

EFFECT OF *PUCCINIA RECONDITA* F. SP. *TRITICI* ON WINTER WHEAT FORAGE

Ervin Williams, Jr. and H. C. Young, Jr.

Department of Botany and Plant Pathology, Oklahoma State University, Stillwater, Oklahoma

Severe infections of leaf rust, caused by *Puccinia recondita* Rob. ex. Desm. f. sp. *tritici*, reduced the dry weight production of forage from winter wheat as much as 47% during a six-weeks growth chamber study. Recovery after clipping of foliage was much slower for rusted wheat plants. Leaf rust also retarded plant root development.

In mid December of 1971, nearly 40% of the fall-seeded wheat was being pastured by livestock in the three-state region of Kansas, Oklahoma, and Texas. In western Oklahoma 65% of the winter wheat acreage was being pastured (1).

Grazing of winter wheat will produce two pounds of beef per day per acre under average conditions (2). This fact has brought about an increased interest in growing winter wheat for livestock. To increase the grazing potential, growers are planting earlier in the fall, which materially increases the chance of infection by the leaf rust fungus. Earlier rust infections will, in turn, greatly increase the possibility of epiphytic development, both in the fall and the spring seasons (3).

Since leaf rust was first recognized as a destructive disease of wheat, nearly all research on the economic effect of the disease has considered only the grain crop (4). Only recently have studies been conducted to determine the effect of leaf rust on the grazing potential of winter wheat. The studies discussed herein deal with the effect of leaf rust on young immature wheat plants grown under controlled conditions, but the observations and measured results may have relevance to effects of leaf rust on forage production under field conditions.

MATERIALS AND METHODS

A uniformly mixed soil of six parts clay loam, one part fine sand, and one part peat moss was obtained by using a Lindig soil shredder followed by an additional screening through a 1/8-inch mesh screen. Three liters of this soil were firmly packed into one-gallon capacity glazed stone jars. A 1/2-

inch diameter drain hole located at the base and to the side of each jar was covered inside with a paper towel to prevent the soil from escaping.

Except for the last trial, 125 "Arasan" (50% Thiram)-treated seeds of the winter wheat *Triticum aestivum* L. cultivar "Triumph 64" were planted in each of ten jars. The seeds were spread uniformly on top of the soil surface of each jar and firmly covered with an additional inch of soil. Water was slowly added until it started to drain at the base of the jars. When drainage stopped, each jar was weighed on a 20-kg capacity balance and the weights were recorded. The first time water was added, and every third time thereafter, "Hyponex" fertilizer (7-6-19, N-P-K formulation) was added at the rate of 2 grams per liter of water.

The Triumph 64 cultivar was used because the Triumph-type cultivars dominate the wheat acreage in Oklahoma (5). Also this cultivar, although showing some degree of tolerance in the field, carries no known genes for resistance to leaf rust in the seedling or early stages of growth (6).

The wheat seedlings were thinned to 100 per jar, except in the last trial where only 20 seeds were planted and then were thinned to 10 per jar. The wheat plants in these experiments were grown in a Sherer-Gillett Model CEL 25-7 growth chamber which is capable of holding ten jars for each experiment in a randomized block design with five rows of two jars. The plants in one jar of each row were inoculated with rust spores, and plants in the other jar were not inoculated. The jar containing the plants to be inoculated in each row was selected at random.

Prior to the experiments on the effect of rust, a uniformity trial was conducted within the growth chamber to be used. The wheat seedlings were grown in the same manner as in the rust studies which were to follow. At the end of 30 days the plants were harvested and the forage weights were recorded. Statistical analysis of the data showed a coefficient of variation for the fresh and dry forage weights of 5.40% and 2.45%, respectively. Since these values were quite satisfactory the rust studies were initiated immediately.

The bench in the growth chamber was adjusted to a light intensity of 2,000 foot-candles at the top of the jars. This light source was six F48T12/CW/VHO 110-watt fluorescent bulbs and twelve 25-watt incandescent bulbs. A photoperiod of 12 hr of light and 12 hr of darkness was provided. The temperature was maintained at 26 C during the light period and 16 C during the dark period. Humidity control was not provided; hygrometer measurements indicated the relative humidity to be, approximately, 50% for the light period and 80% for the dark period.

Forage yields were first obtained by cutting 42-day-old wheat plants, with scissors, at a level of one inch above the soil surface. Cuttings from each jar were weighed, in small paper bags, on a Mettler P-1210N balance. After weighing, the samples were placed in a special dryer, designed for plant material, for 96 hr at 62 C. Then the air-dried samples were again weighed and the results recorded.

