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Heterosis for Yield and Yield Components in Castor (*Ricinus communis* L.) Over Environments

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ABSTRACT

Heterosis, for yield and yield components in castor (*Ricinus communis* L.) was studied in diallel set involving ten parents. Among the yield attributes, seed yield per plant, number of capsules per plant, number of effective branches per plant and oil content have manifested considerable amount of heterobeltiosis compared to shelling outturn, kernel content, 100 seed weight and effective length of main spike. Cross Aruna x SKI-6 recorded highest heterobeltiosis in summer (43.5%) and on average basis (41.08%) for seed yield. These cross combinations could be utilized to develop hybrid for tangible advancement in castor.

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INTRODUCTION

Exploitation of heterosis has become a common feature in castor breeding since the release of first castor hybrid GCH-3 in Gujarat during 1968. With a view to exploit the heterosis further and to assess the feasibility of developing hybrids for different seasons, the extent of heterosis was studied over two seasons. The heterosis measured in terms of superiority over the better parent is more suitable for selection of hybrids for further tests.

Considerably high heterobeltiosis in some hybrids and low in other shows the presence of gene moity which interact with the environment for better productivity. Thus, the high heterobeltiosis in various cross combinations is helpful in isolating superior cross combinations.

MATERIALS AND METHODS

The experimental material comprised of 10 parents viz., SH-41, SH-21, SH-16, SH-62, Aruna, J-1, 1379, SKI-6, VH-25, 48-1 and a half diallel set of 45 crosses developed during the *kharif* 1989. These ten parents alongwith their 45 hybrids were evaluated during *kharif* (August 1990 to January 1991) and summer (February 1991 to July 1991) at Motibaug and Instructional Farm, Agricultural College, GAU, Junagadh, respectively in randomized block design with four replications. Each plot consisted of one row of 4.5 m length. Inter and intra row spacing were 90 and 45 cm respectively. All recommended agronomic practices alongwith necessary plant protection

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TABLE 1

Pooled ANOVA showing mean squares of various characters.

Characters / Sources	Environment	Genotypes	Genotypes x Environment	Parents	F_1S	Parent Vs F_1s	Pooled error
	1^{δ}	54^{δ}	54^{δ}	9^{δ}	44^{δ}	1^{δ}	324^{δ}
Seed yield per plant	8162.220**	1892.893**	234.305**	2422.833**	1549.135**	12248.820**	54.666
Number of capsules per plant	4227.808**	1209.053**	331.401**	1909.481**	962.864**	5737.510**	61.198
Effective length of main spike	5456.627**	279.079**	41.555**	645.953**	209.645**	32.328**	4.078
Number of effective branches per plant	71.688**	2.236**	0.447**	2.235**	2.030**	11.318**	0.151
100 seed weight	10.017**	100.316**	7.509**	177.958**	85.887**	35.438**	1.043
Oil content	1.262**	2.076**	1.406**	1.319**	1.938**	15.005**	0.139
Shelling outturn	444.209**	18.197**	8.170**	12.624**	11.167**	107.676**	1.577
Percent kernel per pod	1177.276**	18.918**	5.902**	24.553**	17.563**	27.833**	0.767

*, ** = Significant at 5% and 1% level of significance, respectively.

measures were followed timely for successful raising of the crop. For recording observations five plants of each genotype were selected randomly from each plot and evaluated for seed yield per plant, number of capsules per plant, effective length of main spike and effective branches per plant. For shelling outturn 25 capsules were obtained from the bulk produce of each plant and percentage of seeds to capsules was workout on weight basis. Kernel content was obtained by kernel to seed ratio on weight basis and expressed in percentage. Oil content was estimated by Nuclear magnetic resonance technique by taking a random sample of 6 gram seeds from bulk seeds of each genotype from each replication. Heterosis for various characters was calculated as per cent increase in F_1 over better parent.

RESULTS AND DISCUSSION

The pooled analysis of variance (Table 1) revealed the presence of significant variation amongst genotypes and significant interaction between genotypes and environments for yield and yield components, indicating the possibility of isolating the suitable genotypes for each environment. The mean squares due to hybrid Vs their parents were also significant for each trait indicating the possible presence of heterosis in all traits in the hybrids.

Range of heterobeltiosis with mean value of best five crosses for different characters are presented in Table 2. In the present study, among the yield attributes, seed yield per plant has been observed to be the most heterotic trait as out of 45 crosses 16, 11 and 18 crosses recorded significantly possitive heterobeltiosis during *kharif*, summer and on average basis respectively. The cross Aruna x SKI-6 showed highest magnitude of heterobeltiosis in *kharif* (53.88%), while cross SH-21 x 48-1 exhibited highest heterobeltiosis in summer (43.53%) as well as on average basis (41.08%). Among seasons the higher rate of heterosis was found in *kharif*, compared to summer. High value of heterosis for seed yield per plant in castor was also reported by Patel *et al.* (1986), Dangaria *et al.* (1987) and Pathak *et al.* (1988).

