Crop specific traits of Pigeonpea [*Cajanus cajan* (L.) Millspaugh) and their implications in seed production

C. V. Sameer Kumar, M. V. Nagesh Kumar, C. Sudhakar[2], Rachit K. Saxena[1] & Rajeev K. Varshney[1]

[1]ICRISAT, Patancheru, Hyderabad
[2]Professor Jayashankar Telangana State Agricultural University, Hyderabad

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important pulse crop of Indian rainfed agriculture. Of the 3.47 m ha grown under the crop in India with mean productivity of 711 kg/ha, the central and southern India contributes over 72.8% in area and 69.5% in production with a mean yield of 649.2 kg/ha.(DAC, 2011). In spite of dedicated variety breeding efforts, the productivity of pigeonpea has remained unacceptably low for over 50 years. Photoperiod and thermoperiod sensitivity and perenniabiltiy are the major issues that cause hindrance in quality seed production of the crop. To break this yield plateau, a hybrid breeding technology, based on natural out-crossing and cytoplasmic nuclear and genetic male-sterility (CGMS) systems were developed at ICRISAT and PJTSAU and a number of hybrids with 30-100% yield advantages over the control were identified. Among these, ICPH 2740 was found most outstanding. In 31 multi-location trials conducted over five years, this hybrid (2793 kg/ha) recorded 41% superiority over the ruling variety Asha (1985 kg/ha). The performance record of hybrids suggests that this technology has a potential for breaking yield barrier in pigeonpea. Genome sequencing (Varshney et al. 2012), development of photo insensitive super early maturing lines, introgression of cleistogamous flower structure to maintain genetic purity of elite lines, use of obcordate leaf shape as NEP to assess genetic purity of hybrid parental lines and development of disease resistant hybrids and elite breeding lines are some of the recent innovations in the crop which offer a scope for the enhancement of production and productivity and ushers the crop as an economical viable option by the public and private seed industry.

Hybrid pigeonpea research to reality

Often cross pollinated nature, mode of pollination and floral biology of the crop offered scope for exploitation of heterosis in pigeonpea. Stable male sterile sources were developed from wild relatives and perfect three line system of breeding was developed to produce hybrids in the crop. Seed production technology is also standardized in the crop for harnessing appreciable amounts of commercial seed from the seed parent. The hybrids ICPH 2671 and ICPH 3762 were released in Madhya Pradesh and Odisha in 2010 and 2014 respectively. ICPH 2740 is released in October 2015 from the state of Telangana.

Development of CGMS system:

Stable male sterility systems were developed from wild relatives *Cajanuscajanifolius* (A4) and *Cajanus Scaraboides* (A2). TheF_1hybridplants derived from this CGMS produceexcellentpollen load and podset. At present theseCMS systemsarebeingusedby pigeonpea breeders in India, Myanmar, and Kenya. (Saxena 2009) for genetic diversification of A-lines and to produce commercial hybrids.

Seed production technology

The commercial seed production of pigeonpea hybrids involves large scale seed production of their female line (A/B), restorer line (R) and hybrid (A x R) combination. Each set of material requires isolation of at least 500 m from other pigeonpea. For seed production of A/B lines, breeder seed of both A- and B- lines are planted using a row ratio ranging from 3:1 to 8:1 (female : male), depending upon the extent of insect

activity (Saxena and Kumar, 2013). In case of higher insect activity 8:1 ratio also gives good seed yield. In general, 4:1 row ratio gives optimum seed yield at most locations. At maturity, the B-line should be harvested first and followed by pods set on the A-line. For the hybrid seed production (A x R) also, the row ratios, as in case of A/B seed multiplication, may be variable. In this programme also, the R-line should be harvested first to ensure seed purity. Roguing and strict crop monitoring are critical aspects of hybrid seed production. The roguing should be done at seedling, flowering, and pre-harvesting stages. Our experience has shown that the hybrid seed can be produced easily by growers, if the pollinators are present in sufficient number. Unlike most pulses, the flowers of pigeonpea contain nectar and its large yellow petals attract honey bees (Megachile spp.) and other pollinating insects (Williams, 1977; Onim, 1981). The cross-pollination takes place when these insects forage on the flowers. It has also been established that wind does not play any role in cross-pollination (Kumar and Saxena, 2010). Hence, the success in seed set on the male-sterile plants entirely depends on the availability of pollinating insects in the seed production plots.

