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CHEMICAL CONTROL OF THE ROOT-KNOT NEMATODE *Meloidogyne incognita* INFECTING EGGPLANT IN DIFFERENT SOIL TYPES

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ABSTRACT: **The efficacy of three nematicides namely carbofuran, fenamiphos and oxmayl for controlling the root knot nematode, *Meloidogyne incognita* infecting eggplant in three soil types i.e. clay, clay loam and sandy was evaluated under greenhouse conditions30±5°C. Results revealed that regardless of the tested soil types, all the tested nematicides, at any rate of application, greatly reduced the nematode penetration, number of galls per root system, number of eggs per eggmass, nematode final population and nematode reproduction. Significant differences in these parameters were recorded between all tested treatments and the untreated one. However, such nematode criteria greatly decreased by increasing the rate of nematicide application in the three soil types. In the clay soil, oxamyl ranked first followed by fenamiphos and carbofuran, whereas, fenamiphos gave better result followed by carbofuran and oxamyl in the clay loam soil at three rates of application .Moreover, in the sandy soil, oxamyl gave the highest effect in suppressing nematode parameters followed by carbofuran and fenamiphos at all rates except the rate 200 mg/kg soil. Results clearly indicated that the nematicidal efficiency of the tested compounds greatly varied according to the tested nematicides and soil types. Moreover, an obvious improvement in eggplant growth parameters was observed with all tested nematicides as compared to untreated soil.**

Key words: Chemical control, nematicides (carbofuran, fenamiphos, oxamyl), *Meloidogyne* spp., *Solanum melongena*, soil types.

INTRODUCTION

Eggplant, *Solanum melongena* L., is one of the major economic solanaceous crops in Egypt. It is severely damaged by the root-knot nematode *Meloidogyne incognita* (Dhawan & Sethi, 1976 and Netscher & Sikora, 1990). Plant parasitic nematodes are controlled by several methods such as resistant crops (Roberts, 1992), plant extracs (Oka, 2000), biological control by micro-organisms (Hallmann *et al.*, 2001, Jafee & Zasoski, 2001 and Sharon *et al.*, 2001), organic amendments (Riegel & Noe, 2001).

Chemical control by nematicides considerably reduced the root- knot nematode populations. Alhazmi (1985) evaluated three nematicides for their suppression of *M. javanica* on eggplant. Juveniles in soil were suppressed by 73.6, 94.0 and 94.5% with yield increases of 204, 142 and 72% in treatments of 1, 3-D; oxamyl and phenamiphos, respectively. Deabes (1996) found that aldicarb, oxamyl and fenamiphos markedly reduced the number of second stage larvae and galls of *M. incognita* infected some plants in comparison with untreated control. Aldicarb was the most effective nematicide followed by fenamiphos and oxamyl. Gugino *et al.* (2006) showed that application, of oxamyl reduced root-galling severity and increased marketable yield. In commercial fields, the cost-effectiveness of oxamyl application was related to the level of soil infestation with *M. hapla*. Hassan *et al.* (2008) reported that Furadan 5G and Miral 3G were tested as side dressing of brinjal plants against the root-knot nematode *Meloidogyne javanica*. They found that, the two chemicals at higher concentrations (60 and 88 mg per plant, respectively) either alone or in combination gave superior response in plant growth characters with corresponding lower number of galls, adult females and eggmasses. In most cases of plant growth and nematode population, Furadan 5G performed superior to Miral 3G as well as an interesting findings of the study as a promising nematicidal role of Miral 3G adhering with conventional nematicide Furadan 5G.

The objective of this study is to evaluate the effect of three nematicides i.e. carbofuran, fenamiphos and oxamyl at three rates of application in controlling the root-knot nematode *M. incognita* infecting eggplant plants grown in three soil types under greenhouse conditions $30 \pm 5^{\circ}C$.

MATERIALS AND METHODS

Eggplant (*Solanum melongena* L.) seeds, were supplied by the Ministry of Agriculture and Land Reclamation. Three soil types with different propertes were used in this study. They were clay, clay loam and sandy soils and obtained from Itay- EL Baroud, Kafr- EL Zayat and Nubaria districts, respectively. Physical and chemical characteristics of these soils are presented in Table (1).

