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CONTROL OF *DITYLENCHUS DIPSACI*, *HETERODERA CAROTAE* AND *MELOIDOGYNE JAVANICA* BY SOLARIZATION

by
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Chemical control is usually very effective against nematodes, nevertheless it is expensive, requires special machinery and well trained personnel for application and may cause environmental pollution. Moreover, several nematicides have lately been banned, and therefore there is an urgent need for alternative control measures which are effective and safe. Heat has, for a long time, been used successfully to kill several soil borne plant parasites, but it is costly. Among heat sources solar energy is economical during the warm season in many countries. Katan (1981), Porter and Merriman (1983), Heald and Thomas (1983) and Raymundo and Alcazar (1984) demonstrated that mulching with transparent plastic film gave satisfactory control of fungi and nematodes. In Italy solar heating has been tested against fungi (Barone, 1980; Tamietti and Garibaldi, 1981) but no information is available on its effect on nematodes. Therefore three experiments were undertaken in 1984 in fields infested with *Ditylenchus dipsaci* (Kühn) Filipjev, *Heterodera carotae* Jones or *Meloidogyne javanica* (Treub) Chitw., respectively.

Materials and Methods

The experiments with *D. dipsaci* and *H. carotae* were established on a sandy soil (98% sand) at Margherita di Savoia (Province of

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Foggia). A field infested with 486 fourth stage juveniles of *D. dipsaci*/ 500 cm^3 of soil, was divided in 54 plots of 4 m^2 (2×2) m each, spaced 30 cm apart. The experimental design was a randomized block including six replications. Treatments consisted of mulching the plots with transparent polyethylene sheets 50 μm thick for 1, 2, 3, 4, 6 or 8 weeks. Controls were plots treated with 300 l/ha of DD on 26 June 1984 and untreated ones. To improve heat conductivity and interrupt nematode dormancy, the field was irrigated before covering the plots. Sampling was done from the central 1 m^2 of each plot at the beginning of the experiments, and then at the end of each mulching period from mulched plots and untreated ones. The plots treated with DD were sampled three weeks after the chemical was applied. Each soil sample was a composite of eighty cores from the top 30 cm soil, collected with a soil sampler of 1 cm diameter. The samples were processed by Coolen's (1979) method and the surviving nematodes counted and expressed as per cent of the numbers extracted from the same plots at the beginning of the experiment.

The experiment with *H. carotae* started one week later and was done in a field infested with 115 eggs/cm^3 of soil, using the same procedure. At the end of each mulching period the plots were uncovered and soil samples collected, from all plots, on 14 September. Four hundred cysts were extracted from wet soil samples by Fenwick can and incubated in carrot root leachate at 20°C for eight weeks, as described by Greco *et al.* (1982). Counts of emerging juveniles and renewal of the root leachate was done weekly. Totals of juveniles were then expressed as per cent of those emerged from cysts of untreated plots.

The effect of solarization on *M. javanica* was assessed at Torchiarolo (Province of Brindisi) in a sandy loam soil field infested with 1217 second stage juveniles of the nematode/500 cm^3 of soil. The field was divided in 54 plots of 8 m^2 (2×4) m each and the treatments established on 10 July. Experimental procedure was as for *D. dipsaci*. However, fumigated and untreated plots were irrigated on 30 July for easier sampling.

Soil temperatures at 10, 20 and 30 cm depth were recorded in covered and non covered plots at both localities. Data were statistically analyzed and comparison done with the Duncan's multiple range test.

Results

Temperature recorded at 10, 20 and 30 cm depth were much higher in solarized plots than in the controls. The highest average maximum temperature (Figs. 1-2) was recorded at 10 cm depth and never increased beyond 46°C at both localities. At 20 and 30 cm depth the temperatures were approximately 7 and 10°C less respectively. At Margherita di Savoia, because the experiments were initiated earlier, the soil temperature at 10 cm depth was maintained above 40°C for a longer time than at Torchiarolo.

