AIRPLANE SPORE TRAPS FOR STUDYING THE ANNUAL MIGRATION OF WHEAT RUST

K. STARR CHESTER
Oklahoma A. and M. College

Leaf-rust of wheat (*Puccinia rubigo-vera tritici* Erikss. and Henn. (Carl.)) has often been regarded as a benign disease, common in all wheat-growing areas but rarely injuring the crop to any serious extent. Yet, on several occasions in the past it has occasioned local losses of 20% or more of the crop, and in 1938 its epidemic development caused a $12,000,000 loss of Oklahoma wheat. Analogous losses were reported from Texas to the Prairie Provinces of Canada as the disease followed the crop northward. In view of the importance of the outbreak it was felt desirable to begin a formal study of the disease. The present paper reports an investigation of the annual cycle of leaf-rust in Oklahoma.

Leaf-rust becomes noticeable in fall wheat in November. It evidently overwinters in the wheat, at least during mild winters, since it has been found sporulating in December, January, and February. If the spring is characterized by abundant moisture and temperatures in the vicinity of 65°F, the rust may multiply, in 10-day cycles, until it reaches epidemic proportions by harvest time. In 1938 the rust was abundant until harvest (July), but from then until November, when the usual infections appeared, the disease could not be found. Attention was therefore directed to a study of the oversummering of the rust. The following hypotheses were entertained:

1. *That the rust oversummers on an alternate host.*

It has been shown experimentally that species of *Thalictrum* can serve as alternate hosts of the leaf-rust. But in America this host appears to be superfluous, and in nature it does not become infected with the rust.

2. *That the rust oversummers on wild grasses.*

Aegilops ovata is the only recorded gramineous host of leaf-rust, other than wheat. This grass has not been found in Oklahoma. Numerous summer collections of rusts on various grasses have been referred to a number of rust species, all distinct from leaf-rust.

3. *That the rust oversummers on volunteer wheat.*

A careful search in the summer and fall of 1938 brought evidence that little or no wheat oversummered in Oklahoma in the vegetative condition, during the drought following harvest. The rust can develop only when the host is in a vegetative stage.

4. *That the rust oversummers as dormant uredospores in the fields.*

Of the spore forms produced on wheat only the uredospores ("red rust" spores) are capable of reinfecting wheat. It is very doubtful if these could survive a summer such as that of 1938. They very rapidly lose their viability when stored at room temperature, and even when carefully preserved in a refrigerator a considerable proportion of the spores lose their viability in 3-4 months. Rust uredospores are adapted to rapid spread of the disease, and not to survival under conditions of high temperatures and alternate periods of moisture and drought.

5. *That the rust oversummers in other regions than the southwest and is borne back to Oklahoma by fall winds.*

Since it was most unlikely that the first four hypotheses could account for oversummering of the rust, there appeared a liklihood that the disease does not oversummer in Oklahoma, but that it passes the summer and fall months in other parts of North America and returns via fall winds. Analogous cases are reported for rusts which overwinter in the south and are air-borne to the northern states each spring.

In order to test this last possibility, the upper air was sampled repeatedly through the fall of 1938. In general the procedure followed that devised by Col. Charles A. Lindberg and F. C. Meier, and used by them in trapping and studying the flora of the upper air [1,2].

The "spore traps" differed in detail but not in principle from those used by Meier. They consisted of three-foot paddles, each bearing at its distal end a magazine holding five microscope slides. Each slide was coated with vaseline on its exposed face. When prepared, six paddles were aseptically sealed into individual compartments of a case, with adhesive tape. They were unsealed at the moment of exposure and again sealed after exposure. Later they were unsealed in the laboratory, covered with cedar oil and cover slips, and examined.

The "spore traps" were exposed in a series of flights over Stillwater through the kind cooperation of Pilot Al Guthrie. The flights were made under various weather conditions, and at altitudes from 800' to 2500'. Each slide was exposed from the cockpit for 4 minutes at speeds between 100 and 120 M. P. H. A total of 60 slides was exposed.

Examination of the slides gave the following results. The slides exposed from Oct. 20-29 showed the presence of rust uredospores corresponding to the relatively high concentration of 1 spore per 700 cu. ft. of air at 1000 ft. elevation. That the spores were of *Puccinia rubigo-vera tritici* was indicated by their measurements, shape, color, and echinulation. Spores which were evidently of wheat bunt were present in a lower concentration The other objects most frequently encountered included spores of various sooty-molds such as are widespread on vegetation in October and November.

