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Control of nematode parasites of potato with certain pesticides and their persistence in soil

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ABSTRACT

A field experiment at Dakhleya, Governorate was carried out to evaluate the efficiencies of four nematicides namely; ethoprophos, cadusafos, oxamyl and fenamiphos and the fungicide, pencycuron against two genera of nematodes; *Meloidogyne Tylenchorhyenchu*s, in addition to the citrus nematode, *Tylenchulus semipenetrans* on potato, where potato was cultivated under grapevine trees. Nematicides gave satisfied reduction in the population densities of nematodes during the experimental period. Ethoprophos offered the best efficiency against the nematodes, where the reproduction rates of nematodes were low. Oxamyl and fenamiphos gave also good control. A comparative study was conducted on the persistence of ethoprophos and pencycuron in soil and in potato tubers. Residues analysis data showed that the initial deposits of the ethoprophos and pencycuron in the upper 10 cm of the soil surface were relatively high. Ethoprophos showed rapid decrease to 2.56 ppm within 10 days after application revealing 91.49 % loss. Graduated dissipation of the applied ethoprophos from soil surface was noted through the following intervals. Ethoprophos residues were 0.02 ppm showing 99.93 % loss after 90 days. On the other hand, pencycuron residues were more stable than ethoprophos under experimental conditions and recorded a percentage loss of 31.98 after 10 days from treatment, while after 90 days the residues was 0.05 ppm, showing 99.93 % loss. No residues of ethoprophos could be detected in potato tubers at harvest (90 days after application), while 0.135 ppm pencycuron residues were found in outer covering of potato tubers after 90 days of application. According to the rate of dissipation, the estimated half-lives of the ethoprophos and pencycuron in soil were 62.7 and 90.07 hrs, respectively.

Keywords: Plant-parasitic nematodes, potato, control, nematicides, residues, population densities.

INTRODUCTION

The genus *Solanum*, which contains the cultivated potato and over 2000 other species, is distributed essentially all over the world except for the polar regions (Hawkes, 1978). The potato is an annual plant but usually subsets from year to year vegetatively as tubers, which are enlarged portions of underground stems adapted to storage of photosynthates. Potato, *Solanum tuberosum* L. is an important crop in Egypt especially as an export commodity. At least 68 species representing 24 genera of plant parasitic nematodes have been found associated with potato culture (Jensen *et al.*, 1979).

The nematodes may be major pests in their own right but also cause economic problems when they interact with other disease organisms to cause more severe crop damage and they transmit viruses to potatoes (Brodie *et al.*, 1993). Non-fumigant nematicides are used to protect the crop from damage and to produce a profitable yield of potatoes in the presence of the nematode (Trudgill *et al.*, 1987).

For many years, the fate of pesticides in the environment was considered to be synonymous with the fate of pesticides in soil. The concept has changed in recent times and now includes interaction with air, water, non-target plants, animals and micro-organisms. However, soil still constitutes a major environmental compartment. Persistence and degradation of pesticides in soils have been the subjects of many research projects (Jakes and Suetts 1992; Mora *et al.*, 1996 and Trabue *et al.,* 1997). When a pesticides reached the soil, its fate is depended on a host conditions including soil type, pH, organic matter, mineral contents, moisture, the nature of the soil colloids, the flow of liquid and air through the soil. In addition, the amount of cultivation, plant growth present and the exposure to environmental parameters, such as wind, sunlight, rain, temperatures, humidity, etc. (Hirahara *et al.,* 1997 and Jones and Norris 1998).

The purpose of the present investigation was planned to study the effect of ethoprophos, cadusafos, oxamyl, fenamiphos and pencycuron on the population densities of three nematode genera. The persistence of ethoprophos and pencycuron in soil and potato tubers was also studied.

MATERIALS AND METHODS

1. Treatments, soil sampling and nematodes extraction: - In 2006, plots were established in a grower's field that has been in a potato cultivar's Spunta, which was cultivated under grapevine trees, on April 1. The soil type studied in Dakhleya, Governorate, was found to be a sandy clay loam. Mechanical and physical characteristics of studied soil are presented in Table (1).

