Effect of some environmental factors on the asexual phase of
Peronosclerospora sorghi

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Abstract. Peronosclerospora sorghi, produced a maximum of 10,800 conidia/cm²
of diseased sorghum leaves at 100% relative humidity but only about 3600 conidia
at 85% relative humidity under in vitro conditions. The sporulation was totally
inhibited at 80% relative humidity and below. Infected sorghum leaves kept in
darkness after completion of the previous crop of the spores, did not sporulate
in continuous darkness even at the optimum relative humidity and temperature.
Optimum temperature for sporulation is 21–23°C, 31°C and 36°C are minimum and
maximum respectively. At 26°C and above, conidiophores were malformed and
produced only a few conidia. For conidial germination, 21–25°C were optimum
while at 13°C conidial germination was as low as 52%. At 32°C, 80% germi-
nation was recorded but 35°C and above no germination occurred. After inocu-
lation with conidial suspension, a minimum of 3 hr moisture was essential to induce
systemic infection.

Keywords. Peronosclerospora sorghi; sorghum downy mildew; epidemiology;
asesexual phase; environment.

1. Introduction

Observations in the past have firmly established that sporulation in Peronoscleros-
spora sorghi (Weston and Uppal) Shaw, the causal agent of sorghum downy
mildew in sorghum and corn, is nocturnal, occurring generally between 8 p.m.
and 6 a.m. Weston (1920, 1923) had shown the intricate relationship between
temperature and relative humidity required for the sporulation process in the
night. This has since been corroborated abundantly (Safeeulla and Thirumalachar
1955; Tarr 1962; Kenneth 1970; Kaveriappa 1973; Bonde et al 1978; Bonde
and Melching 1979). Similar studies have also been carried out in Sclerospora
sacchari in Taiwan (Yang et al 1962; Chang and Wu 1969; Sun 1970),
S. philippinensis in the Philippines, Indonesia (Exconde 1970) and S. maydis in
Jawa and Indonesia (Semangoen 1970). However, no critical studies with data are
available regarding the influence of different environmental factors on the asexual
phase that affect sporulation, germination, infection and disease development on
sorghum. The purpose of this study is to provide necessary information on these
aspects.
2. Materials and methods

The conidial production was induced in the systemically infected sorghum plants (DMS 652) by the technique followed by Safeeulla and Thirumalachar (1955). The desired temperature was maintained and regulated by using a thermoregulator. Humidity was maintained as described by Tuite (1969) and it was checked by using a hygrometer. Artificial day light was used (Philips TL 40W/54 6900° K 2000 lux) as the source wherever required. The experiment was set up in the evening at room temperature of 23 ± 2°C and the conidia were collected using a wash-off method as described by Bonde et al. (1978). Suspension was made in distilled water and the number was counted by using a haemocytometer. The number counted from a defined area was used to estimate production per cm². To test the effect of specific temperature on conidia germination and germ tube growth, conidial suspension was streaked on 1-5% water agar in Petri plates. Agar plate temperatures were equilibrated with the chamber air temperatures prior to seeding the plates. At the end of the incubation period, the plates were opened and placed over 40% formaldehyde in a desiccator to kill the conidia. Germination percentages were determined by microscopic observation of 400 conidia per plate at x 100 magnification. Four to five-day-old sorghum seedlings (DMS 652) were used to test plants as and when required.

To demonstrate the effect of post-inoculation moisture on disease development, the conidial suspension (35,000 conidia/ml) was inoculated into the whorls of 10-day-old sorghum plants (DMS 652) and the inoculated plants were covered for 0, 1, 3, 6 and 12 hr with moistened plastic bags. The time of sowings and disease development were also observed in the sorghum fields.

3. Results and discussion

3.1. Effect of relative humidity on sporulation

From the diseased sorghum leaves, about 10000 conidia/cm² were produced at 100% relative humidity. At 80% relative humidity and below, no conidia were produced (figure 1). Weston (1923) stated that moisture conditions were important for production of conidia in Sclerospora. The present investigation revealed that 100% relative humidity secured maximum sporulation at 21-23°C. Minimum relative humidity required for conidial production was 85%. Futrell and Bain (1968) estimated production of 88-2500 conidia/cm² centimeter in P. sorghi infected leaves of Sudan grass-sorghum hybrids. However, more than 12000 conidia/cm² were reported by Kaveriappa (1973) from the infected sorghum leaves when incubated in the laboratory.

3.2. Effect of temperature on sporulation

Optimum temperature for sporulation is 21-23°C, with a minimum and maximum of 13°C and 30°C respectively (figure 2). At high (26-28°C) and low (15-13°C) temperatures the incubation period required was longer by 1-2 hr and conidial production was greatly reduced. Variation in the temperature during the early
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Figure 1. Sporulation in *P. sorghi* under different relative humidities.

