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HETEROSIS, COMBINING ABILITY AND GENETIC DIVERGENCE IN COW PEA (*VIGNA UNGUICULATA* (L.) WALP.)

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Summary

Manifestation of heterosis for green pod yield and its components viz. plant height, number of branches per plant, pod length, pod weight, number of pods per cluster and per plant, number of seeds per pod and green pod yield per plant were examined in relation to genetic divergence of the parents and specific combining ability of the crosses in a Line x Tester design in vegetable cowpea. ICP-42 × Pusa Komal and ICP-54 × Pusa Komal were found heterotic due to of highly divergent parents. Heterosis did not always occur in crosses between widely divergent parents, but also observed in closely related parents such as in ICP- 45 × Indira Hari and ICP- 54 × Arka Garima. It appeared that the frequency of heterotic crosses as well as magnitude of heterosis was much related with specific combining ability status of crosses. However, consideration of genetic divergence of the parents involved in the crosses along with positive SCA of the crosses would prove to be useful in predicting heterosis in cowpea.

सारांश

बरबटी में अनुवांशिकीय विभिन्नता एवं विशेष संयोजन क्षमता का संबंध संकर ओज से ज्ञात करने के लिए पौधे की लम्बाई, प्रति पौध शाखाओं की संख्या, फली की लम्बाई, फली का वजन, प्रति गुच्छा फलियों की संख्या, प्रति पौध फलियों की संख्या, प्रति फली बीजों की संख्या तथा प्रति पौध हरी फलियों का उपज का लाइन × टेस्टर संकरण पद्धति से अध्ययन किया गया। संकर आई.सी.पी.–54 × पूसा कोमल में अधिक अनुवांशिकीय विभिन्नता वाले पित्रों के कारण अधिक संकर ओज पाया गया। हमेशा अधिक अनुवांशिकीय विभिन्नता वाले पित्रों के संकरण से अधिक संकर ओज वाला संकर प्राप्त होना आवश्यक नहीं है अपितु समीपस्थ पित्रों के संकरण से भी संकर ओज प्राप्त होता है जैसा कि आई.पी.सी.–45 × इंदिरा हरी एवं आई.पी.सी.–54 × अर्का गरिमा। इससे प्रतीत होता है कि अधिक संकर ओज वाले संकरों की संख्या एवं संकर ओज की दिशा, संकरों के विशेष संयोजन क्षमता से संबंधित होता है। अतः बरबटी में संकर ओज के अनुमान के लिए अनुवांशिकीय विभिन्नता के साथ–साथ धनात्मक विशेष संयोजन क्षमता वाले संकरणों का होना आवश्यक है।

Introduction

Yield in vegetable cowpea is defined as marketable green pod yield which is a function of components of yield contributing characters. Heterosis in F_1 generation is of great importance in vegetable crops as heterotic crosses may give transgressive segeregants for economic traits in advanced generations. Genetic divergence of parents has been reported to be essential for the manifestation of heterosis in their crosses in several legume crops (Ramanujam *et al.,* 1974; Hazra *et al.,* 1993). On the other hand, there have been reports where heterosis was not observed even when divergent parents were crossed (Arunachalam *et al.,* 1984). Little information is available on relation of genetic diversity and heterosis, especially in vegetable cowpea. Keeping these views, six extremely diverse genotypes of vegetable cowpea were evaluated in line x tester (6x4) cross for green pod yield and its components to work out relation between genetic divergence of parents and specific combining ability (SCA) of the crosses.

Materials and Methods

The experiment was conducted during *Kharif* season of 2007 to 2008 at Department of Horticulture, IGKV, Raipur. The experiment comprises of 60 cowpea genotypes grouped under seven clusters based on the divergence, as measured by Mahalanobis' D^2 statistics (Rao, 1956). From seven clusters, six genotypes *viz*., ICP-26 (L_1), ICP-38 (L_2), ICP-42 (L_3), ICP-45 (L_4), ICP-49 (L_5) and ICP-54 (L_6) were selected as lines and four genotypes *viz*., Pusa Komal (T_1), Arka Garima (T_2), Indira Hari (T_3) and Khalleshwari (T_4) were selected as testers for line x tester cross. All the parents along with their 24 F_1s were grown in randomized block design with three replications. Each genotype consisted of three rows of 3.15 m long and 7 plants in each row. The plant spacing given was 60 cm between rows and 45 cm within a row. Observations were recorded on ten randomly tagged competitive plants from each genotype for plant height (cm), number of branches per plant, pod length (cm), pod weight (g), number of pods per cluster and per plant, number of seeds per pod and green yield per plant (g) were subjected to combining ability analysis as per Kempthorne (1957). Heterosis was worked out over standard parent (SP) and their significance was determined by t test as suggested by Rai and Rai (2006).

