A Study on Genetic Factors Influencing Seed Yield Mustered

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Abstract

The agricultural economy of India relies heavily on oilseed crops. In terms of vegetable oils, our nation is the fourth biggest in the world, behind the United States, China, and Brazil. Due to favourable agro ecological conditions, seven edible and two non-edible oilseed crops, along with many additional minor oilseed crops, have been commercially cultivated annually. India's primary oilseed crop is a family of plants including rapeseed and mustard. India is first in the global rapeseed-mustard industry, ranking second in both area and output. This work investigates the heritable elements that affect crop yields.

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1. Introduction

India's primary oilseed crop is a family of plants including rapeseed and mustard. India is first in the global rapeseed-mustard industry, ranking second in both area and output. The estimated global rapeseed-mustard area in 2020-21 was 26.79 lakh ha, with output of 46.27 million tonnes and productivity of 1730 kg/ha. Rapeseed-mustard in India is expected to cover 6.49 lakh ha., yield 7.41 million tonnes, and yield 1197 kg/ha in 2020-21. Its primary growing regions in India include the states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Haryana, West Bengal, Assam, Bihar, and Punjab.[1]

There are 7.9 lakh hectares dedicated to growing rapeseedmustard in Uttar Pradesh, yielding 0.99 million metric tonnes at a productivity of 1300 kilogrammes per hectare. Agra, Aligarh, Mathura, Kanpur Nagar, Kanpur Dehat, Ethawah, Firozabad, Bulandshahar, Meerut, Muzaffarnagar, and Saharanpur are the primary growing regions in UP. (Guess who?) in 2011. 2 Brassica rapa (L.) var. Brown sarson and Brassica rapa (L.) var. yellow sarson are among the oleiferous brassicas produced in India. They are all members of the Brassicaceae family. Brassica campestris (L.) var. toria and Indian mustard (Brassica juncea) are three of the most widely grown members of the Brassica family of crops.[2-3]

The botanical names for the various types of rapeseed and mustard seeds include: Brassica juncea (commonly known as rai/Indian mustard), Brassica napus (commonly known as Gobhi sarson or Swede rape), Brassica carinata (commonly known as Ethiopian mustard), Brassica nigra (commonly known as black mustard), and Eruca sativa (commonly known as Taramira).

Newly introduced crops in India include Swedish rape and Ethiopian mustard. While in Sweden, rape is grown only in irrigated fields. [4-6]

Ethiopian mustard thrives in rain-fed environments. In terms of global importance, the oleiferous Brassica species—B. napus, B. campestris, and B. juncea—now account for the second-most-produced vegetable oil. Canada, China, northern Europe, and the Indian subcontinents are all significant places for the cultivation of these crops. Oilseed production in Ethiopia is based on a kind of mustard called B.carinata. [7-8]

There is a large variation in agroclimatic conditions that support the cultivation of these crops. However, of all the oilseed Brassicas, mustard takes up the most space, accounting for more than 75% of the total. Mustard stands out among cultivated oleiferous Brassicae because it produces more biomass, has a higher yield potential, is more drought tolerant, has a higher inherent genetic tolerance to leaf blight disease, aphid infestation, and frost injury, and responds well to the given dose of fertiliser and irrigation. Therefore, it excels in both irrigated and rainfed situations, while other oleiferousBrassicae fail.[9-10]

2. Material And Methods

The current research relied on a wide variety of sources. Strains of Indian mustard or 'Rai' were gathered from Integral University, Lucknow; C.C. Singh University, Haryana. These included the Kranti, Rohni, Pusa Bold, Vardan, Pusa Bahar, RH-30, RLM-198, Jauhar-1, J.D-6, and NDRE-4.During Rabi2009-2010, ten unique [Brassica juncea(L) Czern and Coss] genotypes were exposed to inter mating in a diallel way (without reciprocals).

The F0 seeds from 45 different crossings were developed throughout the 2020-21 Rabi season to produce F1s, and the F1s were then selfed to produce F2s.Self-sufficiency was also used to take care of the parents.

