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MANAGEMENT OF ROOT-KNOT NEMATODES BY COMBINATION OF SOIL SOLARIZATION AND FENAMIPHOS IN SOUTHERN ITALY

by
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Summary. In a three year experiment carried out during 1995-1997 in southern Italy, four or eight weeks of soil solarization failed to increase lettuce yields in fields infested with *Meloidogyne incognita* at Castellaneta (Taranto) and Monteroni (Lecce). At Castellaneta, concomitant application of fenamiphos and four weeks of solarization and fenamiphos after four weeks of solarization increased lettuce yield as did fenamiphos applied at the end of eight weeks of solarization or as single application, just before planting. All combinations of fenamiphos and solarization increased yield of the following crop, cantaloupe, which was also increased by application of 1,3 D in April. All treatments significantly suppressed the root gall index on both crops. At Monteroni, data on both crops, lettuce and tobacco, were erratic and did not provide clear information on yields nor on root gall indices. However, correlations between soil solarization or application of fenamiphos, alone or in combination, and yields or root gall indices clearly showed that soil solarization might be a good practice for the management of root-knot nematodes.

Soil solarization alone or in combination with reduced rates of fungicides or nematicides has been suggested as an alternative to methyl bromide for the control of soilborne pathogens and pests affecting vegetable crops (Lamberti *et al.*, 1998; DeVay and Stapleton, 1998).

To evaluate the effect of soil solarization combined with the granular formulation of the systemic organophosphate nematicide fenamiphos, two trials of nematode control were carried out in southern Italy in the years 1995-1997.

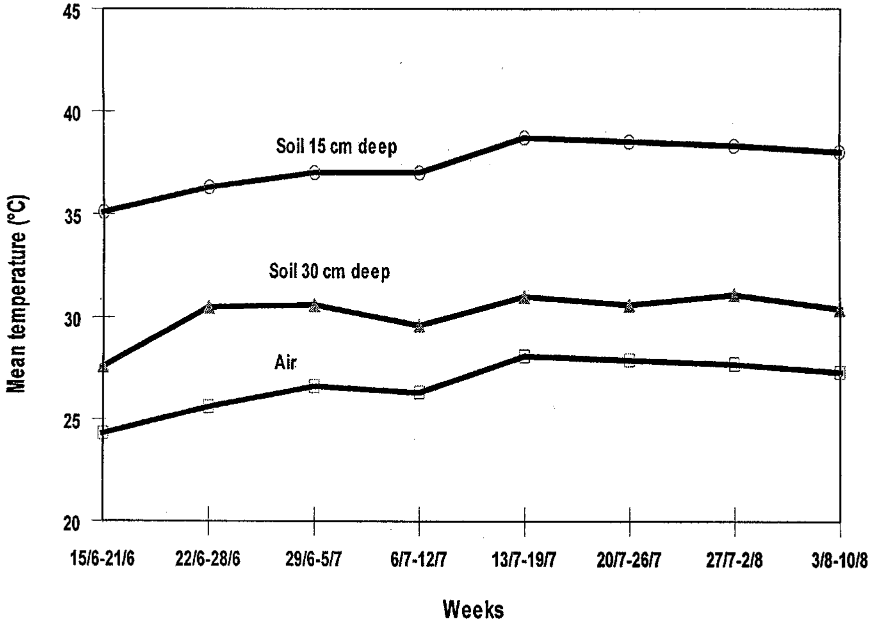
Materials and methods

The first trial was undertaken in June 1995, in a field infested with *Meloidogyne incognita* (Kofoid *et* White) Chitw. at Castellaneta, in the Province of Taranto. The soil was a sandy loam and was ploughed to 30 cm and rotary cultivated. The field was subdivided into 3.5x3.5 m plots, spaced at 1 m from each other.

Soil solarization was performed for either four or eight weeks by covering the soil with a 0.040 mm thick polyethylene film from 1 June to 12 July or 10 August. Temperatures occurring during this period are reported in Fig. 1A.

Granular fenamiphos, at 5% active ingredient, was broadcast on the plot surface and incorporated into the soil to a depth of 15-20 cm by rotary cultivation. It was applied simultaneously (8 June) or soon after soil solarization (13 July or 11 August) or before planting the first (30 August) or the second (20 May 1996) crop, according to the scheme indicated in Table I.

1,3 dichloropropene 97% (1,3 D) was applied by injector gun in holes spaced at 30 cm apart and at a depth of 15 cm on 10 August, 1995 or on 10 April, 1996, before planting either the first or the second crop. Each treatment was



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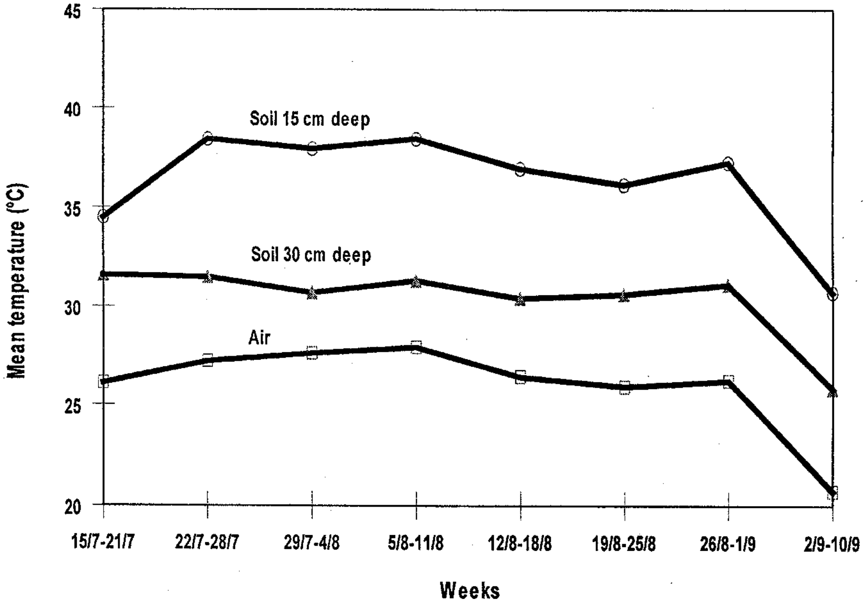

B

Fig. 1 - Temperatures recorded during the solarization period: A), in 1995 at Castellaneta; B), in 1996 at Monteroni.

TABLE I - *Treatments and cropping schedule and results of the trial at Castellaneta.*

Lettuce (June - December 1995)										Cantaloupe (April - September 1996)							
Chemical	Rate/ha	Date of application	Soil solarization period	Yield (kg/plot)			Root gall index			Chemical	Rate/ha	Date of application	Yield (kg/plot)			Root gall index	
Control				33.7	abc	ABC	1.1	ab	A				28.9	a	A	3.6	a	BA
				40.5	abcd	ABCD	1.4	ab	A	Fenamiphos	5 kg a.i.	20 May	39.4	abc	ABC	2.8	b	B
				30.8	a	B	1.2	ab	A	Fenamiphos	10 kg a.i.	20 May	56.6	ef	CD	1.8	efgh	DEFGH
				34.0	abc	ABC	1.5	a	A	Fenamiphos	15 kg a.i.	20 May	62.3	f	D	1.4	ghijkl	FGHIJ
			15 June-12 July	46.0	cde	ABCD	0.5	c	B				37.1	ab	AB	2.5	bc	BC
Fenamiphos	5 kg a.i.	8 June	15 June-12 July	48.3	de	BCD	0.2	cd	B				48.8	bcde	BCD	2.4	bcd	BCD
Fenamiphos	10 kg a.i.	8 June	15 June-12 July	48.7	de	CD	0.1	d	B				50.8	cde	BCD	2.1	cde	CDE
Fenamiphos	15 kg a.i.	8 June	15 June-12 July	50.2	de	CD	0.0	d	B				49.9	bcdef	BCD	1.4	ghijk	FGHIJ
Fenamiphos	5 kg a.i.	13 July	15 June-12 July	43.5	abcde	ABCD	0.0	d	B				41.9	bcd	ABC	2.0	def	CDEF
Fenamiphos	10 kg a.i.	13 July	15 June-12 July	49.7	de	CD	0.1	d	B				46.9	bcde	BCD	1.9	def	CDEFG
Fenamiphos	15 kg a.i.	13 July	15 June-12 July	48.8	de	CD	0.2	cd	B				53.4	def	BCD	1.3	hijklm	GHIJ
			15 June-10 August	42.5	abcd	ABCD	0.3	cd	B				47.0	bcde	BCD	1.8	efg	EFG
Fenamiphos	5 kg a.i.	8 June	15 June-10 August	44.7	bcde	ABCD	0.2	cd	B				46.6	bcde	BCD	1.6	fghi	EFGHI
Fenamiphos	10 kg a.i.	8 June	15 June-10 August	43.2	abcde	ABCD	0.1	d	B				56.3	ef	CD	1.6	fghi	EFGHI
Fenamiphos	15 kg a.i.	8 June	15 June-10 August	46.0	cde	ABCD	0.1	d	B				54.2	def	BCD	1.0	jklmn	IJK
Fenamiphos	5 kg a.i.	11 August	15 June-10 August	51.8	de	D	0.0	d	B				44.4	bcde	ABC	1.4	ghij	FGHIJ
Fenamiphos	10 kg a.i.	11 August	15 June-10 August	55.3	e	D	0.0	d	B				51.1	cde	BCD	1.0	jklmn	IJK
Fenamiphos	15 kg a.i.	11 August	15 June-10 August	50.7	de	D	0.1	d	B				52.8	cdef	BCD	0.7	n	K
Fenamiphos	15 kg a.i.	30 August		49.5	de	CD	0.3	cd	B				53.8	def	BCD	1.2	ijklmn	HIJK
1,3 D 97	150 l	10 August		44.7	bcde	ABCD	0.1	c	B				46.3	bcde	ABCD	1.6	fghi	EFGHI
				32.0	ab	AB	1.0	b	A	1,3 D 97	150 l	10 April	54.1	def	BCD	0.9	klmn	JK

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replicated six times and six untreated plots served as control.

