Influence of Temperature and Light on Spore Production of Puccinia graminis tritici

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ABSTRACT

From a single rust (*Puccinia graminis tritici*) pustule on a Baart wheat plant subjected to a 12-hour photoperiod and sampled hourly for 7 days, significantly more spores were produced during the light period than during the dark. The number of spores produced during the light period was significantly greater than those produced during the dark period when rust pustules were subjected to a 12-hour photoperiod for 9 days. There were no significant differences in spore production on plants exposed to 800 or 150 ft-c.

There were highly significant differences in spore production at different temperatures on plants placed in continuous light and programmed for successive 6-hour periods of 24, 29, 18, and 13 C for 11 days; the greatest number were produced at 29 and the fewest at 13 C. Differences in spore production between individual days also were highly significant. Phytopathology 61:120-121.

Time of day, low humidity, high temp, light, and increased wind speed are factors influencing the liberation and trapping of stem rust spores in the field (1, 4, 5). Although spot trapping in the field provides information on the concn of spores in the air, it has limited value in the determination of factors for spore production.

In our investigation, the effect of light and temp variations on spore production and liberation were studied by sampling uredospores from a single pustule and multirust pustules under controlled conditions.

MATERIALS AND METHODS.—The rust-susceptible variety Baart wheat and stem rust race 15B-2 were used. Inoculated plants were held for sporulation in controlled light-temperature chambers. The Kramer-Collins 24-hr spore sampler was used to obtain the single rust pustule data, and the 24-hr rotorod sequential sampler was used to obtain the multirust pustule data.

RESULTS.—*Single rust pustules.*—A Baart wheat plant in the two-leaf stage, bearing a single stem rust pustule of race 15B-2, was placed in an environmental chamber having an internal volume of 12 ft^3. The leaf bearing the single pustule was inserted in a glass tube attached to a Kramer-Collins spore sampler. Air entered the intake tube at the rate of 2.5 mph. The spores liberated were sampled hourly for 7 days, starting with an 8-day-old pustule. The chamber temp was programmed at 24 C and a 12-hr photoperiod of 800 ft-c intensity. Sampler slides were changed once a day.

In the light intensity experiment, the chamber was programmed for 9 days of 150 ft-c, followed by 15 hr of 800 ft-c for 6 days. Analysis of variance revealed that spore production was significantly greater in the light than in the dark. A mean number of 1,576 spores/hr was trapped in the light, and only 194/hr in the dark. Differences between days within light and dark periods were not significant. There was no significant difference in spores trapped between hours in either the light or dark period.

The data indicate that many spores are produced and released in the dark. There was a sharp increase in spores liberated during the 1st light hr after the dark period and, conversely, a reduction in spores liberated the 1st dark hr after the light period.

In a single-pustule light-intensity experiment, the difference in spores trapped between the 150 and 800 ft-c light intensity was not significant.

Days were significantly different at the 1% level, with a gradual increase in spores trapped through the 3rd day and then a subsequent decline. The max number of spores produced occurred slightly earlier under the high intensity.

Multi-rust pustules.—Sixty 6-inch pots, each containing six Baart wheat plants bearing about 48 stem rust pustules, were arranged around a sequential rotorod sampler in an environmental chamber. In the light-dark experiment, the chamber was programmed for 24 C and 12 hr each of light (2,800 ft-c) and dark. Spore release was sampled hourly over 9 days (Table 1).

The data were submitted to an analysis of variance, and spore liberation was significantly greater in the light period, with a mean of 1,039 spores/hr in the light vs. 783 spores/hr in the dark. There was a significant difference in spore liberation between days. The trend was for a slight reduction for the first 3 days, with a max buildup on the 6th day followed by a gradual decline on the 9th day. The same trend occurred for both light and dark hr, with a slight difference in the days of peaks and lows.

Again, as with the single rust pustule, a considerable number of spores were released in the dark during the 9-day period. On 8 of the 9 days, spore production was greatest during 1 of the first 3 hr of the light period after the dark period.

