

Effects of Temperature and Relative Humidity on Germinability and Infectivity of *Puccinia polysora* Uredospores

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ABSTRACT

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Uredospores of *Puccinia polysora* were maintained at temperatures of 4–36 C at four-degree increments and at relative humidities of 15, 35, 65, and 95% for 1, 3, 7, 28, and 56 days, then germinability and infectivity were evaluated. After treatment, germination was determined after a 24-hr incubation period on water agar. Germinability was best maintained at 12–20 C throughout the testing period, regardless of relative humidity. Germinability decreased from a level of 78–86% at all relative humidities (day 1) to 35% at 15% RH, 27% at 35% RH, and 0% at 65 and 95% RH (day 56). Infectivity, determined by inoculation of excised maize leaf tissue floated on a kinetin/sucrose solution, was directly related to germinability.

Puccinia polysora Underw., incitant of southern rust of maize (*Zea mays* L.), was first reported in 1896 on an herbarium specimen of gammagrass (*Tripsacum dactyloides* L.) collected in Alabama in 1891 (18). It is thought to have been limited to the Western Hemisphere until its sudden appearance in West Africa in 1949. The destructive potential of southern rust was dramatically demonstrated when it swept eastward across Africa in the early 1950s, causing yield losses as high as 50–60% in some areas of maize production (3). In the United States, southern rust is generally considered to be of minor importance, but it can be serious, especially on late-planted maize in the South (8,13,15). At present, maize hybrids with resistance to southern rust are not commercially available in the United States (8,15).

The occurrence of southern rust epidemics in the lower Mississippi Valley from 1972 to 1974 (8) and reports of

damage in Texas and Kansas in 1979 (15) emphasize the need for knowledge of factors affecting epidemiology. Although the epidemiology of southern rust has received some attention (3,8,13), certain environmental factors have not been investigated fully. Epidemiological studies with other cereal rusts have demonstrated the importance of light, temperature, humidity, and host-parasite interactions (1,5–7,12,14,21). Some studies (6,7,12,17,20,21) have evaluated effects of environmental factors on inoculum quality during the post-production-pregermination period, whereas others (1,2,5,11,14) have concentrated on quantitative aspects of epidemiology.

The uredospore of *P. polysora* is the only known spore stage that contributes to southern rust epidemics; therefore, uredospore inoculum should be evaluated both qualitatively and quantitatively. Studying inoculum only in quantitative terms could be misleading, especially if much of that inoculum were noninfectious. The objective of this study was to determine the influence of temperature and relative humidity on the quality of *P. polysora* uredospores as measured by their germinability and infectivity.

MATERIALS AND METHODS

Uredospores were produced on seedlings of a susceptible maize hybrid, Pioneer Brand 3369A, in the greenhouse. Within 3 days of pustule rupture, uredospores were collected with a cyclone spore collector and air-dried in open petri dishes at 22–24 C for 24 hr. Germination of these uredospores on water agar was >98%. Uredospores were maintained in all combinations of postproduction-pregermination treatments involving temperatures ranging from 4 to 36 C at four-degree increments; relative

humidities of 15, 35, 65, and 95%; and times of 1, 3, 7, 28, and 56 days. For each treatment, 1 mg of uredospores was placed in a 3-cm plastic tube (6.5-mm) previously plugged at one end with paraffin wax. The tube was then placed into a 7.1-g scintillation vial containing 7 ml of a specific concentration of KOH to provide the desired relative humidity (10,16). Vials were hermetically sealed with a screw cap and kept in darkness in temperature-controlled incubators (± 2 C) for the desired length of time. All treatments were replicated in three vials.

To evaluate germinability and infectivity after treatment, two 3-cm sections of the fourth leaf of maize seedlings were placed in a spore-settling chamber and inoculated. For comparison, two glass microscope slides, each bearing a strip of 2% water agar, were also placed in the spore-settling chamber. Before placement in the chamber, the leaf sections were sprayed with distilled water containing one drop of Tween 20 per 50 ml. Uniformity of droplet size and distribution were accomplished by spraying the water at 20 psi with an artist's airbrush.

