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Studies on Cytoplasmic Effects Using Iso-Nuclear Pigeonpea Lines

Science

KEYWORDS : Cytoplasm effect, iso-nuclear lines, pigeonpea, yield components.

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ABSTRACT

Two diverse cytoplasmic iso-nuclear pigeonpea lines, Pusa Ageti carrying cytoplasm of cultivated type Cajanus cajan cytoplasm, while 'ICPA 2039' carried the cytoplasm of a wild species Cajanus cajanifolius were used in the study. These were crossed as female parent with six known fertility restorers as male parents. The F1 hybrids were evaluated in replicated trials to study the effect of the two cytoplasm on yield and other traits. The data showed no significant effect on seed yield and other traits that could be attributed to the differences in the cytoplasm of the hybrids.

Introduction

To enhance the productivity of pigeonpea [Cajanus cajan (L.) Millsp.], a hybrid breeding technology was developed and recently the world's first commercial hybrid was released in Madhya Pradesh (Saxena et al., 2013). This technology is based on a cytoplasmic-nuclear male-sterility system carrying the cytoplasm of Cajanus cajanifolius,a wild relative of pigeonpea. To study the effect of this cytoplasm on important agronomic traits, a set of two iso-nuclear lines was developed, one carried the cytoplasm of cultivated pigeonpea, while the other had cytoplasm of the wild species. This paper compares the performance of hybrids synthesized by crossing six known medium duration fertility restorers with two diverse cytoplasmic iso-nuclear lines as female parents.

Materials and Methods

Development of iso-nuclear lines: The lines with similar nuclear genome and different cytoplasm were developed by crossing cultivar Pusa Ageti (carrying cytoplasm of Cajanus cajan) as male with a CMS line ICPA 2039 carrying the cytoplasm of C. cajanifolius. The F1 was found to be totally male sterile that means Pusa Ageti worked as a maintainer (B-) line for ICPA 2039, and it made the job of breeding iso-lines much easier. To breed the true iso-nuclear lines the F1 male sterile plants were backcrossed to Pusa Ageti 10 times. This ensured maximum substitution of the nuclear genome of ICPA 2039 with that of Pusa Ageti.

Development and evaluation of hybrids: To develop hybrid combinations for this study, both the iso-nuclear lines were manually crossed as female parents with six known medium maturing fertility restoring lines ICPRs' 2438, 2618, 2630, 4390, 4392 and 4393 in 2010. The floral buds of Pusa Ageti were emasculated just before pollinations; while male-sterile flowers of ICPA 2039 were pollinated directly. The hybrids were evaluated in three replications using a RCB design in Alfisols at ICRISAT Centre, Patancheru during 2011 rainy season. Each plot consisted of 4 rows of 4m length, with inter- and intra-row spacing of 75 cm and 25 cm, respectively. The package of recommended practices was adopted to raise a healthy crop. The trial was conducted under irrigation with good insect management. Data on yield, days to flower and maturity, plant height, seeds/pod and seed size were recorded on plot basis and analyzed using 'procglm' procedure of SAS software version 9.3 for Windows with lines as fixed effects. To obtain their best linear unbiased estimates, least significant differences (LSD) were estimated to examine the genotypes which vary in the origin of their cytoplasm.

Results and Discussion

The analysis of variance (full ANOVA not reported here) showed that the differences among hybrids were significant for all the traits studied (Table 1). The results further showed that the two sets of crosses representing the different cytoplasm were non-significant for all the traits. A perusal of the variation for individual traits showed that there were minor differences within each set of crosses, but there was no visible trend in favour of any specific cytoplasm.

The literature available on the effect of cytoplasm on hybrids showed in brassica (Chang et al., 2007) and sorghum (Reddy et al., 2006; Hoffman and Rooney, 2013) the hybrids did not show any significant cytoplasmic effect on yield and other traits. On the contrary, Moran and Rooney (2003) recorded statistically significant but little cytoplasmic effect on sorghum yield. In rice, Kong et al. (2014) reported significant effect of cytoplasm on pollen fertility/sterility of temperature sensitive genetic male sterility system. On the other hand, Tao et al. (2011) reported that in rice traits like grain weight and filled grain ratio were significantly influenced with different cytoplasm. In pearl millet, Virk and Brar (1993) found positive and significant effect of cytoplasm on seed yield. They attributed it to the pleiotropic effects of some extra-nuclear genes or heterogeneity at male sterility/fertility loci and /or at linked loci with over-dominance effect.