The wheat seedlings were first inoculated when the plants were seven days old. At this time each jar containing plants to be inoculated was removed from the growth chamber and placed in a moist chamber large enough to hold five such jars. These moist chambers were made of 26 x 20 x 12 inch galvanized metal boxes with a grate of 1/2-inch wooden slats to hold the base of jars above a thin layer of water provided at the bottom of the chambers to maintain high humidity.

The sides and bottom of the moist chambers were thoroughly washed and left wet before the jars of wheat seedlings were placed in the chambers. The plants in the five jars in one moist chamber were inoculated with rust spores and the plants in the

five jars in another moist chamber remained uninoculated. Plants to be inoculated were sprayed with a fine mist of water using a hand-operated 16-oz polyethylene trigger sprayer. A 4-inch clay pot containing approximately 30 wheat seedlings which were infected with physiologic race UN-2A (7) of the leaf rust fungus was brushed over the wheat seedlings in the jars, thus causing urediospores to fall on the leaves. These plants were sprayed again with water until the inoculated leaves were thoroughly covered with small water droplets. After the second spraying the top of the moist chamber box was covered with a 3/16-inch thick sheet of glass. The uninoculated plants were also placed in a moist chamber and handled in exactly the same way as the inoculated plants except that they were not brushed with the rust-infected wheat seedlings or sprayed with water. Plants were kept in the moist chamber for 8 hr, sufficient time for infection with leaf rust at 20 C.

Similarly, two additional inoculations were made on the same plants, one when the second leaf was fully developed and the other when the third leaf was fully developed. A leaf rust infection severity of 100% (modified Cobb scale) (8) was obtained following the third inoculation.

The culture of the leaf rust fungus used, physiologic race UN-2A, was isolated from a field collection made by H. C. Young, Jr. near Alva, Oklahoma in December, 1970. Currently, the UN-2A race group predominates among the isolates of *Puccinia recondita* f. sp. *tritici* in Oklahoma (9).

After the forage cuttings were made, both the rusted plants and the non-rusted plants were allowed to grow 14 more days. Then another forage cutting was made, weighed, dried, and re-weighed in the manner described above.

When forage yield determinations were completed, root development data were obtained. The contents of each jar, soil and plants, were placed on a 1/8-inch mesh screen and, by running a fine stream of water over the root mass, the soil was washed through the screen and only the plant roots remained. The total root volume for all plants in each jar was obtained by placing the roots from each jar in a liter graduate cylinder and measuring the displace-

ment of water. The roots from each jar were then weighed fresh, dried, and reweighed as were the forage cuttings.

RESULTS

Initial trials showed that the non-rusted plants produced 42% more air-dry forage than did the rusted plants (Table 1). Statistical analysis showed this difference to be significant beyond the 1% level of probability. This work was repeated with similar results (Table 1).

TABLE 1. *Effect of leaf rust on winter wheat forage production.*

Experiment	Weights (g/jar) ^a			
	Fresh ^b		Dry ^c	
	Rusted	Non-Rusted	Rusted	Non-Rusted
1	36.2	71.6	6.1	10.4
2	28.9	77.3	5.5	10.6

^a Means of 5 replications

^b LSD, 0.001 for fresh forage = 15.9

^c LSD, 0.001 for dry forage = 2.4

The amount of new growth after the first cutting of forage was indicated by the results of the second cutting (Table 2). The

TABLE 2. *Winter wheat regrowth 14 days after first foliage clipping.*

Experiment	Weights (g/jar) ^a			
	Fresh ^b		Dry ^c	
	Rusted	Non-Rusted	Rusted	Non-Rusted
1	2.5	9.7	0.7	2.1
2	1.4	7.1	0.2	0.8

^a Means of 5 replications

^b LSD, 0.001 for fresh recovery = 3.7

^c LSD, 0.01 for dry recovery = 0.9

data clearly indicated that regrowth of the rusted plants was much slower than that of the non-rusted plants. Forage produced 14 days after the first clipping showed that there was an average of 68% less regrowth on the rusted plants than on the non-rusted plants.

There have been reports that leaf rust disease of wheat can reduce root development (10). The severe reduction in recovery of the inoculated plants prompted the study of the roots. The data in Table 3 involves the root development measured immediately after the second cuttings had been made.

