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Parental order *vis-a-vis per se* performance in multi-way crosses of Indian mustard (*Brassica juncea* L. Czern & Coss)

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Abstract

Multi-way crosses have provided valuable information on the relative importance of arrangement of parents (order effects) in these hybrids. The crosses belonging to same group showed variable *per se* performance despite the commonality of parents involved. A persual of combining ability effects for seed yield and oil content revealed the predominance of two line specific effects of second kind (dominance) being associated with order effects of parents in three-way crosses. Further, order of the parents in three-way crosses also indicated, that the *per se* performance for seed yield was not related to percentage of genetic contribution either by the high yielding grand parents (contributing 25% each) or by immediate parent (contributing 50%).

Key words : *Brassica juncea*, order effects, multi-way crosses

Introduction

Rape seed-mustard group of oil seed crops is the second most important after groundnut. The production of rape seed-mustard in 1997-98 was about 4.94 million tons, with the productivity of 1013 Kg/ha. This has been largely due to the new integrated oilseed policy of Govt. of India in the form of Technology Mission on Oilseeds and resulted in yellow revolution. Nevertheles, the productivity of rape seed-mustard in India is low (1013 kg/ha) as compared to the world average of 1333 kg/ha. Thus, the present average yield in India is much lower than the yield potential achievable in this crop. In this context, diversification of working gene pool through various mating schemes is warranted. Therefore, development of multiple crosses (three-way and double) was carried out. Further, with common parents involved in various cross combinations were grouped to know the order effects of the parents.

Materials and methods

Five genotypes viz., Kranti, RJ10, DLM29, PR8943 and RK919003 were used to develop a set of 10 single crosses at I.A.R.I, New Delhi. Part of F_1 seed was used to produce 30 and 15 three-way and double crosses, respectively during off-season at Wellington. In subsequent year, parents and F_1s of single, three-way and double crosses were raised in randomized block design with three replications to evaluate them. There were three-meter long rows spaced 40 cms apart, with plants spaced 15 cms apart within rows. There were two rows each in the case of single crosses and parents, three rows for three-way crosses and four rows for double crosses. Data on various yield components and oil content were recorded on 10 random plants in each of the parents and single crosses, 20 plants in three-way crosses and 30 plants in double crosses. However, seed yield per plant and oil content were used to know the order effects.

Results and discussion

To know the order effects of parents used in multi-way crosses (three-way and double crosses) *per se* performance of the individual crosses was followed in respect of two economically important traits viz., seed yield and oil content. For this purpose, group wise comparisons were made and superior cross combinations (order effects of the parents) identified from the various groups (Tables 1 and 2).

Order effects of the parents in three-way crosses

With regard to seed yield, ten crosses belonging to the various groups showed superior per se performance. They are (Kranti × RJ10) × DLM 29, (Kranti × RJ10) × PR8943, (Kranti × RK919003) × RJ10, (Kranti × PR8943) × DLM29, (Kranti × RK919003) × DLM29, (kranti × RK919003) × PR8943, (DLM29 × PR8943) × RJ10, (DLM29 × RK919003) × RJ10, (RJ10 × RK919003) × PR8943 and (DLM29 × PR8943) × RK919003. Out of the 10 superior crosses, Kranti was involved as one of the grand parents in six crosses. Among the single crosses involved, Kranti × RK919003

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appeared thrice, followed by Kranti × RJ10 and DLM29 × PR8943 appearing twice each in the above mentioned crosses.

Table 1. Order effects with respect to *per se* performance for seed yield and oil content in three-way crosses

