WHEAT LEAF AND STEM RUST DEVELOPMENT NEAR A WIND BARRIER

M. G. Eversmeyer and E. L. Skidmore

Research Plant Pathologist and Research Soil Scientist, North Central Region, Agricultural Research Service, U. S. Department of Agriculture, Department of Plant Pathology and Department of Agronomy, respectively, Kansas State University, Manhattan, Kansas 66506.

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ABSTRACT

Significant differences in development of wheat leaf and stem rust severities about a wind barrier were observed. Leaf rust severities were generally highest leeward of the barrier. Leaf rust overwintered windward of the barrier, and the primary focus of natural stem rust infection was found near the barrier in both years of the study. Stem rust was more severe, and dew was present about 0.5 hr/day longer, adjacent to the barrier. Urediospore numbers decreased leeward of the barrier as far as six times the barrier height and then increased with distance beyond that point.

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Attempts to increase plant yields by using wind barriers to manipulate the environment surrounding a crop have produced results ranging from no increases to increases greater than 100% (3, 5, 6, 8, 11, 13). Natural or artificial wind barriers tend to change microclimatic conditions by increasing relative humidity and duration of dew periods and by reducing wind movement near the barrier (9, 10). This paper reports on a barrier-induced microclimate's effect on development and distribution of wheat leaf and stem rust caused by *Puccinia recondita* Rob. ex. Desm. f. sp. *tritici* and *P. graminis* Pers. f. sp. *tritici* Eriks. & E. Henn.

MATERIALS AND METHODS

Five cultivars of wheat (Triticum aestivum) -- Shawnee, Parker, Caprock, Blueboy, and Pronto -- were planted in a randomized block plot design in 1971 and 1972. We used four replications of 2.5 by 90-meter plots for each cultivar. In an area of prevailing southerly winds, a 40% porous 2.4-meter-high (H) slat fence was erected as a wind barrier midway across the plot, dividing each replication into equal windward and leeward sections, each 45 meters long. Wheat leaf rust was controlled on two of the replications by applying 2 oz/A 4-n-butyl-1,2,4-triazole (BT) (RH-124) in mid-March. A spray consisting of a coordination product of zinc ion and manganous ethylenebis[dithiocarbamate](zinc + maneb) was applied frequently on 1 m^2 areas 4.8 (2H), 9.6 (4H), 19.2 (8H), and 28.8 (12H) meters windward and leeward of the barrier on the BT-sprayed replications for control of wheat stem rust and other foliar diseases. Taylor dew meters (12) and 5-mm-diam rod spore traps mounted on wind vanes 15 cm above the canopy were placed 1, 2, 4, 8, and 12H windward and leeward of the barrier.

Leaf and stem rust developed from natural infection in both years. Disease severity at the various distances from the barrier was estimated by the modified Cobb scale (4).

RESULTS AND DISCUSSION

Analyses of variance of 1971 disease severity data for stem rust, leaf rust, and powdery mildew (Erysiphe graminis (DC.) Merat tritici Em. Marchal) at 2, 6 and 12H windward and leeward of an east-west barrier are given in Table 1. As indicated in Table 1, there were definite differences in the amount of powdery mildew, leaf rust, and stem rust observed on the various cultivars and replications. Leaf and stem rust distribution about the barrier was affected, but powdery mildew did not seem to be affected by microclimatic changes induced by the barrier. We believe this was because of the light powdery mildew infection, which could not be effectively sampled and analyzed because of large variations within replications and cultivars. The barrier had not yet been erected when the initial powdery mildew infections were observed.

Average stem rust severity on June 21 was 50 and 20% for Blueboy and Parker, respectively. Stem rust severities on Shawnee, Caprock, and Pronto were all less than 3%. Stem rust was more severe within a distance of 2H of the barrier on all cultivars. Centers of stem rust, reaching severities of 30 and 15%, were observed on Parker, and 80 and 30% on Blueboy at 2H and 6H, respectively, windward and leeward of the barrier. Further decreases in severity beyond 6H from the barrier were not noted. Stem rust severities at 6 and 12H windward and leeward were similar (Fig. 1).

