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Yield Potential of CGMS Based Pigeonpea [*Cajanus cajan* (L.) Millspaugh] Hybrids

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Abstract Hybrid pigeonpea technology, based on cytoplasmic nuclear male-sterility was developed at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); 20 CMS-based hybrids along with two standard checks, Asha and Maruti were sown for study of yield potential. Among the hybrids, Seed yield (kg ha^{-1}) was maximum in ICPA 2047 × ICPL 20126 (2635.36kg ha^{-1}) .Out of 22 genotypes, seven hybrids were showed significantly high Seed yield (kg ha^{-1}) over best check Asha (1636.30kg ha^{-1}) and general mean (2095.91 kg ha^{-1}) both. The range of seed yield (kg ha^{-1}) varies from 1381.99 kg ha^{-1} (Maruti) to 2635.36 kg ha^{-1} (ICPA 2047 × ICPL 20126).

Keywords Pigeonpea, CGMS, Hybrids.

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Introduction

Pigeonpea [*Cajanus cajan* (L.) Millspaugh], is a short-lived perennial member of family Fabaceae and it is cultivated as annual crop. It is a deep rooted and drought-tolerant leguminous food crop used in several countries as a source of dietary protein. Being a pulse, pigeonpea enriches soil through symbiotic nitrogen fixation, releases soil-bound phosphorous, recycles the soil nutrients, and adds organic matter and other nutrients that make pigeonpea an ideal crop for sustainable agriculture [1]. At present, the availability of proteins among poor in the developing world is less than one-third of its normal requirements [2]. In spite of high importance in domestic nutrition of Indian population and dedicated research efforts, the productivity of pigeonpea in the last few decades has remained constant at around 700 kg ha^{-1} [3].

The hybrid breeding technology has demonstrated quantum yield jumps in various cereal, vegetable [4] and fruit crops. In most food legumes, the absence of natural cross-fertilization is the major bottleneck in exploiting hybrid vigor at commercial scale because their flower structure forces high level of self-pollination, Pigeonpea permitting outcrossing at sufficient level so production of hybridseed possible. The extent of partial nutural outcrossing (20-70%) in pigeonpea varies considerably. Pigeonpea is the most important pulse crop and development of hybrids at commercial level is the specific feature [5]. Recently , ICRISAT developed a hybrid pigeonpea breeding technology that was based on cytoplasmic nuclear male-sterility (CMS) and insect-aided natural out-crossing systems [6]. So far, over 1500 experimental hybrids have been tested and promising hybrids with yield advantages of 25 to 156% over the best inbred variety [7, 8].

To achieve a breakthrough in pigeonpea productivity, research on breeding a cytoplasmic-nuclear male sterility (CMS) system was initiated at ICRISAT. Cytoplasmic-nuclear male sterility system is ideal for commercial hybrid seed production of field crops. The cost of producing hybrid seed in one hectare was Rs 26,395 (US$523) [5]. One kilogram of seed was sold at Rs 60 (US$ 1.2)/kg and generated a total revenue of Rs 86400 (US$ 1728)/ha. Further, it was also estimated that the hybrid pigeonpea seed production can yield profits as high as Rs 60,000 (US$ 1205)/ha as compared to Rs 34,996(US$ 693)/ha for pure line variety. In this study, the cost of producing 1 kg hybrid seed was estimated at Rs 18.32 (US$ 0.37)/kg. So growing of hybrid pigeonpea is economically beneficial. In the present investigation, 22 genotypes, comprising of 20 hybrids and two standard varietal checks were studied to estimate the yield and yield attributing characters in pigeonpea.

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Materials and Methods

In present study 20 CMS-based hybrids (A_4 based CMS lines, developed at ICRISAT, Patancheru), along with two standard checks, Asha and Maruti were sownat International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (17°53'N, 78° 27'E, 545.5 MSL), India. All 20 hybrids and both checks were sown in a randomized block design withtwo replications during *kharif* of 2013-14. The experiment was sown on 1 July, 2013. Each entry was sown in four rows of 4 meters length with a spacing of 75 × 30 cm row to row and plant to plant. The crop was irrigated at critical stages such as vgetative and pod filling stage. The weeds were controlled by hand weeding at various crop growth stages as per the intensity of the weeds. Two irrigations were provided at the time of early vegetative growth and pod filling period of plant at reproductive stages, respectively.

