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SELECTION OF ELITE GENOTYPES FOR YIELD AND ASSOCIATED TRAITS IN $F_{2:3}$ FAMILIES OF INTERSPECIFIC CROSSES IN *BRASSICA* SPECIES

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Abstract

Interspecific crosses of *Brassica* species were evaluated to identify desirable genotypes for yield and associated traits. Parent al species included *Brassica napus* (Dunkled, Maluko, line A-20-20), *B. campestris* (lines 1203 and 2163), *B. carinata* (Peela raya), and *B. juncea* (lines PR-64 and 89111-1). All traits were segregated in F_2 population. All parameters were decreased in F_3 in comparison to F_2 population, indicating higher response of the crosses to inbreeding depression (0-85%). A reduction in height (12-27%), primary branches (18-35%), pods main raceme^{-1} (19-35%), seed pod^{-1} (10-31%), pod length (14-28%), 100-seed weight (5-28%) and seed yield plant^{-1} (14-35%) of F_3 population was recorded as compared to F_2. Heritability estimates were low to medium (50-70%) for primary branches, medium to high (70-80%) for plant height, pod length, seeds pod^{-1}, and seed yield plant^{-1} while low-medium-high for pods raceme^{-1} and 100-seed weight. It was concluded that selection for one of these characters would be beneficial for the others also. F_3 population of Maluko × 1203 produced the maximum silique main raceme^{-1}, seeds silique^{-1}, silique length and 100-seed weight. Peela raya × PR-64 produced the maximum primary branches plant^{-1}, while 2163 × 89111-1 was the best for seed yield plant^{-1} and plant height in F_3 as compared to the F_2 population.

Introduction

Rapeseed and mustard crops are being cultivated in 53 countries spread over the six continents across the globe covering an area of 24.2 million hectares with an average yield of 1451 kg ha^{-1} ranging from 411 (Russian Federation) to 6250 kg ha^{-1} (Algeria) with the total production of 35.1 million tons. Asian continent alone accounts for 59.1% of the hectarage but contributes only 48.6% to the world production. Europe contributes 29.7% to the global production while its share is only 16.2% in the total global hectarage. However, yield is highly variable ranging from 411 (Russian Federation) to 3528 kg ha^{-1} (France) (Yadav & Singh 1999).

Pakistan is chronically deficient in the production of edible oils and this deficit is being continuously enlarged. The local production of edible oil from all crops is only sufficient to meet about one third of the domestic consumption, remaining being met through imports. These imports are continuously increasing with an alarming rate of 13% annually. During the year 2010-11 local production of oilseed crops accounted for only 23% of the total availability while the remaining 77% was made available through imports (Anon., 2011).

Heritability is an important tool for measuring the transmission of trait from parents to off-springs or consistency of that particular trait. Considerable work has been done in order to estimate the heritability of morphological traits in *Brassica* species. In rapeseed high heritability with high genetic advance has been reported for plant height and seed yield (Singh & Singh, 1997). Skeikh *et al*., (1999) found high heritability coupled with high genetic advance for seed yield plant^{-1}, primary and secondry branches, silique plant^{-1} and seed weight in rapeseed (*B. campestris* L.) genotypes. They also reported correlation of all the yield components with seed yield. Inter-specific and inter-generic hybridizations can be used for the release of genetically modified *Brassica campestris* and *B. napus* hybrids. Interspecific crosses may result in progeny that exhibit partial fertility/sterility. This may be influenced by chromosome number of the cultivated species and the relatives. Although there are many exceptions, higher maternal and paternal ratios improve the chance for a successful cross (Nishiyama & Inomata, 1966).

Estimation of variability, heritability, genetic advance, correlation and inheritance pattern of yield and its components were investigated by Ali *et al*., (2003), Noshin *et al*., (2003), Sohail & Khan (2003), and Ali (1985). In their studies selections were made in local or exotic germplasm but not in combination of local and exotic germplasm for yield and other economic traits. Keeping in view the importance of edible oil in the country, an experiment was designed with the following objectives to:

i. identify the promising interspecific crosses in F_{2-3} generations having high yield and associated traits.
ii. estimate h^2 for yield and quality traits through using parents-offspring regression procedure.

