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COMBINING ABILITY, HETEROSIS AND INBREEDING DEPRESSION FOR YIELD AND YIELD COMPONENTS IN YELLOW SARSON

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ABSTRACT

Combining ability, heterosis and inbreeding depression were estimated in yellow sarson for 11 quantitative characters. Nonadditive genetic variance was preponderant for all characters in both F_1 and F_2 generations except for 1000-seed weight in F_2 generation. The parents 66-197-3 and YSIK-742 in F_1 generation, and RAUYS-3 in F_2 generation were the best general combiners. For seven characters, the best F_2s on the basis of sca involves one parent with high gca effect and the other with poor or average gca effects. The hybrids which exhibited highest heterosis also showed higher inbreeding depression. Heterosis over better parent was highest for siliquae/plant (162.9%), followed by economic yield/plant (129.4%), biological yield/plant (118.7%), and primary branches/plant (88.1%).

Key words: Yellow sarson, combining ability, heterosis, inbreeding depression.

Yellow sarson (*Brassica campestris* L. var. *yellow sarson*) occupies an important position due to its high oil content. Breeding methods for improvement of autogamous crops should be based on the nature and magnitude of genetic variance (combining ability) governing the inheritance of quantitative character [1]. Selection of crosses may be based on sca and per se performance in mustard [2] and if linked with heterosis and inbreeding depression further short out the crosses for exploitation in rapeseed [3]. The present investigation is an attempt in this direction and undertaken to estimate the combining ability of the F_1 and F_2 populations, and the magnitude and direction of heterosis and inbreeding depression in yellow sarson.

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MATERIALS AND METHODS

The materials for the present investigation comprised six parents 66-197-3, RAUYS-3, RAUYS-2, DYS-1, YSIK-742, and YSK-2 and their 15 cross combinations in F_1 and F_2 generations. These crosses, excluding reciprocals, were developed using diallel mating system. The experimental material was planted in randomized complete block design with three replication in rabi 1983 at Tirhut College of Agriculture, Dholi. The parents, check and F_1s were raised in single-row and F_2s in 10-row plots with 3 m row length, row-to-row and plant-to-plant distance 30 and 10 cm, respectively. Observations were recorded on 10 random plants from each plot in the parents and F_1s and on 50 plants in F_2 generation for nine quantitative characters. Days to 75% maturity were recorded on plot basis. Combining ability analysis was done according to Method 2, Model I of Griffing [4]. Heterosis over better parent (BP) and check var. YST-151 were calcuated as per standard methods [5].

RESULTS AND DISCUSSION

The variance due to gca was highly significant for all the characters in both generations except harvest index. Similarly, the variance due to sca was highly significant for all the characters in both F_1 and F_2 generations except for biological yield and harvest index in F_2

Table 1. Analysis of variance (M.S.S. for combining ability parameters) in F_1 and F_2 generations of yellow sarson

Character	Gca		Sca		Error		σ^2 gca		σ^2 sca	
	F_1 (5)	F_2 (5)	F_1 (15)	F_2 (15)	F_1 (40)	F_2 (40)	F_1	F_2	F_1	F_2
Days to flowering	7.25**	26.42**	2.19**	7.39**	0.69	1.68	4.09	16.09	22.5	94.7
Days to maturity	4.88**	11.52**	1.76**	7.57**	0.54	0.63	2.71	6.80	18.2	104.2
Plant height	35.34**	31.55**	136.42**	47.16**	8.20	11.65	16.25	12.43	1923.2	533.0
Primary branches	0.76**	0.24**	2.14**	0.54**	0.07	0.04	0.43	0.12	30.9	7.5
Siliquae/main shoot	58.88**	22.77**	22.65**	12.62**	5.91	3.11	30.10	12.29	251.0	142.6
Siliquae/plant	1444.49**	238.15**	1429.03**	118.74**	7.87	3.54	898.18	146.63	21317.4	1728.1
Seeds/siliqua	36.48**	38.86**	9.74**	8.38**	2.39	2.14	20.67	22.95	110.3	93.7
1000-seed weight	0.55**	0.40**	0.07	0.06	0.05	0.08	0.31	0.19	0.3	0.4
Grain yield/plant	2.90**	0.64**	10.15**	0.39	0.29	0.13	1.63	0.32	147.9	4.1
Biological yield/plant	18.70**	9.63**	71.19**	2.69	3.42	1.76	9.55	4.91	1017.0	13.9
Harvest index	4.42**	3.99	11.44**	4.83	3.34	3.80	0.67	0.11	121.6	15.8

*, **Significant at 5% and 1% levels, respectively.

Note. Degrees of freedom given in parentheses.

generation and for 1000-seed weight in both generations (Table 1), indicating that the parents and crosses differ significantly in their combining ability effects. The estimates of gca (σ^2_{gi}) and sca (σ^2_{sij}), which variance reflected the additive and nonadditive genetic components, are involved in determining the inheritance of these characters. The magnitudes of σ^2_{sij} was higher than σ^2_{gi} for all the characters in both generations except for 1000-seed weight in F_2 generation, for which larger σ^2_{gi} was recorded. Hence, nonadditive genetic variance in playing more important role in the inheritance of these characters as also observed earlier in yellow sarson in F_1 generation [6, 7]. Although the additive gene action would imply some scope for selection in segregating generations, but presence of marked nonadditive action suggests the population improvement followed by recurrent selection to accumulate desirable genes and facilitating for breaking of linkage through disruptive selection would be more appropriate [8].