ICPH 2740 High yielding hybrid

Development of marker- based hybridity test

Grow Out test is time consuming owing to the long duration in pigeonpea. Simple, rapid, and cost effective hybrid seed quality testing approach in pigeonpea based on molecular markers assay was needed. SSR base purity assessment kits are developed which can be used for assessing the purity of the hybrids (Saxena *et al.*, 2010).

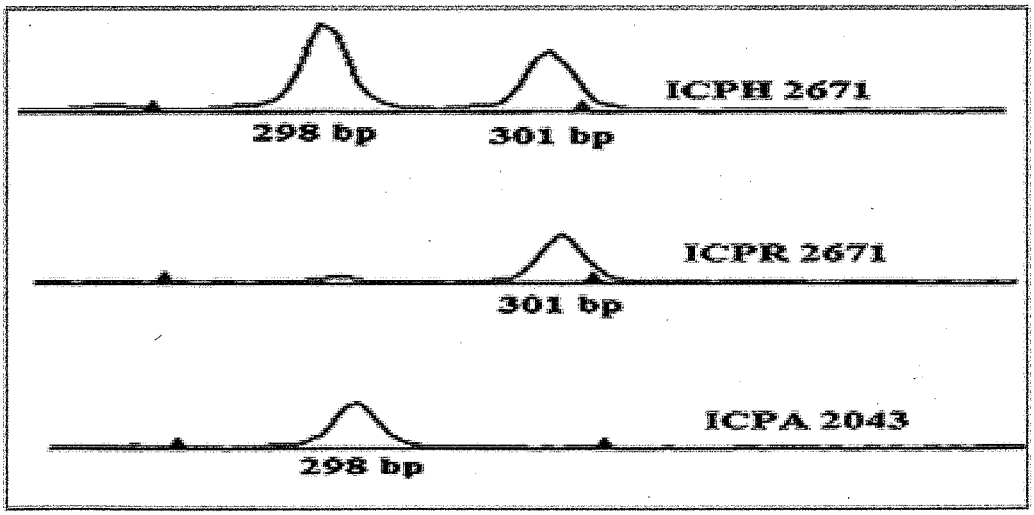


Figure 2. Hybrid purity assessment of hybrid ICPH 2671 with the CcM 0021 marker.

Obcordate hybrids

To enhance efficacy of hybrid seed production and for easy identification of off types in the parental lines obcordate trait (single gene recessive) has been introgressed in male sterile line (Sameer Kumar *et al.*, 2014). The hybrids derived from crosses involving obcordate leaf A-lines and normal leaf fertility restorers (R-lines) were fully fertile and had normal lanceolate leaves. ICPA 2203 and ICPA 2204 are identified as stable male sterile lines with good general combining ability and produced fertile high yielding hybrids.

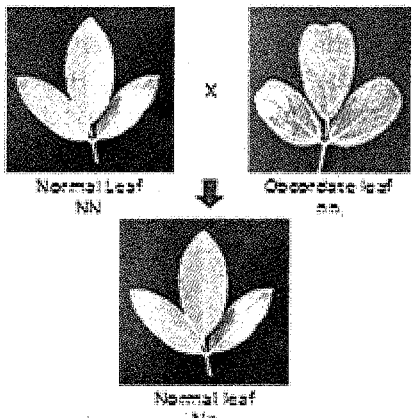


Figure 3. Details of the inheritance pattern of obcordate leaf shape.

Cleistogamous trait

Pigeonpea is an often cross pollinated species and out crossing extent up to 25-30 % (Saxena et al. 1990) and is considered to be a prime constraint in maintaining genetic purity of cultivars and genetic stocks . To maintain a variety true to type especially in partially out-crossed species, it needs lot of resources in terms of isolation distance, installation of insect proof cages and labor charges for rouging and seed cleaning operations. Considering these facts attention was paid on natural mutant with wrapped flower morphology or cleistogamy (Saxena et al. 1994).Cleistogamy trait is governed by single recessive gene and very easy to transfer in the background of commercial lines. A partial cleistogamous line ICPL 87154 was developed earlier with low natural out crossing (<1 %). Similar effort was initiated to develop early maturing cleistogamous lines in the background of elite lines and super early stable breeding lines.

