Recent advances in Pigeonpea [*Cajanus cajan* (L.) Millspaugh) Research

C V Sameer Kumar[1], I P Singh[2], Suyash B Patil[1], Myer G Mula[1], R Vijay Kumar[1], Rachit K Saxena[1] and Rajeev K Varshney[1]

Introduction: Pigeonpea or red gram [*Cajanus cajan* (L.) Millspaugh] is an important food legume of the semi-arid tropics of Asia and Africa. It occupies a prime niche in sustainable farming systems of smallholder rainfed farmers. It occupies a prominent place in Indian rainfed agriculture. It is an integral component in various agro ecologies of the country mainly inter cropped with cereals, pulses, oilseeds and millets. It is the second most important pulse crop next to chickpea, covering an area of around 4.42 m ha (occupying about 14.5% of area under pulses) and production of 2.86 MT (contributing to 16% of total pulse production) and productivity of about 707 kg/ha. It is mainly consumed as dry split dhal throughout the country besides several other uses of various parts of pigeonpea plant. Enhancing the productivity of the crop assumes specific significance in India mainly to combat protein malnutrition as it is the main source of protein to the predominant vegetarian population. The productivity of pigeonpea has remained low and stagnant over the last few decades thus this prompted scientists to search for novel ways of crop improvement. To tackle this challenge, ICRISAT and IIPR are working on number of innovative ideas like, genome sequencing (Varshney et al. 2012), development of CGMS hybrids with 30 to 40 % yield advantage over traditional varieties, 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. These aspects are described briefly below.

CGMS hybrids: The level of realized heterosis for seed yield in pigeonpea is comparable to other crops where commercial hybrids have already made a mark in global agriculture. The hybrid breeding program at ICRISAT and ICAR in recent past focused towards developing a more efficient cytoplasmic-Genetic male-sterility (CGMS) system.

Development of CGMS system;

1. International Crops Research Institute for the Semi-Arid tropics (ICRISAT), Patancheru, Hyderabad.
2. Indian Institute of Pulses Research (IIPR), Kanpur.

Stable male sterility systems were developed from wild relatives *Cajanus cajanifolius* (A4) and *Cajanus Scaraboides* (A2) (Saxena et al. 2005). The F_1 hybrid plants derived from this CGMS produce excellent pollen load and pod set. At present these CMS systems are being used by pigeonpea breeders in India, Myanmar, and China (Saxena 2009) for genetic diversification of A-lines and to produce commercial hybrids.

Development of seed production technology

The commercial seed production of pigeonpea hybrids involves large scale seed production of A-, B-, R- lines, and the hybrid combination (A x R). For seed production of A-line, breeder seed of both A- and B- lines are planted using a female: male row ratio of 4:1. In the production areas where greater bee activity is observed a higher row ratio can be used for getting high yields. For hybrid seed production (A x R) also, the same ratio can be used. In general, roguing of off-type plants is carried out both at seedling as well as reproductive stages.

Since the hybrid seed set on the male-sterile plants is chiefly determined by the availability of bee population in the vicinity, pod set is generally poor in the locations with less number of pollinators. Therefore, to harvest good hybrid yields, it is imperative to select suitable seed production sites with good insect pollinator activity.

ICPH 2671

ICPH 2740

Figure 1. Promising medium duration hybrids of pigeonpea

Development of marker- based hybridity test

In pigeonpea Grow Out test take more time due to the long duration nature of the crop. Therefore a simple, rapid, and cost effective hybrid seed quality testing approach in pigeonpea based on molecular markers assay was needed. SSR base purity assessment kist are developed which can be used for assessing the purity of the hybrids (Saxena et al. 2010).

