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Identification of promising hybrids through exploitation of heterosis in chickpea (*Cicer arietinum* L.)

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Abstract
The present studies was conducted at Sardar Vallabhbhai Patel University of Agriculture & Technology during the crop season 2014-15. It was concluded from nine diverse lines of chickpea (*Cicer arietinum* L.) with four broad genetic base testers were crossed in line x tester fashion and evaluated for ten quantitative characters. Analysis of variances revealed that variances due to lines x testers showed highly significant differences for all the characters indicating wide spectrum of variation among the genotypes. The present finding revealed that KGD-1161×Pusa-256 was promising cross combination for days to 50% flowering. Similarly, GNG-1581×WCG-3 was good cross combination for early maturity. The cross combination HK-4 x Pusa-256 was the best F_1s for harvest index, 100-grain weight and grain yield per plant, whereas GNG-1581 x Pusa-1103 was the best cross combination for number of primary branches per plant and biological yield per plant. The cross C-235 x Sadbhavana, ICC-4958 x WCG-3 and C-235 x Pusa-1103 recorded early for days to maturity. The crosses ICC-4958 x Pusa-1103, HK-4 x Pusa-256 and WCG-9550 x Sadbhavana were found to be most promising crosses among all the thirty six crosses studied.

Keywords: hybrids, chickpea, Agriculture & Technology.

Introduction
Chickpea (*Cicer arietinum* L.) is an integral part of an Indian agriculture since time immemorial, because of its intrinsic value in terms of higher protein content, carbohydrates, minerals, nitrogen fixing ability and indispensability as alternative crop for crop diversification. On the basis of cultivated area, chickpea ranks 19th among the crops, and is grown in 34 countries of the world. Area under pulses in India, Pakistan, Nepal, and Bangladesh covers about 90% of the world acreage. Chickpea, one of the major pulses crop cultivated and consumed in India. Chickpea is a major and cheap source of protein compared to animal protein. In India, Chickpea accounts for about 45% of total pulses produced in the country. Similar to the case of other pulses, India is the major producing country for Chickpea, contributing for over 75% of total production in the world. Chickpea is the third most important pulse crop, after dry bean and peas, produced in the world. The desi type Chickpea contribute to around 80% and the Kabuli type around 20% of the total production. India is the world leader in chickpea production followed by Pakistan and Turkey with about 7.17 mt in area of 8.19 mh with productivity 875.30 kg ha^{-1} in the year 2014-2015 (anonymous 2015) [1]. In Uttar Pradesh production is 475.45 tons and area 558 hectare. The major chickpea producing states are Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Karnataka. Madhya Pradesh is the single largest producer in the country, accounting for over 40% of total production. Rajasthan, Maharashtra, Uttar Pradesh and Andhra Pradesh contributed about 14%, 10%, 9% and 7%, respectively Jharkhand and Chhattisgarh are expanding their area and production of chickpea crop. Although slight increase in area and productivity has occurred at state as well as country level in past 3 decades, it is still very far from being satisfactory. One of the main reasons for low productivity is lack of high yielding chickpea varieties and adapted to different agronomic conditions, such as stress environments. Thus, there is urgent need of developing high yielding varieties, so that, this crop can fulfill its potential in combating the malnutrition prevalent in primarily vegetarian population of our country and develop the resistant varieties to rust, wilt, root-rot and various other biotic and abiotic stresses.
Hybridization is necessary to boost up the production and productivity of any crop with the main ambition of outcome of good qualitative and quantitative production through the

exploitation of heterosis by evolving high yielding varieties and hybrids which could perform better than existing one and face the challenges of increasing production. Development of potential genotypes provides a good avenue for quicker exploitation of both additive and non-additive genetic variances through such alterations. Combining ability analysis has widely been used in crop plants for identifying the superior parents for hybridization programme. The hybridization programme has led to the evolution of promising lines in chickpea, but a systematic approach to understand the genetic constitution of the various complex quantitative traits has not been followed strictly in the crop. Therefore, keeping this in mind the present investigation was carried out to estimate degree of heterosis. The exploitation of heterosis is one of the breeding strategies to enhance the productivity. Line x Tester analysis is an extension of top cross method in which several testers are used which provides the helpful information to identifying best heterotic crosses.