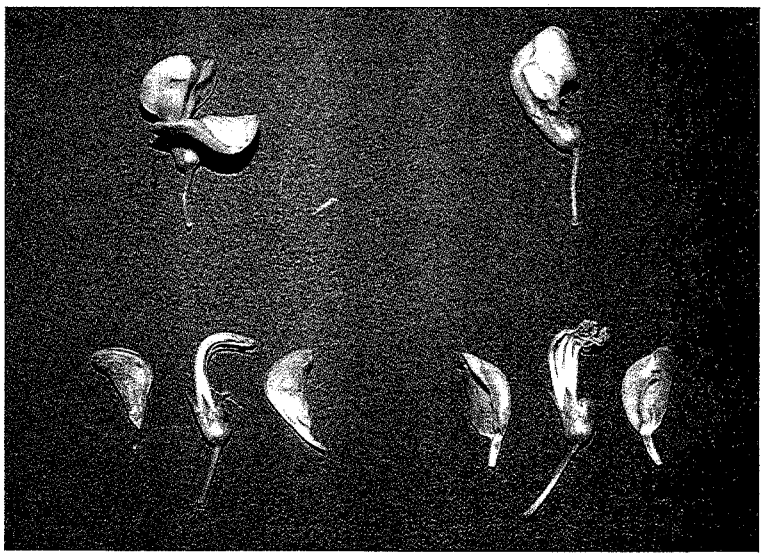
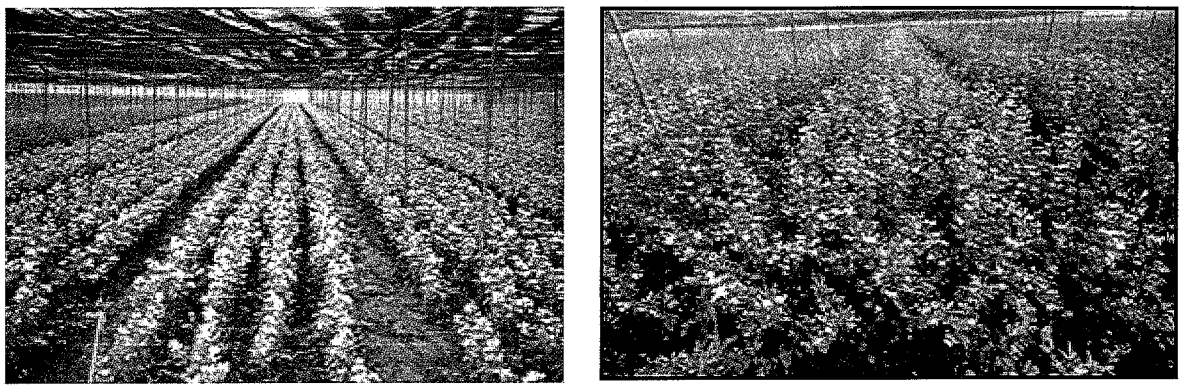


Fig. 4: Flower structure differences in normal and cleistogamous flower

Super early maturing Lines

Photo and thermo sensitivity is the major issues in the crop restricting the horizontal expansion to different cropping systems in varied agro ecologies. Traditional cultivars of pigeonpea are of early (120 to 140 days), Medium (140 to 160 days) and Long duration (> 160 days) types which cannot fit in preceding or proceeding crop situations of rainfed and irrigated ecologies. Super early lines mature within 100 days and have yield potential up to 1.0 to 1.5 t/ha (Vales et al. 2012). Out of these, ICPL 11242 and ICPL 20325 in NDT group and ICPL 20338 and ICPL 11253 in DT group were found promising. These lines provide number of opportunities like expansion of pigeonpea on non-traditional area like rice fallow, could fit the pigeonpea-wheat cropping system, contribute to reduce environmental degradation, attractive option to grow the crop on stored soil moisture, can escape diseases, drought and pod borer attack.



ICPL 20338 (Determinate) **ICPL 11242 (Non determinate)**

Fig. 5: Super early determinate and non-determinate pigeonpea lines

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