(a) FieldLayout

Completely randomised block designs (CRBDs) with three replicates were used to test 100 treatment combinations (10 parents, 45 F1s, and 45 F2s).Rabi2011-12. The plants were spaced at 45 cm between rows and the rows were five metres in length for the parents and F1s and for the F2s.

Characters Studied

Five parents, five F1s, and ten F2s from each treatment and replication were randomly selected and labelled so that observations of the following traits could be recorded.

- **Characters in the Harvest Period Days till Flowering**

The number of days from planting seeds to the appearance of the first flower bud on the main raceme of the tagged plants was recorded.

- **Plant height**

The height of the plant was measured in centimetres from the soil line to the top of the main raceme.

- **Measurement of leaf surface area**

L.A.I. is determined using the formula L.A.I.=leaf area in cm2 per plant x number of plants per square metre / 10000.

- **The average siliquae count per plant**

At full maturity, we tallied the number of siliquae on each plant.

- **Numberofseedspersiliqua**

The average number of seeds per siliqua was calculated by counting 10 siliquae from each plant and averaging the results.

- **Reflections on the Harvest Plant seed production**

The yield per plant was measured in grammes using a physical balance accurate to within two decimal places after the seeds had been dried in the sun.

- **Chemical Composition of Oil**

NMR analysis was used to quantify, in percentage terms, the oil content of well-dried seeds (after being baked at 50 °C for 5.6 hours).

Methods from the fields of statistics and biometry

The average results from each treatment across all three replicates were used to create the experimental data.The following statistical and biometric study was performed on these median values:

i. Analysis of variance

ii. Diallel analysis

a. Combining ability analysis

iii. Estimation of Selection Parameters.

a. Correlation coefficients

3. Results

Distinctiveness Analysis

Tables provide the mean sum of squares and analysis of variance (ANOVA) results for the parents and their 45 F1 and 45 F2 offspring, respectively, for each of the 12 traits listed above. Table shows the results of an ANOVA performed on the 12 attributes using just F1s and F2s.

There were statistically significant differences between the treatments (parents, F1s, and F2s) for all 12 characteristics. All 12 characters showed statistically significant differences between parents and F1s, parents and F2s, and F1s and F2s.

Table 1: Indian mustard (Brassica juncea): Mean sum of squares for analysis of variance on 12 characters in a 10 × 10 diallel cross

Source ofvariation	d.f.	Days toflowering	Leafareaindex	Numberof siliquaeperplant	Numberofseeds Persiliqua	Oilcontent(%)	Seedyield perplant(g)
Replication	02	0.50	0.01	93.29	0.01	0.14	0.25
Treatments	99	159.72	1.07	6854.64	10.75	2.72	24.84
Parents	09	286.48	1.28	3195.82	7.20	6.00	30.97
F1s	44	154.17	0.90	6427.39	11.42	1.67	20.67
Ps.vs.F1s	01	180.91	1.71	2874.41	19.39	2.43	31.16
F2s	44	139.04	1.19	6782.02	9.35	2.79	27.48
F1svs.F2s	01	248.82	0.01	19438.71	223.59	10.80	11.91
Error	198	1.56	0.01	100.83	0.72	0.13	0.02

Table 2: Analysis of variance for F1s and F2s of Indian mustard (Brassica juncea) produced from a 10 x 10 diallel cross for 12 metric traits: Meansumofsquares

Source ofvariation	d.f.	Days toflowering	Leafareaindex	Numberof siliquaeperplant	Numberofseeds Persiliqua	Oilcontent(%)	Seedyield perplant(g)
Replication	02	1.03	0.015	149.00	0.14	0.13	0.22
Treatments	89	147.75	1.03	6745.89	11.19	2.32	24.83
F1s	44	154.17	0.90	6427.39	11.42	1.67	20.67
F2s	44	139.04	1.18	6782.02	9.35	2.79	27.48
F1svs.F2s	01	248.82	0.01	19438.71	223.59	10.80	11.91
Error	178	1.47	0.003	106.69	0.71	0.09	0.09

Ability to Mean and Vary over Generations

Tables show the averages of the 12 characteristics for the parents, F1s, and F2s, as well as the variability represented as standard deviations and interquartile ranges. High statistical significance was reported for all 12 traits when comparing parent to offspring variation. Tables show that the magnitude was not constant between characters.