Temperature programming.—Sixty pots of Baart wheat plants bearing stem rust pustules (9-day-old) were arranged around the 24-hr rotorod sequential sampler in the environmental chamber with an approx volume of 170 ft^3. Air moved in the chamber at the rate of 3 mph. With continuous light of 2,800 ft-c, the chamber was programmed for 6 hr at 24 C, followed by 6 hr at 29, 18, and 13 C for 11 days. Spore production was determined hourly for 60 min, and the greased rods were changed every 24 hr. The rods were examined under the microscope, and the spores counted.

TABLE 1. The average hourly spore production from multipustule- (*Puccinia graminis tritici*) bearing wheat plants in light and dark over a 9-day period

Hr	Avg spore count[a]	
	Light	Dark
1	1,419	783
2	1,527	684
3	1,793	841
4	947	437
5	1,067	588
6	821	552
7	886	441
8	937	979
9	821	870
10	791	1,366
11	623	1,210
12	832	650
Mean	1,039	783

[a] Mean hourly spore production was significantly greater (.05) in light than in dark. Means for daily spore production were also significantly different (.01). Means for hourly spore production within either dark or light were not significantly different.

The average spore counts for an 11-day period for 6 hr at 13, 18, 24, and 29 C are presented in Table 2. An analysis of the data revealed highly significant differences in spore production, and liberation occurred at the various temp. Production and liberation at each temp was significantly different from every other temp except between 24 and 29 C. Spore liberation was greatest the first 3 hr, with a gradual decrease thereafter. Possibly, this was because the fungus was exposed to 24 C, a more favorable temp, in the preceding 6 hr in each instance.

TABLE 2. Average spore production of *Puccinia graminis tritici* for 6 hourly periods at four temp during an 11-day period[a]

Hr	13 C	18 C	24 C	29 C
1	975	1,399	1,797	4,618
2	543	1,285	4,038	4,920
3	695	1,509	3,203	3,257
4	478	1,246	3,444	2,431
5	840	1,252	3,314	2,631
6	109	839	2,959	2,261

[a] F values for days, temp, temp × days, and hr in temp were significant (.01).

DISCUSSION.—Uredospores were released every hr from a single rust pustule. Under continuous temp and light conditions, no definite peak was observed. The hourly cyclical variation in spore numbers was irregular. The experiments demonstrated that, at 24 C, a single rust pustule on the first leaf of a wheat plant released spores for 16 days, beginning with the day of eruption. A peak in the number of spores trapped occurred 8 days after pustule formation.

Spores were produced in great numbers in light and scantily in dark. With *Puccinia recondita* (2), temp (but not light intensity) had a pronounced effect on pustule maturation time. Presumably, the effect of light on spore production is more on the metabolism of the host plant than on the fungus (5). Photosynthesis is known to increase with increase in light. Among all the sugars that are the end products of photosynthesis, sucrose predominates in the leaves and fluctuates during day and night.

The sunlight intensity at noon, on a clear day during the dust season in Iowa, varies from 8,000 to 11,500 ft-c. In our light-intensity experiment, the max light intensity employed was 800 ft-c, or only 0.1 or less of the max supply at noon. Possibly, the differential effect of light intensities was not evident because of the low intensities and continuous light employed in our studies. Studies using light intensities comparable to sunlight at noon might show significant differences in spore production at high vs. low light intensities, because low light intensities have been shown to retard stem rust development in the host (3).

LITERATURE CITED

1. ASAI, G. N. 1960. Intra- and inter-regional movement of uredospores of black stem rust in the Upper Mississippi Valley. Phytopathology 50:535-541.
2. EYAL, ZAHIR, & J. L. PETERSON. 1967. Uredospore production of five races of Puccinia recondita. Rob. ex Desm. as affected by light and temperature. Can. J. Bot. 45:537-540.
3. MELANDER, L. W. 1931. The effect of temperature and light on the development of the uredinial stage of Puccinia graminis. Phytopathology 21:109 (Abstr.).
4. PADY, S. M., C. L. KRAMER, V. K. PATHAK, F. L. MORGAN, & M. A. BHATTI. 1965. Periodicity in airborne cereal rust uredospores. Phytopathology 55: 132-134.
5. SMITH, R. S. 1966. The liberation of cereal stem rust uredospores under various environmental conditions in a wind tunnel. Brit. Mycol. Soc. Trans. 49:33-41.