Winter and Early Spring Survival of *Puccinia recondita* on Kansas Wheat During 1980–1986

M. G. EVERSMEYER, Research Plant Pathologist, USDA-ARS, Department of Plant Pathology, Kansas State University, Manhattan 66506; C. L. KRAMER, Professor, Division of Biology, Kansas State University, Manhattan; and L. E. BROWDER, Research Plant Pathologist, USDA-ARS, Department of Plant Pathology, Kansas State University, Manhattan

ABSTRACT

Eversmeyer, M. G., Kramer, C. L., and Browder, L. E. 1988. Winter and early spring survival of *Puccinia recondita* on Kansas wheat during 1980–1986. Plant Disease 72:1074-1076.

Puccinia recondita survived the winter and early spring in wheat plots at Manhattan, Kansas, in 4 of 7 yr during 1980–1986. Biweekly winter and spring observations of uredinia were recorded. During winter periods in which no uredinia were observed, plants were transplanted into the greenhouse at intervals to allow for development of latent infections. In 1982, 1983, and 1986, uredinia survived on late-planted wheat (October), but in 1985, uredinia survived on early-planted wheat (August and September). *P. recondita* survived on both early- and late-planted wheat in 1986. Losses of less than 2.0% occurred in years with no fungal survival in any of the date-of-planting plots, whereas losses were greater than 2.0% when the fungus did survive the winter and early spring or at least one date-of-planting. Although maximum disease severities may have been identical, losses were greater in years in which *P. recondita* survived than in years in which it did not. This was due to maximum severities being reached up to 2 wk earlier in plots where survival occurred. Pathogenicity of surviving inoculum may be very different from pathogenicity of airborne inoculum being deposited on the plot.

Additional keywords: inoculum survival, leaf rust, overwintering, *Triticum aestivum*, yield losses

Spring initiation of wheat leaf rust epidemics in the central United States may originate from several sources. Primary inoculum of *Puccinia recondita* Rob. ex Desm. f. sp. *tritici* may occur as urediniospores carried upwind by air masses from infected fields or as a result of fall infections that survived the winter in the field. *P. recondita* can survive the winter throughout the Great Plains region of the United States as sporulating or dormant mycelium (1,3,4) and/or as viable urediniospores in uredinia on dead leaves (1–6,8–10). Our previous work (7) on development of models for prediction of epidemic development showed that separate equations were advantageous for areas in which inoculum survived the winter and those areas where the primary inoculum was exogenous.

The primary objective of the present study was to determine if the fungus was more likely to survive the winter and spring months on early- or late-planted wheat in Kansas. A secondary objective was to determine if there was a relationship between inoculum survival and estimated yield loss.

MATERIALS AND METHODS

Trison wheat (*Triticum aestivum* L.), which was susceptible to the prevailing *P. recondita* population, was planted in 1.2 × 50 m plots on six different dates (dates-of-planting) during each of the 1980–1986 crop years at Manhattan, Kansas. Weather permitting, plantings were made within ±3 days of 10 August, 1 September, 20 September, 5 October, and 25 October each year, except during 1986, when the 10 August and 1 September plantings were omitted. The recommended planting date for the Manhattan area is 5 October. Occurrence and development of leaf rust were observed at 10- to 14-day intervals throughout the wheat growing season and recorded as percent severity (11) or as number of uredinia per tiller. During periods in the winter or early spring when no signs of leaf rust were visible within the plots, wheat plants were transplanted into 10-cm^2 pots and transferred to the greenhouse at 20 C to allow for development of uredinia. After 10–14 days, the transplanted plants were examined to determine if uredinia had developed from latent infections. The number of uredinia observed was recorded for each leaf of each plant. During years in which snow cover was a possible factor in the survival of the fungus and/or host tissue, plants were not transplanted into the greenhouse until the snow cover had ended. Winter survival was considered to have occurred when uredinia were observed during January–March in the field or developed on plants transplanted into the greenhouse during the time no uredinia were observed in the field.

To provide control of leaf rust for yield loss studies, various applications of mancozeb were used. Mancozeb was applied weekly beginning at late joint/early boot wheat growth stage to four 1.2

Cooperative investigations of the USDA-ARS and Kansas Agricultural Experiment Station, Department of Plant Pathology and Division of Biology. Contribution 88-26-J.

Accepted for publication 1 August 1988 (submitted for electronic processing).

× 7 m areas in each date-of-planting plot. Yield measurements were obtained from four 1.5-m^2 treated and rusted areas in each date-of-planting plot. Percent increase in yield obtained by control of wheat leaf rust was calculated for each date-of-planting for each year. Data from each year were analyzed by analysis of variance. Waller-Duncan's multiple range test (k-ratio = 100) was used for mean separations.

