomized complete block design with three replications in *Rabi* season of 2017-2018 and 2018-2019. The individual entries were sown in a single row of three meters in length with a row to row spacing of 45 cm and plant to plant distance of 15 cm. This spacing was maintained by thining operation conducted at 15 days after sowing. All the proper agronomic practices were followed as per the general recommendations and fertilizers were applied in equal amount in all the entries @ 80 kg ha^{-1} of N, 40 kg ha^{-1} of P_2O_5, and 40 kg ha^{-1} of K_2O. Three irrigations were also given to all the replications equally.

Parameters recorded

The following plant characteristics or parameters were recorded *viz.* days to 50% flowering, days to maturity, number of siliqua on main shoot, plant height (cm), total number of siliqua per plant, number of seeds per siliqua, weight of 1000 seeds (g), yield obtained per plot (g), biological yield (g), and harvest index (%) of the seeds composited from F_{1S}, parents, and checks. An average of all these parameters was calculated from the collected data for all the germplasms and was used for the statistical analysis.

Statistical analysis

The means obtained from all the recorded data were subjected to analysis of variance (ANOVA) in order to draw appropriate conclusions. The ANOVA for each parameter of each germplasm was done for randomized complete block design (RCBD) as per the procedure given by Fisher, 1938. The replication mean values of 38 entries which constituted of 8 lines, 28 F_{1S}, and 2 standard check varieties were subjected to RCBD analysis. The following model was used:

$Y_{ij} = \mu+b_i+t_j+e_{ij}$; (i = 1, 2, 3, ……., r) and (j = 1,2,3,……,t)

Where,
Y_{ij} = observed response of i^{th} germplasm in the j^{th} replication.
μ = general mean of the population.
b_i = effect of the i^{th} block.
t_j = effect of the j^{th} treatment.
e_{ij} = random error of the i^{th} block and the j^{th} treatment.

The total variation among the germplasm for different parameters were tested for significance by *F*-test using analysis of variance technique. This analysis was conducted as per the method described by Panse and Sukhatme, 1978 [7]. The significant difference among the treatment means was also tested by *F*-test and wherever the *F*-test was found to be significant, the critical difference (C.D.) was calculated to test the significance of difference between any two treatment means. The variance between treatment was further portioned into various components to find the significance of difference between parents and crosses individually. Overall significant difference among the germplasms was also tested by *F*-test.

Results and Discussion

The ANOVA of all the ten parameters pooled over two seasons studied in this investigation is represented in Table 3. The mean square value due to the season for all the parameters except plant height and days to maturity were highly significant, indicating the role for expression of the characters. The mean sum squares due to genotypes foe all the

parameters were also highly significant, except for harvest index proving the genetic variability among the experimental germplasms. The variation due to genotypes was also highly significant for all the parameters under investigation except for the harvest index.

In the recorded parameters for all the thirty-six germplasms, variations in days to 50% flowering was from 33.00 days to 51.33 days with a grand mean of 43.94 days. PM-27 and Kanti were the two germplasms having early 50% flowering at 33.00 days and 35.50 days, respectively. However, the germplasm which has the first flower was Pathan mustard (67). The plant height varied from 128.47 cm to 181.30 cm with a grand mean of 156.33 cm. Gujarat mustard (02) was the tallest germplasm and T2 germplasms was the shortest one. Days to maturity varied from 94.80 days to 146.26 days with a grand mean of 122.57 days. The early maturing germplasm was T2 and the most late-maturing germplasm was NRCDR-02. The number of siliqua in a mustard plant is the major parameter which is looked for in all the breeding programmes as it has a role in total biomass yield. The number of siliqua on the main shoot varied from 25.26 to 39.13 with a grand mean of 32.07. Pusa Jai Kisan germplasm had the highest number of siliqua on the main shoot and Durgamani had the lowest. The total number of siliqua per plant ranged from 55.22 to 96.48 with a grand mean of 73.07. Saurabh (RH811) had the maximum siliquas per plant and Laxmi had the lowest number of siliqua per plant.

