Effect of Low Temperature on the Latent Period of Slow and Fast Rusting Winter Wheat Genotypes

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ABSTRACT

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The latent period of fast and slow rusting winter wheat lines infected with *Puccinia recondita* f. sp. *tritici* was studied at 27, 21, 16, 10 and 4 C in growth chambers and in the field during late winter in Texas. In growth chambers, the latent period lengthened as the temperature decreased, but the latent period of the slow rusting lines increased more than that of the fast rusting lines. In the field, the latent period of the slow rusting lines was significantly longer than that of the fast rusting cultivars. The longer latent period of slow rusting winter wheat cultivars may be effective in reducing the rate of leaf rust development during the winter in Texas.

Fall sown spring wheat in south Texas and winter wheat in central and north Texas are important as pasture for cattle and as a grain crop. Leaf rust, *Puccinia recondita* Rob. ex. Desm. f. sp. *tritici* (Erikss.) C. O. Johnston, commonly overwinters in wheat, *Triticum aestivum* L., in Texas and often becomes severe in early spring. The weather in the spring generally favors leaf rust development so that the severity of epidemics in the southern Great Plains depends mainly on the amount of inoculum produced in the field in late winter (2,3).

Cultivars with the slow rusting type of resistance may reduce the rate of rust development during the winter in Texas and consequently restrict an increase of inoculum. Various components of slow rusting are effective in some seedling and juvenile plants (5,7,9–11), and these components would be effective in reducing the rate of disease development during the winter. Of the components of slow rusting, latent period is easiest to study and is important in reducing disease development. However, the latent period in seedlings of slow rusting cultivars has not differed greatly from that of fast rusting seedlings (6–8), but this conclusion was based on studies at typical summer temperatures. The purpose of this study was to measure the latent period of fast and slow rusting winter wheat lines at typical winter temperatures and conditions.

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MATERIALS AND METHODS

We studied the hard red winter wheat cultivars Palo Duro (CI 14584), Danne (CI 13876), TAM W-103 (CI 17336), and TAM W-101 (CI 15324), which rust rapidly when infected with *P. recondita* f. sp. *tritici* in the field, and the Texas lines 78V2950, 78V2905 and 71A894-2, which rust slowly. Seedlings in the second leaf stage of development were placed on a rotating platform and inoculated with an oil suspension of urediospores of *P. recondita* f. sp. *tritici* at 21–23 C.

We used three cultures of *P. recondita* f. sp. *tritici* with the following avirulent/virulent formulas: LR2A, 2D, 16, 17, 19/LR1, 3, 3B, 9, 10, 11, 18 collected from the winter wheat cultivar Newton near Dallas, TX; LR2A, 9, 18, 19/LR1, 2D, 3, 3B, 10, 11, 16, 17 collected from TAM W-101 near Chillicothe, TX; and LR2A, 2D, 9, 17, 18, 19/LR1, 3, 3B, 10, 11, 16 collected from TAM W-101 near Bushland, TX.

After inoculated seedlings had been in a moist chamber for 12 hr at 21–23 C, they were placed in growth chambers and arranged in a factorial design of four replicates with three seedlings per replicate at 27, 21, 16, 10, and 4 C; the temperature variance was ± 2 C. The photoperiod for seedlings in the growth chambers was 13 hr at about 31,000 lux.

Six replicates of the test wheats were also inoculated during the boot stage of growth with the leaf rust culture from Dallas. Plants were placed in the moist chamber for 12 hr at 21–23 C and then maintained in a growth chamber at 21 ± 2 C with a 15-hr photoperiod.

Latent period was determined on the

Table 1. Effect of temperature on latent periods of fast and slow rusting wheat infected with *Puccinia recondita* f. sp. *tritici* during the second leaf stage and boot stage of growth[a]

	Latent period in days at each temperature (C)					
	Second leaf stage					Boot stage
Cultivar or line	27	21	16	10	4	21
Fast rusting						
Palo Duro	6.1 a	6.2 a	8.4 a	13.9 ab	21.9 ab	6.5 a
Danne	6.8 b	6.2 a	8.6 ab	13.7 a	21.2 a	6.4 a
TAM W-103	6.4 ab	6.3 a	8.3 a	14.0 ab	22.2 bc	6.4 a
TAM W-101	6.6 ab	6.5 ab	8.3 a	14.3 b	22.7 bc	6.7 a
Mean	6.5	6.3	8.4	14.0	22.0	6.5
Slow rusting						
71A894-2	6.7 b	6.9 bc	8.9 b	14.8 c	24.2 d	7.7 b
78V2905	6.7 b	6.8 bc	9.1 c	15.1 c	22.9 c	8.0 bc
78V2950	6.8 b	7.2 c	10.1 d	15.0 c	24.3 d	8.4 c
Mean	6.7	7.0	9.4	15.0	23.8	8.0

[a] Values for second leaf stage and boot stage of growth are means of four and six replicates, respectively. Within a column, values with same letter are not significantly different at $P = 0.05$, according to Duncan's multiple range test.

second leaf of seedlings and on the flag leaf and penultimate leaf of adult plants. Uredia were counted daily after inoculation until no more developed, and the latent period was the time from inoculation until 50% of the uredia had formed.