Materials and Methods

Genetic material: To get F_2 plants, F_1 hybrids obtained from the crosses Dunkled × 1203, Maluko × 2163, A-20-20 × 1203, Peela raya × PR -64 and 2163 × 89111-1 were evaluated during the years 2003-4 and 2004-05 (Rabi season) at New Development Farms, Khyber Pakhtunkhwa Agricultural University, Peshawar. In F_2 population, selection was made for yield and associated traits and was advanced to F_3 generation. Means, variances and heritability estimates (h^2) for plant height, primary branches plant^{-1}, silique main raceme^{-1}, seed silique^{-1}, silique length^{-1} (Table 1), 100-seed weight (Table 2) and seed yield plant $^{-1}$ (Table 3) were recorded for all the populations under study.

Cultural practices: Both the populations (F_2 and F_3) were evaluated in two meters long beds. Bed-to-bed distance was one meter. Each bed was comprised of 11 lines of a single population with 60 cm row to row and 40 cm plant-to-plant spacing. Each line within the bed was a different cross of that particular population. No fertilizer and pest management practices were adopted in order to measure the potential of the crosses under natural conditions.

Table 1. Means, variances and heritability estimates for plant height, primary branches plant^{-1}, silique main raceme^{-1}, seed silique^{-1} and silique length^{-1} of F_2 and F_3 *Brassica* populations.

Plants /Lines		Plant height (cm)	Branches plant^{-1}	Silique main raceme^{-1}	Seed silique^{-1}	Silique length (cm)
		Characters				
Dunkled		150	8	42	14	6.6
1203		150	7	45	16	4.9
Maluko		200	6	45	22	5.9
2163		195	7	47	15	4.5
A-20-20		175	7	41	16	8.5
Peela Raya		180	7	47	19	5.4
PR-64		112	5	40	10	3.5
89111-1		117	7	40	18	6.9
Dunkled × 1203	F_2	175.9	9.0	56.0	18.1	5.0
	F_3	147.9	6.0	44.7	16.2	4.3
	Difference I	-15.0	-33.3	-20.27	-10.50	-14.0
	Difference II	-1.4	-25.0	2.75	8.0	-25.47
	Var I	908.8	9.0	566.6	42.7	1.3
	Var II	375.0	5.6	319.0	15.4	1.0
	h^2	0.83	0.67	0.74	0.83	0.87
Maluko × 2163	F_2	163.2	10.0	74.8	16.6	6.3
	F_3	135.8	7.0	54.8	11.5	4.6
	Difference I	-16.78	-30.0	-26.80	-30.72	-23.8
	Difference II	-21.24	7.69	19.13	-37.83	-8.22
	Var I	1072.3	8.8	755.4	25.0	2.2
	Var II	678.3	2.0	404.7	15.8	0.9
	h^2	0.80	0.68	0.73	0.68	0.74
A-20-20 × 1203	F_2	167.8	9.0	71.5	20.5	6.9
	F_3	122.0	6.0	45.9	14.2	5.2
	Difference I	-27.29	-33.3	-35.84	-30.73	-24.63
	Difference II	-24.92	-14.28	6.74	-11.25	-22.38
	Var I	997.9	14.2	750.4	5.8	0.3
	Var II	214.9	3.8	218.0	32.2	5.2
	h^2	0.70	0.57	0.55	0.70	0.75
Peela Raya × PR-64	F_2	187.9	17.0	18.8	20.7	6.0
	F_3	164.2	11.0	15,2	15.4	4.5
	Difference I	-12.61	-35.2	-19.1	-25.43	25.0
	Difference II	12.46	83.33	-65.05	62.10	0.4
	Var I	580.6	38.6	5.3	23.4	0.8
	Var II	297.4	5.4	4.4	3.8	0.9
	h^2	0.85	0.59	0.80	0.70	0.76
2163 × 89111-1	F_2	183.1	11.0	53.9	15.2	4.9
	F_3	157.6	9.0	37.0	12.6	3.5
	Difference I	-13.92	-18.0	-31.18	-17.28	-28.57
	Difference II	1.02	28.57	-14.94	-23.63	-38.59
	Var I	1086.5	2.4	181.4	4.2	0.4
	Var II	695.2	2.4	299.4	5.8	0.2
	h^2	0.82	0.73	0.66	0.81	0.71

Var I = Variance among F_2 Plants; Var II= Variance among F_3 Plants

Table 2. Means, variances and heritability estimates for 100-seed weight of F_2 and F_3 *Brassica* populations.