There was a range of 36.00 to 67.00 days in the number of days it took the parents to flower, 105.33 to 142.00 days to reach maturity, 130.62 to 199.63 cm in plant height, 1.57 to 3.74 in leaf area index, 3.33 to 7.00 in the number of primary branches, 9.33 to 16.00 in the number of secondary branches, 232.00 to 330.33 in the number of siliquae per plant, 10.33 to 15.00

Table3: Standard deviation and mean performance for a 10x10 diagonal Indian mustard cross

Character	Mean			Range		
	Parent	F1	F2	Parent	F1	F2
Days to flowering	52.20	55.01	53.09	36.00-67.00	35.33-68.00	37.00-63.33
Days to maturity	127.70	129.38	128.16	105.33-	115.67-	113.67-

				142.00	146.00	143.00
Plant height (cm)	167.03	173.86	171.64	130.62-199.63	139.93-214.12	130.80-206.27
Leaf area index	2.55	2.82	2.81	1.57-3.74	1.76-4.60	1.63-4.54
No. of Primary branches	4.94	6.49	6.21	3.33-7.00	3.33-8.33	3.33-7.67
No. f Secondary branches	12.93	15.45	13.97	9.33-16.00	12.33-19.67	9.33-16.67
No. of siliquae per plant	294.97	328.86	346.15	232.00-330.33	222.00-406.00	206.33-430.00
No. of seeds per siliqua	12.13	13.02	11.20	10.33-15.00	9.67-18.00	9.33-16.33
1000-seeds weight (g)	4.16	4.57	4.28	2.65-5.57	3.05-6.52	3.07-5.85
Harvest index (%)	34.53	34.97	35.49	33.19-35.37	31.88-39.12	31.58-39.33
Oil content (%)	38.95	39.72	39.32	37.05-41.06	38.04-41.32	36.34-40.37
Seed yield per plant (g)	15.39	16.53	16.95	10.54-19.73	11.38-23.92	11.73-24.14

The range of F1 hybrids was as follows: 35.33–68.00 days from flowering to maturity; 115.67–146.00 days from sowing to harvest; 139.93–214.12 cm in plant height; 1.76–4.60 in leaf area index; 3.33–8.33 in primary branch number; 12.33–19.67 in secondary branch number; 222–406.00 in siliquae per plant; 9.67–18.00 in seed number per siliqua; 3.05– Table shows oil content between 38.04% and 41.32% and a seed output between 11.38% and 23.92% per plant.

Diallel analysis

Genetic component analysis and combining ability analysis are two methods used in diallel analysis. What we found are detailed down below:

Combining ability analysis

- **Variance Analysis of Combining Ability**

Each of the 12 characters in F1s and F2s underwent a variance analysis for combining ability along the lines proposed by Griffing (1956). You can see the results in Table . For all 12 traits across both generations, the mean sum of squares attributable to general combining ability (gca) and specialised combining ability (sca) was shown to be statistically significant. For all 12 features, the gca mean sum of squares was larger than the sca mean sum of squares in both F1s and F2s, with the exception of the number of secondary branches in F, for which the sca mean sum of squares was larger.

Table 4: Indian mustard combining ability variance analysis for 12 traits throughout F1 and F2 generations from a 10 x 10 diallel cross: Average squared distance

Source ofvariation	Generation	d.f.	Days toflowering	Plant height(cm)	Leafareai ndex
GCA	F_1	09	302.61	1656.07	1.35
	F_2		255.31	1243.16	1.63
SCA	F_1	45	10.17	51.93	0.12
	F_2		13.46	75.86	0.16
Error	F_1	108	0.48	1.38	0.001
	F_2		0.59	2.52	0.00