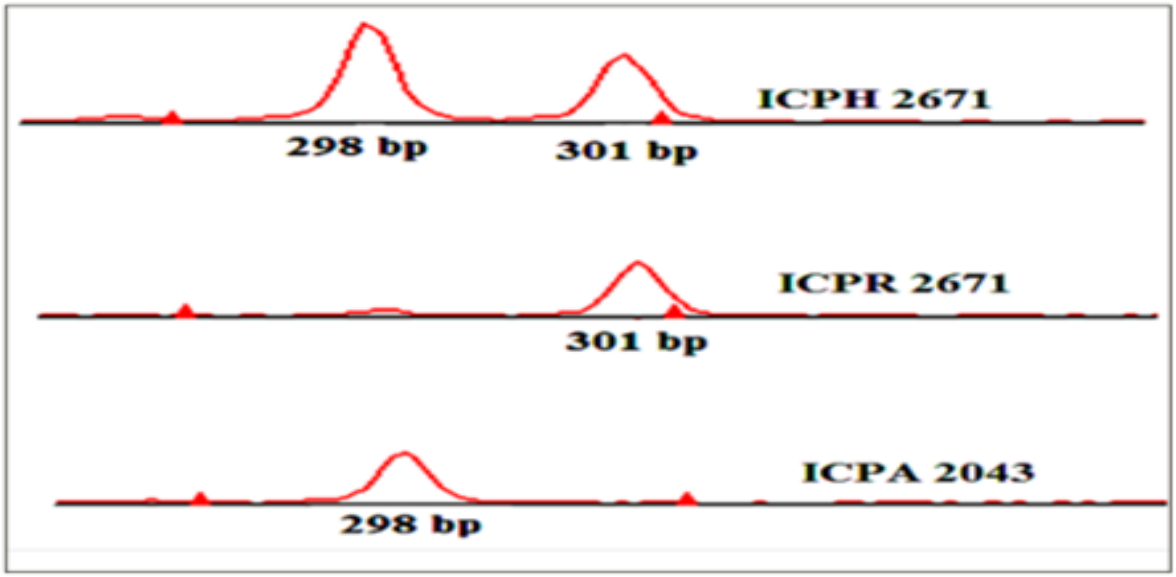


Figure 2**.** Hybrid purity assessment of hybrid ICPH 2671 with the CcM 0021 marker.

Obcordate hybrids: Maintenance of purity by following principles of seed production is a prerequisite in commercial hybrid seed production. 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. The main idea with this technology is, when a commercial seed lot is received for seed purity assessment from different production sources, we can use a representative sample from each lot to undertake grow out test to check the purity of hybrid seed. It takes around 4 to 6 weeks after sowing to express the obcordate leaf shape which is a very

short period as compared to regular grow out test in which we have to wait for six months or more. The off types in the A-line maintenance can be identified with any normal leaf seedling.

