The Relationship Between Time of Cortical Senescence and Foliar Symptom Development of Phymatotrichum Root Rot of Cotton

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Accepted for publication 11 July 1984.

ABSTRACT

Rush, C. M., Lyda, S. D., and Gerik, T. J. 1984. The relationship between time of cortical senescence and foliar symptom development of Phymatotrichum root rot of cotton. Phytopathology 74:1464-1466.

Borescopic observations revealed that *Phymatotrichum omnivorum* is capable of attacking roots of cotton seedlings 5 days after emergence. Roots in contact with the fungus became water-soaked and discolored. The fungus colonized the root and new strands originated from the colonized region. Disease symptoms were restricted to the root; no foliar symptoms appeared until the root cortex sloughed. Cortex sloughing occurred 18–25 days, and plant death 27–50 days after seedling emergence, regardless of the age at which cotton plants were exposed to sclerotial inoculum of *P. omnivorum*. The expression of Phymatotrichum root rot symptoms on cotton is intimately associated with cortical senescence.

Phymatotrichum root rot (PRR) is the most serious disease of cotton in the Blackland region of Texas. The pathogen, *Phymatotrichum omnivorum* (Shear) Duggar is indigenous to the area. Many fields with histories of severe root rot have been taken out of cotton production. The fungus overwinters as sclerotia and hyphal strands (4,7). Foliar disease symptoms generally appear soon after square initiation, approximately 45 days after emergence. Because plants seldom exhibit symptoms before fruiting, cotton seedlings have been considered to be immune or resistant to *P. omnivorum* (2). Others have reported that cotton seedlings are susceptible to *P. omnivorum* (3,5,8). Henderson (3) grew seedlings in a liquid medium inoculated with *P. omnivorum*. Plants wilted in 5–9 days and were stunted compared to controls. Henderson (3) attributed these symptoms to a toxic thermostable metabolite produced by the fungus. Watkins (8) and Watkins and Watkins (9,10) grew cotton seedlings on potato-dextrose agar slants with *P. omnivorum* and also found the seedlings to be susceptible. Roots became water-soaked and discolored within 48 hr and died in 5–10 days. Cellular abnormalities were detected three to four cell layers in advance of the fungus. Similar symptoms could be seen when liquid expressed from infected root pieces was applied to healthy seedling tissue. When the liquid was heated, no symptoms developed. Watkins (8) also found that cotton seedlings grown in association with *P. omnivorum* on a medium low in carbohydrates were resistant and developed none of the previously reported symptoms. Neither Henderson (3) nor Watkins and Watkins (10) attempted to explain the apparent resistance of field grown cotton seedlings.

The majority of studies concerning the susceptibility of cotton seedlings to *P. omnivorum* have been conducted under artificial conditions optimum for fungal growth, but poor for the seedlings. Results from these studies are difficult to relate to actual field observations.

This study was conducted to evaluate the interactions between cotton seedlings and *P. omnivorum* in a more natural soil environment and to determine whether cotton seedlings are susceptible to *P. omnivorum* in situ.

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MATERIALS AND METHODS

In situ observations of *P. omnivorum* on cotton seedlings. Borescopic observations of cotton roots in situ were made as previously described (6). Twenty-five 19-L containers were filled with nonsterile Houston Black clay and inoculated with 3 g of sclerotia of *P. omnivorum*. The sclerotia were placed 12.5-cm deep and in contact with the mini-rhizotron Plexiglas surface. Cotton seeds were planted and seedlings were thinned to one plant per container after emergence. Each seed was positioned above the mini-rhizotron in such a manner that as the seed germinated, the root made contact with the mini-rhizotron surface and grew appressed to it. Observations were made daily for 2 wk and at 2-day intervals thereafter until plant death.

