Effects of Post-dew Period Temperature and Relative Humidity on *Phakopsora pachyrhizi* Urediniospore Production

M.R. Bonde, D.K. Berner, and S.E. Nester

USDA, Agricultural Research Service, Foreign Disease-Weed Science Research Unit, Fort Detrick, MD 21702-5023

ABSTRACT

Soybean plants, cv. Williams, were inoculated with urediniospores of *Phakopsora pachyrhizi,* incubated overnight in a 20ºC-dew chamber, and then transferred to temperature-controlled growth chambers mimicking day/night temperature profiles representative of the U.S. soybean production areas during spring, summer, and fall. At 3-day intervals beginning 14 DAI, urediniospores were collected from each plant and counted. At the end of each experiment, the numbers of lesions and leaf areas were determined for each leaf. Numbers of lesions per cm^2 and urediniospores produced per plant and per lesion were calculated for each temperature profile. Leaflets from each plant were fixed and stained, and average numbers of uredinia per lesion and uredinium diameters determined. The most urediniospores per lesion were produced when the day temperature peaked at 25ºC and night temperature dipped to 12ºC. When day temperatures peaked at 29, 33, or 37ºC, urediniospore production per plant was reduced to 41, 7, and 0.1%, respectively, of that at the optimum. The most lesions were produced when the temperature peaked at 21 or 25ºC, and most uredinia per lesion when the temperature peaked at 25 or 29ºC. Daily temperature data was obtained from NOAA for a 4-year period for selected soybean areas of the U.S. While temperatures of mid-western states (e.g. Illinois and Iowa) were usually conducive for urediniospore production during May through September, temperatures for southern states commonly peaked above 33ºC during July and August, suggesting that high day temperatures limit sporulation. Using a similar approach, it was determined that the fall months of October and November often have night temperatures too cool for development of soybean rust in mid-western states. Post-dew period relative humidity had limited effect on urediniospore production.

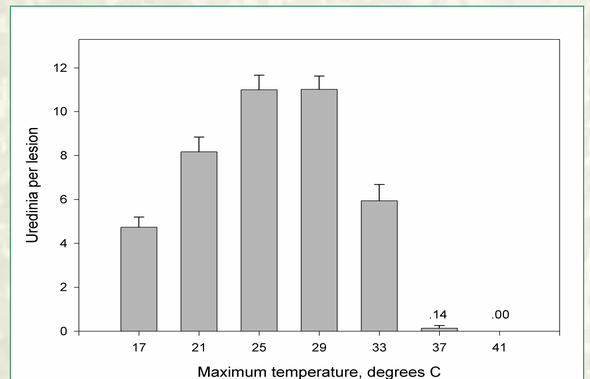

Figure 5. Numbers of uredinia produced per lesion under environmental conditions in which the air temperature peaked daily at specific temperatures from 17ºC to 41ºC.

Figure 1. Soybean plant in Environmental Growth Chamber.

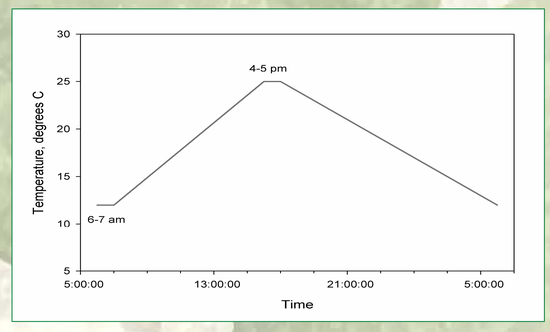

Figure 2. Temperature profile for a 24-hour period in which the high from 4 to 5 pm was 25ºC and low from 6 to 7 am was 12ºC.

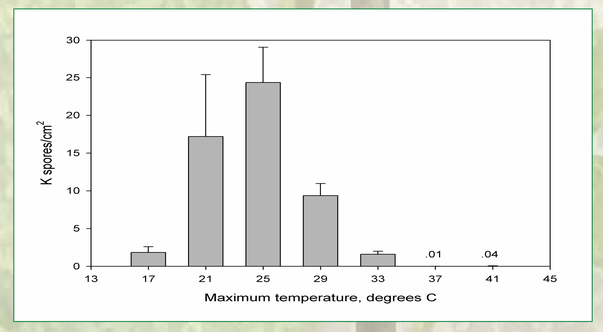

Figure 3. Numbers of urediniospores produced per cm^2 leaf area under environmental conditions in which the air temperature peaked daily at specific temperatures from 17ºC to 41ºC.

