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CONTROL OF *GLOBODERA ROSTOCHIENSIS* ON POTATO WITH FUMIGANT AND NON FUMIGANT NEMATICIDES

by
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The potato cyst nematode, *Globodera rostochiensis* (Woll.), is widespread and economically important on potato (*Solanum tuberosum* L.) in Italy. The tolerance limit of potato varieties susceptible to *G. rostochiensis* is 1.9 eggs and juveniles per g of soil (Greco *et al.*, 1982c). Resistant potato cultivars offer promise in controlling the nematode, but more than one *G. rostochiensis* pathotype may occur in the same field. Several investigators (Giunchi and Tacconi, 1973; Moss *et al.*, 1975; Tacconi and Ugolini, 1971; Trudgill *et al.*, 1978) have demonstrated that nematicides are useful for the control of *G. rostochiensis* when included in an integrated pest management programme. However, in Italy, information is lacking on the effect of nematicides on the viability of the eggs within the nematode cysts under field conditions. Therefore, an experiment was conducted in 1982 in the Fucino area of central Italy, to study the effect of several nematicides on *G. rostochiensis* and potato yield.

Materials and Methods

A field with sandy loam soil, cropped with potato in the previous year and heavily infested with *G. rostochiensis*, was divided into 54 contiguous plots, each 27 m^2 (8 × 3.375 m), according to a randomized

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block design with six replicates per treatment. The soil was prepared using the routine cultural practices of the area. The chemicals used in the experiment were the soil fumigants D-D (50% 1,2 dichloropropane, 50% 1,3 dichloropropene) 300 l/ha, Di-Trapex (80% D-D, 20% methyl isothiocyanate) 300 l/ha, Telone II (92% 1,3 dichloropropene) 200 l/ha and EDB (83% 1,2-dibromoethane) 150 l/ha, and the systemic nematicides Fenamiphos [5% ethyl 4-(methyltio)-m-tolyl isopropyl phosphoramidate] 10 kg/ha and Aldicarb [5% 2-methyl-2-(methyltio) propionaldehyde 0-methylcarbamoyloxime] 10 kg/ha. Fumigants were applied at a depth of 20 cm, 3 weeks before planting (21 April), when the soil temperature was 12° C, using a hand injector. Systemic nematicides were broadcast on the soil surface and then thoroughly mixed into the upper 15 cm of soil 3 weeks or 1 day before planting. All fumigated plots were rolled immediately after the fumigants were applied to reduce their escape from the soil. One week before planting (5 May) all fumigated plots were rotavated to release any remaining chemicals and thus avoid phytotoxicity. The potato cv. Majestic was planted (13 May) in five row plots, spaced 67.5 cm apart and 35 cm between tubers. One week prior to planting a 2 kg soil sample, comprised of 77 one cm diam cores, was collected from the upper 30 cm of soil from a central area of 2.70 cm^2 (2 $\times$ 1.35 m) from each plot. Each sample was thoroughly mixed and a 200 cm^3 sub-sample processed, using a Fenwick can. The cysts were counted and the egg contents of cysts from the plots treated at planting were determined using the Seinhorst and Den Ouden (1966) method. The mortality of eggs within cysts was obtained by placing cysts, from the plots treated three weeks before planting, in a 0.6 mM sodium metavanate solution (Clarke and Shepherd, 1966) as previously described (Greco *et al.*, 1982a) and incubating them at 21.5° C for 6 weeks. The emerging juveniles were removed and counted weekly, and the hatching solution renewed at the same time. At the end of the test, eggs and juveniles remaining within cysts were counted to ascertain the total numbers of eggs and juveniles within cysts at the beginning of the test. Any unhatched eggs or unemerged juveniles were assumed to have been killed by the nematicide. From these data the percentage of mortality was calculated.

