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Heterosis for yield and yield related traits in red cowpea (*Vigna unguiculata* L. Walp)

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Abstract
The present investigation entitled "Heterosis for yield and yield related traits in red Cowpea (*Vigna unguiculata* (L.) Walp)." was carried out to assess the heterosis for phenological traits, yield and yield contributing characters and quality attributes. Experiments were conducted during 2019-20 and 2020-21 at Plant Biotechnology Centre and Education and Research Farm, Department of Agril. Botany, College of Agriculture, Dapoli. The experimental material comprised of 32 genotypes including three check varieties *viz.,* Phule Pandhari, Konkan Sadabahar and Konkan Safed. The fifteen F_1s were obtained by crossing eight genotypically different parents in line x tester design (5 lines and 3 testers) during *Rabi* 2020-21 in randomized block design for a total 16 traits namely, Days to initiation of flowering (DIF), Days to 50% flowering (DFF), Days to maturity (DM), Plant height (PH), No. of primary branches per plant (PBPP), No. of clusters per plant (CPP), No. of pods per plant (PPP), Pod length (PL), No. of grains per pod (GPP), Test weight (TW), Biological yield per plant (BYPP), Grain yield per plant (GYPP), Harvest index (HI), Protein- Seed protein content and Seed Iron content. The lines 4-40-1 and GC 8910 while a tester CD 209 were found to be the superior parents. The crosses TC 210 82 x IC 25 90 69, 4-40-1 x IC 25 9104, TC 210 82 x CD 209, KBC-WS-1 x CD 209 and KBC-WS-1 x IC 25 90 69 were observed to be promising.

Keywords: Red cowpea, heterosis, heterobeltiosis, standard heterosis

Introduction
Cowpea (*Vigna unguiculata* (L.) Walp. (2n=22) is an early, multipurpose and the most widely adapted, versatile and nutritious grain legume crop; belongs to family Leguminosae. It is commonly known as 'vegetable meat' due to its high protein (20-25%) and is multi-utility, drought toleranance, nitrogen fixing crop makes it to be a prominent grain legume (Deepa Priya *et al.*, 2018) [3].
Most of the crop improvement programmes attempted through conventional breeding methods that exploited only the natural variability available in the germplasm (Kumar V. A. *et al.*, 2010) [7]. The ability to accumulate the variability by recombination and isolation of desired genotypes from segregating population hold the key to success of any crop improvement programme. (Kurer *et al.*, 2010) [7].
Identification of the best performing lines (for commercial release) and lines which can be used as parents in future crosses are two principal objects considered in most crop breeding programs. The best performing lines for required characteristics are selected based on conducting multi-environment trials following statistical analysis (Fasahat *et al.*, 2016) [4].

Material and Methods
The present investigation entitled "Heterosis for yield and yield related traits in red Cowpea (*Vigna unguiculata* (L.) Walp)." was carried out to assess the heterosis in red cowpea for phenological traits, yield and yield contributing characters and quality attributes. Experiments were conducted during 2019-20 and 2020-21 at Plant Biotechnology Centre and Education and Research Farm, Department of Agril. Botany, College of Agriculture, Dapoli.
The experimental material comprised of 32 genotypes including three check varieties *viz.,* Phule Pandhari, Konkan Sadabahar and Konkan Safed. The fifteen F_1s were obtained by crossing eight genotypically different parents in line x tester design (5 lines and 3 testers) during *Rabi* 2020-21. The genotypes were selected on the basis of genetic diversity estimated using ISSR markers. The genotypes investigated were obtained from Agricultural Research Station, Pandharpur (MS), NBPGR, New Delhi and from local farmers.

Results and Discussion

The importance of heterosis in plant breeding has been proven in the past. It is a phenomenon of immense practical utility and has a considerable role in improvement of several crop plants. The aim of heterosis is to find out the best combination of parents giving a high degree of heterosis so as to obtain better sergeants.

In order to identify the true heterotic cross combinations, the heterotic response over check and better parent can be desirable (Patel, 2003) [11]. High degree of heterosis in some crosses and low in other reveals the nature of varied gene action and the genetic makeup of the parents. It is better to measure the heterosis in terms of superiority over the better parent rather than the mid-parent.