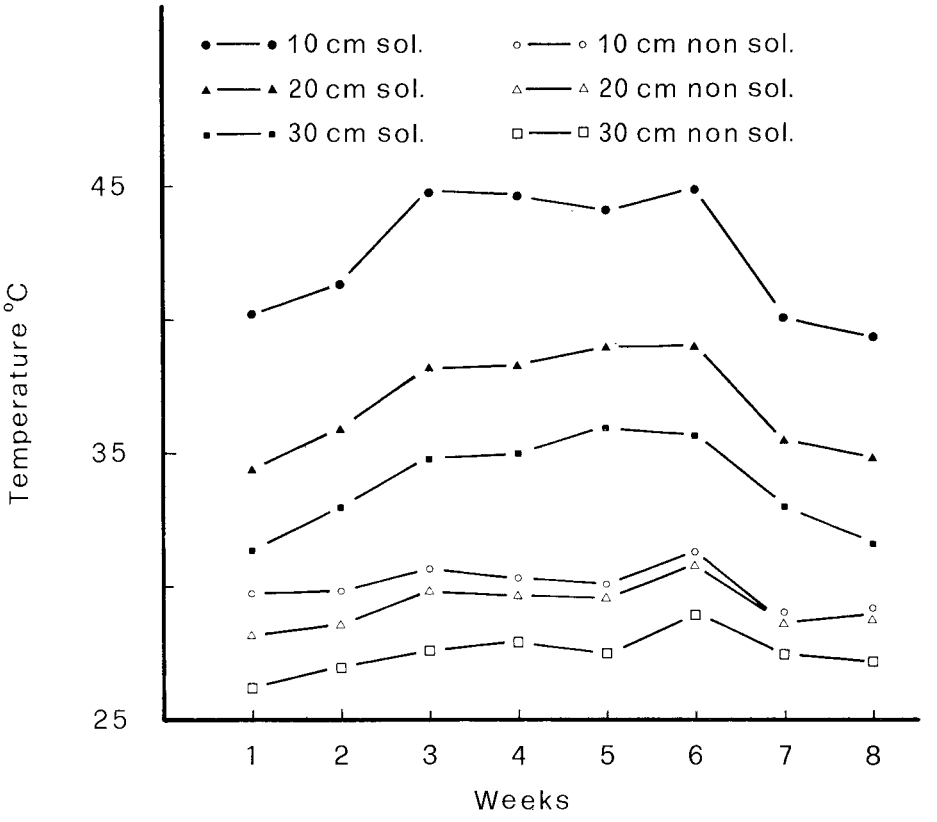

Fig. 1 - Mean maximum temperatures recorded at 10, 20 and 30 cm depth in solarized (sol.) and non solarized (non sol.) plots at Margherita di Savoia.

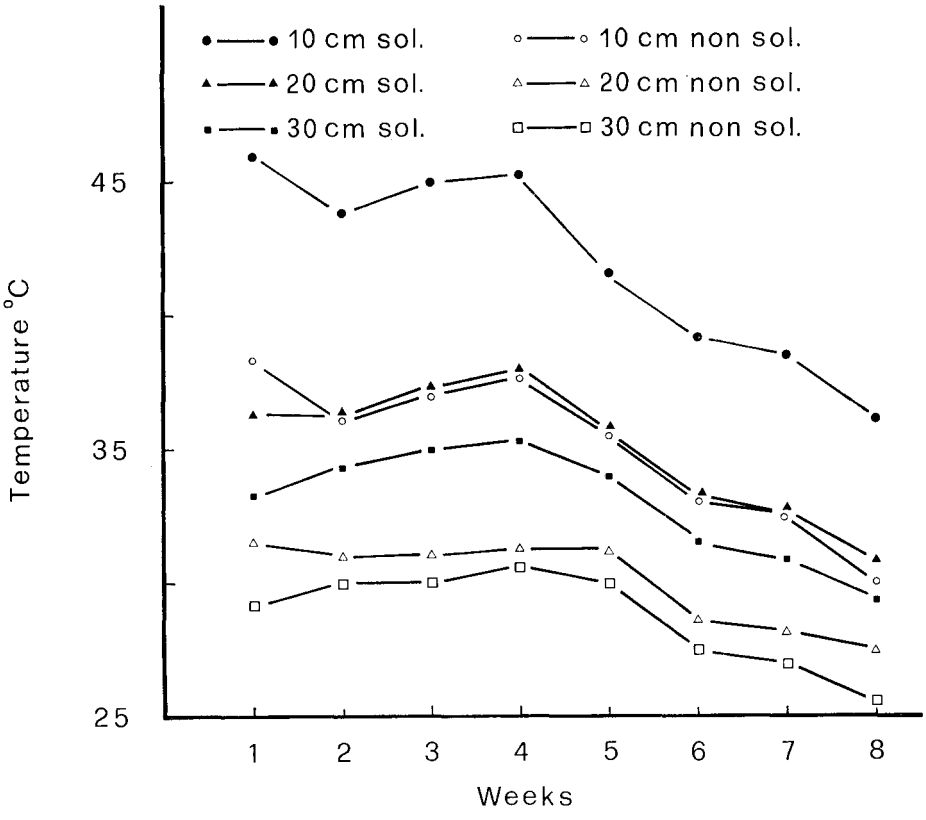

Fig. 2 - Mean maximum temperatures recorded at 10, 20 and 30 cm depth in solarized (sol.) and non solarized (non sol.) plots at Torchiarolo.

