BREEDING FOR LEAF RUST RESISTANCE IN WHEAT

by
L. R. Waldron, Plant Breeder

The story of wheat improvement by breeding is a long one. The earliest wheat we have knowledge of, kernels found in ancient tombs and elsewhere, very likely was in the making for thousands of years, from the wild parent plants which must have been the basic stock for the primitive varieties. In present-day work plant breeders are turning to primitive varieties to find desirable characters to work into our common wheats to secure improved offspring.

The story of this work is of real interest to those who are actively engaged in making over our present varieties. No doubt there are others who would be interested in a brief sketch of some of the work now carried on. The wheat plant, and the grain it produces, has many characters of interest to the growers and to those who work with the grain to produce bread and other foods. Present-day flour is generally of high quality and a well-made loaf, from the home or the bake shop, leaves little to be desired. But the one who grows the wheat finds difficulties which are often of serious concern, particularly because of certain diseases and ravages of insects infesting the growing crop.

There are two diseases, among others, which are of enormous importance, stem and leaf rust. Nature has provided means to increase these diseases with enormous rapidity among the growing plants after once a start is made in key regions. Any treatment of the crop during a rust epidemic fails to cope with the rapid onrush of the disease. Any successful combat of a rust epidemic has to rely upon a roundabout method. This consists in producing a variety which fails to take the disease. This apparently simple method requires some ingenuity to carry out. It depends on Mendel's discovery that inheritance goes by steps, commonly small ones. Not only is this true but these "steps" are taken apart when two wheat varieties are crossed and refitted into other stairways of many kinds into the daughter varieties. There will be a recombination of characters, or steps, whereby a good flour of the male parent, say, will be combined with a rust resistant character of the female parent. Our wheat varieties now commonly grown, such as Rival and Thatcher are resistant to stem rust. This resistance to stem rust traces back to a primitive wheat, either to emmer, a feed wheat, or to a little known durum. In the first instance, a variety called *Hope* resulted, bred by McFadden, then of South Dakota, and in the breeding of Thatcher the resistant durum variety Iumillo was brought into the cross. Our wheat varieties resistant to stem rust, some of them now 20 years old or more, have retained that character and seem now as resistant as when first produced. They have not degenerated or "run out" but evidently have the same genetic make-up as when produced.

For the time being anyhow stem rust epidemics, which caused such enormous losses in the past, have been brought definitely under control. This is emphasized by the kind of seasons we have been having. This was striking in 1948 for in the wheat nurseries at Fargo, where susceptible varieties were grown, stem rust developed to the epidemic stage. Had the wheat fields of North Dakota been seeded to Marquis or to Fife our production of about 100 million bushels of common wheat might easily have been halved.

Leaf Rust

Our present day common wheats, except Thatcher, were likewise resistant to leaf rust when first distributed. Mida and Thatcher are compared below in percents of leaf rust for two 4-year periods:

	Mida	Thatcher
1940-1943	2	55
1944-1947	23	58

This change in the reaction of a once resistant spring wheat variety occurred also with winter wheats in Indiana and elsewhere. The everyday explanation of such an event, the one so commonly heard, would be, the variety has "run out." Certainly in this case the clear-cut explanation is that the variety has remained as it was but it has met new enemies. Leaf rust, like other diseases, is a complex organism with many units some of which attack one variety and some another. One of the problems is to find a wheat variety to use as a parent which can resist many of the races of the leaf rust disease. There are several wheats resistant to leaf rust but none would meet our agronomic or milling demands.

At present the fight is on to produce new varieties by crossing a standard variety such as Rival with a foreign variety resistant to leaf rust. There are four or five breeding centers at present actively engaged in this kind of work. One of these is at the experiment station at Fargo. Space forbids detailed description of all the work being done and the present statements will be limited to our own work being done at Fargo.

Breeding for Leaf Rust Resistance

The selections now grown by us trace to one of the primitive wheats, quite unknown until 1923, when it was discovered in the Russian province, Georgia, east of the Black Sea. This wheat, called *Timopheevi,* is remarkable in that its germ plasm differs greatly from other known wheats and can be used as a parent only with difficulty. As this wheat shows marked resistance to several diseases, particularly rust, it was early recognized as of promise in breeding. *Timopheevi* has 14 pairs of chromosomes while common wheat has 21 pairs. The problem then was to take the *Timopheevi* characters and put them into a new setting, into a wheat plant with 21 chromosome pairs. This remarkable piece of work was carried out by Dr. E. R. Sears of Columbia, Mo. He

crossed *Timopheevi* with a wild grass of Europe, *squarrose aegilops,* with only 7 pairs of chromosomes, but these are similar to one of the sets in our common wheat. The result of this cross was a wholly sterile plant carrying 21 unpaired chromosomes. To bring fertility to the plant these 21 chromosomes had to be doubled to make pairing possible. This was done by the application to a young tiller of a drug obtained from the bulb of meadow saffron which slows the formation of cells and this way results in both sets of chromosomes remaining in a single cell. By this near-magic process this useless and infertile "mule" first produced by Dr. Sears, became ennobled and was able to produce offspring. Also with the doubled chromosomes, now having 21 pairs, crossing with common wheat has become a matter of routine.

