tion period (18 August 1985) and again after harvest of the carrots (31 January 1986). Cysts from the first lot of soil samples were extracted from 200 cm^3 wet sub-samples with the Fenwick can, hand picked and incubated at 20 °C in root exudates of 30 day old carrots. Emerging juveniles were counted weekly and the hatching agent renewed at the same time. Total numbers of juveniles emerging from 350 cysts were expressed as per cent of those emerged from the same number of cysts of the non treated plots. Cysts from samples collected after the carrot harvest were extracted from 200 g air dried sub samples with the Fenwick can and then separeted from debris by the alcohol flotation method (Seinhorst, 1974), but substituting alcohol with a 1.25 sp. g. magnesium sulphate solution. Then the cysts were counted, crushed according to Bijloo's modified method (Seinhorst and Den Ouden, 1966) and the egg content estimated.

All plots were cultivated on 19 August 1985 and the carrot cultivar 92 was sown two days later. Plots were irrigated twice weekly until the start of the rain season in mid October. During the growing season normal agricultural practices were applied to the crop. At harvest (31 Jan-

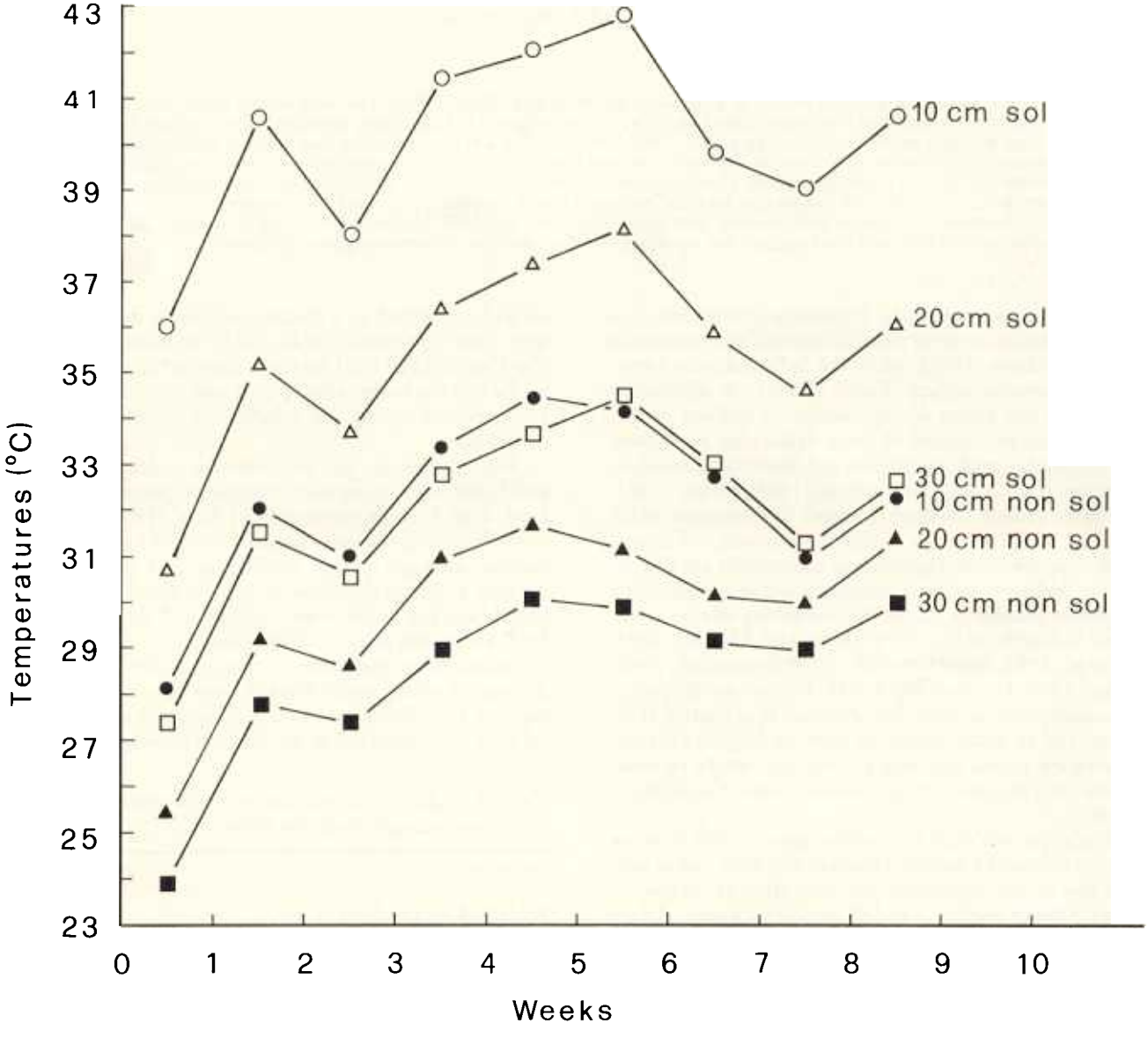

Fig. 1 - Mean maximum temperatures recorded at 10, 20 and 30 cm depth in solarized (sol) and non solarized (non sol) plots at Margherita di Savoia in June-August 1985.

uary, 1986) total plant, and total and marketable carrot tap root weight were recorded. Carrot feeder roots were also collected from each plot and *H. carotae* life stages were extracted from 3 g of these roots according to Coolen's method (Coolen, 1979).

In the experiment with *D. dipsaci*, soil samples were collected from all plots before solarization, before transplanting and after the harvest of the onions. Soil samples were also collected at the end of each solarization period from solarized and control plots, and before fumigation with DD from fumigated and control plots. Nematodes were extracted from 500 cm^3 soil samples according to Coolen's method (Coolen, 1979). The numbers of nematodes found after treatment were expressed as per cent of those present in the same plots before treatment. However, the numbers of nematodes recovered before transplanting onions were low and are not recorded here. Onion seedlings cv Bianca di maggio, free of nematodes, were transplanted on 13 November, 1985. They received normal crop maintenance practices throughout the growing season.

Plants showing symptoms of *D. dipsaci* attack were counted on 4 April 1986. At harvest (20 May, 1986) total plants, and total and marketable bulbs were weighed.

