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Short communication

Combining ability analysis for protein content in relation to heterosis and green pod yield in vegetable cowpea

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ABSTRACT

Six lines (ICP-26, ICP-38, ICP-42, ICP-45, ICP-49 and ICP-54) and four testers (Pusa Komal, Arka Garima, Indira Hari and Khalleshwari) were crossed for protein content and green pod yield. Significance of mean sum of square showed the existence of variability among genotypes and crosses. The highest significant positive relative heterosis & heterobeltiosis was observed for ICP-54 × Khalleshwari and standard heterosis for ICP-26 × Indira Hari. ICP-26 and Khalleshwari were best general combiners and ICP-38 × Arka Garima and ICP-54 × Khalleshwari were identified as best specific combiner. The ratio of GCA variance to SCA variance was found more than unity, which indicated the preponderance of additive gene action for protein content in vegetable cowpea.

Key words: Cowpea, genetic divergence, heterosis, combining ability.

Cowpea [*Vigna unguiculata* (L.) Walp.] is widely grown in tropics and sub-tropics for immature pods and mature seeds. It is an important component in the diet of many peoples especially in African continent, where it is the principle source of protein (Singh *et al.*, 13). It is one of the preferred crops grown in India for green pods as well as mature seeds and good source of protein among vegetables. The demand of protein rich food is increasing day by day, especially in rural areas where malnutrition is becoming a problem, and varieties with high protein can help to augment the situation. Earlier workers reported negative correlation of protein content with green pod yield (Bliss *et al.*, 2). But very scanty literature is available regarding combining ability and heterosis in vegetable type cowpea. Keeping this in view, the study was carried out to determine the magnitude of heterosis and extent of combining ability of cowpea genotypes.

The experiment was conducted during *kharif* season for two years at Department of Horticulture, IGKV, Raipur (C.G.). During first year 60 cowpea genotypes were evaluated for selection of parents. On the basis of genetic divergence analysis six diverse lines, *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) and four testers, *viz*., Pusa Komal (T_1), Arka Garima (T_2), Indira Hari (T_3) and Khalleshwari (T_4) were selected to produce 24 F_1s as per Line × Tester matting design given by Kempthorne (6). During second year the ten parents and their 24 F_1s along with 24 F_2s were grown for investigation. The experiment was laid out 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 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. Fresh green pods were harvested at marketable stage and sun dried. Protein content of lines, testers and crosses was estimated titration method using *Kel Plus* apparatus. Statistical analysis was done as methods suggested by Hayes *et al*. (5) and Kempthorne (6).

The mean sum of square for protein content was significant among the cowpea genotypes suggesting the existence of genetic variability among parental population (Table 1). The treatment mean sum of squares were partitioned into lines, testers and lines × testers. The mean sum of squares due to lines, testers and lines × testers were significant for percent protein content in green pods also indicating the presence of substantial genetic variability for the trait under study. The range of percent protein content in parents and crosses was 2.00 to 3.94% and 2.77 to 3.89% (Table 2). The maximum protein content among the parents was recorded in Khalleshwari (3.94%) followed by Indira Hari (2.80%), Pusa Komal (2.77%), Arka Garima (2.75%) and ICP-45 (2.73%). Among the crosses it was maximum in ICP-54 × Khalleshwari (3.89%) followed by ICP-26 × Khalleshwari (3.86%), ICP-49 × Khalleshwari (3.85%), ICP-45 × Khalleshwari (3.84%), ICP-42 × Khalleshwari (3.70%) and ICP-38 × Khalleshwari (3.57%).

Particularly in legume vegetables moderate protein content is more desirable than very high or low, as increase in protein content reducing pod yield. Therefore, positive estimate of GCA and SCA effects would be measured as desirable. The magnitude

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Table 1. Analysis of variance for protein content in green pod in vegetable cowpea.

Source of variation	d.f.	Mean sum of square for protein content in green pods
Parental cowpea population		
Replication	02	0.32*
Genotype	59	1.48**
Error	118	0.07
Cross		
Replication	02	0.01
Lines	5	0.23*
Testers	3	1.03*
L × T	15	0.43*
Error	46	0.03
$\sigma^2 g$		0.11
$\sigma^2 s$		0.10
$\sigma^2 g/\sigma^2 s$		1.10
Av. degree of dominance $(\sigma^2 g/\sigma^2 s)^{1/2}$		1.048

of different heterosis, *viz.*, relative heterosis (RH), heterobeltiosis (HB) and standard heterosis (SH) and inbreeding depression were represented in Table 3. The estimate of relative heterosis ranged from 4.56 to 30.64%. Out of 24 crosses, twenty one crosses showed significant positive relative heterosis for this trait. The highest significant relative heterosis was recorded in ICP-54 × Khalleshwari (30.64%) followed by ICP-49 × Khalleshwari (26.13%), ICP-42 × Khalleshwari (24.58%), ICP-42 × Indira Hari (23.84%) and ICP-26 × Khalleshwari (22.11%). Heterobeltiosis ranged from -9.39 to 10.36%. Three crosses showed significant positive heterobeltiosis and only one cross exhibited significant negative heterobeltiosis (ICP-38 × Khalleshwari). ICP-26 × Indira Hari (10.36%) exhibited highest significant positive heterobeltiosis followed

