IJTA © Serials Publications

National Academy of Agricultural Science (NAAS) Rating : 3. 03

Exploration of heterotic potential in GMS and CMS based hybrids of pigeonpea (*Cajanus cajan*(L.) Millsp.) for yield and physiological traits

Chithrameenal K. and S. Jebaraj*

Abstract: *An investigation was made by line x tester analysis using two GMS lines viz., IMS 1 and ms CO 5 and one CMS line GT288A with ten testers viz., VBN1, ICPL 83024, APK1, ICPL 83027, ICPL 86020, ICPL87, ICPL 90028, ICPL 91045, ICPL 84031 and ICPL 94032. The Per se performance, combining ability and heterotic vigour of the hybrids were estimated to evaluate their performance. The estimates of GCA and SCA variances indicated the predominance of non-additive gene action for all the characters studied including physiological traits. Based on per se performance and* gca *effects among the lines, the line ms CO 5 was found to be the best for seed yield and number of pods/plant and GT 288A was found to be superior for the physiological traits studied. Among the testers studied, ICPL 86020 had desirable per se and* gca *effects for the characters like number of pods/plant and nitrogen content in leaves apart from seed yield/plant. Based on per se,* sca *effects and standard heterosis, the hybrids ms CO5 x ICPL87 and ms CO5 x ICPL 91045 were identified to be superior for yield and physiological traits.*

Keywords: *pigeonpea, genetic male sterility, cytoplasmic male sterility, heterosis, yield, physiological traits.*

INTRODUCTION

Pigeonpea or redgram (*Cajanus cajan*(L.) Millsp.) is an important legume food crop grown primarily by small farmers in many semi-arid tropical regions of the World. It is an important crop as each and every part of pigeonpea plant provides subsistence economic return to the farmer. It is a low input crop that can be grown under wide range of environmental conditions. It is a protein rich low cost pulse that is feasible for the common people to fulfil their nutrient requirements.

The overall productivity is low in pigeonpea for several decades due to its long duration, thermoand photosensitive nature. Hence, intensive research and development are needed to change the scenario. In this present investigation, experiments were conducted with two GMS lines, one CMS line and 10 testers to assess the extent of heterosis in GMS and CMS based hybrids in 30 cross combinations and to develop a hybrid with high yield and promising physiological outputs.

MATERIAL AND METHODS

Heterosis and combining ability of important yield and physiological traits were studied for 30 synthesized pigeonpea hybrids along with their parents and checks. The experiments were conducted at Millet Breeding Station, Centre for Plant Breeding and Genetics (CPBG), Tamil Nadu Agricultural University, Coimbatore.

Three male sterile lines comprising oftwo GMS lines viz., IMS1 (*ms1ms1*) and ms CO 5 (*ms1ms1* with translucent anthers) and a CMS line GT288A with brown arrow-head shaped anthers were used as 'Lines' in the present study. Ten varieties/cultivars with duration range of 117 to 162 days were used as 'Testers'.

The source of the selected parental materials and their special attributes are furnished in Table 1.

Crosses were made between the three male sterile lines and ten testers in L x T fashion and 30 hybrids developed and studied.

Seven important biometric traits viz., days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of pods per plant, 100 seed weight and seed yield per plant and eight physiological traits viz., harvest index, total dry matter produced per plant and partitioning, leaf area, specific leaf weight, leaf chlorophyll content,

* Research Scholar, Department of Plant Biotechnology, CPMB&B, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu-641003, *E-mail: vk_chithu@yahoo.co.in*

photosynthetic rate, nitrate reductase activity in leaves and nitrogen content in leaves were recorded on five randomly selected plants in each row in each replication. The observations on harvest index, total dry matter produced per plant and partitioning and nitrogen content in leaves were taken at maturity. For the physiological traits viz., leaf area, specific leaf weight, leaf chlorophyll content, photosynthetic rate and nitrate reductase activity in leaves, observations were made using the fully expanded leaves at the axil having 50 per cent filled green pods. Since the female plants of GMS lines segregated for fertility and sterility, only the fertile plants within a row were selected at random for recording the observations. The combining ability analysis was carried out as per the method suggested by Kempthorne (1957). The mean values of each metric trait were used to estimate heterosis percentage by following the methods suggested by Turner (1953) and Fonseca and Patterson (1968).

