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A BREEDING RECIPE FOR EXPLOITING HYBRID VIGOUR IN PIGEONPEA THROUGH SYBRIDS

Agriculture

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ABSTRACT

Sybrid breeding is a new concept for the genetic enhancement of often cross-pollinated crops where sufficient hybrid vigour is present but its commercial exploitation is limited due to one reason or the other. Application of sybrid breeding technology will allow plant breeders to partially harness the hybrid vigour for increasing yield. Sybrid breeding method can be deployed easily to pigeonpea where natural out-crossing is about 30-40%. The large-scale seed production of sybrid is cost effective and hassle-free. To guide the interested pigeonpea breeders the authors hereby present the methodology of selecting a pair of inbred lines and producing a medium maturing sybrid population.

KEYWORDS

Cajanus cajan, heterosis, inbred lines, out-crossing, seed production, yield enhancement

1. BACKGROUND INFORMATION

To break the decades-old shackles of low productivity in pigeonpea [*Cajanus cajan* (L.) Millsp], the crop breeders recently developed a three-parent hybrid technology. The results were encouraging with over 3000 on-farm demonstrations clocking 30-50% yield advantages over the best pure line cultivars. The seed production technology was also developed with on-farm hybrid seed yields ranging from 998 to 1671 kg/ha and mean of 1247 kg/ha (Saxena et al., 2018). These successes led to the release of three hybrids in India; however, their photo-sensitivity and long generation turnover time (Saxena et al., 2021) did not permit to conduct the grow-out tests to keep eye on the quality of hybrid seed.

The molecular breeders at the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) found a way to overcome this vital technology transfer constraint. The large-scale application of this technology may take a few more seasons. Pending this task and considering plateaued yields, an alternate method of breeding "sybrid" (Saxena, 2020) was developed which has potential to exploit hybrid vigour for increasing yield in this pulse crop.

The sybrid breeding technology has been designed to harness a portion of the available hybrid vigour for productivity enhancement in pigeonpea by using its natural cross-pollination but excluding any male sterility system (Saxena et al., unpublished). It is a two-parent population breeding method and its seed production is easy, cost effective and hassle-free; besides it does not require high grade technical skills.

The authors, for the benefit of pigeonpea breeders, hereby delineate the procedure for the synthesis of a high-yielding medium maturing sybrid. The methods for selecting a pair of inbred parental lines and then producing the sybrid seed are described.

SELECTION OF PARENTAL LINES

Authors have identified two high yielding inbred lines to produce the first sybrid. The criteria for selection were the high yield of their F_1 hybrid and similarity of some key morphological traits. A perusal of the plant and grain characteristics of both the parental lines ICPL 99050 and ICPL 87119 (Table 1) show a high degree of similarity between them. The parental lines have high yield potential, high levels of disease resistance, wide adaptation and the market-preferred traits (Saxena et al., 2016). It should be noted that high levels performances of both the inbred parents have led to their releases in the past for cultivation in peninsular India. ICPL 99050 was released as "TDRG 59" while ICPL 87119 was released as "Asha". Both these cultivars mature in about six months from sowing and fit in various cropping systems recommended for deep black cotton soils. These cultivars have potential to perform well under both sole a well as intercrops with cotton, sorghum, groundnut etc.

Interestingly, ICPL 99050 is a maintainer line of cytoplasmic nuclear male sterile line ICPA 2047. This line carries the cytoplasm of *Cajanus cajanifolius* and nuclear genome of ICPL 99050. At this point it should be noted that ICPA 2047 is also the female parent of the released pigeonpea hybrid ICPH 2740. Further ICPL 87119 or Asha has established its credentials as one of the best medium duration variety released in India. This variety is being used as control variety in the national and state level coordinated trials. This cultivar is also the male parent of the hybrid ICPH 2740.

The plant and grain characteristics (Table 1) of ICPL 99050 and ICPL 87119 match so much with each other that visually it would be difficult to distinguish the two inbred lines at any stage of plant growth or for seed traits. Studies conducted earlier at ICRISAT have shown that there are no significant reciprocal differences for any trait in pigeonpea (Pigeonpea Breeding Progress Report 1976-77, unpublished). Therefore, at nuclear-genome level the inbred ICPL 99050, TDRG 59, ICPB 2047 and ICPA 2047 are the same. This means the cross between ICPL 99050 and ICPL 87119 will have the same genetic potential as that of the hybrid ICPH 2740 (ICPA 2740 X ICPL 87119). From above discussion an inference can be drawn that any plant derived from cross ICPL 99050 x ICPL 87119 or ICPL 87119 x ICPL 99050 will have yield potential similar to that of the hybrid plant. Now, extending this equivalence to the context of sybrid, it can be said the cross-pollinated plants produced during the seed production of sybrid will be the representative of the hybrid ICPH 2740 and they will perform better than the parents.