A marked decline of *D. dipsaci* populations was noticed in all plots solarized for two and more weeks and in those fumigated with DD (Tab. I). Although the percentage of the nematodes recovered from these plots was statistically similar, fewer nematodes were collected from the plots solarized for eight weeks than in those solarized for two or three weeks. The differences observed in the per cent *D. dipsaci* recovered from controls after three or eight weeks and from the plots solarized for 1 or 2 weeks also were not significant, but they did differ from plots treated with DD or solarized for a longer period.

Solarization also clearly affected the cysts of *H. carotae* and significantly fewer juveniles emerged from cysts of mulched and

Tab. I - *Effect of solarization by polyethylene mulching on* Ditylenchus dipsaci, Heterodera carotae *and* Meloidogyne javanica.

Treatments	% of nematodes recovered with respect to initial population		
	D. dipsaci	*H. carotae*	*M. javanica*
Mulching 1 week	173.6 a A	65.0 b B	88.0 b AB
» 2 »	72.0 bc ABC	51.1 bc B	95.5 b AB
» 3 »	34.0 c BC	59.0 bc B	164.0 a A
» 4 »	10.3 c BC	33.1 bc B	67.0 bc B
» 6 »	5.8 c BC	24.0 c BC	59.0 bc B
» 8 »	1.6 c C	38.0 bc B	21.0 c B
DD 300 l/ha	18.0 c BC	0.2 d C	12.5 c B
Control 3 weeks	175.0 a A	—	77.0 bc B
» 8 »	136.3 ab AB	100 a A	47.0 bc B

N. B. - Data flanked by the same letters are not statistically different from each other: small letters for P = 0.05, capital letter for P = 0.01.

fumigated plots (Table I). However, differences were not significant among the solarized plots but significantly more juveniles (24-65%) emerged from these plots than from those treated with DD (0.23%).

The results of the experiment on *M. javanica* were erratic (Table I). Most probably the irrigation of the non covered plots done after three weeks and the heavy rain which occured at the end of the investigation may have caused upward movement of the juveniles. In fact, in several plots, mainly controls, the final population of the nematode was larger than that recorded at the beginning of the experiment. Nevertheless a substantial decline of the root-knot nematode occurred and 67%, 59% and 21% of the initial population densities were recorded in the plots solarized for 4, 6 or 8 weeks, respectively, compared with 12.5% of those treated with DD and 77% and 47% of the controls after 3 or 8 weeks.

Discussion

Solarization has shown promise in controlling the three nematode types. It is noteworthy that against *D. dipsaci*, one of the most destructive plant parasitic nematodes, it was as effective as DD. Even though a few nematodes (6-8/500 cm^3 soil) still remained after 6 weeks, solarization would have greatly increased crop yields.

Heterodera carotae appeared less sensitive to higher temperatures and 24% of the eggs within the cysts were still viable. Nevertheless, polyethylene mulching could be of value in fields where population densities are below 20 eggs/cm^3 of soil.

The results obtained with *M. javanica* confirmed the small effect obtained by solarization, as reported by Rammah and Abbad (1984) with *Meloidogyne* sp. in Morocco. Further investigation is needed to test the feasibility of this method for the control of root-knot nematodes.

In their experiments on solarization Porter and Merriman (1983) found no *Pratylenchus penetrans* in the top 11 cm of soil after treatment, but little effect on nematode numbers at more than 24 cm depth. In our experiments soil samples were collected up to 30 cm depth and this may explain why many nematodes were present even after eight weeks of mulching. Moreover, the soil temperatures were well below 50°C as observed in Texas (Heald and Thomas, 1983) and Israel (Katan *et al.*, 1976). In 1984 summer temperatures were not very high and prolonged and in the solarized plots the temperature increase at 30 cm depth was only 4-5°C compared with the non solarized ones. Therefore we assume that the effectiveness of solarization could be improved in hotter summers and areas.

SUMMARY

Three field trials were done in 1984 to investigate the feasibility of solarization for the control of *Ditylenchus dipsaci, Heterodera carotae* and *Meloidogyne javanica* in southern Italy. Control of the first nematode with a 2-8 weeks mulching period was similar to that of 300 l/ha of DD and only 1.6% of the nematodes were found after 8 weeks. The hatching of *H. carotae* in solarized plots was 24-65% compared with 0.2% in the DD treatment. Although there was a substantial decline of *M. javanica* in the solarized plots, it was not significantly different from the DD treatment and control. Solarization is considered to be an additional and useful method for the control of plant parasitic nematodes particularly in warm climates.

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