Results and Discussion

The data on standard parent heterosis for eight quantitative characters are presented in Table 1. Majority of crosses showed significant positive or negative heterosis for all the traits under study except number of seeds per pod. The cross combination ICP-42 x Arka Garima (111.39%) exhibited maximum significant positive heterosis over standard parent for plant height. For number of branches per plant the crosses ICP-49 x Khalleshwari, ICP-38 x Indira Hari and ICP-38 x Pusa Komal showed maximum positive heterosis over standard parent, respectively.

Table 1. Magnitude of heterosis in three best F_1 for yield and its components in cowpea

Characters	Crosses	Heterosis over SP
Plant height (cm)	ICP- 42 x Arka Garima	111.39**
	ICP- 42 x Khalleshwari	96.90**
	ICP- 42 x Pusa Komal	94.10**
Number of branches per plant	ICP- 49 x Khalleshwari	49.11**
	ICP- 38 x Indira Hari	41.88**
	ICP- 38 x Pusa Komal	40.93**
Pod length (cm)	ICP- 42 x Indira Hari	86.45**
	ICP- 42 x Arka Garima	65.73**
	ICP- 54 x Indira Hari	65.30**
Pod weight (g)	ICP- 42 x Arka Garima	89.00**
	ICP- 42 x Indira Hari	81.74**
	ICP- 42 x Pusa Komal	40.63**
No. of pods per cluster	ICP- 38 x Arka Garima	56.54**
	ICP- 45 x Khalleshwari	49.62**
	ICP- 45 x Arka Garima	49.23**
No. of pods per plant	ICP- 54 x Indira Hari	27.44**
	ICP- 42 x Arka Garima	20.45*
	ICP- 54 x Pusa Komal	15.14
No. of seeds per pods	ICP- 42 x Indira Hari	24.95*
	ICP- 42 x Pusa Komal	22.70*
	ICP-38 x Indira Hari and ICP- 38 x Pusa Komal	15.88
Green pod yield per plant (g)	ICP- 42 x Arka Garima	93.52**
	ICP- 42 x Indira Hari	74.37**
	ICP- 54 x Arka Garima	52.00**

*and ** Significant at 5 and 1% level; SP – Standard parent

The cross combinations ICP-42 x Indira Hari,, ICP-42 x Arka Garima and ICP-54 x India Hari exhibited maximum and positive heterosis over standard parent, respectively for pod length (Table 1). Among all the F_1's the cross ICP-42 x Arka Garima (89.00%) showed maximum heterosis over standard parent for pod weight. Regarding number of pods per cluster and per plants were found highest and maximum significant and posistive heterosis over standard parents in the cross combinations, ICP-38 x Arka Garima (56.54%) and ICP-54 x Indira Hari (27.44%), respectively.

Table 1 also exhibited to the crosses ICP-42 x Indira Hari (24.95%), ICP-42 x Pusa Komal, ICP-38 x Indira Hari and ICP- 38 x Pusa Komal showed maximum significant and positive heterosis over standard parent for number of seeds per pod. The highest green pod yield per plant was the most important fruit for considering the performance of a genotype. The cross combination ICP-42 x Arka Garima (93.52%) had highest heterosis over standard parents for green pod yield per plant followed by the crosses ICP-42 x Indira Hari and ICP-54 x Arka Garima exhibited maximum

Table 2. Divergence of parents in the crosses of vegetable cowpea

Crosses	Clusters of parents		Intra-or inter-cluster D^2 value	D^2 value between parents
	Lines	Testers		
ICP- 26 x Pusa Komal	2	5	3.24	508.95
ICP- 26 x Arka Garima	2	5	3.24	569.78
ICP- 26 x Indira Hari	2	5	3.24	227.41
ICP- 26 x Khalleshwari	2	6	4.47	605.65
ICP- 38 x Pusa Komal	5	5	2.86	1323.50
ICP- 38 x Arka Garima	5	5	2.86	234.70
ICP- 38 x Indira Hari	5	5	2.86	338.93
ICP- 38 x Khalleshwari	5	6	5.72	285.27
ICP- 42 x Pusa Komal	7	5	4.67	3133.76
ICP- 42 x Arka Garima	7	5	4.67	1018.25
ICP- 42 x Indira Hari	7	5	4.67	1137.04
ICP- 42 x Khalleshwari	7	6	8.63	1067.33
ICP- 45 x Pusa Komal	3	5	2.78	1096.27
ICP- 45 x Arka Garima	3	5	2.78	375.20
ICP- 45 x Indira Hari	3	5	2.78	183.60
ICP- 45 x Khalleshwari	3	6	5.64	339.30
ICP- 49 x Pusa Komal	3	5	2.78	1167.59
ICP- 49 x Arka Garima	3	5	2.78	317.20
ICP- 49 x Indira Hari	3	5	2.78	166.15
ICP- 49 x Khalleshwari	3	6	5.64	342.99
ICP- 54 x Pusa Komal	7	5	4.67	2201.49
ICP- 54 x Arka Garima	7	5	4.67	570.25
ICP- 54 x Indira Hari	7	5	4.67	652.80
ICP- 54 x Khalleshwari	7	6	8.63	561.69

