The Current Status of the Backcross Method of Plant Breeding

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Thirty years have elapsed since Harlan and Pope (3) called attention to the value of backcrossing as a method of small-grain breeding and since an extensive backcross-breeding program was started by Briggs (1). Despite the advantages pointed out by Harlan and Pope and the successes of plant breeders who have used the method, it has not gained wide acceptance.

There appear to be several reasons for reluctance to adopt this method of breeding. One important reason is the conviction of many plant breeders that they do not possess a satisfactory recurrent parent. Another is the belief that it cannot be used for improving a variety with respect to a number of characters. The criticisms have also been made that the method is laborious and that it is valueless in dealing with quantitative characters. Further, some plant breeders have expressed the belief that it will not work with cross-pollinated crops.

In view of these and other objections to the method, it seems appropriate to discuss both the theoretical concepts basic to backcross breeding and the evidence for their validity gained from a number of backcross programs. In addition, some of the details of the use of the method at the California Station will be presented because of numerous requests for this information.

BASIC REQUIREMENTS OF BACKCROSS BREEDING

If a backcross program is to be successful, the following three requirements must be satisfied: (a) A satisfactory recurrent parent must exist; (b) it must be possible to retain a worthwhile intensity of the character under transfer through several backcrosses; and (c) the genotype of the recurrent parent must be reconstituted by a reasonable number of backcrosses executed with populations of manageable size.

The Recurrent Parent

A satisfactory recurrent parent is likely to exist in any of the crop species which have long been domesticated. In such crops, many highly efficient combinations of genes have been forged over long periods of time through the agencies of "natural selection," selection by farmers, and very recently by plant breeders. In common wheat, for example, a few highly successful varieties qualify as acceptable recurrent parents. Among the older of these varieties are Turkey (and selections from it), Marquis, Fulctz and Fulcaster, Baart, and some others which have performed well over long periods of time. Included among the newer varieties with excellent performance records are Pawnee, Comanche, Thatcher, Thorne, and Ramona. A survey of our other crop species indicates that most of them also include varieties with excellent combinations of genes which qualify them as recurrent parents in backcross breeding.

In the pattern of the replacement of older varieties by new ones, the advantage of the new type has frequently been associated largely with one or two characteristics. For example, resistance to stem rust and early maturity were important features of Thatcher wheat leading to its replacement of Marquis. The most recent hard red spring-wheat varieties, such as Mida, have the added advantage of resistance to leaf rust. In the competition among hard red winter-wheat varieties much of the success of Pawnee, Comanche, Wichita, and Triumph is associated with early maturity. In addition, these varieties have more resistance than their predecessors to one or more of the major diseases or pests of wheat. Among the soft winter-wheat varieties, Thorne, Clarkson, Fairfield, and Yorkwin are less subject to lodging than their predecessors and are resistant to more races of loose smut. Apparently the most important limiting factor in the production of successful varieties is frequently susceptibility to diseases or other equally obvious deficiencies. The backcross method is well suited for effecting the small number of gene substitutions necessary to increase the usefulness of successful varieties, without the risk of breaking up the existing combinations of desirable genes which have made them outstanding in many respects.

Maintenance of the Character under Transfer

Although the backcross breeder need be concerned only with selection for the character being transferred, some of the intensity of the character may be lost even when its genetic control is predominantly monogenic. This problem prompted a series of projects at the California Station dealing with monogenic morphological characters in barley that have been particularly informative regarding problems of character transfers and ways of dealing with these problems. These projects deal with transfers of the hooded, short-haired rachilla, smooth-awn, awnless, and naked characters to Atlas.

In breeding a hooded Atlas barley, Meloy, which has an elevated hood, was chosen as the donor parent. When a few sessile-hooded types appeared in the generations following the first backcross, it was decided to breed this type. With careful selection in moderate-sized populations