Materials and Methods

Present research was conducted at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut research farm ($29^0$4', N latitude and$77^0$42' E longitude a height of 237m above mean sea level) U.P., India. The parent material for the study consulted of nine lines and four testers. Crossing work was done during Rabi, 2014-15, resultant 36 F_1 and 13 parents were grown during Rabi 2015-16 in Randomized Block Design (RBD) and replicated thrice. Each 36 F_1s were planted in two meter long 2 row the parents were sown in three row. The rows were spaced 30cm apart and plant to plant was retained 10cm. All the standard agronomic and plant protection measures were use. The data was recorded on plant basis and plot basis, from each genotype in each replication on five randomly selected plants and there average value was computed for ten quantitative traits viz; plant height, number of primary branches per plant, number of pod per plant, number of seed per pod, biological yield per plant, grain yield per plant, harvest index and 100-grain weight in both the parents and F_1 generation except days to 50% flowering and days to maturity which were recorded on plot basis. Heterosis was calculated our mid parent and batter parent for seed yield and other yield contributing traits. Data in each experiment was subjected to analysis of variance given by Panse and Sukhatme (1969) [7] for testing of significance of treatments. The Heterosis analysis was worked out as per method suggested by Fonseca and Patterson, (1968) [2].

Results and Discussion

The mean sum of square from analysis of variance of ten chickpea traits are presented in (Table-1). It is the evident for the table that highly significant difference among chickpea genotypes, parents, parents vs crosses. Highly significant crosses among parent vs crosses indicated the present of considerable heterosis for all the studied traits. The significance differences could be attributed to genetically divers nature of female and male parents. The estimate of heterosis and heterobeltiosis for indicated chickpea traits are presented in (Table-2).

Negative heterosis is desirable for days to 50% flowering which enable the hybrid to mature as early as compared to their parent thereby enhancing the productivity day^{-1} $unit^{-1}$ area. Among the thirty six hybrids studied for this trait, heterosis was exhibited towards both positive as well as negative direction. Out of thirty six hybrids one or two F_1s showed negative (desired) heterosis over better parent. The top three hybrids exhibiting earliness were ICC-4958×WCG-3, KGD-1161×Pusa-256and C-235×Sadbhavana. Heterosis in positive as well as negative direction for days to 50% flowering have also been reported by Sarode *et al.* (2000) [8], Jeena *et al.* (2000) [5], Singh *et al.* (2000) [10], Kulkarni *et al.* (2004) [6]. Mostly breeders are interested in short duration varieties, therefore heterosis in negative direction is desirable for days to maturity. All hybrid showed negative and significant heterosis over better parents, among them top three hybrids exhibiting short duration were C-235×Sadbhavana (-7.06), Sadbhavana×KGD-1161 and Pusa-1103×C-235. Thirty hybrids showed significant negative heterosis over better parents. These finding are in concurrence with those of Singh *et al.* (2000) [10], Sarode *et al.* (2016) [9], Jeena *et al.* (2000) [5].

Heterosis in negative direction is also desirable for plant height in chickpea as it provides extra strength against lodging. The negative and significant heterosis leading to dwarfness was exhibited by sixteen over BP. Heterotic effects were observed with highest magnitude over the better parent in crosses viz., C-235×Pusa-1103, WCG-9550 × Pusa-1103 and DCP-92-3×Pusa-1103. The findings are in agreement with the result of Sarode *et al.* (2016) [9], Sarode *et al.* (2000) [8], Jeena *et al.* (2000) [5], Singh *et al.* (2000) [10], Kulkarni *et al.* (2004) [6].

Higher number of primary branches/plant contributes to higher grain yield. In the present study, hybrids showed the positive and significant heterosis over BP, respectively. The similar results are also reported by Sarode *et al.* (2000) [8], Jeena *et al.* (2000) [5], Singh *et al.* (2000) [10], Kulkarni *et al.* (2004) [6]. The hybrids showing highest magnitude of heterosis over better parent are ICC-4958×Pusa-1103, ICC-4958×Sadbhavana and RSG-963×Pusa-1103. Sarode *et al.* (2016) [9] also reported such range of heterosis for this trait.

Number of pod/plant with positive and significant heterosis may contribute to enhance the number of pod per plant, subsequently boost the grain yield per plant. Out of thirty six hybrids, twenty five showed positive heterosis with significant values over better parent, respectively. Heterotic effects were observed with highest magnitude over better parents in crosses viz., WCG-9550×WCG-3 WCG-9550×Sadbhavana and HK-4×Pusa-1103 The similar result also reported by Yamini *et al.* (2015) [11], Ghaffar *et al.* (2015) [4] and Gadekar *et al.* (2013) [3].