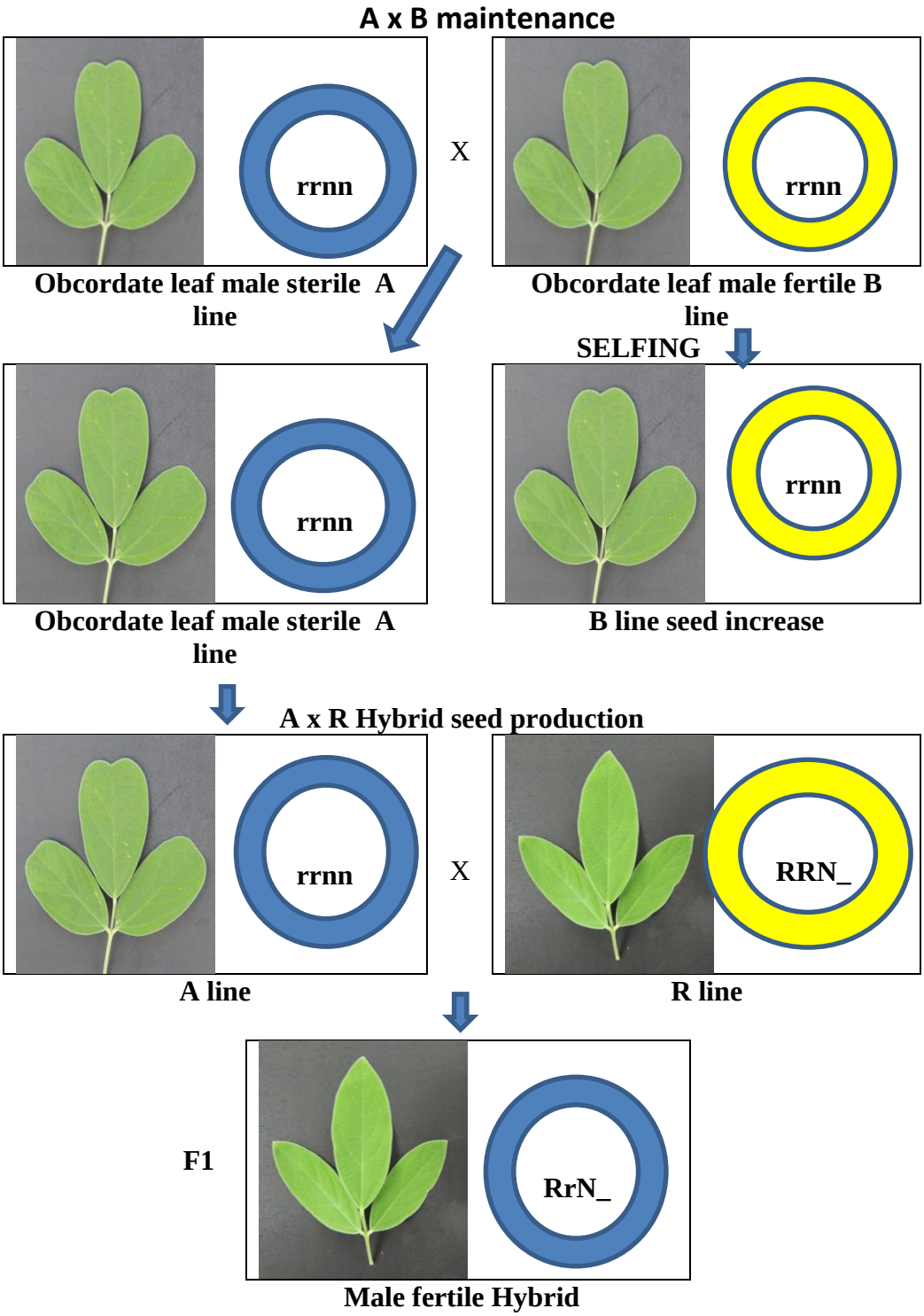


Figure 3. Details of the inheritance pattern of obcordate leaf shape and pollen fertility

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.