The estimates of gca effects (Table 2) revealed that both 66-197- 3 and YSIK-742 are the good general combiners for 5 out of 11 characters: grain yield/plant, biological yield/plant,

Table 2. Ranking of desirable parents based on per se performance and gca effect for 11 characters in yellow sarson

Character	Good parents based on per se performance	Good general combiners	
		F_1	F_2
Early flowering	RAUYS-3, RAUYS-2, YSK-2	RAUYS-3, YSK-2	RAUYS-3, RAUYS-2, YSK-2
Early maturity	RAUYS-3	RAUYS-3	RAUYS-3
Dwarf plant height	66-197-3, RAUYS-3, RAUYS-2 DYS-1, YSIK-742, YSK-2	66-197-3	66-197-3
Primary branches per plant	66-197-3, RAUYS-3, RAUYS-2 DYS-1, YSIK-742, YSK-2	YSK-742	YSIK-742, YSK-2
Siliquae/main shoot	66-197-3, RAUYS-3, RAUYS-2 DYS-1, YSIK-742, YSK-2	66-197-3, YSIK-742	RAUYS-3
Siliquae/plant	66-197-3, RAUYS-3, YSIK-742	66-197-3, YSIK- 742, YSK-2	RAUYS-3, YSIK-742, YSK-2
Seeds/siliqua	RAUYS-2, DYS-1	RAUYS-2	RAUYS-2, DYS-1
1000-Seed weight	66-197-3, RAUYS-2, DYS-1	RAUYS-2	RAUYS-2
Grain yield/plant	66-197-3, RAUYS-2, DYS-1	66-197-3, YSIK-742	RAUYS-3, RAUYS-2
Biological yield per plant	66-197-3, RAUYS-3, RAUYS-2 DYS-1, YSIK-742, YSK-2	66-197-3, YSIK-742	RAUYS-3, RAUYS-2
Harvest index	66-197-3, RAUYS-3, RAUYS-2 YSK-2	YSK-2	66-197-3

siliquae/main shoot, and siliquae/plant in F_1 generation, and 66-197-3 for dwarfness in both generations and for harvest index in F_2 generation. YSIK-742 is also a good general combiner for primary branches/plant in both generations. Howeves, RAUYS-3 was a good general combiner in F_2 for 6 out of 11 characters (Table 2). The difference in genetic make up of two generations may be responsible for the difference in combining ability of different parents. It is clear from Table 2 that the parents 66-197-3 and YSIK-742, which are good general combiners for seed yield also showed high gca effects for siliquae/main shoot, siliquae/plant and biological yield/plant in F_1 generation. These characters are also reported to be positively associated with economic yield in toria [9]. Range of BP heterosis and standard heterosis and best hybrid on the basis of mean performance, standard heterosis, and sca effects are presented in Table 3. The extent of inbreeding depression for various characters in F_2 is given in Table 4.

Table 3. Range of heterosis and best hybrid for various quantitative characters in yellow sarson

Character	Range		Best hybrid based on mean performance
	BP heterosis	standard heteroris	
Days to flowering	–9.0 – 0.0	–9.9 – 1.9	66-197-3 x YSK-2 (A x G)*
Days to maturity	–2.3 – 0.9	–1.2 – 2.0	DYS-1 x YSIK-742 (P x P)
Plant height	–0.1 – 29.6	–9.4 – 18.0	DYS-1 x YSK-2 (A x A)
Primary branches	–28.9 – 88.1	–27.4 – 92.1	DYS-1 x YSIK-742 (P x G)
Siliquae/main shoot	–14.2 – 54.1	–29.3 – 25.3	RAUYS-3 x YSIK-742 (A x G)
Siliquae/plant	–143.1 – 162.9	–44.3 – 149.4	66-197-3 x YSK-2 (G x G)
Seeds/siliqua	–27.8 – 11.8	–8.1 – 65.2	66-197-3 x RAUYS-2 (A x G)
1000-seed weight	–14.2 – 10.9	–13.1 –19.1	RAUYS-2 x DYS-1 (G x A)
Grain yield/plant	–12.7 – 129.4	–22.6 – 94.8	RAUYS-3 x YSK-2 (P x A)
Biological yield/plant	–22.7 – 118.7	–4.4 – 115.9	66-197-3 x RAUYS-2 (G x A)
Harvest index	–14.5 – 38.9	–27.7 – –2.5	DYS-1 x YSIK-742 (P x A)

*G—good, A—average, P—poor general combiner.