Lettuce (*Lactuca sativa* L.) cv. Bounty was planted on 31 August with 30 day old seedlings, $6/m^2$, separated from each other by 30 cm in the row and 50 cm between rows. Harvest was done as the plants ripened, during the period 15-24 November. Plants were uprooted on 6 December and gall index on the roots evaluated according to a scale between 0 and 5 where 0 represents no galling and 5 is a root system completely deformed by large galls on the primary roots.

In the following spring, the plot layout was used without change and after soil cultivation 30 day old seedlings of cantaloupe (*Cucumis melo* L.) cv. Gallant, 15 plant/plot spaced each other 0.5x1 m, were planted on 23 May 1996.

Fruits were harvested four times between 1 and 23 August. Root galling was determined on 9 September.

A similar experiment was carried out in 1996-1997 at Monteroni, in the Province of Lecce on a sandy loam soil also infested by *M. incognita*. Plots measured 3x2 m with 1 m interspace. Soil solarization took place from 15 July to 11 August (four weeks) and to 10 September (eight weeks). The temperature occurring during this period is indicated in Fig. 1B. Fenamiphos was applied simultaneously with soil solarization (9 July) or just before planting the first crop (12 September); it was broadcast, in a 30 cm wide band along the row or at the planting sites (Table II), in the two latter cases saving about 50% of the chemical. 1,3 D was injected into the soil on 9 August 1996, before the first crop, or on 27 March, 1997 before the second crop. Each treatment was replicated six times. Lettuce cv. Romanella, was planted on 13 September, spacing the seedlings as previously indicated. Harvest took place between 17 December, 1996 and 20 January, 1997. Root gall index was determined on 25 January.

On 23 April, 40 day old seedlings of oriental tobacco (*Nicotiana tabacum* L.) cv. Erzegovina 6B were planted in the same plots, 60/plot,

TABLE II - *Treatments and cropping schedule and results of the trial at Monteroni.*

Lettuce (July 1996-January 1997)						Tobacco (March-August 1997)				
Chemical	Rate/ha	Date of application	Soil solarization period	Yield (kg/plot)	Root gall index	Chemical	Rate/ha	Date of application	Yield (kg/plot)	Root gall index
Control				12.8 abc AB	2.3 a A				1.4 abc	2.7 a
Fenamiphos	5 kg a.i.	12 September		14.1 abcde AB	1.9 abc AB				1.5 abc	2.4 abc
Fenamiphos	10 kg a.i.	12 September		13.3 abcd AB	1.7 abc AB				1.7 abc	1.9 abc
Fenamiphos	15 kg a.i.	12 September		13.4 abcd AB	1.9 abc AB				1.5 abc	2.0 abc
			15 July-11 August	15.1 abcde AB	2.0 ab AB				1.8 abc	2.4 abc
Fenamiphos	5 kg a.i.	9 July	15 July-11 August	14.3 abcde AB	1.5 abc AB				1.9 abc	2.5 ab
Fenamiphos	10 kg a.i.	9 July	15 July-11 August	14.9 abcde AB	1.5 abc AB				2.0 bc	2.0 abc
Fenamiphos	15 kg a.i.	9 July	15 July-11 August	14.9 abcde AB	1.6 abc AB				1.8 abc	1.9 abc
Fenamiphos	5 kg a.i.	12 September	15 July-11 August	15.6 abcde AB	1.7 abc AB				1.6 abc	1.9 abc
Fenamiphos	10 kg a.i.	12 September	15 July-11 August	13.8 abcde AB	1.4 bc AB				2.1 c	1.8 abc
Fenamiphos	15 kg a.i.	12 September	15 July-11 August	13.8 abcde AB	1.0 c B				2.1 c	1.4 c
			15 July-10 September	15.9 abcde AB	1.8 abc AB				2.0 bc	2.2 abc
Fenamiphos	5 kg a.i.	9 July	15 July-10 September	17.6 e B	1.6 abc AB				1.8 abc	1.6 bc
Fenamiphos	10 kg a.i.	9 July	15 July-10 September	15.4 abcde AB	1.5 abc AB				1.8 abc	1.6 bc
Fenamiphos	15 kg a.i.	9 July	15 July-10 September	17.1 de AB	1.2 bc AB				1.8 abc	1.5 bc
Fenamiphos	5 kg a.i.	12 September	15 July-10 September	14.8 abcde AB	1.0 c B				2.0 bc	1.8 a
Fenamiphos	10 kg a.i.	12 September	15 July-10 September	16.8 cde AB	1.2 bc AB				1.8 abc	1.6 bc
Fenamiphos	15 kg a.i.	12 September	15 July-10 September	16.5 cde AB	1.3 bc AB				1.9 abc	1.6 bc
Fenamiphos	7.5 kg a.i. on bands	12 September		14.5 abcde AB	2.0 ab AB				1.5 abc	1.9 abc
Fenamiphos	7.5 kg a.i. at plant. site	12 September		13.4 abcd AB	2.0 ab AB				1.7 abc	1.6 bc
Fenamiphos	2.5 kg a.i. on bands	12 September	15 July-10 September	15.1 abcde AB	1.9 abc AB				1.2 a	2.3 abc
Fenamiphos	2.5 kg a.i. at plant. site	12 September	15 July-10 September	12.1 a A	1.7 abc AB				1.3 ab	1.8 abc
1,3 D 97	150 l	9 August		15.3 abcde AB	1.5 abc AB				1.6 abc	2.0 abc
				12.6 ab AB	1.7 abc AB	1,3 D 97	150 l	27 March	1.9 abc	2.4 abc

Data flanked on the columns by the same letters are not statistically different according to Duncan's multiple range test (small letters for P = 0.05; capital letters for P = 0.01).

spaced at 15 cm in the row and 55 cm between the rows. Leaves were harvested between 25 June and 29 July. Weights of air dried leaves were also determined. Root galling was evaluated on 2 August.

All data were processed statistically by Duncan's Multiple Range Test; correlations between treatments and either yields or gall indices were also calculated.

Results

Soil temperatures recorded at Castellaneta during the solarization period in summer 1994 were never below 35 °C and did not exceed 40 °C at 15 cm of depth (Fig. 1A).

Four or eight weeks of soil solarization did not significantly increase the lettuce yield with respect to the control (Table I). The application of fenamiphos at 15 kg a.i./ha, just before planting, without any previous treatment, statistically increased the lettuce yield, as did its simultaneous application, at all rates, with four weeks solarization or its application at 10 or 15 kg/ha at the end of four weeks solarization. Fenamiphos at all rates of application did not increase lettuce yield, compared to the control, when applied simultaneously with eight weeks solarization, but was statistically effective when applied at the end of eight weeks solarization. Application of 1,3 D did not statistically increase lettuce yield compared to the control.

All treatments significantly reduced the lettuce root gall index compared to the control; however, the reduction was statistically less on the root systems of plants grown in solarized plots which received no chemical treatment (Table I).

There was a statistically significant positive correlation between duration of soil solarization combined with 5 or 10 kg a.i./ha of fenamiphos applied after completion of solarization and lettuce yield (Fig. 2) and between fenamiphos rates applied simultaneously with four weeks of soil solarization and lettuce yield (Fig. 3). Conversely, there was a statistically significant negative correlation between the duration of soil solarization alone and with 10 or 15 kg/ha of fenamiphos applied after completion of solarization and root gall index (Fig. 4) and between fenamiphos rates of application simultaneously with four or eight weeks of solarization (Fig. 5).

In the following cantaloupe crop planted at Castellaneta in 1996, yields were significantly increased after eight weeks, but not after four weeks soil solarization (Table I). All treatments, except 5 kg a.i./ha of fenamiphos as a single application or after completion of four weeks solarization, statistically increased cantaloupe yield, but differences between treatments were not significant (Table I), including 1,3 D applied either in August 1995 or April 1996. Fenamiphos at 15 kg a.i./ha, as single application just before planting, gave the highest yield. Root gall indices of all treatments were statistically suppressed compared to the control, with a decreasing trend dependent on the highest doses of fenamiphos and the spring application of 1,3 D (Table I).

There were statistically significant positive correlations between the duration of solarization, alone or with 5 kg a.i./ha of fenamiphos applied after completion of solarization, and cantaloupe yield (Fig. 6) and rates of fenamiphos, as single application, just before the second crop and after or simultaneously with four weeks solarization and cantaloupe yield (Fig. 7).

