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SyBrid - A New Breeding Method for Food Legumes

K. B. Saxena

Former Principal Pigeonpea Breeder, ICRISAT, Patancheru, Telangana, India
Presently at: 2, ICRISAT Colony (I), Bowenpally, Secunderabad, Telangana, India

Abstract: ***Legumes in general, are grown under subsistence agriculture and their productivity is invariably low. Being predominantly a self –pollinated group of crops, only inbred cultivars were bred in the past with marginal yield advantages. An alternate breeding method has been proposed that is capable of exploiting part of hybrid vigour to improve yield potential of some legume crops without any serious seed production hassle. The breeding product, named "SyBrid", is an amalgam of the concepts of breeding synthetic and hybrid cultivars. It uses natural cross-pollination but no male sterility system. Potentially, the "SyBrid" cultivars are expected to boost yield by a margin of 10-15% or more. The seed production of "SyBrid" cultivars is cost effective and easy.***

1. Introduction

Legumes are integral part of ecosystem since they contribute in sustaining agricultural systems in the tropics and sub-tropics. The protein-rich legumes, predominantly cultivated in developing countries, are also known for their role in maintaining nutritional security of masses. Globally, more than a dozen legumes are cultivated, but the commercial class legumes are groundnut, soybean, faba bean, mung bean, common bean, urd bean, cowpea, dry pea, pigeonpea, chickpea, and lentil. Of these, only soybean, groundnut and lentil produce >1000 kg/ha yield and the rest are far behind. The breeding efforts for increasing yields in these legumes have not been highly successful.

Legumes, as a group, are viewed as self-pollinated crops but it is not entirely true; and in some legumes appreciable extent of natural cross-pollination occurs. Among these faba bean (*Vicia faba* L.) and pigeonpea (*Cajanus cajan* L.) are prominent; and cowpea (*Vigna unguiculata* L.), mung bean (*Vigna radiata* L.), and common bean (*Phaseolus vulgaris* L.) come next (Table 1). In the absence of wind pollination, the out-crossing in legumes is facilitated by a variety of foraging insects.

In the past few decades, the productivity rise in cereals has been phenomenal, but the legumes could never reach even near to it. A greater share of the successes in cereals is attributed to the breeding of high yielding hybrids. In order to enhance the productivity of legumes, some crop breeders also tried to emulate cereal breeders and started research for exploiting hybrid vigour in this group of crops. Unfortunately in spite of the presence of significant amounts of hybrid vigour, the success in developing hybrids eluded them (Saxena et al., 2020a) either on account of non-availability of stable male sterility (faba bean), insufficient cross-pollination (soybean) or seed quality control (pigeonpea). In conclusion, the hybrid vigour, though available in legumes, could never be exploited to benefit the farming community. Therefore, a new breeding concept was evolved. This technology, called as "SyBrid Breeding", that is based on partial exploitation of hybrid vigour was designed.

"SyBrid" – a new breeding product

In this research article, a new breeding method that is capable of exploiting a part of hybrid vigour without any seed production hassle is presented. Breeding of this product, named as "SyBrid", is an amalgam of the concepts of breeding synthetic and single cross hybrid cultivars. To develop this, two high yielding inbred lines are selected and the natural cross-pollination is used to produce hybrid seed on one line from the pollen transferred by insects from the other. The seeds, produced by the self-pollination on the female parent and those produced by cross-pollination, are bulk harvested is called as "SyBrid". This seed mixture is grown only once to reap the benefits of hybrid plants as well as the inbred line. In contrast to hybrids, the "SyBrids" utilize only natural cross-pollination but excludes any male sterility system. It seed production of "SyBrids" is easy, cost effective and does not require high grade technical skills.

2. Theoretical Considerations

Breeding synthetic cultivars is one of the established methods for cross-pollinated crops. In this method 5-8 elite inbred lines are crossed with each other and equal number of the crossed seed is bulked together. This mixture is exposed for random mating using natural cross-pollination. Such synthetic populations are heterogeneous as well as heterozygous. Its seeds can be sown for 4-5 consecutive seasons; and hence the yield will be influenced by both, the hybrid vigour and inbreeding depression.

