Study of heterosis and pollen fertility in CGMS based pigeonpea [Cajanus cajan(L.) Millspaugh] hybrids

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Abstract: Twenty CGMS-based pigeonpea [Cajanus cajan(L.) Millspaugh] hybrids were synthesized manually by crossing five CMS lines (A lines) with 11 male lines (R lines) and these hybrids were evaluated to study yield potential with the performance of their R- lines. The results showed that the restoring capacities of restorer lines are very important to quality seed production and for yield potential. Result from the study indicated that most of the R- line acts as good restorer and it ranged from 96.50% (ICPL 20108) to 59.22% (ICPL 2009). In present study most of the hybrids showed standard heterosis towards in desirable direction for yield and yield contributing characters over the checks so these cross combination of parent may be exploited to developed the hybrid in pigeonpea for obtaining higher grain yield. The range of standard heterosis over Asha for grain yield per plant was ranged from -13.06 (ICPA 2092 x ICPL 20123) to 40.91% (ICPA 2047 x ICPL 20126).

Key words: CMS, Heterosis, Hybrids, Pigeonpea, Restorer

Introduction

Pigeonpea [Cajanus cajan(L.) Millsp.] is an important food legume crop grown mainly in tropics and sub-tropics under rainfed agriculture by resource-poor farmers because crop is cultivated with low inputs. As world population increasing demand of protein also increases specially in India, where most of the people are vegetarian. Pigeonpea seeds have 20-22% protein and are used as green peas, whole grain or split peas (Saxena et al., 2002). Globally pigeonpea is cultivated on 4.64 mha with an annual production of 3.43 mt. The average productivity of 780 kg ha-1 (http://faostat.fao.org/2010) indicates further need for improving its yield potential. Recently, 25 to 156% of seed yield over the best inbred variety have been reported by Saxena and Nadarajan (2010). Pollen fertility (%) is an important character to evaluate the restoration of fertility and amount of viable pollens produced by particular hybrid which is a basic need for the successful production of high yielding CMS-based hybrids of pigeonpea. Thus, main objective of this investigation was to estimate the extent of heterosis for seed yield and its component characters including restoring capacities of R- lines for better yield potential by using CGMS lines.

Materials and Methods

Germplasm used in the present study consists of five cytoplasmic-nuclear male sterile (CMS) lines, viz., ICPA 20092, ICPA 2078, ICPA 2048, ICPA 2047 and ICPA 2043 which were derived from A4 cytoplasm of Cajanus cajanifolius, and 11 male lines of pigeonpea, such as ICPL 87119, ICPL 20093, ICPL 20096, ICPL 20098, ICPL 20106, ICPL 20108, ICPL 20111, ICPL 20123, ICPL 20126, ICPL 20129 and ICPL 20186, were derived from diverse inbred lines. In kharif 2012-13, a total of 20 hybrids were generated by manually pollination of these five cytoplasmic-nuclear male sterile (CMS) lines with 11 male lines at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (17°53'N, 78°27'E, 545.5 MSL), India and sufficient quantity of crossed seeds were produced. 20 F1 hybrids along with two standard checks, Asha and Maruti were sown in a randomized block design with two replications during kharif 2013-14. Each entry was sown in four rows of 4 meters length with a spacing of 75 x 30cm row to row and plant to plant. Observations on five randomly selected competitive plants were recorded for days to 1st flowering, days to 50 per cent 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), pollen viability (per cent) and grain yield (kg/ha). To identify fertility/sterility of pollen grains, 2% aceto-carmine solution was used. Five well developed flower buds were collected randomly from different parts of each plant at the time of anthesis (9-10 AM). From each bud, the anthers were collected on a glass slide and crushed with a drop of 2% aceto-carmine stain and examined under a light microscope. The mean value of pollen fertility/sterility of five plants was considered as pollen fertility/sterility (%) for that genotype (Saxena et al. 2011).

Results and Discussion

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 F1 hybrids and standard checks. All the twenty hybrids were compared with both checks, Maruti and Asha for estimation of standard heterosis. Early flowering and maturity is one of the desirable traits in hybrid pigeonpea as it helps in escaping drought. Two hybrids viz., ICPA 2043 x ICPL 87119 (-11.81%) and ICPA 2078 x ICPL 87119 (-8.02%) were showed significant negative standard heterosis over Asha and its range was -11.81 (ICPA 2043 x ICPL 87119) to 3.80% (ICPA 2048 x ICPL 20106) for days to 1st flowering. The range of...
standard heterosis over Maruti was -0.95 (ICPA 2043 x ICPL 87119) to 16.59% (ICPA 2048 x ICPL 20106) and no any hybrids were showed significant negative standard heterosis over Maruti for days to 1st flowering. Sarode et al. (2009) showed significant negative heterosis for this trait in long duration pigeonpea. Similarly, significant negative heterosis in CMS based hybrids was reported by Shoba and Balan (2010) and Sameer Kumar et al. (2012).

