

MASTER NEGATIVE NUMBER: 09295.81

Arunachalam, V. and Das, G. R.

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*Proceedings of the Indian National Science
Academy*, 51B (1985): 104-109.

Record no. D-62

Intra-population Selective Mating as a Means of Improving Seed Yield in *Brassica campestris* var. Brown Sarson

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(Received 27 November 1984)

Six populations of brown sarson (*Brassica campestris* L.) which were complex multiple crosses in their second generation were selected on the basis of genetic, geographic and general combining ability divergence of their parents. In each population, early and late plants were selected and raised to their next generation. In the early and late progeny families, several plants were full-sibbed to produce early and late sib-populations, EE and LL. In addition, phenotypically superior (High) female plants were pollinated with mixed pollen from phenotypically superior (High) or inferior (Low) plants to produce 4 categories of intra-population crosses—Early high \times Late high, Early high \times Late low; Late high \times Early high, Late high \times Early low. EE and LL sib-populations registered significant yield advance compared to their original counterparts. But the yield advances recorded by intra-population selective mating were much higher and consistent. The extent of yield improvement was proportional to the initial genetic variability in the populations. The results suggest that disruption of mating between intermediate types even within a genetically broad-based population will be a potent method to breed for enhanced productivity.

Key Words: *Brassica campestris* L., Population improvement, Selective mating, Full-sib, Multiple crosses, Genetic advance

Introduction

Brassica campestris is an important oleiferous crop consisting of three distinct cross-compatible varieties—brown sarson, yellow sarson and toria. Brown sarson contains self-incompatible, self-compatible and intermediate compatible genotypes. Yellow sarson is

distinguished by its yellow seeds, bi- or multi-locular siliquae and high clarity of oil. Early maturing and dwarf genotypes occur more often in toria. Cross-pollination mainly by insects and varying levels of incompatibility permit a variety of breeding procedures for

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enhancing the productivity of brown *sarson*. Nevertheless breeding efforts made so far have laid emphasis mainly on pedigree breeding method for evolving pure lines from single crosses. Earlier work in our unit has demonstrated the possibility of producing productive populations using multiple crosses (Arunachalam & Katiyar 1978, Bandyopadhyay & Arunachalam 1980). This paper reports further yield improvement in such populations by selective hybridisation.

Material and Methods

Six populations which were multiple crosses in their second generation were selected for the study. They had single crosses, biparental progeny or 3-way crosses as female parents and were pollinated earlier with mixed pollen from two or three cultivars (table 1). The female parent of population 1 (P1) was a single cross between brown and yellow *sarson*; that of population 2 (P2) was a single cross between a brown *sarson* line derived from disruptive and another from stabilising selection. Populations 3 and 4 (P3 and P4) had biparental progeny from a toria \times brown *sarson* and a yellow *sarson* \times brown *sarson* cross as their respective female

parents. Populations 5 and 6 (P5 and P6) involved a female parent that was a 3-way cross of the type, (productive variant \times original type) within a brown *sarson* cultivar, GBS2 crossed to another brown *sarson* cultivar, K1.

The multiple crosses producing the populations P1 to P6 had male parents which were mixed pollen from two or three cultivars of brown *sarson*, of which 71-6809 was from Canada, Bele, Torpe were from Sweden and others from India. Further, one parent of the multiple crosses had high and the other low overall general combining ability in their F₁ generation. Thus the parents of the crosses constituting the populations had geographic, genetic and general combining ability diversity. The populations P1, P2 had relatively low and P4, P5, P6 high variability.

In each of the population, eight early and eight late plants were selected and raised to their next generation. In the progeny families, several plants were full-sibbed to produce early and late sib-populations, to be denoted as EE and LL hereafter.

In addition, in the early and late progeny families, phenotypically superior plants were

Table 1 Pedigree of the six populations

Code	Pedigree	Parental description	Parental gca at multiple cross F ₁ level
P1	(KL 17 \times IB 3) \times (Torpe + 71-6809)	SC \times DP	H \times L
P2	(DS-KL 17 \times SS-PBST2) \times (DS17D + PK + 184-63)	SC \times TP	H \times L
P3	(TL1842 \times GBS2 (BIP F2)-7-3) \times (Bele + PK)	BP \times DP	H \times L
P4	(IB6 \times DS17D (BIP F2)-2-1) \times (Bele + PK + DS17D)	BP \times TP	L \times H
P5	(GBS2-B1-1-E3-PV \times OR) \times K1) \times (Torpe + 71-6809)	TC \times DP	H \times L
P6	(GBS2-1-B1-1-E3-PV \times OR) \times K1) \times (DS17D + PK + 184-63)	TC \times TP	H \times L

SC, Single cross; BP, Biparental progeny; TC, Three-way cross; DP, Pollen mixture of two cultivars; TP, Pollen mixture of three cultivars

identified as females. They were pollinated with mixed pollen from several phenotypically superior (high) or inferior (low) plants to produce four categories of intra-population crosses:

EL 1 = Early high × Late high

EL 0 = Early high × Late low

LE 1 = Late high × Early high

LE 0 = Late high × Early low

In the plants used as females, some branches were used for crosses and from some others parental seeds were collected at harvest.