RESULTS AND DISCUSSION

The analysis of variance for the characters studied indicated that the variances due to both parents and hybrids were highly significant for all the 15 traits. The variance due to lines was highly significant for all the yield components except days to maturity and 100 seed weight. This revealed the diverse nature of the selected lines owing to the inherent mechanism prevailing in these genotypes to contribute for variability among yield contributing traits. But in the case of physiological traits, no significant difference was noticed. The significance of line x tester interaction for all characters indicated that certain cross combinations were significantly superior over others.The combining ability variances for various characters are given in the Table 2.

The best parents based on per se performance and gca and the best hybrids based on mean performance, sca effects and standard heterosis are given in Table 3 and 4 respectively. These studies indicated that all the characters were largely under the influence of non-additive gene action as the SCA variance was higher than the GCA variance (Table 2). Therefore the parents of these hybrids could be effectively utilized for exploration of the heterotic potential through the breeding programme. This was in accordance with the reports by Reddy *et al.* (1979), Sidhu *et al.* (1979) and Jayamala and Rathnaswamy (2001).

Among the lines, IMS 1 was found to be a good general combiner for the characters viz., days to 50% flowering, days to maturity, plant height, harvest index, specific leaf weight, chlorophyll content in leaves, nitrate reductase activity in leaves, leaf nitrogen content and photosynthetic rate. This was in accordance with the results of Vanniarajan et al. (1999). The ms CO 5 had higher gca effects for the traits number of branches per plant, number of pods per plant, 100 seed weight, leaf area, dry matter production and seed yield per plant. This was in accordance with the reports of Patel (2007). GT 288A showed higher gca effects for the characters viz., chlorophyll content in leaves, nitrate reductase

Table 1
Source and Special features of the parents

S.N	*Code*	*Parents*	*Source*	*Special features*
1.	L_1	IMS 1	ICRISAT, Patancheru, Andhra Pradesh	Early, compact, determinate and yellow flower
2.	L_2	ms CO 5	TNAU, Coimbatore, Tamil Nadu	Early, compact, indeterminate and yellow flower
3.	L_3	GT 288A	Gujarat Agricultural University, S.K.Nagar, Gujarat	Medium, compact, indeterminate and yellow flower
		Testers		
1.	T_1	VBN 1	National Pulses Research Centre, Vamban, Tamil Nadu.	Early, compact, determinate and yellow flower
2.	T_2	ICPL 83024	ICRISAT, Patancheru, Andhra Pradesh	Early, compact, determinate and reddish yellow flower
3.	T_3	APK 1	Regional Research Station, Arupukottai, TNAU, Tamil Nadu	Early, compact, determinate and red flower
4.	T_4	ICPL 83027	ICRISAT, Patancheru, Andhra Pradesh	Early, compact, determinate and yellow flower
5.	T_5	ICPL 86020	ICRISAT, Patancheru, Andhra Pradesh	Early, compact, determinate and yellow flower
6.	T_6	ICPL 87	ICRISAT, Patancheru, Andhra Pradesh	Early, compact, determinate and yellow flower
7.	T_7	ICPL 90028	ICRISAT, Patancheru, Andhra Pradesh	Early, compact, determinate and yellow flower
8.	T_8	ICPL 91045	ICRISAT, Patancheru, Andhra Pradesh	Medium, compact, indeterminate and yellow flower
9.	T_9	ICPL 84031	ICRISAT, Patancheru, Andhra Pradesh	Early, compact, determinate and yellow flower
10.	T_{10}	ICPL 94032	ICRISAT, Patancheru, Andhra Pradesh	Early, compact, determinate and yellow flower

Table 2
Combining ability variance

Characters	*GCA variance*	*SCA variance*	*GCA/SCA*
Days to 50 % flowering	0.34	13.87	0.03:1
Days to maturity	3.47	331.05	01.01:1
Plant height	26.73	333.09	0.081:1
Number of branches per plant	0.03	1.67	0.02:1
Number of pods per plant	93.09	1946.01	0.05:1
100 seed weight	0.01	0.77	0.02:1
Harvest index	0.98	208.17	0.005:1
Specific leaf weight	0.0005	2.35	0.0002:1
Leaf chlorophyll content	1.42	155.78	0.0009:1
Leaf nitrate reductase activity	389.05	91305.65	0.004:1
Leaf area	7977.75	444708.82	0.02:1
Leaf nitrogen content	0.0006	0.08	0.008:1
Photosynthetic rate	0.25	40.57	0.0006:1
Dry matter production	39.27	1036.35	0.04:1
Seed yield per plant	12.27	252.18	0.05:1

activity in leaves, photosynthetic rate, dry matter production and seed yield per plant.