Nematicides used: Commercially available formulations of the tested nematicides were obtained from Ministry of Agriculture, Egypt. Trade, common and chemical names as well as formulation type for these compounds were as follows: Furadan (carbofuran 10% G.) 2.3 – dihydro – 2.2 dimethylbenzofuran -7- yl methyl carbamate, Nemacur (fenamiphos 10% G.)Ethyl 4- methylthio – m – tolyl is opropylphosphoramidate and Vydate (oxamyl 10% G.) NN-dimethyl -2- methyl carba – moyloxyimino -2-(methylthio) acetomide at three rates of application 100,200 and 300 mg/kg soil.

Clay pots (15.0 cm diam.) were surface sterilized by 5% formalin solution. The used soils were air dried and sieved through a 2mm screen. Soil were packed in bags and steamed in an autoclave until a temperature of 100- 110°C (1.3 to 1.4 Lb pressure) was reach and then holding the temperature at 90 – 110°C (1.1 to 1.4 Lb pressure) for one hour according to a method described by Knudsen and Bin (1990).

The seeds of eggplant were sown in nursery and after three weeks, the seedlings were transplanted to pots contained 1.0 kg of sterilized soil of each soil type under study. Each pot was planted with two seedlings and one week later thinned to one. All treatments were replicated four times. Seedlings were inoculated at the rate of 1000 fresh newly hatched second stage juveniles of *Meloidogyne incognita*. Three days later, the rate of application for each of the tested nematicides were added and incorporated in the upper 5.0 cm of pot soil.The plants were then irrigated immediately and allowed to grow at 30±5°C. Five weeks after inoculation, all plants were harvested and root system of each plant was carefully removed gently, washed in water and stained in lactophenol acid fuchsin (Byrd *et al.*, 1983).

Table 1. Some physical and chemical properties of the tested soils

Source of Soil Samples	PH	Organic matter %	T.S.S %	Total Caco3 %	E.C.m. mohs cm	Chemical analysis								Physical analysis			
						Solube cations meq/L				Soluble anions meq/L				Particle size distribution			
						Ca++	Mg++	Na++	K+	Co_3	Hco_3	Ci	So_4	Total clay%	Total Sand%	Total Silt%	Textural class
Itay El-Baroud	7.35	0.55	0.41	1.33	0.95	3.16	2.45	5.10	0.81	0.00	1.30	6.81	3.64	62.31	23.82	13.87	Clay
Kafer El-Zayat	7.41	0.91	0.22	1.19	0.55	0.49	0.78	3.20	0.16	0.00	1.23	2.75	0.72	36.92	27.98	35.10	Clay Loam
Nubaria	6.81	0.03	0.08	1.75	0.22	0.19	0.14	1.20	0.04	0.00	0.63	0.65	0.28	5.97	88.30	5.73	Sandy

T.S.S. = Total soluble salts.

E.C. = Electric conductivity.

Stained roots were examined and numbers of developmental stages and females were recorded. Nematodes were then extracted from soil by sieving and modified Baermann-techique (Goodey 1957), then final nematode population was determined and recorded. The number of galls per root system and number of eggs per eggmass were also counted. The percentage reduction of these values was also calculated. Nematode final population,rate of nematode reproduction, percentage of nematode penetration and percentage of nematicidal efficacy was also calculated according to Norton (1978) as follows:

Reproduction factor (RF) =

$$\frac{\text{Final population } (P^f)}{\text{Initial population } (P^i)}$$

Nematicide efficiency (NE) =

$$\frac{\text{control } (R^f) - \text{treatment } (R^f)}{\text{Control } (R^f)} \times 100$$

Length and fresh weights of both shoots and roots were estimated and recorded. The percentage of increase in plant growth parameters of each treatment was estimated. Data were statistically analyzed using F test and means were compared according to Duncan's multiple range test (1955).