Some of the seeds produced in the above manner by Dr. Sears were sent to Dr. Allard of Madison, Wis. and there were crossed twice with a hybrid selection. Seeds from these crosses as well as some of the parent-type seeds were sent to Dr. Glenn Smith of Fargo, then engaged in breeding durum wheat, and from him the writer obtained his start. This seed, secured in May 1944, produced plants that year which were crossed with a hybrid selection of our own breeding. Using the greenhouse, one crop was added during the winter and in 1945 another parent, Newthatch, was used in this series of multiple crosses. Sixteen F_1 plants, the first seeds secured from the cross, were used to seed 16 F_2 rows in the nursery in 1946. Only 10 rows of the 16 were used for increase and selection but from these there have since arisen plants of the widest diversity as even casual observation has shown many hundreds of plants each one different, with a much larger number to be noted with closer study. It would be a simple matter, aside from the labor and area involved, to produce or select more than a thousand distinct varieties from the hybrid material now available. This great range of wheat types, coming originally from 10 seeds and each type capable of selection to a pure variety, is due to Mendelian or gene inheritance. We have good reason to believe that each character is to be traced back to a molecule-sized particle, a gene, each responsible for straw strength, yielding capacity, disease resistance, or what not.

Each hybrid selection, as indicated, has 42 chromosomes and on each chromosome is located the genes, no doubt hundreds to each chromosome. At each sexual stage, when seed is produced, the chromosomes, and the genes themselves in a measure, are rearranged at random which in theory accounts for thousands of new types of wheat.

Diversity of Offspring

In the present instance some of the parents used differed radically and as a result many undesirable characters appear. During the past season we have found susceptibility to rust, smut, and black chaff, weakness of straw, poor yielding capacity, and poor quality of the flour. From such a list one might think the ex-

periment a failure but this is still to be shown. For each of the undesirable characters listed a correspondingly good one has been found. A large number of plants have proved so far to be resistant to leaf and stem rust. And some of these have produced excellent loaves of bread with high protein content. And so with other characters. But it is difficult to find one plant or one 8-foot row with the maximum of desirable characters. When that is done a variety will be available which will satisfy the demands of the breeder and also the farmer. The aim of the work was the production of an otherwise good variety resistant to leaf rust. The road to that goal is a complicated one and the end is not yet. If success is finally secured the cost of the work will be a mere nothing compared with the calculated savings which would result from disease free crops.

Some 1948 Pasture Seedings on Fargo Clay

Fourteen one-acre pastures were seeded with the grasses, pasture mixtures, or legumes noted herein on May 25 and 26, 1948 at Fargo. The seed bed was dry, cloddy fall plowed land which had been disked and packed in the spring. Establishment counts made October 12, 13, and 14, 1948 follow. Stand ratings used were as follows: (1) Less than one plant per square foot—Very poor, (2) One plant per square foot—Poor; two plants per square foot—Fair; 3 to 4 plants per square foot—Good; 5 or more plants per square foot—Excellent. All stands rated poor, very poor, or failure are scheduled for reseeding. Each square foot contained in addition to the species seeded variable numbers of weedy grasses and other weeds.

Species	Plants per square foot	Stand Rating
Standard crested wheat grass	2.6	Fair
Fairway crested wheat grass	0.5	Very poor
Intermediate wheat grass	3.4	Good
Mandan wild rye	4.7	Good
Russian wild rye	0.9	Very poor
Bromegrass northern strain	35.1	Excellent
Brome-alfalfa	10.1 brome 3.9 alfalfa	Excellent
Sweet clover Albotrea	9.5	Excellent
Subterranean clover	3.9	Good
Green stipa grass	0.1	Very poor
Big bluestem	0.4	Very poor
Switch grass	1.0	Poor
Meadow Fescue	5.9	Excellent
Kentucky blue grass	Failure	

Stand counts will be made again in the spring of 1949 to test winter survival. (Abstracted from Annual Report of Departments of Animal Husbandry and Botany.)