The testers ICPL 91045, APK 1, ICPL 84031 and ICPL 86020 were found to be good general combiners for yield component traits.The line IMS1 exhibited the highest mean performance for days to 50% flowering (negative direction), days to maturity (negative direction), harvest index, specific leaf weight, chlorophyll content of the leaf and leaf nitrogen content. In testers APK1 and ICPL 83024 showed higher mean performance for yield component traits. This was similar to the results got by Baskaran and Muthiah (2007).

The hybrids msCO5 x ICPL 91045, msCO5 x ICPL 83027 and msCO5 x ICPL 87 were found to be good specific combiners for yield and yield component traits. The hybrids viz., IMS1 x VBN1 and IMS1 x APK1 involving atleast one of the good combining parents for earliness could be utilized for exploiting earliness; msCO5 x ICPL 87 and msCO5 x ICPL 91045 registered higher per se performance for dry matter production and seed yield per plant.

The hybrid IMS1 x VBN1 showed significant standard heterosis for days to 50% flowering, days to maturity, plant height, 100 seed weight and nitrate activity in leaves; msCO5 x ICPL 91045 exhibited significant standard heterosis for leaf area, dry matter production and seed yield per plant.

From the above results msCO5 x ICPL 91045 was found to be a promising hybrid based on higher mean performance, positive SCA effect and positive heterosis over standard check (Table 4).

Since, all the 15 characters including the physiological traits exhibited non-additive gene action, effective hybridization programme could be done and hybrid vigour could be exploited commercially besides selections could also be made in further generations to improve the characters concerned.

CONCLUSION

Discovery of stable genetic male sterility and cytoplasmic male sterility, coupled with often-outcrossing nature of pigeonpea has opened the possibility for commercial utilization of heterosis in pigeonpea. Since all the 15 characters studied were found to have non-additive gene action, efforts can be made for utilizing the parents for further hybridisation and selection programmes. The potential hybrids chosen from the experiment can then be visualized as new ideotypes, since they are of short-duration, short-statured, determinate in growth habit and with desirable yield components and physiological traits.

REFERENCES

Baskaran K and Muthiah AR (2007), Studies on combining ability in pigeonpea(*Cajanus cajan* (L). Millsp.) Legume Res. 30(1): 67-69.

Fonseca S and Patterson FL (1968), Hybrid vigour in seven parent diallel cross in common wheat (*T. aestivum* L). Crop Sci. 2: 85-88.

Jayamala P and Rathnaswamy R (2001), Combining ability in pigeonpea. Madras Agric. J 87(7/9): 418-422.

Kempthorne D (1957), An Introduction to Genetic Statistics. John Wiley and Sons Inc., Newyork. pp. 157-158.

Patel MP (2007), Combining ability analysis to identify superior male sterile and pollinator lines in medium duration pigeonpea under rainfed conditions. Int J. of Bioscience Reporter. 5(1): 11-16.

Reddy RP, Vidhyasagar Rao K and Rao NGP (1979), Heterosis and combining ability in pigeonpea. Indian J. Genet. 39: 240-246.

Sidhu PS, Devinder Sandhu, Sekhon RS and Sarlach RS (2000), Combining ability studies involving male sterile lines in pigeonpea. J. of Res. Punjab Agricultural University 37 (1/2): 1-8.

Turner JH., JR (1953), A study of heterosis in upland cotton, II. Combining ability and inbreeding effects. Agron. J 45: 487-490.

Vanniarajan C, Rangasamy P, Ramalingam J and Nadarajan N, (1999), Genetic analysis of yield and important yield traits in hybrid pigeonpea. Crop Res. 18(1): 64-70.

