Hybrid seed production system in pigeonpea

*by K B Saxena**

Pigeonpea *[Cajanus cajan (L.) Millsp.]* is globally cultivated on 5.25 m ha land with an average production of 3.2 m tonnes. It is grown mainly in semi-arid regions of Asia and Africa. The yield levels of pigeonpea over the past few decades have remained low and unchanged at about 600-700 kg ha-1. Therefore to meet the demand of this pulse, there is a need to enhance its productivity. To achieve this objective concerted efforts are being made to exploit the natural out-crossing of this crop and develop high -yielding commercial hybrids. Recently, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has developed an excellent cytoplasmic-nuclear male-sterility (CMS) and its fertility restoring systems in pigeonpea and the experimental hybrids have demonstrated high yield advantages.

Fig 1: A standard field layout for seed production of a CMS line
A: CMS line B: Maintainer line

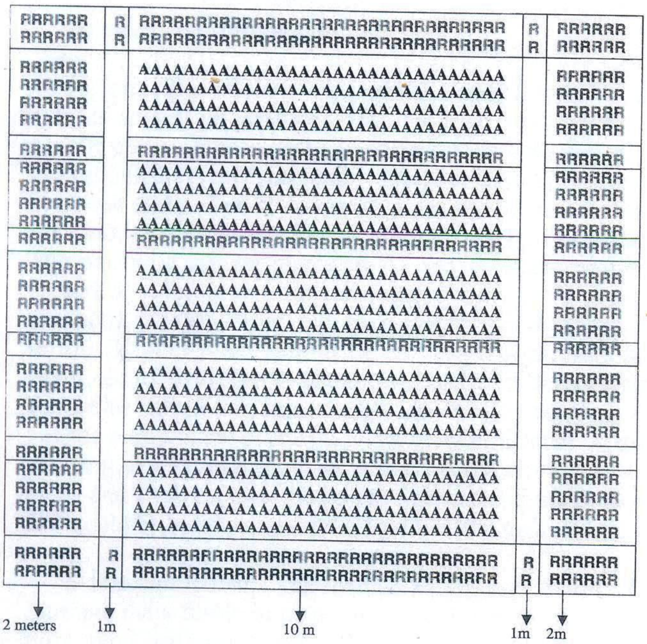
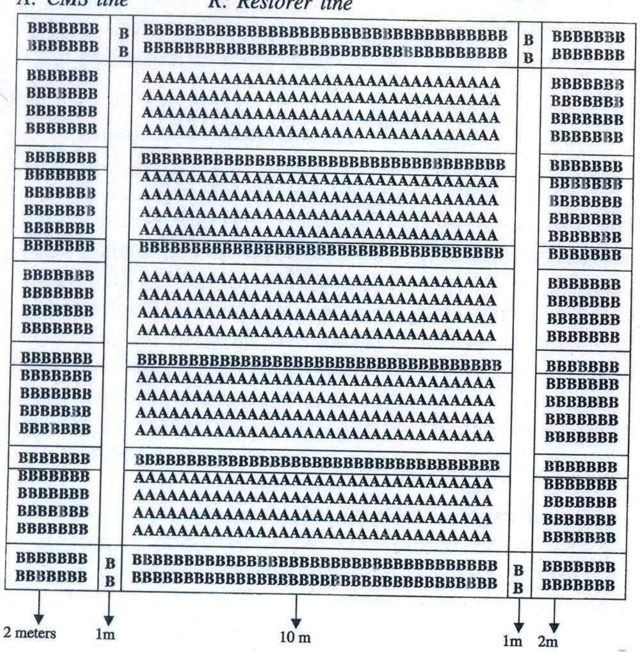


Fig 2: A standard field layout for hybrid seed production
A: CMS line R: Restorer line



Cytoplasmic-nuclear Male-sterility Systems

So far five primary CMS systems derived from variants inter-specific crosses have been reported in pigeonpea. These are (i) A1 cytoplasm, derived from *C. sericeus*; (ii) A2 cytoplasm, derived from *C. scarabaeoides*; (iii) A3 cytoplasm, derived from *C. volubilis*, (iv) A4 cytoplasm derived from *C. cajanifolius*, and (v) A5 cytoplasm derived from cultivated types. Of these, the CMS with A4 system has been found to be very stable and is being extensively used in the hybrid breeding programmes.