The intra-population crosses, full-sibs and parents were grown in the next generation on ridges of 3 m length with a plant to plant distance of 10 cm. The number of ridges occupied by each treatment like EL1, EL0, full-sib etc. varied according to the available seeds. In each treatment, seed yields on two random samples of variable sizes from 30 to 100 plants were recorded. For purposes of analysis, the yields of samples were adjusted to a uniform size of 100 plants.

The crop received basal fertilizers of 40 kg N, 40 kg P₂O₅ and 40 kg K₂O/ha 40 kg. N/ha was top-dressed about 45 days after sowing. Irrigation and regular plant protection measures were given as usual.

The improvements in yields of intra-population crosses over their female parents and also the better of the early or late parental bulks, and of full-sib populations over the better of the early or late general bulk were calculated. The variation in yield advances (%) of the duplicate samples per plot were statistically analysed.

Results

The differences in yield advance over female parent by intra-population selective mating were significant among the four crosses and the six populations. The within population variances and the population × cross interaction were also significant (table 2). This means that the four types of crosses registered

variable amounts of response in the populations (table 3). For instance, late high × early low cross caused 93% improvement in Population 1 while early high × late low crosses failed to bring about improvement in Population 2. Late high × early low and late high × early high crosses produced high yields in most of the populations. Late high females and high pollen were generally responsible for increasing yield. The % of crosses recording significant yield advance confirmed these results (table 3).

The yield advances in EE and LL sib-populations were significant (table 4). But the differences between EE and LL over the populations were not significant. The EE sib-population recorded an yield advance of 117.3% in P4 followed by P2 and P5 (36%). The yield advances recorded in the corresponding LL sib-populations were, however, consistent (53 to 89%). The most responsive population to full-sibbing was P4 and the least responsive was P1 (table 5).

Table 2 ANOVA of yield improvement over female parent by intra-population selective mating

Source	d.f.	m.s.
Treatments	23	5005.3*
Populations	5	9163.9*
Crosses	3	7760.9*
Early vs. Late female	1	17323.9*
EL1 vs. ELO	1	5946.5*
LE1 vs. LEO	1	12.3
Populations × Crosses	15	3068.0*
Within treatments	137	3317.8*
P1	27	7562.5*
P2	28	3590.8*
P3	25	1640.9*
P4	17	2299.4*
P5	22	2517.3*
P6	18	795.3*
Error	161	459.0

*Significant at 5% level

Table 3 Number of intra-population crosses (n) made in the 6 populations, and those (%) recording significant yield advance (p) and magnitude of improvement (%) over female parent (q)

		Mating system				Female		Pollen		Weighted mean
		EL1	EL0	LE1	LE0	Early	Late	High	Low	
P1	n	10	5	11	5	15	16	21	10	
	p	40.0	20.0	45.5	60.0	33.3	50.0	42.9	40.0	42.0
	q	38.7*	21.5*	38.9*	93.1*	32.9*	55.9*	38.8*	57.3*	44.8*
P2	n	10	5	12	5	15	17	22	10	
	p	30.0	20.0	50.0	60.0	26.7	52.9	40.9	40.0	40.6
	q	12.9*	-4.7	39.6*	39.1*	7.0	39.5*	27.5*	17.2*	24.3*
P3	n	11	5	8	5	16	13	19	10	
	p	36.4	20.0	62.5	40.0	31.3	53.8	47.4	30.0	41.4
	q	19.5*	1.4	44.2*	23.9*	13.8*	39.4*	29.9*	12.6*	23.9*
P4	n	4	5	7	5	9	12	11	10	
	p	0	40.0	0	20.0	22.2	8.3	0	30.0	14.3
	q	5.9	24.1*	9.7	20.5*	16.0*	14.2*	8.3	22.3*	15.0*
P5	n	8	4	9	5	12	14	17	9	
	p	62.5	25.0	44.4	40.0	50.0	42.9	52.9	33.3	46.1
	q	38.8*	12.9	33.8*	19.0*	30.1*	28.5*	36.2*	16.3*	29.3*
P6	n	6	5	6	5	11	11	12	10	
	p	16.7	0	50.0	0	9.1	27.3	33.3	0	18.2
	q	5.7	3.3	12.3*	0.5	4.6	6.9	9.0*	1.9	5.8
Over-	n	49	29	53	30	78	83	102	59	
all	p	34.7	20.7	43.4	36.7	29.5	41.0	39.2	28.8	35.4
	q	22.4*	9.6*	32.1*	32.7*	17.7*	32.3*	27.5*	21.4*	25.2*

*Significant at 5% level

The yield improvement by early × late (= EL1 + EL0) or by late × early (= LE1 + LE0) intra-population mating showed significant differences among the six populations. early × late and late × early matings produced significant differences in yield advance over the populations (table 6). Population 4 gave again the best response to intra-population mating followed by P2, P3 and P5. Population 1 recorded a negative response (table 7).

