Applications of Microwave Energy to Control Nematodes in Soil

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The use of microwave energy to heat substances is widespread in food service and food processing fields. Control of microbes in electronically heated foods is well documented (4). Use of radio-frequencies to control microorganisms in plant materials and soils has received less attention (2, 5, 6, 7). Recently, Eglitis and Johnson (3) reported the effectiveness of radio-frequency at 27.12MHz for pasteurization of six different greenhouse soils infested with four damping-off fungi. Seedling survival in irradiated soils ranged from 86 to 92% compared with 8 to 67% in nonirradiated soils.

When microwave energy, emitted from an electron tube, strikes an object, it is variously reflected, absorbed, or transmitted depending upon its: (i) dielectric coefficient; (ii) shape; (iii) mass; and (iv) moisture content. Soil absorbs the microwave energy to varying degrees and converts it into heat. This conversion results from the interaction between the microwave and the molecules of the exposed material. The principal lethal effect of microwaves on organisms is due to the heating of the soil mass (1).

We report here an investigation of the use of highpower microwave energy to control *Meloidogyne incognita* (Kofoid & White) Chitwood in potting soil.

The tests were conducted in a cavity-type microwave oven ($32 \times 30 \times 14$ cm) designed for home use (there are models that can be adapted for treating a larger soil mass) with a nominal power output of 1250 w of radio-frequency microwave energy, operated at 2450MHz. Samples under treatment were placed on a raised glass shelf 2.5 cm above the chamber floor and centered in the chamber.

Two series of treatments were made with composted greenhouse soil infested with root-knot nematode eggs and larvae. The soil mix used was composed of a 1:2:3 mixture of 2-year-old composted manure, sandy clay loam and coarse sand with a *p*H of 7.0. In the first series, 90cc of screened soil were placed in each of 30 standard petri dishes that were 1.7 cm deep. Soil moisture at time of treatment was 11% (oven-dry basis). Soil samples in petri dishes with lids were individually treated in the microwave oven. Exposure to the microwaves was timed at 0 (control), 15, 30, 45, 60, and 300 sec. There were five replicates for each time interval. Immediately after exposure, the dish was removed and the temperature of the soil in the center bottom of the dish was recorded with a mercury thermometer. In a second series of treatments, 400cc of soil at 13% moisture were placed in 5-cm deep petri dishes. Microwaves were applied to uncovered soil samples.

Viability of nematodes was determined by placing treated and untreated samples in steam pasteurized soil in 4-inch pots. Tomato (*Lycopersicon esculentum*) seedlings were transplanted to each pot. After 8 weeks in a greenhouse at temperatures ranging from 16–25 C, the plants were harvested, and the roots were washed and observed for galls. A relative root-knot gall rating was determined for each plant as indicated in Table 1.

Within a few seconds exposure of soil

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TABLE 1. *Meloidogyne incognita* infection of tomatoes grown in soils exposed to 2450MHz, 1250 w for 0–300 sec.

Exposure (sec.)	Soil volume[a]			
	90cc		400 cc	
	C	RK index[b]	C	RK index
0 (Control)	Ambient	2.5	Ambient	2.0
15	72	1.0	49	1.0
30	88	0.0	80	0.0
45	90	0.0	97	0.0
60	90	0.0	96	0.0
300	92	0.0	116	0.0

[a] Mean of 5 replications.
[b] Relative root-knot index: 0 = no galls; 1 = slight to light; 2 = light to moderate; 3 = moderate to heavy; and 4 = heavy to severe galling.

to microwave energy, soil temperatures rose to levels lethal to the nematode. Microwave treatment substantially reduced root-knot nematodes at an exposure of 15 sec. Based on gall formation, the nematode was eliminated at all the longer exposure periods. A 300-second exposure resulted in complete drying of the soil in both series.

At this point it is not known whether the lethal effects were directly attributable to the microwaves, or to the lethal heating effects of microwave-energy action on the soil system. However, because of the high temperatures attained, we assume the lethal effect was due to the heating process.

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