Immediately after inoculation, the excised leaf sections were floated on an aqueous solution containing 5% sucrose and 20 ppm kinetin in petri dishes (9). After a 14-day incubation period at 26 C and with a 14-hr day/10-hr night regime, pustule density was evaluated using a scale of 0–3, where 0 = no pustule, 1 = one or two pustules per square centimeter, 2 = three or four pustules per square centimeter, and 3 = five or more pustules per square centimeter. A mean pustule density value was calculated for each treatment.

After 24 hr of incubation on water agar at 26 C, 100 single uredospores from each of three vials were observed microscopically. All spores with tube length greater than the spore diameter were considered germinated.

All data on germinability and infectivity were analyzed by analysis of variance, and means were separated by Duncan's new multiple range test at $P = 0.05$.

RESULTS

Germinability and infectivity were greatest for uredospores stored at 12–20 C and decreased considerably at 8 C regardless of percent relative humidity (Figs. 1 and 2). Uredospores held at 4 C

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for only 1 day did not germinate or infect. Generally, germinability and infectivity also decreased as temperatures increased above 20 C, especially above 28 C. For example, after storage of spores for 7 days at 36 C, very little germination or infection was observed, even for spores kept at 15% RH.

Uredospore germinability and infectivity decreased in direct proportion to the duration of treatments. As treatment time increased, the temperature range for storage tolerance was reduced. These reductions occurred more rapidly at higher temperatures than those in the middle portion of the range.

Germinability and infectivity were consistently reduced by high storage relative humidity (Figs. 1 and 2), regardless of storage temperature. Even after only 1 day of storage at temperatures above 24 C, 65 and 95% RH reduced germination and infection more than 15 and 35% RH. At day 7, the reduction was more evident, especially at 95% RH. At

day 28, germinability and infectivity of inoculum maintained at 65% RH was greatly reduced, and inoculum maintained at 95% RH failed to germinate or cause infection. At day 56, germinability and infectivity were sharply reduced at 15 and 35% RH, and no germination or infection occurred with inoculum maintained at 65 or 95% RH.

DISCUSSION

Germinability and infectivity of *P. polysora* uredospores were affected similarly in this study; all treatments that reduced germinability reduced infectivity. Our results therefore indicate that the percentage germination of *P. polysora* uredospores may accurately indicate infectivity. In a similar study (21) of *P. graminis* and *P. recognita* on wheat, infectivity was reduced more than could be accounted for by reductions in

germinability alone.

Temperatures of 4 and 8 C consistently reduced germination and infection regardless of relative humidity or treatment length. At higher temperatures (>24 C), germination and infection decreased more rapidly at high than at low relative humidity, suggesting that high relative humidity had a detrimental effect. By day 7, this was more evident, especially at 95% RH, where no germination or infection occurred at temperatures above 20 C. Von Meyer (19) reported that high humidity was less favorable than low humidity, but this was studied only at 26 C and for uredospores maintained in leaf pustules.

The postproduction-pregermination environment of *P. polysora* uredospores is critical to uredospore quality as measured by germinability and infectivity. Furthermore, our results indicate that *P. polysora* uredospores have little tolerance of environmental extremes, especially low temperatures and high relative humidity, for even relatively short times (Figs. 1 and 2). Hence *P. polysora* movement on air currents from the Western Hemisphere to West Africa in the late 1940s seems unlikely, and Cammack's (4) suggestion that uredospores were transported across the Atlantic Ocean to West Africa in airplanes seems plausible. Because of the relatively shorter distances, however, it seems more reasonable that windborne uredospores could travel from the Caribbean or Central American to the Gulf Coast and retain viability. Subsequent northward movement of *P. polysora* in the United States depends on suitable environmental conditions that promote infection and uredospore increase and maintain germinability and infectivity during windborne transport. Although early and destructive southern corn rust epidemics have not yet occurred in the corn belt, the known destructive potential of *P. polysora* (8,13,15) and the lack of any significant resistance in currently used commercial hybrids (8,15) suggest that this disease may still pose a serious threat to maize production in the United States. An understanding of inoculum quantity alone, such as information obtained through spore trapping, may be misleading in estimating the potential of southern rust. Assessment of inoculum quantity is essential.

