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CHEMICAL CONTROL OF THE ROOT-KNOT NEMATODE *Meloidogyne incognita* INFECTING TOMATO PLANTS *(Lycopresicon esculentum)* GROWN IN DIFFERENT SOIL TYPES

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ABSTRACT

The efficacy of three nematicides i.e. carbofuran,fenamiphos and oxmayl and three soil types i.e.clay, clay loam and sandy for controlling , *Meloidogyne incognita* infected tomato plants cv.super strain B was evaluated under greenhouse conditions30±5ºC. Results revealded that regardless of the tested soil types , all tested nematicides at any dose added 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 such nematode criteria were recorded between all tested treatments and the untreated one. However, such nematode values greatly decreased by increasing the dose of nematicides application in the three soil types . Oxamyl ranked first in reducing such nematode criteria followed by fenamiphos and carbofuran in the sandy soil, whereas, in the clayloam soil, fenamiphos gave better result in reducing nematode criteria values followed by oxamyl and carbofuran at three doses of application .Moreover, in clay soil, oxamyl at all doses gave the highst effect in nematode parametes followed by fenamiphos and carbofuran at the dose 300 mg/kg soil. Results also, clearly indicated that the nematicidal efficiency of the tested compounds greatly varied according to the tested nematicide compounds and soil types. Carbofuran showed the lowest effect on such nematode values in clay, clay loam and sandy soils, respectively .

Moreover an obvious improvement in tomato growth parameters was observed in all tested nematicides as compared with untreated soil. The highest percentage increase was obtained in plant grown in clay soil as compared with other tested soil types.

Keywords: Chemical control, nematicides (carbofuran, fenamiphos, oxamyl), *Meloidogyne* spp. *Lycopersicon esculentum* Soil types .

INTRODUCTION

Nematodes are most abundant soil inhabiting animals . Plant parasitic nematodes cause great economic losses to agriculture cropworld wide (Sasser and Freckman, 1987) . Root-knot nematode *Meloidogyne* spp. are economically important pthogens of a wide range of crops (Sasser and Carter), 1985 ; Riegel and Noe, 2000 and Walker *et.al.*, 2000).Plant parasitic nematodes are controlled by several methods such as crop resistant (Roberts, 1992), plant extract (Oka 2000), biological control by micro-organisms (Hallmann *et.al.*, 2001, Jafee and Zasoski, 2001 and Sharon *et.al.*, 2001) , organic amendments (Riegel and Noe, 2001).

Chemical control , all nematicides considerably reduced the root- knot nematode populations, (Darkar *et.al.*, 1990). They also said that all the tested granular nematicides i.e. 10 % aldicarb ; 3 % carbofuran , 5 % qunialphos, 10

% phorate and 10 % disulfoton at 2 Kg ai/ha were effective in reducing the *M. incognita* population in tomato cv. Pusa Ruby nersery beds . Moreover aldicarb gave the lowest root-knot index, while carbufuran recorded the maximum seedling weight. El Morshedy (1988) used fenamiphos and oxamyl to control *M.incognita* by dipping tomato roots in these compounds. He found that both compounds at 150, 300 and 600 ppm reduced nematodes in soil, gall formation and number of egg masses on root system, whereas, finamiphos was superior to oxamyl in decreasing the nematode population in soil as well as the number of galls and egg masses on roots .Meanwhile, carbofuran, oxamyl, fenamiphos and aldicarb were high effective in reducing root-knot index and eggmasses of *M.incognita* and *M. javanica* infecting tomato plants and improving plant growth as compared with untreated(Jain 1990; Stephan *et.al.*, 1990; El Shoura *et.al.*, 1992; Grico *et.al.*, 1992; Rathore 1995 and Sharma *et.al.*, 1996) . Zaki and Maqbool (1995) found that rugby , tenekil and furadan significantly reduced *Meloidogyne* infection on tomato plants. Deabes (1996) stated that aldicarb, oxamyl and fenamiphos markedly reduced the number of second stage larvae and galls of *M. incognita* infected tomato plants in comparison with untreated control and he added that aldicarb was the most effective nematicide followed by fenamiphos and oxamyl. D'Errico *et.al.*, (2000) studied the effect of ethoprophos and fenamiphos in controlling the root-knot nematode *M.incognita* in tomato. They repoted that all treatments increased yield, stimulated plant growth and lowered the nematode number in soil . Meher *et.al.*, (2001 and 2003) proved that cadusafos at (0.25 or 0.50 Kg a-i./Ka) and (2.0Kg a.i. /ha,1.0 Kg a.i / ha and 0.5 kg a.i. / ha) at different application methods against *M.incognita* infested tomato plants and recorded that all application of cadusafos reduced population of the root-knot nematode in the soil .