Plants/lines	**Populations**									
	Dunkled × 1203		**Maluko × 2163**		**A-20-20 × 1203**		**Peela raya × PR 64**		**2163 × 89111-1**	
Parents	**Dunkled**	**1203**	**Maluko**	**2163**	**A-20-20**	**1203**	**Peela raya**	**PR 64**	**2163**	**89111-1**
Values	0.34	0.33	0.41	0.31	0.22	0.33	0.31	0.36	0.32	0.83
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Mean	0.4	0.4	0.5	0.4	0.3	0.3	0.5	0.3	0.4	0.3
Difference I	-9.09		-16.98		-5.88		-26.92		-28.57	
Difference II	33.33		11.11		11.11		0.0		-41.17	
Var	0.02	0.006	0.01	0.01	0.01	0.009	0.01	0.002	0.02	0.008
h^2	0.79		0.81		0.91		0.69		0.65	

Table 3. Means, variances and heritability estimates for seed yield plant^{-1} of F_2 and F_3 *Brassica* populations.

Plants/lines	Populations									
	Dunkled × 1203		Maluko × 2163		A-20-20 × 1203		Peela raya × PR 64		2163 × 89111-1	
Parents	**Dunkled**	**1203**	**Maluko**	**2163**	**A-20-20**	**1203**	**Peela raya**	**PR 64**	**2163**	**89111-1**
Values	90.6	131.76	58.68	62.88	36.96	131.76	62.32	82.56	104.8	85.0
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Mean	163.1	114.2	156.1	112.3	140.2	103.8	95.9	83.6	185.7	140.0
Difference I	-29.9		-28.0		-25.9		-18.6		-24.5	
Difference II	2.71		84.76		23.02		15.19		47.52	
Var	8470.7	4150.6	5823.2	3014.68	2227.00	1219.4	116.5	77.06	11458.1	6513.0
h^2	0.70		0.71		0.74		0.86		0.75	

Data collection and statistical analysis: Data regarding different yield and associated traits i.e., plant height, number of primary branches, pod length, pods raceme^{-1}, seeds pod^{-1}, 100-grain weight, seed yield plant^{-1} were recorded.

Mean and variances were calculated from the average data recorded using Microsoft Excel software. Heritability for all traits was also estimated using procedure described by Fehr (1988).

Results and Discussion

Plant height: A reduction of various magnitude occurred for plant height of all the crosses in F_3 as compared with F_2 generation. Reduction was 15% in cross Dunkled × 1203, 16.78% in cross Maluko × 2163, 27.29% in cross A-20-20 × 1203, 12.61% in cross Peela raya × PR-64 and 13.92% in cross 2163 × 89111-1. These observations revealed that selection in F_2 was probably made for medium plants had the maximum tolerance to lodging. In comparison to the parental lines, plant height in F_3 was reduced 1.4% in Dunkled × 1203, 31.24% in Maluko × 2163, 24.92% in A-20-20 × 1203, while increased 12.46% in Peela raya × PR-64 and 1.02% in 2163 × 89111-1(Table 1). Heritability estimates for plant height in *brassica* populations were 0.83 for Dunkled × 1203, 0.80 for Maluko × 2163, 0.70 for A-20-20 × 1203, 0.85 for Peela raya × PR-64, and 0.82 for 2163 × 89111-1. High heritability values indicate that plant height could be used as selection criterion. This indicates effectiveness of selection for plant height in the current *brassica* populations. High heritability coupled with genetic advance is reported by Diwakar & Singh (1993), Mahmood *et al*., (2003) and Mahak *et al*., (2011) observing high GCV coupled with high heritability for plant height, seed yield and days to maturity while working on Indian mustard.

Primary branches plant^{-1}: Number of primary branches were reduced 33.3% in cross Dunkled × 1203, 30% in cross Maluko × 2163, 33.3 % in cross A-20-20 × 1203, 35.2% in cross Peela raya × PR-64 and 18% in cross 2163 × 89111-1 in F_3 in comparison to F_2 populations. Comparing parental values, number of primary branches increased 7.69% in Maluko × 2163, 83.33% in Peela raya × PR-64, and 28.57% in 2163 × 89111-1, while reduced 25% in Dunkled × 1203 and 14.28% in A-20-20 × 1203 (Table 1). Heritability estimates were 0.67 (Dunkled x 1203), 0.68 (Maluko × 2163), 0.57 (A-20-20 × 1203), 0.59 (Peela raya × PR-64), and 0.73 (2163 × 89111-1).

