

# The Effects of Soil Salinity and *Meloidogyne javanica* on Tomato<sup>1</sup>

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**Abstract:** A non-sodic, non-saline sandy loam soil was salinized to anion-cation ratios similar to those naturally occurring in Iraq and California. The interactions of saline soils (conductivities 4, 8, 12 and 16 mmhos/cm) with a moderately salt-tolerant plant (*Lycopersicon esculentum* 'Marimond') and a plant parasitic nematode (*Meloidogyne javanica*) were investigated. Plant parasitic nematodes were shown to be an important modifying influence within the plant environment, either accentuating or ameliorating salinity stress effects. **Key Word:** root-knot nematode.

The increasing use of marginal lands for agricultural production necessitates an understanding of the influence of less productive soil types on the development of plant disease in areas where there is continuous cropping. The soil, and the chemical composition of the soil solution, directly affect both plants and nematodes, as well as nematode eggs in the soil (1, 2, 3, 4, 5, 6, 7, 8). There is also an indirect influence on those plant parasitic nematodes living within plant tissues that results from the profound effect of salinity on plant growth (2, 6). The purpose of this study was to investigate the interaction of *Meloidogyne javanica* (Treub) Chitwood and soil salinity relative to their effects on plant growth.

## MATERIALS AND METHODS

The *Meloidogyne javanica* population for this study was collected from field tomatoes near Karbela, Iraq, and maintained in greenhouse cultures on the common tomato of Iraq, *Lycopersicon esculentum* Mill. 'Marimond' grown in sterilized soil. The soil used in this experiment was a non-sodic, non-saline sandy loam. Prior to artificial salinization the soil was autoclaved 1.5 hr at 121 C. The mixtures of salts for salinization and their ratios were within the range of those common to both Iraq and California: NaCl, MgCl<sub>2</sub>, CaCl<sub>2</sub>, Na<sub>2</sub>SO<sub>4</sub> and MgSO<sub>4</sub>; the ratio of Na:Mg:Ca was 1:1:1 and Cl:SO<sub>4</sub> was 2:1. The electrical conductivities of the saturation extract of the artificially salinized soils were 4, 8, 12 and 16 mmhos per cm (EC<sub>e</sub>). These levels were achieved by spraying salt solutions on soil

pads (2.5-cm layers of soil, approximately 25 kg in each treatment). The sprayed soil layer was covered with plastic tarpaulins for 24 hr to equilibrate moisture. The soil layer was turned and sprayed in this manner once on each side. After the soil pads were air dried, the conductivity of the saturation extract was checked. Variation from the calculated salinity was negligible. Sterilized, non-salinized soil was utilized as the control treatment. Ten 20-cm pots, each lined with a plastic bag, and containing 2.5 kg of soil, were planted with two tomato seedlings 3 weeks old; five pots of each series were infested with approximately 1000 *M. javanica* larvae. Pots were maintained at field capacity (ME 20%) by daily additions of water (EC<sub>e</sub> of 0.24 mmhos/cm) to a given pot weight, so that no drainage occurred. Watering was performed in this manner to avoid great fluctuations in the EC<sub>e</sub> of the soil solution during this experiment.

## RESULTS

Plant heights did not differ significantly between infected and noninfected plants at each EC<sub>e</sub> (Fig. 1). However, in the absence of *M. javanica*, height reduction at levels of salinity higher than 8 mmhos/cm was significantly different from controls at the 1% level. Vegetative growth steadily declined in the absence of nematodes and with increased salinity, but in the presence of nematodes there was no significant change in top growth between 4-12 mmhos/cm. With increasing salinity to EC<sub>e</sub>=4 (Fig. 1), the nematode population level initially dropped to less than one-half. Beyond that salinity level, the population remained essentially constant.

The dry weights of tops and roots of plants with and without nematodes, are plotted as a function of EC<sub>e</sub> in Fig. 2-A. The dry weights of tops in the controls (non-salinized), with and without nematodes, were equal; the control root systems with nematodes were heavier than

Received for publication 30 January 1973.

<sup>1</sup>A portion of this research was carried out under the sponsorship of Fulbright Authorization No. 540301-B.

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control roots without nematodes. At 4 mmhos/cm, there was a significant difference ( $P = 0.01$ ) between the dry weight of tops with and without nematodes. Even though the dry weight of nematode-infected roots at  $EC_e=4$  was less than that of roots without nematodes, the difference was not significant. Likewise, the differences in dry weight of tops of noninfected plants from control to  $EC_e=8$  were not significant. However, the reduction in vegetative growth due to salinity was significant ( $P = 0.01$ ) above  $EC_e=8$  with noninfected plants and above  $EC_e=4$  with infected plants. There was no significant difference in infected plants at 8-12 mmhos/cm from the controls.