RESULTS

Fall infection occurred in all but one plot (25 October 1980 planting), and inoculum survived in trace amounts in at least one date-of-planting plot until mid-January every year except 1981 (Table 1). *P. recondita* survived in plots planted on or after the recommended planting date of 5 October in 1982, 1983, and 1986 and survived in plots planted before the recommended planting date in 1985. The fungus survived in 1984 until the snow cover had disappeared and subfreezing temperatures and/or sudden changes to low temperatures caused the infected leaves to senesce where snow cover was not present (Table 1).

Data on fungal survival, maximum disease severities, and average increase in wheat yields in the fungicide-treated plots are shown in Table 2. Average yield increase from fungicide treatment during those 4 yr ranged from 10.1 to 40.8%. In the 3 yr in which winter survivial did not occur, increase in yield due to control of leaf rust was less than 2%. Estimates of statewide losses for Kansas were also under 2% for the same 3 yr (12). Maximum leaf rust severities were less than 50% during years without winter survival and were greater than 50% during years with winter survival of the fungus. However, maximum severities did not always reach 100% even when winter survival occurred.

DISCUSSION

P. recondita is capable of surviving the winter in its uredinial stage on the wheat plant throughout the winter wheat growing region of the United States (1,3,4). *P. recondita* mycelium is apparently capable of surviving all environmental conditions that the infected host tissue can survive (9). We have assumed that the fungus survived most seasons on the youngest wheat leaves from late fall or early winter infections or from infections that occurred during favorable infection periods during January or February. Normally, the wheat plant loses many of the older lower (probably infected) leaves throughout the winter months because of senescence. In our study, we found that mycelium survived in the second to the fourth youngest leaves of the plant in 6 of the 7 yr. During 1985 and 1986, uredinia were found on all ages of leaves in the plots.

Low temperature is probably less important to the survival of *P. recondita* during the winter and early spring than snow cover, snow depth, sudden temperature changes, hardiness and survival of host tissue, and topography of the wheat field, all of which affect host tissue survival. Periods with conditions favorable for reinfection during winter and early spring are extremely important for winter survival when snow cover does not provide protection throughout the winter or where another pest or management practice removes the infected leaves. In the early spring when temperatures

Table 1. Survival of *Puccinia recondita* throughout the wheat growing season at Manhattan, Kansas, during 1980–1986 and yield increase obtained with disease control

Crop year	Planting date	Leaf rust severity at growth stage[x]									Yield increase[y] (%)
		Fall	Winter	Winter (GH)	J(GH)	J	B	H	SD	Max	
1980	10 Aug. 1979	10	0	0	0	0	0	0	5	20	0.1
	1 Sept.	10	0	0	0	0	0	0	5	20	0.9
	20 Sept.	5	T	T	0	0	0	T	2	20	1.0
	5 Oct.	T	0	0	0	0	T	T	2	10	0.1
	25 Oct.	0	0	0	0	0	T	T	T	2	1.1
1981	10 Aug. 1980	10	0	0	0	0	T	1	5	20	1.5
	1 Sept.	10	0	0	0	0	T	1	5	20	1.3
	20 Sept.	5	0	0	0	0	T	2	10	20	1.9
	5 Oct.	T	0	0	0	0	T	5	10	20	1.5
	25 Oct.	T	0	0	0	0	T	5	10	20	0.7
1982	10 Aug. 1981	20	0	0	0	0	T	5	50	70	14.3
	1 Sept.	10	T	0	0	0	T	5	50	70	12.8
	20 Sept.	10	0	0	T	T	2	5	50	70	8.4
	5 Oct.	10	T	T	T	T	T	5	40	70	2.2
	25 Oct.	T	T	T	T	T	2	10	50	70	12.8
1983	10 Aug. 1982	40	3	1–5	0	0	T	10	30	50	12.8
	1 Sept.	40	3	1–5	0	0	T	10	40	50	9.8
	20 Sept.	30	3	1–5	0	0	T	10	40	50	12.1
	5 Oct.	10	1	1	T	T	2	20	50	60	15.9
	25 Oct.	T	T	1	T	T	2	20	50	60	10.0
1984	10 Aug. 1983	40	1	T[z]	0	0	T	1	20	30	1.9
	1 Sept.	40	1	T[z]	0	0	T	1	20	30	1.1
	20 Sept.	40	1	T[z]	0	0	T	1	20	30	1.1
	5 Oct.	10	T	T[z]	0	0	T	1	20	30	0.3
	25 Oct.	1	T	T[z]	0	0	T	1	20	30	0.2
1985	10 Aug. 1984	60	1	2	1	3	10	30	100	100	57.8
	1 Sept.	60	1	2	1	3	10	30	100	100	53.4
	20 Sept.	30	1	2	1	3	5	10	80	100	19.6
	5 Oct.	1	0	0	0	0	1	5	60	100	8.9
	25 Oct.	0	0	0	0	0	1	5	60	100	14.8
1986	20 Sept. 1985	40	20	1	2	3	10	20	50	100	36.9
	5 Oct.	20	20	1	2	3	10	20	50	100	49.6
	25 Oct.	10	20	1	1	2	10	20	50	100	35.9

[x] Percent severity estimated using modified Cobb scale, where T = at least one uredinium and <1%. Wheat growth stages: J = joint, B = boot, H = heading, SD = soft dough, Max = maximum severity observed. Fall = maximum severity observed before 1 December, winter = maximum severity observed during January–March, GH = estimates of uredinia developing in the greenhouse after 10–14 days; 30 uredinia per tiller = 1%.