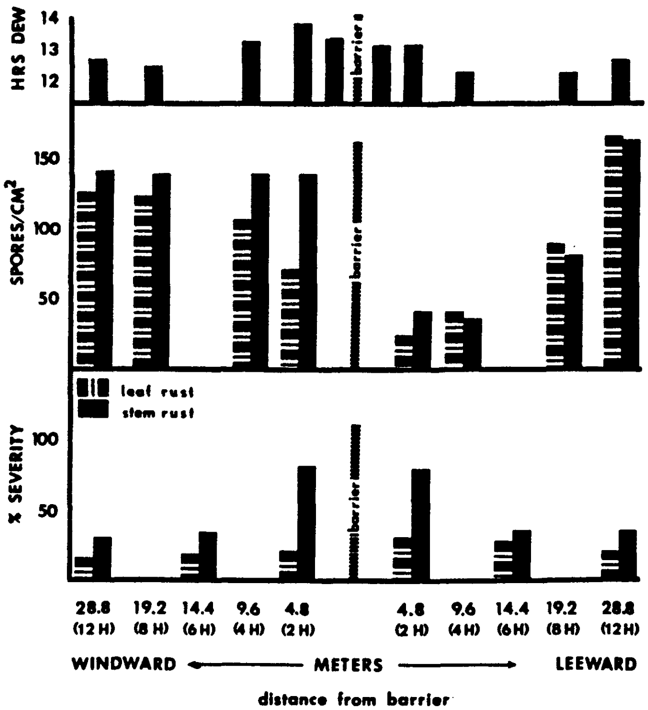

FIGURE 1. Distribution of average hours of dew, maximum wheat leaf and stem rust severities in 1971, and average number of Puccinia graminis and P. recondita urediospores trapped/cm^2 near a wind barrier from June 1-11. H = Barrier height.

The initial stem rust foci were found May 19 on Blueboy, 2H on the windward side (south) of the barrier; however, stem rust did not spread far enough from the primary infection foci to cause severe general reductions in yields at various distances from the barrier. High stem rust severities were in foci usually covering an area less than 1 meter in diameter. Comparisons of means of the percent yield loss showed nonsignificant differences caused by relative position from the barrier. Variation in losses between cultivars and replications within cultivars was large because, by chance, varying amounts of wheat in these severely rusted foci were included in the areas harvested for yield measurements. A general pattern of greater loss next to the barrier was noted. Although precipitation was above average in 1971, warm southerly winds were less prevalent, and lower-than-normal air temperatures were not favorable for a rust epidemic.

Leaf rust developed too late to cause severe damage, even though severities were significantly different at the various distances from the barrier (Table 1). Differences in distribution of severities in the plot were more highly significant early in the epidemic than later, when the inoculum load was high. Maximum leaf rust severities were generally less than 20% on the flag leaf, which is the best indicator of damage caused by leaf rust (1). Leaf rust severities of 30 to 50% occurred on leaves lower in the canopy. Generally, leaf rust severities were higher up to 6H leeward (north) of the barrier, in contrast to stem rust severities, which were higher 2H either side of the barrier (Fig. 1).

Table 1. Analysis of variance of distribution of disease severity estimates windward and leeward of a wind barrier in 1971.

Source of variation	Degrees of freedom	Sum of squares	Mean square	Variance ratio
Stem rust				
Date (June 14 & 21, 1971)	1	11,512	11,512	176.84***
Variety	4	35,317	8,829	135.62***
Replication	4	1,023	256	3.93**
Distance	5	3,570	714	10.96***
Date x variety	4	16,619	4,154	63.81***
Date x distance	5	2,212	442	6.49***
Variety x distance	20	5,442	272	4.17***
Date x variety x distance	20	3,394	170	2.60***
Residual	236	15,386	65	
Total	299	94,475		
Leaf rust				
Date (June 1, 8, & 14, 1971)	2	10,098	5,049	180.30***
Variety	2	2,686	1,343	47.96***
Replication	2	339	170	6.07**
Distance	5	413	83	2.96*
Date x variety	4	5,445	1,361	48.61***
Date x distance	10	884	88	3.14**
Variety x distance	10	191	19	0.68
Date x variety x distance	20	410	21	0.75
Residual	106	2,984	28	
Total	161	23,450		
Powdery mildew				
Date (May 22 & 29, 1971)	1	827	827	8.8**
Variety	4	20,740	5,185	55.2***
Replication	4	35,252	8,813	93.8***
Distance	5	856	171	1.8
Date x variety	4	599	150	1.6
Date x distance	5	437	87	0.9
Variety x distance	20	973	49	0.5
Date x variety x distance	20	417	21	0.2
Residual	236	22,190	94	
Total	299	82,291		

*, **, *** Significant at P = 0.05, 0.01, and 0.001, respectively.