heterosis over standard parents, respectively. Manifestation of green pod yield and its components were studied by many researchers Mak and Yap (1977), Sangwan and Lodhi (1995), Kumar *et al.* (1999) and Bhusana *et al.* (2000). The ranks of the crosses on the basis of heterosis and *per se* performance did not match which was possibly due to differences in the performance of parent themselves. It would be therefore judicious to consider *per se* performance along with heterosis while identifying promising crosses for future breeding programme.

Genetic divergence of the parents depicted in Table 2. ICP-42 x Pusa Komal and ICP-54 x Pusa Komal for plant height, pod length, number of pods per plant and green pod yield per plant could be explained by high parental divergence (D value) but such explanation is difficult to propose for different heterotic parameters recorded in crosses ICP- 42 x Arka Garima for plant height, pod weight and green pod per plant and ICP- 54 x Indira Hari for number of pods per plant which had lower parental divergence. Extremely divergent parents (ICP-42 x Pusa Komal) did not produce highest heterotic combination for number of branches per plant, pod length, pod weight number of pods per plant and green pod yield, while the cross having lower parental divergence. ICP- 45 x Indira

Table 3. GCA of parents and SCA of crosses for green pod yield and its components in vegetable cowpea

Parents	Plant height	Number of branches per plant	Pod length	Pod weight	No. of pods per cluster	No. of pods per plant	No. of seeds per pod	Green pod yield per plant (g)
Lines								
ICP-26 (L_1)	-19.59*	-0.49*	-3.99*	-3.09*	-0.20*	-2.41*	-0.03	-82.47*
ICP-38 (L_2)	-52.62*	2.10*	0.82	-0.07	0.05	1.42*	1.14*	4.07
ICP-42 (L_3)	65.66*	-1.15*	5.80*	3.68*	0.10*	1.18	1.72*	94.30*
ICP-45 (L_4)	38.61*	-1.27*	-2.16*	-0.84*	0.08	-0.83	-0.03	-27.33*
ICP-49 (L_5)	-9.26	0.08	-4.38*	-0.21	-0.09	-2.75*	-0.78	-31.38*
ICP-54 (L_6)	-22.80*	0.73*	3.90*	0.53*	0.06	3.39*	-2.03*	42.81*
SE $\pm$	4.31	0.14	0.50	0.10	0.04	0.47	0.31	4.64
Testers								
Pusa Komal (T_1)	-1.24	-0.61*	3.87*	1.07*	-0.44*	0.87	0.69	33.03*
Arka Garima (T_2)	10.38	-1.01*	3.43*	2.00*	0.56*	0.71	-0.92*	46.80*
Indira Hari (T_3)	-6.41	0.14	5.24*	0.87*	-0.58*	0.41	1.19*	21.00*
Khalleshwari (T_4)	-2.73	1.49*	-12.55*	-3.94*	0.46*	-1.99*	-0.97*	-100.82*
SE $\pm$	3.34	0.11	0.39	0.08	0.03	0.37	0.24	3.60
Crosses								
$L_1 \times T_1$	4.35	-0.04	-1.21	0.10	-0.06	-1.61	-0.36	-13.17
$L_1 \times T_2$	8.69	-0.57*	-1.48	-1.50*	0.14*	-1.59	0.25	-34.99*
$L_1 \times T_3$	-4.84	0.47	-1.32	-0.87*	-0.32*	-0.01	0.14	-23.08*
$L_1 \times T_4$	-8.20	0.13	4.01*	2.37*	0.24*	3.20*	-0.03	71.25*
$L_2 \times T_1$	-6.74	0.78*	1.60	0.21	-0.11	1.27	-0.19	8.85
$L_2 \times T_2$	-8.39	0.51*	1.74*	0.15	0.16*	0.67	0.08	6.76
$L_2 \times T_3$	4.27	0.09	-2.20*	-0.72*	0.10	-0.29	-0.69	-18.95*
$L_2 \times T_4$	10.86	-1.39*	-1.14	0.35	-0.14*	-1.65	0.81	3.34
$L_3 \times T_1$	-0.84	-0.10	-1.27	-1.26	0.08	0.58	0.22	-16.23*
$L_3 \times T_2$	10.43	0.10	1.47	1.81*	-0.22*	3.49*	0.50	51.81*
$L_3 \times T_3$	-13.95	-0.39	4.46*	2.34*	0.33*	-3.70*	0.06	39.98*
$L_3 \times T_4$	4.36	0.40	-4.65*	-2.89*	-0.19*	-0.38	-0.78	-75.56*
$L_4 \times T_1$	7.26	0.35	1.02	0.09	-0.01	0.73	-0.03	6.86
$L_4 \times T_2$	-8.63	0.28	-0.91	-0.72	-0.06	-0.94	-0.08	-25.05*
$L_4 \times T_3$	-1.24	-0.34	-1.15	0.16	0.02	0.32	-0.19	2.65
$L_4 \times T_4$	2.60	-0.29	1.04	0.46*	0.05	-0.11	0.31	15.54
$L_5 \times T_1$	0.64	-1.20*	-1.26	0.45*	0.21*	-0.77	0.06	-2.22
$L_5 \times T_2$	1.52	-0.54*	-1.42	-0.33	0.10	-1.46	-0.33	-20.24*
$L_5 \times T_3$	4.30	0.44	-1.24	-0.29	-0.31*	0.34	-0.11	-3.91
$L_5 \times T_4$	-6.46	1.30*	3.93*	0.17	0.01	1.89*	0.39	26.37*
$L_6 \times T_1$	-4.67	0.21	1.13	0.50*	-0.11	-0.21	0.31	15.90*
$L_6 \times T_2$	-3.62	0.21	0.60	0.59*	-0.11	-0.18	-0.42	21.71*
$L_6 \times T_3$	11.46	-0.28	1.46	-0.62*	0.19*	3.34*	0.81	3.32
$L_6 \times T_4$	-3.17	-0.15	-3.18*	-0.48*	0.03	-2.95*	-0.69	-40.93*
SE $\pm$	7.47	0.24	0.86	0.18	0.06	0.82	0.54	8.04