Statistically significant negative correlations were observed between duration of solariza-

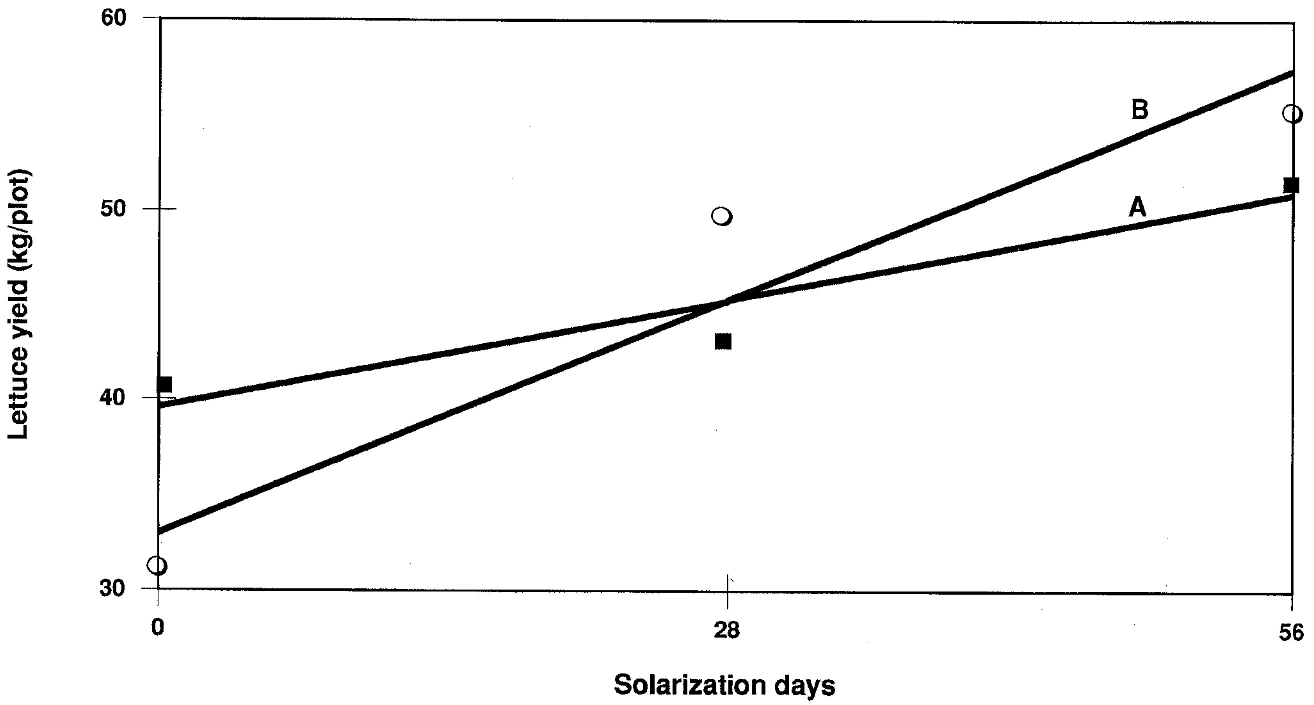

Fig. 2 - Correlation between soil solarization duration and yield of lettuce at Castellaneta: A, ■ solarization + 5 kg a.i./ha fenamiphos applied at completion of solarization ($y = a + bx$; a = 36.92; b = 0.202; r^2 = 0.932; P = 0.01); B, ❍ solarization + 10 kg a.i./ha fenamiphos applied at completion of solarization ($y = a + bx$; a = 33.02; b = 0.437; r^2 = 0.910; P = 0.01).

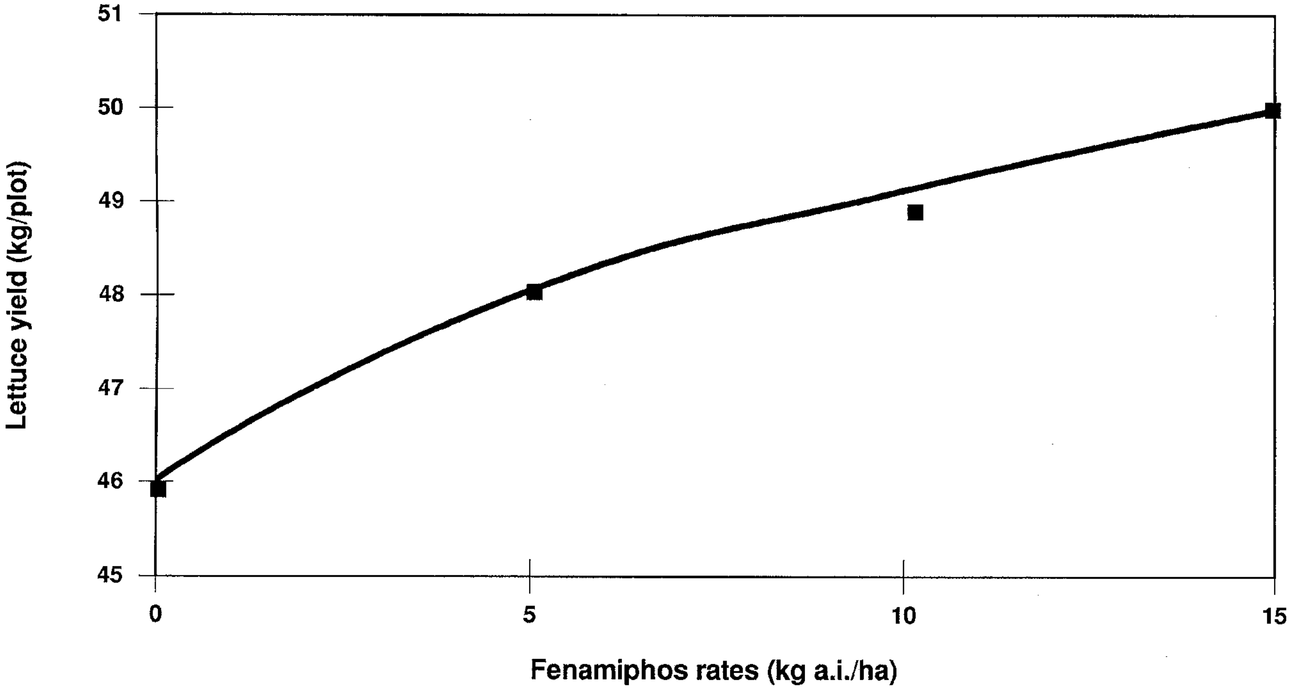

Fig. 3 - Correlation between rate of fenamiphos applied simultaneously with 4 wk solarization and yield of lettuce at Castellaneta ■ ($y = a + bx^c$; a = 42.62; b = 0.038; c = 0.747; r^2 = 0.969; P = 0.01).

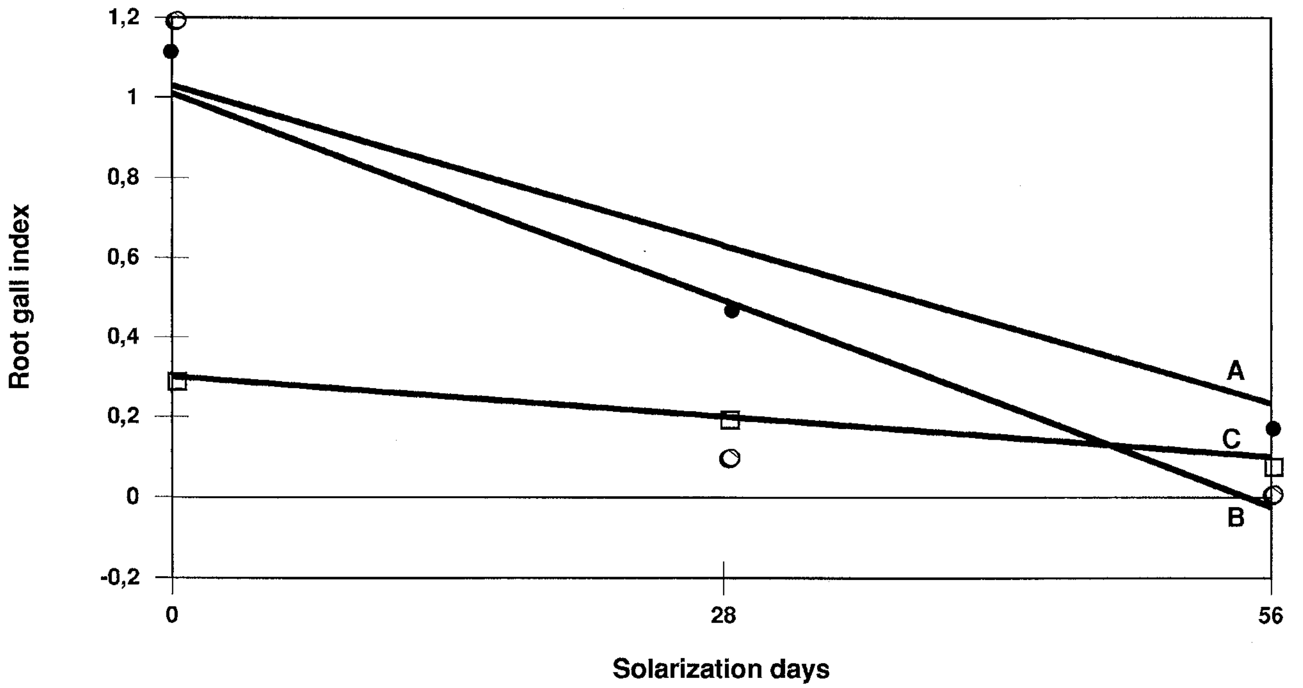

Fig. 4 - Correlation between soil solarization duration and root gall index of lettuce at Castellaneta: A, ● solarization alone ($y = a + bx$; a = 1.3; b = -0.0143; r^2 = -0.923; P = 0.01); B, ○ solarization + 10 kg a.i./ha fenamiphos applied at completion of solarization ($y = a + bx$; a = 1.033; b = -0.021; r^2 = -0.812; P = 0.01); C, □ solarization + 15 kg a.i./ha fenamiphos applied at completion of solarization ($y = a + bx$; a = 0.3; b = -0.00357; r^2 = -1.00; P = 0.01).