Observations on five randomly selected competitive plants were recorded for days to 1st flowering, days to 50% flowering, days to maturity, plant height (cm), number of primary branches/plant, number of secondary branches/plant, number of pods/ plant, number of grains/ pod, 100-seed weight (g) and grain yield (kg/ha). Analysis of data done by R [9].

Results and Discussion

The analysis of variance (ANOVA) for all 20 hybrids

Table 1. Analysis of variance for yield and related traits in pigeonpea hybrids.

Sl. No.	Source df	Replication 1	Treatment 21	Error 21
1.	Days to 1st flower	0.09	53.09**	9.85
2.	Days to 50% flower	20.45	55.66**	11.45
3.	Days to maturity	3.27	25.41*	10.18
4.	Plant height (cm)	17.82	221.37	197.96
5.	No. of prim.branchesplant^{-1}	0.23	23.60*	9.18
6.	No. of sec. branchesplant^{-1}	9.09	17.31*	8.21
7.	Pods plant^{-1}	173.41	2615.99*	1133.93
8.	Seeds pod^{-1}	0.03	0.08*	0.04
9.	100-seed weight (g)	0.06	1.81*	0.22
10.	Yield plant $^{-1}$ (g)	0.15	336.93*	127.20
11.	Yield plot^{-1} (g)	10832.68	180953.14**	335.23
12.	Yield (kg ha^{-1})	10412.04327	173926.51**	322.21

Table 2. *Per se* performance of pigeonpea hybrids and checks for yield and yield related traits at Patancheru, *kharif* 2013-14.