Table 2. Mean protein content of parents and their crosses, gca effects of parents and sca effects of crosses in vegetable cowpea.

Parent	% protein in green pods	Green pod yield per plant (g)	GCA effects	SCA effects
ICP-26 (L_1)	2.37	78.13	0.19*	-
ICP-38 (L_2)	2.34	149.64	0.01	-
ICP-42 (L_3)	2.00	214.93	-0.07	-
ICP-45 (L_4)	2.73	126.99	0.02	-
ICP-49 (L_5)	2.17	126.22	-0.02	-
ICP-54 (L_6)	2.01	210.15	-0.03	-
Average of line	2.27	151.01	-	-
SE ± (Lines)	-		0.04	-
Tester				
Pusa Komal (T_1)	2.77	196.53	-0.25*	-
Arka Garima (T_2)	2.75	192.46	-0.25*	-
Indira Hari (T_3)	2.80	145.87	-0.15*	-
Khalleshwari (T_4)	3.94	70.08	0.65*	-
Average of testers	3.07	151.24	-	-
SE ± (Tester)	-	-	0.03	-
Cross				
$L_1 \times T_1$	2.97	124.80	-	-0.01
$L_1 \times T_2$	3.02	116.74	-	0.04
$L_1 \times T_3$	3.09	102.85	-	0.00
$L_1 \times T_4$	3.86	75.36	-	-0.03
$L_2 \times T_1$	2.96	233.37	-	0.07
$L_2 \times T_2$	3.00	245.04	-	0.18*
$L_2 \times T_3$	3.03	193.53	-	0.04
$L_2 \times T_4$	3.57	94.00	-	-0.22*
$L_3 \times T_1$	2.83	298.51	-	0.02
$L_3 \times T_2$	2.77	380.32	-	-0.05
$L_3 \times T_3$	2.97	342.68	-	0.05
$L_3 \times T_4$	3.70	105.32	-	-0.02
$L_4 \times T_1$	2.93	199.97	-	0.03
$L_4 \times T_2$	2.87	181.83	-	-0.03
$L_4 \times T_3$	2.97	183.72	-	-0.04
$L_4 \times T_4$	3.84	74.79	-	0.04
$L_5 \times T_1$	2.80	186.84	-	-0.06
$L_5 \times T_2$	2.84	182.58	-	-0.02
$L_5 \times T_3$	2.96	173.12	-	-0.01
$L_5 \times T_4$	3.85	81.58	-	0.09
$L_6 \times T_1$	2.81	279.15	-	-0.05
$L_6 \times T_2$	2.80	298.73	-	-0.05
$L_6 \times T_3$	2.92	254.54	-	-0.04
$L_6 \times T_4$	3.89	88.47	-	0.13*
SE ± (Cross)			-	0.07

Table 3. Magnitude of heterosis in F_1 for protein content (%) in green pods of vegetable cowpea.

Hybrid	Relative heterosis	Heterobeltiosis	Standard heterosis	Inbreeding depression
ICP- 26 × Pusa Komal	15.49**	7.22	7.22	-8.08*
ICP- 26 × Arka Garima	17.82**	9.82*	9.03	-7.95
ICP- 26 × Indira Hari	19.46**	10.36*	11.55*	-9.06*
ICP- 26 × Khalleshwari	22.11**	-2.03	39.35**	4.15
ICP- 38 × Pusa Komal	16.06**	6.86	6.86	-8.11*
ICP- 38 × Arka Garima	17.88**	9.09*	8.30	-8.00*
ICP- 38 × Indira Hari	17.98**	8.21	9.39	-8.25*
ICP- 38 × Khalleshwari	13.59**	-9.39**	28.88**	-8.12*
ICP- 42 × Pusa Komal	18.88**	2.17	2.17	-8.13*
ICP- 42 × Arka Garima	16.49**	0.73	0.01	-8.30*
ICP- 42 × Indira Hari	23.84**	6.07	7.22	-8.08*
ICP- 42 × Khalleshwari	24.58**	-6.09	33.57**	-8.11*
ICP- 45 × Pusa Komal	6.67	5.78	5.78	-7.85
ICP- 45 × Arka Garima	4.56	4.36	3.61	-8.36*
ICP- 45 × Indira Hari	7.29	6.07	7.22	-8.08*
ICP- 45 × Khalleshwari	15.18*	-2.54	38.63**	-7.55
ICP- 49 × Pusa Komal	13.44*	1.08	1.08	-8.21*
ICP- 49 × Arka Garima	15.45**	3.27	2.53	-7.75
ICP- 49 × Indira Hari	19.06**	5.71	6.86	-8.45*
ICP- 49 × Khalleshwari	26.13**	-2.28	38.99**	-8.05*
ICP- 54 × Pusa Komal	17.52**	1.44	1.44	-8.19*
ICP- 54 × Arka Garima	17.65**	1.82	1.08	-8.21*
ICP- 54 × Indira Hari	21.50**	4.29	5.42	-8.22*
ICP- 54 × Khalleshwari	30.64**	-1.27	40.43**	-8.23*