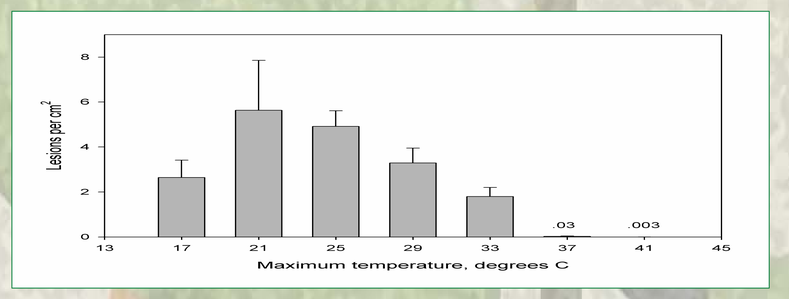

Figure 4. Numbers of lesions produced per cm^2 leaf area under environmental conditions in which the air temperature peaked daily at specific temperatures from 17ºC to 41ºC.

INTRODUCTION

Temperature and moisture are the two most important environmental factors affecting development of soybean rust *by Phakopsora pachyrhizi*. Not only do they affect pathogen survival, they determine whether or not urediniospores germinate, infect, colonize the host, as well as the subsequent production of urediniospores on the infected host. The purpose of our study was to specifically determine the effects of post dew-period temperatures on colonization of soybean leaves and subsequent urediniospore production, information required in order to develop a soybean rust prediction model. The diurnal temperature profiles selected covered the span of temperatures, as reported by NOAA, experienced over a 4-year period during the growing seasons of soybean growing regions of the U.S.

MATERIALS AND METHODS

Experimental design. Soybean plants, cv. Williams, were inoculated by dipping four trifoliolate leaves/plant into a urediniospore suspension (3 x 10^4 urediniospores/ml) in 0.01% Tween 20 in a 4-liter beaker. Inoculated plants then were placed overnight in a 20ºC-dew chamber, and transferred to temperature-controlled growth chambers (Figure 1).

A total of seven temperature profiles were tested in groups of three experiments. Each experiment group included three temperature profiles, one of which was included in a different group. This made it possible to compare results across all experiments.

In each growth chamber, the temperature was gradually ramped from a low at 6 to 7 am to a high at 4 to 5 pm, with 1-h durations at the low and high (Figure 2). The length of daylight was always set at 14-h, with twilight and dusk (incandescent lights only) lasting ½ h each.

Measuring urediniospore production. Beginning at 14 DAI, at 3-day intervals, urediniospores were collected by vacuum harvester (2) from each plant and counted using a hemocytometer.

Measuring lesion numbers. At the end of each experiment, leaves were collected from each plant, placed in metal pans, covered with damp paper towels, and incubated overnight in a 4ºC-cold room to enhance lesion visibility. The next day, four trifoliolates from each of three replicate plants per temperature profile were photographed for later examination of digital images to enumerate lesions per cm^2 and area per leaf. Date and position of each leaf that fell from plants were recorded and photographed for later adjustment of lesion numbers over time.

Uredinia numbers per lesion and uredinia diameters. At the end of each experiment, representative leaf samples were fixed in Farmer's solution, cleared in lactophenol, and stained in cotton blue in lactophenol as previously described (1). Leaf pieces were examined at 20x and 90x magnification and average numbers of uredinia per lesion and average uredinia diameters calculated for each temperature profile.

Data analyses. From the data obtained, average numbers of lesions per cm^2 leaf area, and per plant, and average numbers of uredinia per lesion and average uredinia diameters were calculated for each temperature profile. Also determined were average numbers of urediniospores collected per cm^2 leaf area and per plant at 3-day intervals.

RESULTS AND CONCLUSIONS

Temperature. The most urediniospores per cm^2 leaf area were produced when the day temperature peaked at 25ºC, and night temperature dipped to 12ºC (Figure 3). When the day temperature peaked at 29, 33, and 37ºC, urediniospore production per plant was 41, 7, and 0.1%, respectively, of that for the optimum temperature profile. The most lesions were produced when the temperature peaked at 21 or 25ºC (Figure 4), and most uredinia per lesion when the temperature peaked at 25 or 29ºC (Figure 5).

