# Reduction of Electrical Resistance in Sunflower Roots Infected with Lesion Nematodes

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Paper No. 1092, Massachusetts Agricultural Experiment Station, University of Massachusetts at Amherst. This research supported from Experiment Station Project No. Hatch 290.

Accepted for publication 25 March 1976.

ABSTRACT

KAPLAN, D. T., T. A. TATTAR, and R. A. ROHDE. 1976. Reduction of electrical resistance in sunflower roots infected with lesion nematodes. Phytopathology 66: 1262-1264.

Decreases in the electrical resistance of sunflower root tissue infected with *Pratylenchus penetrans* indicated that changes had occurred in infected tissues within 3-6 hours although lesions were not evident until 16-24 hours after inoculation. No changes in electrical resistance or discoloration of tissues were detected in lesion nematode-infected corn root tissue even at 24 and 43 hours after inoculation. Changes in electrical resistance were not detected in tissues 2 cm from the inoculation site of either of the species tested. A technique to determine accurately the electrical resistance of vegetative tissue is described.

*Additional key words:* pulsed current, platinum electrodes, *Helianthus annuus, Zea mays.*

*Pratylenchus penetrans* (Cobb) is a migratory endoparasite of plant roots. Feeding by this species causes breakdown of cells of the cortex and browning of adjacent cells which produces a characteristic lesion (1, 3).

Decreases in electrical resistance have been associated with wood deterioration (9), host response to fungal infection (2), and injury of apple (5). The aim of this study was to determine the effect of lesion nematode infection on host root tissue as measured by electrical resistance.

## MATERIALS AND METHODS

**Host plants.**—Seeds of sunflower (*Helianthus annuus* L. 'Mammoth') and sweet corn (*Zea mays* L. 'I O Chief') were treated with captan-pentachloronitrobenzene and captan, respectively, placed on germination paper which was rolled into cylinders, and left standing upright in a germination chamber (30 C day, 20 C night) for 5 days. The cylinders were then unrolled and seedlings with roots of similar length and diameter were selected. One Miracloth disk (5-mm diameter) (Chicopee Mills, Inc., New York) was placed approximately 5 mm from the tip of each root.

**Nematode.**—Lesion nematodes, *P. penetrans,* were raised axenically on alfalfa callus (7). Adults and larvae were extracted with a Baermann funnel, collected in distilled water, and 0.2 ml of the nematode-distilled water suspension containing approximately 500 nematodes was placed on each Miracloth disk on half of the test plants. An equal number of control plants were treated with 0.2 ml of distilled water only. In each experiment, approximately 40 plants were used for each treatment. The experiment was repeated three times with sunflower and twice with corn.

**Measurement of electrical resistance.**—Changes in electrical resistance of lesion nematode-infected, noninfected adjacent tissues, and noninoculated root tissue were estimated by measurements with a Shigometer (Northeast Electronics Co., Concord, N.H.), a device which measures electrical resistance to a pulsed direct current (8). Seedlings were placed individually on a platform composed of nylon mesh stretched over an open glass petri dish which was secured to a glass block (Fig. 1). In preparation for measurement the Miracloth disk was removed and a single layer of nylon mesh stretched across a plastic hoop was lowered over the seedling. Two subdermal platinum needle electrodes, 10 mm long and 0.5 mm in diameter (Grass Instrument Co., Quincy, Mass.), previously fixed in position 3 mm or 5 mm apart

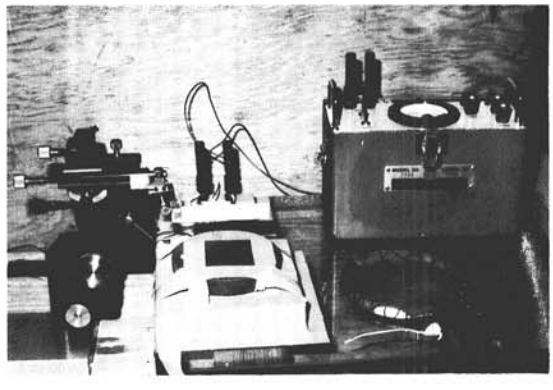

**Fig. 1.** Electrical resistance of corn and sunflower roots was determined with two subdermal platinum needle electrodes attached to a Lucite block supported by a micromanipulator. Roots were supported between two layers of nylon mesh and resistance to a pulsed current was measured with a Shigometer.

on a Lucite block which was supported by a micromanipulator (Fig. 2), were inserted completely through the root in the area of inoculation. Electrical resistance of the root tissue was measured and recorded in kilohms (KΩ). The effect of inoculation of root tissue with lesion nematodes on electrical resistance was determined immediately after inoculation, at 3 and at 5 or 6 hours after inoculation.

The placement of seedlings between two layers of nylon mesh limited root movement during electrode insertion and thereby minimized root damage. The Miracloth disks served as inoculation site markers, aiding in the location of inoculated root tissue in the absence of lesion formation. The use of a micromanipulator for placement of the electrodes standardized the extent of electrode-root surface contact and the types of tissue that contacted the electrode.

A measurement was made at the inoculation site and the electrodes were immediately withdrawn and reinserted to obtain measurements 1- and 2-cm distant from the inoculation site. Data were collected from 8-10 seedlings for each of both inoculated and noninoculated treatments at each sampling time.

