Leaf Diffusive Resistance of Sunflowers Infected by Pratylenchus penetrans

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ABSTRACT

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Diffusive resistance measurements of leaves of sunflower with roots infected by small populations of lesion nematodes indicate that internal water status of otherwise symptomless plants may be lower than that of healthy plants. Younger plants showed greater diffusive resistance than did older plants; however, regardless of age, infected plants showed increased diffusive resistance in advance of healthy plants growing under similar conditions. Such moisture stress may induce the stunting commonly associated with lesion nematode infection.

Additional key words: porometer, horizontal sensor.

All plant physiological processes depend on water and if growth and development are to proceed normally, internal water stresses must not develop within plant tissues (6). Relatively low leaf moisture stress inhibits such processes as photosynthesis (1) and transport to the shoot system of cytokinins synthesized in root tips (8). As water deficits intensify, organelles and other cell components become disrupted (14). This causes further reductions in metabolic activity, which ultimately result in reduced growth (5, 6).

Yield reductions of a wide variety of crops also result from root infestations by the lesion nematode *Pratylenchus penetrans* (Cobb) Filip. and Stek. (4). Stunting resulting from lesion nematode infection often occurs in the absence of extensive root tissue damage. Infected plants have been reported to appear to be more susceptible to wilt than healthy plants during periods of slight water stress (13), although the effect of *P. penetrans* on host-water relations has never been quantitatively measured.

The purpose of this investigation was to determine the effect of *P. penetrans* on host-water relations. Measurement of water vapor loss from leaves with a diffusive resistance porometer was selected as an accurate means of estimating the internal water status of healthy and diseased plants (5, 10).

MATERIALS AND METHODS

Sunflower seedlings (*Helianthus annuus* 'Mammoth') were grown singly in loam:sand (1:1, v/v) in 10-cm diameter plastic pots at 25 C in a growth chamber with a 12-hour light period. Light intensity was measured with a spectroradiometer (ISCO Model SR).

Upon cotyledonary expansion, 11 seedlings were inoculated with approximately 2,000 *P. penetrans* larvae and adults and 11 were uninoculated controls. Inoculum was obtained from alfalfa callus grown aseptically on nutrient medium containing 2,4-D (11).

Soil was brought to field capacity at the beginning of each experiment and no further water was added. Diffusive resistance of abaxial leaf surface (r_l) of healthy and nematode-infected sunflowers was measured with a diffusive resistance porometer (Lambda, Model LI-60) (9) at 8-hour intervals commencing 12 hours after saturation of the rooting medium with water, and ending upon the first signs of leaf flaccidity. Raw data in seconds, collected from diffusive resistance measurements of the first and third pairs of true leaves at similar physiological ages were converted to sec cm^{-1} (12). In initial experiments, growth chamber humidity was monitored with a thermal hygrometer and was found to range from 40%-60% in the light and 55%-65% in the dark.

RESULTS

The diffusive resistance (r_l) of nematode-infected plants, taken in the dark, increased before that of healthy plants as soil moisture decreased. Older plants experienced significant increases in diffusive resistance 58 hours after initial readings (Fig. 1), whereas younger plants experienced increases in diffusive resistance 40 hours after initial measurements (Fig. 2). Therefore, significant differences occurred in younger plants when soil was near field capacity whereas differences in older plants did not occur until the soil appeared dry. In agreement with the findings of Davies and Kozlowski (3), diffusive resistance measurements taken during light hours were found to be independent of air moisture at high light intensity. However, Hall and Kaufmann (7) found diffusive resistance measurements of sesame

(Sesamum indicum) to be indirectly related to air moisture.

Inoculation of sunflower seedlings with 2,000 lesion nematodes did not produce stunting or other foliar symptoms at the times of measurement of diffusive resistance. However, the roots, particularly the tap root, exhibited extensive lesion formation and browning. In stained parasitized roots, nematodes were observed in cortical tissues behind differentiating meristem regions and many eggs were seen throughout the cortex.

An attempt was made to study the effect of 12,000 lesion nematodes per plant on leaf diffusive resistances. These plants were severely stunted and leaf surface areas of inoculated plants were too small to be measurable by the sensor aperture of the diffusive resistance porometer. Many of the plants inoculated with high population levels of nematodes died after two weeks and those which survived had very few roots.

DISCUSSION

Leaves of nematode-infected plants, when compared with those of healthy plants, exhibited premature increases in diffusive resistance before any other symptoms could be detected. When roots of plants infected with low population levels of *P. penetrans* and roots of healthy plants were placed side by side, they appeared to have root systems of equal size. Nevertheless, diffusive resistance in leaves of infected plants declined in advance of that in healthy plants as soil moisture became limited. It would appear, therefore, that root tissue integrity and distribution are essential for efficient soil moisture utilization.