Crosses	Seed yield (g)	Oil content (%)
Group I		
1. (Kranti × RJ10) × DLM29	20.50	37.90
2. (Kranti × DLM29) × RJ10	20.39	40.04
3. (RJ10 × DLM29) × Kranti	12.89	38.32
Group II		
1. (Kranti × RJ10) × PR8943	16.97	40.65
2. (Kranti × PR8943) × RJ10	10.21	37.52
3. (RJ 10 × PR8943) × Kranti	9.19	39.24
Group III		
1. (Kranti × RJ10) × RK919003	6.89	38.30
2. (Kranti × RK919003) × RJ10	15.57	39.51
3. (RJ10 × RK919003) × Kranti	8.69	37.74
Group IV		
1. (Kranti × DLM29) × PR8943	7.58	38.69
2. (Kranti × PR8943) × DLM29	12.95	39.57
3. (DLM29 × PR8943) × Kranti	9.68	38.03
Group V		
1. (Kranti × DLM29) × RK919003	10.99	38.68
2. (Kranti × RK919003) × DLM29	13.04	39.73
3. (DLM29 × RK919003) × Kranti	11.24	39.64
Group VI		
1. (Kranti × PR8943) × RK919003	9.48	37.27
2. (Kranti × RK919003) × PR8943	14.76	38.50
3. (PR8943 × RK919003) × Kranti	12.54	38.97
Group VII		
1. (RJ10 × DLM29) × PR8943	14.87	41.46
2. (RJ10 × PR8943) × DLM29	12.93	39.20
3. (DLM29 × PR8943) × RJ10	15.88	40.13
Group VIII		
1. (RJ10 × DLM29) × RK919003	9.35	40.28
2. (RJ10 × RK919003) × DLM29	8.21	37.72
3. (DLM29 × RK919003) × RJ10	17.05	43.41
Group IX		
1. (RJ10 × PR8943) × RK919003	11.14	38.29
2. (RJ10 × RK919003) × PR8943	15.97	41.20
3. (PR8943 × RK919003) × RJ10	12.71	38.75
Group X		
1. (DLM29 × PR8943) × RK919003	15.66	39.24
2. (DLM29 × RK919003) × PR8943	14.87	42.01
3. (PR8943 × RK919003) × DLM29	10.68	40.45
S. E.	2.91	1.34

With regard to oil content, crosses recording superior performance are (Kranti × DLM29) × RJ10, (Kranti × RJ10) × PR8943, (Kranti × RK919003) × RJ10, (Kranti × PR8943) × DLM29, (Kranti × RK919003) × DLM29, (PR8943 × RK919003) × Kranti, (RJ10 × DLM29) × PR8943, (DLM29 × RK919003) × RJ10, (RJ10 × RK919003) × PR8943 and (DLM29 × RK919003) × PR8943. It is interesting to note that DLM29, a high oil yellow seeded parent was involved in five out of ten superior crosses irrespective of its position as a parent or a grand parent, indicating its use in breeding programme for improvement of oil content. Kranti a national variety, was involved as one of the grand parents in six superior crosses. Further, it is worth while mentioning that Kranti also showed superior performance for seed yield. Single crosses *viz.*, (Kranti × RK919003) and DLM29 × RK919003 were involved twice each in superior crosses for oil content.

Table 2. Order effects with respect to *per se* performance for seed yield and oil content in double crosses

Crosses	Seed yield (g)	Oil content (%)
Group I		
1. (Kranti × RJ10) (DLM29 × PR8943)	16.59	40.07
2. (Kranti × DLM29) (RJ10 × PR8943)	11.02	38.47
3. (Kranti × PR8943) (RJ10 × DLM29)	11.88	39.30
Group II		
1. (Kranti × RJ10) (DLM29 × RK919003)	11.63	38.77
2. (Kranti × DLM29) (RJ10 × RK919003)	18.68	38.07
3.(Kranti × RK919003) (RJ10 × DLM29)	8.81	38.40
Group III		
1. (Kranti × RJ10) (PR8943× RK919003)	9.67	38.77
2. (Kranti × PR8943) (RJ10× RK919003)	14.92	38.43
3. (Kranti × RK919003) (RJ10× PR8943)	12.81	35.47
Group IV		
1. (Kranti × DLM29) × (PR8943× RK919003)	11.92	38.23
2. (Kranti × PR8943) (DLM29× RK 919003)	14.83	41.03
3. (Kranti × RK919003) (DLM29 × PR8943)	10.48	39.70
Group V		
1. (RJ10 × DLM29) (PR8943 × RK919003)	12.66	40.53
2. (RJ10 × PR8943) (DLM29 × RK919003)	12.68	39.00
3. (RJ10 × RK919003) (DLM29 × PR8943)	10.14	40.10
S. E.	1.0	2.62

Six crosses *viz.*, (Kranti × RJ10) × PR8943, (Kranti × RK919003) × RJ10, (Kranti × PR8943) × DLM29, (Kranti × RK919003) × DLM29, (DLM29 × RK919003) × RJ10 and (RJ10 × RK919003) × PR8943 recorded superior performance for both seed yield and oil content, suggesting possibility for simultaneous improvement.