Table (1): Physical and chemical characteristics of studied soil.

Location	Particle size distribution								Organic matter %
	Coarse Sand %	Fine Sand %	Silt %	Clay %	$CaCO_3$	Texture			
15 cm	4.85	45.99		28	3.4	Sandy clay loam			2.56
Soluble anions (meg/100 g soil)				Soluble Cations (meg/100 g soil)					pH
HCO_3	SO_4	CL	CO_3	Ca^{++}	Mg^{++}	Na^{+}	K^{+}		
0.52	1.2	1.29	--	0.7	0.52	1.2	0.6		8

There was one untreated check and four granular nematicides namely; ethoprophos (Mocap) 10 % at 30 kg / fed. Cadusafos (Rugby) 10 % at 30 kg / fed, oxamyl (Vydate) 10 % at 20 kg / fed and fenamiphos (Nemacur) 10 % at 20 kg / fed as well as one fungicide namely; pencycuron. (Monceren) 25 % S.D at 16 kg / fed.

Each plot of control, ethoprophos and pencycuron was 7.0 X 7.0 meter while plots of cadusafos, oxamyl and fenamiphos were 14 X 7 meter. The experimental design was a randomized complete blocks with four replicates. Soil samples were taken just before nematicides application on April 16, then at four-week intervals till harvest. A shovel was used to obtain soil and roots from a depth of 15 – 30 cm. Samples were collected from 2-3 locations within each replicate. Soil samples were placed in plastic bags to prevent drying, kept out of the sun, and transferred in insolated containers (ice box) to prevent overheating (Barker, 1985). Samples were pooled; carefully hand-mixed and 150 cm^3 subsamples were extracted for 72 hrs on Baermman trays (Townshend, 1962 and 1963). Three replicates of 500 cm^3 subsample were also recovered for 72 hrs, by using the Baermman funnel technique.

2. Sampling for residue analysis: Field experiments were conducted in separate areas of potato tuber during the 2006 season at Dakahlea, Governorate. The whole area of experiments was 900 m^2. This experiment was carried out in a separate area of 300 meters for each one. Two experiments of them were done by sawing the granules of 10 % ethoprophos and 25 % pencycuron at the rate of 30 and 16 Kg / feddan, to depth of about 10 cm at the tops of soil. The third soil area was left untreated as control check.Irrigation was done immediately with 15 days interval after soil treatments.

2.1. Soil: The initial (zero times) samples of the treated were taken to depth of 10 cm from the tops of the treated soil one hr after application, before and after irrigation. Regular soil samples were collected at intervals of 4, 10, 20, 34, 45, 60, 70 and 90 days after pesticides application.

2.2. Potato tubers: Three samples of full-grown potato tubers were taken randomly. Each sample consists of five potato tubers. Samples from untreated soil were taken in the same time to study its contamination by tested pesticides and rate of recovery. Sub-sampling was done by removing outer covering of potato tubers, samples were kept at -20 ^{o}c in nylone bags until time of analysis.

3. Residue analysis techniques:

Extraction of ethoprophos and pencycuron from soil: The adapted methods of Kruse et al. (1986) was followed through partioning by chloroform, 100 g soil was shaken mechnically with 200 ml of acetone–water (3:1 V/V) for one hr in 500 ml glass stopper bottle. The extract was carefully decanted and filtered through a clean pad of cotton, evaporated using a rotary evaporator on a water bath at 40 ^{o}C to remove acetone and then extracted twice with 100 ml chloroform, the combined chloroform was dried through anhydrous sodium sulfate and then evaporated near dryness at 40 ^{o}C using a rotary evaporator. Then the residues of ethoprophos were determined using Gas Liquid Chromatograph (Mollhoff, 1975 and Abu-Zahw *et al.,* 1988).

One hundred grams of representative soil sample were transferred into a 500 ml flask and 10 g of anhydrous sodium sulfate were added. The samples were extracted with 200 ml chloroform by shaking the flask on an electric shaker for one hr. The extract was left for 10 minutes to settle and then

filtered through a piece of washed cotton into 250 ml-graduated cylinder. A known volume of the filtrate was taken and evaporated under vacuum in a rotary evaporator to dryness. The residues of pencycuron were ready to chromatographic determination using high performance liquid chromatography.