Effects of plant age on disease development. One hundred forty-four containers, 10-cm wide and 60-cm deep, were filled with nonsterile Houston Black clay and placed in a temperature tank maintained at 28 C. Cotton was planted in these containers over a period of 4 wk, 36 plants per week. Following emergence of the last planting group, the soil in all containers was infested with sclerotia of *P. omnivorum* by burying approximately 2 g of sclerotia 5 cm deep next to the seedling root. First disease counts were taken 15 days after inoculation. Plants exhibiting typical wilt symptoms of PRR were counted positive for disease. Disease development was monitored daily for 50 days.

RESULTS

In situ observations of *P. omnivorum* on cotton seedlings. Cotton seedlings began to emerge 3–4 days after planting. In all 25 containers, sclerotia and developing roots were clearly visible through the mini-rhizotron, and seedling roots approached the level of sclerotial placement. Five days after emergence, young hyphal strands of *P. omnivorum* were observed and after 8 days, strands were well developed and in contact with roots. The initial reaction of cotton roots following contact with the fungus was a slight water soaking and discoloration which occurred within 24 hr at the point of contact. The discolored area enlarged and the fungus colonized the discolored region, forming a hyphal mantle over the root. Numerous strands grew outward in all directions from this point. Within 15 days after plant emergence, much of the tap root was covered by the fungus (Fig. 1). Although the root appeared to be severely infected, there were no aboveground symptoms of PRR at this time. The plants had three or four true leaves.

From 19–25 days after plant emergence, the root cortex sloughed

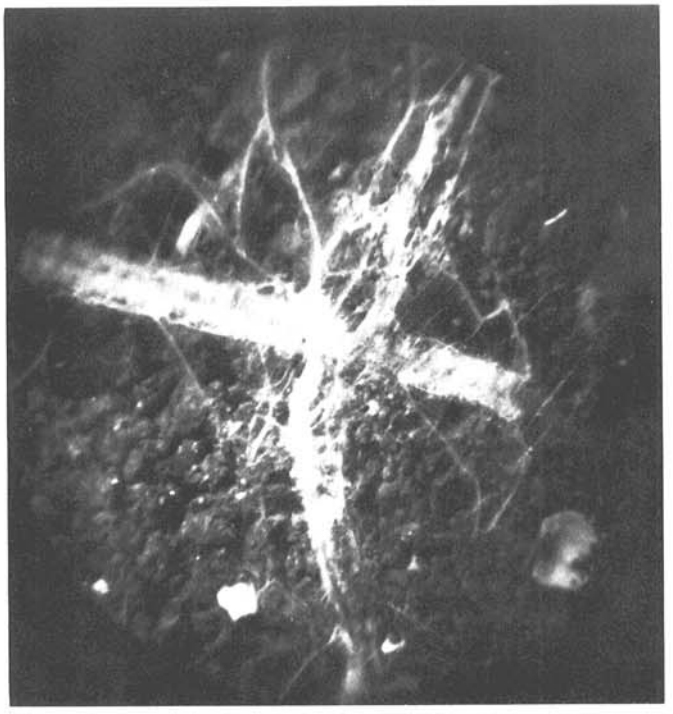

Fig. 1. *Phymatotrichum omnivorum* on cotton seedling root 3 wk after emergence. The fungus has formed a hyphal mantle around the root, but no aboveground symptom has developed (×4.5).

