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Research Note

Character association between seed yield and component traits among CMS-based pigeonpea hybrids

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Abstract
Twenty two CMS-based pigeonpea [*Cajanus cajan* (L.) Millsp.] hybrids were evaluated to study the nature and magnitude of relationship of important agronomic traits with seed yield along with their direct and indirect effects in determining yield. The results showed that days to flower, number of secondary branches, pods/plant, seeds/pod, and seed size in hybrids had direct positive effects in determining yield. Among hybrids only the number of pods/plant was positively associated with seed yield.

Key words:
Pigeonpea, Correlation, path analysis, hybrids

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important rainy season pulse crop of subsistence agriculture in Asia and Africa. In spite of dedicated research efforts in the last few decades, the global productivity (774 kg/ha) of pigeonpea has remained low (FAO, 2010). In order to break this yield barrier, breeders have recently started breeding high yielding hybrids. This was possible due to successful breeding of a stable cytoplasmic nuclear male-sterility (CMS) system (Saxena *et al*., 2005) and by exploiting partial natural out-crossing of the crop (Saxena and Sharma, 1990). The release of two pigeonpea hybrids ICPH 2671 (Saxena *et al.*, 2013) and ICPH 2740 (Saxena *et al.*, unpublished) with 40% yield advantage over the pure line cultivars in the farmers' fields is considered a giant step towards genetic enhancement of productivity in pigeonpea. Seed yield in pigeonpea is a function of its component traits which influence the productivity both directly as well as indirectly. Information on the extent and direction of association of different characters with yield may help in identifying some key traits which could be useful in selecting superior hybrid parents and hybrids. This paper contains information on trait associations among pigeonpea hybrids.

Twenty two pigeonpea hybrids were evaluated in a randomized complete block design with three replications during rainy season 2011 at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh. These hybrids were synthesized by crossing six CMS lines with 14 restorers of diverse origin in different combinations. The CMS lines were ICPAs 2043, 2047, 2048, 2078, 2092 and 2209; and the restorers included ICPLs 87119, 20093, 20096, 20106, 20108, 20129, 20177, 20342, 20343, 20344, 20346, 20347, 20348, and 20349. Each experimental plot consisted of two rows of 4m length with row-to-row and plant-to-plant spacing of 75 cm and 30 cm, respectively. The recommended agronomic practices (Mula *et al.*, 2010) were followed for optimum crop growth. Five competitive plants in each plot were selected randomly for recording observations on days to 50% flower, plant height (cm), number of primary and secondary branches, pods/plant, seeds/pod, 100-seed weight (g), and seed yield/plant (g). Phenotypic correlation coefficients were computed according to Al-Jibouri *et al.* (1958). The direct and indirect contribution of an individual trait in the manifestation of yield was determined using path analysis (Dewey and Lu, 1959).

Significant treatment mean squares of different traits indicated large differences among the test entries (Table 1). The phenotypic correlation coefficients for seed yield and component traits in pigeonpea hybrids under study were estimated. The studies on correlation and character associations among hybrids revealed that seed yield was significantly associated to only pods/plant (0.91**). Similar results were also reported among pigeonpea hybrids by Singh (1999) and Sawargoankar *et al.* (2011). Further, it was also revealed that the number of primary branches was positively linked with seed size and seeds/pod. The hybrid plants with more number of pods produced smaller seeds, which may be attributed to competitive distribution of photosynthates and nutrients within the plants or due to some vascular limitation that restrict the supply of assimilates to pods during peak pod setting (Rawson and Constable, 1981). Also, Sheldrake and Narayanan. (1979) postulated that seeds/pod and seed size may be adversely affected by certain environmental conditions that limit the supply of assimilates during reproductive growth.

Lawn and Troedson (1990) observed that the retention and transformation of flowers into pods was predominantly determined by the availability of assimilates to the flowers and it was perhaps regulated by the capacity of plant to supply photosynthates and/or by some intrinsic mechanism within the plant. The proportion of photosynthates channeled towards growth of stem and branches in pigeonpea is generally high which results in greater competition for pod set and their development (Pandey, 1980).

According to Chauhan (1990) in the intensively managed pigeonpea crop, the production of both yield and biomass were high and the plants removed relatively more nutrients from the soil. There is little information available concerning the extent of genotypic differences in carbon exchange capacity within pigeonpea leaves and their relation to enhance the plant biomass. It was further suggested by Tekale *et al*. (2009) and Chauhan *et al.* (1995) that the productivity of pigeonpea was not only dependent on accumulation of dry matter but its partitioning into economic sink. The pigeonpea hybrids produce 40-50% more biomass than varieties and the partitioning of the phototsynthates remained unchanged which has been conclusively demonstrated at ICRISAT. With these results, the seed rate for the hybrids has been reduced by 50% (Saxena *et al.,* 2013).