Source ofvariation	Generation	d.f.	No. ofsiliquaeper plant	Oilcontent(%)	Seed yieldper plant(g)
GCA	F_1	09	4636.12	1.42	34.68
	F_2		5826.48	2.55	45.17
SCA	F_1	45	1593.58	0.76	2.58
	F_2		1734.47	0.82	2.43
Error	F_1	108	47.71	0.07	0.04
	F_2		16.67	0.04	0.01

- **Estimates of combining ability effects**

General Combining Ability (GCA) Effects

For 12 traits, Table provides estimates of the gca impacts of 10 parents throughout F1 and F2 generations.For days to blooming and days to maturity, the parents with negative gca effects were deemed to be excellent general combiners, whereas the parents with positive gca effects were deemed to be good general combiners for the other 10 qualities.

Days to flowering

Negative and substantial gca effects were passed on from the parents NDRE-4, J.D.-6, RH-30, and Kranti to their F1 offspring, whereas the parents NDRE-4, J.D.-6, RH-30, Kranti, and Pusa Bold were major general recombinants in the F2 generation. Kranti RH-30 J.D.-6 and NDRE-4 for daystofloweringindicatingearlyflowering were the bestgeneral combiners shared by both generations, with good per seperformance and strong gca effects.

Plantheight

Five plants from both the F1 and F2 generations showed satisfactory height increases due to the gca impact.When taking into account both spread performance and gca effects, the five generic combiners (Kranti, RLM-198, PusaBahar, Jawaher-1, and Rohini) were discovered to be shared by both generations.

Leaf area index

Significant and positive gca effects for leaf area index were found in offspring of all four parents (Rohini, Kranti, and RLM-198 in F1s; Kranti, Rohini, RLM-198, and Jawaher-lin in F2s). When considering per se performance and gca impacts, the same three general combiners were present in both generations. These, in order of merit, were Rohini, RLM-198 and Kranti for the trait.

Number of siliquae per plant

Jawaher-l, Rohini,Kranti, PusaBahar, and RH-30 were the best parents for increasing the average number of siliquae per plant in the F1 generation, whereas Jawaher-1, RH-30, Rohini, PusaBahar, Vardan, and Kranti were the best parents for doing so in the F2 generation. There were a total of 5 shared parents between the two sets of children. Rohini, Jawaher-1, RH-30, and Krantias, as evaluated by their per se values and gca effects, were the strongest general combiners throughout both generations for silica content per plant.

Number of seeds per siliqua

When looking at the quantity of seeds produced per siliqua in the F1 and F2 generations, five parents showed significantly significant gca impacts. Jawaher-1 is an example of a generic combiner. excellent combiner when considering both per se performance and substantial gca impacts for total seed yield in silica.

Oil content

Rohini, J.D.-6, RH-30, and Kranti showed the most significant and beneficial gca impacts on oil content in F1s, while Kranti, RH-30, Rohini, PusaBahar, and Pusa Bold topped the list in F2s. Three of them are really parents.In terms of oil content, the names Rohini, Kranti, and RH-30 were widely used in both generations.

Seed yield per plant

Seed yield per plant in the F1 generation was significantly influenced by five parents, and in the F2 generation, by six.Five of these popular general-purpose combiners stood out. Rohini, Kranti, PusaBahar, Pusa Bold, and Vardan were the best general blenders when taking into account both spread performance and substantial gca effects.

Table 5: Mean for 12 characters in a 10x10 diallel cross in Indian mustard and parentage estimates for the influence of general combining ability (GCA)

Parent	Daysto flowering			Plantheight(cm)		
	GCA effect		Mean	GCA effect		Mean
	F_1	F_1		F_2	F_2	
Kranti	-0.39	-2.46	155.98	-3.83	-2.17	47.00
Rohini	3.58	5.87	180.03	3.15	3.02	59.33
PusaBold	-0.28	-3.02	158.06	-0.85	-0.78	53.67
Vardan	4.47	9.18	182.93	7.21	4.22	63.33
PusaBahar	0.49	7.81	195.60	5.27	1.27	53.67
RH-30	-2.28	-6.98	153.03	0.15	-1.37	46.33
RLM-198	7.88	18.50	199.63	15.47	7.16	67.00
Jawaher-1	1.94	6.14	183.35	6.10	2.24	55.67
J.D.-6	-6.28	-16.03	131.45	-13.46	-4.92	41.00
NDRE-4	-9.12	-19.02	130.62	-19.22	-8.67	36.00
$\bar{X}$			167.00			52.30
SE[gi-gj]( )	0.19	0.32		0.44	0.21	
SE[gi-gj]( )	0.28	0.48		0.65	0.31	
SE (meandiff.)			1.97			1.26

