

THE SIGNIFICANCE AND USEFULNESS OF THE LEAF-RUST REACTIONS OF PAWNEE WHEAT

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Pawnee wheat (C. I. 11669), the result of a cross of Kawvale x Tenmarq, was developed by the Nebraska Agricultural Experiment Station, in cooperation with other States and the U. S. Department of Agriculture, and released by the Nebraska and Kansas Stations in 1943. It was described (Reitz and Laude 1943) as having moderate resistance to leaf rust (*Puccinia triticina* Erikss.), and since this was combined with good milling and baking qualities, capacity for high yield and test weight, short stiff straw, and resistance to smuts, stem rust, and Hessian fly, Pawnee wheat has become very popular with farmers in the Southern Great Plains, and its seed is in great demand. The purposes of this paper are (a) to describe and explain an apparent decline in leaf-rust resistance of Pawnee wheat, and (b) to give the results of a biological test for determining the varietal purity of Pawnee seed wheat.

LOSS OF FIELD RESISTANCE TO LEAF RUST IN PAWNEE WHEAT

Wheat leaf rust exists as numerous physiologic races, morphologically similar but each with a different set of host reactions among wheat varieties. I have recently proposed a simplified grouping of these races, which abandons the use of three unstable wheat varieties formerly used in identification of leaf-rust races (Chester 1946: 78-90). Following this grouping, there are 7 rust race groups commonly found in Oklahoma—race groups 2, 5, 6, 9, 12, 21, and 65. The reactions of the 5 wheat varieties used in leaf-rust-race identification and of Pawnee wheat, with respect to 6 of these races, are shown diagrammatically in Fig. 1.

It will be observed that Pawnee wheat is resistant to race group 9, tolerably so to race group 65, and susceptible to race groups 2, 5 (not shown in the figure), 6, 12, and 21. This pattern of resistance is evidently inherited from Pawnee's Kawvale parent, which has the same leaf-rust reactions, while the other parent, Tenmarq, is susceptible to all 7 of these race groups. A similar pattern of reactions is seen in Democrat wheat and in numerous Hope-wheat derivatives.

At the time Pawnee wheat was released, race group 9 predominated in the Southern Great Plains, two-thirds of rust collections being referred to this race group with the remaining third divided among several minor races. Since Pawnee wheat is resistant to race group 9, which made up the bulk of the leaf-rust population, Pawnee behaved as resistant in the field, contracting only light and late infections with rust of the less prevalent race groups.

During subsequent years, Pawnee has shown an apparent loss of rust resistance in the field, until by the spring and fall of 1946 it was as heavily rusted as the most susceptible commercial varieties, such as Fulcaster, Khar'kov, and Cheyenne. Some farmers believed that Pawnee wheat had changed, losing its inherent resistance to rust. It is not that Pawnee has undergone any change; the relative proportions of rust races in the rust population have changed, with a shift from the principal race to which Pawnee is resistant over to races to which it is susceptible. The increasing acreage of Pawnee has favored this, the variety selecting those races which can attack it.

These relationships are brought out in Figure 2. Here we can see the decline in the prevalence of race group 9, with a corresponding increase in certain other race groups, notably 12; meanwhile the severity of rust on Pawnee in the field has increased from 30 percent of the severity on the susceptibility check variety to 99 percent of the latter.

