The Influence of Leaf Wetness on Wheat Leaf Rust

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INTRODUCTION

It has been known for 30 years that moisture is required for infection by wheat leaf rust (*Puccinia recondita* Rob. ex. Desm. f. sp. *tritici*) (3). Free moisture (to the point of complete wetness) present on the leaf surface during the incubation period increases numbers of infections (1,8).

Adhesion of water and pesticides to leaf surfaces have been determined by wettability experiments (4,5). The contact angle (4,6) is the angle between a water droplet and the leaf surface and has been used to measure wettability. Roughness and waxiness of the leaf surface govern the droplet contact angle. Glaucous leaves (powdery or waxy coating) have deposits of wax rodlets or platelets (5,7) and cause contact angles greater than 120°. Contact angles between leaf and water droplet less than 110° occur on leaves that have little wax and a flat wax topography.

Since we have been unable to obtain uniform rust infection on durum cultivars unless we rubbed the leaves prior to misting or added Tween 20 (a surfactant) to the water mist, we determined the effect of these treatments on leaf water retention and subsequent infection by the leaf rust fungus.

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MATERIALS AND METHODS

Two cultivars of hard red spring wheat 'Thatcher' and 'Waldron,' and two cultivars of durum wheat 'Botno' and 'Rolette' were used. Botno and Rolette are moderately susceptible (infection type 3) to *P. recondita tritici* N. D. isolate 72-35; Thatcher is susceptible and Waldron is resistant.

Primary leaves of 10 day old seedlings were spray inoculated with 5 mg uredospores in 1 ml light oil (Soltrol 170, Phillips Petroleum Company) prior to misting with water or 1% Tween 20 in water. Three treatments determined the effect of rubbing or Tween 20 on amount of infection: 1) water misted on an undamaged leaf surface laden with spores; 2) water misted onto inoculated leaves which had been rubbed lightly to damage the wax layer; and 3) water containing 1% Tween 20 was misted onto undamaged inoculated leaves (Table 1). Inoculated plants were incubated at room temperature and approximately 100% relative humidity for differing incubation periods, then the plants were air dried and returned to the greenhouse for the duration of the experiment. Treated plants were removed from the incubation chamber at 3, 4, 5, 6, 8, 12 and 24 hr intervals; and after 14 days pustules (uredia) were counted on ten leaf sections, each 5 cm long taken 1 cm from the apical end. The entire experiment was repeated 4 times and data were analyzed as a factorial design with Duncan's multiple range test.

RESULTS

The hard red spring wheat Thatcher had significantly more pustules than the durum cultivars for all treatments and incubation times except after 4 hr (Table 1).

The treatment in which leaves were rubbed prior to inoculation had significantly more pustules than water only except after 4 hr incubation. Water with Tween 20 promoted significantly more pustules than water alone except after 4 or 5 hr incubation. When pustule counts from all the trials were averaged, we observed that rubbing or addition of Tween 20 to the water mist significantly increased the number of pustules. Variability was significantly greater for the water mist treatment than for rubbing or the addition of Tween 20 to the mist.

Table 1. Average number of uredia of *Puccinia recondita* f. sp. *tritici* on three Tritium cultivars following three treatments and six incubation periods.

		Treatment	
Cultivar	Water	Tween 20	Rub & Water
Botno	1.78[a]	5.19[c]	8.64[d]
Rolette	4.20[b]	8.17[d]	8.79[d]
Thatcher	5.51[c]	14.62[f]	12.65[e]

		Cultivar	
Incubation time/(hr)	Thatcher	Rolette	Botno
4	1.46[a]	0.49[a]	0.59[a]
5	3.77[b]	1.08[a]	0.95[a]
6	5.92[c]	2.36[ab]	3.35[b]
8	14.10[gh]	9.87[de]	6.33[c]
12	20.05[i]	13.09[fg]	8.49[d]
24	20.23[i]	15.43[h]	11.51[ef]

		Treatment	
Incubation time/(hr)	Water	Tween 20	Rub
4	0.37[a]	1.86[ab]	0.31[a]
5	0.75[a]	2.43[ab]	2.61[b]
6	1.28[ab]	5.60[cd]	4.75[c]
8	7.17[d]	11.14[e]	11.98[e]
12	5.62[cd]	17.32[f]	18.70[f]
24	7.77[d]	17.60[f]	21.79[g]

Average of all treatments

Treatment		Cultivar		Incubation Time/(Hr)	
Water	3.83[a]	Botno	5.20[a]	4	0.85[a]
Tween 20	9.33[b]	Rolette	7.05[a]	5	1.93[a]
Rub	10.03[b]	Thatcher	10.92[b]	6	3.88[a]
				8	10.10[b]
				12	13.88[c]
				24	15.72[c]

Values with the same letter are not significantly different by Duncan's multiple range test P = 0.05.

Significantly more pustules occur following 8, 12, and 24 hr incubation than following 4, 5, or 6 hr incubation. In general, numbers of uredia increased with longer incubation times. Incubation time correlated significantly (0.85) with numbers of uredia on leaves following 4 to 24 hr incubation.

DISCUSSION

Results of prior research on pesticide spray retention suggested an inverse relationship between leaf surface roughness and spray retention (4, 5, 6, 7). Data from our experiments supported this inverse relationship. Rubbing the leaf surface flattens the wax cuticle and in turn reduces the surface tension of water. This allows a greater adherance to plant surfaces, causes droplets to be in close contact with the leaf surface, and thus provides a better microclimate for spore germination than water alone.

Our studies demonstrate that increased water retention by rubbing or the use of Tween 20 in the water mist was responsible for greatly increased infection for all cultivars and incubation times.

A significantly higher coefficient of variability for water mist than for rubbed plants or for 1% Tween 20 indicates more variability in infection when water is used alone.

Our results aid in understanding rust development in the field. Dew in generally the most prevalent form of free moisture. Dew may adhere well to some leaves but may form drops and roll off other leaves following slight movement (wind). Dew loss may confer a type of plant resistance to disease.

Weathering through the season (2) could reduce the wax layer, promote better retention of dew by older leaves, and increase susceptibility. We demonstrated that rubbing, which may imitate weathering, allows more water to adhere to the leaves.

Rubbed leaves averaged 21 pustules per 5 cm of leaf compared to only 0.31 pustules on leaves with water mist. There was a highly significant correlation between number of uredia and length of incubation between 4 and 24 hours. This indicated that the longer free moisture stays on leaves in the field, the more infection will be observed. The fact that numbers of infections is affected by length of incubation period may be caused by self-inhibitors in urediospores (1).

Our incubation time data illustrated that the number of infections increased on the durum cultivars up to 24 hr but did not increased on Thatcher, the susceptible hard red spring wheat after 12 hr. There were also less pustules on the durums at every incubation time. This demonstrated that a longer incubation time is necessary for the durums in our study. A certain moisture regime may be sufficient for establishment and build-up of *P. recondita tritici* on one variety but inappropriate for other varieties. Moisture retention by leaves may affect rates of rust development observed for different varieties. Leaf wettability may partially explain our field observation that rust developed 7-10 days later on susceptible durum cultivars than on susceptible hard red spring wheats in the field (9). This study also indicates that surfactants used with pesticides may enhance conditions for rust development. This study provides an additional factor that plant breeders may consider for developing new varieties resistant to leaf rust.

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