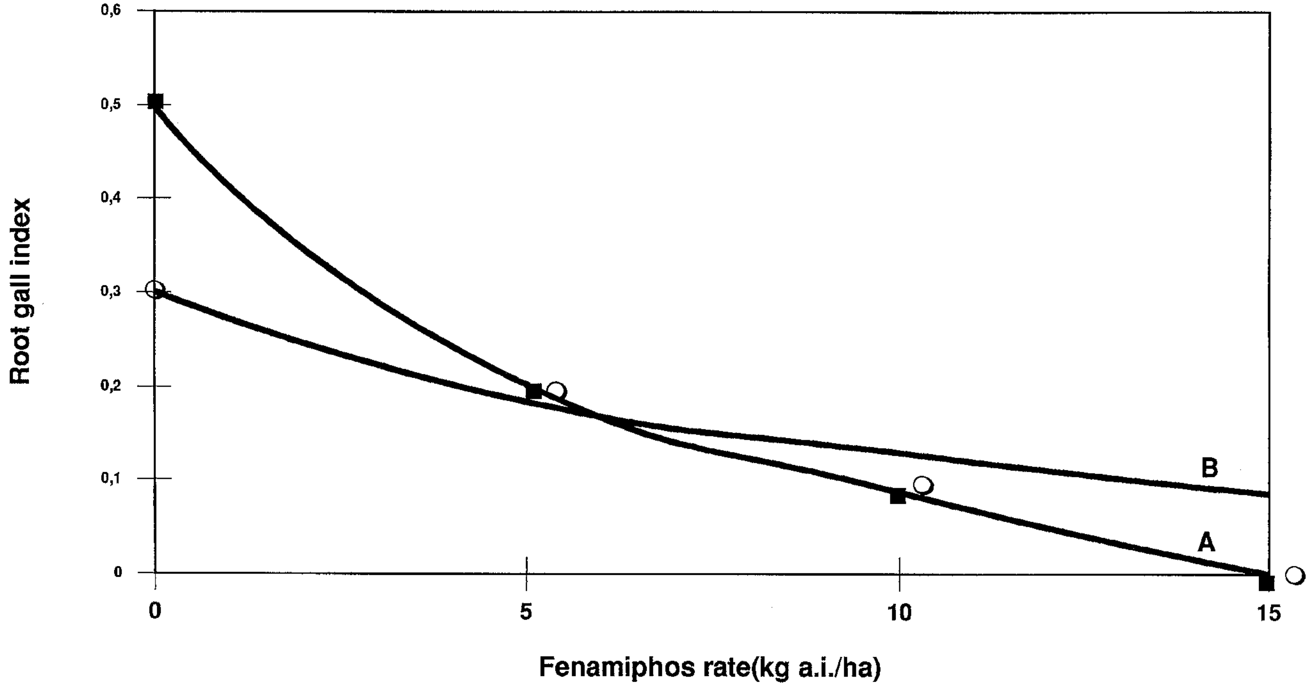

Fig. 5 - Correlation between rate of fenamiphos and root gall index of lettuce at Castellaneta: A, ■ fenamiphos applied simultaneously with 4 week solarization (y = a + bx^c; a = 0.499; b = -0.034; c = 0.471; r^2 = -0.999; P = 0.01); B, ❍ fenamiphos applied simultaneously with 8 wk solarization (y = a + bx^c; a = 0.301; b = -0.0090; c = 0.557; r^2 = -0.952; P = 0.01).

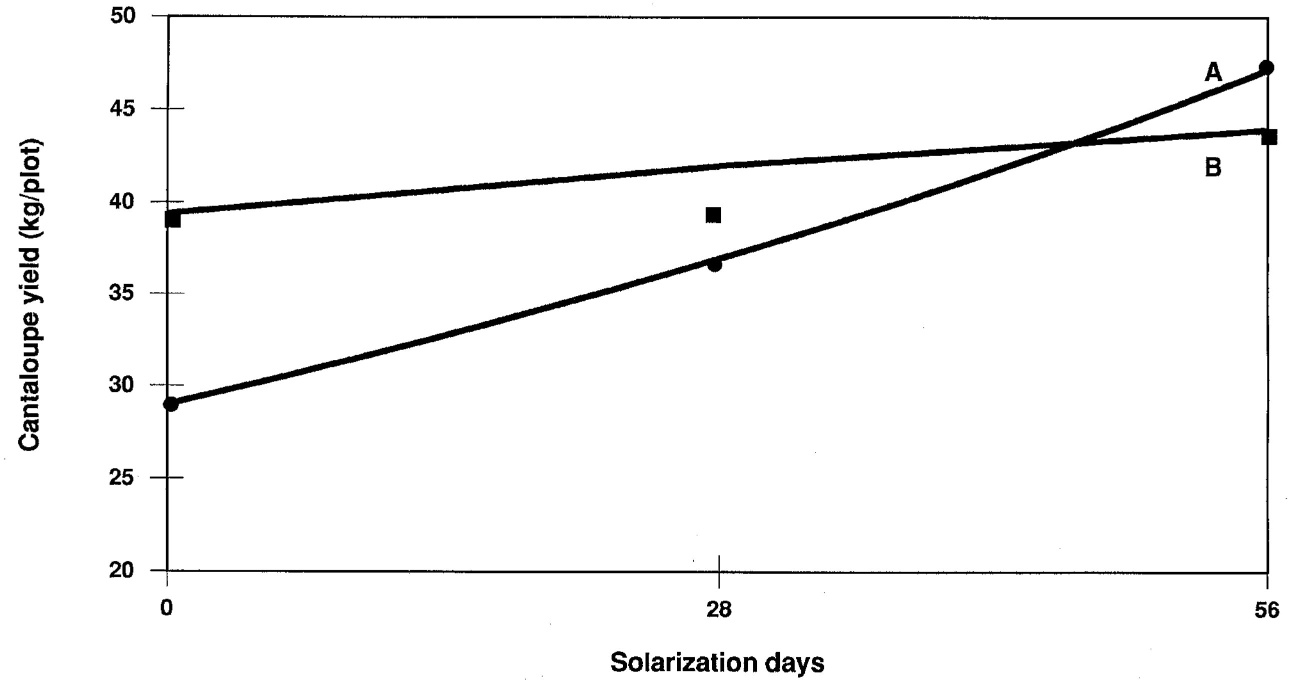

Fig. 6 - Correlation between soil solarization duration and yield of cantaloupe at Castellaneta: A, ● solarization alone (y = a + bx; a = 28.7; b = 0.321; r^2 = 0.997; P = 0.01); B, ■ solarization + 5 kg a.i./ha fenamiphos applied at completion of solarization (y = a + bx; a = 39.50; b = 0.082; r^2 = 0.999; P = 0.01).

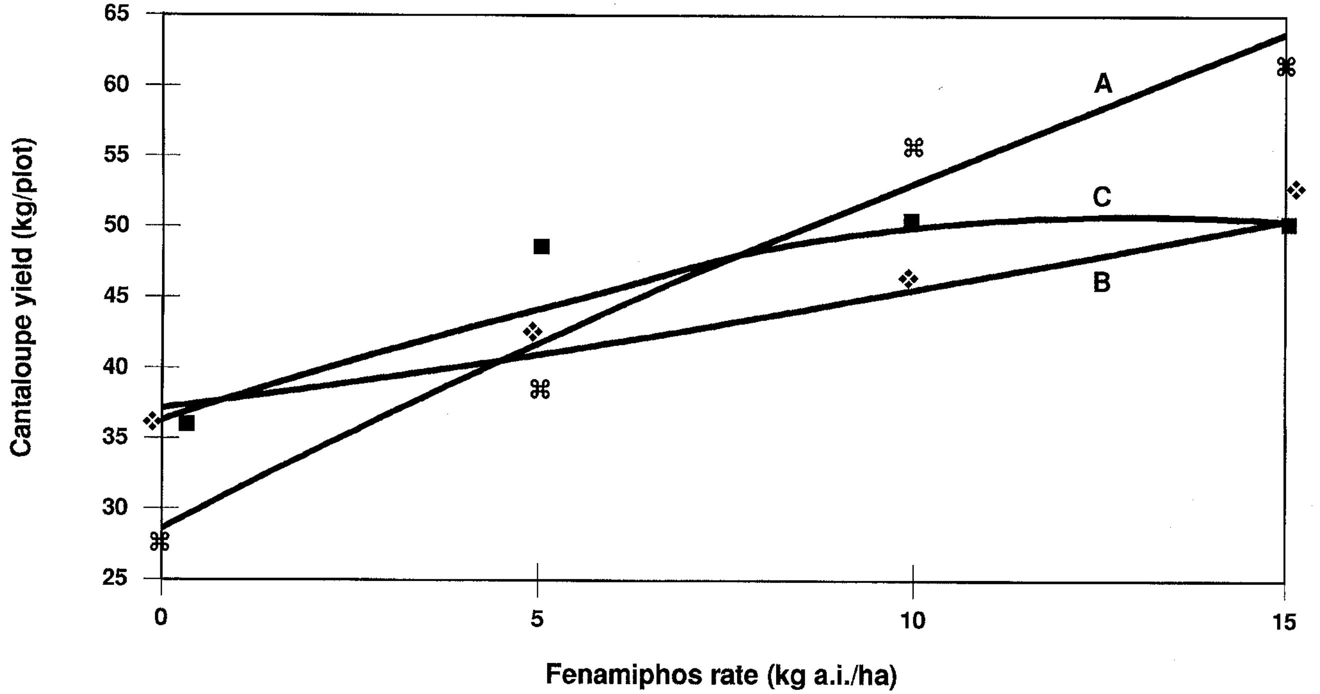

Fig. 7 - Correlation between rate of fenamiphos and yield of cantaloupe at Castellaneta: A, ⌘ fenamiphos only, applied just before planting cantaloupe ($y = a + bx^c$; a = 28.56; b = 0.216; c = 0.893; r^2 = 0.971; P = 0.01); B, ❖ fenamiphos applied at completion of 4 wk solarization ($y = a + bx^c$; a = 37.16; b = 0.02; c = 1.14; r^2 = 0.998; P = 0.01); C, ■ fenamiphos applied simultaneously with 4 wk solarization ($y = a + bx^c$; a = 36.32; b = 8.59; c = 0.087; r^2 = 0.99; P = 0.01).

tion, alone or with 5 kg a.i./ha fenamiphos, applied at completion of solarization or simultaneously, and root gall index of cantaloupe (Fig. 8) and between rates of fenamiphos, applied before planting and at completion of solarization or simultaneously with four or eight weeks solarization and root gall index (Fig. 9).