100-grain weight and number of seed/plant is an important yield-related trait which influences the yield decisively. Heterosis for 100-grain weight and number of seed/plant was both in positive as well as in negative direction in different crosses. Heterosis for grain yield, biological yield and harvest index over the better parents is of more practical utility, which were manifested in 30, 25 and 9 crosses, respectively. Top three hybrids exhibiting heterosis for grain yield, biological yield and harvest index over the better parents were ICC-4958×Pusa-1103 (76.42), HK-4×Pusa-256 (46.67) and WCG-9550×Sadbhavana. Ghaffar *et al.* (2015) [4] also reported high standard heterosis to the extent of 27 and 34% for grain yield during wet and dry seasons, respectively. The quantum of heterosis obtained in present study fully justifies the commercial exploitation of heterosis in chickpea as the yield advantage of 20-30% over best available better parent. It may encourage farmers to take up hybrid chickpea cultivation. The results obtained from present study indicated that the grain yield heterosis was mainly influenced by number of primary branches per plant, number of pod per plant, number of seed per pod, days of maturity, biological yield per plant, grain yield per plant, harvest index and100-grain weight. A wide range of variations in the expression of heterosis for grain yield was reported by many workers i.e. Sarode *et al.* (2000) [8], Jeena *et al.* (2000) [5], Singh *et al.* (2000) [10], Kulkarni *et al.* (2004) [6], Sarode *et al.* (2016) [9].

Table 1: Analysis of variance for L × T analysis for ten characters of chickpea

Source of variation	d.f.	Days of 50% flowering	Days of maturity	Plant height (cm)	No of primary branches/ plant	No of pod/plant	No of seed/pod	Biolo. yield / plant	Harvest index	100 grain weight (g)	Grain yield / plant
Blocks	2	3.86	1.76	0.51	0.08	1.00	0.01	2.68	34.74	4.74	2.27
Treatment	48	7.76**	41.07**	23.31**	1.65**	96.78**	0.13**	62.70**	96.25**	142.60**	22.40**
Parent	12	9.60**	46.14**	34.63**	1.89**	137.47**	0.10**	36.99**	137.13**	91.98**	13.97**
Parent vs. Crosses	1	36.89**	603.97**	76.12**	20.67**	1001.31**	1.29**	1583.55**	7.40	815.69**	379.73**
Crosses	35	6.29**	23.24**	17.92**	1.03**	56.99**	0.11**	28.07**	84.78**	140.72**	15.08**
Line	8	11.12**	54.29**	30.15**	2.00**	163.56**	0.06**	11.10**	162.08**	74.43**	13.67**
Tester	3	8.75**	32.44**	58.12**	1.42**	89.01**	0.25**	20.84**	65.29**	169.42**	18.06**
Line × Tester	1	0.02	22.06**	0.00	2.46**	74.15**	0.01	292.51**	153.08**	0.10	4.03**
Error	96	1.27	2.01	0.07	0.05	0.60	0.01	2.43	10.87	1.64	1.81

*, ** Significant at 5% and 1% levels, respectively

Table 2: Estimates of per cent heterosis based on mid parent (average heterosis) and better parent (heterobeltosis) of 36 chickpea genotypes for ten characters