The objective of this study is to study the effect of three nematicides i.e. corbofuran , fenamiphos and oxamyl at three rates of application in controlling the root-knot nematode *Meloidogyne incognita* infecting tomato plants grown in three soil types under greenhouse conditions30±5^{o}C .

MATERIALS AND METHODS

Tomato (*Lycopersicon esculentum* Mill) seeds, c.v. Super Strain B were supplied by the Ministry of Agriculture of Egypt . Three types of soil with different characteristic were used , these were clay , clay loam and sandy soils .They were obtained from Itay EL Baroud , Kafr EL Zayat and Nubaria districts. Physical and chemical characteristics of these soils are presented in Table (1) .

Three commercial formulations of nematicides were used , the trade , common and chemical names of these nematicides are shown in Table (2). 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 ^{o}C (1.3 to 1.4 Lb pressure) was reach and then holding the temperature at 90 – 110 ^{o}C (1.1 to 1.4 Lb pressure) for one hour according to a method described by Knudsen and Bin (1990) .

T1

Table (2): List of The Tested Nematicides.

Trade name	Concentration and Formulation	Common name	Chemical name (IUPAC)	Rate / Kg soil
Furadan	10% Granules	Carbofuran	2.3 – dihydro – 2.2 dimethylbenzofuran -7- yl methyl Carbamate	1- 100mg 2- 200mg 3- 300mg
Nemacur	10% Granules	Fenamiphos	Ethyl 4- methlthion – m – tolyl is opropylphosphoramidate	4- 100mg 5- 200mg 6- 300mg
Vydate	10% Granules	Oxamyl	NN- dimethyl -2- methyl carba – moyloxyimino -2- (methylthio) acetomide	7- 100mg 8- 200mg 9- 300mg

According to International union of Pure and Applied chemistry.

The seeds of tomato were sown in nursery and after three week , the seedlings were transplanting to pots contains 1.0 Kg of sterilized soil of each soil type under study. Each pot was planted with tow seedlings and one week later thinned to one . Each treatment was replicated four times. Each, seedling pot was inoculated with 1000 fresh newly hatched of secondstage juveniles of *Meloidogyne incognita* . Three days later , the dose of each tested nematicide 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^{o}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 Byd ea al., (1983). Stained roots were examined and numbers of developmental stages and females were recorded. Nematodes were then extracted form 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 egg mass were also counted. The percentage reduction of these values was also calculated . Nematode final population , nematode reproduction, percentage of nematode penetration and percentage of nematicidal efficey was also calculated according to Norton (1978) as follow:

$$\text{Reproduction factor (RF)} = \frac{\text{Final population}(P^f)}{\text{Intial population}(P^i)}$$

$$\text{Nematicide efficieny (NE)} = \frac{\text{control}(R^f) - \text{treatment}(R^f)}{\text{control}(R^f)} \times 100$$

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

RESULTS AND DISCUSSION

The effect of the tested nematicides i.e. carbofuran, fenamiphos and oxamyl i.e. 100, 200 and 300 mg/kg soil/pot at three rates of application on penetration, development and reproduction of the root knot nematode *M. incognita* infecting tomato plants grown within three soil types under green house conditions at 30±5^{o}C are presented in Table (3) and Fig. (1).

Table (3): Effect of the tested nematicides on development and reproduction of the root knot nematode *Meloidogyne incognita* infecting tomato plants grown in different soil typs under greenhouse conditions 30±5 °C.