For days to 50% flowering, nine hybrids viz., ICPA 2043 x ICPL 87119 (-11.28%), ICPA 2078 x ICPL 87119 (-8.27%), ICPA 2047 x ICPL 20108 (-7.14%), ICPA 2047 x ICPL 87119 (-6.02%), ICPA 2047 x ICPL 20098 (-4.89%), ICPA 2092 x ICPL 87119 (-4.51%), ICPA 2047 x ICPL 20126 (-3.76%) and ICPA 2048 x ICPL 87119 (-3.76%) showed significantly early with respect to Asha and its range was –11.28% (ICPA 2043 x ICPL 87119) to 0.75% (ICPA 2048 x ICPL 20106). The range of standard heterosis over Maruti was 5.36% (ICPA 2043 x ICPL 87119) to 19.64% (ICPA 2048 x ICPL 20106) and no any hybrids were showed significant negative standard heterosis over Maruti for days to 50% flowering. Similarly, Wankhade et al. (2005) reported significant negative heterosis in the hybrids based on genetic male-sterility system for days to 50% flowering. The significant negative heterosis for earliness was earlier reported by Singh et al. (1989) and Pandey and Singh (2002) for flowering. For days to maturity any hybrids were showed significant negative standard heterosis over both checks (Asha and Maruti). Among the twenty hybrids, Ten hybrids, ICPA 2043 x ICPL 20108 (17.68%), ICPA 2048 x ICPL 20098 (15.66%), ICPA 2048 x ICPL 20111 (14.14%), ICPA 2092 x ICPL 20123 (11.36%), ICPA 2048 x ICPL 2006 (10.86%), ICPA 2047 x ICPL 20108 (10.61%), ICPA 2048 x ICPL 20106 (10.10%), ICPA 2092 x ICPL 20106 (9.60%), ICPLA 2092 x ICPL 20108 (9.60%) and ICPA 2047 x ICPL 20129 (9.34%) were showed significant standard heterosis over the check variety Asha for plant height.

Solomon et al. (1957), Singh (1971) and Sharma et al. (1973) also reported similar results.

For number of primary branches plant\(^{-1}\), six hybrids, ICPA 2048 x ICPL 87119 (76.09%), ICPA 2092 x ICPL 20108 (60.14%), ICPA 2092 x ICPL 20108 (44.93%), ICPA 2047 x ICPL 20098 (44.93%), ICPA 2048 x ICPL 20098 (42.03%) and ICPA 2047 x ICPL 20126 (36.23%) were showed significant positive standard heterosis over Maruti with the range of -26.81 (ICPA 2043 x ICPL 87119) to 76.09% (ICPA 2048 x ICPL 20108) and twelve hybrids were showed significant positive standard heterosis over Asha with the range of -12.93 (ICPA 2047 x ICPL 87119) to 109.48% (ICPA 2048 x ICPL 87119). For number of secondary branches plant\(^{-1}\), hybrids viz., ICPA 2078 x ICPL 87119, ICPA 2047 x ICPL 20126, ICPA 2047 x ICPL 20108, ICPA 2048 x ICPL 20096, ICPA 2047 x ICPL 20129 and ICPA 2092 x ICPL 20106 showed significant standard heterosis over Maruti whereas ICPA 2078 x ICPL 87119 showed significant standard heterosis over Asha. The present study showed both positive and negative standard heterosis for number of primary branches plant\(^{-1}\) and also fornum of secondary branches plant\(^{-1}\). Similar results were reported by Shoba and Balan (2010) in CMS/GMS based pigeonpea hybrids. Shrivastava et al. (1976) reported that 96% heterosis for secondary branches per plant. Mudaraddi and Saxena (2013) reported that the days to flower, number of secondary branches, pods per plant and seeds per pod in hybrids haddirect positive effects in determining yield.