S. No.	Genotypes	Days of 50% flowering		Plant height in (cm)		No of primary branches/plant		No of pod/plant		No of seed/pod	
		BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
1	ICC-4958×Sadbhavana	-2.68**	-1.86*	4.62**	7.80**	15.85**	16.74**	10.43**	11.97**	2.10**	14.07**
2	GNG-1581×Sadbhavana	-1.96	0.00	-4.57**	0.93**	1.37**	14.39**	-1.43*	17.97**	3.82**	9.24**
3	KGD-1161×Sadbhavana	-2.31**	-0.84	-2.40**	4.76**	9.92**	23.14**	7.63**	11.01**	-15.84**	-7.84**
4	C-235×Sadbhavana	-5.18**	-2.82**	0.64*	2.24**	6.12**	15.00**	11.44**	11.95**	8.78**	19.75**
5	RSG-963×Sadbhavana	-2.04*	-1.54	2.19**	4.99**	11.02**	16.26**	6.59**	13.87**	6.87**	13.82**
6	DCP-92-3×Sadbhavana	-2.31*	-0.84	5.30**	6.36**	11.02**	11.02**	-0.09	16.07**	-0.57**	6.33**
7	Vallabh Hara ×Sadbhavana	-1.70	-1.70*	-4.70**	3.49**	-0.69**	16.19**	3.68**	12.22**	8.78**	10.57**
8	HK-4×Sadbhavana	-2.00*	-1.01	-7.42**	0.96**	6.20**	8.64**	-4.94**	14.18**	-0.76**	17.91**
9	WCG-9550×Sadbhavana	-4.59**	-2.84**	0.21	1.68**	9.09**	14.59**	12.77**	14.09**	-6.49**	-1.51**
10	C-235× Pusa-256	-1.94*	-0.98	-6.71**	0.53*	2.50**	8.07**	6.13**	11.76**	25.00**	33.58**
11	HK-4×Pusa-256	0.00	0.50	0.38	3.28**	-1.16**	14.65**	-9.33**	13.08**	10.72**	13.00**
12	WCG-9550×Pusa-256	-0.66	-0.33	-2.65**	1.94**	6.16**	15.46**	10.23**	14.28**	1.27**	13.03**
13	Vallabh Hara×Pusa-256	-2.64**	-1.17	1.31**	3.77**	9.59**	13.24**	10.90**	14.68**	-20.12**	-7.96**
14	DCP-92-3×Pusa-256	-0.99	-0.99	-1.30**	3.80**	9.82**	24.91**	-4.33**	15.63**	14.69**	26.18**
15	RSG-963×Pusa-256	-2.97**	-1.01	-0.85*	2.56**	2.50**	21.30**	0.83	12.56**	11.96**	23.65**
16	KGD-1161× Pusa-256	-2.97**	-2.97**	3.91**	5.12**	3.72**	5.53**	10.08**	11.96**	4.39**	12.16**
17	GNG-1581×Pusa-256	-1.63	-1.15	3.06**	3.49**	-15.80**	6.20**	-6.60**	16.08**	-20.34**	-11.01**
18	ICC-4958×Pusa-256	0.00	0.66	4.11**	7.38**	9.82**	25.74**	8.86**	15.65**	16.43**	22.49**
19	ICC-4958×Pusa-1103	-1.33	-0.83	-1.22**	5.94**	16.21**	23.76**	4.96**	16.03**	30.19**	33.91**
20	RSG-963×Pusa-1103	-1.66	0.17	-5.10**	2.06**	11.91**	23.56**	11.30**	17.02**	7.39**	16.10**
21	C-235×Pusa-1103	-3.24**	-2.13*	-11.74**	-1.29**	6.12**	8.94**	1.33*	12.96**	14.49**	19.66**
22	DCP-92-3×Pusa-1103	-0.66	-0.50	-7.87**	0.68**	7.60**	13.77**	10.62**	15.41**	19.52**	28.69**
23	WCG-9550×Pusa-1103	-1.31	-0.82	-10.77**	-2.91**	11.91**	12.68**	12.12**	26.78**	-5.52**	3.25**
24	KGD-1161×Pusa-1103	-0.99	-0.83	1.13**	4.12**	2.34**	8.83**	-0.21	14.77**	1.62**	6.80**
25	Vallabh Hara×|Pusa-1103	-1.66	-0.34	0.44	2.13**	0.46	11.89**	-5.53**	13.33**	-11.24**	0.22
26	HK-4×PUSA-1103	0.00	0.33	3.34**	4.61**	3.30**	11.59**	12.74**	22.20**	23.27**	28.71**
27	GNG-1581×PUSA-1103	-2.94**	-2.30**	-2.05**	2.39**	11.91**	32.54**	11.89**	20.77**	13.35**	23.99**
28	GNG-1581×WCG-3	-0.98	-0.98	-3.20**	2.53**	-10.56**	13.77**	-8.90**	10.65**	5.04**	11.71**
29	KGD-1161× WCG-3	-0.33	0.16	-0.35	7.12**	7.34**	10.43**	9.36**	10.75**	7.65**	19.09**
30	C-235×WCG-3	-1.94*	-1.46	12.73**	14.34**	7.34**	14.40**	10.58**	13.14**	2.05**	13.49**
31	ICC-4958×WCG-3	-4.25**	-3.14**	2.70**	5.99**	10.91**	28.23**	10.58**	14.17**	-3.92**	8.42**
32	RSG-963×WCG-3	-3.27**	-0.84	2.83**	5.82**	-8.17**	9.69**	-1.66*	6.88**	11.94**	20.48**
33	DCP-92-3×WCG-3	-2.94**	-2.46**	4.47**	5.69**	9.72**	26.03**	-1.34*	16.41**	-1.49**	6.45**
34	Vallabh Hara×WCG-3	-1.96	0.00	-3.41**	5.04**	9.59*	11.99**	3.11**	9.69**	9.70**	12.75**
35	HK-4×WCG-3	-2.94**	-1.98**	-4.02**	4.82**	7.34**	25.70**	-7.45**	12.81**	13.81**	36.47**
36	WCG-9550×WCG-3	-2.29*	-2.13**	3.67**	5.36**	7.34**	17.96**	13.79**	14.58**	1.31**	7.85**
S. E. (Diff) (±)		0.95	0.88	0.22	0.18	0.19	0.17	0.66	0.58	0.07	0.05

