Liberation of Helminthosporium maydis spores by wind in the field

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ABSTRACT

To separate the process of spore liberation by wind from subsequent dispersal, observations were made directly on lesions of *Helminthosporium maydis* in the field. Winds of about 1.0 m/sec liberated 60 to 75% of the spores and most spores were liberated during periods of high wind variability. Leaf abrasion hastened spore liberation but had little effect on the total number of spores removed by noon. About 25% of the spores were not liberated.

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Additional key words: Southern corn leaf blight, spore dispersal.

Many Helminthosporium diseases are spread by wind (4, 5). It is crucial in modeling the airborne spread of a plant pathogen to know the number of spores leaving the host per unit time; i.e., the strength of the source. In particular, knowing how spores of *Helminthosporium maydis* Nisikado and Miyake are dislodged is required to simulate a southern corn leaf blight epidemic (7).

Recent laboratory experiments (6) have shown that wind of 3-6 m/sec are needed to dislodge *H.*

maydis spores. A possible conclusion from these experiments is that few spores are liberated in the field since the wind within the canopy is generally slower than 3 m/sec. Other possibilities are that long exposure to turbulent wind and the rubbing together of leaves in the breeze may dislodge spores in the field.

Few spores of *H. maydis* were trapped above infected fields (1, 8). However, spore trapping does not reveal source strength because of an imperfect knowledge of dispersion between the source and the sampler. Thus, to understand spore takeoff in the field, direct observations are required.

In this article we report the time course of spore liberation per unit area of lesions in the field. We consider both the direct effect of the wind blowing on the spores and the indirect effect of wind causing leaves to rub together.

MATERIALS AND METHODS.–In 1973, at the Lockwood Farm, Mount Carmel, Connecticut, three isolated blocks of about 100 plants each of corn (*Zea mays* L. 'Northrup King PX446', Texas male sterile cytoplasm) were grown within a 0.8-hectare (ha) field of normal cytoplasm corn (Agway 595S) at a plant density of $9/m^2$. Within the blocks on 6, 10, and 25 July the density of plants was 10 plants/m^2; the leaf area index (LAI) was 3.2, 3.9, and 5.2, and the mean plant height was 1.0, 1.3, and 2.3 m., respectively.

On June 28, leaves of seven plants in each block were inoculated on the lower surface with hyphal fragments of *H. maydis* Race T by the punch method (3). By 6 July lesions had grown to 15 to 20 mm long and spores were being produced. Spore removal from lesions was observed on 6, 10, and 25 July. Lesions were washed clean of spores by sprinkling the plants with water during the evening of 9 July so that observations on 10 July would be on new spores formed during the night. On 25 July, newer lesions produced on upper leaves by secondary infection were observed.

Observations were made by three people. Each worked in a separate block and noted the presence or absence of spores on the stalks within a predetermined area of a lesion using a $\times$ 20 hand lens with a viewing field of about 12 mm^2. The spores per unit area were ranked by integer values 8-to-0, where 8 corresponded to a density of about 50 spores/mm^2 and 0 to none/mm^2.

In each plot, one leaf was kept from rubbing other leaves by fixing its tip on the previous day to a stake. This leaf on the average was exposed to faster wind speed and brighter insolation than the other leaves and dried first in the morning. Subsequently we will call this the "fixed leaf".

The vertical profile of wind was measured at the center of the field at several heights with sensitive cup anemometers. The anemometer heights were adjusted to the growth of the crop and were about 1.0, 1.6, 2.4, and 3.6 m on the first two dates and at 1.3, 2.8, 3.7, 4.9, and 6.4 m on 25 July. The time course of relative humidity (RH) within the canopy was measured with an aspirated psychometer.

RESULTS.–The temporal variation of the wind and the concurrent removal of spores from their stalks is shown in Fig. 1 for each test plot on each date.

Wind description.—Fig. 1-a, -b, and -c show the wind speed at observation times both near the ground

