PRODUCTION OF SYNTHETIC VARIETIES

Madhu Choudhary*, Kana Ram Kumawat, Ravi Kumawat and Mamta Bajya
Department of Plant Breeding and Genetics, S.K.N. Agriculture University, Jobner-303329, Jaipur (Rajasthan), India
***Corresponding Author E-mail: anamikaz0129@gmail.com**

Introduction

The possibility of commercial utilization of synthetic varieties in maize was first suggested by Hayes and Garber in 1922. Synthetic varieties have been of great value in the breeding of those cross-pollinated crops where pollination control is difficult, *e.g.*, forage crop species, many clonal crops like cacao, alfalfa, clovers etc. Even in maize improvement programme, CIMMYT, Mexico is based on population improvement; the end-product of such a programme is usually a synthetic variety. The same applies, albeit to a lesser extent, to the pearlmillet improvement programme of ICRISAT, Hyderabad, India.

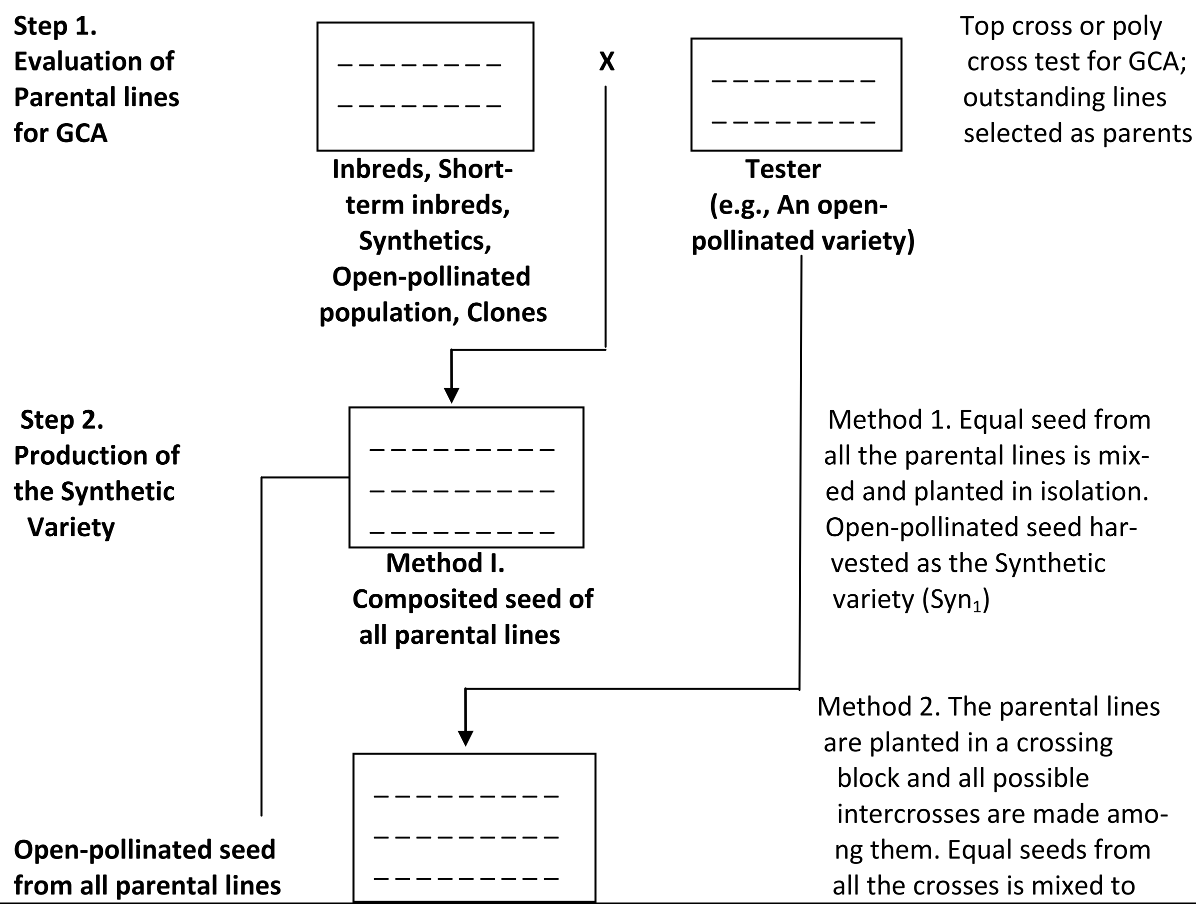
Definition

A synthetic variety is produced by crossing in all combinations a number of lines that combine well with each other and is maintained by open-pollination in isolation. It would be seen that such a synthetic variety is essentially a mixture of several single cross hybrids.