Entry name	Days to 1st flower	Days to 50% flower	Days to maturiy	Plant height (cm)	No. of primary branches plant^{-1}	No. of secondary branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100 seed -weight (gm)	Yield plant^{-1} (gm)	Yield plot^{-1} (gm)	Yield (kg /ha)
ICPA 2078 × ICPL 87119	109	122	184	208.5	15.1	24.5	247.0	4.25	11.91	99.47	2345.85	2299.8
ICPA 2043 × ICPL 87119	105	118	185	211.0	15.7	20.5	233.0	3.84	11.09	101.58	2098.30	2057.15
ICPA 2047 × ICPL 87119	119	125	186	199.5	10.1	19.1	251.3	3.72	10.72	85.06	1905.51	1868.15
ICPA 2047 × ICPL 20098	121	127	188	204.0	20.0	19.8	207.2	3.71	10.80	89.92	2112.96	2071.53
ICPA 2047 × ICPL 20108	115	124	185	219.0	14.3	22.6	310.9	3.52	10.88	107.95	2551.10	2501.07
ICPA 2047 × ICPL 20126	118	128	186	209.0	18.8	23.0	307.7	3.80	11.21	115.73	2688.07	2635.36
ICPA 2092 × ICPL 87119	118	127	184	201.0	15.2	15.5	247.0	3.38	10.10	84.73	1951.61	1913.34
ICPA 2092 × ICPL 20108	121	128	187	217.0	22.1	14.6	341.2	3.67	10.19	106.96	2514.39	2465.09
ICPA 2048 × ICPL 87119	119	129	186	206.0	24.3	18.8	306.2	3.57	11.96	95.14	2229.67	2185.95
ICPA 2048 × ICPL 20093	121	132	191	195.0	16.7	18.1	244.2	3.81	12.38	89.37	2106.46	2065.15
ICPA 2047 × ICPL 20111	123	131	187	214.0	17.5	17.5	265.0	3.53	9.45	83.43	1961.24	1922.78
ICPA 2047 × ICPL 20129	121	131	187	216.5	14.6	21.3	213.6	3.76	10.98	91.44	2130.93	2089.14
ICPA 2048 × ICPL 20106	123	134	191	218.0	13.3	18.7	230.0	3.79	12.14	106.41	2007.89	1968.52
ICPA 2048 × ICPL 20096	122	130	88	219.5	16.8	21.4	214.3	3.74	11.05	88.32	2069.05	2018.48
ICPA 2048 × ICPL 20098	120	130	187	229.0	19.6	19.5	246.4	3.72	10.94	97.97	2308.12	2262.86
ICPA 2048 × ICPL 20108	121	132	185	233.0	16.0	19.0	242.1	3.87	11.47	79.56	1910.49	1873.03
ICPA 2048 × ICPL 20111	119	130	186	226.0	13.0	16.6	249.3	3.50	10.10	77.26	1813.31	1777.75
ICPA 2092 × ICPL 20106	120	130	188	217.0	14.0	21.0	287.2	3.59	11.02	82.71	1942.73	1904.64
ICPA 2092 × ICPL 20186	122	133	187	210.5	20.0	18.8	291.9	3.58	8.40	104.73	2463.03	2414.74
ICPA 2092 × ICPL 20123	122	132	188	220.5	17.7	11.4	233.3	3.57	9.82	71.4	1669.03	1636.30
Maruti (Check)	106	112	172	197.0	13.8	17.3	22.0	3.37	9.84	64.26	1409.63	1381.99
Asha (Check)	119	133	185	198.0	11.6	20.8	272.0	3.36	10.12	82.13	1920.87	1883.21
Mean	118	128	186	212.23	16.27	19.08	257.4	3.67	10.75	91.16	2095.91	2054.82
Range	105-123	112-134	172-191	195-233	10.10-24.30	11.40-24.50	207.2-341.2	3.36-4.25	8.40-12.38	64.26-115.73	1409.63-2688.07	1381.99-2635.36
SEm±	2.22	2.39	2.26	9.95	2.14	2.03	23.81	0.14	0.33	7.98	12.94	12.69
CD (5%)	6.53	7.04	6.63	–	6.3	5.96	70.03	0.41	0.97	23.45	38.07	37.32
CV (%)	2.66	2.65	1.72	6.63	18.51	15.02	13.08	5.33	4.32	12.37	0.87	0.87

and standard varieties is presented in Table 1. The ANOVA showed that the mean sum of squares were significant for all characters except for plant height. These results indicated highly significant genotypic differences in all the hybrids and standard checks.

Maturity duration is a very important factor that determines the adaptation of varieties to various agro-ecological conditions and cropping systems. In the present investigation ICPA 2043 × ICPL 87119 required minimum number of days to 1st flowering and for 50% flowering and it was significantly earlier than check Asha, while ICPA 2048 × ICPL 20106 required maximum number of days to 1st flowering and 50% flowering. Pigeonpea is a considered as quantitative short-day flowering plant i.e., onset of flowering is hastened as the day-length reduces. Moreover, both low and high temperature may also delay flowering in pigeonpea. The *per se* performance for all the characters studied of hybrids and standard checks are presented in Table 2.

Out of 22 genotypes, check Maruti was the earliest to mature, while ICPA 2048 × ICPL 20093 exhibited maximum number of days to mature. Most of the tested materials showed delay in maturity. It may be due to interaction between the effect of temperature and photo-period. Bright and dry days are favourable for fertilization, while cloudy, damp weather results in excessive flower drop. During the crop season, the extended rainfall and cloudy conditions occurred and there was a serious flower drop

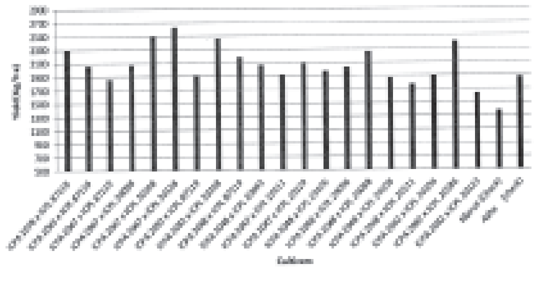

Fig. 1 The yield potential of pigeonpea hybrids with checks.

resulting in delayed maturity. Maturity duration is a very important factor that determines the adaptation of varieties to various agro-ecological conditions and cropping systems.