Keeping in view the above said fact, the hybrids superior over better parents would be of prime importance in further breeding programme. The parents and hybrids in the study were observed for a total of sixteen characters which are broadly classified as phenological, yield and quality contributing characters.

On the basis of mean performance of lines testers, checks and hybrids for the different characters under study, it is revealed that none of these categories of breeding material showed consistently superior performance for all the characters. However, out of the total 16 traits for phenological, direct or indirect growth yielding contribution and quality characters based on the mean performance of grain yield per plant and other yield related traits, the lines 4-40-1 and GC 8910 while a tester CD 209 were found to be the superior parents (Table 1).

The mean performance of the Fifteen crosses during the present investigation revealed that the most promising hybrid was TC 210 82 x IC 25 90 69 followed by 4-40-1 x IC 25 9104, TC 210 82 x CD 209, KBC-WS-1 x CD 209 and GC 8910 x IC 25 90 69 for grain yield per plant and other yield contributing traits (Table 2).

Promising hybrids for various characters with significant heterobeltiosis and standard heterosis in red cowpea over the standard checks Phule Pandhari (SC1), Konkan Sadabahar (SC 2) and Konkan Safed (SC 3) is mentioned in Table 3. The effect of crosses on the various characters is discussed:

Phenological characters

As regards the days to initiation of flowering is concerned, five hybrids exhibited significant negative heterobeltiosis whereas no hybrid yielded desirable economic heterosis over checks Konkan Sadabahar and Konkan Safed. Eight hybrids showed negative significant economic heterosis over Phule Pandhari (SC1). Negative significant heterobeltiosis was seen in six hybrids for days to 50% flowering and in four hybrids for days to maturity.

Eleven and eight hybrids showed earlier initiation of flowering as well as lesser days to 50% flowering respectively than better parent whereas eight hybrids showed earlier initiation of flowering and days to 50% flowering than two checks *viz.,* Phule Pandhari and Konkan Safed. For the trait days to maturity; four hybrids found desirably significant heterosis over mid parent and better parent while two hybrids over check Konkan Safed (SC3) respectively. These results are in consonance with that obtained by Shashibhushan and Chaudhari (2000) [18], Bhushana *et al.,* (2000) [1] for days to 50% flowering, Meena *et al.,* (2009) [8], and Raut *et al.,* (2017) [15] for days to 50% flowering and days to maturity, Ushakumari *et al.,* (2010) [19] for economic heterosis, and Pandey and Singh (2015) [10] and Varan *et al.,* (2017) [20] for better parent and economic heterosis for the traits days to first flowering and days to pod maturity.

Yield contributing characters

a. Characters indirectly contributing towards yield

For the trait plant height, the hybrid GC 8910 x IC 25 9104 showed desirable *i. e.* negative significant average heterosis (-48.68%), heterobeltiosis (-55.42%), standard heterosis over check Phule Pandhari (-38.81%) and negative standard heterosis over check Konkan Sadabahar (SC2) (-18.09) whereas other 3 and 4 hybrids showed desirable significant average heterosis and heterobeltiosis respectively for the trait plant height. Similar results were obtained for the trait plant height by Patil and Gosavi (2007) [13], Pandey and Singh (2015) [10] Raut *et al.,* (2017) [15] for mid parent, better parent and standard heterosis while by Chaudhari *et al.,* (2013) [2] for heterobeltiosis and Varan *et al.,* (2017) [20] for better parent and standard heterosis. However, even though plant breeders prefer dwarfness while planning the breeding strategy; surprisingly, the highest and significant magnitude of all types of heterosis for the trait plant height was found associated with the hybrids heterotic for trait grain yield per plant.