Table 3: ANOVA for the ten quantitative parameters in Indian mustard germplasms

Source	df	Mean square									
		50% flowering	Plant height (cm)	Days to maturity	No of siliqua on main shoot	Total no of siliqua per plant	No of seed per siliqua	Biological weight	Test weight	Harvest Index	Seed yield
Replication	2	0.476	298.174	7.823	114.420**	209.139	4.049**	114.118**	0.025	38.352**	0.146
Season	1	14.004**	36.096	32.666	82.881*	7000.864**	1.945**	2090.107**	1.822**	173.648**	24.691**
S x R	2	1.976	106.590	10.537	20.167	346.644*	0.243	123.563**	0.089	14.478	1.373**
Overall Sum	5	3.782	169.125	13.877	70.411**	1622.486**	3.306**	513.094**	0.410**	55.862**	5.546**
Genotype	35	132.045**	915.301**	1028.559**	58.592**	733.111**	3.274**	54.805**	4.039**	11.019	1.814**
Error	175	1.782	161.216	10.740	21.546	109.363	0.659	23.784	0.057	78.554	0.261

* and ** are significance at 0.05& 0.01 levels, respectively.

Table 4: Mean performance of all the thirty-six germplasms of Indian mustard for the ten parameters

	50% flowering	Plant height	Days to maturity	No of siliqua on main shoot	Total no of siliqua per plant	No of seed per siliqua	Biological weight	Test weight	Harvest Index	Seed yield
Rohini	51.33	156.43	124.13	32.10	79.21	12.31	24.93	3.46	13.82	3.65
Jagannath	44.33	144.63	143.16	30.50	68.55	12.48	17.21	4.44	18.60	3.73
Shivani	45.83	163.00	105.66	32.50	73.05	12.83	22.29	3.80	14.32	3.56
Swarna Jyoti	47.83	156.86	112.66	28.73	66.92	13.20	20.78	4.44	15.83	3.51
Pusa Bold	49.00	156.60	117.00	32.80	65.03	12.66	20.65	4.48	16.54	3.67
Pusa Agrani	39.16	153.43	110.33	31.46	58.93	13.10	22.02	5.20	15.66	3.89
Laxmi	47.00	155.60	137.10	33.36	55.22	12.16	18.72	5.44	17.53	3.58
Kanti	35.50	144.03	111.30	32.16	59.01	12.23	23.49	5.35	14.76	3.84
Pathan Mustard(67)	51.00	170.41	112.10	39.13	58.37	12.66	21.55	5.16	14.64	3.48
Vasundhara	45.83	154.28	136.70	32.80	70.68	13.56	22.00	4.17	15.78	3.85
Pusa Jaikisan	44.00	146.03	121.86	30.50	66.24	13.61	18.62	4.17	15.93	3.41
Durgamani	44.00	149.15	119.93	25.26	70.34	11.76	17.97	4.56	18.09	3.69
NRCHB-101	40.83	153.20	120.66	32.63	58.21	13.46	22.80	5.59	15.06	3.90
NRCDR-02	38.16	146.43	146.26	29.53	49.78	12.56	19.62	4.90	16.12	3.60
Varuna(T-59)	37.00	132.76	135.50	32.76	64.08	11.80	21.23	5.37	16.90	3.94
Saurabh(RH-8113)	40.83	150.00	144.20	34.16	96.48	11.46	24.87	4.46	15.66	5.03
Vaibhav	49.33	151.98	109.16	31.83	91.68	11.93	21.30	3.44	14.79	3.68
PV	42.50	149.78	141.96	28.40	71.91	13.50	21.38	4.28	15.46	3.83
T2	35.83	128.46	94.80	31.53	91.21	13.93	23.62	3.44	16.39	4.29
RH-30	39.66	166.50	134.93	34.10	81.65	12.56	27.31	3.51	14.00	3.81
Jawahar Mustard-01	47.83	168.63	114.76	33.33	62.15	12.53	21.76	5.68	17.15	4.25
Jawahar Mustard-02	47.16	175.03	133.46	37.33	67.45	14.03	28.30	6.43	17.42	5.62
Gujarat Mustard-01	45.33	176.93	132.00	37.56	65.92	12.70	22.49	5.39	17.59	4.33
Gujarat Mustard-02	44.50	181.30	133.23	37.90	69.47	13.43	25.09	4.70	15.53	4.13
Gujarat Mustard-03	46.50	172.30	119.23	36.13	85.87	12.23	28.15	5.46	16.40	5.42
Pusa Mahak	46.33	167.53	113.00	29.70	92.42	12.40	28.11	3.54	15.04	3.98
Geeta	43.66	164.73	117.10	34.73	75.14	13.43	24.97	3.75	13.55	3.62
PM-21	49.00	172.33	141.06	28.96	81.30	12.83	27.94	4.30	13.98	4.23
PM-22	41.33	145.53	129.20	27.33	73.57	13.23	23.44	5.54	17.75	5.23
PM-25	43.50	165.36	114.26	33.53	86.96	12.20	21.66	3.63	14.89	3.82
PM-26	46.50	162.63	117.13	31.96	82.00	13.83	24.42	3.43	14.08	3.80
PM-27	33.00	153.23	109.83	27.83	72.61	13.36	18.11	4.30	17.91	3.80
PM-28	40.83	147.23	114.23	31.53	83.70	13.76	20.94	3.60	14.10	4.12
PM-29	49.33	153.16	133.56	31.66	81.97	10.86	17.79	3.72	16.13	3.36
PM-30	49.66	156.16	126.66	27.53	67.00	13.03	20.91	4.41	15.56	3.62
TPM	38.66	136.43	104.36	31.20	77.37	12.96	17.26	3.48	17.29	3.48
RANGE(lowest)	33.00	128.46	94.80	25.26	55.22	10.86	17.21	3.43	13.55	3.36
RANGE(highest)	51.33	181.30	146.26	39.13	96.48	14.03	28.30	6.43	18.60	5.62
GM	43.94	156.33	122.57	32.07	73.07	12.79	22.19	4.47	15.92	3.96
CV	3.03	8.12	2.67	14.47	14.31	6.34	21.97	5.34	17.25	12.89
SE	0.54	5.18	1.33	1.89	4.26	0.33	1.99	0.09	1.12	0.20
CD at 1%	2.00	19.09	40.92	6.97	15.72	1.22	7.33	0.36	-	0.76
CD at 5%	1.52	14.46	3.72	5.28	11.91	0.92	5.55	0.27	-	0.58