For capsules per plant, SH-41 x Aruna (30.97%), Aruna x 48-1 (29.77%) and Aruna x 48-1 (23.35%) depicted highest heterobeltiotic effects in *kharif*, summer and on average basis, respectively. Overall, 11 crosses recorded significantly higher number of capsules over better parents. The results are in confirmity with Gujarat *et al.* (1973) and Pathak *et al.* (1988).

Heterotic response for effective length of main spike was marginal and varied in both directions. The frequencies of crosses which manifested negative heterobeltiosis were higher for this trait. The crosses SH-41 x Aruna and J-1 x VH 25 recorded highest heterobeltiosis in *kharif* and summer respectively.

An appreciable amount of heterosis was observed for number of effective branches per plant. More number of crosses turned out with positive heterosis in summer compared to *kharif*, which indicated the profound seasonal effect in the expression of this trait. Overall, cross SH-21 x SH-62 depicted highest heterosis to the tune of 50.28% over better parent.

Only few crosses registered heterobeltiosis for seed weight, and shelling percentage. The cross SH-62 x SKI-6 in *kharif* and SH-21 x SKI-6 in summer and on average basis revealed highest heterobeltiosis; 2.61%,

TABLE 2

Heterobeltiosis related parameters for different characters in castor.

Characters	Envt.	Mean of hetero-beltiosis	Range of heterobel-tiosis	Number of crosses with S^-	Number of crosses with S^+	Best crosses with mean values of traits				
						First	Second	Third	Fourth	Fifth
1. Seed yield per plant	E_1	10.46	-22.00 to 53.88	3	16	$P_5 \times P_8$ (58.55)	$F_1 \times P_7$ (63.55)	$P_2 \times P_{10}$ (97.95)	$P_1 \times P_9$ (61.05)	$P_1 \times P_5$ (60.60)
	E_2	3.97	-44.00 to 43.53	8	11	$P_2 \times P_{10}$ (126.45)	$P_6 \times P_{10}$ (93.50)	$P_4 \times P_{10}$ (108.85)	$P_1 \times P_8$ (67.65)	$P_8 \times P_9$ (55.70)
	AV	2.28	-24.89 to 41.08	9	18	$P_2 \times P_{10}$ (112.20)	$P_5 \times P_8$ (56.46)	$P_6 \times P_{10}$ (88.57)	$P_4 \times P_8$ (90.45)	$P_1 \times P_{10}$ (80.15)
2. Number of capsules per plant	E_1	5.86	-20.73 to 30.97	3	16	$P_1 \times P_5$ (96.85)	$P_1 \times P_7$ (80.40)	$P_1 \times P_8$ (80.40)	$P_1 \times P_{10}$ (95.55)	$P_1 \times P_6$ (84.20)
	E_2	-3.42	-44.59 to 29.77	13	7	$P_5 \times P_{10}$ (105.70)	$P_8 \times P_9$ (65.15)	$P_4 \times P_{10}$ (112.60)	$P_8 \times P_{10}$ (89.40)	$P_2 \times P_{10}$ (73.95)
	AV	1.22	-24.32 to 23.35	10	11	$P_5 \times P_{10}$ (97.22)	$P_1 \times P_5$ (94.55)	$P_1 \times P_{10}$ (91.02)	$P_6 \times P_{10}$ (98.00)	$P_8 \times P_9$ (62.93)
3. Effective length of main spike	E_1	-4.54	-43.81 to 53.26	18	9	$P_1 \times P_5$ (27.05)	$P_5 \times P_7$ (23.15)	$P_6 \times P_{10}$ (35.40)	$P_5 \times P_8$ (22.15)	$P_4 \times P_6$ (29.00)
	E_2	-35.24	-70.36 to 19.55	38	1	$P_6 \times P_9$ (21.10)	$P_7 \times P_8$ (08.55)	$P_6 \times P_8$ (17.75)	—	—
	AV	-19.99	-55.42 to 21.26	29	4	$P_1 \times P_5$ (20.17)	$P_6 \times P_9$ (23.67)	$P_6 \times P_{10}$ (30.05)	$P_7 \times P_8$ (12.35)	$P_6 \times P_8$ (22.25)
4. Number of effective braches per plant	E_1	-0.71	-33.33 to 58.23	12	8	$P_2 \times P_4$ (01.90)	$P_4 \times P_7$ (02.00)	$P_4 \times P_5$ (03.50)	$P_1 \times P_5$ (02.70)	$P_5 \times P_8$ (03.00)
	E_2	7.05	-25.97 to 43.24	3	9	$P_2 \times P_4$ (04.15)	$P_2 \times P_{10}$ (04.05)	$P_5 \times P_8$ (04.00)	$P_3 \times P_5$ (04.00)	$P_4 \times P_5$ (03.85)
	AV	3.80	-22.31 to 50.78	10	12	$P_2 \times P_4$ (02.28)	$P_4 \times P_5$ (03.67)	$P_3 \times P_8$ (03.25)	$P_5 \times P_6$ (03.60)	$P_5 \times P_9$ (03.47)