Soil temperatures at 10, 20, and 30 cm depth were recorded in non mulched and polyethylene mulched plots in an area near the experiments.

Results

Environmental conditions during the growing season were suitable for carrot and *H. carotae*, while the soil in the field infested with *D. dipsaci* was excessively wet from mid February to late March, which may have reduced nematode infestation and reproduction.

In the solarized plots mean soil temperatures at 10 cm depth increased to 38-44°C and remained at highest level for about two hours per day. Temperatures above 40°C are lethal to nematodes when maintained for several hours and, therefore, high mortality for both nematode species is likely to have occurred in the top 10 cm soil. At 20 cm depth soil temperature increased to 38°C during July-August. This temperature also damages nematodes if it persists for several days. At 30 cm depth the temperature reached 36°C but this represented an increase of only 3-4°C and therefore of less effect, especially on the cyst nematode.

The efficacy of soil solarization increased with the length of the mulching period and only 17.5% of *H. carotae* eggs survived in soil mulching for eight weeks (Table I). Aldicarb did not prevent infestation of carrot feeder roots by *H. carotae*, while SIP 5561 and soil solarization significantly suppressed infestation as did DD (Table II). There was a general increase in the number of *H. carotae* cysts after harvest, but the numbers of eggs declined significantly (Table III).

All treatments increased the yield of marketable carrots (Table II). However, the highest yield increase was obtained with DD, with double the yield of control plots. Significant yield increases were also obtained with SIP 5561 as single application and all solarization periods, the eight week period giving highest yield increase (Table II).

Results obtained with *D. dipsaci* were less satisfactory probably because of the low soil nematode infestation and of the adverse weather conditions during late winter and early spring. The lowest percentages of plant showing symptoms of nematode attack were in the plots treated with aldicarb, single application of SIP 5561 or solarized for eight weeks but these were not significantly different from the control (Table IV). The nematode soil population densities estimated after harvest of onions showed a similar pattern (Table IV). Yield of onions increased in all treated plots, except in those treated with a split application of SIP 5561, but the increase was significant ($P < 0.05$) only in plots treated with a single application of aldicarb (Table IV). The yield increases in the solarized plots ranged from 18 to 50%.