During the solarization period in summer 1996 at Monteroni, soil temperature at 15 cm depth never exceeded 37 °C and dropped only slightly below 35 °C in the last week (Fig. 1B).

Fenamiphos, applied at the rate of 5 or 15 kg a.i./ha simultaneously with eight weeks solarization statistically increased lettuce yield (Table II); applications of fenamiphos just before planting and after four or eight weeks solarization, or simultaneously with eight weeks solarization, significantly reduced the root gall index of lettuce.

No statistically significant differences occurred among fresh weights of leaves of tobacco (data omitted). Some statistical difference with respect to the control were noted among the air dried leaf weights, in which applications of fenamiphos at the rate of 10 kg a.i./ha simultaneously with four weeks solarization, at the rate of 10 or 15 kg a.i./ha, in the previous September, after four weeks solarization or at the rate of 5 kg a.i./ha after eight weeks solarization significantly increased yields, as did eight weeks of solarization alone.

A significant reduction in the root gall index of tobacco was achieved in the plots treated with 15 kg a.i./ha of fenamiphos in the previous September, after four weeks solarization or with any dose of fenamiphos applied simultaneously with eight weeks solarization (Table II).

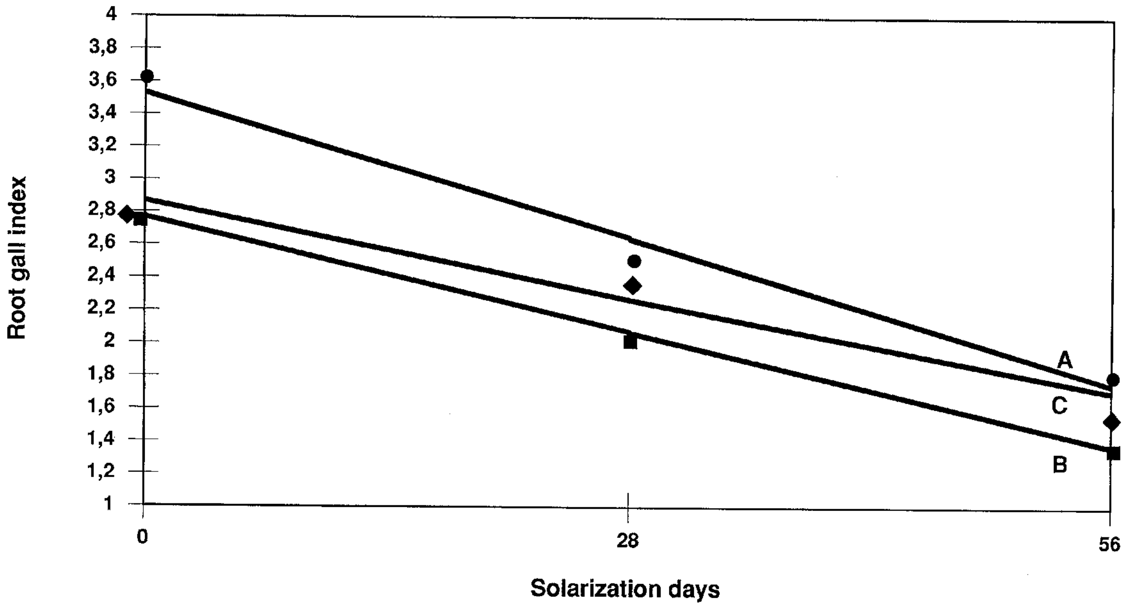

Fig. 8 - Correlation between soil solarization duration and root gall index of cantaloupe at Castellaneta; A, ● solarization alone (y = a + bx; a = 3.53; b = -0.032; r^2 = -0.984; P = 0.01); B, ■ solarization + 5 kg a.i./ha fenamiphos applied at completion of solarization (y = a + bx; a = 2.77; b = -0.025; r^2 = 0.993; P = 0.01); C, ◆ solarization + 5 kg a.i./ha fenamiphos applied simultaneously (y = a + bx; a = 2.87; b = -0.021; r^2 = -0.964; P = 0.01).

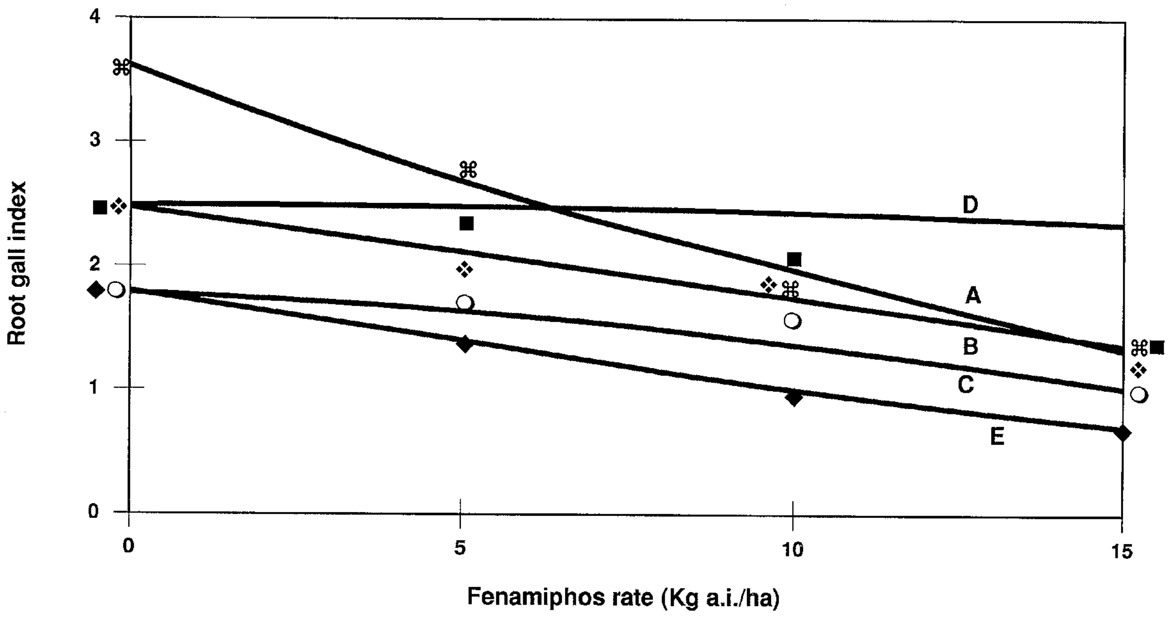

Fig. 9 - Correlation between rate of fenamiphos and root gall index of cantaloupe at Castellaneta: A, ⌘ fenamiphos only, applied just before planting cantaloupe ($y = a + bx^c$; a = 3.618; b = -0.0211; c = 0.822; r^2 = -0.983; P = 0.01); B, ❖ fenamiphos applied at completion of 4 wk solarization ($y = a + bx^c$; a = 2.47; b = -0.03; c = 1.35; r^2 = -0.941; P = 0.01); C, ◆ fenamiphos applied at completion of 8 wk solarization ($y = a + bx^c$; a = 1.79; b = -0.001; c = 1.49; r^2 = -0.998; P = 0.01); D, ■ fenamiphos applied simultaneously with 4 week solarization ($y = a + bx^c$; a = 2.49; b = -9.6^{-7}; c = 2.443; r^2 = -0.999; P = 0.01); E, ❍ fenamiphos applied simultaneously with 8 wk solarization ($y = a + bx^c$; a = 1.74; b = -3.01^{-15}; c = 2.98; r^2 = -0.938; P = 0.01).

Significant reduction of the tobacco root gall index also occurred in the plots treated with 10 or 15 kg a.i./ha of fenamiphos at the completion of eight weeks solarization and in the plots in which in the previous September fenamiphos was applied only at the lettuce planting sites.

Statistically significant positive correlations occurred between duration of solarization alone or with fenamiphos applied at 10 or 15 kg a.i./ha either simultaneously or in September and lettuce yield (Fig. 10). Conversely there were statistically significant negative correlations between duration of solarization alone or with fenamiphos applications at all rates either in September or simultaneously, except for 10 kg a.i./ha as a simultaneous application, and root gall index of lettuce (Fig. 11). Statistically significant negative correlations occurred also between rates of fenamiphos, applied alone or in September after four weeks solarization or simultaneously with either four or eight weeks solarization, and root gall index of lettuce (Fig. 12).

In the following tobacco crop statistically significant positive correlations were noted between duration of solarization, alone or with 5 kg a.i./ha of fenamiphos applied in September, and leaves fresh weight (Fig. 13), and between fenamiphos rates applied simultaneously with four weeks solarization and leaf fresh weight (Fig. 14).

