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Study of CGMS based pigeonpea [*Cajanus cajan* (L.) Millsp] hybrids in terms of combining ability

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Abstract
To ascertain combining ability 24 hybrids were made from 10 parents in a line × testes mating design, during kharif 2023 and tested in a Randomized Block Design with two Replication during kharif 2024. Analysis of variance for quantitative traits, revealed that all characters were significantly different and a wide range of variability exists for most of the traits studied. The hybrids BDN2004-1A × BDNHR 31-25-1, BDN2004-3A × BDNHR-250157, BDN2004-1A × BDNHR 31-14-2 and BSMR 736A × BDNHR 24-1-1. were good specific combiners for seed yield/plant and BDN2013-41A× BDNHR24-1-1, BSMR736 × BDNHR24-1-1for50percent flowering, BSMR736A× BDNHR 250157, BSMR736A×BDNHR-36-1-1, BDN2004-1A ×BDNHR31-25-1 for days to maturity, BSMR736A× BDNHR31-25-1, BDN2004-1 BDNHR250157 for plant height, BDN2004-1A× BDNHR250157, BDN2004-1A× BDNHR24-1-1 for number of primary branches, BDN2004-× BDNHR24-1-1, BSMR736A× BDNHR-250157 for number of secondary branches, BDN2004-1A × BDNHR36-1-1, BDN2004-1A× BDNHR31-14-2 for number of pods/plant. The results also revealed that some crosses exihibited high order significant & desirable SCA effects for different characters involved parentsBDNHR24-1-1, BDNHR-250157, BDN2004-3A, BDN2013-41A for 50 per flowering, BDNHR36-1-1, BDNHR-250157for days to maturity, BSMR736A, BDNHR 31-25-1 for number of primary branches, BDN2004-1A, BDNHR24-1-1 for number of secondary branches, BDN2004-3A for number of pods/plant, BSMR736, BDNHR-250157 for number of seeds/plant, BDN2004-3A, BDNHR 24-1-1for 100 seed weight, BDN2004-1A, BDNHR 24-1-1 for seed yeild having GCA effect.

Keywords: Pigeonpea, general combining ability, specific combining ability and CGMS

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] holds the position as India's second-most important pulse crop, right after chickpea. It is often referred to as *Arhar*, Red gram, or *Tur*. This crop is a valuable source of plant-based protein, particularly in developing nations where a large segment of the population relies on affordable vegetarian meals. In addition to being a significant protein source, pigeonpea also provides carbohydrates, vitamins, lipids, and several minerals. It has multiple uses, including as food, feed for animals, fodder, and fuel. Breeding of pigeonpea has proven to be more difficult compared to other legumes due to unique crop characteristics and high sensitivity to biotic and abiotic stresses.

Worldwide, pigeonpea is grown on approximately 4.23 million hectares and produce 4.68 million tons with a productivity of 751 kg/ha. India stands at 5th position in productivity with 776 kg per hectare. India is the largest producer of Red gram in the world, produces 4.34 million tonnes from an area of 5.05 million hectares, with a productivity of 859 kg/ha during 2023-24. The major pigeonpea cultivating states are Maharashtra (1.111 million hectares), Uttar Pradesh (0.35 million hectares). In India, Uttar Pradesh is the leading producer, with 0.47 million tonnes from 0.49 million hectares and a productivity of 944 kg/ha, In India, the area under pigeonpea cultivation reported during 2023-24 was 40.42 lakh hectares. (ANGRAU Red gram Outlook Report-June to May 2023-24).

Pigeonpea serve as a critical source of protein supplements for most vegetarians in India. With its high protein content of 24.6. percent, along with 1.6 percent fat, 3.5 percent minerals, 1.2 percent fiber, 57.6 g of carbohydrates, 73mg of calcium, and 0.5mg of iron per 100g, pigeonpea provides a nutritious source of food (Saxena *et al.* 2010) [13]. Therefore, plant breeders must prioritize the development of high-yielding pigeonpea hybrids to meet the increasing demand for protein among the population while also ensuring these hybrids can withstand a range of climatic conditions. The present study was therefore planned, initiated and executed in pigeonpea to examine the combining ability studies in CGMS based hybrids of pigeonpea [*Cajanus cajan* (L.) Millsp.]