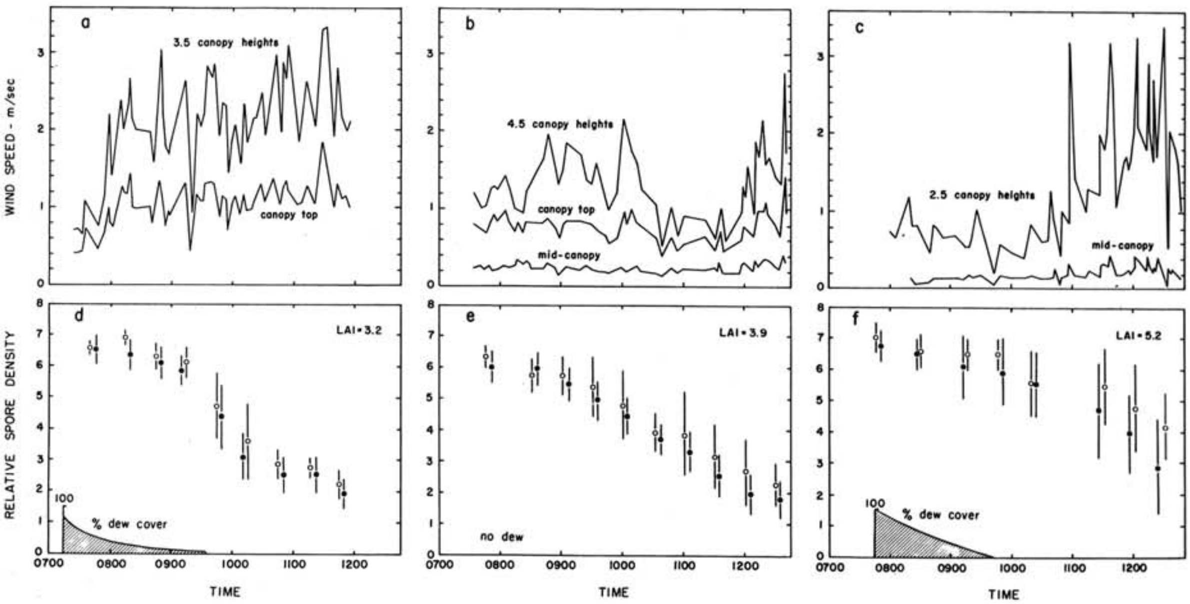

Fig. 1-(a to f). Wind speed and spore liberation from corn infected with *Helminthosporium maydis*. **(a-c)** Time courses of wind speed on 6, 10, 25 July. **(d-f)** Time courses of relative densities of stalk-borne spores per unit leaf surface (0=0/mm^2 and 8=50/mm^2). Each datum point is the mean of 18 to 36 observations of fixed leaves (0) and the leaves free to move (●). The vertical leaves indicate the standard deviation from the mean and LAI-leaf area index. The percent of dew covering the leaves is shown along the abscissa.

and well above the crop on 6, 10, and 25 July respectively.

On 6 July the sky was clear and the sun bright. The mean wind speed at a height of 3.6 m increased to a maximum of about 2 m sec at 0800 hrs. Gusts came from the northwest and the southwest intermittently as the sea breeze strengthened. The wind direction and speed were extremely variable during the observations.

On 10 July, the overcast skies at 0700 gradually became a light overcast as the easterly and southeasterly wind shifted to the southwest. The mean wind speed 2.6 m high was less than 1.5 m/sec during the early period, decreased to about 0.7 m/sec between 1030 and 1130 hrs, and then steadily increased to about 2 m/sec at the end of the observations. The wind was generally less variable than on 6 July.

On 25 July, initially the wind at 6.4 m height was less than 1 m/sec and generally steady from the northeast. A light haze reduced the insolation little, and accounted for the fresh gusts of wind from the southwest starting around 1100 hr. By 1200 the sky was becoming increasingly overcast, and by 1230 the wind speed lessened. Before 1100, the variability of the wind was much like that on 10 July, but after 1100 it was more like that on 6 July.

Liberation of spores.—Fig. 1-(d to f) depicts spore removal during the three mornings and shows the percent of the leaves wet by dew. Four results are clear in comparing wind speed and spore liberation. First, spores are removed as the wind rises after the leaves dry. Second, relatively slow wind of about 1 m/sec within the canopy removes about two-thirds of the spores. Third, although the spores are somewhat more readily removed from leaves that are free to rub other leaves than from the fixed leaves, by noon there was no significant difference between the total numbers of spores liberated. Finally, as shown in the laboratory (6) a certain percentage (25% in this study) of the spores are not removed.

DISCUSSION.—In the laboratory 15-sec exposures of 3 to 6 m/sec wind were required to remove 80% of the spores, and repeated 15-sec exposures to 3.6 m/sec wind dislodged additional spores (6). Nevertheless, in our field, about 75% of the spores were removed by noon at winds near 1 m/sec. Specifically, between 0900 and 1100 hrs on 6 July (Fig. 1-a) when many spores were being dislodged, the leaves were dry and the wind at canopy top was highly variable between 0.5 and 1.4 m/sec. Since variable winds accounted for most peak air concentrations of rust spores over an infected field (2), prolonged exposure to the variable wind in the field is apparently responsible for liberating spores at a slower speed than expected.

The slightest touch of a lesion by another leaf blown by the wind can dislodge spores. Fixed leaves were allowed to flap in the breeze, but could not be rubbed by other leaves. Since the jarring due to leaf flapping does not impart sufficient impulse to dislodge spores because of their small mass, leaf flapping would not liberate spores. We anticipated that large differences would exist between free and fixed leaves because of leaf rubbing.

Although spores were dislodged from the free leaves somewhat easier than from the fixed ones (Fig. 1), the differences were small. Several factors may have contributed to the small differences. We found that only about 10% of a leaf surface is abraded by adjacent leaves for the LAI's of our experiment. Additionally, drying, maturing, and aging of the spore may influence the bond between the spore and sporophore. For instance, spores do not blow when wet (4) and all our leaf sections did not dry simultaneously, and in fact the leaves fixed at the top of the canopy dried first on 6 and 25 July. Spore age has little effect on spore removal (6). The effects of the spore maturation process on liberation have not been studied. However, in our case the spores matured under natural conditions. Thus, the earlier drying and maturing may have decreased the expected differences between free and fixed leaves. A further study of these factors, and the force required to remove spores should resolve the differences between the laboratory and the field results.

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