In case of the character number of primary branches per plant, the hybrid 4-40-1 x IC 25 9104 showed positive significant relative heterosis (170.06%), heterobeltiosis (129.27%), standard heterosis over three checks *viz.,* Phule Pandhari (SC1) (137.69%), Konkan Sadabahar (SC2) (80.41%) and Konkan Safed (SC3) (41.09%) while two hybrids *viz.,* 4-40-1 x IC 25 90 69 and KBC-WS-1 x IC 25 90 69 showed positive significant magnitude in all the kinds of heterosis except standard heterosis over SC3 and SC2 respectively. Considering the trait number of clusters per plant, the hybrids TC 210 82 x IC 25 90 69 and TC 210 82 x CD 209 showed the positively significant heterotic performance in case of relative heterosis (93.29%, 30.65%), heterobeltiosis (84.50%, 22.40%), standard heterosis over SC1 (52.82%, 16.04%), over SC2 (146.00%, 86.79%), and over SC3 (141.61%, 83.45%) respectively**.** In the present investigation, it has been observed that the hybrids heterotic for the trait number of clusters per plant showed significant positive magnitude for all kinds of heterosis for the trait grain yield per plant which is always a major breeding objective. For the trait number of pods per cluster, the hybrids GC 8910 x IC 25 90 69 and GC 8910 x CD 209 showed the highest as well as positive significant heterosis in terms of average heterosis (54.20%, 45.45%), heterobeltiosis (45.66%, 41.96%), standard heterosis over SC1 (61.24%, 57.15%), over SC2 (20.99%, 17.93%), and over SC3 (30.93%, 27.61%) respectively whereas the remaining hybrids showed the varying positive and negative significant performances in all categories of heterosis. The heterobeltiosis ranged from -1.44% (TC 210 82 x IC 25 90 69) to 45.66% (GC 8910 x IC 25 90 69). These results were in conformity with those obtained by Bhushana *et al.,* (2000) [1] for primary branches per plant for the traits branches per plant and number of clusters per plant, Raut *et al.,* (2017) [15] for number of branches per plant, Sharma *et al.,* (2010) [17] for number of branches per plant and pods per cluster in case of standard heterosis, Sarath and Reshma (2017) [16] for traits number of pods per plant, length of pod, seeds per pod Zaveri *et al.,* (1983) [21] for clusters per plant, Pethe *et al.,* (2017) [14] for clusters per plant for average heterosis, heterobeltiosis and standard heterosis over SC1 and SC2 and Get *et al.,* (2021) [5] for heterosis and heterobeltiosis in case of trait pods per cluster.

For the character number of pods per plant, the hybrid TC 210 82 x IC 25 90 69 recorded the highest positive significant average heterosis (108.37%), heterobeltiosis (99.30%), standard heterosis over SC1 (46.15%), over SC2 (81.41%) and over SC3 (66.62%) followed by TC 210 82 x CD 209 which exhibited average heterosis (65.66%), heterobeltiosis (36.51%), standard heterosis over SC1 (41.03%), over SC2 (75.05%) and over SC3 (60.77%). The magnitude of heterobeltiosis and standard heterosis over SC1, SC2 and SC3 ranged from -72.66%, 59.49%, -49.71% and -53.81% (4-40-1 x IC 25 90 69) to 99.30%, 46.15%, 81.41% and 66.62% (TC 210 82 x IC 25 90 69) respectively. These findings were supported by Bhushana *et al.,* (2000) [1] for mid and better parent heterosis, Shashibhushan and Chaudhari (2000) [18], Patel (200***3***) [11], Patil *et al.,* (2007) Pandey and Singh (2015) [10] for mid parent, better parent and standard heterosis, Zaveri *et al.,* (1983) [21] and Varan *et al.,* (2017) [20] for better parent and standard heterosis, Sharma *et al.,* (2010) [17] and Pallavi *et al.,* (2020) [9] for standard heterosis, Patil *et al.,* (2005), Sarath and Reshma (2017) [16] for heterobeltiosis and Get *et al.,* (2021) [5] for mid and better parent heterosis for the trait number of pods per plant.

Two hybrids showed positive heterobeltiosis whereas none of them was observed to be positively significant for the trait pod length. Five hybrids exhibited significant positive standard heterosis over SC1 and SC3 and nine hybrids over SC2. Hybrid GC 8910 x CD 209 showed the highest magnitude of standard heterosis over three checks SC1 (39.26%), SC2 (50.93%) and SC3 (36.12%) for trait pod length. These results were supported by Meena *et al.,* (2009) [8], Ushakumari *et al.,* (2010) [19] and Pethe *et al.,* (2017) [14] for better and standard parent heterosis, Sharma *et al.,* (2010) [17] and Pandey and Singh (2015) [10] for standard parent heterosis while Patil *et al.,* (2005) and Sarath and Reshma (2017) [16] for heterobeltiosis.