Table 3
Best parents based on mean performance and *gca*

Characters	*Lines*		*Testers*		*Mean and gca*	
	Mean	*gca*	*Mean*	*gca*	*Lines*	*Testers*
Days to 50% flowering	IMS 1	IMS 1	ICPL 90028, APK 1,ICPL 83024	ICPL 84031,ICPL 83027, VBN 1	IMS 1	-
Days to maturity	IMS 1	IMS 1	APK 1, ICPL 87, ICPL 84031	VBN 1, ICPL 94032, APK 1	IMS 1	APK 1
Plant height	IMS 1	IMS 1	ICPL 84031, APK 1, ICPL 94032	ICPL 94032, VBN 1, ICPL 84031	IMS 1	ICPL 94032, ICPL 84031
No. of branches/plant	ms CO 5	ms CO 5	ICPL 90028, ICPL 94032, ICPL 83027	ICPL 83024, APK 1, ICPL 90028	ms CO 5	ICPL 90028
No. of pods/plant	ms CO 5	ms CO 5	ICPL 83027, ICPL 91045, ICPL 86020	ICPL 90028, ICPL 86020, ICPL 91045	ms CO 5	ICPL 86020, ICPL 91045
100-seed weight	GT 288A	ms CO 5	ICPL 90028, ICPL 87, ICPL 86020	ICPL 90028, VBN 1, ICPL 84031	GT 288A, ms CO 5	ICPL 90028
Harvest index	IMS 1	IMS 1	APK 1, ICPL 83024, ICPL 90028	ICPL 84032, VBN 1, ICPL 94032	IMS 1	-
Specific leaf weight	IMS 1	IMS 1	ICPL 83024, VBN 1, ICPL 90028	VBN 1, ICPL 90028, ICPL 83024	IMS 1	VBN 1, ICPL 90028, ICPL 83024
Chlorophyll content in leaves	IMS 1	GT 288A	ICPL 84031, VBN 1, ICPL 86020	ICPL 84031, ICPL 83027, APK 1	IMS 1, GT 288A	ICPL 84031
Nitrate reductase activity in leaves	GT 288A	IMS 1	ICPL 86020, ICPL 83027, APK 1	ICPL 91045, ICPL 86020, APK 1	IMS 1, GT 288A	-
Leaf area	ms CO 5	ms CO 5	ICPL 91045, ICPL 83027, APK 1	ICPL 91045, ICPL 86020, APK 1	ms CO 5	ICPL 91045, APK 1
Leaf nitrogen content	IMS 1	IMS 1, GT 288A	ICPL 86020, VBN 1, ICPL 83024	ICPL 86020, ICPL 87, ICPL 94032	IMS 1, GT 288A	ICPL 86020
Photosynthetic rate	GT 288A	IMS 1	ICPL 83024, ICPL 83027, APK 1	VBN 1, ICPL 86020, ICPL 94032	IMS 1, GT 288A	-
Dry matter production	GT 288A	ms CO 5	ICPL 83027, ICPL 91045, ICPL 83024	ICPL 90028, ICPL 86020, ICPL 91045	ms CO 5, GT 288A	ICPL 91045
Seed yield/plant	GT 288A	ms CO 5	ICPL 83027, ICPL 83024, ICPL 86020	ICPL 90028, ICPL 87, ICPL 86020	ms CO 5, GT 288A	ICPL 86020