Genetic Control of Pollen Fertility Restoration

Limited data available from F1 and F2 generations of five crosses indicated that the fertility restoration in the hybrids between A- and R- lines is controlled by two dominant genes. The details studies are in progress.

High-yielding Hybrids

During 2005 rainy season, 272 experimental hybrids were evaluated at ICRISAT. Among the short-duration hybrids, ICPH 3310 was found to be the best, with seed yield of 4580 kg ha-1. This hybrid exhibited 207% superiority over the control UPAS 120 (1494 kg ha-1). The other promising hybrids in this group were ICPH 3309 (2273 kg ha-1, 52% superiority) and ICPH 3308 (3069 kg ha-1) with 66% superiority over UPAS 120 (1842 kg ha-1). In the medium-duration group ICPH 2471 (3364 kg ha-1) was the best, which exhibited 102% superiority over the most popular variety Asha (1658 kg ha-1). The other elite hybrids were ICPH 3489 (2901 kg ha-1, 75% superiority) and ICPH 3479 (2975 kg ha-1) with 61% superiority.

Isolation Specifications

Since the extent of natural out-crossing in pigeonpea is determined by the population of the pollinating insects, its extent may vary from one place to another. Therefore, it is

* *Special Project Scientist – Pigeonpea Breeding*
ICRISAT, Andhra Pradesh, India

difficult to specify isolation distances for different seed classes that would be effective at different locations. However, some safe and standard guidelines are essential to maintain the purity standards of the hybrids. Overall we feel that an isolation distance of 500 m will be sufficient for quality hybrid seed production in pigeonpea.

Seed Production Technology of Hybrid Parents

Nucleus seed production

A-line: The nucleus seed of the parental lines of the hybrids should be produced with the highest standards of genetic purity. For multiplying nucleus seed both A- and B-lines should be grown, preferably inside an insect proof cage. Each and every plant of A- and B- lines should be examined for various genetic purity parameters and off-types be rogued. The pair-wise (single plants of A- and B- lines) crossing should be continued until the desired number of pods is produced. The seed from each male-sterile (A-line) and male-fertile (B-line) plant should be harvested separately and examined for seed purity. The crossed seed of different plants should be bulked only after the breeder is satisfied about the genetic purity of the plants involved in hybridization. In case the breeder is assured about the genetic purity and uniformity of A- and B- lines, then the pollen from several plants of B-line could be bulked and used for pollinating male-sterile.

B-line and R-line: The maintainer (B) and restorer (R) lines are male-fertile in nature and thus produce genetically pure seed without much difficulty. For nucleus seed production of B- and R-lines, about 100 plants are harvested from the central portion of the breeder's seed production plot and their progenies be grown in the subsequent generation. After assessing their purity aspects, the selected progenies are bulked to serve as nucleus seed.

Breeder's seed production

A-line: For the production of breeder's seed of A-line, a field with appropriate isolation distance is selected and A- and B-lines are grown with recommended agronomic package. At ICRISAT, a ratio of 4 rows of A-line: 1 row of B-line has been found effective in producing pure seed of a given A-line (Fig 1). In the short-duration CMS line, the mature pods on male-sterile and fertile plants be harvested by pod picking or by cutting the top pod bearing portion of the plants. The perennial nature of species will force the plants to re-generate to produce a second flush of flowers and pods.

B-line and R-line: The source seed for breeder seed production is nucleus seed. These male-fertile lines should be multiplied in separate isolations. It is also important to multiply seed in large quantities so that foundation seed production is feasible. In addition, the B-line seed can also be harvested from the A-line seed production isolation.