Table 2: Estimates of per cent heterosis based on mid parent (average heterosis) and better parent (heterobeltosis) of 36 chickpea genotypes for ten characters

S.No.	Genotypes	Days of maturity		Biolo. yield/plant		Grain yield/plant		Harvest index		100 grain weight (g)	
		BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
1	ICC-4958×Sadbhavana	-4.99**	-3.28**	5.43**	9.12**	9.49**	28.80**	3.72	18.53**	-4.24**	13.25**
2	GNG-1581× Sadbhavana	-5.17**	-3.17**	8.60**	18.18**	21.67**	25.59**	-5.97*	5.21*	9.47**	29.23**
3	KGD-1161×Sadbhavana	-6.71**	-3.98**	18.91**	25.25**	25.71**	31.54**	4.47	5.03	-9.51**	11.92**
4	C-235×Sadbhavana	-7.06**	-3.96**	19.70**	22.60**	3.41*	13.59**	-13.72**	-7.24**	20.95**	29.39**
5	RSG-963×Sadbhavana	-2.59*	-1.74	9.39**	19.04**	-2.45	2.18	-33.74**	-24.84**	4.51**	31.88**
6	DCP-92-3×Sadbhavana	-5.38**	-3.49**	7.02**	16.46**	9.49**	17.32**	-1.57	0.25	15.90**	24.29**
7	Vallabh Hara×Sadbhavana	-5.14**	-2.95**	6.22**	13.92**	-0.65	9.39**	-6.47*	-3.77	1.70	9.24**
8	HK-4×Sadbhavana	-1.89	-0.53	2.26	9.67**	15.57**	27.90**	13.06**	17.11**	26.58**	61.16**
9	WCG-9550×Sadbhavana	-1.72	-1.72	-5.67**	3.42*	31.79**	34.03**	18.69**	28.20**	-0.73	9.04**
10	ICC-4958×Pusa-256	-3.29**	-2.79*	15.66**	16.90**	19.42**	34.33**	3.35	15.11**	7.51**	21.17**
11	GNG-1581×Pusa-256	-2.47*	-2.27	16.49**	23.96**	15.97**	25.80**	-12.39**	0.56	-10.05**	1.55
12	KGD-1161×Pusa-256	-4.07**	-3.48**	20.65**	24.17**	22.36**	23.14**	-4.02	-0.68	15.56**	23.74**
13	C-235×Pusa-256	-4.44**	-3.46**	26.48**	26.48**	10.41**	15.48**	-12.61**	-8.61**	-12.80**	18.99**
14	RSG-963×Pusa-256	-6.38**	-3.40**	18.16**	25.73**	2.38	12.61**	-35.64**	-25.14**	42.65**	48.95**
15	DCP-92-3×Pusa-256	-3.70**	-3.41**	4.84**	11.57**	8.16**	10.19**	-6.17*	-1.67	-9.84**	11.37**
16	HK-4×Pusa-256	-2.06	-1.14	1.51	6.42**	46.67**	54.63**	26.57**	27.37**	49.84**	54.64**
17	WCG-9550×Pusa-256	-4.94**	-2.74*	9.84**	17.77**	11.18**	15.16**	-12.73**	-3.19	-7.73	11.69**
18	Vallabh Hara×Pusa-256	-1.24	-1.24	0.68	5.54**	27.49**	33.68**	20.80**	20.87**	-28.47**	-11.75**
19	C-235×Pusa-1103	-6.45**	-3.93**	14.15**	16.92**	28.46**	34.25**	7.50**	14.99**	7.05**	39.34**
20	RSG-963×Pusa-1103	-4.68**	-3.24**	11.77**	21.63**	8.30**	28.77**	-28.00**	-8.33**	36.88**	40.52**
21	GNG-1581×Pusa-1103	-1.86	-0.42	21.28**	31.98**	25.48**	47.34**	-13.28**	9.14**	3.39**	9.48**