In case of the trait number of grains per pod, four hybrids manifested positive heterobeltiosis while none of the hybrids exhibited positively significant performance for heterobeltiosis. Considering standard checks, 12 hybrids over SC1 and 15 hybrids over SC2 and SC3 expressed positive significant magnitude of standard heterosis for the trait number of grains per pod. The highest positive performance (33.70%, 61.49% and 76.14%) regarding standard heterosis was shown by the hybrid TC 210 82 x IC 25 9104 over three checks SC1, SC2 and SC3 respectively. These results showed conformity with those obtained by (Patel, 200***3***) [11], Sharma *et al.,* (2010) [17] for standard heterosis, Patil *et al.,* (2005), Ushakumari *et al.,* (2010) [19] and Chaudhari *et al.,* (2013) [2] for better parent heterosis. These findings were supported by Patil and Gosavi (2007) [13] Pandey and Singh (2015) [10] for mid parent, better parent and standard heterosis, Pallavi *et al.,* (2020) [9] for standard heterosis, Sarath and Reshma (2017) [16] for heterobeltiosis and Get *et al.,* (2021) [5] for mid and better parent heterosis for the trait number of seeds per pod.

Six hybrids manifested positive significant heterobeltiosis and one hybrid found to be heterotic over check SC1 and SC3 while four hybrids over check SC2 respectively for the trait test weight. The magnitude of heterosis was deviated from -38.34%, -50.08%, -39.63% and -46.54% (4-40-1 x CD 209) to 46.59%, 24.16%, 50.14% and 32.97% (GC 8910 x CD 209) for heterobeltiosis and standard heterosis over three checks SC1, SC2 and SC3 respectively for the trait test weight. These findings were in agreement with Bhushana *et al.,* (2000) [1] for mid and better parent heterosis, Shashibhushan and Chaudhari (2000) [18], Patil *et al.,* (2007) for mid parent, better parent and standard heterosis, Patil *et al.,* (2005), Chaudhari *et al.,* (2013) [2] and Sarath and Reshma (2017) [16] for heterobeltiosis, Varan *et al.,* (2017) [20] for better parent and standard heterosis, Pallavi *et al.,* (2020) [9] for standard heterosis and Get *et al.,* (2021) [5] for mid and better parent heterosis.

For the trait biological yield per plant, the hybrid TC 210 82 x IC 25 90 69 was associated with the highest magnitude of heterobeltiosis (26.46%) as well as standard heterosis over three checks *viz.,* SC1 (21.60%), SC2 (126.12%) and SC3 (69.91%) respectively. In case of heterobeltiosis, three hybrids exhibited significant positive performance while 2, 15 and 14 hybrids showed significant positive standard heterosis over three checks *viz.,* SC1, SC2 and SC3 respectively. The extent of heterobeltiosis and standard heterosis over three checks SC1, SC2 and SC3 ranged from -41.56%, -38.13%, 15.05% and 13.55% (CP-210 x IC 25 90 69) to 26.46%, 21.60%, 126.12% and 69.91% (TC 210 82 x IC 25 90 69) respectively for the trait biological yield per plant. Similar results were reported by Pethe *et al.,* (2017) [14] for biological yield per plant for mid parent, better parent and standard heterosis over SC1 and SC2 while by Get *et al.,* (2021) [5] for the trait biomass for mid and better parent heterosis.

b. Characters directly contributing towards yield

In case of directly yield contributing characters like grain yield per plant and harvest index, 4 and 5 hybrids expressed positive significant heterobeltiosis respectively. However, 7 hybrids in case of grain yield per plant and 10 hybrids in case of harvest index exhibited highly significant mid parent heterosis. The economic heterosis for these two characters was significant in 5 hybrids over SC1 and 11 hybrids each over SC2 and SC3 for grain yield per plant.