Although differences in development of powdery mildew were not significantly correlated with distance from the barrier (Table 1), the disease was severest from 2H windward to 6H leeward of the barrier.

Significant differences in development of disease severities about the barrier were observed among cultivars and replications in both 1971 and 1972. Disease severities observed in the plots in 1972 were slightly lower than those in 1971, probably because of a cool wet spring, unfavorable for epidemic development of either leaf or stem rust. Only trace amounts of powdery mildew were observed in the 1972 plots; however, the same general pattern observed in 1971 was also noted in 1972. Leaf rust was observed to overwinter immediately windward of the barrier in both 1971 and 1972.

The primary foci of stem rust were found within 2H of the barrier during both 1971 and 1972. We assumed that the barrier reduced wind speed, allowing P. graminis urediospores to be deposited more readily near the barrier. A check of dew records at various distances from the barrier indicated that dew was present an average of 0.5 hr/day longer near the barrier, especially early in the growing season, when temperatures and duration of dew were near the minimum for spore germination. Temperatures on the windward (south) side of the barrier may have been modified enough to allow germination when unprotected areas were still below the minimum for spore germination. Average hours of dew recorded at various distances from the barrier May 10 to June 1 are shown in Figure 1.

Immediately leeward of the barrier, wind velocity decreased rapidly and was minimal about 6H leeward. The barrier did not affect wind velocity at distances greater than 12H leeward. Velocity was also considerably slower 2H windward of the barrier. Because data from other researchers (7) indicate that number of spores trapped over a 100 m plot should not be significantly different over these distances, we assumed that reduced wind velocities and turbulence caused by wind flowing over and through the barrier affected the number of urediospores that became airborne and were deposited on the spore traps. P. recondita urediospore numbers decreased rapidly from 4H windward to 2H leeward of the barrier and generally followed the pattern of decreasing and then increasing wind velocities around a barrier.

Fewer P. graminis urediospores were deposited/cm^2 on glass-rod spore traps located up to 8H on the leeward side of the barrier than on the windward side or farther from the barrier on the leeward side (Fig. 1). With wind velocity beginning to decrease 2H windward of the barrier, we would not have expected as many urediospores to be deposited at that point; however, the high stem rust severities near the barrier must have provided an extremely high concentration of spores immediately windward of the barrier. The number of urediospores trapped at 12H on the leeward side was slightly greater than the number trapped at any distance on the windward side.

After the wheat reached the anthesis growth stage, the top of the barrier was about 1.2 meters above the canopy. Because the leeward distribution of spores was affected up to 8 times the height of the barrier or about 15 times the height of the barrier above the canopy, we assumed that the distribution of inoculum, applied either artificially or naturally, could be similarly affected by cultivars of different heights within a nursery. That is a possible explanation for our observation of fewer leaf rust uredia on rows of a cultivar next to a 15-cm-taller cultivar 12 days after the nursery had been artificially inoculated. Inoculation was accomplished by allowing P. recondita urediospores to be disseminated by wind over the nursery. Uredia counted on rows 1, 2, 3, 4, 5, 6, 7, and 8 feet leeward from the taller cultivar were 9, 6, 4, 8, 10, 16, 18, and 17, respectively. Number of uredia counted on rows of the same cultivar 1, 2, 3, 4, 5, 6, 7, and 8 feet leeward of a cultivar of the same height were 14, 16, 17, 16, and 17, respectively. Numbers of urediospores deposited per cm^2 on 5 mm-diam glass rods about 120 cm above the ground (about 15 cm above the taller cultivar) were nearly equal over the nursery, with 194 trapped over the taller cultivar, while 203 were trapped over the shorter cultivar.

Because the windbreak affected distribution of the air flora, we assume pollination and other biological phenomena influenced by spore distribution can be affected by windbreaks or by differential heights of host lines being used in a research program. In previous oversummering and overwintering studies (2), we occasionally found leaf rust uredia close to hedge and fence rows or snow fences when it could not be found elsewhere in the field. In the spring, centers of stem rust uredia were occasionally found in similar protected areas before it was found in the open field. Apparently distribution of pollen, inoculum, and disease severities can be affected by a wind barrier, which may be important in seed set and overwintering and/or establishment of primary infections in a field.

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