The effectiveness of the nematicides in preventing root invasion by *G. rostochiensis* juveniles was examined by collecting the roots of five potato plants from the central row of each plot on June and July 29. Roots were gently washed free of soil, chopped and a 10 g sub-sample per plot processed using Coolen's (1979) method. The recovered nematodes were counted and identified as either juveniles, females or cysts.

Potatoes from the second and fourth rows were harvested on 1 September, weighed and classed as marketable ($\geq$ 38 mm diam) or unmarketable. At the same time a 2 kg soil sample was collected, as described, from each of the plots. The samples were air dried and a 200 cm^3 sub-sample from each sample was processed using the Fenwick can and ethanol method (Seinhorst, 1974). These samples gave an estimate of the post-cropping population of the nematode.

During the experiment, routine cultural practices were followed, and special care was taken to control Colorado beetle (*Leptinotarsa decemlineata* Say), aphids and late blight disease [*Phytophthora infestans* (Mont) De Bary]. Soil temperature, at 20 cm depth, was recorded during the experiment. All data were statistically analysed by Duncan's multiple range test or Student's *t* test.

Results

Soil temperature fell to 8-10° C soon after the chemicals were applied, remained in the range 12-18° C during May, and rose to 18-25° C during June, where it remained until harvest. Plant emergence was delayed by one month in the plots treated with EDB, probably because early shoots were injured by its residues in the soil. The hatching test (Table I) showed that all the nematicides, except Fenamiphos, significantly ($P = 0.05$) reduced the numbers of juveniles emerging with respect to the untreated plots. Di-Trapex controlled *G. rostochiensis* better than any of the other treatments and 78.3% of the eggs were estimated to have been killed. Also it is noteworthy that after one week of the hatching test the emergence of juveniles from the cysts of the plots treated with Di-Trapex was negligible (1.3%), but after two weeks 8% of the juveniles had emerged. This suggests that the fumigant may have a nematistatic effect on the eggs.

The invasion of the potato roots by *G. rostochiensis* (Table II) was significantly ($P = 0.05$) reduced by the nematicides. The systemic nematicides Aldicarb and Fenamiphos, as well as the fumigants, controlled the nematode. No significant differences were recorded

Table I - *Effect of nematicides on the emergence of juveniles after 1 week and the percent mortality of the eggs within the cysts of* Globodera rostochiensis.

Treatments	% emerged juveniles	% mortality
Di-Trapex	1.3 a	78.3 a
EDB	17.7 bcd	55.8 b
Telone II	13.3 bc	54.3 b
D-D	11.1 b	50.2 b
Aldicarb	22.2 cd	41.7 b
Fenamiphos	34.4 e	19.1 c
Untreated	26.7 de	20.9 c

Figures followed by the same letters do not significantly differ by Duncan's multiple range test at P = 0.05.

Table II - *Effect of nematicides on the number of* G. rostochiensis *juveniles, females and cysts recovered from 10 g of fresh roots in 1982.*

Treatments	Juveniles		Females		Cysts	
	29 June	29 July	29 June	29 July	29 June	29 July
Di-Trapex	479 ab	297 a	45 abcd	74 ab	1.0 a	5 ab
EDB	547 ab	413 a	11 a	40 ab	0.5 a	0.8 a
Telone	1134 ab	570 a	89 abcd	69 ab	3.0 a	60 bcd
D-D	1346 b	781 a	137 d	121 b	7.0 a	73 d
Aldicarb preplanting	187 a	251 a	3 a	16 a	0.6 a	0.8 a
Aldicarb at planting	392 ab	320 a	15 ab	14 a	1.0 a	7 ab
Fenamiphos preplanting	341 ab	256 a	25 abc	42 ab	2.0 a	12 abc
Fenamiphos at planting	930 ab	312 a	104 cd	33 ab	3.0 a	67 cd
Untreated	6252 c	1823 b	463 e	316 c	48.0 b	301 e

Figures followed by the same letters do not significantly differ by Duncan's multiple range test at P = 0.05.