High heritability values obtained in the current studies revealed that early selection could be valuable for primary branches. On the basis of these observations, phenotypic or pedigree selection could be more efficient for the improvement of this trait. These results are also supported by Gosh & Gulati (2001) who reported higher heritability in Indian mustard. Results are also in agreement to the findings of Khulbe *et al*., (2000) who found higher heritability and genetic advance for number of branches and other parameters.

Silique main raceme^{-1}: The range and average for silique main raceme^{-1} in F_2 was from 11 to 80 for cross Dunkled × 1203, 44 to 116 for Maluko × 2163, 25 to 119 for cross A-20-20 × 1203, 12 to 22 for cross Peela raya × PR-64, and from 30 to 74 for cross 2163 × 89111-1 averaging 54.09, 74.72, 71.54, 16.90, 53.90, respectively (Table 1). In F_3 it was observed that pods main raceme^{-1} of the five *Brassica* populations reduced 20.27% in cross Dunkled × 1203, 26.80% in cross Maluko × 2163, 35.84% in cross A-20-20 × 1203, 19.1% in cross Peela raya × PR-64 and 31.18% in cross 2163 × 89111-1 in comparison to F_2 population. Heritability estimates were 0.74 for cross Dunkled x 1203, 0.73 for cross Maluko × 2163, 0.55 for cross A-20-20 × 1203, 0.80 for cross Peela raya × PR-64, and 0.66 for cross 2163 × 89111-1, respectively (Table 1).

The results of current studies are supported by earlier findings of Mahmood *et al*., (2003) in mustard, who obtained higher heritability for silique plant^{-1}. Similarly, Gosh & Gulati (2001) and Hashemi *et al*., (2010) reported higher heritability for number of pods main shoot^{-1} during F_2 and F_3 generations. High heritability combined with high genetic advance was also reported by Ali (1985) in mustard germplasm.

Seeds silique^{-1}: In comparison to $F_{2,}$ number of seed silique^{-1} in F_3 of the five *Brassica* populations reduced 10.50% for cross Dunkled × 1203, 30.72% for cross Maluko × 2163, 30.73% for cross A-20-20 × 1203, 25.43% for cross Peela raya × PR-64 and 17.28% for cross 2163 × 89111-1. In comparison to the parental values, seeds silique^{-1} decreased 37.83% in Maluko × 2163, 11.25% in A-20-20 × 1203 and 23.63% in 2163 × 89111-1, while increased 8.0% in Dunkled × 1203 and 62.10% in Peela raya × PR-64 in F_3 populations (Table 1).

Heritability estimates were 0.83 for cross Dunkled × 1203, 0.68 for cross Maluko × 2163, 0.70 for cross A-20-20 × 1203, 0.70 for cross Peela raya × PR-64, and 0.81 for cross 2163 × 89111-1, respectively for number of seeds silique^{-1} (Table 1).

However, higher heritability estimates found in the current studies are supported by the earlier findings of Gosh & Gulati (2001). They reported high heritability with high genetic advance for seed silique^{-1}, they further suggested that phenotypic selection could be used for the improvement of this trait. However, Rao & Gulati (2001) reported medium heritability for seed silique^{-1}.

Silique length (cm): In F_3, silique length of five *Brassica* populations, a reduction of 14.0% for cross Dunkled × 1203, 23.8% for cross Maluko × 2163, 24.63% for cross A-20-20 × 1203, 25% for cross Peela raya × PR-64 and 28.57% for cross 2163 × 89111-1 in comparison to the F_2 populations (Table 1). In comparison to the parental lines, silique length in F_3 reduced 25.47% in Dunkled × 1203, 8.22% in Maluko × 2163, 22.38% in A-20-20 × 1203 and 38.59% in 2163 × 89111-1, while increased 0.4% in Peela raya × PR-64.

