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Research Note

Heterosis for seed yield and its components over environments in castor (*Ricinus communis L.)*

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Abstract

A study was conducted in castor (*Ricinus communis L.*)to assess the extent of heterosis over environments for twelve quantitative traits including seed yield per plant. Four pistillate lines and 13 monoecious lines were crossed in a line x tester fashion to develop 52 F_1 hybrids. The pooled analysis of variance over environments showed significant differences among the environments (Sowing dates) for all the characters except number of capsules on primary raceme indicating wide variation in environmental conditions or differential expression of traits under different sowing dates. The mean square due to parents,hybrids and parents vs. hybrids were also found significant for all the characters, indicating the presence of sufficient amount of genetic diversity in the material for the twelve traits studied. Heterosis was worked-out over better parent and standard check, GCH-7. Significant desired heterobeltiosis ranged from -37.14 to 75.95%and standard heterosis ranged from -61.77 to 18.64%for seed yield per plant. However, magnitude of heterosis was found to vary substantially from cross to cross and character to character. The crosses JP-89 x PCS-124, JP-89 x RG-2826, SKP-84 x 48-1, SKP-106 x 48-1 and SKP-106 x PCS-124were the best heterotic combinations for seed yield per plant, which recorded75.95, 70.45, 61.11, 60.45 and 58.57 % heterobeltiosis, respectively. The heterosis for seed yield per plant was associated with the heterosis expressed by its component characters.

Keywords
Heterosis, seed yield, yield components, castor

Castor (*Ricinus communis* L.) is one of the most important non-edible oilseed crops in the world. It is generally distributed in the tropical, sub-tropical and warm temperate zones (Weiss, 2000). Castor is a highly cross pollinated crop in which, most of the cultivars have been developed by hybridization followed by selection. The exploitation of heterosis has been an important breeding tool in castor, which became feasible due to availability of 100% pistillate lines (Gopani *et al*., 1968). India is the pioneer of castor hybrid. In Gujarat, real breakthrough in castor production has come with the development and release of hybrids for commercial cultivation. Still there is potential to further increase in yield level of castor through genetic improvement. Castor is sensitive to environmental differences, particularly fertility status of soil, moisture availability and sowing period. Therefore, it is highly essential to examine the performance of new hybrids over a large range of environments. In the consideration to this, heterotic performance of 52 F_1 hybrids was studied in different environments created by sowing dates.

Fifty two crosses were generated from crossing between four pistillate lines as females and 13monoecious lines as males in line x tester fashion during *kharif*2012-13.Pistillate lines (JP 96, SKP-84, SKP-106 and JP-89) and monoecious lines (PCS-124, DCS-85, SKI-215, SKI-343, SKI-341, SKI-352, JI-244, JI-353, JI-357, 48-1, RG-2800, RG-2826 and JC-18) were selected on the basis of desirable agronomic characters. The experimental material, consisting 70 entries including 17 parents and their resultant 52 crosses along with one check hybrid (GCH-7), was raised in a randomized block design with three replications at Main Oilseeds Research Station, J.A.U. Junagadh over three environments (sowing dates) during *kharif* 2013-14. Environments were created through different dates of sowing during *kharif* 2013-14 i.e. E_1 = 1st week of August, E_2 = 3rd week of August and E_3 =2nd week of September. Each entry was accommodated in single row of 7.2 m. length spaced at 90 cm apart with plant-to-plant spacing of 60 cm. recommended practices and plant protection measures were adopted timely to raise the healthy crop. The observations on five randomly selected plants were recorded for 12 characters *viz.*, days to 50 % flowering of primary raceme, days to maturity of primary raceme, plant height up to primary raceme (cm), number of nodes up to primary raceme, length of primary raceme (cm), effective length of primary raceme (cm), number of effective branches per plant, number of capsules on primary raceme, shelling out-turn (%), seed yield per plant (g), 100-seed weight (g) and oil content (%). The mean values were statistically analyzed for heterosis as per method suggested by Fonseca and Patterson, 1968.