22	DCP-92-3×Pusa-1103	-5.38**	-4.09**	4.64**	13.87**	5.29**	12.88**	-15.82**	-2.17	-2.71	13.58**
23	HK-4×Pusa-1103	-3.77**	-3.06**	10.98**	19.02**	18.06**	22.40**	-7.65**	2.40	17.10**	21.65**
24	WCG-9550×Pusa-1103	-3.62**	-3.00**	2.26	12.11**	21.67**	37.02**	-2.31	19.34**	0.22	14.43**
25	KGD-1161×Pusa-1103	-5.69**	-3.53**	13.36**	19.41**	0.11	9.84**	-20.55**	-8.69**	8.51**	8.52**
26	ICC-4958×Pusa-1103	-4.57**	-3.47**	9.39**	13.22**	76.72**	82.80**	18.35**	18.50**	22.41**	29.37**
27	Vallabh Hara×Pusa-1103	-3.29**	-1.67	3.05*	10.52**	11.75**	16.49**	-6.22*	4.62	-3.44**	12.56**
28	ICC-4958×WCG-3	0.42	0.52	13.72**	23.16**	14.31**	39.69**	0.41	14.68**	2.19	21.58**
29	GNG-1581×WCG-3	-3.93**	-3.53**	-4.28**	8.73**	10.62**	12.32**	-9.18**	1.68	26.75**	50.55**
30	KGD-1161×WCG-3	-3.05**	-1.85	5.80**	16.52**	25.37**	37.11**	17.21**	17.92**	-9.27**	12.86**
31	C-235×WCG-3	-6.45**	-4.92**	6.52**	14.23**	12.46**	28.80**	5.30*	13.14**	36.01**	44.49**
32	RSG-963×WCG-3	-4.38**	-1.92	2.20	16.09**	0.02	0.02	-24.50**	-14.31**	-0.12	26.73**
33	DCP-92-3×WCG-3	-2.28*	-1.97	-3.56**	9.55**	-5.97**	5.18**	-6.29*	-4.49	1.88	10.01**
34	Vallabh Hara×WCG-3	-3.91**	-3.31**	-1.40	10.46**	-18.88**	-6.89**	-17.89**	-15.57**	-5.62**	2.07
35	HK-4×WCG-3	-3.33**	-3.03**	-3.56**	8.04**	6.93**	23.34**	10.54**	14.42**	18.68**	51.92**
36	WCG-9550×WCG-3	-3.13**	-1.48	-3.56**	10.32**	10.62**	17.75**	-2.47	5.42*	4.46**	15.52**
S. E. (Diff) (±)		1.26	1.28	1.30	1.51	1.15	1.22	2.78	2.55	1.08	0.98

*,** significant at P= 0.05 and 0.01, respectively

Table 3: Best three mid and better parents for yield of chickpea in Line x Tester analysis

Components	Best mid parent (*per se* performance)	Best better parent (*per se* performance)
Grain yield / plant	ICC-4958×Pusa-1103 HK-4×Pusa-256 ICC-4958×WCG-3	ICC-4958×Pusa-1103 HK-4×Pusa-256 WCG-9550×Sadbhavana

Conclusion

The cross combination HK-4 x Pusa-256 was the best F1s for harvest index, 100-grain weight and grain yield per plant, whereas GNG-1581 x Pusa-1103 was the best cross combination for number of primary branches per plant and biological yield per plant. The cross C-235 x Sadbhavana, ICC-4958 x WCG-3 and C-235 x Pusa-1103 recorded early for days to maturity. The crosses ICC-4958 x Pusa-1103, HK-4 x Pusa-256 and WCG-9550 x Sadbhavana were found to be most promising crosses among all the thirty six crosses studied.

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