Seedlings of the test wheats, in growth stage 3 of the Romig scale (tillers formed [1]) on 8 February 1979, and seedlings in growth stage 4 (leaf-sheaths beginning to lengthen) on 6 March 1979 were transplanted from the field into pots. Seedlings were inoculated with each of the cultures of *P. recondita* f. sp. *tritici* and placed in a moist chamber at 21–23 C for 12 hr. Then seedlings in growth stage 3 were placed in a growth chamber at 16 ± 2 C and seedlings in growth stage 4 were placed in growth chambers at 16 ± 2 and 21 ± 2 C. Three replicates of five tillers per replicate per cultivar or line and each rust isolate were placed in each growth chamber.

In a field experiment at Chillicothe, TX, two 1-m rows each of the four fast rusting and three slow rusting wheats were inoculated with an oil suspension of urediospores. Plants in growth stage 4 were inoculated with the culture of leaf rust from Dallas on 20 March 1979 when temperature and moisture conditions were satisfactory for infection. This date marked the first occurrence of favorable temperature and moisture conditions for infection since late fall. Signs of the leaf rust fungus were not found in wheat fields surrounding the test plots for a radius of several kilometers. Noninoculated check rows and an adjacent 12-ha wheat field were observed for signs of leaf rust during and after the experiment to monitor possible external inoculum. The latent period was determined for eight plants of each cultivar or line.

Single-degree of freedom contrasts were computed to test differences between the fast rusting and slow rusting wheats in each experiment.

RESULTS

The latent periods of the three cultures of leaf rust did not differ significantly, and data for the three cultures were combined (Tables 1 and 2).

The latent period of the slow rusting lines in the second leaf stage of growth at 27 C was not significantly different ($P < 0.05$) from the latent period of the fast rusting cultivars. However, the latent period of the slow rusting lines was significantly longer ($P < 0.01$) at 21, 16, 10, and 4 C than the latent period of the fast rusting cultivars (Table 1). The interaction term between the latent period of the cultivars and the temperatures during incubation was significant ($P < 0.01$).

The latent period of all cultivars and lines increased as the temperature decreased (Table 1), but the latent period of the slow rusting lines increased more than that of the fast rusting cultivars. The difference in the mean latent period of the slow rusting lines and the fast rusting cultivars increased from 0.2 days at 27 C to 1.8 days at 4 C. The difference in latent period of the slow rusting line with the longest latent period (71V2950) and the mean of the fast rusting cultivars increased from 0.3 days at 27 C to 2.3 days at 4 C (Table 1).

In the boot stage of growth the latent period of the slow rusting lines was significantly longer ($P < 0.01$) than that of the fast rusting cultivars (Table 1). The difference in the latent period of the slow and fast rusting lines in the boot stage at 21 C was greater than at 21 C in the seedling stage of growth (Table 1).

The latent period of slow rusting lines in growth stages 3 and 4 was significantly longer ($P < 0.01$) than that of the fast rusting cultivars at both 16 and 21 C (Table 2). The latent period of the slow rusting lines increased more than the latent period of the fast rusting cultivars as the temperature decreased from 21 to 16 C (Table 2).

The latent periods of the slow rusting lines in the field were significantly longer ($P < 0.01$) than the latent period of the fast rusting cultivars (Table 2). The average maximum temperature during the latent period was 20 C with a daily maximum range of 10.7–27.8 C; the average minimum temperature was 5 C with a daily minimum range of −0.6 to 16.7 C; and the mean temperature was 12.2 C with a daily range of 6.7–21.7 C.

Table 2. Latent period of slow and fast rusting wheat inoculated with *Puccinia recondita* f. sp. *tritici* and placed in growth chambers or inoculated in the field in late winter[a]

	Latent period (days)			
	Growth chamber			Field
	GS3[b]	GS4[c]	GS4[c]	GS4[c]
Cultivar or line	16 C	16 C	21 C	12.2 C[d]
Fast rusting				
Palo Duro	8.7 a	8.9 a	6.7 ab	14.0 ab
Danne	8.8 ab	8.9 a	6.6 a	13.4 a
TAM W-103	8.5 a	8.7 a	6.7 ab	14.1 ab
TAM W-101	9.0 abc	8.8 a	6.6 a	14.8 bc
Mean	8.8	8.8	6.7	14.1
Slow rusting				
71A894-2	9.4 c	9.6 b	6.9 bc	16.8 d
78V2905	9.3 bc	9.7 b	7.0 c	15.6 c
78V2950	10.1 d	10.9 c	7.9 d	17.1 d
Mean	9.6	10.1	7.3	16.5

[a] Values are means for three to eight replicates. Within a column, values with same letter were not significantly different at $P = 0.05$ according to Duncan's multiple range test.
[b] GS3 = growth stage 3 on the Romig scale (1): tillers formed, leaves twisted spirally.
[c] GS4 = growth stage 4 on the Romig scale (1): beginning of erection of the pseudostem, leaf sheaths beginning to lengthen.
[d] Mean 12.2, range −0.6 to 28 C.