The hybrid technology in pigeonpea is of recent origin (Saxena et al., 2013) and it based on the male sterility that has cytoplasm of a wild species (C. cajanifolius) that is considered to be a putative progenitor of the cultivated type (van der Maesen. 1980). According to Sinha (unpublished) the male sterility in ICPA 2039 was due to deletion of a single gene (nad 7a) in the cytoplasmic DNA. In the present study cytoplasmic effects on yield and other related traits were insignificant, suggesting that the cytoplasm of C. cajanifolius did not yield any penalty in the expression of important agronomic traits in pigeonpea. These results are considered significant from hybrid breeding point of view and the C. cajanifolius can be designated as 'friendly cytoplasm' donor. However, since this inference is based on limited number of male parents, any generalization in this regards would be unfair and more reliable information on this aspect with systematic investigations involving diverse male parents and multi-environment testing of hybrids is necessary.

The success of hybrid technology has given an alternative option to breeders to break the yield barrier in pigeonpea that is persisting for over half century. For a sustainable hybrid breeding programmes in future the breeders need to take enough care to diversify the cytoplasmic base of male sterile lines and fully understand the positive and negative effects of each cytoplasm. Any large-scale hybrid programme that is based on a single cytoplasm cannot be considered sustainable in the long run because it may carry a potential risk of susceptibility of the extra-nuclear gene(s); and thereby may lead to any outbreak of insect or diseases to cause huge yield losses. Hence, for a sustainable hybrid breeding programme the importance of cytoplasmic diversity has been advocated, particularly after the outbreak of corn leaf blight in the USA that was associated with Texas cytoplasm (Tatum, 1971). Since then the role of cytoplasm in hybrid breeding has been a subject of investigation in all the field crops where commercial hybrids are the end products.

Table 1. Comparison of hybrids made on female lines with similar nucleus and different cytoplasm.

Cross	Days to flower	Days to maturity	Plant ht. (cm)	Seeds/ pod	100-seed wt (gm)	Yield (kg/ ha)
ICPA 2039 x R 2438	102.3^{d}	141.7^{c}	173.3^{ab}	3.6^{bc}	8.8^{abc}	$1057.^{.cde}$
Pusa Aget x R 2438	107.3^{ab}	150.0^{ab}	166.6^{abc}	3.8^{abc}	8.9^{ab}	1339.2^{bcde}
ICPA 2039 x R 2630	115.0^{abc}	165.0^{bc}	160.0^{abcd}	3.4^{ab}	9.1^{abc}	1071.7^{cde}
Pusa Aget x R 2630	109.0^{a}	151.7^{ab}	168.3^{cde}	3.6^{bc}	9.4^{de}	1151.7^{cde}
ICPA 2039 x R 4390	104.7^{a}	151.7^{a}	163.0^{cde}	3.8^{abc}	9.6^{abc}	1158.8^{cde}
Pusa Aget x R 4390	106.7^{bcd}	150.0^{ab}	156.7^{a}	3.7^{abc}	8.9^{e}	937.8^{de}
ICPA 2039 x R 4392	111.7^{abcd}	156.7^{bc}	168.3^{cde}	3.8^{bc}	9.3^{ab}	1771.4^{bcde}
Pusa Aget x R 4392	115.0^{abc}	160.3^{bc}	172.7^{ab}	3.8^{abc}	7.8^{bcd}	1318.7^{bcde}
ICPA 2039 x R 2618	107.5^{bcd}	155.0^{bc}	161.7^{de}	3.7^{abc}	7.6^{a}	1476.2^{bcde}
Pusa Aget x R 2618	110.7^{bcd}	160.0^{bc}	175.0^{ab}	3.7^{a}	8.5^{cde}	1217.1^{cde}
ICPA 2039 x R 4393	110.0^{bcd}	154.3^{bc}	155.0^{ab}	3.9^{ab}	8.4^{abc}	962.6^{de}
Pusa Ageti x R 4393	106.7^{bcd}	150.0^{ab}	158.3^{bc}	3.8^{abc}	8.7^{bc}	796.8^{e}
Mean(ICPA 2039 cross)	108.3	154.1	163,6	3.7	8.8	1249.7
Mean (P. Ageti crosses)	109.2	153.7	166.3	3.7	8.7	1126.9
Treatment MSS	S	S	S	S	S	S
ICPA 2039 vs P.A.. MSS	NS	NS	NS	NS	NS	NS
LSD (5%)	6.9	12.3	13.3	0.2	0.8	501.1
CV%	3.1	4.5	4.8	3.4	5.6	24.2

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