CHAPTER TEN

Parent Selection

One of the most important decisions a plant breeder must make involves the selection of parents for population development. The decision-making process includes identifying the characters to be improved, understanding how the characters are inherited, and identifying sources of parental germplasm.

CHARACTERS TO BE IMPROVED

The proper selection of parental germplasm begins with a clear understanding of the goal of the breeding project. Breeding a better cultivar is not an adequate statement of the objective, because the breeder can consider many characters for improvement. The methods used in a cultivar development program and their probability of success are dependent on the number of characters to be improved simultaneously. The proportion of desired individuals for multiple characters in a population is obtained by multiplying together the proportion of desired individuals expected in the population for each character to be improved. This assumes that the characters are inherited independently, i.e., are not genetically correlated. As an illustration of the principle, assume that there are five characters, A through E, that could be improved in developing cultivars of a species. The proportion of desired individuals in a population for character A is $^1/_4$, B $^1/_8$, C $^1/_{20}$, D $^1/_{60}$, and E $^1/_{100}$. If improvement of all five characters were the objective, the proportion of desired individuals would be $^1/_4 \times {}^1/_8 \times {}^1/_{20} \times {}^1/_{60} \times {}^1/_{100} = {}^1/_{3,840,000}$. Selection for characters A, B, C, and D would involve the proportions $^1/_4 \times {}^1/_8 \times {}^1/_{20} \times {}^1/_{60} = {}^1/_{38,400}$, and selection for characters A, B, and C would involve $^1/_4 \times {}^1/_8 \times {}^1/_{20} = {}^1/_{640}$. The probability of success would be greater by considering improvement of characters A, B, and C, instead of A through D or A through E.

The breeder generally is required to assign priorities to the characters that could be considered for improvement. Most breeding programs have one or a few characters that are of paramount importance. In most instances, these are the characters that are of greatest economic importance. They would include plant or seed yield, for many agronomic crops; attractiveness of the flower or plant, for ornamental species; and flavor and color, for fruit crops. The characters of major importance are given first priority in determining the parents that will be used for population development.

In determining the characters of highest priority, it is important for the breeder to clearly understand the requirements of consumers, be they farmers, manufacturers, or the end users. It is not uncommon to hear a breeder say that the consumer demands a certain characteristic. Such a statement must be based on fact, not personal opinion. For example, lodging resistance is a trait considered important by many breeders of agronomic crops. One of the most widely grown soybean cultivars in the midwestern United States during recent years was 'Corsoy,' a lodging-susceptible cultivar. Farmers commonly said that the only good characteristic of the cultivar was its high yield. The widespread use of 'Corsoy' indicated that farmers considered yield a first priority and lodging resistance of secondary importance. The breeder can limit the characters considered in a breeding program by paying attention to the real demands of the consumer. A direct means of acquiring information on consumer preference is an appropriate survey. Reinhart (1979) surveyed randomly selected oat growers in Iowa to identify production practices used by farmers, as well as the characteristics the growers considered important when selecting a cultivar for commercial production. High grain yield was a clearly preferred characteristic, as were medium plant height and medium time of maturity.

INHERITANCE OF THE CHARACTER TO BE IMPROVED

The inheritance of characters ranges from control by one major gene whose expression is not influenced by the environment (qualitative characters) to control by many genes and much influence by the environment (quantitative characters). Selection of appropriate parents for a qualitative character controlled by a single major gene is relatively easy, because the breeder can determine through appropriate tests if the parent has the gene or does not. At least one parent of a cross must have the gene for it to be recovered in the progeny. Specific resistance to a plant pest often is controlled by a single major gene. The breeder chooses one or more parents that possess the necessary gene when developing a population for selection of cultivars that must have resistance. The same principle applies for characters controlled by one or a few major genes or quantitative characters with a high heritability. Time of maturity is a quantitative character in most species. The distribution for maturity among progeny in a population will be closely associated with maturity in the parents selected. It is possible to obtain transgressive segregation for maturity within a population, but the frequency of such segregates would be less than the frequency of offspring with a maturity within the range of that of the parents.