All the hybrids were taller than both the checks (Asha and Maruti) except ICPA 2078 × ICPL 87119. In present study all the genotypes are non-determinate type for plant height. The range of plant height was from 195.0 to 233.0 cm, while general mean was 212.2 cm. Plant height is influenced by maturity duration, photoperiod, and environment. It can be substantially increased through prolongation of the vegetative phase by exposure to long-day conditions. Pigeonpea was used in different ways in remote areas such as domestic fuel, to construct huts, and fences. Hence, plant height is also an important character to consider for plant selection.

Most of the hybrids were showed high number of primary and secondary branches per plant with respect to check Asha. The range of number of primary branches plant^{-1} varies from 10.1 to 24.30, while general mean was 16.37. In over 8000 world germplasm accessions the average number of primary branches at harvest time ranged from 2.3 to 66 with a mean of 13.2. In pigeonpea, the plant grows slowly and primary branches start appearing from the 6th to 10th nodes. Varieties differ greatly in the number and angle of their branches when grown at fairly wide plant-to-plant spacing.

Among the hybrids, ICPA 2092 × ICPL 20108 had the highest number of pods plant^{-1}. The range of number of pods plant^{-1} varies from 207.20 to 341.2, while general mean was 257.4. Among 22 genotypes, all hybrids showed higher mean performance for number of sees pod^{-1} over check Maruti and Asha. The range of number of Seeds pod^{-1} varies from 3.36 (Asha) to 4.25 (ICPA 2078 × ICPL 87119), while general mean was 3.67. Similar results were reported earlier [10] in pigeonpea. Most of the hybrids performed good for 100 seed weight and Seed yield plant^{-1}. 100-seed weights (g) were maximum in ICPA 2048 × ICPL 20093 and it was bold seeded.

Out of 22 genotypes, seven hybrids were showed significantly high Seed yield (kg ha^{-1}) over check Asha (1636.30 kg ha^{-1}) and general mean (2095.91 kg ha^{-1}) both. The range of seed yield (kg ha^{-1}) varies from 1381.99 kg ha^{-1} (Maruti) to 2635.36 kg ha^{-1} (ICPA 2047 × ICPL 20126 (Fig.1). In pigeonpea [11] reported the heterosi of pigeonpea in yield and its related traits. The range of standard heterosis for grain yield over standard variety was -46.03 to 180%.

Conclusion

Economic yield is most importent for all crops, on that point of view, among the hybrids, Seed yield (kg ha^{-1}) was maximum in ICPA 2047 × ICPL 20126 (2635.36 kg ha^{-1}) followed by ICPA 2047 × ICPL 20108 (2501.07 kg ha^{-1}), ICPA 2092 × ICPL 20108 (2465.09 kg ha^{-1}), ICPA 2092 × ICPL 20186 kg ha^{-1}), (2414.74 kg ha^{-1}), ICPA 2078 × ICPL 87119 (2299.85 kg ha^{-1}), ICPA 2048 × ICPL 20098 (2262.86 kg ha^{-1}) and ICPA 2048 × ICPL 87119 (2185.95 kg ha^{-1}) showed significantly high Seed yield (kg ha^{-1}) over best check Asha (1636.30 kg ha^{-1}) and general mean (2095.91 kg ha^{-1}) both. According to Mahajan et al. [12] to achieve this, it will be neccessary to keep the hybrid seed costs within the reach of resource-poor farmers. In India, both public and private seed sectors are strong, and these are being harnessed to improve the accessibility of hybrid seed to farmers. As a grower friendly hybrid seed production technology is now available, it can be concluded that hybrid vigor can be exploited commercially to increase the pigeopea production and productivity.

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