Treatments	Dose of application mg/kg soil	% rate of nematode penetration	No. of galls/ root *	No. of eggs /egg mass*	Nematode Final population	Nematode repro-duction (RF)	Nematicidal efficacy
				Clay Soil			
Furadan 10%G (carbofuran)	100	6.3	48 b	262 b	6327	6.32	69.18
	200	4.2	36 c	256 b	4122	4.12	79.91
	300	3. 3	26 d	260 b	3659	3.66	82.15
Nemacur 10%G (Fenamiphos)	100	2.9	25 d	172 c	1910	1.91	90.69
	200	2.4	17 e	154 d	1860	1.86	90.93
	300	1. 7	17 e	105 g	953	0.95	95.37
Vydate 10%G (oxamyl)	100	2.5	20 e	142 e	1294	1.29	93.71
	200	1.7	17 e	131 e	1057	1.06	94.83
	300	1. 3	12 f	118 f	1066	1.06	94.83
Check	------	13.6	83 a	284 a	20512	20.51	——
				Clay Loam Soil			
Furadan 10%G (carbofuran)	100	4.8	42 c		7062	7.06	69.02
	200	4. 2	33 d	335 a	5946	5.95	73.89
	300	2.8	23 e	329 a	4176	4.18	81.66
Nemacur 10%G (Fenamiphos)	100	3.2	30 d	320 a	2608	2.61	88.55
	200	2.2	17 f	185 c	1282	1.28	94.38
	300	1.8	16 f	141 e	781	0.78	96.58
Vydate 10%G (oxamyl)	100	5. 5	50 b	110 f	3403	3.40	58.08
	200	4.7	40 c	187 c	2627	2.63	88.46
	300	1.6	15 f	173 cd	958	0.96	95.79
Check	------	14.2	77 a	158 d 303 b	22972	22.79	——
				Sandy Soil			
Furadan 10%G (carbofuran)	100	9.2	72 b	355 ab	23456	23.46	58.96
	200	8.7	64 c	342 b	21911	21.91	61.67
	300	7. 4	55 d	343 b	20594	20.59	63.98
Nemacur 10%G (Fenamiphos)	100	7. 0	39 f	193 c	9670	9.67	83.08
	200	5.3	34 f	172 cde	6551	6.55	88.54
	300	3.5	24 g	147 e	3247	3.25	94.31
Vydate 10%G (oxamyl)	100	5.3	47 e	189 de	6257	6.26	89.05
	200	4.5	38 f	168 cde	4714	4.71	91.76
	300	3.4	24 g	162 cd	4042	4.04	92.93
Check	------	23.1	133 a	378 a	57158	57.16	——

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

Results revealed that regardless of the tested soil types all tested nematiciedes at any dose of application greatly reduced penetration of nematodes , number of galls per root , number of eggs per egg mass , nematode final population and nematode reproduction as compared with that of the untreated plant .

F1

Significant differences ($P \leq 0.05$) in number of galls per root and number of eggs per egg mass were found between all tested treatments and the untreated once of each soil type. However, such nematode values decreased gradually with increasing the dose of nematicides in the three soil types. Oxamyl gave the best results in reducing the rate of nematode penetration and such nematode criteria at any dose of nematicide added, followed by those of fenamiphos and carbofuran in sandy soil . In clay loam soil, fenamiphos at 200 and 300 mg/kg soil showed the highest percentage of reduction in nematode penetration, galls / root system, eggs / egg mass and nematode reproduction followed by oxamyl at 300mg / kg soil with values of 2.2 % , 77.9 % , 53.5 % and 1.28; and 1.8% , 79.2% , 63.7 % and 0.78; and 1.6 % , 80.5 % 47.9 % and 0.96, respectively . In clay soil , Oxamyl at all doses of application gave the highest effect on rate of nematode penetration percent, reduction of galls per root , eggs per egg mass and nematode reproduction, followed by fenamiphos at all doses and carbofuran at dose of 300 mg / kg soil, respectively .

Concerning the nematicidal efficacy data presented in Table(3) clearly indicated that the nematicidal efficiency of the tested compounds varied between nematicides and between soil types. Cabofuran gave the lowest effect in all tested soil types, whereas, fenamiphos and oxamyl gave the highest effects in clay, clay loam and sandy soils, respectively. In clay loam and sandy soils, oxamyl showed the in best results controlling nematode parameters at 100 and 200 mg/kg soil, followed by fenamiphos whereas the lowest values were recorded by carbofuran. At the dose of 300 mg / kg soil of carbofuran nematicide gave relatively good results in clay and clay loam soil with values of 82.15 and 81.66, respectively (Table 3).

Data presented in Fig.(2) indicated that all tested nematicides improved plant growth parameters as compared with untreated one. Likewise, the same trend was observed in all soil types. The highest percentage increase in lengths and fresh weight of both shoots and roots of tomato plants was obtained in plant grown in clay soil as compared with other tested soil types. In sandy soil, fenamiphos at the higher doses gave the highest increase percentages in plant growth parameters, followed by those of oxamyl. Meanwhile, fenamiphos showed the same trend in plant growth of clay loam soil.

