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In the world of microbes, this is a shifting and fluctuating universe. This is particularly true for those parasitic microbes which attack cereal crops so lowering the quality and yields of such crops that large regions of the world are quite often threatened with starvation.

Were it not for the shifting nature of these parasites, the problem of controlling the diseases which they induce would be much simplified. If the fungi called rusts and smuts would remain fixed and unvarying in their ability to parasitize certain varieties while leaving other varieties free from serious attacks, the growers and breeders of such crops would merely need to note which varieties remain free from disease and give good yields and reject those that do not. Unhappily, however, there is no variety of wheat, oats, barley, or rye which has remained resistant to these parasites for any long time. The reason for this is that when any new variety resistant to the current races of rusts and smuts is grown on large acreage, a new race of rust or smut appears sooner or later which attacks this variety.

As an illustration of the shifting nature of these parasites, we may take the disease known as crown rust of oats, a disease which has engaged and often enraged your speaker for over 16 years. In 1935, there were 33 races of crown rust known on the North American continent. By 1936, 44 races were identified; by 1937, 46 races; by 1940, 56 races; by 1945, 85 races; and by 1951, 101 races. In 1936, 3 races were prevalent in Arkansas, predominantly race 1. In 1937, a new race appeared, race 45, which gradually became a first rate menace and replaced race 1 in prevalence and destructiveness.

In 1949 still another new race of crown rust was discovered in Arkansas which threatens nearly all the commercial varieties now commonly grown in this state. It is tentatively listed as race 101.

In 1936, the Arkansas Agricultural Experiment Station initiated a breeding program primarily aimed at controlling crown rust, smut, and other diseases of oats. At that time this state had the unenviable record of producing an average yield of 20 bushels to the acre, one of the lowest state yields in America. The state utilized an average of about 100,000 acres for growing oats. The result was that millions of dollars were spent annually by our livestock producers to purchase feed out of the state.

Not a single oat variety commonly used in 1936 had sufficient disease resistance coupled with enough winter hardiness to guarantee satisfactory yields. Varieties which had considerable winter hardiness possessed almost no rust or smut resistance, while those that did have disease resistant qualities had such little winter hardiness that they could not be depended upon, especially in the hilly parts of the state.

The breeding problem that confronted us was essentially one of combining disease resistance with good winter hardiness. We therefore started in 1936 by making several thousand crosses, utilizing disease resistant varieties which had no winter hardiness as part of the parentage and disease susceptible varieties with considerable winter hardiness as the other parent.

Selections from the progenies of these crosses were begun in the F_2 generation. These were tested for disease resistance by artificially inoculating them in the greenhouse and in the field and by subjecting them to natural epidemics. Over 10,000 of such selections were tested in 1938. They were also tested for winter hardiness under natural conditions.

One of these selections first revealed certain outstanding qualities in 1940 following an exceptionally severe freeze on November 11. While most of the selections were completely killed by this freeze, this selection came through with very little injury and produced a yield of over 90 bushels to the acre. In

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addition to its winter hardiness it proved to be uniformly resistant to the races of rust and smut prevalent in Arkansas at that time. After several years of additional testing, it was released to Arkansas growers in 1944 and named, "Traveler."

This variety has had much to do with the marked increase in oat acreage in this state and in lifting the state average yield of 20 bushels to 30 or more bushels. It is at present occupying about one-third of the state oat acreage and is also being grown in adjoining states.

But Traveler is now meeting the fate of all new cereal varieties. In fact, the very year when it was first released, we discovered a new disease, Helminthosporium blight, to which this variety was susceptible. Fortunately, we also discovered that this disease does very little damage when the temperature falls below 70° F. and we soon found that by rotating crops and treating the seed with an organic mercury compound, the disease is readily controlled. Thus by seeding two or three weeks later in the fall, when the mean temperature is likely to be below 70°, and by treating the seed and rotating crops, Traveler still gave good yields. In fact yields of 90 to 100 bushels per acre were not very rare for this variety last year.

But in addition to its susceptibility to Helminthosporium blight, we have found new races of smut which attack Traveler, a new virus disease, and perhaps worst of all, a new race of crown rust, race 101 (mentioned previously) to which it is susceptible.

Fortunately we now have other varieties coming up in our breeding plots which offer resistance to these new diseases and one of these will probably be released this fall. In fact, back in 1937, as soon as we found crown rust race 45 present in the state, we immediately began looking for resistance to this race and the older races, and when Helminthosporium blight, new smut races, red spot mosaic, and race 101 appeared, a search was immediately begun in our own breeding material as well as that available from other breeders for resistance to these new diseases. Up to the present we have been able to find each new disease before it became very prevalent and have thus been able to anticipate the need for new varieties bred for resistance to the new as well as the old parasites. But it has meant constant work, constant vigilance, and no end to the breeding program.

Truly these microbes are shifty enemies.