METHODS CURRENTLY BEING USED IN WHEAT IMPROVEMENT

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Basically the plant breeder has only three different approaches to improving a self-pollinated plant such as wheat, namely, introduction of plant materials form other areas, selection in "native" or introduced materials and selection in hybrid populations. Within these basic approaches there are many modifications in handling the plant materials. The method or approach to be used by any individual country will be governed by a number of considerations, among which are the following:

1) The specific needs and objectives of the country in which the program is being developed.
2) The availability of trained personnel.
3) The physical facilities at the experimental stations where the breeding program is to be carried out.
4) The availability of funds for the development of the breeding program.
5) The current stage of evolution of the agriculture in the country where the program is being developed.

Improvement through Introductions:

Generally this type of approach is used when improvement programs are being initiated in a country. Moreover, this may often be the only type of improvement which is justified if wheat is of little importance in the country in question. Within the past eight years, with the establishment

of the Cooperative International Spring Wheat Rust Nursery, a wonderful opportunity has presented itself for wheat improvement through this approach. The wheats in this nursery include the main commercial spring wheat varieties of the world as well as the most promising materials from the breeding programs in most of the cooperating countries. In Mexico each year this material is examined very carefully with the purpose in mind of using as commercial varieties any varieties or lines which outperform our commercial and experimental varieties. Many countries which do not have facilities to establish large breeding programs of their own will be able to develop useful commercial varieties from this source by carefully studying and choosing the best of the materials in this nursery. Subsequently, these materials must be tested in more extensive and intensive tests where they are compared directly with the best local varieties.

Improvement through Selection:

The Cooperative International Spring Wheat Rust Nursery also offers frequent opportunities for improvement through selection of individual plants. Many of the experimental lines which are included in this nursery may appear to be uniform under the conditions where they were bred, but show considerable variation when grown in other parts of the world. They may be variable for disease reaction, maturity, height and many other characters. Within the best adapted lines in a given location one has a good opportunity to select individual plants which are much better adapted than the bulk population. This is an opportunity for crop improvement with a very nominal expenditure of time and effort, which might prove effective in many countries. At the

present time this possibility is largely being neglected or overlooked.

Improvement through Breeding and Selecting in Hybrid Populations:

Regardless of the method in which the plant material is handled after the cross is made, this approach to plant improvement has one thing in common, namely, artificially crossing two or more varieties carrying different genetic characters with the object of combining in the progeny one or more desirable characteristics that are found independently in the different parents. The primary consideration is to select parental materials that possess the characters which are needed in a commercial variety and through one or a series of crosses combine these characters in a new variety.

Depending upon how the plant populations of the "hybrid" or segregating generations are to be handled the methods are known as:

1. The Bulk Method of Breeding
2. The Pedigree Method of Breeding
3. The Backcross Method of Breeding
4. The Multilineal or Composite Method of Breeding.

The choice of the method to be used will depend largely upon local conditions, especially with respect to trained personnel, land and greenhouse facilities, and budget.

The Bulk Method, or some modification thereof, is the least expensive. In this method the segregating generations are grown in bulk (en masa) through four to six generations, after which a large number of heads are selected individually. The progeny of each head is grown in a separate row, and subsequently the best rows are harvested and included in yield tests.

The Pedigree Method has the advantage of initiating selection on an individual plant basis in the first generation and carrying through this procedure in each successive generation until uniformity is obtained. The progeny of each plant is planted in a separate row in each successive generation and hence the performance of each family during each generation becomes self evident. This is the system used in most genetic studies and by many of the countries carrying on large breeding programs. It requires more trained personnel, more plot facilities and budget facilities than the Bulk method.

The Backcross method, which was developed at California, is best used to produce further improvement in a commercially acceptable variety that is deficient in only one character.

The Multilineal or Composite Variety Method:

This method is an attempt to develop a multilineal variety by mechanically mixing together a number of phenotypically similar lines which differ genotypically for disease resistance. The individual lines are developed through a backcrossing program. The objective of this type of breeding is to prevent regional rust epidemics when new races of rust become epidemic. The mixed population of such a variety will reduce the rate of spread of inoculum, retard the development of epidemics, and thereby permit the commercial crop to mature without damage.

Within the past year we have obtained experimental information that multilineal varieties can be produced which are acceptable from an agronomic, yield, quality and disease resistant standpoint.

Continuous Revision of Objectives of Breeding Programs are Essential.

Periodic reexamination of aims and objectives are essential if satisfactory progress is to be maintained through breeding, regardless of the method of breeding being employed.

For example, in Mexico leaf rust was formerly considered to be the least important of the three rusts. Now that the commercial varieties possess adequate stem and stripe rust resistance, leaf rust is the most important disease of wheat. More emphasis must now be given to this aspect of breeding. Similarly, the first improved varieties such as Yaqui 48, Lerma 50 and Montana 48, although bred primarily for high yield and stem rust resistance, were also far superior to all other varieties because of their better resistance to lodging. Today, with heavy rates of chemical fertilizers being used in most areas, further improvement in straw strength and straw length is now urgently needed. Japanese dwarf varieties are being used to incorporate short straw into commercial varieties, thereby permitting higher rates of nitrogen fertilization without danger from lodging, which should thereby substantially increase yields.

Continuous Search for Basic Information to Support Breeding Program.

Any breeding program to be successful over a long period of time must be guided by sound basic data. It is essential to develop basic information on race population studies of the principal diseases which must be taken into consideration in breeding. Basic studies must also develop information on sources of resistance to these races. Research is frequently needed to improve the techniques used in evaluating breeding materials. Basic studies are essential to develop information on sources of genes for

strength and shortness of straw, strength of glumes, varietal differences to highly acid or high alkaline soils, and resistance to frost. Certain parental materials will contribute broad climatic and soil adaptation in crossing programs whereas others will contribute to yield or quality. All of this background information is basic to a soundly based breeding program.

Successful Plant Breeders must keep Abreast with Research Development in Related Scientific Fields:

Unless the objectives of the breeding program are modified periodically to take into consideration discoveries in related fields, it will not be highly successful, and varietal limitations will hinder rather than serve as a catalyst in crop production. The research in soil fertility, management and cultural practices, and irrigation practices, are of vital importance for they will largely determine the degree of resistance to lodging which will be needed in the future. Pathologic studies which indicate changes in the races of rust pathogens must be taken into consideration promptly to avoid disaster.

The recent development in turbo-milling may have a tremendous impact on wheat quality standards. Through this discovery it is possible to produce from a single variety of wheat a number of different flours which differ greatly in baking characteristics. This is done by turbo-air separation of fractions of conventionally milled flour. Currently there are three commercials mills using this process in the United States, with others being planned. The breeder must watch developments in the field in order to modify his quality standards if this becomes advisable.