Generally, the rate of nematode penetration of the root-knot nematode *M. incognita* on tomato plants was higher in sandy soil and varied between other tested soil types. *M. incognita* was sensitive to some nematicide than others. The efficiency of the tested nematicides varied between tested soil types with the same compound. The higher effectiveness of the tested nematicides in increasing lengths and fresh weight of both shoots and roots of tomato plants was evident in clay or clay loam than sandy soil. These maybe attributed to the present of organic matter or plant nutrient in clay or clay loam soils with great amount than sandly soil (Table 1).

F2

These present findings are in agreement with those obtained by Wallace (1964) who stated that the influence of soil type on nematode is a highly complex problem because the physical and chemical factors of soil vary so much between localties even where the textural composition of the soil is more less similar. Schuman (1976) found that carbofuran and methomyle gave better control of *M. javancia* infecting tomato plants and reduced the number of galls and larvae in loamy sand more than sandy loam and clay loam. Ramdu (1979) also indicated that the activity of pesticides in soils is largely controlled by the adsorption of the same by soil component . He further added that clay is considered to be the most reactive part of the soil and said that quantity, nature of clay, surface area, soil structure, organic matter, water content, quality of pesticides, temperature and pH of the pesticides and soil largely influence the efficiency of the pesticides applied to the soil . In addition to mineral fraction of soil, soil organic matter also influences considerably the adsorption of the pesticides in soils. Moreover, results of the present investigation on the efficiency of such tested nematicides in controlling *M. incognita* infecting tomato are in accordance with those reported by Abuoul – Eid and Youssef (1993) in respect to fenamiphos on number of eggs/eggmass and number of 2nd stage juveniles of *M. incognita* infecting tomato plants ; and Murthy and Rao (1994) in respect to the efficiency of aldicarb, carbofuran and phorate on *M. incognita* in betelvine. Deabes (2005) reported that rate of reproduction of *M. incognita* was high in sandy loam than loam soil.

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المكافحة الكيميائية لنيماتودا تعقد الجذور "ميلودوجينا إنكوجنيتا" التي تصيب نباتات الطماطم النامية في انواع مختلفة من التربة.

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تمت هذه الدراسة بإستخدام ثلاث أنواع من المبيدات النيماتودية و هي (مبيد الفيورادان – مبيد النمياكور – مبيد الفايديت) لمكافحة بيماتودا تعقد الجدور مليودوجينا انكوجنيا التي تصيب نباتات الطماطم التي زرعت في ثلاثة أنواع مختلفة من التربة وهي (تربة طينية – تربة طينية طمييه – تربة رملية) . ولقد أوضحت لنتائج ما يلي :

إن كل المبيدات النيماتودية المختبرة قد أدت إلي انخفاض كبير في معدل اختراق النيماتودا لجذور نباتات الطماطم وكذلك عدد العقد النيماتودية المتكونة على الجذور وعدد البيض داخل كيس البيض وكذلك التعداد النهائي لأفراد النيماتودا ومعدل تكاثرها على جذور نباتات الطماطم (Super Strain B) وذلك عند مقارنتها بالنباتات غير المعاملة . وقد وجد أن هذا الانخفاض يزداد بزيادة معدلات الإضافة في كل المبيدات النيماتودية المختبرة .

كما اوضحت النتائج أيضا أن مبيد الفايديت قد أعطى أعلى نتائج لانخفاض تعداد النيماتودا يليه مبيد النيماكور ثم مبيد الكاربوفيورام و ذلك في التربة الرملية- بينما أعطي مبيد النيماكور عند معدل أضافه ١٠٠- ٢٠٠ ملجم / كجم تربة أفضل النتائج في التربة الطينية الطميية – و قد أعطي مبيد الفايديت بكل معدلات الإضافة أفضل النتائج يليه مبيد النيماكور بكل معدلات الإضافة يليه مبيد الفيورادان عند معدل إضافة ٣٠٠ ملجم / كجم تربة في التربة الطينية .

علاوة على ذلك فقد أدت كل معاملات المبيدات النيماتودية المختبرة إلى تحسن في نمو نباتات

الطماطم وذلك عند مقارنتها بالنباتات غير المعاملة – وقد كانت أعلى نسبة مئوية للزيادة في نمو النباتات في التربة الطينية وذلك عند مقارنتها بالمعاملات الأخرى المختبرة من التربة . و بناء علية ينصح عند المكافحة الكيماوية لنباتات الطماطم المصابة بنيماتودا تعقد الجذور في الأراضي الرملية المستصلحة استخدام مبيد الفايدت يلية مبيد النيماكور.

Table (1) : Some Physical and chemical properties of the tested soils.

Source of Soil Samples	PH	Org-nic mat-er %	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 district	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