Table III - *Effect of nematicides on the yield of potato tubers and soil populations of* G. rostochiensis.

Treatments	Yield kg/11.2 m^2		Eggs/ml soil	
	Total	Marketable	Before treatment	After harvest
Di-Trapex	26.8 a	15.4 a	103	150
EDB	10.2 d	5.5 cd	47	22
Telone II	22.4 ab	11.9 b	68	211 *
D-D	17.1 c	10.0 b	116	294
Aldicarb preplanting	18.9 bc	10.9 b	81	72
Aldicarb at planting	16.7 c	9.2 b	104	113
Fenamiphos preplanting	18.4 bc	10.2 b	82	106
Fenamiphos at planting	16.7 c	8.3 bc	64	205 **
Untreated	6.5 d	2.2 d	153	239

Figures followed by the same letters do not significantly differ by Duncan's multiple range test at P = 0.05.
Averages significantly different from the initial population using the Student's *t* test: * for P = 0.05; ** for P = 0.01.

when the non volatile nematicides were applied 3 weeks or one day before planting.

The total and the marketable yield of potato (Table III), significantly (P = 0.05) increased in the treated plots with the exception of those treated with EDB. The yield of potatoes was seven times greater in plots treated with Di-Trapex than the untreated plots. Again, the systemic nematicides gave similar results when incorporated into the soil three weeks or one day before planting.

Thus, all nematicides gave good protection of the roots against nematode attack, the post-harvest nematode soil populations (Table III) generally showing a slight increase compared with the pretreatment samples. Significantly (P = 0.05) more eggs were found after harvest in the plots treated with Telone II and Fenamiphos at planting than in the other plots. The population of the nematode declined, but not significantly, only in plots treated with EDB and with Aldicarb applied three weeks before planting.

Discussion

This experiment confirmed the effectiveness of the nematicides used in controlling *G. rostochiensis*. The mortality of the eggs achieved with D-D was much less than that obtained by Greco *et al.* (1982b) against *Heterodera schachtii* Schmidt. According to McKenry and Thomason (1976), low soil temperature and high soil moisture content will reduce the diffusion of the fumigant through the soil profile. This may explain the higher tuber yield and nematode mortality obtained with Di-Trapex in comparison with other fumigants, which agrees with the findings of Tacconi and Ugolini (1971), and may be the result of the higher water solubility of methyl isothiocyanate. Unfortunately, the hatching test did not indicate how long the nematistatic effect of Di-Trapex lasted, and more investigations are required in this area.

EDB, even though it gave a similar level of control of the nematode compared with other nematicides, did not significantly improve the yield of tubers, probably because it delayed the emergence of the potato plants.

Homeyer and Wagner (1981) reported that preplanting applications of Fenamiphos were more effective than applications at planting in controlling *G. rostochiensis*. In our investigation preplanting applications of Aldicarb and Fenamiphos also gave higher yields and less nematodes in the roots than applications at planting, but the observed differences were not significant.

The results reported here suggest that systemic nematicides may prove to be as effective as most of the fumigants. Therefore, their use may be advantageous in those areas in which soil temperature and/or soil moisture content may reduce the effectiveness of the fumigants.

SUMMARY

A field experiment was done in 1982 to control *Globodera rostochiensis* with the nematicides Di-Trapex and D-D (300 l/ha), Telone II (200 l/ha), EDB (150 l/ha) and Aldicarb and Fenamiphos (10 kg a.i./ha) preplanting and at plant applications. Di-Trapex significantly killed more eggs (78.3%) compared with all the other nematicides, and Fenamiphos had no effect on egg mortality. All the nematicides reduced root invasion by *G. rostochiensis* and increased the yield of potato tubers. Only EDB failed to increase yield, probably because it delayed plant emergence by one month. The post harvest population of the nematode declined only in the plots treated with EDB and with Aldicarb applied three weeks before planting.

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