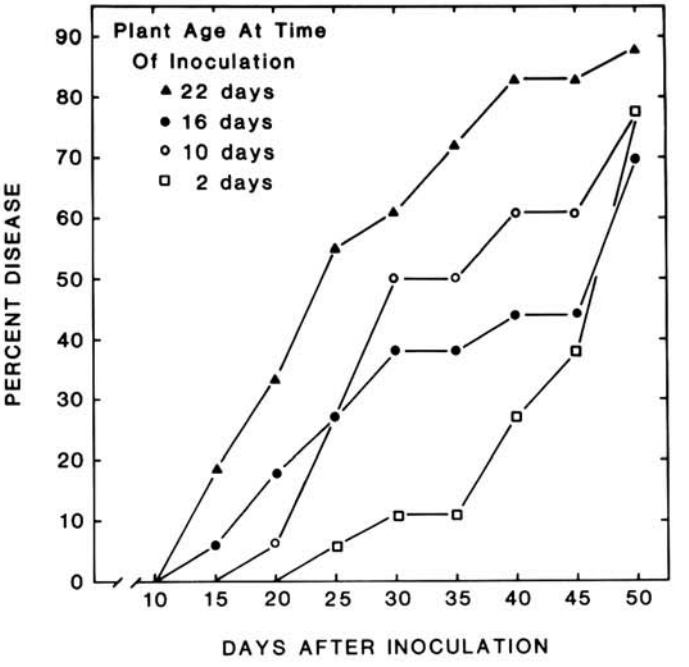

Fig. 2. The effects of plant age at time of inoculation on Phymatotrichum root rot development in cotton. The first plants to die after inoculation were in the group planted first. Chronologically, all planting groups began to express disease symptoms at approximately the same time, 27–32 days after emergence.

along with the mantle of hyphal strands. Seedling roots that were previously covered with fungal strands and appeared discolored and infected now appeared healthy and free of any strands. The aboveground portion of the plant had five or six true leaves. Over the next 10 days, strands were again observed growing on tap roots. Roots with fungal strand regrowth developed discolored and sunken lesions, and within three or four days, aboveground symptoms of PRR appeared. Plants first began to die 31 days after emergence. Forty-five days after emergence, 90% of the plants had died and the experiment was terminated.

Disease development as affected by plant age. Foliar disease symptoms first appeared on the oldest plants, approximately 12 days after inoculation (Fig. 2). Disease symptoms did not appear on the youngest plants until 25 days after inoculation. Regardless of planting date, no plant died until at least 27 days after emergence, and the majority of plants in each group died 30–50 days after emergence. The final percentage of disease was similar among the four planting dates.

DISCUSSION

Borescopic observations revealed that *P. omnivorum* is capable of attacking cotton seedlings soon after emergence. The prolific fungal growth on the root and the production of new strands suggest that *P. omnivorum* was using the root as a nutrient source either by parasitizing the root or surviving saprophytically on root exudates. The pathogenic response, water-soaking and discoloration, of the root to fungal contact, however, suggests a parasitic interaction or response to toxic substances produced by the fungus. These observations are similar to those made by Watkins (8). He reported that within 5–10 days after placing cotton seedlings in association with *P. omnivorum* on agar plates, the plants became water-soaked and discolored and died. In this study, no aboveground symptoms or plant death occurred until at least 27 days after emergence.

The development of typical PRR symptoms is closely related to cortex sloughing. Seedlings with roots highly discolored and covered by the fungus never exhibited foliar symptoms before the cortex sloughed. Immediately after the cortex sloughed the root appeared healthy, but within 1–2 wk the fungus had recolonized the root, lesions developed, and foliar wilting followed. Borescopic observations showed that the cortex sloughs rapidly 18–25 days after plant emergence. In the plant-age study, the majority of plants in each planting group died 30–50 days after plant emergence regardless of the age of the plants when initially exposed to the sclerotial inoculum. No plants died until at least 27 days after emergence. These results are in agreement with those presented by Blank (1). In his study, no plant died from PRR until 25 days after emergence, and the average plant age at disease onset was 32 days.

The results and observations from this study suggest that *P. omnivorum* is capable of colonizing cotton seedlings as soon as contact is made between root and fungus. However, the susceptible seedling's response is confined to the root and no aboveground symptom appears until after cortical sloughing. Cotton roots that are discolored and covered with the fungus appear healthy after cortical sloughing, indicating that the fungus is probably restricted to the cortex of the seedling root. Watkins (9,10) reported that seedlings grown in association with *P. omnivorum* on potato-dextrose agar or soil amended with starch were killed and that the fungus entered the vascular tissues. The fact that cotton seedlings growing in nonamended soil exposed to *P. omnivorum* do not die until the cortex sloughs suggests that the fungus is unable to grow beyond cortical tissue without an external energy source. Although *P. omnivorum* is capable of colonizing very young seedling roots, the complex nature of disease development seems to prevent symptom expression before the cortex is destroyed.

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