RESULTS AND DISCUSSION

The nematicidal activity of carbofuran, fenamiphos and oxmayl was studied on penetration, development and reproduction of the root knot nematode *M. incognita* infecting eggplant plants grown in three soil types under greenhouse conditions at 30±5°C. The results presented in Table 2 and Fig. 1 showed that significant differences ($P \leq 0.05$) in number of galls per root and number of eggs per eggmass were found between all tested treatments and the untreated once in each soil type. However, these criteria decreased gradually with increasing the rate of nematicides application.

Oxmayl compound in clay soil at all rates of application showed the highest reduction in the rate of nematode penetration, number of galls per root, number of eggs per eggmass and rate of nematode reproduction (2.5%, 72%, 46.26% and 1.25%), (2.0%, 76.54%, 56.58% and 1.11%) and (1.8%, 81.48%, 54.09% and 0.91%) at 100, 200 and 300 mg /kg soil, respectively, followed by fenamiphos and carbofuran. Although, in sandy soil, in general, oxmayl gave the best results at all

Table 2. Effect of the tested nematicides on development and reproduction of the root knot nematode *Meloidogyne incognita* infecting eggplant plants grown in different soil types under greenhouse conditions 30±5 °C

Treatments	Rate of application mg/kg soil	% rate of nematode penetration	No. of galls/root *	No. of eggs/egg mass *	Nematode Final population	Nematode reproduction (RF)	Nematicidal efficacy
				Clay Soil			
Furadan 10%G (carbofuran)	100	4.4	36 b	261 a	4724	3.74	66.12
	200	3.1	27 cd	278 a	3632	3.63	67.12
	300	3.2	17 ef	282 a	2550	2.55	76.90
Nemacur 10%G (Fenamiphos)	100	3.4	28 c	182 b	2025	2.03	81.61
	200	2.3	21 ef	152 c	1533	1.53	86.14
	300	2.3	21 ef	79 d	803	0.80	92.75
Vydate 10%G (oxamyl)	100	2.5	22 de	151 c	1525	1.52	86.23
	200	2.0	19 ef	122 c	1109	1.11	89.94
	300	1.8	15 f	129 c	914	0.91	91.76
Check	——	11.8	81 a	281 a	11038	11.04	——
				Clay Loam Soil			
Furadan 10%G (carbofuran)	100	3.9	34 de	336 a	6069	6.06	80.46
	200	3.4	28 ef	305 bc	5506	5.51	82.23
	300	2.3	19 g	297 c	3279	3.28	89.42
Nemacur 10%G (Fenamiphos)	100	4.1	37 d	208 d	3993	3.99	87.13
	200	2.8	21 fg	187 de	2260	2.26	92.71
	300	2.5	21 fg	125 f	1265	1.26	95.94
Vydate 10%G (oxamyl)	100	6.4	62 b	190 de	4222	4.22	86.39
	200	5.1	48 c	174 e	3338	3.33	89.26
	300	2.3	20 g	168 e	1526	1.53	95.07
Check	——	13.4	84 a	326 ab	31009	31.01	——
				Sandy Soil			
Furadan 10%G (carbofuran)	100	7.2	50 c	336 b	14142	14.14	74.29
	200	4.6	34 d	344 ab	11022	11.02	79.96
	300	4.7	33 d	342 ab	11300	11.30	79.45
Nemacur 10%G (Fenamiphos)	100	11.0	79 b	333 b	25674	25.67	53.32
	200	9.1	74 b	214 de	12445	12.44	77.38
	300	7.6	70 b	176 ef	7951	7.95	85.54
Vydate 10%G (oxamyl)	100	7.1	59 c	266 c	11201	11.20	79.63
	200	6.3	56 c	232 cd	8379	8.38	84.76
	300	2.8	20 e	160 f	2572	2.57	95.33
Check	——	27.2	127 a	381 a	54992	54.99	——

* Means followed by the same letters within a column are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