Statistically significant positive correlations occurred also between duration of solarization, alone or with 5 kg a.i./ha fenamiphos, applied in September, and dry weight of tobacco leaves

Fig. 10 - Correlation between soil solarization duration and yield of lettuce at Monteroni: A, ● solarization alone ($y = a + bx$; a = 13.05; b = 0.05; r^2 = 0.928; P = 0.01); B, ❍ solarization + 10 kg a.i./ha fenamiphos applied in September ($y = a + bx$; a = 12.88; b = 0.06; r^2 = 0.855; P = 0.05); C, ☐ solarization + 15 kg a.i./ha fenamiphos applied in September ($y = a + bx$; a = 13.02; b = 0.05; r^2 = 0.845; P = 0.05); D, ✡ solarization + 10 kg a.i./ha fenamiphos applied simultaneously ($y = a + bx$; a = 13.48; b = 0.04; r^2 = 0.916; P = 0.01); E, ❒ solarization + 15 kg a.i./ha fenamiphos applied simultaneously ($y = a + bx$; a = 13.28; b = 0.07; r^2 = 0.988; P = 0.01).

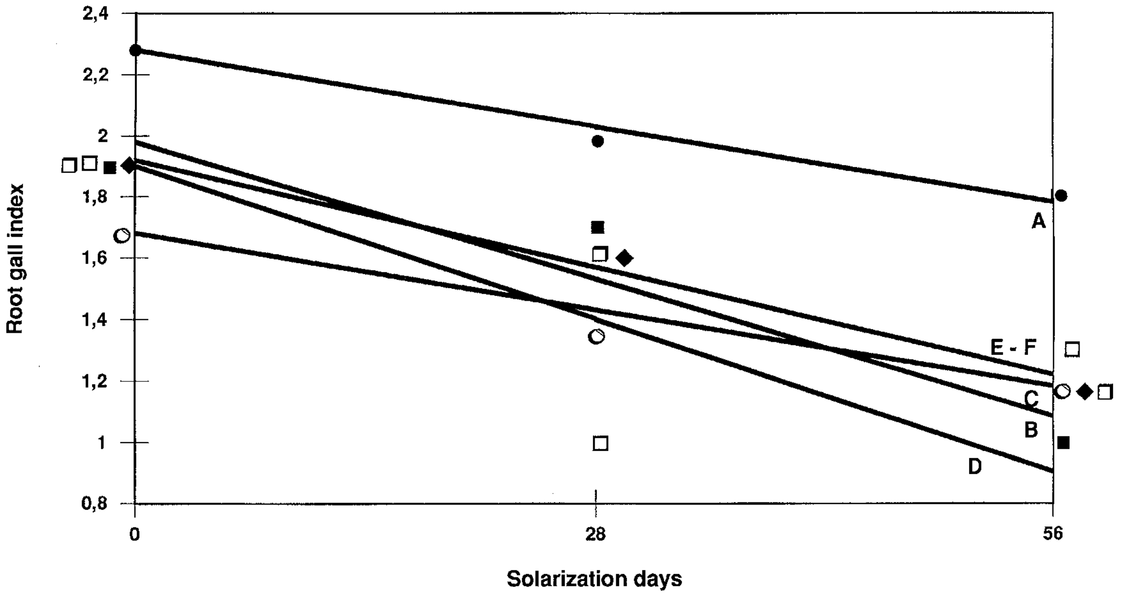

Fig. 11 - Correlation between soil solarization duration and root gall index of lettuce at Monteroni: A, ● solarization alone ($y = a + bx$; a = 2.28; b = -0.007; r^2 = -0.987; P = 0.01); B, ■ solarization + 5 kg a.i./ha fenamiphos applied in September ($y = a + bx$; a = 1.98; b = -0.02; r^2 = -0.907; P = 0.01); C, ❍ solarization + 10 kg a.i./ha fenamiphos applied in September ($y = a + bx$; a = 1.68; b = -0.009; r^2 = -0.987; P = 0.01); D, □ solarization + 15 kg a.i./ha fenamiphos applied in September ($y = a + bx$; a = 1.85; b = -0.02; r^2 = -0.964; P = 0.01); E, ◆ solarization + 5 kg a.i./ha fenamiphos applied simultaneously ($y = a + bx$; a = 1.92; b = -0.01; r^2 = -0.993; P = 0.01); F, ❐ solarization + 15 kg a.i./ha fenamiphos applied simultaneously ($y = a + bx$; a = 1.92; b = -0.01; r^2 = -0.993; P = 0.01).

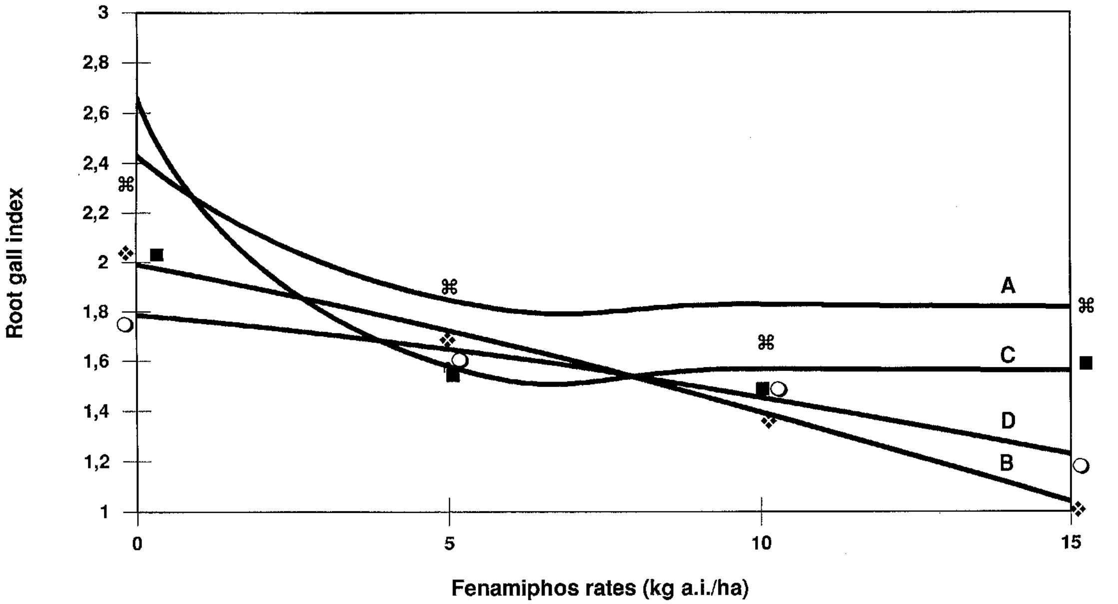

Fig. 12 - Correlation between rate of fenamiphos and root gall index of lettuce at Monteroni: A, ⌘ fenamiphos only ($y = a + bx^c$; a = 2.43; b = -0.474; c = 0.045; r^2 = -0.862; P = 0.05); B, ❖ fenamiphos applied in September after 4 wk solarization ($y = a + bx^c$; a = 1.99; b = -0.001; c = 1.16; r^2 = -0.998; P = 0.01); C, ■ fenamiphos applied simultaneously with 4 wk solarization ($y = a + bx^c$; a = 2.66; b = -1.01; c = 0.01; r^2 = -0.956; P = 0.01); D, ❍ fenamiphos applied simultaneously with 8 wk solarization ($y = a + bx^c$; a = 1.79; b = -0.0004; c = 1.274; r^2 = -0.971; P = 0.01).

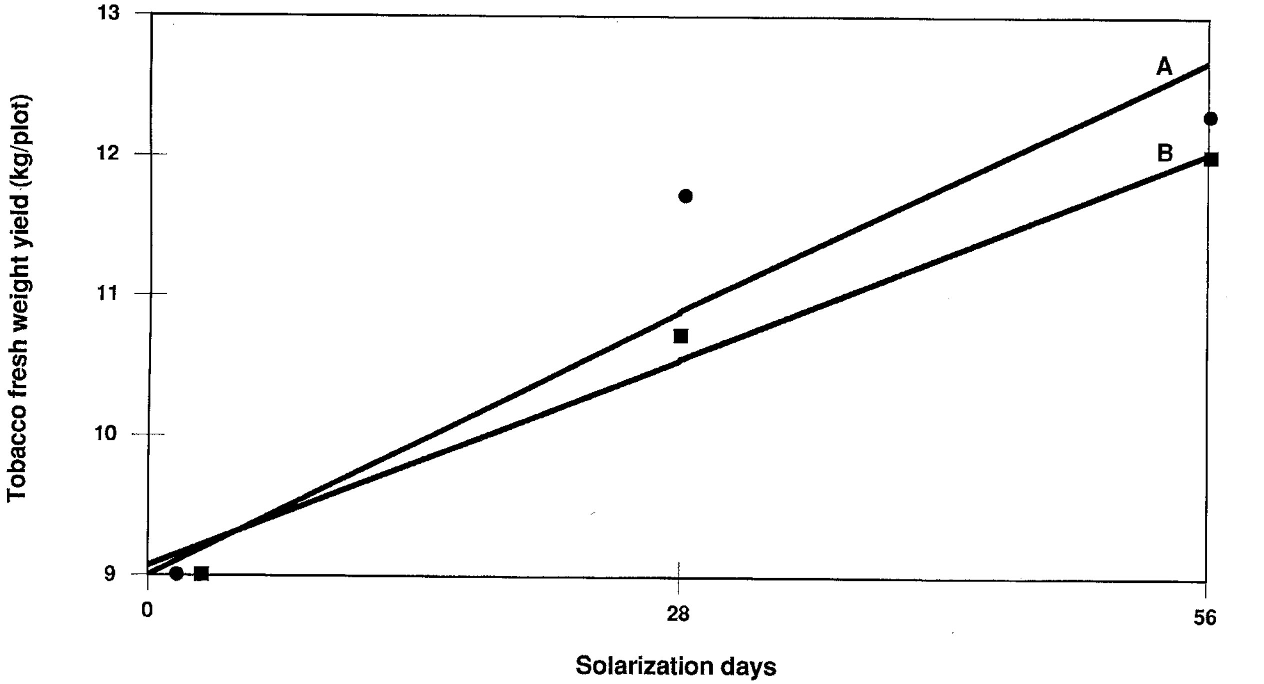

Fig. 13 - Correlation between soil solarization duration and fresh weight yield of tobacco at Monteroni: A, ● solarization alone (y = a + bx; a = 9.05; b = 0.07; r^2 = 0.849; P = 0.05); B, ■ solarization + 5 kg a.i./ha fenamiphos applied in September (y = a + bx; a = 9.07; b = 0.05; r^2 = 0.994; P = 0.01).