	Leaf areaindex	Numberofsiliquaeperplant

Parent	GCA effect		Mean	GCA effect		Mean
	F_1	F_2		F_1	F_2	
Kranti	0.41	0.58	310.00	17.01	4.64	2.80
Rohini	0.54	0.48	330.33	18.98	18.78	3.74
PusaBold	-0.07	-0.13	285.00	-8.19	-14.91	2.70
Vardan	-0.01	0.03	316.00	-9.27	5.01	2.51
PusaBahar	-0.12	-0.04	304.67	15.09	10.12	2.32
RH-30	-0.09	-0.09	312.33	14.87	22.23	2.43
RLM-198	0.28	0.24	286.00	-16.52	-29.69	3.29
Jawaher-1	-0.01	0.08	325.33	22.03	32.64	2.48
J.D.-6	-0.38	-0.49	248.00	-29.24	-21.88	1.68
NDRE-4	-0.55	-0.56	232.00	-24.74	-26.94	1.57
$\bar{X}$			294.97			2.55
SE[gi-gj]( )	0.01	0.01		1.89	1.12	
SE[gi-gj]( )	0.02	0.01		2.82	1.67	
SE (meandiff.)			5.65			0.07

Parent	Oilcontent(%)			Seed yieldperplant(g)		
	GCA effect		Mean	GCA effect		Mean
	F_1	F_2		F_1	F_2	
Kranti	0.11	0.69	18.52	1.63	1.63	40.45
Rohini	0.75	0.38	19.73	2.30	2.38	41.06
PusaBold	-0.06	0.13	16.43	1.22	1.45	38.24

Vardan	0.06	-0.05	15.98	0.69	0.71	39.03
PusaBahar	0.04	0.21	17.79	1.16	1.63	40.00
RH-30	0.27	0.52	16.06	-0.55	-0.47	40.27
RLM-198	-0.26	-0.55	12.04	-1.84	-2.34	37.86
Jawaher-1	-0.10	-0.23	16.02	0.07	0.36	38.27
J.D.-6	0.36	-0.63	10.54	-2.39	-2.84	37.04
NDRE-4	-0.44	-0.46	10.75	-2.31	-2.52	37.32
$\bar{X}$			15.38			38.95
SE[gi-gj]	0.07	0.06		0.06	0.02	
SE[gi-gj]	0.10	0.08		0.08	0.03	
SE (meandiff.)			0.07			0.53

Selection Parameters

- **Correlation Coefficient**

Coefficients of association were estimated for each of the 12 traits over all possible couples in the parental, first, and second filial generations. The data for the parent, F1, and F2 generations are shown in Tables, respectively.

In all character combinations except 2/3 of the time, the magnitude of the genotypic correlation coefficients was higher than thatpi' phenotypic connections in the parental, F1, and F2 generations.

34 out of 66 possible character pairs in parents had statistically significant association coefficients. Number of secondary branches was inversely and substantially related to days to blooming, whereas days to maturity, plant height, leaf area index, number of siliquae per plant, number of seeds per siliqua, and yield per plant were all positively related.The number of days to maturity was positively and significantly correlated with plant height, leaf area index, siliquae per plant, seeds per siliqua, and yield per plant. There was a positive and substantial correlation between plant height and germination rate, days to blooming, days to maturity, leaf area index, siliquae per plant, seeds per siliqua, and total yield per plant. Significant and positive

correlations were found between leaf ca index and blooming and fruiting times, siliquae per plant, seed output, and siliquae per plant.