Extraction of ethoprophos and pencycuron from potato tubers: The tested pesticides were extracted from potato samples (100 g of peeled, unpeeled and outer covering of potato tubers) using the same method of soil samples as described above.Then the residues were ready to chromatographic determination.

4. Chromatographic conditions: Quantitative analysis of ethoprophos residues were performed by gas liquid chromatograph (GLC) HP 6890 serial equipped with flame photometric detector (FPD) operated in the phosphorus mode (529 nm filter) under the following condition: Capillary column PAS 1701 (30m x 0.32mm x 0.52mμ), detector temperature: 250 ^{o}C, Injector temperature: 245 ^{o}C and Oven temperature program: initial temp. 160 ^{o}C for 2min., rise 10 ^{o}C / min., final temp. 240 ^{o}C. Hold time 8 min. Nitrogen carrier gas: 3 ml/min., Hydrogen flow 75 ml/min. Airflows 100 ml/min. Under these conditions, the retention time for ethoprophos was 5.1min. Quantitaive analysis of pencycuron residues were performed by high performance liquid chromatography (HPLC). Agillent 1100 series with work solution, the wave length set at 254 nm the analytical column Nucleosil-C_{18}, sum (4 x250nm) was used. The mobile phase was acetonitrile–water 30:70 at flow rate of 1m/min. The retention time of pencycuron under these conditions was 3.2 min.The reliability of the analytical methods was examined by fortifying untreated soil and potato tuber samples with known quantities (1 ppm) of tested pesticides, followed by the same procedure of analysis. The results were calculated on the soil dry weight bases and fresh potato tuber. The data adjusted by the rates of recovery percentages.

The rates of recovery of ethoprophos and pencycuron in soil and potato tubers were (97.88 and 100 %) and (100 and 98.23 %), respectively.

RESULTS AND DISCUSSION

1. Nematode control : Data in Table (2) indicated that the population of the citrus nematode, *T. semipenetrans* was the dominant and the highest that is

obviously due to the presence of grapevine trees. All chemicals used offered different reduction in this nematode population. Oxamyl and ethoprophos gave efficiency better than the others, where achieved 0.25 reproduction rates for each. The other genera were less in initial population and then, increased noticeably at the last period of the experiment.

Meloidogyne nematode forms the important and economic nematode genera. Ethoprophos and pencycuron were the best, where they achieved less reproduction rates (0.56 and 0.48), respectively of the *Meloidogyne* nematode. *Tylenchoryhenchus*, was recovered from the soil tested as a third genus. Ethoprophos and fenamiphos gave the least reproduction rates (0.33 and 0.55), respectively. However *Ditylenchus* and *Helicotylenchus* nematodes were appeared with valuable populations during extraction throughout the experiment but in different months. They were considered out of control and out of data. O Bannon *et al*. (1966) and Hamid *et al.*, (1988) reported that low soil temperatures in winter reduce developmental and reproductive rates and result in population declines.

2. Residues of ethoprophos and pencycuron in soil and potato tubers: Data in Table (3) showed that the initial deposit of ethoprophos residues in the soil surface was 30.10 ppm after one hr of application and before irrigation, then decrease rapidly to 7.08 ppm, showing 76.47 % Loss within four days. The decline in residual amounts continued after 45 and 60 days, gave 0.31 and 0.10 ppm with 98.97 and 99.66 % loss, respectively. After 90 days, the recovered of ethoprophos residues was 0.02 ppm (99.93 % loss). The calculated half-life value of ethoprophos in the soil surface was about 62.7 hrs. Also, the residues data of pencycuron indicated that the initial deposit of pencycuron in soil surface was 72.93 ppm after one hr of application and before irrigation. The residues declined to 34.06 (53.29 % loss), after four days.