For harvest index, 10 hybrids were significantly superior over mid parent whereas 5 hybrids showed positive significant performance over check SC1, four hybrids over SC2 and eleven hybrids over SC3. Hybrid TC 210 82 x IC 25 90 69 found superior showing highest positive significant heterobeltiosis (69.84% and 33.80%) as well as standard heterosis over three checks SC1 (44.56%, and 18.90%), SC2 (161.72% and 14.62%) and SC3 (132.60% and 37.05%) for the traits grain yield per plant and harvest index respectively.

These findings were in consonance with Shashibhushan and Chaudhari (2000) [18], Patel (200***3***) [11], Patil *et al.,* (2005), Patil *et al.,* (2007), Pandey and Singh (2015) [10], Raut *et al.,* (2017) [17] and Pethe *et al.,* (2017) [14] for mid parent, better parent and standard heterosis, Chaudhari *et al.,* (2013) [2] and Sarath and Reshma (2017) [16] for heterobeltiosis, Ushakumari *et al.,* (2010) [19] and Varan *et al.,* (2017) [20] for better parent and standard heterosis, Pallavi *et al.,* (2020) [9] for standard heterosis and Bhushana *et al.,* (2000) [1] and Get *et al.,* (2021) [5] for mid and better parent heterosis for the trait seed yield per plant. Similar finding were reported by Patel *et al.,* (2014) and Pethe *et al.,* (2017) [14] for the trait harvest index.

Quality characters

In the present experiment, two quality parameters in red cowpea (seed) are studied namely protein content and seed iron content. Three and two hybrids expressed highly significant positive heterobeltiosis for the protein and iron content respectively. Positive significant average heterosis observed in seven and three hybrids for the same two traits respectively whereas in seven and two hybrids for economic heterosis over SC1 and SC2 respectively. Standard heterosis observed to be significant and positive over SC1, SC2 and SC3 in two, three and two hybrids respectively for iron content. These results are in consonance with Bhushana *et al.*, (2000) [1], Patel (2003) [11], Patil *et al.*, (2007), Meena *et al.*, (2009) [8], Chaudhari *et al.*, (2013) [2], Pandey and Singh (2015) [10], Raut *et al.*, (2017) [15], Varan *et al*,. (2017) [20], Sarath and Reshma (2017) [16], Pallavi *et al.*, (2020) [9] and Get *et al.*, (2021) [5].

Table 1: Mean performance of eight parents (5 Lines and 3 Testers) three Checks for various phenological and growth contributing characters in red cowpea genotypes

Sr. No.	Parents	Days to initiation of flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of Primary branches per plant	No. of Clusters per plant CPP	No. of Pods per Cluster	No. of Pods per plant
	Lines								
L1	GC 8910	52.00	58.67	87.67	36.93	5.80	9.53	1.64	15.13
L2	TC 210 82	41.33	51.33	80.67	49.67	4.47	7.33	1.20	8.70
L3	KBC-WS-1	41.00	50.00	79.67	32.93	3.13	11.10	1.35	15.00
L4	4-40-1	44.00	52.67	82.33	48.53	2.23	11.01	1.74	19.27
L5	CP-210	38.67	46.33	77.00	51.37	3.67	11.09	1.46	16.20
	Mean	43.40	51.80	81.47	43.89	3.86	10.01	1.48	14.86
	Range	38.67-52.00	46.33-58.67	77.00-87.67	32.93-51.37	2.23-5.80	7.33-11.10	1.20-1.74	8.70-19.27
	Testers								
T1	CD 209	45.00	55.67	81.00	54.40	3.72	8.39	1.56	13.43
T2	IC 25 9104	45.33	56.67	81.33	50.10	3.20	10.89	1.86	20.53
T3	IC 25 90 69	56.00	61.00	86.33	27.07	2.87	6.67	1.46	9.53
	Mean	48.78	57.78	82.89	43.86	3.26	8.65	1.63	14.50
	Range	45.00-56.00	55.67-61.00	81.00-86.33	27.07-54.40	2.87-3.72	6.67-10.89	1.46-1.86	9.53-20.53
	Checks								
C1	Phule Pandhari	48.67	57.33	69.00	36.50	3.08	8.85	1.48	13.00
C2	Konkan Sadabhar	38.67	50.00	75.00	27.27	4.07	5.50	1.98	10.47
C3	Konkan Safed	43.00	56.33	79.67	21.73	5.20	5.60	1.82	11.40
	Mean	43.44	54.56	74.56	28.50	4.12	6.65	1.76	11.62
	Range	38.67-48.67	50.00-57.33	69.00-79.67	21.73-36.50	3.08-5.20	5.50-8.85	1.48-1.98	10.47-13.00