The pooled analysis of variance over environments (Table 1) showed significant differences among the environments (Sowing dates) for all the characters except number of capsules on primary raceme indicating wide variation in environmental conditions or differential expression of traits under different sowing dates. The mean squares due to parents and hybrids were found significant for all the characters indicating the presence of sufficient diversity among the parents and hybrids for all the characters. The mean squares due to parents vs. hybrids also revealed significant differences for all the characters, which indicated variation between parents and hybrids and the presence of mean heterosis for all the traits.

The mean squares due to parents, hybrids and parents vs. hybrids interacted significantly with varying environments for all the characters except P x E, H x E and (P vs. H) x E for days to 50 % flowering of primary raceme, days to maturity of primary raceme and 100-seed weight; H x E and (P vs. H) x E for oil content and (P vs. H) x E for number of capsules on primary raceme and seed yield per plant, indicating variable response of the parents and hybrids in different environments.

On considering the performance of hybrids over the environments in respect of seed yield per plant, 20 hybrids over better parent and four hybrids over standard check hybrid exhibited significant and positive heterosis (Table 2). The range of heterosis over better parent was from -37.14 to 75.95%, while over standard check hybrid it ranged from -61.77 to 18.64%. High heterosis for seed yield seed yield per plant has been reported by Barad *et al.*(2009), Sridhar *et al*. (2009) and Chaudhari *et al*. (2011).

In general, it might be inferred that magnitude of heterotic effects were high for seed yield per plant, plant height up to primary raceme, number of effective branches per plant and number of capsules on primary raceme; moderate for days to 50% flowering of primary raceme, days to maturity of primary raceme, number of nodes up to primary raceme, length of primary raceme, effective length of primary raceme and 100-seed weight and low for shelling out-turn and oil content.

It is of profound interest to know the cause of heterosis for seed yield. Whitehouse *et al.* (1958) and Grafius (1959) have suggested that there may not be any gene system for yield *per se*, as yield is an end product of the multiplicative interaction between the yield components. This would indicate that the heterosis for seed yield should be through heterosis for the individual yield components or alternatively due to the multiplicative effect of partial dominance of component characters. Williams and Gilbert (1960) have reported that even simple dominance in respect of yield components may lead to expression of heterosis for yield. Hagberg (1952) observed similar effects and termed it “combinational heterosis”. In order to see whether similar situation exist in castor or not, a comparison of ten most heterotic crosses for seed yield was made with other yield related characters along with average mean seed yield per plant over environments (Table3). The crosses JP-89 x JI-357 and SKP-106 x JI-357 which manifested significant and desirable heterobeltiosis and standard heterosis for seed yield per plant also recorded significant and positive heterosis for length of primary raceme, effective length of primary raceme, number of effective branches per plant and number of capsules on primary raceme. Therefore, heterotic effects for seed yield per plant could be a result of combinational heterosis. Hence, to obtain maximum heterotic effects for seed yield per plant, desired level of heterosis of each component character should be worked-out to identify superior hybrids.

Highly significant and positive heterobeltiosis was exhibited for length of primary raceme by JP-89 x PCS-124, SKP-84 x 48-1, JP-89 x JI-357, SKP-106 x JI-357, JP-89 x 48-1 and JP-89 x SKI-343; for effective length of primary raceme by JP-89 x JI-357 and SKP-106 x JI-357; for number of effective branches per plant by JP-89 x PCS-124, JP-89 x RG-2826, SKP-106 x 48-1, SKP-106 x PCS-124,JP-89 x JI-357, SKP-106 x JI-357 and JP-89 x SKI-343;for number of capsules on primary raceme by SKP-84 x 48-1, JP-89 x JI-357, SKP-106 x JI-357 and JP-89 x SKI-343; for shelling out-turn by SKP-84 x SKI-215 and JP-89 x SKI-343; for 100-seed weight by SKP-84 x SKI-215; for oil content by JP-89 x PCS-124, SKP-106 x 48-1, SKP-106 x JI-357, SKP-106 x JI-357 and SKP-84 x SKI-215. The results indicated that in different crosses, pathway for releasing heterotic effects varied from cross to cross. It also revealed that length of primary raceme, effective length of primary raceme, number of effective branches per plant, number of capsules on main raceme, shelling out-turn and 100-seed weight were the main contributors towards increased seed yield. High association of heterosis between these characters and seed yield per plant in castor has also been earlier reported by Golakia *et al.* (2008), Sridhar *et al.* (2009) and Sodavadiya (2010).