Discussion and conclusion

The results demonstrated that SIP 5561 is more effective than aldicarb in preventing the invasion of carrot feeder roots by *H. carotae* (Table II). This may be due to longer persistence of SIP 5561 but this was not tested. The better performance of SIP 5561 against *H. carotae* was confirmed by the higher yield increase obtained with this chemical than with aldicarb. Control of *D. dipsaci*, however, was equally effective with a single application of either chemicals, but when the application was split, aldicarb was more effective than SIP 5561 (Table IV).

The experiment with *H. carotae* confirms that soil solarization provides effective control of this nematode in

TABLE II - *Effect of nematicides and soil solarization on the infestation of carrot feeder roots by* Heterodera carotae *and on the yield of marketable carrots.*

Treatments	Nematodes/3g feeder roots	Yield (kg/m^2)
SIP 5561 10 kg a.i./ha	396 c	4.0 bcd
» 5+5 » »	122 c	3.5 cdef
Polyethylene mulching 4 wk	808 b	3.8 bcde
» » 6 »	406 bc	4.4 bc
» » 8 »	209 c	4.6 b
DD 300 l/ha	157 c	5.5 a
Aldicarb 10 kg a.i./ha	1.215	3.0 ef
» 5+5 » »	1.484 a	3.1 def
Untreated	1.278 a	2.6 f

Figures in each column followed by the same letter are not significantly different for $P < 0.05$ according to Duncan multiple range test.

Italy. DD gave the highest yield increase, but this does not differ significantly ($P < 0.05$) from the increased yield in the eight week polyethylene mulching treatment. In our experiment low soil population densities of *D. dipsaci*, toghether with unfavorable weather condition, limited the differences in yield between treatments.

Siti *et al.* (1982) obtained impressive control of *D. dipsaci* and increase in the yield of garlic by soil solarization and therefore more investigations are required to ascertain its effect on *D. dipsaci* and onion yield.

In a previous study (Greco *et al.*, 1985) it was postulated that good control of *H. carotae* can be achieved by soil solarization when population densities of the nematode do not exceed 20 eggs/g soil. Our experiments confirm this but also demonstrate that soil solarization would have little effect on nematodes present at more than 25-30 cm depth. Therefore to improve nematode control in the deeper soil profiles, the combination of a low rate of fumigant applications injected 30-35 cm deep and soil solarization is suggested.

The experiment with *H. carotae* has also confirmed that in the soil, the numbers of eggs of the nematode contained within cysts may greatly decline even in control plots when carrots are harvested before the nematode has produced new cysts.

We wish to thank Mr. P. De Cosmis for technical assistance.

TABLE III - *Effect of nematicides and soil solarization on the number of cysts and eggs of* Heterodera carotae *in the soil.*

Treatments	Cysts/200 g soil		Eggs/g soil	
	Before treating	After harvest	Before treating	After harvest
SIP 5561 10 kg a.i./ha				8**
» 5 + 5 » »				8**
Polythylene mulching 4 wk				14**
» » 6 »				13**
» » 8 »				17**
DD 300 l/ha				21 n.s.
Aldicarb 10 kg a.i./ha				11**
» 5 + 5 » »				11*
Untreated				10**

Figures of nematode counts after harvest, flanked by * and **, are significantly different from those before treating according to *t* test. * for $P < 0.05$ and ** for $P < 0.01$; n.s. = not significant.

TABLE IV - *Effect of nematicides and soil solarization on the per cent of onions showing symptoms of* Ditylenchus dipsaci *attack, on the nematode population at harvest, and on the yield of marketable onion bulbs.*

Treatments	% plants showing symptoms	Nematodes /500 cm³ soil	Yield (kg bulbs/m²)
SIP 5561 10 kg a.i./ha	3 b	0 a	2.1 ab
» 5 + 5 » »	37 a	201 a	1.6 b
Polyethylene mulching 4 wk	19 ab	316 a	1.9 ab
» » 6 »	13 ab	211 a	2.4 ab
» » 8 »	6 b	10 a	2.2 ab
DD 300 l/ha	20 ab	306 a	2.0 ab
Aldicarb 10 kg a.i./ha	2 b	11 a	2.6 a
» 5 + 5 » »	4 b	12 a	1.9 ab
Untreated	24 ab	323 a	1.6 b

Figures in each column followed by the same letter are not significantly different for $P < 0.05$ according to Duncan multiple range

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