by ICP-26 × Indira Hari (9.82%) and ICP-38 × Arka Garima (9.09%). Standard heterosis is the useful heterosis which is found better over the check variety. The standard heterosis ranged from 0.01 to 40.43%. Among 24 crosses only seven crosses expressed significant positive standard heterosis for this trait. The highest significant positive standard heterosis was observed for ICP-54 × Khalleshwari (40.43%) followed by ICP-26 × Khalleshwari (39.35%), ICP-49 × Khalleshwari (38.99%), ICP-45 × Khalleshwari (38.63%), ICP-42 × Khalleshwari (33.57%) and ICP-38 × Khalleshwari (28.88%) for protein content. Mak and Yap (8) and Lodhi *et al.* (7) also observed negative to positive heterosis for protein content in crosses studied by them.

The magnitude of inbreeding depression in segregating population of all 24 crosses was very important for selection of superior genotypes (Table 3). The inbreeding depression ranged from -9.06 to 4.15%. Nineteen crosses expressed significant negative inbreeding depression for protein content among all 24 F_2 populations. The lowest inbreeding depression was recorded in ICP-26 × Khalleshwari (4.15%) followed by ICP-45 × Khalleshwari (-7.55%), whereas, highest inbreeding depression was observed for ICP-26 × Indira Hari (-9.09%).

The variance between crosses was partitioned in to different components, representing the main effects of lines, testers and their interactions. The lines (females), testers (males) and interactions (line × tester) were significant. The estimates of general combining ability (gca) variances were significant due to lines and testers and specific combining ability (sca) due to crosses. The estimates of GCA of parents and SCA of crosses for percent protein content in green pods are given in Table 2. Among the parents only one line ICP-26 (0.19) and one testers Khalleshwari (0.65) showed significant positive gca effects, whereas, rest of the three testers had significant negative gca effects. Both ICP-26 and Khalleshwari were recognised as best general combiner for this trait. Among the crosses ICP-38 × Arka Garima (0.18) and

ICP-54 × Khalleshwari (0.13) had significant positive sca effects whereas cross ICP-38 × Khalleshwari showed significant negative sca effect. Both parental and maternal genomes influenced the protein content in legumes (Pereira *et al*., 11). It revealed that to incorporate another/few more lines and testers to improve this trait up to the level of desirability of the trait or the traits showing level of satisfaction. These findings are similar to the reports of Emebiri (3), and Patel *et al.* (9).

The ratio of gca to sca variance was more than unity for this trait but very close to one, which indicates predominance of additive gene action, but it was also influenced by non-additive component. This result is in accordance with the findings of Sandhu *et al.* (12) and Patel *et al.* (9). Additive and dominance action was reported by Mak and Yap (8), and Biradar *et al.* (1). Contrary to this only non-additive gene action was reported by Ponmariamma and Das (10).

The cross ICP-26 × Indira Hari had high heterosis as well as highest inbreeding depression. ICP-26 × Khalleshwari had significant heterosis along with lowest inbreeding depression was useful but its green pod yield was lower than its parents and standard check Pusa Komal. Therefore, it can be again crossed with suitable genotype for improving green pod yield. In fact high yielder genotypes among parents and crosses were poor combiner for protein which may be due to marked negative association between them as reported by earlier workers (Bliss *et al*., 2; Pereira *et al*., 11). The crosses involving Khalleshwari (low green pod yielder) as one of the parent showed high magnitude of heterosis along with significant positive gca effect suggesting it can be used as the best donor for the improvement of protein level up to a certain level in vegetable cowpea. This situation imposes restriction on enhancement of protein content without concomitant loss in green pod yield, therefore necessitates some compromise in the breeding strategy (Hazra *et al*., 4).

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