Reduction of weight of noninfected roots was closely correlated with reduction of dry weight of top at salinities less than  $EC_e=12$ . At  $EC_e=4$  and higher, there was a reduction of approximately 50% in dry weight of infected

roots relative to control roots. The increase of dry weight noted with plant tops was also noted for infected root systems at  $EC_e=8$  and 12. Above  $EC_e=8$ , weights of noninfected roots declined rapidly.

In Fig. 2-B the ratio of the dry weight of tops to roots, infected and noninfected, are plotted as a function of  $EC_e$ . The similarity of pattern indicates the effect of salinity; the differential between the dry-weight ratio of infected and noninfected plants at each  $EC_e$  is indicative of the influence of root-knot nematode. When salinity was at 4 mmhos/cm the total plant growth was retarded. At 8 mmhos/cm vegetative growth was increased and then showed a steady decline. At 16 mmhos/cm the top/root ratio was the same as that recorded for 4 mmhos/cm.

## DISCUSSION

The dry weight of infected roots was greater than that of noninfected roots; this weight difference was not reflected by a difference in dry weight of tops. The root weight difference may, in part, be explained by gall development, gall mass being heavier than an equivalent linear length of similar non-galled root.

The effects of root-knot nematode on plants grown under saline conditions are complex and plant height measurements alone provide only a partial picture. That nematodes cause a decline in growth with increasing salinity was shown by height measurements (Fig. 1). When the dry weights or ratios of tops to roots were examined, the decline at 4 mmhos/cm and the recovery at 8 mmhos/cm was clearly evident (Fig. 1, 2-A, B). Reduction in height was not correlated with a decrease in vegetative or root mass. This may indicate that though salinity primarily affected moisture availability, nematode activities intensified nutritional stress effects.

The decrease at  $EC_e=4$  of dry and wet weight of roots (Fig. 2-A), as well as its influence on the dry-weight ratio of top to root (Fig. 2-B) was not an isolated observation. Each  $EC_e$  level was replicated five times, with and without nemas. In addition, the  $EC_e$  was checked before and after experimentation. Because of the unusual response, the  $EC_e$  at 4 was re-checked after 6 months from stored soil samples. There was no detectable difference from the original  $EC_e$  level. In addition, the decline in top growth was linear. If the observed weight reduction was due to

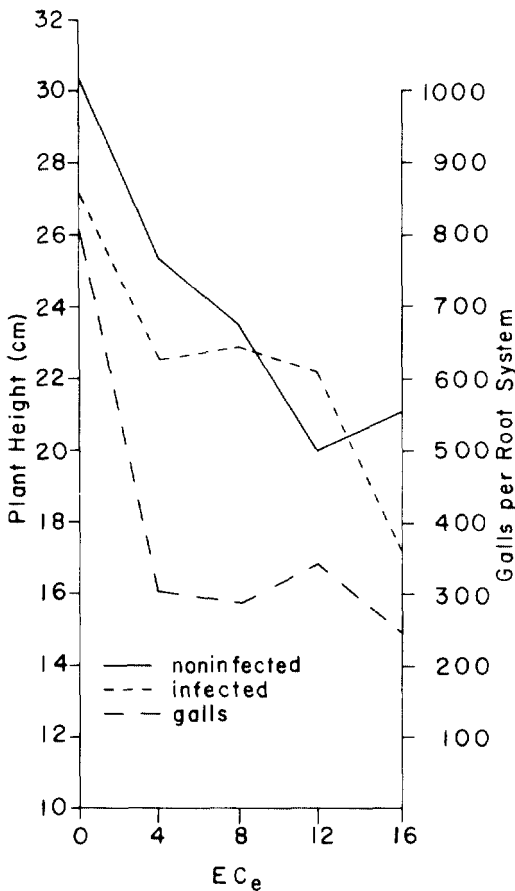


FIG. 1. Effect of salinity ( $EC_e$ ) upon height and root galling by *Meloidogyne javanica* on tomato relative to noninfected controls.

experimental error, it should have been detected in an erratic response of height and this was not the case (Fig. 1).

The decrease in dry weight of tops and roots at  $EC_e=4$  and the increase at  $EC_e=8$  may be explained by the effect of salinity on absorption and plant tissue formation. The salinity at  $EC_e=4$  may have influenced the balance of nutrients such as to cause a decrease in growth and mineral absorption. Concurrently, the salt concentration at  $EC_e=4$  was not high enough to cause a notable increase in the osmotic pressure of the soil solution. At  $EC_e=8$  the osmotic pressure of the soil solution was high enough to cause a compensatory increase in the concentration of the cell sap. Thus, although the plant height was decreasing at  $EC_e=8$ , the mineral absorption and cell sap

concentration was increasing; this in turn would be reflected by an increase in the dry weight of tops and roots (Fig. 2-A, B). That is, the decrease in height of plants with increasing  $EC_e$  may have been accompanied by a decrease in mineral absorption and tissue formation to  $EC_e=4$ . At higher levels of  $EC_e$ , absorption of nutrients increased the cell's osmotic pressure to equal the osmotic pressure of the soil solution. Furthermore, the thickness of the cell walls of stems and leaves may have increased, thus, reducing transpiration and counteracting the reduction in water uptake caused by the relatively higher salt concentration of soil solution around  $EC_e=8$ . Above  $EC_e=8$ , salinity was high enough to affect height, growth, absorption and tissue formation, as reflected in the dry weight recordings.