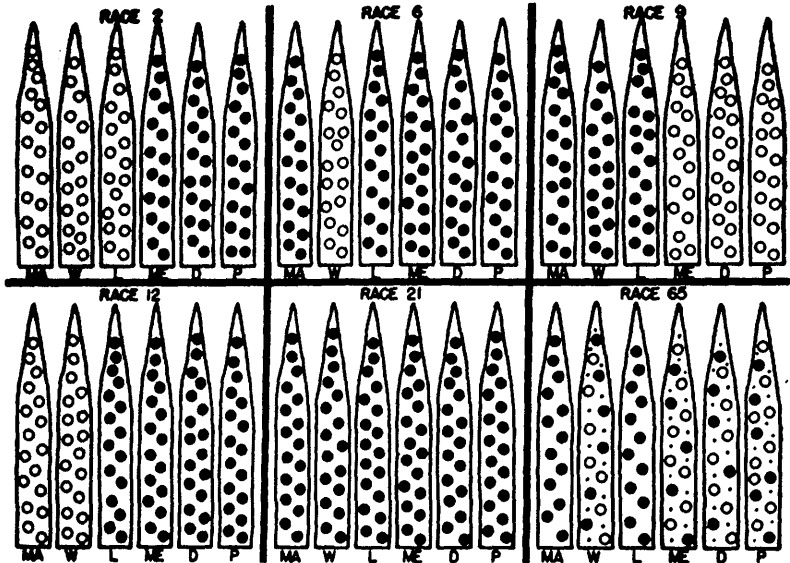


Fig. 1. Types of wheat leaf-rust infection caused by the designated race groups on the differential wheat varieties used in rust-race identification. Legend: Malakoff (Ma), Webster (W), Loros (L), Mediterranean (Me), Democrat (D), and Pawnee wheat (P). Circles indicate resistant reactions; large solid dots, susceptible reactions; and the mixture of symbols seen in the reactions to race 65 indicates an indeterminate reaction associated with a moderate degree of rust resistance.

SHIFT IN WHEAT LEAF RUST RACE POPULATION AND RUST REACTION OF PAWNEE WHEAT OKLAHOMA 1938-1946

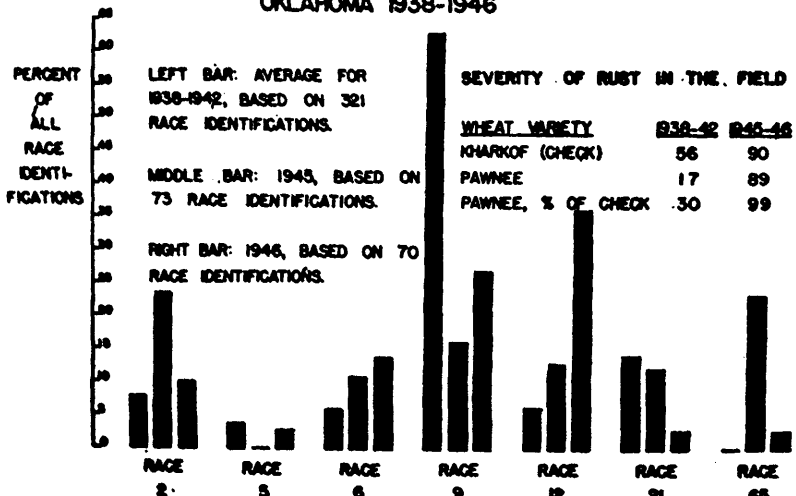


Fig. 2. The notations in the figure are self explanatory. Rust severity is expressed in percentages according to the Cobb rust-intensity scale.

In the fall of 1946 there was an unusually severe outbreak of leaf rust on wheat in Oklahoma and Kansas. Twenty-six single-pustule cultures of leaf rust from Pawnee wheat made at that time yielded 9 cultures of race group 2, 8 of race group 6, 3 each of race groups 5 and 12, and 1 each of race groups 45, 65, and 9. The single isolation of race group 9 can be attributed to contamination of the Pawnee seed with a small percentage of seed of some other variety of wheat. It is noteworthy that no one race group predominated on Pawnee to the exclusion of others. Only race group 21, of those common in Oklahoma, was lacking, a race group which has a wide assortment of factors for aggressiveness but appears to be unable to reproduce as freely as some of the other race groups (Chester 1946: 94).

The loss of field resistance of Pawnee wheat, due to a shift in proportions of race groups in the rust population, is indicative of the fate of any new cereal variety which is not resistant to all the races to which it may be exposed. Other instances of this have made history in cereal breeding, notably the downfall of *Ceres* wheat, correlated with the rise of race 56 of stem rust. It is clear from these cases that we cannot be content with incorporating into a variety resistance that is limited to the commoner races of pathogens; a new variety must possess resistance to every rust race, common or scarce, to which it may be exposed, if field resistance is to endure in the face of changing pathogenic populations.