In pooled analysis, the crosses *viz.*, JP-89 x PCS-124, JP-89 x RG-2826, SKP-84 x 48-1, SKP-106 x 48-1 and SKP-106 x PCS-124 exhibited the significant and positive heterobeltiosis for seed yield per plant and its components. Such crosses could be exploited further for yield advancement in castor through multi-locational testing over different environments.

References

Barad, Y.M.; Pathak, A.R. and Patel, B.N. 2009. Heterosis for yield and yield attributing traits in castor (*Ricinus communis* L.). *J. Oilseeds Res.*,**26(2)**:102-104.

Chaudhari, K. N. Chaudhary, R. F. Patel, D. K. Patel, H. N. Pathak, H. C. and Prajapari, B. H. 2011. Heterosis for seed yield and yield components over environments in castor (*Ricinus communis* L.). *Elec. J. Pl. Breed.*,**2(3)**: 372-376.

Fonseca, S. and Patterson, F. 1968. Hybrid vigour in a seven parent diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop Sci*., **8**: 85-95.

Golakia, P. R. Monpara, B. A. and Poshiya, V. K. 2008. Heterosis for yield determinants over environments in castor (*Ricinus communis* L.). *J. Oilseeds Res.*,**25(1)**: 25-28.

Gopani, D. D. Kabaria, M. M. and Patel, R. H. 1968. Study of hybrid vigour in castor. *Indian J. Agric. Sci*., **38**: 520-527.

Grafius, J. E. 1959. Heterosis in barley. *Agron. J.*, **40(1)**: 58-83.

Hagberg, A. 1952. Heterosis in F_1 combinations in Galeopsis. I and II. *Heriditas*, Lund. 1:b221-225. (Fide: *Indian J. Genet.*, **29**(1): 53-61).

Sodavadiya, P. R. 2010. Genetic architecture of seed yield and yield attributing traits in castor (*Ricinus communis* L.). Ph.D. Thesis (Unpublished) submitted to Junagadh Agricultural University, Junagadh.

Sridhar, V. Dangi, K. S. Reddy, A. V. Sudhakar, R. and Sankar, A. S. 2009. Heterosis for seed yield and yield components in castor (*Ricinus communis* L.). *Intern. J. Agric. Bio.*,**2(1)**: 64-67.

Weiss, E.A. 2000. Oilseed crops. 2nd ed. Blackwell Science, Oxford.

Whitehouse, R. N. H.Thompson, J. B. and Riberio, D. V. 1958. Studies on the breeding of self-pollinated cereals. 2. The use of diallel cross analysis in yield prediction. *Euphytica.*, **7**: 147-169.

Williams, W. and Gilbert, N. 1960. Heterosis and the inheritance of yield in the tomato. *Heredity*, **14**: 133-145.

Table 1. Analysis of variance for the experimental design over environments for different characters in castor

Source	DF	Days to 50 % flowering of primary raceme	Days to maturity of primary raceme	Plant height up to primary raceme (cm)	Number of nodes up to primary raceme	Length of primary raceme (cm)	Effective length of primary raceme (cm)
Replications in E	6	2.19	5.55	6.98	2.19	6.78	12.75
Environments (E)	2	409.34*	526.22*	3912.74*	3322.48*	1478.07*	1008.12*
Parents(P)	16	132.20*	474.34*	3315.89*+	20.76*+	300.92*+	364.17*+
Hybrids(H)	51	137.73*	448.75*	1052.32*+	19.72*+	281.35*+	351.88*+
P vs H	1	136.17*	744.21*	19205.39*+	44.01*	5174.97*+	3080.76*
P x E	32	0.87	4.89	122.59*	6.41*	42.00*	38.66*
H x E	102	2.70	1.84	195.26*	4.00*	53.49*	49.96*
(P vs H) x E	2	1.29	14.93	82.18*	4.22*	81.50*	153.03*
Pooled error	414	5.00	7.43	14.77	1.36	9.48	12.56