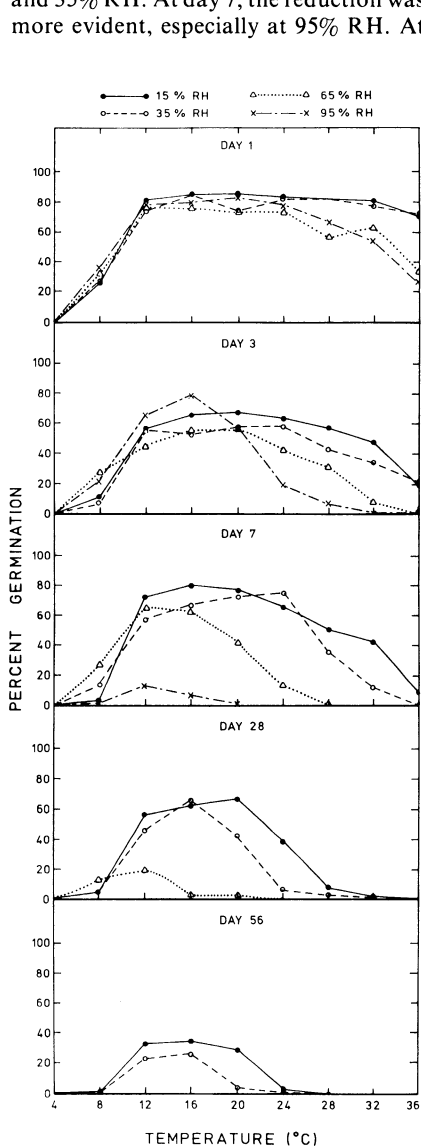


Fig. 1. Percent germination on water agar of uredospores of *Puccinia polysora* maintained for 1, 3, 7, 28, and 56 days at different temperatures and in atmospheres of 15, 35, 65, and 95% relative humidity. Values are a mean of three replicates.

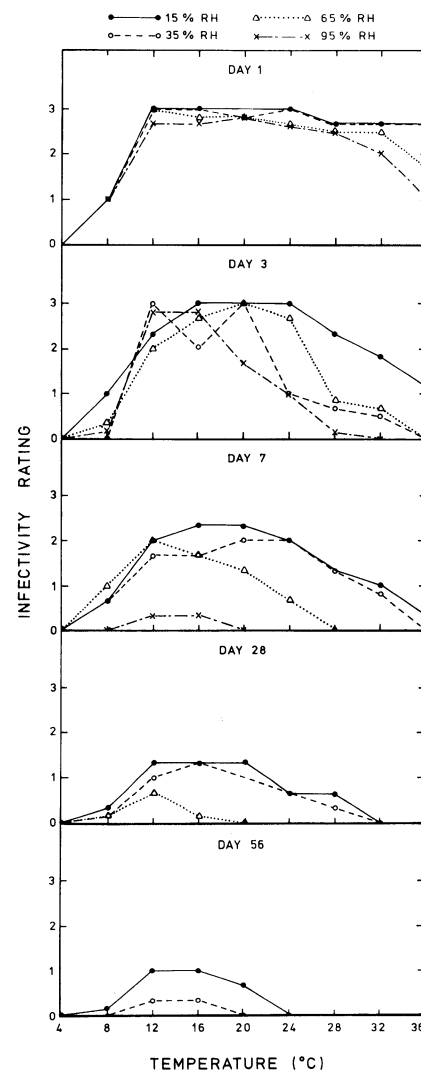


Fig. 2. Infectivity ratings of uredospores of *Puccinia polysora* on excised maize tissue after 1, 3, 7, 28, and 56 days at different temperatures and in atmospheres of 15, 35, 65, and 95% RH. An infectivity rating scale of 0-3 was used: 0 = no pustules, 1 = one or two pustules, 2 = three or four pustules, and 3 = five or more pustules per square centimeter. Values are a mean of three replicates.

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