Procedure

The lines that make up a synthetic variety may be inbred lines, short-term inbred lines, clones, open-pollinated varieties or other populations tested for GCA or for combining ability with each other. The procedure for production of synthetic varieties are briefly described below and depicted in Fig.

Procedure for Production of Synthetic Varieties



harvested

Method II.
Crossing block

produce the Synthetic variety (Syn_1)

All possible intercrosses made and equal seed from all the crosses composited

Step 3.
Seed Multiplication

Seed multiplication (open-pollination in isolation)

Seeds of the synthetic variety may be multiplied for one or two generations before distribution by open-pollination in isolation

1. **Evaluation of Lines for GCA**
   GCA of the parental lines of synthetic varieties is generally estimated by top cross or poly cross test because these varieties exploit that portion of heterosis, which is produced by GCA. The lines that have high GCA are selected as parents of a synthetic variety.
2. **Production of a Synthetic Variety**
   A synthetic variety may be produced in one of the following two ways; the available experimental evidence suggested that both the methods yield comparable results.
   - **a.** Equal amounts of seed from all the parental lines, i.e., Syn_0 generation, are mixed and planted in isolation. Open-pollination is allowed and is expected to produce crosses in all possible combinations among the parental lines. The seed from this population is harvested in bulk and the population raised from this seed is the Syn_1 generation of the synthetic variety.
   - **b.** All possible crosses among the selected parental lines are made in isolation. Equal amounts of seed from all the crosses are composited to produce the synthetic variety; the population derived from this composited seed is the Syn_1 generation.
3. **Multiplication of Synthetic varieties**
   After a synthetic variety has been synthesised, it is generally multiplied by open-pollination in isolation for one or more generations before its distribution for cultivation. This is done to obtain commercial quantities of seeds and is a common practice in most of the crops. But in some crops, e.g., sugarbeets, the synthetic varieties are distributed for cultivation without seed increase, i.e., in the Syn_1 generation itself.
   The open-pollinated progeny from the Syn_1 generation is termed as Syn_2, that from Syn_2 as Syn_3, etc. The performance of Syn_2 is expected to be lower than that of Syn_1 due to the production of new genotypes and decrease in the level of heterozygosity as a consequence of random mating. However, there would not be noticeable decline in the subsequent generations (Syn_3, Syn_4, Syn_5 etc.) produced by open-pollination since the zygotic equilibrium for any gene is reached after one generation of random mating. The synthetic varieties are usually maintained by open-pollinated seed and may be further improved through population improvement schemes, particularly through recurrent selection.

Factors determining the performance of synthetic varieties

The yield of Syn_2 , as noted earlier, is lower than that of Syn_1 due chiefly to (1) the production of new gene combinations and to some extent, (2) a loss in heterozygosity, both being the consequence of random mating in Syn_1.

1. **Decline in Heterozygosity**

   Random mating in Syn_1 leads to a marginal to appreciable loss in heterozygosity in Syn_2 as compared to that in Syn_1. The magnitude of decline in heterozygosity in Syn_2 depends on the number of inbreds involved in a synthetic and on the proportion of inbreds having different alleles at a given locus. In the Syn_2 generation, produced by random mating in Syn_1, there will be a decline of 5.5 to 10 per cent in heterozygosity, depending on the proportion of inbreds having different alleles at the given locus. When short-term inbreds are used for production of synthetic varieties, some of the inbreds would be heterozygous for the gene in question. It can be readily shown that this situation reduces the maximum heterozygosity attainable in Syn_1 and the magnitude of decline in heterozygosity in Syn_2.

2. **Decline in Syn_2 Performance**

   The yield of Syn_2 is lower than that of Syn_1 mainly due to the loss in heterozygosity as a result of random mating. This decrease in Syn_2 generation would depend upon (1) the number of parental lines (Syn_0 populations) constituting the synthetic and (2) on the difference in yielding abilities of Syn1 and Syn_0 generations. Syn_1 is the first generation synthetic produced by mating in all possible combinations the n parental lines (designated as Syn_0). This relationship was first suggested by Sewall Wright in 1922 and may be represented as follows:

   $\overline{Syn_2} = \overline{Syn_1} – [(\overline{Syn_1} – \overline{Syn_0}) / n]$

   Where, n is the number of parental lines entering the synthetic variety. The performance of Syn_3 and the subsequent generations obtained by random mating is expected to be comparable to that of Syn_2, provided contamination by foreign pollen and inbreeding are avoided. Available evidence shows that the above formula estimates the yield of Syn_2 populations quite reliably.

