Strategies for pigeonpea improvement

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Abstract: In order to feed an ever-increasing population, it is essential to deal yield-reducing factors. Climate smart crop varieties that yield more with fewer inputs will be required to achieve the success. In this scenario pigeonpea plays an important role as it can stand in relatively harsh environmental conditions. Hybrid breeding along with the pure line breeding, genetic resources and genomics advances are enriching this crop. However, the pigeonpea improvement program must be re-oriented in order to deal with the yield-reducing factors and to break the yield plateau.

Key words: genomics assisted breeding, pigeonpea, quality control, value chain

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is rich in seed protein (20% - 22%) and its de-hulled split grains (dal) constitute a major supplement in the diets of most vegetarian families around the globe (5). In spite of extensive research and development activities in the last four decades, the yield levels remain stagnated in pigeonpea. The development of hybrid technology (6) has shown promise in this direction but its adoption is below the expectations due to some production and marketing reasons. Now the time has come to move forward more vigorously with backing of new technologies to overcome the present constraints and breed new cultivars at a rapid pace (4).

In this article we are sharing experiences and ideas to improve pigeonpea research for resource poor farmers in Asia and sub-Saharan Africa.

Integration R & D for hybrid and inbred cultivars

In a dynamic breeding program it is important that cultivars are released from time to time to cater the changing needs of farmers and market. In pigeonpea the technologies for breeding both hybrids and pure line cultivars are available and both types of products are in demand now. Considering the cost and resources involved in breeding, it is logical to integrate these two types of breeding programs. It should be done in such a way that the objectives and primary activities in either program are not compromised. For example breeding of inbred lines for variety development and breeding of new testers for hybrid program should go hand in hand. Selection of parents to develop breeding populations can be done together by considering their combining ability, genetic diversity, and market traits. Similarly screening of selections for biotic and abiotic stresses, their evaluation and maintenance for the two programs can be integrated together. In advance stages of pedigree selection, a set of high yielding inbreds can be picked to identify cultivars for a given region. On the other hand, a greater early generation selections from the same lot can be used as testers for hybrid breeding program to select potential fertility restorers and maintainers. The other research and development areas that would require serious attention are: exploitation of photo thermo sensitivity in hybrid breeding, diversification of hybrid parents, development of heterotic groups, refining seed technology and technology transfer to the farmers (Fig. 1).

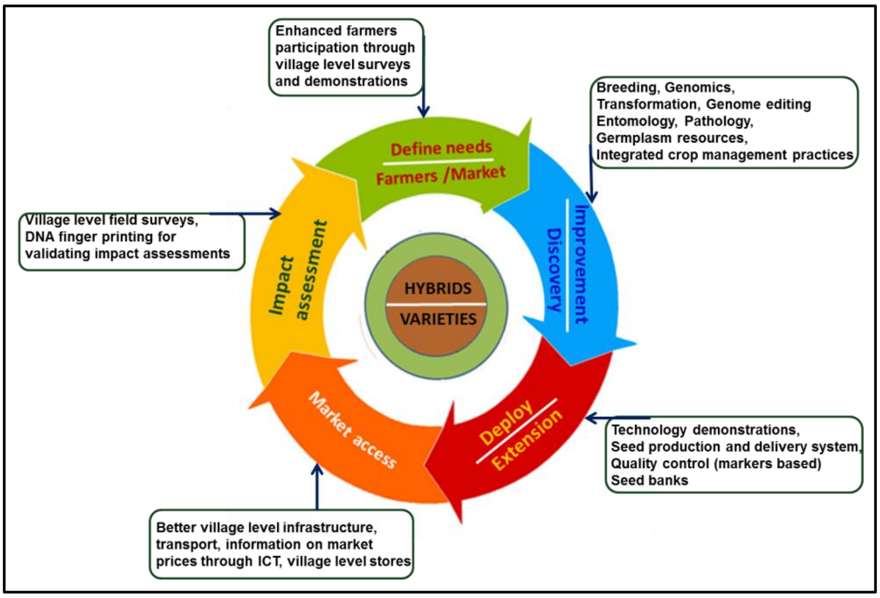

Figure 1. A schematic diagram representing different components for pigeonpea (hybrids and varieties) value chain

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Breeding high-yielding second-generation hybrids

The present set of hybrid parental lines has produced several good hybrids and showed high productivity in farmers' fields. In most places the hybrids have recorded the productivity between 2,500 kg ha^{-1} - 3,500 kg ha^{-1} with a yield advantage of 35% - 45% over ruling cultivars (6). This can be considered a good start to break the decades-old yield barrier, however, considering the potential of hybrid technology and realized yields from hybrids in other field crops, it is reasonable to believe that pigeonpea breeders would be aiming to produce new generation hybrids with yields of over 5,000 kg ha^{-1}. To achieve this, however, concerted efforts will be made to breed new hybrid parents using modern resources available in germplasm and genomics.

Enhanced participation of genomics and germplasm resources

For sustainable and rapid development in pigeonpea it is highly imperative to use genomics and germplasm resources in all possible breeding programs. In the case of genomics starting from markers based selection for key traits (biotic and abiotic stresses, fertility restoring genes, etc.), markers based purity testing of hybrids and parental lines, characterization and documentation of elite genotypes, understanding molecular basis of CMS systems and defining the heterotic groups are the prime targets. Recent advances in pigeonpea genomics have created an opportunity where we can deploy genomics in all above mentioned areas (4). For instance markers have been identified for fusarium wilt (7), sterility mosaic diseases (3), fertility restoration (2), and hybridity testing (1). Efforts are underway to detect markers for key agronomic traits. This will certainly enhanced the capacity of pigeonpea breeding programs. On the other hand initiatives to define heterotic groups and exploiting photo thermo sensitivity will certainly enrich the hybrid breeding.

Germplasm resource is very rich and contains a large variability with respect to various morphological traits. However limited resources from germplasm have been used in breeding programs. For continuous induction of new allelic combinations from germplasm in ongoing breeding programs, efforts have to be made to evaluate the situation and their systematic use. Genomics can play a major role in deployment of germplasm resources in breeding programs by fingerprinting and cataloging the desirable genes/genomic segments. Genomics data will be helpful in avoiding the linkage drag and the generation of well-planned breeding materials in collaboration with major disciplines involved in improving pigeonpea.

Outlook

In view of above it is evident that following are required to enhance the pigeonpea improvement program 1) research should be guided by farmers' needs, 2) advance breeding methodologies should be deployed by integrating genomics, genetic transformation for insect resistance and genome editing such as CRISPR/Cas9 multiplex editing for desirable traits, 3) improved seeds should be developed and seed delivery system should be strengthened and 4) agronomy and integrated crop management practices should be refined to achieve maximum yield potential of varieties or hybrids.

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