Percent of days with temperature highs above 33ºC for each month over a 4-year period are presented for representative southern states (Alabama and Georgia) and mid-western states (Illinois and Iowa) in Figure 6 A-D. It is apparent that the frequency of days in which the temperature peaked above 33ºC, particularly in July and August, was considerably higher for southern states. For example, in Georgia 78 and 62% of days peaked above 33ºC for July and August, respectively, and were considered too hot for urediniospore production. In contrast, in Iowa 23 and 18% of days during July and August, respectively, peaked above 33ºC.

Percent of days with temperature lows below 4ºC for each month are presented for representative states in Figure 6 A-D. In general, during October and November night temperatures often were too low in mid-western states (e.g. Iowa and Illinois) for development of soybean rust.

Relative humidity. To date, post-dew period relative humidities from 70 to 90% have been tested and compared. The numbers of lesions per cm^2 and urediniospores per lesion were little affected by relative humidity within this range.

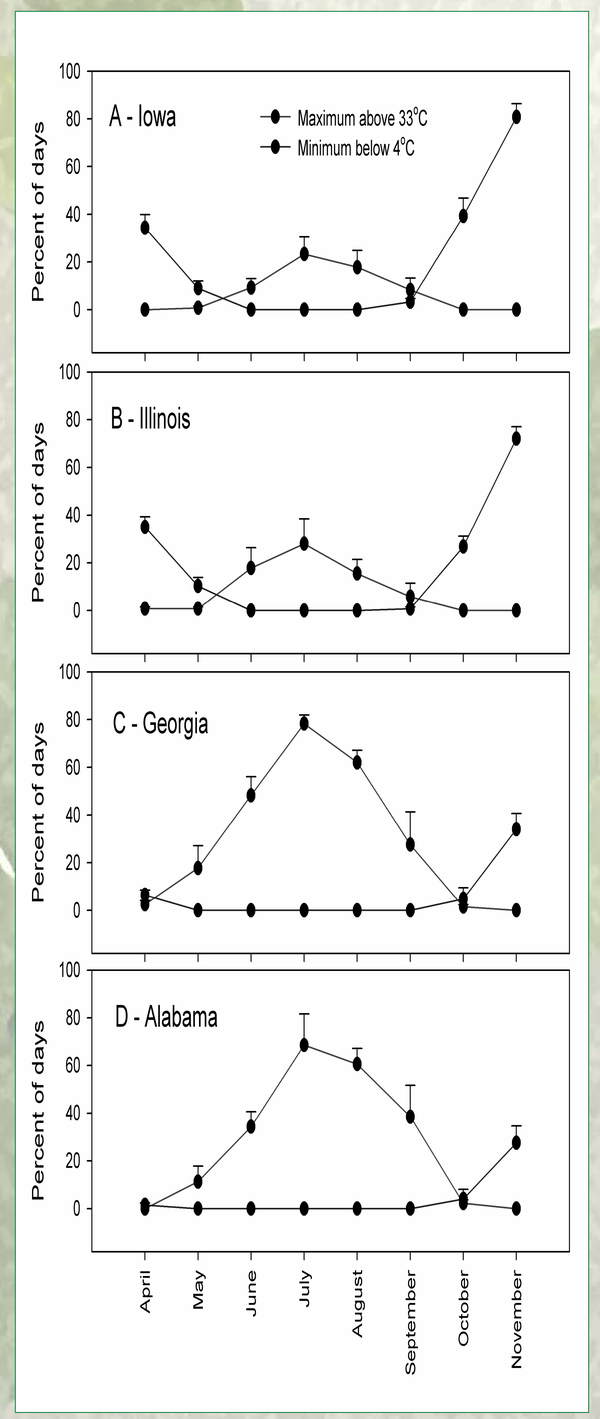

Figure 6 (A-D). The % days during each month from April through November in which the maximum temperature was above 33ºC or the minimum below 4ºC.

REFERENCES

1.Bonde, M.R., Nester, S.E., Austin, C.N., Stone, C.L., Frederick, R.D., Hartman, G.L., and Miles, M.R. 2006. Evaluation of virulence of *Phakopsora pachyrhizi* and *P. meibomiae* isolates. Plant Dis. 90:708-716.

2.Cherry, E., and Peet, C.E. 1966. An efficient device for the rapid collection of fungal spores from infected plants. Phytopathology 56:1102-1103.