TABLE 3. *Effect of leaf rust on root growth of winter wheat.*

Experiment	Root Production ^a			
	Dry weights (g/jar) ^b		Volume (ml/jar) ^c	
	Rusted	Non-Rusted	Rusted	Non-Rusted
1	2.0	8.7	35	104
2	5.4	10.7	30	70

^a Means of 5 replications

^b LSD, 0.001 for dry roots = 4.0

^c LSD, 0.001 for root volume = 34.9

Only the air-dry root weights and root volume measurements are given. Since the soil was washed away from the roots with water, the actual amount of water still adhering to the roots could not be equated from jar to jar and the net weights could, therefore, be quite variable. The differences in root growth for the rusted and the non-rusted plants were highly significant for both air-dry weights and root volume.

A reduction in plant survival following the clipping of the severely rusted plants was noted. Therefore, a final test was conducted using only ten plants in each jar to avoid the "crowding" condition of the plants in the jars in the earlier experiments. This thinly spaced planting reduced the competition between plants and, as a result, tillering occurred. The non-rusted plants in this trial had an average of two tillers per plant seven days after the first cutting. No tillering occurred on the rusted plants. Hendrix and Fuchs have reported similar findings with the stripe rust disease of wheat (11).

Two weeks after the first clipping in this final test, only 64% of the previously rusted plants were still alive; whereas, 96% of those plants that had never been infected were still alive.

DISCUSSION

The data presented certainly gave evidence that leaf rust can reduce forage production of winter wheat. When rust infections on young wheat seedlings occurs early, the overall plant vitality appears to be greatly retarded. The possibility of early infections will likely be increased with earlier fall planting of wheat.

The soils in the described trials were not sterile, and when the crowns of some

dead plants, as well as healthy plants, were examined conidia of several soil-borne fungi were found. Some of these fungi may have contributed to death of some of the plants. However, equal amounts of these soil fungi were found on the rusted and non-rusted plants. Fenster, *et al.* have indicated that leaf rust weakens growing wheat and makes it more vulnerable to attack by soil pathogens (12).

The authors realize that plant production in a growth chamber may be entirely different from that under field conditions. Certainly the growth chamber work has merit when trying to control certain environmental conditions. It was necessary to keep the humidity low enough to prevent the rust from spreading to uninoculated plants. Such regulation of humidity would be difficult to maintain in the field. Root development in these small jars was restricted and plants growing under field conditions might not necessarily be affected to the same degree. However, the similarity of results obtained from trials repeated three times, with five replications each, indicates the results are valid under the conditions used.

ACKNOWLEDGMENT

This research was supported in part by the Oklahoma Wheat Research Foundation.

REFERENCES

1. OKLAHOMA CROP LIVESTOCK REPORTING SERVICE, *Wheat Pastures*, U.S.D.A. Statist. Rept. Serv., Oklahoma City, Okla., Dec., 1971, pp. 1-2.
2. W. E. MCMURPHY and B. B. TUCKER, *Pasture Research, Okla. Agr. Exp. Sta., Research Progr. Rep.*, Stillwater, Okla., 1970, pp. 25-26.
3. J. E. VAN DER PLANK, *Plant Diseases: Epidemics and Control*, Academic Press, New York, 1963.
4. T. JOHNSON, G. J. GREEN, and D. J. SAMBORSKI, *Ann. Rev. Phytopathol.* 5: 163-182 (1967).
5. OKLAHOMA CERTIFIED SEED NEWS, 1972 *Small Grains Crops Performance*, Okla. Crop. Imp. Assoc., Stillwater, Okla., Aug., 1972, pp. 1-3.
6. H. C. YOUNG, JR., *Plant Disease Problems*, Indian Phytopathological Soc., Indian Agr. Research Institute, New Delhi, 1970, pp. 3-8.
7. R. BASILE, *Plant Disease Repr.* 41: 508-511 (1957).
8. K. S. CHESTER, *The Cereal Rusts*, Chronica Botanica, Waltham, Mass., 1946, p. 21.
9. H. C. YOUNG, JR., *Leaf Rust Race Population Trends and Stability*, Proc. Ninth Hard Red Winter Wheat Conference, Lincoln, Neb., 1962, pp. 90-91.
10. C. O. JOHNSTON and E. C. MILLER, *J. Agr. Res.* 49: 955-981 (1934).
11. J. W. HENDRIX and E. FUCHS, *Plant Disease Repr.* 54: 347-349 (1970).
12. C. R. FENSTER, M. G. BOOSALIS, and J. L. WEIHING, *Date of Planting Studies of Winter Wheat and Winter Barley in Relation to Root and Crown Rot, Grain Yields and Quality*, Neb. Agr. Exp. Sta. Res. Bull. No. 250, Univ. of Neb., Lincoln, Neb., 1972, p. 11.