Table 1: Contd…

Sr. No.	Parents	Pod Length (cm)	No. of Grains per pod	Test Weight (g)	Biological yield per plant (g)	Grain Yield per plant (g)	Harvest Index (%)	Protein Content (%)	Iron content (ppm)
	Lines								
L1	GC 8910	19.98	16.84	10.98	56.10	28.00	50.16	16.63	58.50
L2	TC 210 82	16.30	17.80	12.75	45.55	19.72	43.48	16.63	39.00
L3	KBC-WS-1	14.50	15.23	10.06	50.71	22.98	45.30	13.13	33.50
L4	4-40-1	13.50	16.55	10.50	59.00	33.45	56.97	19.25	40.00
L5	CP-210	13.70	15.15	7.21	50.15	17.68	35.29	13.13	37.50
	Mean	15.60	16.31	10.30	52.30	24.37	46.24	15.75	41.70
	Range	13.50-19.98	15.15-17.80	7.21-12.75	45.55-59.00	17.68-33.45	35.29-56.97	13.13-19.25	33.50-58.50
	Testers								
T1	CD 209	16.40	17.35	10.10	51.69	23.52	45.49	18.38	35.00
T2	IC 25 9104	11.90	14.23	7.23	44.87	21.10	47.03	15.75	57.50
T3	IC 25 90 69	14.63	16.91	9.14	39.33	14.75	38.11	12.25	67.50
	Mean	14.31	16.17	8.82	45.29	19.79	43.55	15.46	53.33
	Range	11.90-16.40	14.23-17.35	7.23-10.10	39.33-51.69	14.75-23.52	38.11-47.03	12.25-18.38	35.00-67.50
	Checks								
C1	Phule Pandhari	13.55	13.75	12.97	47.37	23.17	48.93	14.00	54.50
C2	Konkan Sadabhar	12.50	11.38	10.72	25.47	12.80	50.74	18.38	45.50
C3	Konkan Safed	13.86	10.44	12.11	33.90	14.40	42.45	22.25	59.00
	Mean	13.30	11.86	11.93	35.58	16.79	47.37	18.21	53.00
	Range	12.50-13.86	10.44-13.75	10.72-12.97	25.47-47.37	12.80-23.17	42.45-50.74	14.00-22.25	45.50-59.00

Table 2: Mean performance of fifteen hybrids for phenological and growth contributing characters in red cowpea genotypes

Sr. No.	Hybrids	Days to initiation of flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of Primary branches per plant	No. of Clusters per plant	No. of Pods per Cluster	No. of Pods per plant
1	GC 8910 x CD 209	40.00	50.00	69.00	45.67	2.87	4.15	2.33	9.40
2	GC 8910 xIC 25 9104	40.00	50.33	69.67	22.33	2.50	7.48	1.71	13.33
3	GC 8910 xIC 25 90 69	42.00	51.00	85.00	37.40	4.40	5.67	2.39	13.47