Materials and Methodology

Experimental Material

The present investigation was carried out at Experimental Farm, Agricultural Research Station, Badnapur (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani) during *Kharif* 2023 and Summer 2024. The experimental material consists of four male sterile lines (BDN-2004-1A, BDN-2004-3A, BDN-2013-41A and BSMR-736A) and six restorers (BDNHR 24-1-1, BDNHR 31-25-1, BDNHR 31-49-1, BDNHR 31-14-2, BDNHR 36-1-1 and BDNHR 250157). These four male sterile lines and six restorers were crossed in Line × Tester mating system and produced twenty-four hybrid combination during *kharif* 2023-24. The experimental material includes total 36 entries comprising twenty-four hybrids, four male sterile lines and six restorers along with two checks BDN 716 and Renuka was evaluated during *Kharif* 2024 at the Experimental field of Agricultural Research Station, Badnapur.

Results and Discussions

The analysis of variance (Table-1) revealed highly significant differences among the parents and hybrids for most of the yield traits indicating large parental diversity. The mean squires due to lines × tester interactions were found to be highly significant for number of secondary branches/plant, number of pod/plant, number of seed/pod, 100 seed weight (gm), grain yield/plant (gm) and non-significant for other characters. Variances due to lines were only significant for 100 seed weight.

Combing ability

Combing ability analysis is an essential step for identifying lines possessing a built-in genetic potential or superior performance in hybrid combination. Combining ability is the relative ability of genotype to transmit desirable performance to its crosses.

The results obtained in General Combining Ability effect. (Table 2) indicated that among the lines BDN 2004-1A was good general combiners for the character no. of secondary branches/no of seeds/pods, 100 seed weight and seed yield followed BDN 2004-3 for Days to 50% flowering, Days to maturity, No of secondary branches/plant, 100 Seed weight and No of pods/plant followed by BDN 2013-41 for Days to 50% flowering and Days to maturity, BSMR736 for No of Seeds/pod. while, among testers, BDNHR 24-1-1, BDNHR-250157, BDN2004-3A, BDN2013-41A was shown to be a good general combiner for the character days to 50% flowering, BDNHR 36-1-1, BDNHR 250157, BDN2004-3A, BDN2013-41A for days to maturity, BSMR736, BDNHR31-25-1 primary branchs, BDN 2004-1A, BDNHR 24-1-1 number of secondary branches, BDN2004-3A number of pods/plant, BSMR736, BDN2004-1A, BDNHR 31-49-1, BDNHR 250157, BDNHR 31-14-2 for number of seeds/pod, BDN2004-3A, BDNHR24-1-1, BDNHR31-25-1 for 100 seed weight, BDNHR 24-1-1, BDNHR 31-49-1, BDN2004-1A for seed yield.

The results obtained (Table 3) in Specific Combining Ability effect indicated that among the 24 f1 crosses, the highest magnitude of negative SCA effect for days to 50% Flowering was exhibited for cross BDN 2013-41A × BDNHR 24-1-1 (-6.458), followed by BSMR 736A × BDNHR24-1-1(-4.65) while the highest Specific Combining Ability for days to maturity was observed in Cross BSMR 736A × BDNHR 250157 (-8.063) followed by BSMR 736A × BDNHR 36-1-1, BDN 2004-1A×BDNHR 31-25-1, BSMR736 BDNHR31-25-1, BDN2004-1 BDNHR 250157 for plant height.

The negative SCA effect is favourable early flowering and maturity than the parents is favourable for producing early hybrids. The top performer cross combination for yield component were observed in crosses *viz* BDN2004-3A × BDNHR-250157(1.840) for Number of primary branches/plant, BDN 2004-3A × BDNHR 24-1-1, BDN 2004 A×BDNNHR 24-1-1 for Number of secondary branches/plant, BDN 2004-1A × BDNHR 36-1-1, BSMR736A×BDNHR-250157 for Number of Pods/plant followed BDN 2004-1A × BDNHR 31-14-2, BDN 2004-3 A× BDNHR 250157, BDN 2004-3A × BDNHR 31-25-1, BDN 2004-3A × BDNHR 24-1-1, BDN 2013-41A × BDNHR 31-49-1, BDNHR 2013-41A × BDNHR 31-25-1, BDN 2004-1A×BDNNHR 36-1-1, BDN2004-1A ×BDNHR31-142, BDN2004-3A × BDNHR 250157, BDN2004-3A × BDNHR 31-25-1, BDN2004-3A × BDNHR 24-1-1 for Number of Seeds/Pod, BDN2004-3A × BDNHR 31-25-1, BDN 2004-3A × BDNHR-250157, BDN 2004-1A × BDNHR 31-14-2, BSMR 736A × BDNHR 24-1-1 BDN 2013-41A × BDNHR 250157, BDN 2013-41A × BDNHR 31-25-1 for Seed yield/Plant (g).

