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*Commentary*

# Yes, breeders can smash the low yield plateau in pigeonpea!

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**A graduate from G. B. Pant University of Agriculture and Technology, Pant Nagar, Dr Saxena completed his doctorate in Plant Breeding and Genetics in 1974. He then joined ICRISAT as a pigeonpea breeder and was responsible for breeding both *dal* and vegetable type pigeonpea cultivars with wide adaptation and several varieties were bred and released with his collaboration and ICAR. During 1980-82, he was deputed to serve as a Visiting Scientist at the University of Queensland, Australia to introduce pigeonpea in drylands of the province. On return, he led the hybrid breeding project and his team succeeded in developing the world's first pigeonpea hybrid ICPH 8; and later, three more hybrids were also released. Dr Saxena also worked as Project Scientist for five years to promote pigeonpea in the dry lands of Sri Lanka. During his assignment in China, he helped local scientists in promoting pigeonpea in hilly areas of southern provinces for soil conservation and fodder purposes. Dr Saxena was also recognized with China's highest civilian honor "Friendship Award". During his long research career, extending over four decades, he has published more than 350 research papers.**

The mean pigeonpea productivity has clocked around 700 ± 50 kg/ha only between 1960 to 2020. This scenario indicates that increasing pigeonpea productivity has now become breeders' nightmare. Differing in opinion, it is now time to remove this low yield plateau by using new emerging technologies and alternate breeding schemes.

It would be worthwhile to take into consideration the factors that make pigeonpea plant vastly different from that of chickpea and other pulses; and these might partly be responsible for its poor harvests. Such plant traits include natural cross-pollination, low harvest index, perennial growth habit, photosensitivity, and long generation turnover time. Besides these, a few issues such as limited genetic diversity, susceptibility to various stresses, and unpredictable response to selection also adversely affect breeding value of selected individuals.

To save on research time and cost and enhance the efficiency of pure line breeding, breeders may resort to programs like transforming pigeonpea (an allogamous species) to autogamous type, early generation testing of crosses, rapid generation turn-over for speed breeding, and selection for traits like synchronous flowering and rapid seed growth. It is obvious that natural cross-pollination is the main villain of pure line breeding programme. This is because it not only creates hindrance in purity maintenance of the selections but may also misleads the breeder in implementing pedigree breeding. The chances are that the vigorous plants with more pods, present within a breeding population, could be natural hybrids; and in the next generation these will segregate and not breed true. This will lead to poor heritability and low breeding value of the selections. A potenital solution to this problem is to transform pigeonpea from allogamous to autogamous types. This can be done by incorporating a floral trait called "cleistogamous flower". This floral mutant does not encourage insect visitation and restricts out-crossing to <2%. This simply inherited recessive trait can easily be incorporated into breeding populations. The selections carrying cleistogamous flowers will record high heritability and it will make the pedigree breeding more meaningful and productive by fixing the additive genetic variation without any danger of losing the productive alleles.

Inherent limited genetic diversity in pigeonpea is another factor that needs to be enhanced to develop productive recombinants. This is achieved by incorporating genetic materials from related wild species. Considering the complexities of wide hybridization and potential linkage drag, a two-stage breeding programme is envisaged. Initially, unselected advanced generation “pre-breeding populations” are bred from inter-specific crosses. In the second phase, selection of desirable recombinants from these populations is exercised. Besides diverse crosses, the establishment and use of heterotic pools in crop breeding is also practised to develop diverse genetic materials. In this approach it is observed that the heterotic effects due additivity or epistasis are generally greater when lines with diverse genetic backgrounds or heterotic groups are mated. It is opined that in this breeding scheme pure lines with potential genes from diverse origin can combine to produce more productive individuals. This approach can easily be implemented in pigeonpea since a range of its wild relatives with wealth of genetic diversity are available.

The third and most potential approach is breeding CMS-based pigeonpea hybrids. Among pulses, pigeonpea offers a unique opportunity for exploiting hybrid vigour for significant yield gains. In this endeavour, significant R&D work has already been accomplished and published and at present four high yielding CMS-based hybrids are already available. The hybrid breeding technology has a real potential to break the decades-old yield barrier in pigeonpea. This is evident from the results of over 4000 on-farm trials conducted in four states. These trials demonstrated that the hybrids, on average, exhibited mean standard heterosis of 30-50%. Unfortunately, despite such positives, at present the farmers are unable to reap the benefits of this technology; and this is due to a single constraint of seed quality control. The great news, however, is that this constraint has now been addressed adequately using various genomics tools, and at present, a complete hybrid breeding and promotion package is ready for use to achieve the long-awaited breakthrough in pigeonpea yields.

It is essential to reiterate that yield stagnation in pigeonpea is a serious nutritional safety issue, particularly in the backdrop of population increments and need of more and more edible protein to secure the health of masses. Although breeders have produced improved pure line varieties and area under pigeonpea has also recorded significant increase, yet productivity enhancement remains a challenge. It is felt that among the approaches discussed, hybrid technology stands tall as an option. This is because it has already demonstrated its worth as on-farm yield advantages. Also, the hybrids have greater homeostatic-led stability effects. These twin benefits will surely help breeders in overhauling the existing productivity ceiling in pigeonpea. A concerted effort, however, is the need of the hour to take this technology to the doorstep of farmers. This responsibility can be undertaken jointly by coordinated efforts of institutions like ICAR-IIPR, ICRISAT, and public and private seed companies.