3. **Enhancing the Performance of Syn_2**

   It is apparent from the above relationship that the performance of Syn_2 can be improved as follows: (1) by increasing the number of lines entering into the synthetic, (2) by increasing the performance of Syn_1 and (3) by improving the performance of Syn_0 or the parental lines.

   (1) Increasing the number of parental lines

   An increase in the number of lines entering a synthetic would improve the performance of its Syn_2 generation. Practically, lines with outstanding GCA in any crop are limited in number. Therefore, as n is increased, lines with poorer GCA would have to be included in the synthetic. This would reduce the performance of Syn_1 and therefore, that of Syn_2. Thus n cannot be increased beyond a certain level without adversely affecting the performance of Syn_1 unless several lines with outstanding GCA are available. Generally, a compromise has to be made between these two opposite forces. Obviously, the appropriate n would depend upon the GCA of the available lines. In practice, the number of lines entering a synthetic variety varies from 3-15, but 4-10 is the most common number.

   (2) Increasing the performance of Syn_1

   The performance of Syn_1 is the average performance of all single crosses among the parental lines. Clearly, Syn_1 performance depends upon GCA of the parental lines.

   (3) Improving the performance of parental lines (Syn_0)

   Syn_2 performance can be improve by increasing the performance of parental lines themselves. This can be achieved in the following three ways. First, second and third cycle inbreds may be developed as their performance would be better than that of the first cycle ones. Second, inbreds may be isolated after the population has been subjected to recurrent selection for GCA. Finally, short-term inbred lines or even non-inbred lines or population may be used as a parent.

The use of short-term inbreds is an attractive idea. Plants differ in GCA in the early stages of inbreeding process and even S_0 plants differ for GCA. Thus synthetic varieties may be constituted from plants or lines that have undergone only limited inbreeding, e.g., for one or two generations or no inbreeding at all. Theoretically, the performance of a Syn_2 from non-inbred lines is expected to be higher than that of a Syn_2 derived from inbred lines if the performance of Syn_1 populations were comparable or equal. Further, the peak performance of Syn_2 would be attained with a relatively smaller number of non-inbred lines than with inbred lines. It may be pointed out that synthetics constituted by crossing of populations subjected to RSGCA and RRS would serve the same purpose as developing synthetic varieties from short-term inbreds or non-inbreds.

Maintenance of Synthetic Varieties

Synthetics are generally maintained from open-pollination seed produced in isolation. The seed preserved for raising the next generation should be a sufficient large random sample to prevent inbreeding. However, there is evidence that the genetic constitution of synthetic varieties changes due to natural and artificial selections. This may adversely affect the performance of synthetic varieties but in some cases it may improve their performance appreciably. Hence it is desirable to reconstitute synthetic varieties at regular intervals from parental lines. Exact reconstitution of a synthetic variety is possible only when the parental lines are inbreds or clones. In such cases, the synthetic varieties have to be maintained from open-pollinated seed or have to be reconstituted from the parental lines that may have undergone genetic changes.

The synthetic varieties have considerable genetic variability, which responds to population improvement. Thus they offer an excellent opportunity for further improvement in yielding ability through selection, particularly recurrent selection.

Merits of Synthetic Varieties

1. Synthetic varieties offer a feasible means of utilizing heterosis in crop species where pollination control is difficult and production of hybrid varieties would not be commercially viable.
2. Farmers can use the grains produced from a synthetic variety as seed to raise the next crop. If care is taken to avoid contamination by foreign pollen and to select a sufficiently large number of plants to avoid inbreeding, the synthetics can be maintained for several years from open-pollinated seed. As a result, farmers do not have to purchase new seed every year.
3. In variable environments, synthetics are likely to perform better than hybrid varieties because of their wider genetic base.
4. Cost of seed is relatively lower than that of hybrid varieties.
5. Seed production of hybrid varieties is a more skilled operation than that of synthetic varieties.
6. Synthetic varieties are good reservoirs of genetic variability.
7. Performance of synthetic varieties can be considerably improved through population improvement without appreciably reducing variability.

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