In conclusion, both the parental lines selected for developing the sybrid are established pure line cultivars with high specific combining ability; and they produced a high yielding hybrid ICPH 2740. Further, the sybrid derived from these parental lines will be more or less similar to the hybrid ICPH 2740, but with the reduced productivity. Theoretically, such a sybrid will perform better than both the inbred lines; and the extent of its superiority will be in proportion to the level of out-crossing (minimum 30-40%) that occurred in its seed production plot.

2. Chronology of a Sybrid Seed Production Programme

1. Acquire breeder seed of ICPL 99055 (or ICPB 2740) and ICPL 87119 (or ICPR 2740). If needed, the seed purity assessment can be done using genomics tools.
2. Identify an isolation plot with a minimum of 500 m distance from other pigeonpea genotypes. Preferably it should be near some bushes and a water body to harbour pollinating insects.
3. Prepare field, ensure good drainage, apply DAP @ 100 kg/ha and make ridges 75 cm apart
4. For sowing use a row ratio of 2: 2 with one row vacant between the two genotypes. Spray a pre-emergence herbicide soon after sowing is completed. Tag the rows carefully.
5. Arrange rouging at late seedling, pre-flowering and flowering stages.
6. For controlling pod borer damage during the reproductive phase, spray insecticide late in the evening or early in the morning to protect the visiting pollinating insects.
7. At maturity harvest one genotype first in the entire plot and then go for the second to avoid any physical mixing.

8. Determine the proportion of hybrid seeds using genomics tools (Bohra et al. 2020).

Table 1: Plant and grain characteristics of the two parents and their hybrid selected for breeding a medium duration pigeonpea sybrid

Plant and seed trait	Parent 1 (ICPL 99050)	Parent 2 (ICPL 87119)	Sybrid (P_1 x P_2 or P_2 x P_1)*	
			Data	Compatibility
50% Flowering (days)	120-125	115-125	115-122	High
75% Maturity (days)	175-185	180-190	180-190	High
Plant height (cm)	>200	>200	>200	High
Primary branches	Profuse	Profuse	Profuse	High
Secondary branches	Profuse	Profuse	Profuse	High
Stem colour	Green	Green	Green	High
Photoperiod reaction	Sensitive	Sensitive	Sensitive	High
Flower colour	Yellow with dark brown streaks	Yellow with dark brown streaks	Yellow with dark brown streaks	High
Pod colour	Green with dark brown streaks	Green with dark brown streaks	Green with dark brown streaks	High
Seeds/pod (no.)	4 – 6	4 – 6	4 – 6	High
100-seed weight (g)	10-12	10-12	11-12	High
Seed colour	Brown, shining	Brown, shining	Brown, shining	High
Seeds shape	Round	Round	Round	High
Fusarium wilt disease	Resistant	Resistant	Resistant	High
Sterility mosaic disease	Resistant	Resistant	Resistant	High
Mean yield (kg/ha)	High	High	High	High
Dal recovery (%)	75-80	75-80	75-80	High
Dal appearance	Excellent	Excellent	Excellent	High
Dal protein (%)	20-22	19-21	20-23	High
Released as	cv .TDRG 59	cv. Asha	Hyb, ICPH 2740.	
Adaptation areas	Deep black cotton soils; sole and intercrops; and rainfed and irrigated			

*No reciprocal differences observed; Data source: Saxena et al. (2016) and some unpublished reports.

3. CONCLUSIONS

The inbred line used as female parent in developing a sybrid will play a major role in the overall performance of the sybrid; and the yield-topping (yield advantage) in the sybrid will come from the hybrid plants; and its proportion will be determined by the extent of cross-pollination that took place during its seed production. Breeding sybrid is a new concept in plant breeding and it can be applied easily to pigeonpea where sufficient hybrid vigour and cross-pollination are already documented. The suggested breeding approach is cost effective and exploits a portion of hybrid vigour. The sybrids will provide an alternative to develop high yielding cultivars. It is a procedure that does not require highly skilled personnel for its implementation. The outstanding feature of this method is that, unlike CMS-based hybrids, its seed production is very easy and hassle-free.

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