The most responsive population P4 was obtained from a cross whose female parent was a biparental progeny from a yellow × brown *sarson* cross and male was a pollen mixture of three varieties, one from Sweden

and two from India. The least responsive population P1 was from a cross whose female parent was a single cross of the type brown × yellow *sarson* and male was a pollen mixture of two exotic cultivars (table 1). Thus the initial genetic variability present in the population P4 was far greater than that in P1. Populations P2 and P5 originated from multiple crosses of the type, single cross × pollen from 3 cultivars and 3-way cross × pollen from 2 cultivars. Their genetic base, though broad, was only next to population P4. Thus the level of response to intra-population selective mating or full-sibbing was proportional to the composition and diversity of the initial genetic base.

Table 4 ANOVA of yield advances due to sibbing

Source	d.f.	m.s.
Treatments	11	7220.0*
EE	5	9836.3*
LL	5	5969.4*
EE vs. LL	1	391.6
Error	12	336.8

*Significant at 5% level

Table 5 Yield advance in populations due to sibbing

	EE	LL	mean
P1	-27.9	-63.0*	-45.4* e†
P2	36.0*	53.3*	44.6* bc
P3	15.4	14.4	14.9 d
P4	117.3*	88.8*	103.0* a
P5	35.9*	75.9*	55.9* b
P6	17.4	36.2*	26.8* cd
Mean	32.3*	34.3*	33.3*

†Values carrying identical letters do not differ significantly

*Significant at 5% level

Table 6 ANOVA of yield advances due to selective hybridisation

Source	d.f.	m.s.
Treatments	11	6082.9*
EL	5	6924.2*
LE	5	6442.6*
EL vs. LE	1	77.7*
Error	12	11.0

*Significant at 5% level

Table 7 Yield advance due to intra-population selective hybridisation

	EL	LE	mean
P1	-29.5*	-19.2*	-24.3*
P2	66.9*	76.0*	71.5*
P3	49.8*	57.2*	53.5*
P4†	146.6*	141.0*	143.8*
P5	38.5*	51.6*	45.0*
P6	14.4*	1.8*	8.1*
Mean	47.8*	51.4*	49.6*

†Advance due to EL not significantly different from that to LE; *Significant at 5% level

Discussion

Most of the successful varieties in cereals initiate from a broad genetic base. Such a base was created by the multiple crosses that involved high levels of genetic, geographic and combining ability diversity. Selection for flowering time within such diverse populations established extremes even for yield, as was shown earlier too (Ram et al. 1969, Murty et al. 1972). The broad initial genetic base sustained sufficient variability within the moities selected for early and late flowering in each population. Full sib-mating broke linkage disequilibrium and released new recombination (Kojima & Kelleher 1963, Miller & Rawlings 1967, Sprague 1971). This could be a plausible explanation for yield advance under sib-mating.

Intra-population hybridisation in populations descending from multiple crosses one of whose parents had high and the other low overall general combining ability generated a high frequency of productive recombinants. They compared well with the recorded productive potential of dent × flint, dent × flour and flint × flour crosses in maize (Richey 1922), high × low crosses (Hull 1952 in maize; Langham 1961 in sesamum) and winter × spring crosses in wheat (Mckenzie & Grant 1974). The selection of early or late mother

plants and high or low pollen provided another dimension of disruptive and negative assortative mating within populations to increase productive recombinations further (see also Thoday 1972). The disruptive mating between early and late extremes gave, as expected, higher yield improvement than recorded by full-sib mating within early or late extremes. The extent of improvement was proportional to the initial genetic variability as was evident by a comparison of yield advances in populations P4, P5, P3 and P1.

The results suggest that disruption of mating between intermediate types even within a genetically broad-based population would

shuffle desirable genes from the extremes to produce a new potential source of variability. Repeated cycles of such intra-population selective mating should result therefore in a uniform and highly productive population within a reasonably short time. This technique is hence worthy of practice in toning up the productivity of *Brassica campestris* as demonstrated by this study.

Acknowledgement

One of the authors (GRD) wishes to thank Professor V L Chopra for his sustained interest and guidance in part of the studies reported here.

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