The biological weight of an Indian mustard plant plays an important role in providing us with an idea of about how much a genotype is capable of accumulation of photosynthates. In the present study, biological weight per plant ranged from 17.21g to 28.30g with a grand mean of 22.19g. Jawahar Mustard-02 had the maximum weight and Jagannath had a minimum biological weight per plant. The test weight or weight of 1000 seeds is also another mustard characteristic which is minutely studied by the breeder as the seeds are the economically important part. The test weight ranged from 3.43g to 6.43g with a grand mean of 4.47g. Jawahar Mustard-02 had the highest test weight while PM-26 had the lowest test weight. The harvest index ranged from 13.55% in Geeta to 18.60% in Jagganath germplasm with a grand mean of 15.92%. The yield of seed per plant was highest in Jawahar Mustard-02 at 5.623g and lowest in Geeta with 3.62g. The grand mean of seed yield per plant was 3.96g. All the data recorded of all the parameters in the thirty-six germplasms are given in Table 4.

The results obtained from the present investigation showed the highest variability in biological weight, height of the plant, total siliqua per plant, and seed yield per plant. The results were similar to the findings of Om, 2010; Yadava *et al*., 2011 [11]. The result of test weight was in concurrence to the findings of Yadava *et al*., 2011 [11]. The number of seeds per plant was similar to findings of Bind *et al*., 2014 [1]; Tripathi *et al*., 2015 [10]; Lodhi *et al*., 2016 [4]; Neeru *et al*., 2017 [5]; and Tiwari *et al*., 2017 [9].

Conclusion

On the basis of the performance and data obtained from all the parameters of germplasm including the yield of grains, we can conclude that Jawahar Mustard-02, Saurabh (RH8113), Gujarat Mustard-03, PM-22, Gujarat Mustard-01, and T2 are the promising ones. The most important parameter for Indian mustard germplasm for it to be used in a breeding programme is seed yield per plant which was highest in Jawahar Mustard-02 along with other quantitative parameters. Hence out of thirty-six germplasms which was used in the present investigation, six of them can be further utilized as a parental line in breeding programmes of Indian mustard for enhancing quantitative characters.

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