## RESULTS

The presence of lesion nematodes in the cortex of sunflower roots, 3-6 hours following inoculation, was correlated with decreases in electrical resistance (Fig. 3). Macroscopic lesions, however, were not evident until 16-24 hours after inoculation.

No changes in electrical resistance of corn root tissue were detected either at the inoculation site or in adjacent noninoculated tissue. Measurements were made at 0, 3, 7.5, 19.5, 24, and 43 hours following inoculation. Although lesion-nematode infection of corn was comparable to infection of sunflower, with respect to the rate and number of nematodes that entered the roots, none of the cells in infected areas turned brown and macroscopic lesions were not evident.

## DISCUSSION

Decreases in electrical resistance, similar to those detected in sunflower tissue infected with lesion nematodes prior to symptom expression, also have been reported for Fusarium wilt of tomato and bacterial soft rot of chicory (2, 5).

The path of small, direct-current pulses at low frequencies, of the type used in this experiment, was reported to follow almost entirely the channels of the cell walls in healthy tissue and within the sap in the vascular tissue of healthy plants (4). Electrical resistance of plant tissue was inversely correlated with the concentration of mobile cations, principally potassium and calcium (4, 9). Injury and/or membrane damage result in electrolyte loss from cells and subsequent decreases in the electrical resistance of injured tissues (6). Electrical resistance also decreases during discoloration and decay of wood (9). In tissue infected by lesion nematodes, movement of the nematodes throughout the root cortex has been observed to cause mechanical and enzymatic disruption of cell walls and protoplasts (1).

Sixteen hours after inoculation, intact cortical cells of sunflower roots which were 3 to 4 cells away from nematode-infected cells within the inoculation site exhibited browning. Such changes may result from the action of enzymes liberated from parasitized cells or from the nematodes. In a similar study, increased electrical conductivity of chicory tissue in advance of a bacterial

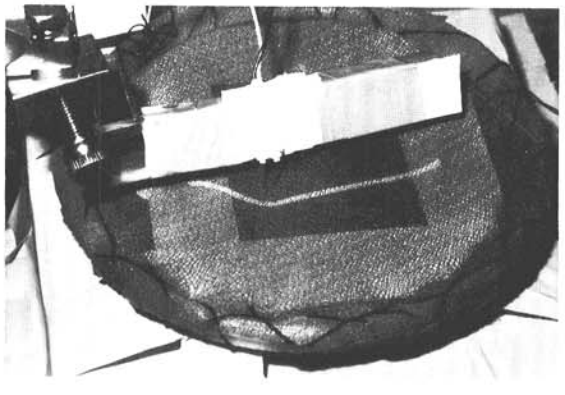

**Fig. 2.** Two subdermal platinum electrodes were inserted through corn and sunflower roots which were supported between two layers of nylon mesh.

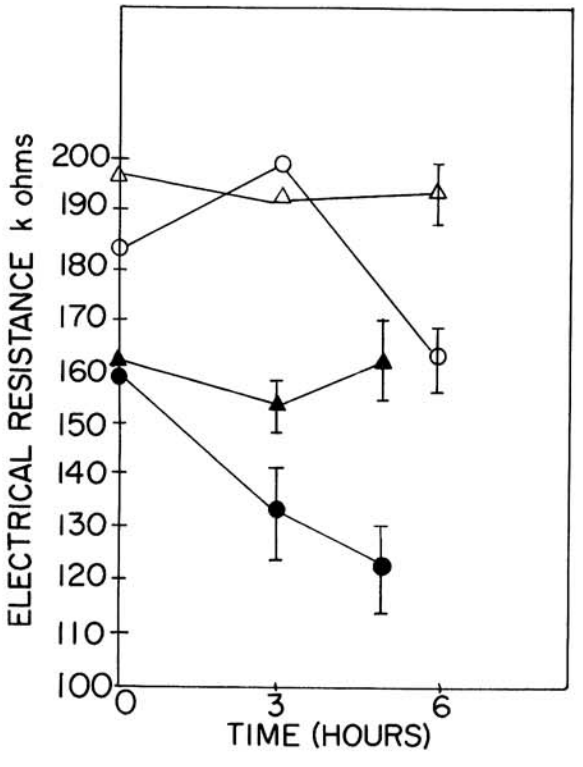


**Fig. 3.** Electrical resistance of nematode-infected sunflower root tissue, showing decrease between 3 and 6 hours after inoculation. (Electrodes were 5 mm apart in healthy (△) and diseased (○) root tissue or 3 mm apart in healthy (▲) and diseased (●) root tissue. Confidence intervals ($P = 0.05$) are indicated for significantly different treatment means. Means are based on at least 24 measurements.

soft-rot infection was correlated with the presence of pectolytic enzymes (5). However, in this experiment, a slight decrease in electrical resistance was detected 1-2 cm away from the inoculation site in only one replicate 3 hours after inoculation, but similar measurements of two additional replicates revealed no changes in electrical resistance even after 6 hours.

Our observations of the corn variety tested agree with previous findings that *P. penetrans* moves through the root cortex of corn and other gramineous species by tearing cross walls and, yet, no discoloration occurs (3, 10). The reason for this differential response of corn and sunflower to lesion nematode attack, as indicated by histological examination and lack of change in electrical resistance, is unknown; perhaps it is due to differential effects of enzyme activity on the respective host tissues or to differences in the number of cells that are killed.

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