BIOLOGICAL TEST FOR PURITY OF PAWNEE SEED WHEAT

The grain of Pawnee wheat is difficult if not impossible to distinguish in appearance from that of two other common winter-wheat varieties, Tenmarq and Comanche. With the growing importance of Pawnee wheat, and the rapidly expanding acreage it occupies, good Pawnee seed is at a premium. Since it is indistinguishable from seed of the two other common varieties, there is no visual means of detecting accidental or deliberate contaminations of Pawnee seed with that of the less-scarce varieties, once the crop is harvested. Crop improvement associations, seedsmen, and progressive growers are anxious to preserve the varietal purity of Pawnee seed, and the following test was developed as an aid in this.

While Pawnee wheat is highly resistant to leaf-rust race group 9, its most confusing possible contaminants, Tenmarq and Comanche, are susceptible to this race (as indeed, are nearly all present commercial wheats in Oklahoma). By inoculation of leaf-rust race 9 on Pawnee seedlings from seed suspected of contamination with other wheats, it has been found possible, with a minimum of effort and a high degree of accuracy, to determine the degree of purity or contamination of the seed.

In a routine test, 100 to 150 wheat seedlings are grown in a 6-inch pot. Eight to ten days after planting the seedlings are inoculated on the first leaf by slipping the leaf between fingers wet with a spore suspension of the rust. Both hands are used for this, and an assistant separates inoculated from uninoculated plants with glass rods. The inoculated pot is covered with an inverted pot of the same size, the hole plugged with cotton, and the whole covered with wet canvas for 20 to 24 hours, after which canvas and covering pot are removed. Readings are made in another 8 to 10 days. Pawnee seedlings show only well-defined chlorotic spots on the leaves, while seedlings of contaminant varieties are richly laden with spore pustules. Inoculation and reading are sufficiently simple and clear cut that the work can be performed by persons with a minimum of training.

If numerous seed samples are tested at one time, the expenditure of labor is relatively small, averaging 20 to 30 minutes per sample per test. This includes the time required for planting the seed, routine care of the pots, culturing the rust for inoculation, inoculating, subsequent care, reading, and

disposal of the plants and soil. During the test, data may also be taken on the germination rate in soil, adding useful information to that obtained from germinator tests. This is a small allotment of time compared with that required for the other steps—field inspection, taking and examination of reference samples, and germination tests—in control of certified seed. I believe that it is practicable to include this biological test in the routine control of certified Pawnee seed wheat, and that similar tests may be developed in the future for other new wheat varieties, bearing resistance to one or another of the rust races.

Using this method in the winter of 1946-47, 113 farmers' samples of Pawnee wheat, grown for certification by the Oklahoma Crop Improvement Association, were tested, each twice or in a few cases 3 times. Forty-nine of these showed 0-1 percent of contamination, 38 had 1.1 to 2 percent, 17 had 2.1 to 3 percent, 5 had 3.1 to 6 percent, and 3 showed 88.1, 94.8, and 99.8 percent susceptible plants respectively. When these last 3 samples were traced to their origin it was learned that in each case they were in mislabelled sacks. While labelled "Pawnee", two of them were actually Comanche and one was Tenmarq wheat.

In all, 257 individual tests were performed, including 21 tests of a susceptible sample of Cheyenne wheat, used as an index of concentration of the rust-spore suspension. Since many of these tests were replicates of one another it was possible to calculate the mean error, which for all tests was 0.97 percent, i. e., the average test was accurate within 1 percent of the amount of contamination present in the seed.

The only case involving use of this type of test for determining varietal purity of grain that has come to my attention is that of Johnston and Bower (1924) who made use of reaction toward a race of stem rust in connection with the certification of Kanred wheat. Since the above described method is simple, economical of time, and highly accurate, and no other satisfactory means exists for distinguishing Pawnee seed wheat from likely contaminants, the method is proposed for routine use in certification of Pawnee seed.

SUMMARY

1. The decline in leaf-rust resistance of Pawnee wheat from 1943 to 1946 is interpreted in terms of a shift in the race populations of the rust, from a predominance of race group 9, to which Pawnee is resistant, to other races to which Pawnee is susceptible.

2. A simple method of detecting varietal mixture in Pawnee seed wheat by inoculating seedlings with leaf-rust race 9 is described. Since the method requires an average of only 20-30 minutes' work per sample and has an average accuracy within 1 percent, and since no other ready means is available for distinguishing the grain of Pawnee wheat from its likely contaminants, the method is recommended for routine use in Pawnee-seed-wheat certification.

LITERATURE CITED

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