Hari, ICP- 54 x Arka Garima were surprisingly heterotic even over better parents not only for green pod yield but also for plant height, number of pods per cluster and number of pods per plant. Thus, the realised heterosis when considered against corresponding D values between the parents of the crosses, and one to another correspondence may not necessarily be established between parents. In fact, it should be admired that genetic divergence and heterosis may not proceed hand in hand because of internal balancing or canceling of various components of heterosis. Similar findings were also reported by Hazra *et al*. (1993) in cowpea.

To relate the heterosis with specific combining ability magnitude of crosses, general combining ability (gca) of parents and specific combining ability (sca) of the crosses are presented in Table 3. Among the parents ICP-42, ICP-54, Pusa Komal, Arka Garima and Indira Hari were good general combiner for pod length and pod weight. Whereas, ICP-42, Arka Garima and Khalleshwari were good general combiners for number of pods per cluster. The parents, ICP-38 and ICP-54 were observed good general combiners for number of pods per plant, whereas, ICP-42, Arka Garima and ICP-54 for green pod yield per plant. It can be seen from Table 3 that crosses having significant for sca effects is not necessary to have significant gca effect of parents. The cross combinations ICP-42 x Arka Garima and ICP-42 x Indira Hari had significantly positive sca with significant gca of parents, but did not have high parental divergence. The crosses with significant negative sca, even if having very high parental divergence did not exhibit heterosis especially over better parent. For example, the crosses ICP-42 x Khalleshwari and ICP-54 x Khalleshwari exhibited negative heterosis and negative sca for pod length, pod weight and green pod yield per plant. It was also observed that heterosis was absent in the cross with significant negative sca combined with low parental divergence for a particular character. The only exception was ICP-26 x Khalleshwari for pod length, pod weight, number of pods per plant and green pod yield per plant. From the above observations it become apparent that the parental divergence may not serve as a reliable parameter for predicting heterosis especially in crop like cowpea. On other hand, whatever be nature of parental divergence (high or low), the positive sca effects of the crosses continue to maintain high heterotic expression for different characters. Similar observations were also made by Hazra *et al*. (1993).

In this context, the crosses ICP-42 x Indira Hari and ICP-54 x Pusa Komal gave some interesting observation and both the crosses involved Sesquipedalis and Unguiculata culti groups which were widely divergent (Table 2). Significant sca effects were revealed for pod weight and number of pods per plant in these two crosses and heterosis was also manifested for above mentioned characters. The *per se* performance of these crosses was also high for green pod yield was also very high. This would suggest that high genetic divergence of the parents in association with high positive sca effects would likely to manifest high heterosis for the characters under study. Hence, parental divergence should not be ignored, rather it must be considered along with sca of crosses for predicting heterosis. This result is in confirmation with the finding of Hazra *et al*. (1993).

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