# Hatching Response of *Meloidogyne incognita acrita* to Electric Shock

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*Abstract:* The influence of electric shock on hatch of *Meloidogyne incognita acrita* from egg masses taken from roots of 'Acala SJ-1' cotton (*Gossypium hirsutum* L.) was studied. Egg masses in tap water were individually placed between the tips of needle electrodes 1 mm apart and exposed to potentials of 1, 10, 20, and 60 vdc/mm at 1, 1, 1, and 86 milliamperes dc, respectively, for periods of 2 and 60 seconds. Hatched larvae were counted at five-day intervals for 60 days. Of the eight treatment combinations used, six gave a greater egg hatch than the control. The largest hatch, 520 percent greater than the control, resulted from exposure to 1 vdc/mm for 60 seconds; 60 vdc/mm for 2 and 60 sec decreased egg hatch 11 and 94 percent of the untreated control. Hatched larvae from all treatments except the 60 vdc/mm, 60-second exposure were infective and reproduced on young cotton plants in a glasshouse. *Key Words: Meloidogyne incognita acrita,* Hatch, Electrostimulation, Egg masses.

Mechanisms of induced hatching and of the survival of eggs during periods of unfavorable environment for plant-parasitic nematodes have been the subject of much investigation and speculation. Temperature, moisture stress, root diffusates, host specificity, concentrations of gases, time, and larval movement all apparently play a part. That electricity had an effect on nematodes was demonstrated by Daulton and Stokes (2). They found a comparatively small voltage killed *Meloidogyne* spp. larvae, but a greater (unspecified) voltage was required to kill other stages.

Caveness and Caveness (1) showed adults and free larvae of *Panagrellus redivivus* and larvae of *M. incognita acrita* were killed by exposures ranging from 5 vdc/mm for 20 seconds to less than 1 second at 60 vdc/mm. However, larvae and eggs within female *P. redivivus* were not killed at 10 times that voltage. They also exposed *M. incognita acrita* egg masses to electric shocks of 20 vdc/mm for 2 seconds and 60 vdc/mm for 2 seconds and 60 seconds. The 2-second treatment stimulated the hatching of larvae. Investigations on the influence of electric shock on egg masses of *M. incognita acrita* are reported in this paper.

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## MATERIALS AND METHODS

The electrical apparatus was as described in Caveness and Caveness (1) except that needle electrodes were used (Fig. 1).

Egg masses were individually placed in about 0.009 ml of tap water on a glass ruled with one-millimeter marks except for the 86-milliampere exposures, in which sufficient water was used to prevent excessive heat generation. Two needle electrodes, 1 mm apart, were brought into contact with the water. The potentials and amperages applied and the times of exposures are given in Table 1. Each replication contained ten egg masses, and there were five replications of each treatment. Each replication was placed in a Baermann funnel on a Scottie® (Scott Paper Co., Chester, Pa.) filter, and the hatched larvae were counted each five-day period for a total of 60 days. To test for infectivity following treatment, larvae were inoculated onto potted cotton seedlings. The room temperature was 24 ± 2 C.