From Oct. 29 to November 20 practically no spores were found corresponding to leaf-rust or wheat bunt, although the sooty molds were represented in about the same concentration as in October.

The evidence from the slides indicates a leaf-rust spore shower over Oklahoma from Oct. 20-29. During this period little or no leaf-rust was present in the fall-sown wheat. Ten days to two weeks later the first scattered primary infections of leaf-rust became apparent in 60% of the fields examined during a 250-mile survey trip. After another two weeks secondary infections were generally present, and the fall infestation was well under way.

It appears that the spore shower of late October originated outside Oklahoma. This is concluded from the facts that: Leaf-rust and bunt were very scarce or absent from Oklahoma fields, on either new or volunteer wheat, at the time of the shower and for many weeks previously; other fungus spores which were known to be prevalent in Oklahoma fields in late October were less abundant on the slides than the leaf-rust and bunt; the presence of small amounts of rust in Oklahoma wheat in November, and its apparent absence in October is inversely correlated with the findings from the spore traps; leaf-rust and bunt spores which were liberated in

June would long since have been removed from the air over Oklahoma by the air drift due to the earth's rotation.

The source of the late October spore shower would in all probability be a region where leaf-rust uredospores were most recently liberated in quantity since the uredospores are not adapted to survive long periods in the absence of their host. A study of the 1938 wheat harvest shows that the disease followed the crop northward from April to October. Spores were liberated in large quantities up till threshing time and not thereafter except in small amounts on volunteer wheat. Threshing was completed in the United States and in Canada as far west as Manitoba by Sept. 213. It was one to two weeks later in Saskatchewan; and in Alberta, according to the Canadian Department of Agriculture, threshing was not completed until October 30.

Oklahoma weather in late October is regularly characterized by "cold fronts,"—continuous northwest winds following the prevalent south winds of early autumn. In 1938 the first "cold front" appeared at about the time of the first slide exposure on Oct. 20. On the 18th a high pressure area was over British Columbia and a low over Minnesota. Between these there was a band of northwest winds beginning in Saskatchewan and Alberta and extending to Nebraska. On succeeding days the high moved southward to Utah as a low moved in from the northeast. During the entire period of the spore shower (Oct. 20-29), the prevailing winds were northwest and north in a continuous path from the western provinces of Canada to Oklahoma.

From the foregoing considerations the conclusion appears to be justified that the fall wheat in Oklahoma in 1938 received its primary rust infestation from a source outside the state. The most likely source appears to be Alberta, the only region east of the Rocky Mountains in which spores were being produced in abundance in late October, and a region which was in direct wind connection with the Southwest during this period. Additional spores may have been picked up by the north winds from volunteer wheat in the northern states. The presence of bunt spores in the October collections is likewise susceptible to the same interpretation.

Such a manner of fall infection permits the following suggestions with reference to the control of the disease:

1. It has often been assumed that leaf-rust oversummers on grasses and volunteer wheat, and the destruction of these plants has been recommended as a measure for rust-reduction by sanitation. If the rust is annually brought in from other areas, such practices would be of little avail in controlling the disease.

2. The rust strains which appear in the fall wheat may have orginated at points very distant from the infection courts. Since these strains condition the character of the disease the following year, the routine analysis of fall infections in the Southwest appears to be desirable, and an appreciation of the source of these infections should prove helpful in interpreting the annual shifts in strain populations, and in giving a "preview" of the rust strains which may be available for epidemic spread the following year.

3. The additional evidence on the long-distance movement of the rust diseases brings further indication that the rust problems cannot be regarded as local problems, subject to local control measures. Ultimate control will depend on the widespread use of rust-resistant wheat varieties, and the testing of such varieties is a part of the continued work on the cereal rusts at the Experiment Station.

LITERATURE CITED

1. Meier, F. C. and C. A. Lindberg, 1935. Collecting microorganisms from the arctic atmosphere. Sci. Mo. 40:5-20.

2. Meier, F. C. and E. Artschwager, 1938. Airplane collections of sugar-beet pollen. Science 88:507-508. (Nov. 25, 1938).

3. Correspondence with Dr. Margaret Newton, Senior Plant Pathologist, Dr. Wm. Newton, Dominion Plant Pathologist, and R. M. Putman, Supervisor of Extension Service, Canada Dept. of Agriculture, Oct. and Nov. 1938.