4	TC 210 82 x CD 209	43.00	57.67	83.33	64.43	4.17	10.27	1.80	18.33
5	TC 210 82 x IC 25 9104	39.67	53.00	85.67	43.33	0.87	7.07	1.75	12.33
6	TC 210 82 x IC 25 90 69	40.67	54.00	86.67	127.07	1.67	13.53	1.44	19.00
7	KBC-WS-1 x CD 209	40.00	54.33	75.33	49.13	3.67	8.87	1.65	14.80
8	KBC-WS-1 x IC 25 9104	43.00	50.00	75.00	35.70	3.20	7.29	1.13	8.20
9	KBC-WS-1 x IC 25 90 69	49.33	59.00	74.33	40.27	4.00	7.53	1.61	12.00
10	4-40-1x CD 209	42.33	50.33	72.00	45.93	2.33	10.07	1.09	10.80
11	4-40-1 x IC 25 9104	47.00	60.33	82.33	75.93	7.33	9.07	1.75	16.00
12	4-40-1 x IC 25 90 69	60.00	65.00	81.33	44.60	5.40	4.73	1.19	5.27
13	CP-210 x CD 209	40.00	56.67	75.00	48.77	3.60	9.51	1.73	16.13
14	CP-210 x IC 25 9104	43.00	60.00	81.33	53.53	2.33	11.93	1.46	17.47
15	CP-210 IC 25 90 69	55.33	61.00	79.00	47.27	3.40	7.33	1.43	10.47
	Mean	44.36	55.51	78.33	52.09	3.45	8.30	1.63	13.13
	Range	39.67-60.00	50.00-65.00	69.00-86.67	22.37-127.07	0.87-7.33	4.15-13.53	1.13-2.39	5.27-19.00
	GM	45	54.91	79.31	42.09	3.67	8.4	1.63	13.53
	CV	7.87	7.24	6.81	7.5	8.94	6.74	7.72	6.87
	S.Em ±	2.03	2.32	3.11	2.03	0.19	0.33	0.07	0.53
	CD at 5%	5.76	6.6	8.83	5.76	0.53	0.94	0.2	1.52

Table 2: Contd…

Sr. No.	Hybrids	Pod Length (cm)	No. of Grains per pod	Test Weight (g)	Biological yield per plant (g)	Grain yield per plant (g)	Harvest Index (%)	Protein content (%)	Iron content (ppm)
1	GC 8910 x CD 209	18.87	16.66	16.10	50.33	25.22	50.19	19.25	40.50
2	GC 8910 x IC 25 9104	18.00	16.24	12.12	49.67	26.24	52.97	13.13	67.00
3	GC 8910 x IC 25 90 69	16.31	15.20	13.29	49.00	27.21	55.60	16.63	36.00
4	TC 210 82 x CD 209	13.80	18.07	9.34	52.03	30.93	59.32	13.33	39.00
5	TC 210 82 x IC 25 9104	14.50	18.38	10.05	45.73	22.78	49.96	22.75	39.50
6	TC 210 82 x IC 25 90 69	14.87	16.67	10.58	57.60	33.50	58.17	15.75	41.00
7	KBC-WS-1 x CD 209	16.07	16.10	11.73	48.85	27.92	57.02	18.38	68.50
8	KBC-WS-1 x IC 25 9104	14.10	15.20	10.06	41.47	12.54	30.24	13.13	28.00
9	KBC-WS-1 x IC 25 90 69	16.27	17.44	11.42	48.27	23.88	49.49	21.88	42.50
10	4-40-1 x CD 209	13.40	15.62	6.47	36.67	10.91	29.91	13.13	22.00
11	4-40-1 x IC 25 9104	14.73	16.08	12.71	56.68	32.79	57.78	14.00	53.50
12	4-40-1 x IC 25 90 69	14.63	16.58	10.92	46.20	9.53	20.70	14.00	38.00
13	CP-210 x CD 209	12.90	17.08	7.76	44.90	21.39	47.64	16.63	37.50
14	CP-210 x IC 25 9104	12.83	16.63	8.86	48.09	25.73	53.52	14.88	27.00
15	CP-210 x IC 25 90 69	12.87	15.27	7.10	29.31	11.36	38.94	14.88	33.00
	Mean	14.94	16.48	10.57	46.99	22.79	47.43	16.12	40.87
	Range	12.83-18.87	15.20-18.38	6.47-16.10	29.31-57.60	9.53-32.79	20.70-59.32	13.13-19.25	22.00-68.50
	GM	14.54	15.21	10.41	45.4	20.94	46.15	16.39	47.23
	CV	6.6	6.92	7.79	11.21	10.85	6.09	4.1	6.39
	S.Em ±	0.56	0.63	0.47	3.01	1.38	1.64	0.38	1.62
	CD at 5%	1.6	1.8	1.34	8.55	3.93	4.67	1.09	4.6
	Minimum	11.9	10.44	6.47	25.47	9.53	20.7	12.25	22
	Maximum	19.98	18.38	16.1	59	33.5	59.32	22.75	68.5