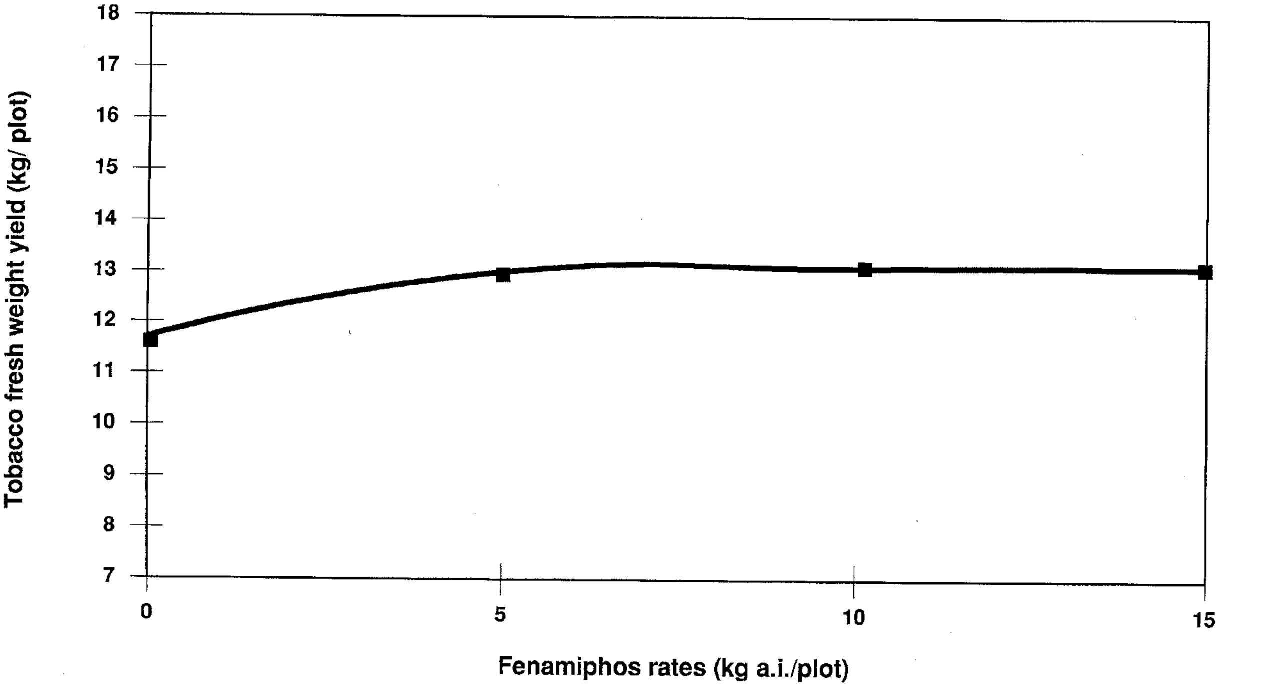

Fig. 14 - Correlation between rate of fenamiphos applied simultaneously with 4 wk solarization and fresh weight yield of tobacco at Monteroni: ■ (y = a + bx^c; a = 11.65; b = 0.99; c = 0.07; r^2 = 0.999; P = 0.01).

(Fig. 15). This parameter was positively correlated also with rates of fenamiphos, alone or applied in September after four weeks solarization (Fig. 16). On the other hand, statistically significant negative correlations were noted between duration of solarization, alone or with fenamiphos applied in September at 5 or 10 kg a.i./ha or fenamiphos at 15 kg a.i./ha applied simultaneously, and root gall index (Fig. 17), and between rates of fenamiphos, applied alone or in September after either four or eight weeks solarization or simultaneously with either four or eight weeks solarization, and root gall index (Fig. 18).

Conclusions

Among the four cropping cycles: lettuce at Castellaneta in 1995, cantaloupe at Castellaneta in 1996, lettuce at Monteroni in 1996, tobacco at Monteroni in 1997, only with cantaloupe at Castellaneta did all of the treatments consistently increased crop yield. Yield increases of lettuce and tobacco were erratic and, when consistent, much less than cantaloupe. At Castellaneta only eight weeks soil solarization produced significant increase on the second crop, cantaloupe, but not on lettuce. In any case, both fenamiphos or 1,3 D gave better results when applied just before the second crop, rather than before the first.

Root gall reduction in all treatments was very consistent in both crops at Castellaneta, but very erratic on either crop at Monteroni. However, an examination of the correlations of both experiments indicates a positive trend in root-knot nematode control with increasing rates of fenamiphos, with the duration of the solarization period and with their combinations.

Four weeks soil solarization is perhaps insufficient to give acceptable and consistent results and eight weeks may not be sufficient if the soil temperature does not approach 40 °C for the treatment duration (Lamberti and Greco, 1991).

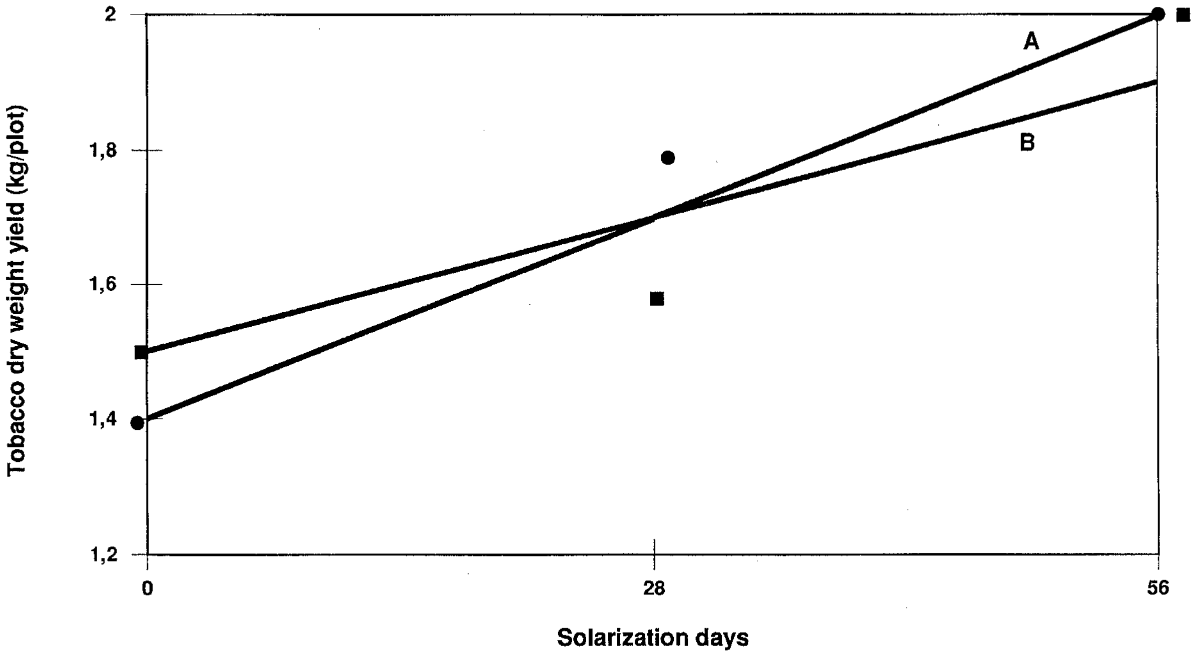

Fig. 15 - Correlation between soil solarization duration and dry weight yield of tobacco at Monteroni: A, ● solarization alone (y = a + bx; a = 1.43; b = 0.01; r^2 = 0.964; P = 0.01); B, ■ solarization + 5 kg a.i./ha fenamiphos applied in September y = a + bx; a = 1.45; b = 0.009; r^2 = 0.892; P = 0.05).