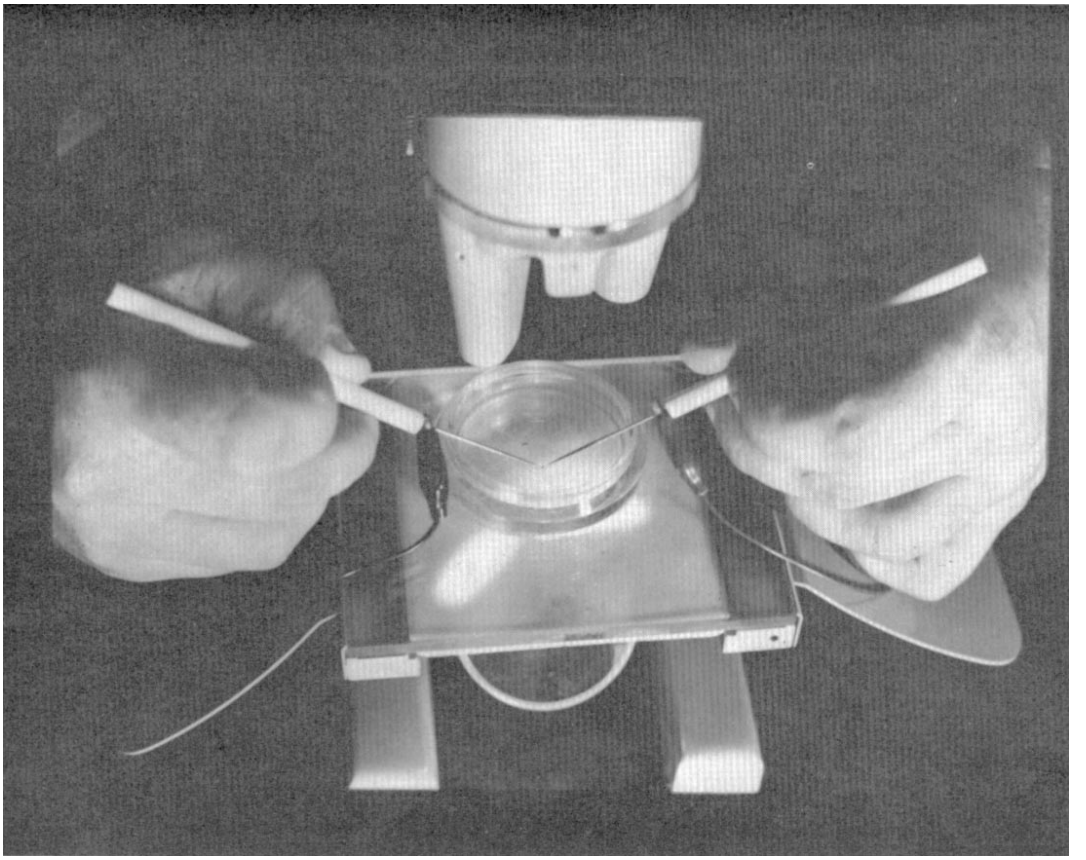

FIG. 1. Physical setup for electrical stimulation of *M. incognita acrita* egg masses.

## RESULTS

Of the eight treatments used (Table 1), six yielded a greater egg hatch than the control; five of these were significantly greater (Table 2). The largest hatch, which was 520 percent greater than the control, was obtained by 1 vdc/mm for 60 seconds. The second-largest hatch, which was 406 percent greater than the control, was obtained by 1 vdc/mm for 2 seconds. The higher potential of 60 vdc/mm for 2 and 60 seconds decreased egg hatch to 89 percent and 6 percent, respectively.

Egg hatches at 1 and 10 vdc/mm were 98 to 99 percent complete at 15 days, compared to 81 percent for the control (Table 3). Egg hatches at 20 vdc/mm for 60 seconds and 60 vdc/mm for 2 seconds were similar to the control and were essentially complete by the 25th day. The cumulative egg hatch at 20

TABLE 1. Electric shock treatments of *M. incognita* egg masses.

| Potential (vdc/mm) | Current (milliamps) | Duration (seconds) |
|---|---|---|
| 1 | 1 | 2 |
| 1 | 1 | 60 |
| 10 | 1 | 2 |
| 10 | 1 | 60 |
| 20 | 1 | 2 |
| 20 | 1 | 60 |
| 60 | 86 | 2 |
| 60 | 86 | 60 |

TABLE 2. The mean numbers of *M. incognita* larvae hatched from 10 egg masses during five-day intervals following exposure to various electric shocks.

| Days of Incubation | Control | Number of Larvae (time and vdc/mm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2 sec 1 | 60 sec 1 | 2 sec 10 | 60 sec 10 | 2 sec 20 | 60 sec 20 | 2 sec 60 | 60 sec 60 |
| 5 | 109[c] | 766 | 1028 | 336 | 174 | 239 | 108 | 168 | 1 |
| 10 | 116 | 611 | 697 | 420 | 233 | 154 | 433 | 99 | 7 |
| 15 | 106 | 272 | 384 | 183 | 82 | 59 | 373 | 65 | 7 |
| 20 | 56 | 19 | 25 | 7 | 6 | 58 | 80 | 14 | 1 |
| 25 | 17 | 2 | 2 | 2 | 2 | 8 | 44 | 4 | 1 |
| 26–60 | 7 | 0 | 1 | 0 | 2 | 143 | 34 | 14 | 7 |
| Grand means† | 411d | 1670ab | 2137a | 948c | 499d | 661c | 1072ab | 364d | 24e |
| Percent of control | 100 | 406 | 520 | 231 | 121 | 161 | 261 | 89 | 6 |