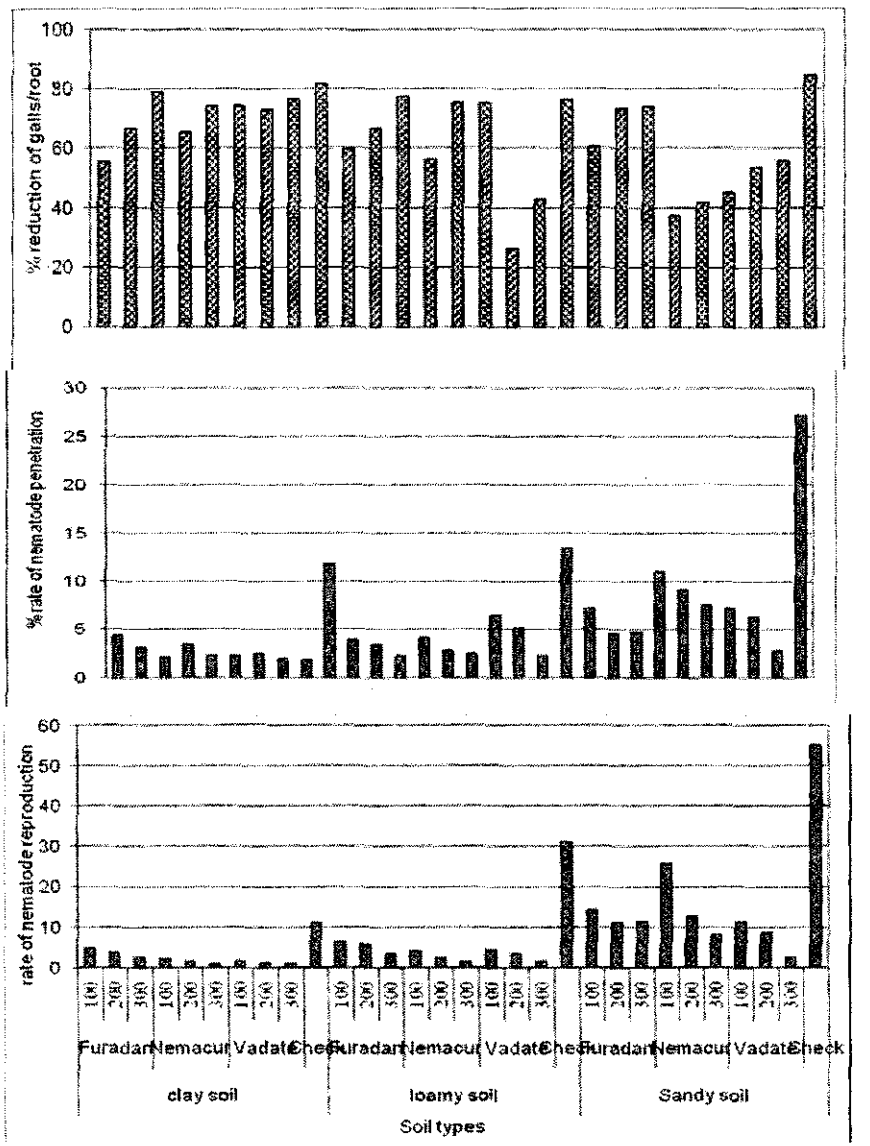

Fig. 1. The effect of the tested nematicides at different rates of application (mg/kg soil) on the percentage reduction of galls/root, percentage of nematode penetration and nematodes reproduction of *Meloidogyne incognita* infected eggplant plants grown in three soil types

rates of application followed by carbofuran, while the lowest values were recorded by fenamiphos compound at all rates (11.0%, 37.39%, 25.67%), (9.10%, 41.73% and 12.45%) and (7.6%, 44.88% and 7.95%) as a reduction in nematode penetration rate, number of galls per root and nematode reproduction at 100, 200 and 300 mg /kg soil, respectively. On the other hand, in clay loam soil data indicated that, the nematicidal efficiency of the tested compounds varied according to rate of application. At 100 mg /kg soil, the best results were recorded with carbofuran followed by fenamiphos and oxmayl. Fenamiphos gave better results than carbofuran and oxmayl at 100 mg /kg soil, while at rate 300 mg /kg soil the highest results of *M. incognita* control in eggplant were recorded by carbofuran and oxmayl followed by fenamiphos Table 2 and Fig. (1).