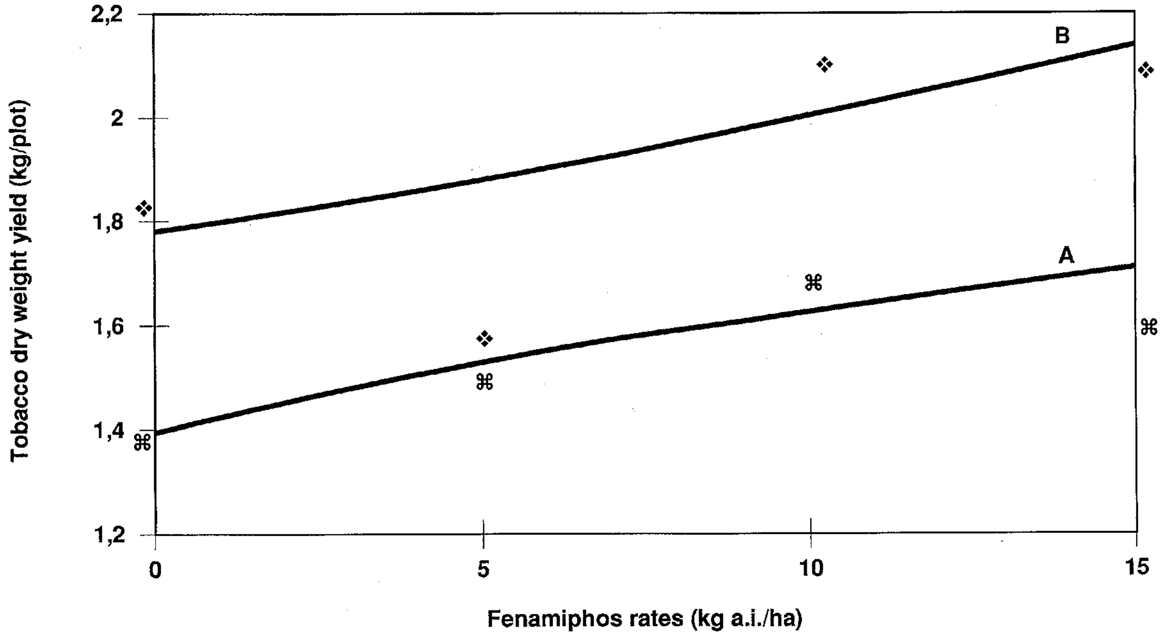

Fig. 16 - Correlation between fenamiphos rates and dry weight yield of tobacco at Monteroni: A, ⌘ fenamiphos only ($y = a + bx^c$; a = 1.39; b = 0.004; c = 0.766; r^2 = 0.911; P = 0.01); B, ❖ fenamiphos applied in September after 4 wk solarization ($y = a + bx^c$; a = 1.78; b = 0.0005; c = 1.16; r^2 = 0.805; P = 0.05).

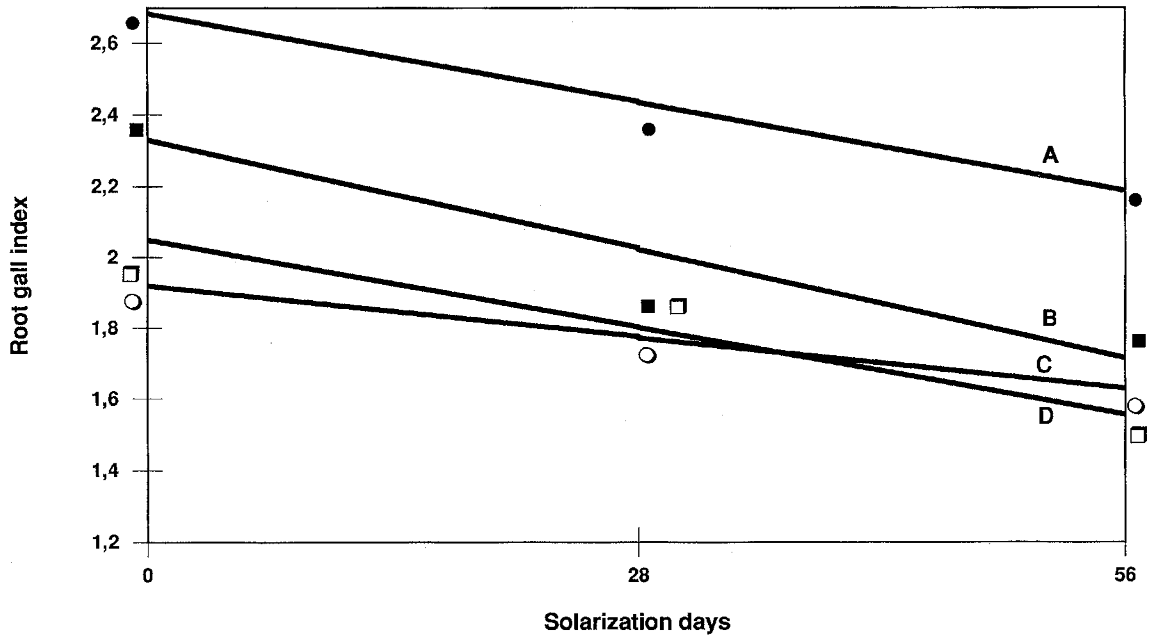

Fig. 17 - Correlation between soil solarization duration and root gall index of tobacco at Monteroni: A, ● solarization alone ($y = a + bx$; a = 2.68; b = -0.009; r^2 = -0.974; P = 0.01); B, ■ solarization + 5 kg a.i./ha fenamiphos applied in September ($y = a + bx$; a = 2.33; b = -0.01; r^2 = -0.871; P = 0.05); C, ❍ solarization + 10 kg a.i./ha fenamiphos applied in September ($y = a + bx$; a = 1.92; b = -0.005; r^2 = -0.964; P = 0.01); D, ❐ solarization + 15 kg a.i./ha fenamiphos applied simultaneously ($y = a + bx$; a = 2.05; b = -0.009; r^2 = -0.893; P = 0.05).

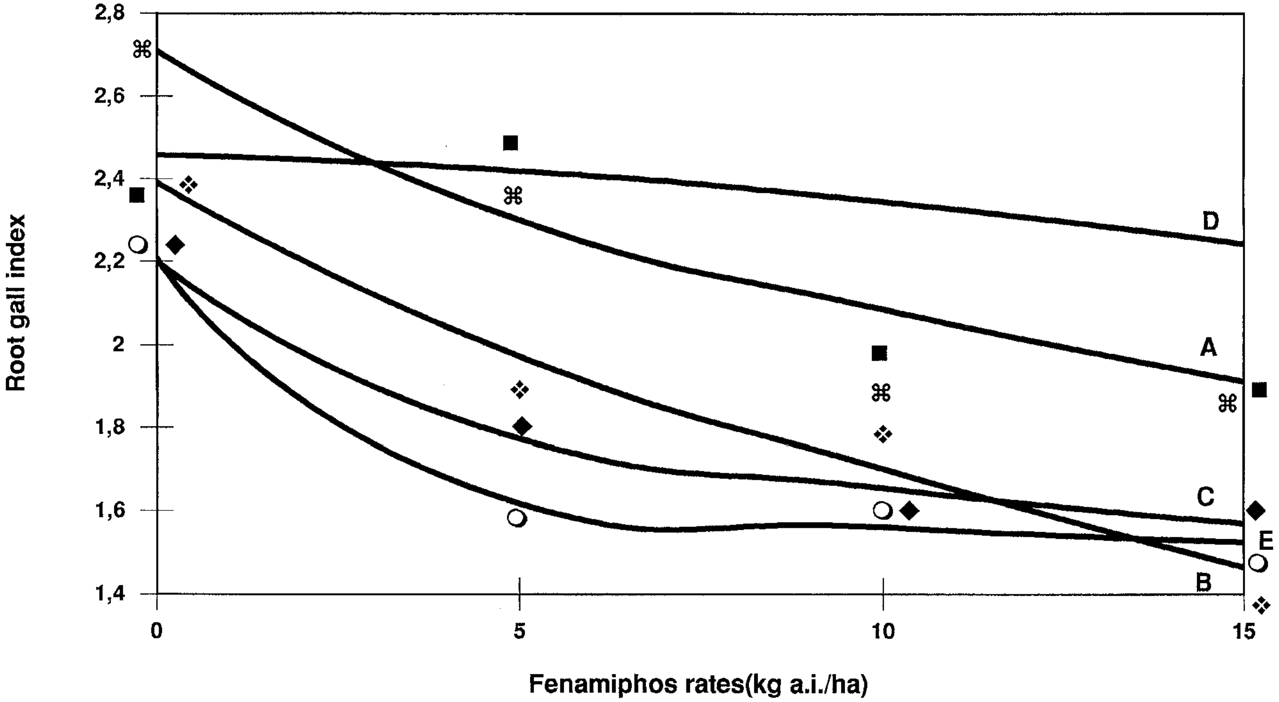

Fig. 18 - Correlation between fenamiphos rates and root gall idnex of tobacco at Monteroni: A, ⌘ fenamiphos only ($y = a + bx^c$; a = 2.71; b = -0.02; c = 0.603; r^2 = -0.872; P = 0.05); B, ❖ fenamiphos applied in September after 4 wk solarization ($y = a + bx^c$; a = 2.39; b = -0.015; c = 0.723; r^2 = -0.962; P = 0.01); C, ◆ fenamiphos applied in September after 8 wk solarization ($y = a + bx^c$; a = 2.20; b = -0.08; c = 0.356; r^2 = -0.980; P = 0.01); D, ■ fenamiphos applied simultaneously with 4 wk solarization ($y = a + bx^c$; a = 2.46; b = -8.09^{-5}; c = 1.56; r^2 = -0.956; P = 0.01); E, ❍ fenamiphos applied simultaneously with 8 wk solarization ($y = a + bx^c$; a = 2.21; b = -0.32; c = 0.132; r^2 = -0.991; P = 0.01).

Four weeks solarization might be sufficient if combined with fenamiphos, but whether it should be applied simultaneously, at the end of the solarization period, or just before planting and the rates of fenamiphos application it is still unclear on the basis of these results.

Certainly the application of a nematicide just before planting a crop and without any other nematode control practice, could be the easiest way to control root-knot nematodes. But such treatments are not always advisable because of their cost and the possibility of soil pollution. However, a soil solarization period in excess of four weeks and at relatively high temperatures will have some positive effect on the management of *Meloidogyne* species.

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