Seed yield increased with greater pod number due to improved sink capacity (Thirathon *et al*., 1987). A significant positive correlation of days to flower, plant height, number of primary branches, seeds/pod, and seed size with yield was also observed among the inbreds (Sodavadiya *et al.*, 2009). However, in the present study dealing with hybrids such correlations were non-significant. It was also noticed that the number of primary and secondary branches were positively associated with seed yield in the inbreds (Saxena and Sharma, 1990), wherein such relationships were not significant in the present experiment with hybrids. Such differences in the nature of relationship may be attributed to the genetic variation among the genotypes involved in the studies and the differences in cultural practices adopted for the evaluation of hybrids (Byth *et al.*, 1981). Further, Mula *et al.* (2011) have reported that in comparison to inbreds, the hybrids require wider spacing for their optimum phenotypic expression.

A study of direct and indirect effects of individual trait on yield revealed that pods/plant (0.96), seed size (0.19), days to flower (0.11), number of secondary branches (0.06), and seeds/pod (0.05) were important parameters in determining seed yield in pigeonpea hybrids (Table 2). The number of primary branches had direct negative effect on seed yield; this however, was compensated indirectly through days to flower, seed size, and plant height. The number of pods/plant had both direct as well as indirect positive influence on yield. Seed size in the hybrids had direct positive as well as indirect negative effect on yield. Such unequal reciprocal effects suggested that the level of influence of these traits on each other was not similar. In the present study it was concluded that for realizing high yields in the hybrids days to flower, number of primary branches, pods/plant, seeds/pod, and seed size should be given weightage in selection. The residual effect on seed yield was 0.3537 indicating that the characters under study explained nearly 65% of the total variation which may be attributed in determining yield in pigeonpea hybrids.

The productivity of pigeonpea has been stagnant for the past half century; and to date, it has remained a challenge to the breeders. The successful breeding of CMS system (Saxena *et al.,* 2005) triggered the long-awaited process of breeding hybrid cultivars. The field performance of hybrids and the ease in their large-scale seed production (Saxena and Nadarajan, 2010) is encouraging various public and private seed organizations to launch commercial hybrid pigeonpea breeding programs. The present research was carried out to generate information that may help breeders in developing productive hybrids and their parents. Plant character such as pods/plant was correlated with yield, as has also been reported in pure line cultivars. However, unlike pure line varieties, the number of primary branches was negatively associated with yield in the hybrids. This is attributed to the inherent capacity of hybrid plants to produce more branches and biomass; but lot of flowers dropped due to competition for resources. Hence, to overcome this constraint, it is recommended that both the additional research and exercise of breeding high yielding hybrids with emphasis on plants traits like pods/plant should be given importance.

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Table 1. Phenotypic correlation coefficients for seed yield and component traits among pigeonpea hybrids

	Days to flower	Plant height (cm)	Number of primary branches	Number of secondary branches	Pods/ plant	Seed s/pod	100 seed-weight (g)	Yield (g)
Treatment Mean Square (df = 21)	424.4**	937.9**	4.7**	15.0*	15324.8**	1.4**	4.3**	1008.9**
Days to flower	1	0.43*	0.11	-0.11	0.25	-0.08	0.20	0.35
Plant height (cm)			0.01	0.09	0.08	0.32	-0.02	0.11
Number of primary branches				-0.17	-0.04	-0.33	0.34	-0.10
Number of secondary branches					0.07	0.32	-0.20	0.12
Pods/plant						-0.09	-0.33	0.91**
Seeds/pod							-0.34	-0.05
100 seed-weight (g)								-0.28

*, **- significant at 5% and 1% level respectively

Table 2: Effect of different plant traits on seed yield in pigeonpea hybrids

Character	Days to flower	Plant height (cm)	Number of primary branches	Number of secondary branches	Pods/ plant	Seeds/ pod	100 seed weight (g)	Correlation with Yield (g)
Days to flower	**0.105**	-0.019	-0.012	-0.010	0.240	-0.003	0.047	0.35
Plant height (cm)	0.046	**-0.044**	-0.001	0.007	0.083	0.019	-0.006	0.11
Number of primary branches	0.011	0.0002	**-0.122**	-0.015	-0.036	-0.020	0.086	-0.10
Number of secondary branches	-0.017	-0.005	0.029	**0.063**	0.079	0.031	-0.063	0.12
Pods/plant	0.026	-0.004	0.005	0.005	**0.962**	-0.005	-0.077	0.91**
Seeds/pod	-0.007	-0.016	0.049	0.038	-0.093	**0.051**	-0.073	-0.05
100 seed weight (g)	0.027	0.001	-0.057	-0.021	-0.398	-0.020	**0.185**	-0.28

Bold diagonal values indicate the direct effects. Residual effect = 0.3537
*, **- significant at 5% and 1% level respectively.