For pods plant\(^{-1}\), seven hybrids, ICPA 2092 x ICPL 20108 (53.69%), ICPA 2047 x ICPL 20108 (40.05%), ICPA 2047 x ICPL 20126 (38.60%), ICPA 2048 x ICPL 87119 (37.93%), ICPA 2092 x ICPL 20186 (31.49%), ICPA 2092 x ICPL 20106 (29.37%) and ICPA 2047 x ICPL 20111 (19.37%) showed significant positive heterosis over standard check Maruti. Only one hybrid, ICPA 2092 x ICPL 20108 (25.44%) showed significant positive heterosis over standard check Asha. The range of standard heterosis from -6.67% (ICPA 2047 x ICPL 20098) to 53.69% (ICPA 2092 x ICPL 20108) against Maruti while -23.82% (ICPA 2047 x ICPL 20098) to 25.44% (ICPA 2092 x ICPL 20108) against Asha, which is in agreement with reports of Singh (1971), Shrivastava et al. (1976), Patel and Patel (1992), Pandey and Singh (2002), and Phad et al. (2009).

For seeds pod\(^{-1}\), twelve hybrids, ICPA 2078 x ICPL 87119 (26.49%), ICPA 2048 x ICPL 20108 (15.18%), ICPA 2043 x ICPL 87119 (14.29%), ICPA 2048 x ICPL 20093 (13.39%), ICPA 2047 x ICPL 20126 (13.10%), ICPA 2048 x ICPL 20106 (12.80%), ICPA 2047 x ICPL 20129 (11.90%), ICPA 2048 x ICPL 20096 (11.31%), ICPA 2048 x ICPL 20098 (10.71%), ICPA 2047 x ICPL 87119 (10.71%), ICPA 2047 x ICPL 20098 (10.42%) and ICPA 2092 x ICPL 20108 (9.23%) showed significant positive heterosis over standard check Asha. The range of standard heterosis was from 0.60% (ICPA 2092 x ICPL 87119) to 26.49% (ICPA 2078 x ICPL 87119) against Asha. Similarly, significant positive heterosis for seeds pod\(^{-1}\) was reported by Wankhade et al. (2005).

Among the 20 hybrids, fourteen of them exhibited significant positive standard heterosis over both checks (Maruti and Asha) for 100 seed weight. The range of standard heterosis for Maruti was from -14.63 (ICPA 2092 x ICPL 20186) to 25.81% (ICPA 2048 x ICPL 20093) and for Asha it was from -17.0 (ICPA 2092 x ICPL 20186) to 22.33% (ICPA 2048 x ICPL 20093). In pigeonpea positive standard heterosis for 100-seed weight was reported by Reddy et al. (1979), Manivel et al. (1999), Deshmukh et al. (2001) and Wankhade et al. (2005). For grain yield plant\(^{-1}\), eight hybrids viz., ICPA 2047 x ICPL 20126 (40.91%), ICPA 2047 x
The positive and high magnitude standard heterosis for seed yield, plant height, and days to maturity may be attributed to one or more yield contributing characters. Yadav and Singh (2004), Sekhar et al. (2004), Wankhadeet al. (2005) and Phadet al. (2009) recorded positive standard heterosis for seed yield plant$^{-1}$ in pigeonpea.

For Seed yield plot ($g$) all 20 hybrids showed significant positive standard heterosis over Maruti, whereas 16 hybrids showed positive standard heterosis over Asha. The range of standard heterosis over Maruti was from 15.54 (ICPA 2092 x ICPL 20123) to 47.55% (ICPA 2047 x ICPL 20126) and for Asha it was from -15.09 (ICPA 2092 x ICPL 20123) to 47.55% (ICPA 2047 x ICPL 20126).
Manivel, P., Rangasamy, P. and Samdur, M.Y.: Heterosis studies involving CMS-based hybrids of pigeonpea. At Patancheru, the variability for fertility (%) is an important character to evaluate the restoration of hybrids, ICPA 2047 x ICPL 20108 recorded maximum pollen fertility (98.50%) followed by ICPA 2078 x ICPL 87119 (98.05%) and ICPA 2092 x ICPL 20123) to 28.54% (ICPA 2047 x ICPL 20126). Pollen fertility was recorded in ICPA 2048 x ICPL 20096 (59.22%) followed by Maruti (99.58%). Heterosis for seed yield in hybrid pigeonpea and checks), Asha recorded maximum pollen fertility (99.76%) followed by Rathore, A., Kishor, P. B.K. and Varshney, R.K.: Genetics of fertility restoration in A4-based, diverse maturing hybrids of pigeonpea [Cajanus cajan (L.) Millsp.]. hybrids involving male sterile lines. Indian J. of Genetics & Plant Breeding, 62: 221-225 (2002).


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