Generally, data showed that the nematicidal efficiency of the tested compound varied according to nematicides and soil types. Oxmayl gave the highest effects in clay and sandy soils, whereas, carbofuran gave the highest effects in clay loam soil and the lowest results in clay and sandy soils.

Data presented in Fig. 2 showed that, length of roots and shoot as well as fresh weight showed large increase in all treatments as compared to non- treated pots with all tested nematicides and all soil types. Generally, in shoot and root length assay, the best results were obtained in clay soil by using all tested nematicides, followed by sandy and clay loam soils. In fresh weight assay, the sandy soils gave the highest increase percentages as compared to other soil types. Carbofuran compound gave the large results in plant growth parameters in clay and sandy soils, while in clay loam soil oxmayl was the best nematicide in effects on plant growth.

Generally, the rate of *M. incognita* penetration eggplant was higher in sandy soil and varied between the tested soil types. *M. incognita* was sensitive to some nematicides than others. The efficiency of the tested nematicides varied between the tested soil types with the same compound.

These results agree with (Srivastava and Upadhyay, 1974; Fazal *et al.*, 2001; Haseeb and Shukla, 2004; Deseager and Csinos, 2006; Hassan *et al.*, 2006). Wallace (1964) stated that the influence of soil type on nematode

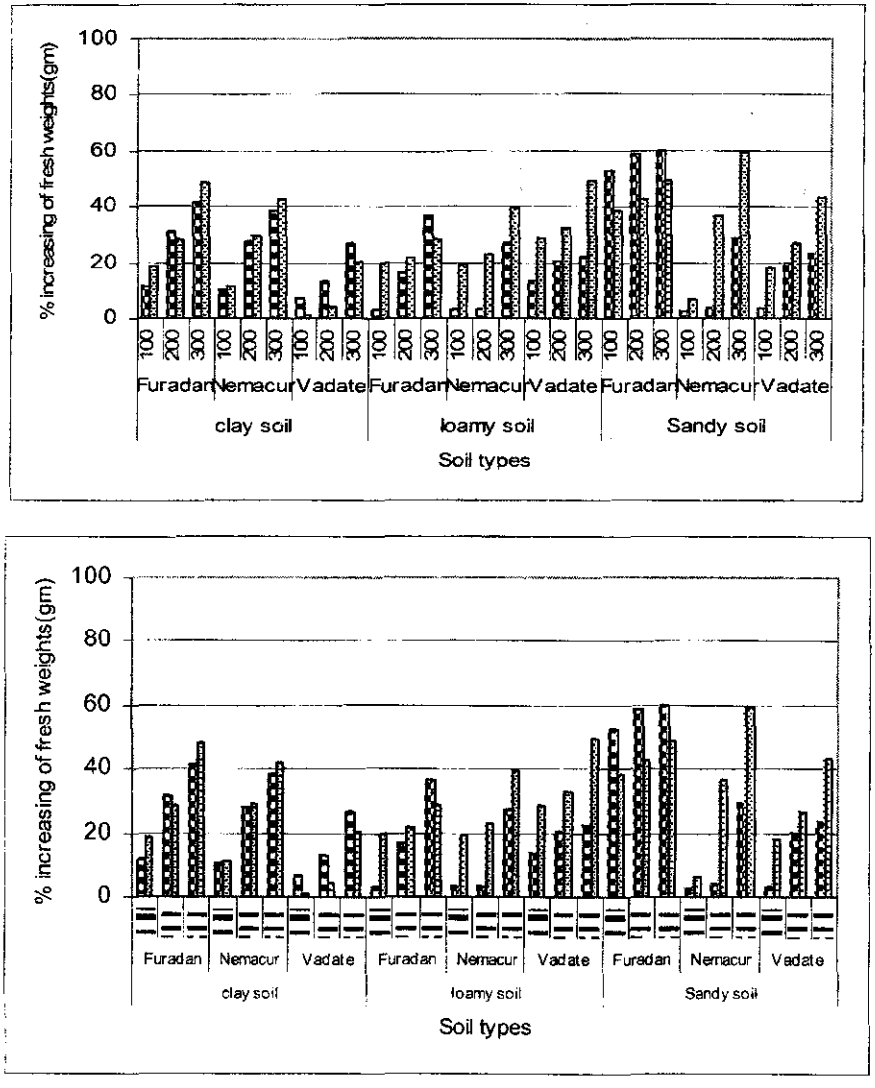

Fig. 2. The effect of the tested nematicides at different rates of application (mg/kg soil) on the percentage increase of eggplant plants infected with *Meloidogyne* grown in three soil types *incognita*