In contrast, the "SyBrids" is a mixture of self-pollinated seeds of the female parent and cross-pollinated (hybrid) seeds. Hence, theoretically, the "SyBrid" is a heterogeneous population and the proportion of inbred and hybrid plants will depend on the extent of cross-pollination that took place in its seed production plot in the preceding season. A "SyBrid" population is expected to be benefitted from additive, dominance and epistatic genetic gene actions to produce more grains. Since for commercial sowing always new seed will be used, there will not be any yield loss on account of inbreeding depression.

In comparison to an inbred or hybrid cultivar, a "SyBrid" has broader genetic base and, therefore, it is expected to demonstrate high buffering capacity to resist various stresses. Besides high yield, the hybrid plants present in the "SyBrid" population will also have faster seedling growth, greater biomass, and ability to tolerate drought (Saxena et al., 1992; Lopez et al., 1996, Saxena et al., 2020b). These unique traits of the hybrid plants, though less in number, can provide some benefits to farmers from intermittent droughts and in completion from companion crops.

Breeding methodology

Selection of parental lines: Selection of inbred parents for developing a "SyBrid" cultivar is critical and a great care should be taken in this process. Since the "SyBrid" will be a mixture of inbred and hybrid seeds, there will be a certain level of heterogeneity in the population with respect to various plant traits. Therefore, to give it a uniform appearance, attempt should be made to select the two parents which look more or less similar in plant type, growth habit, flowering time etc. It is also important that the female inbred is high yielder. Besides per se performance, the parental lines selected for "SyBrid" breeding should also have high combining ability. Another important factor that needs consideration, while breeding "SyBrids" is the genetic diversity of the two parents, because this factor positively correlated with the expression of hybrid vigour.

Breeding methodology: The ten generalized steps involved in breeding of a "SyBrid" cultivar are summarized in Table 2. These may be followed with care while implementing a breeding programme.

Seed production: Seed of a "SyBrid" should be produced in isolation that is separated from other pigeonpea by at least 500 meters. Preferably, the isolation plot should be located near wild bushes, trees and water bodies as these are likely to harbour more insect pollinators and, thereby, result in increased cross-pollination rate in the production plot. Roughing should be done in the parental lines at seedling, flowering and green pod stages. At harvest, extra care is required and the male rows should be removed first and then the female rows be harvested.

3. Conclusions

Breeding "SyBrids" cultivars is a new concept in plant breeding. It can be applied for yield enhancement to the crops where some degree of out-crossing takes place and hybrid vigour is present. But, the regular hybrid production is not possible either due to non-availability of stable male-sterility or insufficient level of out-crossing. In this system, the productivity enhancement can be achieved by harnessing a part of the available hybrid vigour in a cross through natural cross- pollination and without using any male sterility system. It is expected that by cultivating "SyBrids", the farmers can harvest 10-15% additional grains. It is a good breeding provides option to increase crop yield. It is cost effective, easy to implement and does not require highly skilled personnel.

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Table 1: Cross-pollination values reported in some legumes

Crop	Scientific name	% cross-pollination
Faba beans	*Vicia faba* (L.)	84
Pigeonpea	*Cajanus cajan* (L.)	70
Cowpea	*Vigna unguiculata* (L.)	15
Mung bean	*Vigna radiata* (L.)	13
Common bean	*Phaseolus vulgaris* (L.)	10
Lentil	*Lens culinaris* (Medik)	6
Soybean	*Glycine max* (L.).	3
Chickpea	*Cicer arietinum* (L.)	2
Pea	*Pisum sativum* (L.)	2

Source: Cited from Saxena et al. (2020a)

Table 2: Ten easy steps to breed a "SyBrid" cultivar for a specific area or production system

Step	Activity
1	Set objective in relation to location, maturity, plant type, and disease resistance.
2	List promising germplasm, cultivars, and advanced breeding lines.
3	Get information on per se performance and genetic diversity of lines and finally select 6-8 lines
4	Collect pure seeds; make diallel crosses; study their combining ability and heterosis in crosses.
5	Select the best combination. Plant the parental lines in isolation using 1 Male: 2 Female rows.
6	Undertake roguing at seedling, flowering, and early podding stages.
7	Allow cross-pollination between the two parents
8	Harvest male rows first.
9	Harvest female rows later; collect "Sybrid" seeds.
10	Evaluate the "SyBrid" with locally adapted cultivar.