Verticillium albo-atrum: the Quantitative Relationship Between Inoculum Density and Infection of Cotton

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ABSTRACT

The threshold of infection for cotton plants by *Verticillium albo-atrum* was about 0.03 microsclerotia/g soil, under field conditions. Twenty to 50% infection occurred at the end of the growing season when the inoculum density was 0.3 to 1.0 microsclerotia/g soil, and essentially 100% infection occurred where the inoculum density was 3.5 or more microsclerotia/g soil.

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Verticillium albo-atrum Reinke & Berthe. is a destructive soil-borne plant pathogen in the temperate zones of the world. It systemically invades the vascular systems of numerous plant species, causing wilting of foliage and, often, death of the entire plant. Members of the families *Compositae, Malvaceae, Rosaceae, Solanaceae, Cucurbitaceae,* and *Leguminosae* are among the important hosts of the fungus.

Rotations with nonsusceptible crops can be helpful in control of *V. albo-atrum* because its persistent infective propagule, the microsclerotium (4), germinates repeatedly in moist soil (2) and, therefore, contributes to its own eventual demise in the absence of susceptible hosts (5, 6). This is an important factor since the fungus is not strongly saprobic in soil (5). The potential of crop rotation as a means for controlling this fungus has not been fully realized because of the lack of procedures for quantitatively determining survival of the fungus under different cropping practices, except for the laborious procedure of growing hosts in potentially infested soils (4, 6). Several substrates have been reported for trapping the fungus from soils (4), but none appear to have gained widespread acceptance, since their usefulness is limited because of interference from other microorganisms in naturally infected field soils that overgrow and obscure slow-growing *V. albo-atrum* (3). This criticism may not apply to a sorbose-containing substrate recently

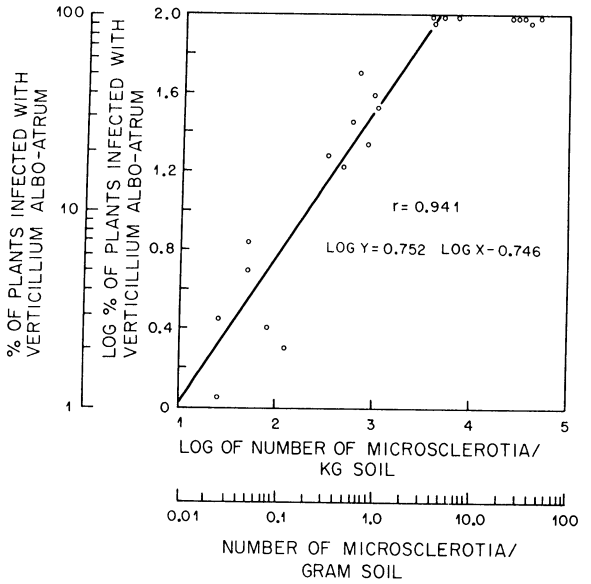

Fig. 1. The logarithmic relationship between the inoculum density of *Verticillium albo-atrum* in field soils and infection of cotton plants at the end of the growing season.

reported by Jordan (3). However, he did not indicate the species of *Verticillium* recovered from soil on his substrate.

We recently reported (1) that an inoculum density of as few as 0.13 microsclerotia of *V. albo-atrum*/g soil can be assessed quantitatively. No interference due to overgrowth by other microorganisms occurred with 32 samples of field soil. This paper reports results of assays of soil from 24 fields planted with cotton (*Gossypium hirsutum* L.) in the central valley of California during 1971, and relates the inoculum content of the soils with the number of infected plants observed at the end of the growing season. In this way, both the number of microsclerotia necessary for minimal and epidemic disease occurrence in cotton plantings were determined.

Soil samples were taken from 0- to 15-cm (0 to 6 inches) depth from three rows/field at three to four locations/row of 100 plants in June and November 1971. The subsamples of each row were bulked and homogenized by hand mixing. A 15-g sample of soil from each replicate was assayed for microsclerotia free from plant debris according to the quantitative procedure reported earlier (1). These results were compared with the percentages of infected plants observed at the end of the growing season. Each of the 100 plants of each replication was cut near the soil line and observed for presence of necrotic xylem tissue. This symptom usually is indicative of infection by *V. albo-atrum* in California where Fusarium wilt of cotton is endemic in only two or three places (R. H. Garber, *personal communication*).

Determinations were made in 24 cotton fields, some of which were reported on in an earlier report on methodology (1). Microsclerotia were not detected in 2 of the 24 fields, and plants in these fields were free from infection by *V. albo-atrum*. Microsclerotia were detected, however, in the other 22 fields, and infected plants also were present. A positive log-log relationship between inoculum density in soil and infection of cotton plants was observed (regression coefficient [r] = .941). The equation log Y = 0.752 log X-0.746 accurately expresses this relationship between trace- and essentially 100% infection. Inoculum density values first were converted to the number of microsclerotia per kg soil (Fig. 1) in order to avoid use of a negative logarithmic plot. This procedure allowed use of parallel legends showing the actual number of microsclerotia detected in soils.

The threshold number of microsclerotia required for trace amounts of infection was about 0.03/g soil under field conditions (Fig. 1). Infection always was less than 10% where 0.1 or fewer microsclerotia/g soil were detected. Above this critical inoculum density, amounts of infection increased sharply. Twenty to 50% infection occurred when inoculum density was 0.3 to 1.0 microsclerotia/g soil. Essentially 100% infection occurred in soils containing 3.5 or more microsclerotia/g soil. Thus, the amount of disease observed at the end of the growing season in November was closely associated with the number of microsclerotia detected at about the same time (Fig. 1). This relationship also held for microsclerotial assays of the same soils made in June, except in one instance. In this case, there was a dramatic decrease in the number of microsclerotia between June and November (from 38.9/g to 0.48/g soil), but the amount of disease observed in November agreed with the results of the November microsclerotial assays. The cause for the apparent decline in inoculum density in this case is not known.

These data show, for the first time, that the amount of infection from *V. albo-atrum* in a crop plant can be quantitatively estimated before the end of the growing season. The data also show that crop rotations may not always be satisfactory for cotton production because essentially 100% infection can occur whether a soil contains 3.5 or 50 microsclerotia/g soil (Fig. 1). Thus, a short-term rotation may be satisfactory for a field containing 3.5 microsclerotia/g soil, whereas a similar rotation might fail in a field containing 50 microsclerotia/g soil. Results of these tests should provide a basis for selection of fields safe for planting cotton so as to avoid severe losses from Verticillium wilt. Additional data are needed on the seasonal changes in inoculum density. These data also provide a basis for determining the survival of microsclerotia of *V. albo-atrum* in different soils and under different cropping practices which should be useful for determination of efficient crop rotation systems.

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