Heritability estimates were 0.87 for cross Dunkled × 1203, 0.74 for cross Maluko × 2163, 0.75 for cross A-20-20 × 1203, 0.76 for cross Peela raya × PR-64, and 0.71 for cross 2163 × 89111-1 (Table 1).

The importance of silique length is obvious and as a yield component consideration was given to this trait in the current study. Higher heritability estimates suggest that the selection of this trait could be beneficial for the improvement of yield. Chay & Thurling (1989) reported that Seed weight plant^{-1} tended to increase with increasing silique length. They further reported that families with longest silique generally produce significantly higher yields than those with shorter silique.

100-Seed weight: During the study it was observed that 100-seed weight of the five *Brassica* populations reduced 9.09% in cross Dunkled × 1203, 16.98% in cross Maluko × 2163, 5.88% in cross A-20-20 × 1203, 26.92% in cross Peela raya × PR-64 and 28.57% in cross 2163 × 89111-1 in F_3 as compared to the F_2 population (Table 2). In comparison to the seed weight of parental, in F_3 a reduction of 41.17% was observed in 2163 × 89111-1, while for the remaining all crosses 100-seed weight increased 33.33% in Dunkled × 1203, 11.11% in both Maluko × 2163 and A-20-20 × 1203.

Heritability estimates were 0.79, 0.91, 0.69 and 0.65 for crosses Dunkled x 1203, Maluko × 2163, A-20-20 × 1203, Peela raya × PR-64, and 2163 × 89111-1, respectively (Table 2).

Higher heritability estimates were experienced in the current studies for 100-seed weight, which are also supported by the results of Ali (1985) who observed a range of heritability (0.51-0.95) for the said trait in mustard germplasm. Medium heritability (0.55) was reported by Ali *et al*., (2003) suggesting that this parameter could be improved through mass selection.

Seed yield plant^{-1}: From the data it is revealed that seed yield plant^{-1} of the five *Brassica* populations reduced 35.68% in cross Dunkled × 1203, 33.66% in cross Maluko × 2163, 26.91% in cross A-20-20 × 1203, 14.45% in cross Peela raya × PR-64 and 23.89% in cross 2163 × 89111-1 in F_3 in comparison to F_2 populations (Table 3). In comparison to parental genotypes, an increase in seed yield plant^{-1} of Maluko × 2163 (48.28%), A-20-20 × 1203 (0.69%), Peela raya × PR-64 (29.53%) and 2163 × 89111-1(58.70%) was recorded. A reduction of 40.61% in seed yield in Dunkled × 1203 was also noticed.

Heritability estimates were 0.70 for cross Dunkled ×1203, 0.71 for cross Maluko × 2163, 0.74 for cross A-20-20 × 1203, 0.86 for cross Peela raya × PR-64, and 0.81 for cross 2163 × 89111-1, respectively (Table 3).

In current studies high to medium heritability was observed for seed yield plant^{-1}. Similarly Ali *et al*., (2003) and Mahak *et al*., (2011) observed high GCV coupled with high heritability for plant height, seed yield and days to maturity However, Rao & Gulati (2001) observed medium to low heritability for seed yield plant^{-1} in crosses. The difference could be due the difference in genetic material and environmental conditions. However, low heritability is obtained by Li *et al*., (1990). Yadav *et al*., (1993) suggested that selection under normal sowing condition could improve the seed yield plant^{-1}.

Conclusions and recommendations: The study aimed to identify promising genotypes, having high yield and associated traits, by combination of local and exotic germplasm. A high level of inbreeding depression was observed among all the populations under the study. Evaluation of parental lines and their respective progenies in two separated years may also be a reason for it.

The study revealed that *Brassica* is much influenced by environmental stress. Temperature is having a significant role in vegetative growth of *Brassica* plant. During the second year of evaluation rainfall was more than normal so vegetative growth was enhanced which may also be the reason for increased heritability. All the characters were highly correlated to each other so selection for one of the character would be beneficial for the other one also. Taller plants were having significant impact on yield as they have more silique plant^{-1} and have more number of branches.

During the study, no pest management studies were carried out, however, all the lines advanced to the next generation were resistant to both disease and insect pests. In future, it is recommended that exclusive work should be carried out to develop resistance against disease and insect pests. As the study aimed to identify promising genotypes for local cultivation, combination of *Brassica napus* × *B. campestris* proved superior for local cultivation.

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