The estimates of the SCA effect revealed that none of crosses were consistently to be superior for all the characteristics. These findings are similar with preceding findings of Savaliya *et al.* (2023) [14], Jaybhaye, *et al.* (2020) [1], S Rama Devi *et al.* (2013) [17], Yamanura *et al.* (2014) [18], Jahagirdar *et al.* (2020) [2] Pandey *et al.* (2015) [9] Pandey *et al.* (2002) [8] and Kumar *et al.* (2017) [5], Shoba *et al.* (2010) [15], Kumar *et al.* (2020) [5], Mallikarjuna *et al.* ((2018) [7], Sudhir Kumar *et al.* (2017) [5], Praveen Pandey *et al.* (2015), N.pandey and N.B singh (2002), G.S mhasal *et al.* (2015) [9], Gite *et al.* (2014) [4] P. Pandey *et al.* (2013) [10], M. Reddy Sekhar *et al.* (2004) [11],

Table 1: Analysis of variance for different characters in pigeonpea.

Source	D.F.	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant	No. of pods/plant	No. of seeds/pod	100 seed weight (g)	Seed yield/plant (g)
Replications	1	4.083	6.021	11.21	0.075	7.60	108.00	0.227	0.380	27.150
Genotypes	33	47.45**	231.42**	726.10**	3.39**	37.91**	3803.36**	0.4045**	2.1857**	802.63**
Parents	9	29.56**	355.47**	881.69**	6.650**	42.16**	1924.11**	0.5293**	1.1293**	469.91**
Hybrids	23	56.51**	192.19**	597.27**	2.034**	37.52**	4234.24**	0.286**	2.694**	877.735**
Parents v/s Hybrids	1	0.165**	17.21**	2289.00**	5.332**	7.687**	10806.27**	2.016**	0.00012**	2069.67**
Error	33	7.811	8.912	71.88	0.589	3.740	76.289	0.08160	0.121	11.94

Table 2: General combining ability (GCA) effects for yield and yield contributing characters for line and restorers in pigeonpea.

Sr. No	Parents	Days to 50% Flowering	Days To maturity	Plant height	No. of primary branches/Plant	No. of secondary branches/plant	No. of pods/plant	No. of Seeds/pod	100 seed weight (g)	Seed yield/plant (g)
1.	BDN 2004-1 A	0.792	2.688	-12.867 ***	0.073	4.285 **	6.250	0.144 ***	-0.115 ***	6.044 *
2.	BDN 2004-3 A	-4.875 ***	-11.313 ***	0.433	0.306 *	-0.615 ***	35.750 *	-0.365 ***	0.394 ***	2.435
3.	BDN 2013-41 A	-0.542 ***	-1.063 ***	1.567	-0.606 ***	-0.748 ***	-19.500 ***	0.027	-0.265 ***	3.519
4.	BSMR 736 A	4.625 *	9.688 **	10.867	0.227 *	-2.923 ***	-22.500 ***	0.194 ***	-0.015 ***	-11.998 ***
5.	BDNHR 24-1-1	-5.542 ***	4.229	-5.258 ***	0.242	4.240 **	26.833	-0.210 ***	1.202 ***	17.852 **
6.	BDNHR 31-25-1	1.208	1.604	-0.358 ***	0.523 *	-1.448 ***	-7.792 ***	-0.248 ***	0.327 ***	-5.948 ***
7.	BDNHR 31-49-1	1.958	2.729	-5.883 ***	-0.471 ***	0.077	21.708	0.227 ***	-0.448 ***	14.952 **
8.	BDNHR 31-14-2	1.958	2.104	-9.658 ***	-0.002 ***	0.227	-17.917 ***	0.102 **	0.577 ***	-11.523 ***
9.	BDNHR 36-1-1	0.958	-1.396 ***	13.017	-0.440 ***	0.852	-7.167 ***	-0.048 ***	-0.160 ***	-14.110 ***
10.	BDNHR-250157	-0.542 ***	-9.271 ***	8.142	0.148	-3.948 ***	-15.667 ***	0.177 ***	-1.498 ***	-1.223 ***