Table 4
Best hybrids based on mean performance, *sca* and standard heterosis

Characters	*Mean*	*sca*	*Standard heterosis*	*Mean, sca and standard heterosis*
Days to 50% flowering	IMS 1 x ICPL 84031, IMS 1 x VBN 1, IMS 1 x APK 1, IMS 1 x ICPL 91045	IMS 1x ICPL 84031, ms CO 5 x ICPL 83027, IMS 1 x ICPL 91045	IMS 1 x ICPL 84031, IMS 1 x VBN 1, IMS 1 x APK 1, IMS 1 x ICPL 91045	IMS 1 x ICPL 84031, IMS 1 x ICPL 91045
Days to maturity	IMS 1 x ICPL 83024, IMS 1 x VBN 1, GT 288A x ICPL 86020	GT 288 A x ICPL 86020, ms CO 5 x ICPL 83027, GT 288A X ICPL 84031	IMS 1 x ICPL 83024, IMS 1 x VBN 1, GT 288 A x ICPL 86020	GT 288A x ICPL 86020
Plant height	IMS 1 x ICPL 94032, IMS 1 x VBN 1, IMS 1 x APK 1	GT 288A x ICPL 86020, ms CO 5 x ICPL 83027, IMS 1 x ICPL 91045	IMS 1 x ICPL 94032, IMS 1 x VBN 1, IMS 1 x APK 1	
No. of branches/plant	IMS 1 x ICPL 83024, ms CO 5 x APK 1, IMS 1 x ICPL 83027	IMS 1 x ICPL 83027, ms CO 5 x APK 1, ms CO 5 x ICPL 91045	IMS 1 x ICPL 83024, ms CO 5 x APK 1, IMS 1 x ICPL 83027	ms CO 5 x APK 1, IMS 1 x ICPL 83027
No. of pods/plant	ms CO 5 x ICPL 87, ms CO 5 x ICPL 91045, ms CO 5 x ICPL 86020	ms CO 5 x ICPL 87, GT 288A x ICPL 83027, ms CO 5 x ICPL 91045	ms CO 5 x ICPL 87, ms CO 5 x ICPL 91045, ms CO 5 x ICPL 86020,	ms CO 5 x ICPL 87, ms CO 5 x ICPL 91045
100-seed weight	IMS 1 x VBN 1, GT 288A x ICPL 90028, ms CO 5 x ICPL 84031	IMS 1 x VBN 1, GT 288A x ICPL 83027, ms CO 5 x ICPL 84031	IMS1 x VBN 1, GT 288A x ICPL 90028, ms CO 5 x ICPL 84031	IMS 1 x VBN 1, ms CO 5 x ICPL 84031
Harvest index	IMS 1 x ICPL 90028, GT 288A x ICPL 86020, GT 288A x ICPL 84031	GT 288A x ICPL 86020, IMS 1 x ICPL 90028, ms CO 5 x ICPL 83024	IMS 1 x ICPL 90028, GT 288A x ICPL 86020, GT 288A x ICPL 84031	IMS 1 x ICPL 90028, GT 288A x ICPL 86020
Specific leaf weight	IMS 1 x ICPL 90028, IMS 1 x APK 1, ms CO 5 x VBN 1	IMS 1 x APK 1, IMS 1 x ICPL 90028, GT 288A x ICPL 84031	IMS 1 x ICPL 90028, IMS 1 x APK 1, ms CO 5 x VBN 1	IMS 1 x APK 1, IMS 1 x ICPL 90028
Chlorophyll content in leaves	ms CO 5 x ICPL 84031, GT 288A x APK 1, GT 288A x ICPL 90028	GT 288A x ICPL 90028, GT 288A x APK 1, GT 288A x ICPL 83024	ms CO 5 x ICPL 84031, GT 288A x APK 1, GT 288A x ICPL 90028	GT 288A x APK 1, GT 288A x ICPL 90028
Nitrate reductase activity in leaves	IMS 1 x ICPL 83027, IMS 1 x APK 1, IMS 1 x VBN 1, IMS 1 x ICPL 91045	IMS 1 x ICPL 91045, ms CO 5 x ICPL 86020, GT 288A x ICPL 87	IMS 1 x ICPL 83027, IMS 1 x APK 1, IMS 1 x VBN 1, IMS 1 x ICPL 91045	IMS 1 x ICPL 91045
Leaf area	ms CO 5 x ICPL 91045, IMS 1 x ICPL 83027, ms CO 5 x ICPL 90028	IMS 1 x ICPL 83027, ms CO 5 x ICPL 91045, ms CO 5 x ICPL 90028	ms CO 5 x ICPL 91045, IMS 1 x ICPL 83027, ms CO 5 x ICPL 90028	IMS 1 x ICPL 83027, ms CO 5 x ICPL 91045, ms CO 5 x ICPL 90028
Leaf nitrogen content	IMS 1 x ICPL 86020, GT 288A x ICPL 87, IMS 1 x ICPL 83027	IMS 1 x ICPL 86020, ms CO 5 x ICPL 94032, ms CO 5 x ICPL 91045	IMS 1 x ICPL 86020, GT 288A x ICPL 87, IMS 1 x ICPL 83027	IMS 1 x ICPL 86020
Photosynthetic rate	GT 288A x VBN 1, IMS 1 x ICPL 94032, IMS 1 x ICPL 87	GT 288A x VBN 1, ms CO 5 x ICPL 91045, IMS 1 x ICPL 87	GT 288A x VBN 1, IMS 1 x ICPL 94032, IMS 1 x ICPL 87	GT 288A x VBN 1, IMS 1 x ICPL 87
Dry matter production	ms CO 5 x ICPL 90028, ms CO 5 x ICPL 91045, ms CO 5 x ICPL 87,	IMS 1 x ICPL 86020, ms CO 5 x ICPL 91045, ms CO 5 x ICPL 87	ms CO 5 x ICPL 90028, ms CO 5 x ICPL 91045, ms CO 5 x ICPL 87	ms CO 5 x ICPL 90028, ms CO 5 x ICPL 91045
Seed yield/plant	ms CO 5 x ICPL 87, ms CO 5 x ICPL 90028, ms CO 5 x ICPL 91045	ms CO 5 x ICPL 87, GT 288A x ICPL 83027, ms CO 5 x ICPL 91045	ms CO 5 x ICPL 87, ms CO 5 x ICPL 90028, ms CO 5 x ICPL 91045,	ms CO 5 x ICPL 87, ms CO 5 x ICPL 91045