Current Trends in Control of Cereal Rusts by Plant Breeding

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The development and distribution of rust-resistant wheat varieties during the past 30 years has resulted in the saving of untold hundreds of millions of dollars to the farmers of North America. Despite the tremendous advances that have been made along this front, the rust problem is by no means permanently solved.

Confining the discussion for the moment to stem rust of wheat, changes in races in the rust population have twice in the past thirty years made it necessary to change the commercial varieties of North America. In 1935 race 56 became epidemic throughout the U.S. and Canada, and this new menace was countered with the variety Thatcher, and somewhat later by many varieties carrying Hope or H 44 type of resistance. These two types of resistance remained effective until 1950 when race 15B became epidemic. During the period of 1950 to 1954 while newer varieties combining resistance to the older races and to 15B were being developed and distributed, the North American wheat crop was disconcertingly vulnerable to rust attack. During this period losses running into the hundreds of millions of dollars did occur, but although serious, these losses were prevented from becoming national disasters twice only by very timely changes in weather conditions, which adversely affected the rust and hastened the ripening of the grain. There is no way to predict how long the current commercial varieties will remain effective, for it is impossible to know when a new race will appear which is capable of attacking this kind of resistance. The barberry eradication programs in the principal grain

producing areas have reduced the number of new races developing through hybridization of existing races on the alternate host, thereby perhaps tending to prolong the useful life of resistant varieties. Nevertheless, in recent years researches on the nature of variation in the rust pathogens in many parts of the world point an ever-increasingly guilty finger at mutations, heterocaryosis, and parasexuality as methods whereby new races are constantly evolving in nature. This being the case, the problem of maintaining resistance becomes more involved rather than simpler.

As though the stem rust problem were not difficult enough to contend with in the development and maintenance of rust-resistant wheat varieties, we must also contend with the leaf rust problem which appears to be even more complex. Varieties which are developed for leaf rust resistance seldom retain their resistance for more than five or six years. The problem is most complex in regions where climatic conditions are favorable to the development of epidemics of the three rusts, stem, stripe and leaf. Here the breeders' problem is at its worst.

Recognizing the great complexity of the rust problem, several years ago we began to investigate the feasibility of developing multi-lineal or composite wheat varieties as a hedge against rust losses. The procedure being followed is to select the best commercial variety and develop a series of phenotypically similar lines which will differ for resistance to stem rust. These lines are developed by crossing the commercial variety to each of a considerable number of parents containing different factors for rust resistance. After the original cross each line is backcrossed to the commercial or recurrent parent

until lines which are phenotypically similar to the recurrent parent can be isolated. Type of head, height of plant, maturity, color and texture of the grain are the most important considerations in determining how far backcrossing should be continued. The best lines developed from each backcross family are tested against each of the prevalent stem rust races, using both seedling and adult plant tests.

The multilineal or composite variety which the farmer will grow will be made up of a mechanical mixture of 8 to 12 different lines which are phenotypically similar but which differ genotypically for stem rust resistance. Rust race population studies are of vital importance in deciding on the composition of such a variety. All of the lines of a composite or multilineal variety need not be resistant to all of the prevalent races of rust in the area. However, it is essential that no more than 8 to 12 percent of the population be susceptible to any individual race of the rust population. It is our contention that it is very difficult to develop stem rust epidemics in mixed populations of wheat plants, if the composition of the variety is based upon a sound analysis of the rust population in a given area and upon the reaction of the individual lines to each of these races.

When new races arise in nature it is highly improbable that all of the lines in such a variety will be susceptible to this new race, and it follows that the development of rust epidemics will be delayed in such a mixture, thus permitting the plants to mature and escape serious injury. With the appearance of a new race the composition of the variety can be modified

by removing lines which are susceptible to the new race and substituting others which are resistant to it. Nevertheless, while this is being done the protection afforded by the mixed plant population will delay epidemics and permit escape.

As many genotypically different lines of wheat can be developed as there are known genes for rust resistance. These lines can be incorporated into the variety when developed or held in reserve until needed.

Within the past year we have demonstrated that with this method it is possible to develop acceptable varieties from an agronomic, yield, and quality standpoint. Basic studies on rates of rust spread in mixed versus uniform populations are continuing.

We are now investigating the possibility of incorporating leaf rust resistant lines developed through backcrossing, into the stem rust resistant composite varieties. We have also begun a program to incorporate dwarf straw genes into such varieties.

This type of an approach to maintaining rust resistance is both time-consuming and expensive. While major emphasis is being given the rust-resistant phase of wheat varietal improvement less emphasis can be given to breeding for shorter straw, stronger glumes, better quality and higher yield. Nevertheless, until you scientists who are assembled here today find an effective rust control chemical it will be necessary for the plant breeder to continue devoting a great part of his time and budget toward breeding for rust resistance, at the expense of other much needed agronomic improvement.

There seems to be little doubt of the need for a successful rust control chemical. If such a product is found it will, in all probability, not only find use against stem rust of wheat, but against leaf and stripe rust as well,

and against the rusts on oats, rye, corn, etc. The potential market for such a chemical product exists; let's hope that within the not too distant future, you research scientists find such a product which will permit the cereal breeder to divert his attention from putting out "rust fires" and dedicate more of his efforts to agronomic, yield and quality improvement.