Five crosses flowered earlier than their respective early parents and six crosses were earlier than the check YST-151. The cross 66-197-3 x YSK-2 was earliest among all. DYS-1 x YSK-2 is the only hybrid which is shorter than the check variety and exhibited highest standard heterosis for dwarfism (–9.4%). None of the F_2 progenies was earlier on pooled basis than their F_1 hybrids. Devarthinam et al. [10] also reported low heterosis for flowering period in yellow sarson. Five F_2 progenies were shorter in plant height than the corresponding F_1 hybrid (Table 4).

Heterosis over better parent was highest for siliquae/plant (162.4%), followed by economic yield/plant (129.4%), biological yield/plant (118.78%), and primary branches/plant (88.1%). Similarly, these characters also exhibited the highest standard heterosis.

For primary branches/plant, 12 hybrids showed significant positive heterosis over BP and check. The cross DYS-1 x YSIK-742 was best for this character. For siliquae/main shoot only RAUYS-3 x YSK-742 showed significant standard heterosis (25.3%) while 4 crosses showed significant BP heterosis (Table 3). The cross RAUYS-3 x RAUYS-2 showed a significant negative inbreeding depression for siliquae/main shoot.

The cross 66-197-3 x YSK-2 showed the maximum improvement for siliquae/plant both over better parent (162.9%) and check YST-151 (149.4%). One hybrid (RAUYS-2 x YSK-2) showed significant negative inbreeding depression (–43.7%) for siliquae/plant. Six hybrids exhibited positive standard heterosis for seeds/siliqua. The inbreeding depression for this trait ranged from 37.6% to –42.1%. In general, low heterotic values and inbreeding depression was observed for 1000- seed weight. The same observations were also recorded in black mustard [11].

For economic yield nine hybrids were significantly superior than both of their better parent and check variety. The cross RAUYS-3 x YSK-2 recorded the best heterosis (Table 3).

Table 4. Range of inbreeding depression (I.D.) and crosses showing lowest and highest I.D. for different characters in F_2 generation

Character	Range of I.D.	Cross showing	
		lowest I.D.	highest I.D.
Days to flowering	–17.7 – 2.9	66-197-3 x YSK-2	RAUYS-3 x RAUYS-2
Days to maturity	–6.7 – 65.7	DYS-1 x YSIK-742	RAUYS-2 x YSK-2
Plant height	–0.3 – 30.2	66-197-3 x RAUYS-3	66-197-3 x DYS-1
Primary branches/plant	0.5 – 65.5	RAUYS-2 x YSK-2	RAUYS-2 x DYS-1
Siliaquae/main shoot	–22.0 –34.0	RAUYS-3 x RAUYS-2	66-197-3 x YSK-2
Siliquae/plant	–43.7 – 73.6	RAUYS-2 x YSK-2	66-197-3 x YSK-2
Seeds/siliqua	–42.1 – 37.6	66-197-3 x DYS-1	66-197-3 x RAUYS-2
1000-seed weight	–10.0 – 17.9	DYS-1 x YSIK-742	RAUYS-3 x DYS-1
Grain yield/plant	–10.3 – 56.4	RAUYS-3 x RAUYS-2	66-197-3 x YSK-2
Biological yield/plant	–13.9 – 55.6	RAUYS-3 x DYS-1	66-197-3 x RAUYS-2
Harvest index	–0.1 – 15.5	66-197-3 x RAUYS-3	DYS-1 x YSIK-742

The inbreeding depression for seed yield ranged from –10.3% to 56.4% (Table 4). Ten hybrids over check and nine hybrids over their better parent were observed significantly superior in biological yield. For harvest index three hybrids showed positive heterosis over better parent.

In F_2 generation 7 best F_2s for 7 characters out of 11, involved one parent with high gca effect and other with poor or average gca effect. Out of these 7 characters: primary branches/plant, siliquae/main shoot, siliquae/plant, and seeds/siliqua also had the minimum or negative inbreeding depression such F_2s may throw up desirable transgressive segregants. Such observations were also reported in rapeseed [3]. For all the characters the best F_1 on the basis of mean performance, standard heterosis and sca effect was same. Hence, equal importance shall be given to per se performance while making selection for these attributes.

In general, the hybrids which showed high heterosis for seed yield also had high heterosis for primary branches/plant, siliquae/plant and biological yield/plant beside other yield contributing characters. Such a situation of "combinational heterosis" by Hagberg [12] was also reported in rapeseed [13, 14]. Out of 9 hybrids which exhibited significant positive heterosis for seed yield, 6 crosses involved one parent with tetralocular and other with bilocular siliquae. This indicated that the parents having siliquae with different locular number may be utilized for better expression of yield heterosis in yellow sarson.

A close relationship between heterotic response and inbreeding depression, i.e. hybrids which showed high heterosis linked with high inbreeding depression as well as the high magnitude of σ^2_{sij} suggested the importance of nonadditive gene action in inheritance of these traits in yellow sarson. Similar observations were reported in rapeseed [3]. The cross RAUYS-3 x YSK-2 had the highest yield in F_1 coupled with high biological yield and harvest index and high positive heterosis for these characters with high sca effects both in F_1 and F_2 generations. Such crosses may be exploited for yield improvement in this crop.

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