Figure 2. Effect of temperature on sporulation (--- × --- × ---) and conidial germination (--- · · ---) in *P. sorghi*. 
period of incubation did not affect sporulation. Soon after collection excised leaves exposed to 32 °C for 15-20 min had stimulatory effect on the quantity of spores produced. However, the infected leaves exposed to 10 °C for 1-2 hr had no effect on sporulation. Thirumalachar and Narasimhan (1952) working on *S. dichanthicola* found that temperature below 70 °F was essential for conidial formation, and above that temperature no conidial formation took place in spite of heavy condensation of moisture on the leaves. Optimum temperature for sporulation is 22-25 °C in *S. sacchari* (Chang and Wu 1969) and 21-6-25 °C in *S. philippinensis* (Barredo 1972). For *S. sorghi*, Kenneth (1970) stated that sporulation in the field, on sorghum, did not occur when temperature dropped below 23 °C, but Safeeulla and Thirumalachar (1955) obtained the maximum at 20 °C.

It has been observed that during summer when the temperature was between 30-35 °C, incubated infected leaves produced only hyphoid structures. Infected leaves exposed to 6-8 hr at 30 °C when incubated at 21-23 °C produced normal conidiophores and conidia.

For conidial germination the optimum temperature is 21-25 °C at 100% relative humidity. Conidia at 13 °C had a germination rate of 52%. Germination reduced to 80% at 32 °C and conidia did not respond for germination at 35 °C and above (figure 2). Between 28-35 °C conidial germination is very fast, and takes only 10 min while below 18 °C it takes more than 1 hr to germinate. The germ tube also takes more than 6 hr to develop haustoria and infection pegs in contact with host shoot tip below 20 °C, however, above 25 °C it completes this process within 1 hr.
Bonde et al (1978) determined the optimum temperatures for conidial germination and germ tube growth of an American isolate of *P. sorghi* to be 15 and 22°C respectively. Results of this and our studies indicate the existence of temperature sensitive strains in *P. sorghi*. According to Bonde et al (1978) it is possible that the lower optimum for germination of the American isolate represents adaptation to the more temperate environment of the continental USA.

### 3.3. Effect of light on sporulation

Infected leaves kept in darkness after removing the previous spore crop did not sporulate in continuous darkness at the optimum relative humidity and temperature. The results indicated that exposure to light at least for 1 hr, is necessary for sporulation. The amount of sporulation on sorghum leaves increased with increase in time of pre-sporulation exposure to light upto 3–5 hr (figure 3). However, no increase or decrease in sporulation was noticed when the pre-exposure light period was more than 5 hr.

The relationship of sporulation to photoperiod was demonstrated in other downy mildews of hop, onion, grape, lettuce (Yarwood 1937), Cucumber (Kajiwara and Iwata 1959), and tobacco (Cruickshank 1963; Urozomi and Krober 1967). In most of these cases actual sporulation started after termination of the light period and occurred in darkness. There are reports, however, of a few cases in which light was not necessary for sporulation in *Helminthosporium gramineum* on barley (Houston and Oswald 1946) and *Alternaria pori* f. sp. *solani* on potatoes and tomatoes (Rotem and Esther Bashi 1969).

### 3.4. Post-inoculation moisture

In the conidial inoculation technique it is essential to provide moisture soon after inoculation for various lengths of time depending upon the host and the pathogen. Singh et al (1970) kept inoculated plants in a moist chamber for 96 hr before exposing them to the open to obtain maximum per cent of infection of brown stripe downy mildew of maize. Raros (1968) and Barredo and Exconde (1973) with *P. philippinensis* found that moisture was most favourable for the infection of maize in the Philippines. In the present investigation it has been observed that exposing inoculated plants to moist conditions for 1, 3, 6 and 12 hr gave 55, 72, 85 and 96% systemic infection respectively. Comparatively a higher percentage of systemic infection was obtained for those plants that were covered for 6 and 12 hr. Plants without covering by moistened plastic bags recorded only 35% systemic infection.

### 3.5. Time of sowing and downy mildew incidence

It has generally been observed in sorghum fields that the incidence of downy mildew is heavy in susceptible cultivars in June–October plantings when the average atmospheric temperature is 25°C and over 95% relative humidity at least for 4 hr during the night. Very little or no disease is seen during November–January plantings when the average temperature is 18°C. Even the susceptible cultivars can be sown during November–January without substantial loss in yield.
From these observations it is possible to predict that temperature coupled with relative humidity influences to a great extent the production of inoculum and disease development in sorghum. The favourable temperature and relative humidity combination available during June to October could be the reason why sorghum downy mildew occurs in greater percentage than in November-January.

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