Selection of parents is more difficult for characters that are to be improved beyond the level that is present in available germplasm. Yield is an example of a quantitative character that breeders attempt to improve beyond the level of that present in current cultivars. The selection of parents for such characters generally involves selection of elite germplasm with the best performance for the character and the greatest genetic diversity available. The common practice of crossing together elite lines, referred to as making good × good crosses, has narrowed the genetic diversity among commercial cultivars of most species (National Academy of Science, 1972). This decreases the array of alleles available among parents for continued improvement of the species. Unfortunately, the most elite breeding lines often have the least amount of genetic diversity, because they were selected as the progeny of parents with similar ancestry. Plant breeders attempt to develop populations from elite parents that have the most diverse ancestry possible, to increase the chance of obtaining a superior progeny with different favorable alleles from all of the parents.

SOURCES OF PARENTAL GERMPLASM

The breeders of most species have several sources of parental germplasm available to them. The soures can be subdivided into classes on the basis of their similarity to commercially grown cultivars of the crop.

Commercial Cultivars

The parents most widely used by plant breeders are current cultivars that are grown commercially, the inbred parents of hybrid cultivars, or parents of synthetic cultivars. These cultivars represent the most elite source of germplasm for characters of major importance. The mean performance of a population developed from commercial cultivars will be high, and the probability of obtaining superior progeny with no major weaknesses is good. On the other hand, if the genotypes of the cultivars used for population development are similar, the possibility of obtaining adequate genetic variability in the population to achieve major improvement in a character may be small.

Elite Breeding Lines

Lines in advanced stages of testing are a useful source of parental germplasm. The lines may be destined for release as cultivars or may closely approach that level of performance. Plant breeders increase their potential genetic gain per year by using breeding lines as parents as soon as the superiority of the lines is identified (Chap. 17). The availability of elite breeding lines generally is limited to the originator. Public breeders commonly exchange elite breeding lines with each other, as do private breeders within the same company. Exchange of elite breeding lines among public institutions and private companies is determined by the policy of the institutions involved. In the United States, public universities and the U.S. Department of Agriculture have guidelines for release of germplasm to the public, referred to as the ESCOP policy (App. B). The ESCOP policy provides the guidelines for germplasm release from public institutions, but each institution has its own system for determining what qualifies for release and how the germplasm will be distributed. The release of breeding lines from private companies generally involves a specific request from one breeder to another.

Acceptable Breeding Lines with Superiority in One or a Few Characters

Breeders commonly have breeding lines that do not have the overall performance required for a cultivar but are superior for one or a few characters. These lines would include old cultivars that have been replaced by newer cultivars with better overall performance. Despite the lack of overall performance, the older cultivars may have a few characters in which they excel. Plant breeders employed by public universities and the U.S. Department of Agriculture frequently release lines that have been improved for one or a few characters to a level unavailable in commercial cultivars and elite breeding lines. These improved lines are referred to as genetic stocks or germplasm lines. For example, Iowa State University released a germplasm line of soybean designated A2 (Fehr and Bahrenfus, 1980). It did not have adequate yield potential to be released as a cultivar, but possessed useful resistance to iron-deficiency chlorosis on calcareous soil.

Plant Introductions of the Cultivated Species

Plant introductions and collections of species native to the United States are maintained as a source of parental germplasm (Chap. 11). They often have several characters that are unacceptable commercially, but possess a specific character of value. Genes for pest resistance commonly are obtained from this source of germplasm. For example, although the soybean plant introduction 'Peking' has black seed and is unacceptable for commercial production in the United States, it has been used as an important source of resistance to the soybean cyst nematode.

Related Species

When a desirable characteristic is lacking in the cultivated species, breeders consider related species as a source of parental germplasm. The related species generally are unacceptable for many characteristics and may not readily hybridize with the cultivated species. Nevertheless, they may possess characteristics of significant value, particularly with respect to pest resistance. Breeders and geneticists have developed techniques for interspecific hybridization that facilitate the transfer of characters between species (Chap. 14).

REFERENCES

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