Source	DF	Number of effective branches per plant	Number of capsules on primary raceme	Shelling out-turn (%)	Seed yield per plant (g)	100-seed weight (g)	Oil content (%)
Replications in E	6	0.75	9.15	2.43	155.09	1.28	1.66*
Environments(E)	2	386.50*	48.78	217.66*	137536.15*	25.98*	4.91*
Parents(P)	16	48.42*+	2328.12*+	37.53*	24540.56*	168.82*	25.86*
Hybrids(H)	51	41.67*+	1765.64*+	31.48*+	25869.93*	87.62*	8.22*
P vs H	1	354.51*+	11393.05*	1024.01*	270137.00*	50.80*	243.45*
P x E	32	5.87*	161.90*	27.51*	4271.57*	0.33	0.97*
H x E	102	8.99*	194.70*	12.37*	7107.03*	0.30	0.58
(P vs H) x E	2	7.67*	23.10	78.97*	40.78	0.20	0.03
Pooled error	414	0.49	24.23	2.27	369.53	0.61	0.66

* Significant at P = 0.05 when tested against error mean square.

+ Significant at P=0.05 when tested against interaction mean square

Table 2. Magnitude of heterobeltiosis (H_1) and standard heterosis (H_2) over environments for different characters in castor

Sr. No	Characters	Range of heterosis (%)		Number of crosses with significant heterosis			
		H_1	H_2	H_1		H_2	
				+ve	-ve	+ve	-ve
1	Days to 50 % flowering of primary raceme	-13.81 to 14.23	-17.18 to 4.36	23	11	-	32
2	Days to maturity of primary raceme	-15.59 to 15.68	-18.71 to 10.86	18	16	17	15
3	Plant height upto primary raceme (cm)	-1.92 to 150.96	-23.39 to 30.86	49	-	17	19
4	Number of nodes upto primary raceme	-14.14 to 17.71	-19.72 to 13.50	9	8	6	13
5	Length of primary raceme (cm)	-24.09 to 22.54	-24.66 to 15.88	24	2	11	10
6	Effective length of primary raceme (cm)	-27.54 to 20.31	-31.96 to 14.26	11	9	12	13
7	Number of effective branches per plant	-55.86 to 93.32	-57.27 to 30.44	23	14	7	34
8	Number of capsules on primary raceme	-37.38 to 38.61	-37.46 to 24.71	18	15	15	21
9	Shelling out-turn (%)	-5.91 to 8.16	-6.28 to 6.45	24	4	11	7
10	Seed yield per plant (g)	-37.14 to 75.95	-61.77 to 18.64	20	10	4	47
11	100-seed weight (g)	-23.72 to 12.00	-20.93 to 21.40	14	24	24	16
12	Oil content (%)	-6.99 to 8.05	-4.72 to 3.92	25	5	19	4

Table 3. Comparative study of ten most heterobeltiotic (H_1) crosses along with standard heterosis (H_2) and *per se* performance for seed yield and its component characters over environments in castor