Foundation seed production

The source seed for the production of foundation seed is breeder seed supplied by the breeder of the respective line. The package of practices followed in producing breeder seed is also followed in producing the foundation seed of the parental lines. Always sufficient care should be taken to rogue off-types as and when such plants are identified in the seed production plot.

Seeds of both A- and B-lines are planted at the same time in the ratio of 1 male (B-line) to 4 female (A-line) rows (Fig 2). Soon after flowering the pod set on male-sterile plants is observed as a consequence of natural out-crossing. Our experience at ICRISAT shows that insect activity at the farm is sufficient for the development of full pod load. However, if for some reason the pod load on the male-sterile plants is not full and the pollinator plants have also podded, then de-podding of male rows will help in the emergence of second flush of flowers. In the short-duration group more than one harvest of the crossed pods is possible. In the seed multiplication of ICPA 2039 at ICRISAT 27 kg of crossed

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seed was harvested from 225 m2 block with an estimated yield of 1111 kg ha-1. In another isolation of the same male-sterile line, 200 kg seed @ 877 kg ha-1 was harvested. The pods from the male-sterile rows should be harvested when their color turns from green to grey. It is advisable that threshing of pods should commence after three days of sun drying. The seed thus harvested be again dried in sun and packed after treating with Malathion powder @ 1 g kg-1 seed. From the same seed production isolation the seed of B- line can also be harvest. In case a large quantity of B- line seed is required, then it may be grown in a separate isolation. In the similar way seed of R-line can be produced in another isolation.

Certified seed production of hybrid

In a three-line hybrid seed production system, the hybrid seed produced by crossing A- line with R-line, is commonly called certified seed and it is grown on a larger scale. For the production of certified seed of hybrids the A-line and its pollen parent (R-line) are grown in 4: 1 ratio in an isolated block. Some additional rows of pollen parent can also be sown on each side of the plot. This will enhance pollen availability for cross pollination. The pollinati-ng insects visit the male and female flowers in a random fashion and in the process collect pollen from fertile plants and carry out hybridisation on the male-sterile plants. From a small (120m2) isolation a total of 15 kg seed @ 1250 kg ha-1 of hybrid ICPH 2671 was produced during 2005 rainy season with a row ratio of 1 male: 4 female. This ratio, however, cannot be recommended for all the environments and depending on the insect activity and time of sowing, it should be modified. If the hybrid parents are of short-duration then in the hybrid production block also the multiple harvesting is possible. For some reason if the pod set on A-line is inadequate and in the pollinator lines full pod set has occurred then depodding of the pollinator rows will be essential to additional pod set on A-line plants. The seed from the pollinator rows can be used in the subsequent generations also. In case the demand for R-line seed is high, then it should be multiplied in an isolation block.

Seed production cost of parents and hybrids

Seed cost plays an important role in the adoption of hybrids. Both, the technology itself and crop management practices are critical in determining the production costs. So far no study has been conducted to determine the production cost of CMS-based hybrids and their parents. However, the seed production feasibility studies conducted earlier using genetic male-sterility system showed that the hybrid pigeonpea seed could be produced at a reasonable price. Later, a detailed cost of seed production study was undertaken by Tamil Nadu Agricultural University, Coimbatore. In this experiment 813 kg ha-1 of hybrid seed was obtained in a single harvest resulting in approximately 1:32 seed-to-seed ratio (Murugrajendran et al., 1990). The estimated cost of hybrid seed in this trial was Rs 6.25 kg-1. Experiments at ICRISAT have also demonstrated that adoption of multiple harvest system could reduce the production costs significantly.

The author, Dr. Saxena (left), and ICRISAT Director General, Dr. William Dar inspect a pigeonpea field.

Conclusions

The seed production technology developed at ICRISAT will be useful for commercial seed production of hybrid pigeonpea. To select a row ratio for a particular area, the detailed production cost studies are needed. The low seed production cost in GMS-based technology suggests that the seed production cost of hybrid with CMS-technology will be within the affordable price range. Since the hybrid pigeonpea production technology is fully developed and private sector is showing keen interest, we hope that the farmers will soon reap the benefit of this technology.

**Reference/publication credits available*