Owing to the high light intensity under which diffusive resistances were measured, it is probable that internal water deficits were not detectable during light hours. Under high light intensity leaf water deficits had little effect on stomatal movement until extreme internal water deficits existed (10). However, in the dark, when stomatal water loss is restricted, diffusive resistance is more dependent on cuticular water loss (5). In spite of oscillations in transpiration (2) which were probably responsible for the variability in diffusive resistance measurements, dark-hour measurements of the first set of true leaves (Fig. 2) indicated that diffusive resistance developed in diseased plants even when soil moisture was abundant. This difference between the diffusive resistance of healthy and diseased plants became substantial between 16 and 40 hours after initial measurements (Fig. 2). Diffusive resistance of infected plants, which were approximately three weeks older, did not appear to differ from that of healthy plants until 58 hours after initial readings (Fig. 1) when the soil surface appeared to be dry.

Healthy plants experienced short-term increases in diffusive resistance during the day when transpiration exceeded absorption. Significant differences of diffusive resistance in nematode-infected plants were determined to occur during the night. If such increases in diffusive resistance reduce or stop restoration of normal internal water deficits, then such stresses could account, in part, for the stunting that is often associated with the attack of lesion nematodes.

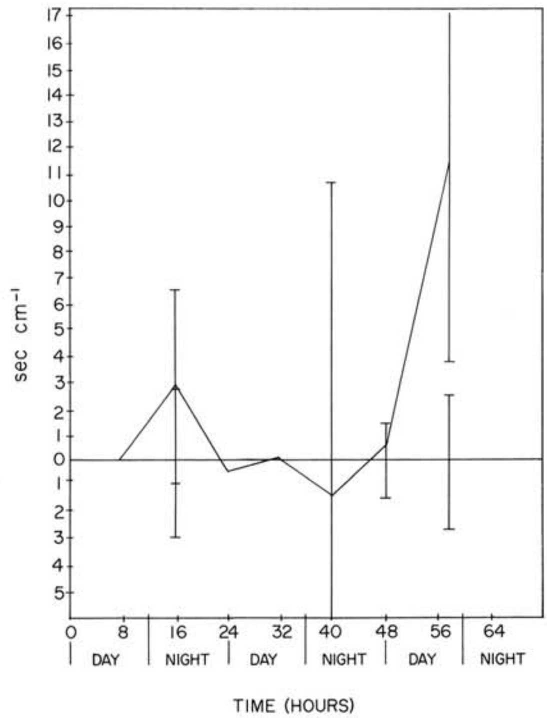

Fig. 1. Absolute differences in diffusive resistance (sec cm^{-1}) of the third true leaf pairs of 6-week-old healthy (0 line) and lesion nematode-infected sunflower plants which arose as soil moisture decreased. The $P = 0.05$ intervals of means are indicated. Means are based on 22 plants.

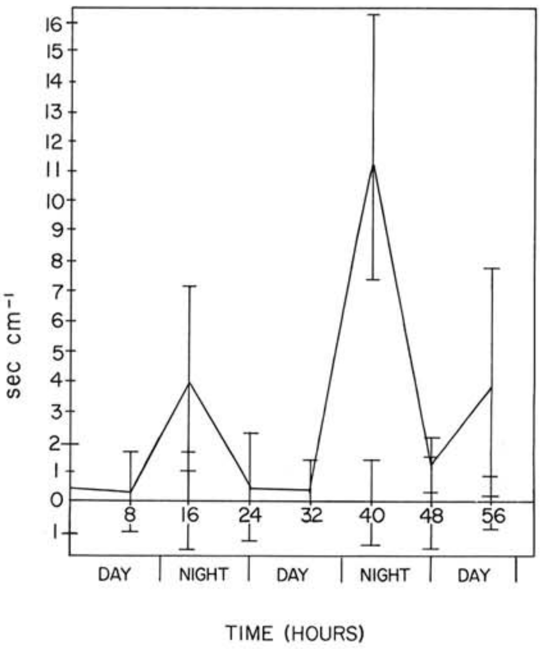

Fig. 2. Absolute difference in diffusive resistance (sec cm^{-1}) of the first true leaf pairs of 3-week-old healthy (0 line) and lesion nematode-infected sunflower plants which arose as soil moisture decreased. The $P = 0.05$ intervals of means are indicated. Means are based on 22 plants.

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