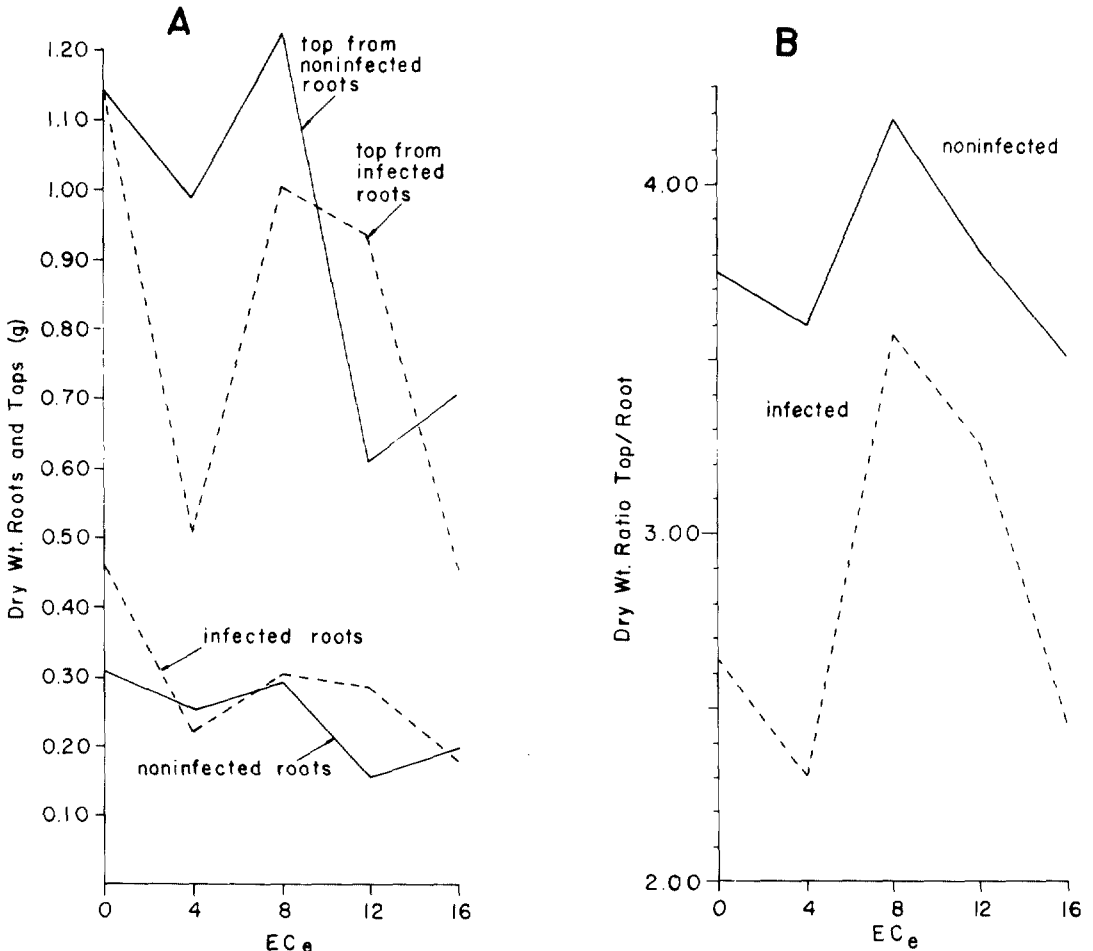


FIG. 2. A. Effect of salinity ( $EC_e$ ) upon dry weight of tops and roots of tomato by *Meloidogyne javanica* relative to noninfected controls. B. Effect of salinity upon dry-weight ratio of tomato tops to roots infected with *Meloidogyne javanica* relative to noninfected controls.

The initial drop in nematode population at  $EC_e=4$  and then the maintenance of an almost constant population at the higher levels of salinity may reflect larval survival rather than a lowering of the reproductive potential. Larvae were not preconditioned in saline solutions and, therefore, the effect of direct inoculation into salinized soils may have been lethal to some. If the latter assumption is correct, then approximately one-third of the population of *M. javanica* larvae were able to osmoregulate. In future experimentation, investigators should recognize this and compensate for the effects of increasing salinity by inoculating saline-adapted populations to both the control and salinized soils. Continued population suppression may result from egg mortality, suppression of hatching (2), larval mortality or the lowering of the reproductive potential (6).

The foregoing further emphasizes that plant parasitic nematodes are a modifying influence within the plant environment and, depending upon the conditions under which plants are grown, the nematode may either accentuate or ameliorate the effects of other environmental stresses.

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