DISCUSSION

Late winter in the southern Great Plains of the United States is a critical period in the epidemiology of leaf rust of wheat (2,3). *P. recondita* commonly overwinters in wheat in this area, and when weather conditions are favorable, it completes several reproductive cycles during winter and produces relatively large quantities of inoculum. Wheat is generally in late jointing stages of growth at the end of winter.

Slow rusting cultivars in seedling and juvenile stages of growth may reduce the rate of leaf rust development during the winter in the southern Great Plains. Seedlings of slow rusting cultivars and lines restrict pustule size (5,10,11), reduce sporulation (10), and have fewer uredia (5,9) and a longer latent period (6–8) than seedlings that rust rapidly. The latent periods of seedlings of slow and fast rusting wheats have not been shown to differ greatly (6–8). However, the latent period of wheats in seedling and juvenile stages of growth at low temperatures in this study have been 1–3 days longer than that of fast rusting wheats. The latent period of seedlings of slow rusting winter wheat cultivars with the cumulative effect of several other components of slow rusting should be effective in reducing the rate of leaf rust development during the winter in the southern Great Plains.

A relatively high infection rate during the spring could negate the effect of a reduced rate of leaf rust development during the winter (4,12). However, if slow rusting cultivars were widely used in a control strategy, the rate of leaf rust development would not only be reduced during the winter but also during the spring when the resistance of slow rusting cultivars in adult stages of growth is operating.

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Maintenance of *Sclerotinia camelliae* Cultures on Sterilized Wheat

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ABSTRACT

HOLCOMB, G. E. 1980. Maintenance of *Sclerotinia camelliae* cultures on sterilized wheat. Plant Disease 64:1008.

Sclerotinia camelliae, the causal fungus of camellia flower blight, was grown on sterilized wheat seeds and placed in storage at 4 C. Cultures remained viable and pathogenic during 84 mo of storage.

Sclerotinia camelliae Hara is the cause of flower blight of camellia. Several researchers have reported on the longevity (5,6) and the difficulty of maintaining (1,2) the fungus in culture. McCain reported that *S. camelliae* was viable in 9-mo-old cultures that had been maintained at 21–24 C. Johnson found the fungus remained viable for 30 mo when stored at 15 C on sterilized wheat seed. In my study, *S. camelliae* was maintained in storage for 84 mo.

MATERIALS AND METHODS

Cultures of *S. camelliae* were started from infected flower tissue placed on acidified potato-dextrose agar (PDA). Subcultures were grown at 16 and 20 C and used after 7–10 days to start cultures on sterilized wheat seed. One-ounce French Square bottles were two-thirds filled with 15 g of dry seed and covered with 10 ml of water. Cultures were stored at 4 C after the fungus had overgrown the wheat seed (about 2 wk).

Individual wheat seeds were withdrawn after 22 and 84 mo in storage and placed on acidified PDA in plastic culture dishes to check for viability of the fungus. Nine to 16 seeds were taken from each of four or five stored cultures on the two sampling dates. Pathogenicity of the fungus was tested by dropping mycelium (shredded 5 sec in a blender) onto the petals of detached camellia flowers that were then placed in a moist chamber.

Table 1. Recovery of *Sclerotinia camelliae* from cultures after long-term storage on sterilized wheat seed

Culture no.	Sampling date	
	22 mo	84 mo
1	7/14[a]	0/15[b]
2	6/9	13/15
3	6/13	0/15
4	...[c]	0/15
5	6/9	7/16

[a] Number of seeds from which viable fungus was recovered/total number of seed sampled.
[b] Cultures from which the fungus was not recovered showed moderate to severe desiccation of the seed, which probably indicated a poor seal. These cultures were resampled (21–22 seed from each) 10 days after the last sampling, again with negative recovery results.
[c] Culture not sampled.

RESULTS AND DISCUSSION

S. camelliae was recovered from cultures grown on wheat seeds after 84 mo in storage (Table 1). The fungus was also pathogenic when inoculated onto camellia flowers and produced the typical soft rot associated with the blight disease. Maintenance difficulties experienced by others (2) may have been due in part to growing and maintaining the fungus at unfavorably high temperatures (25 C). Although Barnett and Lilly (3) reported best mycelial growth of *S. camelliae* at 25 C, Hanson and Thomas (4) and Johnson (5) reported 15–18 and 20 C, respectively, as supporting best mycelial growth.

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