Table 3: Promising hybrids for various characters with significant heterobeltiosis and standard heterosis in red cowpea

Sr. No.	Hybrid	Mean Grain yield per plant (g)	Hetero-beltiosis (%)	Standard heterosis over SC1	Standard heterosis over SC2	Standard heterosis over SC3	Useful and significant component traits for			
							BP	SC1	SC2	SC3
1	TC 210 82 x IC 25 90 69	33.50	69.84	44.56	161.72	132.60	DIF, DFF, CPP, PPP, BYPP, GYPP, HI.	DIF, DFF, CPP, PPP, GPP, BYPP, GYPP, HI, Protein.	CPP, PPP, PL, GPP, BYPP, GYPP, HI.	DIF, DFF, CPP, PPP, GPP, BYPP, GYPP, HI.
2	4-40-1 x IC 25 9104	32.79	-1.18	41.52	156.22	127.72	PB, TW.	DIF, PB, PPC, PPP, GPP, BYPP, GYPP, HI.	PB, CPP, PPP, PL, GPP, TW, BYPP, GYPP, HI, Fe.	PB, CPP, PPP, GPP, BYPP, GYPP, HI.
3	TC 210 82 x CD 209	30.93	31.50	33.50	141.69	114.80	DIF, DFF, CPP, PPC, PPP, GYPP, HI.	DIF, PB, CPP, PPC, PPP, GPP, GYPP, HI.	CPP, PPP, GPP, BYPP, GYPP, HI.	CPP, PPP, GPP, BYPP, GYPP, HI.
4	KBC-WS-1 x CD	27.92	18.70	20.50	118.16	93.89	DIF, DFF, DM, PH, TW, GYPP,	DIF, DFF, PB, PPP, PL, GPP,	CPP, PPP, PL, GPP, BYPP,	

	209						HI, Fe.	GYPP, HI, Protein, Fe.	GYPP, HI, Fe.	
5	KBC-WS-1 x IC 25 90 69	23.88	3.9	3.05	86.57	65.81	DI, DFF, DM, PB, TW, Protein.	PB, PL, GPP, Protein.	DM, CPP, PL, GPP, BYPP, GYPP, Protein.	DM, CPP, PL, GPP, BYPP, GYPP, HI.

DIF- Days to initiation of flowering	PBPP-No. of Primary Branches per plant	PL - Pod length	GYPP- Grain yield per plant (g)
DFF- Days to 50% flowering	CPP- No. of Clusters per plant	GPP - No. of grains per pod	HI- Harvest Index (%)
DM-Days to maturity	PPC- No. of Pods per cluster	TW- Test weight (g)	Protein- Seed Protein content (%)
PH- Plant height (cm)	PPP- No. of Pods per plant	BYPP- Biological Yield per plant (g)	Fe- Seed Iron content (ppm)

Conclusion

It was observed in the present study that by and large the crosses exhibiting good performance over better parent were also better than mid parent. The crosses TC 210 82 x IC 25 90 69 and TC 210 82 x CD 209 proved to be better in grain yield per plant and harvest index while no cross showed consistency in the test weight, protein and iron content. Different crosses showed better performance for these characters. In most of the cases, heterosis in grain yield was associated with number of pods per plant.

There appears to be a definite trend in the expression of standard heterosis as hybrids TC 210 82 x IC 25 90 69, TC 210 82 x CD 209 and 4-40-1 x IC 25 9104 observed to be better in grain yield per plant and harvest index whereas TC 210 82 x IC 25 9104 and KBC-WS-1 x IC 25 90 69 found promising for protein content and KBC-WS-1 x CD 209 and GC 8910 x IC 25 9104 for Iron content.

The significant performance of almost all characters studied indicates that there is substantial extent of variability in the lines and testers which forms a broad base for crop improvement.

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