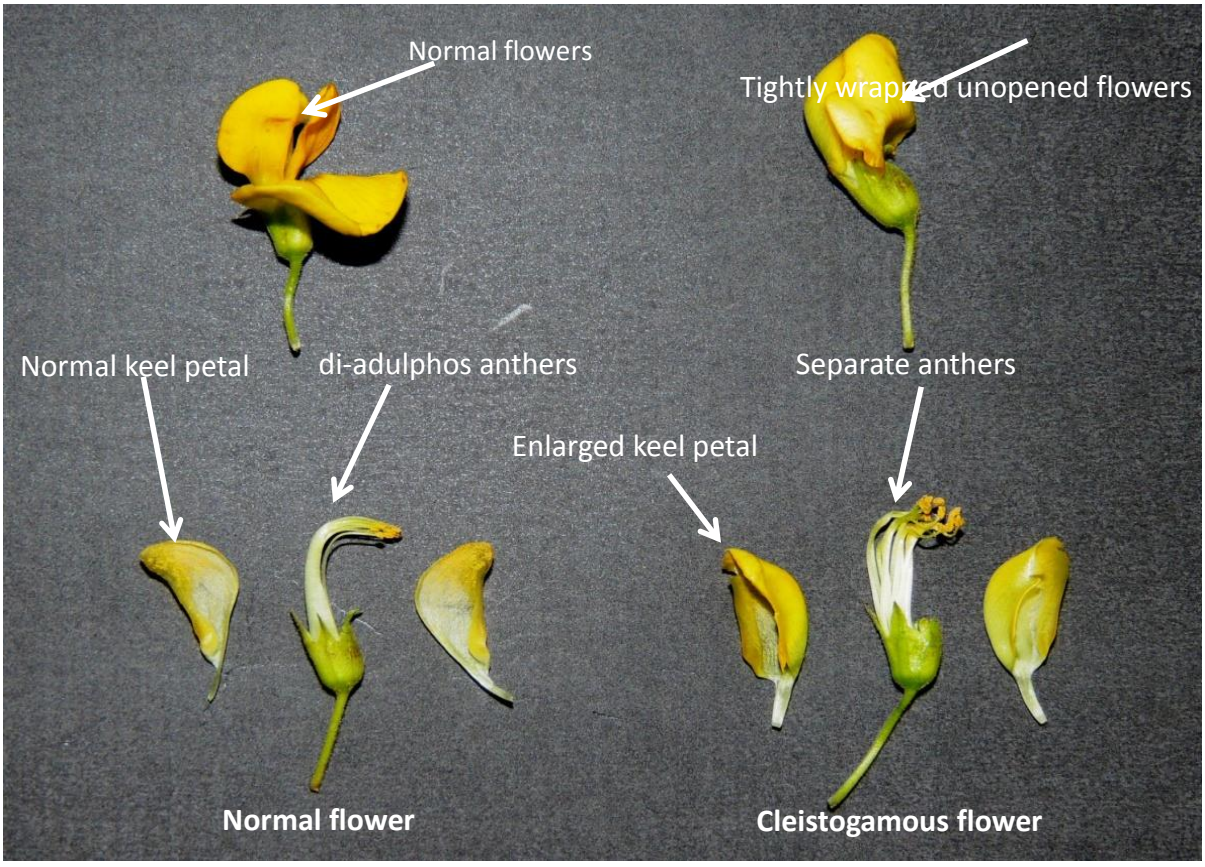
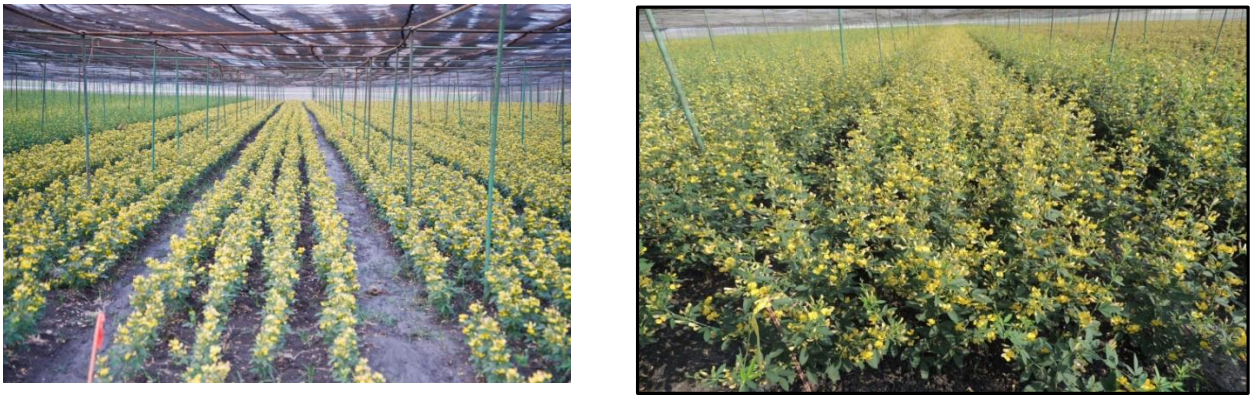


Figure 4. Flower structure differences in normal and cleistogamous flower

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)

Figure 5. Super early determinate and non-determinate pigeonpea lines

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