† Statistical significance of the grand means at the 5-percent probability level as determined by Duncans' multiple-range test.

vdc/mm for 2 seconds—although significantly greater than the control—was 20 percent less than the hatch rate of the control. The egg hatch from 60 vdc/mm for 60 seconds was negligible.

Hatched larvae from all treatments were infective and reproduced on young cotton plants in a glasshouse, excepting at 60 vdc/mm for 60 seconds, in which the larvae were probably insufficient in number to cause detectable infection.

## DISCUSSION AND CONCLUSIONS

These data indicated that an electric shock induces hatching of *M. incognita acrita* eggs. Whether this is a direct effect on the develop-

TABLE 3. Percentages of total eggs hatched during five-day intervals following exposure to electrical shock (cumulative percentages in parentheses).

| Days of Incubation | Control | Treatment (vdc/mm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1† | 1‡ | 10 | 10 | 20 | 20 | 60 | 60 |
| 5 | 27 | 46 | 48 | 35 | 35 | 36 | 10 | 46 | 4 |
| 10 | 28 | 37 | 33 | 44 | 47 | 23 | 41 | 27 | 29 |
| | (55) | (83) | (81) | (79) | (82) | (59) | (51) | (73) | (33) |
| 15 | 26 | 16 | 18 | 19 | 16 | 9 | 35 | 18 | 29 |
| | (81) | (99) | (99) | (98) | (98) | (68) | (86) | (91) | (62) |
| 20 | 13 | 1 | 1 | 1 | 1 | 9 | 7 | 4 | 4 |
| | (94) | (100) | (100) | (99) | (99) | (77) | (93) | (95) | (66) |
| 25 | 4 | | | | | 1 | 4 | 1 | 4 |
| | (98) | | | | | (78) | (97) | (96) | (70) |
| 26–60 | 2 | | | | | 22 | 3 | 4 | 29 |
| | (100) | | | | | (100) | (100) | (100) | (99) |

† Duration of exposure for the first potential was 2 seconds.
‡ Duration of exposure for the second potential was 60 seconds.

ing embryo, or on the hatching of second-stage larvae, or both, or an effect on the egg shell or the gelatinous matrix of the egg mass, we can only speculate.

The eggs of *Meloidogyne* spp. have two layers; the outer layer, which is a chitinous membrane, and the inner layer, which is a vitelline membrane of a lipoid nature. Wallace (12) suggests that after moulting to the second stage, the larva secretes enzymes which dissolve the water-impermeable vitelline membrane. Larval activity in the egg then increases until hatching occurs; hatch appears to be caused by rupture of the outer chitinous membrane by the stylet (5, 6, 8, 9). Doncaster and Shepherd (4) observed that emergence of *Heterodera rostochiensis* was always preceded by some minutes or hours of stylet thrusting, and that once stylet thrusting had begun, hatching usually resulted. The possibility of passive hatching (3, 7) seems to be discounted by these workers.

That eggs of some nematode species develop from the one-cell stage to hatch in water suggests hatch initiation might be determined by physiological maturation at a certain stage of development (8, 10, 11, 13). We suggest that treatment by electric shock might influence or alter this regulatory mechanism.

Caveness and Caveness (1) observed that eggs and larvae within *P. redivivus* females were often unaffected by electric shock that readily killed free larvae and adults. We suggest that treatments at 60 vdc/mm were lethal to the eggs, and larvae that did hatch survived because of their position in the egg mass. These eggs were bypassed as the electric current followed paths of lower resistance (1). Further studies are needed on egg masses, cysts, and individual eggs to fully determine whether hatch stimulation or inhibition by electric shock arises from direct effects upon developing embryos and unhatched larvae or indirect effects upon egg shell structure or gelatinous matrix composition.

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