After 60 and 70 days from application, the recovered of pencycuron residues were 6.93 and 2.07 ppm with 90.94 and 97.16 % loss, respectively. On the other hand, 0.05 ppm residues were detected after 90 days from application. The rapid dissipation of the residues of ethoprophos and pencycuron from the soil through the few weeks could be attributed to the removal from the soil as a result of volatilization, evaporation, irrigation,

Table (2): Population densities of recovered nematodes , their reproduction rates and the nematicides efficiencies against those nematodes.

Pesticide		Genera														
		Tylenchulus					*Tylenchorhynchus*					*Meloidogyne*				
		16/11	17/12	20/1	20/2	Mean	16/11	17/12	20/1	20/2	Mean	16/11	17/12	20/1	20/2	Mean
Control	PD	700	200	240	370	378	130	90	60	170	113	200	60	140	90	123
	Rr		0.28	0.34	0.53	0.38		0.69	0.46	1.31	0.82		0.3	0.7	0.45	0.48
Ethoprophos	PD	600	280	160	300	355	340	140	60	140	170	240	200	140	230	202
10 % GR	Rr		0.47	0.27	0.5	0.25		0.41	0.18	0.41	0.33		0.59	0.41	0.68	0.56
30 kg / f.								40.6								
Monceren	PD	200	460	60	230	237	140	170	200	180	173	460	200	200	210	268
25 % WP	Rr		2.3	0.3	1.15	1.25		1.2	1.4	1.29	0.87		0.44	0.43	0.47	0.45
4g /1 m2																
Cadusafos	PD	400	140	140	270	238	130	170	60	170	133	140	60	60	130	98
10 GR	Rr		0.35	0.35	0.67	0.46		1.31	0.46	1.31	1.03		0.43	0.42	0.93	059
30 kg /f.																
Oxamyl	PD	2200	540	460	630	958	300	400	60	200	240	100	70	60	90	80
20 kg/f.	Rr		0.25	0.21	0.29	0.25		1.33	0.2	0.67	0.73		0.7	0.6	0.9	0.73
Fenamiphos	PD	100	340	60	160	165	500	460	140	230	332	80	80	60	170	97
	Rr		3.4	0.6	1.6	1.87		0.92	0.28	0.46	0.55		0.8	0.6	1.7	1.03

PD= Population density Rr = Reproduction rate

Table (3): persistence of ethoprophos and pencycuron in soil.

Days after application	Ethoprophos		Pencycuron	
	Residues found (ppm)	% loss	Residues found (ppm)	% loss
Initial after irrigation	30.10	0.00	72.93	0.00
1hr	22.2	26.24	52.43	28.35
4	7.08	76.47	34.06	53.29
10	2.56	91.94	31.98	56.15
20	1.47	95.11	22.35	69.95
34	0.511	98.30	18.46	74.68
45	0.31	98.97	10.62	85.46
60	0.10	99.66	6.93	90.49
70	0.08	99.73	2.07	97.16
90	0.02	99.93	0.05	99.93
Rl_{50} (hrs)	62.7		90.07	

chemical and microbial degradation (Gruzdyev *et al.*, 1983). The data also showed that the dissipation of ethoprophos residues were more than pencycuron, this may be due to the alkalinity of the tested soil and irrigation water where as the ethoprophos is rapidly degraded in alkaline media (Nasr, 2001) and (Soliman *et al.*, 2005). These results agree with those found by Smelt *et al.* (1977) who reported that the loss of ethoprophos approximated to first order kinetics and the half-life ranged between 14 and 28 days in a sandy loam and loam soil with pH of 7.2 and 7.3, respectively. Analysis of potato tuber samples collected from potato-treated soil showed that, no residues of ethoprophos were found in samples taken from treated potato tubers after 90 days from application. These results are in agreement with that found by Nasr, (2001) who showed that no residues detected in orange fruits taken from orchard treated with ethoprophos after 180 days from treatment. Meanwhile 0.135 ppm of pencycuron was detected in outer covering of potato tubers. This result is coincide with El-Morshedy *et al.* (1990) who found that the residue of cadusufos in potato tubers taken from treated soil at the harvest (12 weeks) was 0.027 ppm.

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