[y] Percent increase in yield obtained by fungicide application.

[z] Mild temperatures melted snow cover with infected tissue, then exposure to −5 C temperatures caused leaves to senesce.

Table 2. Survival of *Puccinia recondita*, maximum wheat leaf rust severity, and average yield increase obtained by fungicide application at Manhattan, Kansas

Year	Inoculum overwintered[x] (%)	Leaf rust severity (%)	Yield increase[y] (%)
1980	No	20	0.6 d[z]
1981	No	20	1.4 d
1982	Late	70	10.1 c
1983	Late	50	12.1 c
1984	No	30	0.9 d
1985	Early	100	30.9 b
1986	Either	100	40.8 a

[x] Late = fungus survived on wheat planted on or after 5 October, early = fungus survived on wheat planted before 5 October, either = survival on all plantings.
[y] Percent increase calculated by sprayed yield minus rusted yield × 100.
[z] Means followed by the same letter are not significantly different as separated by Waller-Duncan's multiple range test at $P = 0.05$.

become warm enough to initiate regrowth in the wheat plants, temperatures may fluctuate between 10–15 C and near freezing or below within a few hours. Such sudden changes in temperature may be more destructive to host tissue than more gradual changes in temperature. Hassan et al (9) found that if mycelium was allowed to develop for at least 24 hr before being subjected to freezing temperatures, it would survive within the host tissue and develop to sporulation.

Survival of *P. recondita* in the form of sporulating uredinia, dormant mycelium, or viable urediniospores can provide the primary inoculum to initiate severe epidemics when environmental conditions are favorable. Environmental conditions that allow the infection process to proceed to completion occur irregularly during the winter and early spring in Kansas. Thus, the probability of airborne inoculum being deposited and remaining viable until conditions are suitable for infection is rather low. Should inoculum remain viable through that hazardous period, however, the possibility of infection is greatly increased. Fungal survival also provides inoculum virulent to the cultivar, whereas exogenous inoculum may or may not be virulent. Pathogenicity of surviving inoculum may be very different from pathogenicity of airborne inoculum deposited on the wheat cultivar in the field. Surviving inoculum in the Harper and Sumner county areas in 1987 resulted in higher than expected severities on the cultivar Arkan, which was resistant to a majority of the prevailing pathogen population in 1986. Arkan acreage in several of the surrounding counties, where early observations indicated that leaf rust failed to survive from the fall infections, had lower severities of leaf rust than Arkan acreage in the Harper and Sumner areas.

LITERATURE CITED

1. Arthur, J. C. 1929. The Plant Rusts (Uredinales). John Wiley & Sons, New York. 446 pp.
2. Bolley, H. L. 1889. Wheat rust. Indiana Agric. Exp. Stn. Bull. 26:3-19.
3. Burleigh, J. R., Schulze, A. A., and Eversmeyer, M. G. 1969. Some aspects of the summer and winter ecology of wheat rust fungi. Plant Dis. Rep. 53:648-651.
4. Chester, K. S. 1946. The Cereal Rusts. Chronica Botanica Co., Waltham, MA. 269 pp.
5. Christman, A. H. 1904. Observations on the wintering of grain rusts. Trans. Wisc. Acad. Sci. 15:98-107.
6. Eversmeyer, M. G., and Burleigh, J. R. 1968. Effect of temperature on the longevity of *Puccinia recondita* f. sp. *tritici* urediospores on dry wheat foliage. Plant Dis. Rep. 52:186-188.
7. Eversmeyer, M. G., and Burleigh, J. R. 1970. A method of predicting epidemic development of wheat leaf rust. Phytopathology 60:805-811.
8. Freeman, E. M., and Johnson, E. C. 1911. The rusts of grains in the United States. U.S. Dep. Agric. Bur. Plant Ind. Bull. 216:1-87.
9. Hassan, Z. M., Kramer, C. L., and Eversmeyer, M. G. 1986. Summer and winter survival of *Puccinia recondita* and infection by soilborne urediniospores. Trans. Br. Mycol. Soc. 86:365-372.
10. Hitchcock, A. S., and Carlton, M. A. 1893. Preliminary report on rust of grain. Kans. Agric. Exp. Stn. Bull. 38:1-14.
11. Peterson, R. F., Campbell, A. B., and Hannah, A. E. 1948. A diagrammatic scale for estimating rust intensity of leaves and stems of cereals. Can. J. Res. 26:496-500.
12. Sim, T., IV, Willis, W. G., and Eversmeyer, M. G. 1988. Kansas plant disease survey. Plant Dis. 72:832-836.