Sr. No	Crosses	Mean seed yield per plant (g)	Seed yield per plant (g)		Days to 50 % flowering		Days to maturity of primary raceme		Plant height up to primary raceme (cm)		Number of nodes up to primary raceme		Length of primary raceme (cm)	
			H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
1.	JP-89 x PCS-124	285.34	75.95**	-8.46*	-8.05**	-10.37	-1.88	2.30	44.43**	-13.03**	2.08	-12.97**	17.16**	-4.26
2.	JP-89 x RG-2826	277.73	70.45**	-10.90*	6.61**	-1.74	3.24**	2.01	111.59**	27.41**	17.15**	13.50**	1.31	-17.22**
3.	SKP-84 x 48-1	283.74	61.11**	-8.98*	5.94*	-3.66	-2.41	0.62*	97.88**	3.18	2.48	4.17	11.20**	5.15
4.	SKP-106 x 48-1	271.91	60.45**	-12.77**	0.83	-7.85**	-2.83*	1.67	80.36**	-12.41**	-7.45	-5.93	5.03	-8.91*
5.	SKP-106 x PCS-124	257.15	58.57**	-17.51**	-3.88	-9.33**	-3.53*	0.57	87.46**	-8.96**	9.51*	-8.96**	8.73*	-5.95
6.	JP-89 x JI-357	369.82	55.67**	18.64**	7.96*	-6.63*	5.02**	-0.81	99.23**	19.97**	3.81	0.57	17.51**	7.22*
7.	SKP-106 x JI-357	357.08	50.31**	14.55**	6.55*	-7.85**	1.22	-4.40*	95.85**	-4.88	-5.32	-6.07	21.00**	10.40**
8.	JP-89 x 48-1	254.09	49.93**	-18.49**	-13.81**	-15.69**	-15.59**	-11.67**	83.75**	10.65**	10.01*	6.58	11.32**	-3.46
9.	SKP-84 x SKI-215	318.19	44.48**	2.07	11.03**	0.96	3.10*	-1.20	90.30**	-0.77	-0.95	2.16	4.59	-1.10
10.	JP-89 x SKI-343	230.62	44.03**	-26.02**	-3.93	-14.82**	-7.73**	-14.93**	80.58**	3.38	-10.98*	-16.77**	10.38**	8.54*

Continue.

Table 3. Cont…..

Sr. No	Crosses	Effective length of primary raceme (cm)		Number of effective branches per plant		Number of capsules on primary raceme		Shelling out-turn (%)		100-seed weight (g)		Oil content (%)	
		H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
1.	JP-89 x PCS-124	4.05	-6.54	59.30**	16.34**	-6.46	-28.92**	1.58	0.02	-10.52**	-12.56**	3.66**	3.08*
2.	JP-89 x RG-2826	-13.08*	-21.92**	37.07**	3.27	8.93	-29.22**	3.73*	2.14	-3.80*	4.44*	-0.85	-2.95*
3.	SKP-84 x 48-1	7.40*	7.39	8.05	-12.65*	14.65**	12.87**	2.64*	1.02	-9.01**	-0.76	0.74	0.11
4.	SKP-106 x 48-1	-2.75	-7.53	27.06**	2.71	-5.09	-7.51*	1.56	-1.21	-13.99**	-6.19**	3.52**	2.87*
5.	SKP-106 x PCS-124	3.38	-1.70	32.90**	-2.94	-5.44	-7.86*	-0.43	-3.15*	-6.67**	-19.44**	3.14*	2.57*
6.	JP-89 x JI-357	20.31**	11.32*	55.31**	30.44**	15.21**	12.65**	3.17*	4.29**	-11.46**	17.74**	2.30*	0.95
7.	SKP-106 x JI-357	18.38**	12.57*	43.83**	22.37**	21.82**	19.11**	-0.99	0.09	-23.72**	1.43	5.07**	3.69**
8.	JP-89 x 48-1	6.26	-4.55	8.96	-11.92*	1.59	-4.92	3.63*	2.04	1.44	10.64**	3.07*	2.42*
9.	SKP-84 x SKI-215	2.50	2.49	10.23*	8.91*	5.55	3.91	4.67**	3.02*	5.95**	-0.22	6.72**	-0.64
10.	JP-89 x SKI-343	-4.22	-2.33	36.26**	-12.62*	38.61**	-8.41*	5.75**	4.13**	4.47*	2.09	-1.52	-2.05

*, ** Significant at 5 and 1 per cent levels of probability, respectively