is a highly complex problem because the physical and chemical factors of soil vary so much between localities even where the textural composition of the soil is more less similar. Valley-Lamboy and Ayala (1976) observed the increase of plant height after 60 days of treatment with Furadan 5G or Mocap 10G against *Radopholus similis* and *M. incognita*. Similarly, Mello-Filho *et al.* (1978) reported a better above ground development of Furadan 5G treated plants after 90 days of transplanting. The activity of pesticides in soils is largely controlled by the adsorption of the same by soil component (Ramdu, 1979). Deabes (2005) reported that rate of reproduction of *M. incognita* was high in sandy loam than loam soil. Hasan *et al.* (2005) also observed the increased root and shoot length and weight as well as suppression of adult, L2, L3 and L4 stages with the application of Curaterr (carbofuran). Furadan 5G and Miral 3G appeared superior for increasing growth of plants with corresponding decrease in *Meloidogyne* nematode population on brinjal plants (Hassan *et al.* 2008).

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المكافحة الكيميائية لنيماتودا تعقد الجذور "ميلودوجينا إنكوجنيتا" التي تصيب نباتات الباذنجان في أنواع مختلفة من التربة

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استخدم فى هذه الدراسة ثلاثة أنواع من المبيدات النيماتودية هي (الفيورادان – النمياكور –الفايديت) لمكافحة نيماتودا تعقد الجذور التي تصيب نباتات الباذنجان المنزرعه في ثلاثة أنواع مختلفة من التربة وهي (طينية –طينية طمية –رملية). ولقد أوضحت لنتائج ما يلي :

أدت المبيدات النيماتودية المختبرة إلي انخفاض كبير في معدل اختراق النيماتودا لجذور نباتات الباذنجان وكذلك عدد العقد النيماتودية المتكونة على الجذور وعدد البيض داخل كيس البيض وكذلك التعداد النهائي لأفراد النيماتودا ومعدل تكاثرها على جذور نباتات الباذنجان وذلك عند مقارنتها بالنباتات الغير المعاملة. ويزداد هذا الانخفاض بزيادة معدلات الإضافة في كل المبيدات النيماتودية المختبرة.

كما أعطى الفايديت أعلى نتائج فى خفض تعداد النيماتودا يليه مبيد النيماكور وأخيرا مبيد الفيورادان و ذلك في التربة الطينيه- بينما أعطي مبيد النيماكور أفضل النتائج في التربة الطينية الطميية يليه مبيد الفيورادان ثم مبيد الفايديت, أما فى التربه الرمليه كان مبيد الفايديت هو الأفضل فى النتائج يليه مبيد الفيورادان ثم مبيد النيماكور فى كل معدلات الإضافة باستثناء المعدل ٢٠٠ ملجم / كجم تربة حيث كان مبيد الفيورادان هو الافضل يليه مبيد الفايديت.

علاوة على ذلك فقد أدت كل معاملات المبيدات النيماتودية المختبرة إلى تحسن في نمو نباتات الباذنجان وذلك عند مقارنتها بالنباتات غير المعاملة، و كانت أعلى نسبة مئوية للزيادة في نمو النباتات في التربة الطينية وذلك عند مقارنتها بالانواع الأخرى المختبرة من التربة. وبناء على ما سبق ينصح فى الأراضي الرملية المستصلحة عند المكافحة الكيماوية لنباتات الباذنجان المصابة بنيماتودا تعقد الجذور استخدام مبيد الفايديت يلية مبيد الفيورادان بينما يكون مبيد النيماكور هو الاختيارالأخير.