In order to understand the precise nature of gene action in relation to the order effects of the parental

Table 3. Relationship between order effects of the parents and the nature of gene action in three-way crosses

Superior cross in each group	Seed yield (g)		Oil content (%)		
	per se performance	Predominant gene action	Superior cross in each group	*per se* performance	predominant gene action
1. (Kranti × RJ10) × DLM29	20.50	dij,sij	(Kranti × DLM29) × RJ10	40.04	sij
2. (Kranti × RJ10) × PR8943	16.97	dij,sij	(Kranti × RJ10) × PR8943	40.65	sij
3. (Kranti × RK919003) × RJ10	15.57	gi	(Kranti × RK919003) × RJ10	39.51	gi,hi
4. (Kranti × PR8943) × DLM29	12.95	sij	(Kranti PR8943) × DLM29	39.57	hi,sij
5. (Kranti × RK919003) × DLM29	13.04	sij	(Kranti × RK919003) × DLM29	39.73	hi,sij
6. (Kranti × RK919003) × PR8943	14.76	sij	(PR8943 × RK919003) × Kranti	38.97	hi,sij
7. (DLM29 × PR8943) × RJ10	15.88	gi,sij	(RJ10 × DLM29) × PR8943	41.46	sij
8. (DLM29 × RK919003) × RJ10	17.05	gi,sij	(DLM29 × RK919003) × RJ10	43.41	dij,sij
9. (RJ10 × RK919003) × PR8943	15.97	sij	(RJ10 × RK919003) × PR8943	41.20	sij
10. (DLM29 × PR8943) × RK919003	15.66	sij	(DLM29 × RK919003) × PR8943	42.01	dij

Where hi = General line effect of first kind (as grand parents)
gi = General line effect of Second kind (as immediate parent)
dij = Two-line specific effect of first kind (as single cross)
sij = Two-line specific effect of second kind (one of the grand parents with immediate parent)

lines in three-way crosses, combining ability effects for seed yield and oil content revealed predominance of two-line specific effects of second kind (dominance) in a majority of the superior crosses identified, thereby indicating some degree of relationship between the order effects of parents and dominance nature of gene action. This observation was in conformity with the works of Rawlings and Cockerham [1] and Ponnuswamy *et al.* [2] who also indicated the role of dominance and dominance based interactions in the expression of order effects. Further, order of the parents in the three-way crosses also indicated that *per se* performance was not related to percentage of genetic contribution either by the high yielding grand parents (25% each) or by the immediate parent (50%). In essence, the crosses belonging to the same group showed variable *per se* performance despite the commonality of parents involved. This clearly brings out that order or position of the parents in multi-way crosses is one of the crucial factors in determining the performance and must be considered while planning the hybridization programmes for improvement of Indian mustard. Comparable information is not available in literature in respect of Indian mustard as well as in other related *Brassica* species. However, relevant information on other crops by Chaudhary [3] in barley, Joshi and Sharma [4] in wheat and Ram *et al.* [5] in rice also lends support to the findings of the present investigation.

Order effects of the parents in double crosses

Crosses recording superior *per se* performance for seed yield are (Kranti × RJ10) (DLM29 × PR8943), (Kranti × DLM29) (RJ10 × RK919003), (Kranti × PR8943) (RJ10 × RK919003), (Kranti × PR8943) (DLM29 × RK919003) and (RJ10 × PR8943) (DLM29 × RK919003). Further, it is interesting to note that parent Kranti was involved in three out of five superior crosses as one of the grand parents (Table 4).

Table 4. Superior double crosses identified in each group (involving common parents) based on the order effects of parents.

Superior cross in each group	Seed yield (g)	Superior cross in each group	Oil content (%)
1. (Kranti × RJ10) (DLM29 × PR8943)	16.59	(Kranti × RJ10) (DLM29 × PR8943)	40.07
2. (Kranti × DLM29) (RJ10 × RK919003)	18.68	(Kranti × RJ10) (DLM29 × RK919003)	38.77
3. (Kranti × PR8943) (RJ10 × RK919003)	14.92	(Kranti × RJ10) (PR8943 × RK919003)	38.77
4. (Kranti × PR8943) (DLM29 × RK919003)	14.83	(Kranti × PR8943)(DLM29 × RK919003)	41.03
5. (RJ10 × PR8943) (DLM29 × RK919003)	12.68	(RJ10 × DLM29) (PR8943 × RK919003)	40.53

With regard to oil content, five crosses belonging to various groups recorded superior performance. They are (Kranti × RJ10) (DLM29 × PR8943), (Kranti × RJ10) (DLM29 × RK919003), (Kranti × RJ10) (PR8943 × RK919003), (Kranti × PR8943) (DLM29 × RK919003) and (RJ10 × DLM29) (PR8943 × RK919003). DLM29 a high yielding yellow seeded parent with high oil content, was involved in four out of the five superior crosses. Two double crosses namely (Kranti × RJ10) (DLM29 × PR8943) and (Kranti × PR8943) (DLM29 × RK919003) showed superior performance for both seed yield and oil content, suggesting possibility of simultaneous improvement. Double crosses also showed occurrence of the order effects, like in the case of three-way crosses. Singh and Chaudhary (6-7) reported the order effects of parents in double crosses of barley which support the results of present study.

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