The correlation coefficients were positively and substantially linked with yield per plant and number of main branches among component features in the parental generation. plant siliquae count 1000 seeds of siliqua, their mass and oil content.

In the F1 generation, 34 of 66 possible character pairings had the significant connections documented. There were 31 different permutations where both values were significantly positive and more than 0.05. More than 25% of the correlation coefficient was accounted for by the relationships between flowering days and harvesting days, plant height and leaf area index, harvesting days and plant height, leaf area index and 1000-seed test weight, and harvesting days and seed yield per plant.

The number of seeds per siliqua, harvest index, and oil content were all positively correlated with seed yield per plant in the F1 generation. So were the number of days to blooming, plant height, leaf area index, number of main branches, number of secondary branches, and number of seeds. The number of days it took to blossom, mature, and produce a harvest per plant were all positively and substantially correlated with oil content.

When comparing F2s to F1s, both the strength and direction of connections held true The values were comparable to the F1 generation in terms of the total number of possible permutations. There were 35 instances of 66 character combinations in the second generation when a significant correlation was noted.There were six relationships where the correlation between responses was greater than 25%.There was a very significant and positive correlation between the number of days from flowering to harvest, as well as between the height of the plant and the leaf area index, the number of days from harvest to blooming, and the weight of 1,000 seeds, the weight of 1,000 seeds tested, and the yield of seeds produced by a single plant.

Days to blooming, days to maturity, plant height, leaf area index, main branch count, seeds per siliqua, harvest index, and oil content were all significantly correlated with seed yield per plant in the F2 generation. Oil content was inter-related seeds per plant, days to blooming, and weight per thousand seeds all correlate positively and substantially.

Table 6: Among F1 utilised in a 10x10 diallel cross of Indian mustard (Brassica juncea), we calculated the genetic and phenotypic correlation coefficients for 12 different traits.)

Characters	Days tofloweri ng	Leafareaind ex	Numberof siliquaeperpla nt	Numberofsee ds Persiliqua	Oilcontent(%)	Seedyield perplant(g)
Daysof flowering	ph^{r}g	0.545	0.171	0.143	0.263	0.333
Plantheight (cm)	0.833	0.537	0.146	0.113	0.123	0.291
Leafareainde x	0.533	ph^{r}g	0.300	0.268	0.213	0.400
Numberof siliquae perplant	0.158	0.289	ph^{r}g	0.278	-0.042	0.336
Oilcontent(%)	0.219	0.184	-0.14	0.075	ph^{r}g	0.255
Seed yieldper plant(g)	0.327	0.392	0.322	0.299	0.222	ph^{r}g

Table 6(a):Genotype-phenotype correlation values for 12 features in a 1010 diallel cross of Indian mustard (Brassica juncea) including F2.

Characters	Days tofloweri ng	Leafareaind ex	Numberof siliquaeperpla nt	Numberofsee ds Persiliqua	Oilcontent(%)	Seedyield perplant(g)
Daysof flowering	ph^{r}g	0.565	0.124	0.143	0.392	0.240
Plantheight (cm)	0.554	ph^{r}g	0.217	0.143	0.154	0.389

Leafareaindex	0.123	0.215	phrg	0.245	0.165	0.288
Numberof siliquae perplant	0.055	0.350	0.313	0.272	0.165	0.369
Oilcontent(%)	0.384	0.150	0.160	0.047	phrg	0.292
Seed yieldper plant(g)	0.234	0.388	0.282	0.248	0.285	phrg

4. Conclusion

It is clear from the results that both additive and additive x additive genetic effects played a significant role in determining the characters studied. Traditional breeding methods are useful for increasing seed yield in self-fertile species like Indian mustard by capitalizing on the portion of genetic variability that is attributable to these effects. However, modified recurrent selection, such as bi-parental mating, could be purposeful in releasing dormant genetic variability, including beneficial genes, and breaking undesirable linkages, allowing for more efficient use of both additive and non-additive genetic variances. Heterosis breeding is advantageous in the current context since it increases production.

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