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
5.	100-Seed weight	E_1	-6.28	-26.56 to 10.05	24	4	$P_1 \times P_4$ (31.49)	$P_4 \times P_9$ (30.42)	$P_4 \times P_7$ (30.36)	$P_2 \times P_8$ (34.18)	$P_7 \times P_9$ (29.28)
		E_2	-5.91	-25.56 to 13.31	21	8	$P_2 \times P_8$ (31.57)	$P_1 \times P_8$ (30.27)	$P_2 \times P_{10}$ (34.97)	$P_8 \times P_{10}$ (31.67)	$P_3 \times P_8$ (32.84)
		AV	-5.50	-26.06 to 06.62	24	5	$P_7 \times P_9$ (29.61)	$P_2 \times P_{10}$ (34.03)	$P_2 \times P_8$ (34.01)	$P_1 \times P_7$ (26.73)	$P_1 \times P_4$ (30.85)
6.	Shelling outturn	E_1	-0.76	-4.04 to 2.61	7	1	$P_4 \times P_8$ (69.30)	$P_1 \times P_5$ (70.46)	$P_2 \times P_6$ (68.42)	$P_5 \times P_8$ (68.76)	$P_3 \times P_9$ (68.97)
		E_2	+0.78	-4.85 to 6.23	4	9	$P_2 \times P_8$ (69.98)	$P_2 \times P_7$ (70.86)	$P_1 \times P_{10}$ (75.02)	$P_4 \times P_7$ (70.40)	$P_4 \times P_6$ (70.15)
		AV	-0.15	-3.10 to 3.52	7	7	$P_2 \times P_8$ (69.00)	$P_2 \times P_7$ (68.95)	$P_2 \times P_6$ (68.37)	$P_6 \times P_8$ (68.38)	$P_3 \times P_9$ (70.60)
7.	Kernel content	E_1	-1.36	-5.07 to 3.43	13	2	$P_2 \times P_9$ (73.04)	$P_1 \times P_2$ (76.71)	$P_3 \times P_6$ (74.24)	$P_3 \times P_7$ (73.64)	$P_2 \times P_8$ (74.47)
		E_2	0.00	-6.68 to 5.58	11	10	$P_5 \times P_9$ (77.32)	$P_5 \times P_6$ (76.19)	$P_2 \times P_4$ (80.26)	$P_5 \times P_{10}$ (77.09)	$P_8 \times P_{10}$ (77.06)
		AV	-0.58	-4.84 to 4.50	13	3	$P_5 \times P_9$ (75.18)	$P_1 \times P_2$ (77.64)	$P_2 \times P_4$ (77.10)	$P_2 \times P_4$ (77.10)	$P_5 \times P_6$ (76.19)
8.	Oil content	E_1	1.00	-4.38 to 4.14	4	19	$P_2 \times P_5$ (50.05)	$P_2 \times P_4$ (49.83)	$P_3 \times P_4$ (49.26)	$P_3 \times P_5$ (72.72)	$P_2 \times P_8$ (74.47)
		E_2	-0.28	-2.40 to 1.99	9	5	$P_2 \times P_8$ (48.95)	$P_2 \times P_{10}$ (48.85)	$P_8 \times P_{10}$ (48.75)	$P_2 \times P_4$ (80.26)	$P_2 \times P_3$ (77.08)
		AV	0.40	-1.76 to 2.53	6	13	$P_2 \times P_8$ (49.24)	$P_2 \times P_4$ (49.45)	$P_2 \times P_5$ (49.24)	$P_2 \times P_{10}$ (76.12)	$P_3 \times P_4$ (75.21)

E_1 = Kharif. E_2 = Summer. AV = Average. S^+ = Positively significant. S^- = Negative significant.

6.33% and 3.52% respectively. Thus, there was no much heterosis for shelling outturn.

Heterotic response for kernel content was low and varied in both the directions. The top most cross Aruna x VH 25 depicted highest heterosis upto 4.5% and it resulted from the parents having low kernel content.

The magnitude of heterosis for oil content was moderate and the number of crosses which registered higher oil content were quite high. The number of crosses exceeded in oil content over better parent were 19 in *kharif*, 5 in summer and 13 on an average basis. Cross SH-21 x SKI-6 depicted highest heterosis over better parent (1.99%) in summer and (2.53%) on an average basis. Ranking of five best crosses was in close agreement with *per se* performance indicating the real manifestation of heterosis for these crosses.

Among yield contributing characters, the number of capsules per plant was observed to be the most important yield attribute as it had shown positive heterotic effects in all the top crosses consistently whereas other yield attributes were not consistent and had shown different combinations for realization of heterosis for seed yield per plant. The results are in accordance with findings of Thakkar (1987) and Patel (1991).

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