Table 3: Specific combining ability (SCA) effects for yield and yield contributing characters for hybrids in pigeonpea

Sr. No.	Hybrids	Days to 50% flowering	Days to maturity	Plant height	No. of primary branches/plant	No. of secondary branches/plant
1.	BDN 2004-1 A × BDNHR 24-1-1	8.208 ***	-2.063	-3.158	1.171 *	-1.423
2.	BDN 2004-1 A × BDNHR 31-25-1	-2.542	-4.438 *	-13.258 *	-0.260	-0.835
3.	BDN 2004-1 A × BDNHR 31-49-1	-0.292	-2.563	-16.233 *	-1.267 *	-1.260
4.	BDN 2004-1 A × BDNHR 31-14-2	0.708	3.063	6.542	-1.685 **	0.390
5.	BDN 2004-1 A × BDNHR 36-1-1	-3.292	2.563	6.867	0.202	2.065
6.	BDN 2004-1 A × BDNHR-250157	-2.792	3.438	19.242 **	1.840 **	1.065
7.	BDN 2004-3 A × BDNHR 24-1-1	2.875	-2.063	-7.158	-0.262	4.277 **
8.	BDN 2004-3 A × BDNHR 31-25-1	-0.875	-3.438	9.942	0.756	-1.435
9.	BDN 2004-3 A × BDNHR 31-49-1	-1.625	-2.563	-0.533	-0.350	-3.060 *
10.	BDN 2004-3 A × BDNHR 31-14-2	-1.625	-1.938	13.242 *	1.031	2.190
11.	BDN 2004-3 A × BDNHR 36-1-1	-0.625	5.563 *	-0.933	-0.206	0.365
12.	BDN 2004-3 A × BDNHR-250157	1.875	4.438 *	-14.558 *	-0.969	-2.335
13.	BDN 2013-41 A × BDNHR 24-1-1	-6.458 **	0.688	4.708	-0.650	1.110
14.	BDN 2013-41 A × BDNHR 31-25-1	2.792	5.313 *	-18.192 **	-0.831	0.698
15.	BDN 2013-41 A × BDNHR 31-49-1	3.042	-0.313	0.833	0.762	3.373 *
16.	BDN 2013-41 A × BDNHR 31-14-2	0.042	-4.188	4.908	1.294 *	-3.377 *
17.	BDN 2013-41 A × BDNHR 36-1-1	0.042	-1.688	-3.567	-0.044	0.398
18.	BDN 2013-41 A × BDNHR-250157	0.542	0.188	11.308	-0.531	-2.202
19.	BSMR 736 A × BDNHR 24-1-1	-4.625 *	3.438	5.608	-0.258	-3.965 **
20.	BSMR 736 A × BDNHR 31-25-1	0.625	2.563	21.508 **	0.335	1.573
21.	BSMR 736 A × BDNHR 31-49-1	-1.125	5.438 *	15.933 *	0.854	0.948
22.	BSMR 736 A × BDNHR 31-14-2	0.875	3.063	-24.692 ***	-0.640	0.798
23.	BSMR 736 A × BDNHR 36-1-1	3.875	-6.438 **	-2.367	0.048	-2.827
24.	BSMR 736 A × BDNHR-250157	0.375	-8.063 ***	-15.992 *	-0.340	3.473 *

Conclusion

1. The BDN 2004-1 among male sterile lines and BDNHR 31-49-1 among restorers ex hibited significant and desirable GCA effects for seed yield and for secondary branches. This parent can be utilized for breeding program to produce high yielding pigeonpea hybrid.
2. The hybrids BDN 2004-3 A × BDNHR 24-1-1, BDN 2004-3 A × BDNHR-250157 and BDN 2004-1 A × BDNHR 31-25-1 for seed yield per plant exhibited higher per se performance, positive and significant SCA effects and positive GCA effects for atleast of one of the parents of every cross for seed yield per plant and yiled contributing characters. Such hybrids rcan be used for their commercial exploitation pigeonpea.

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