

Effect of Various Herbicides on Root-Knot Nematode (*Meloidogyne incognita*) and Growth Parameters of Tomato

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ABSTRACT

Nematicidal properties of 13 herbicides viz. alachlor, glyphosate, thiobencarb, diphenamid, monolinuron, paraquat, diquat, MCPA, diallate, oxyfluorfen, 2,4-D, amitrole and dichloromate, including furadan and nequon, were assayed against *M. incognita* in tomato. The result of the direct contact toxicity revealed a higher percentage of mortality in diallate, dichloromate and monolinuron along with nequon. However, in the pot experiment, none of the chemicals, except diallate, resulted neither in reducing the population of nematodes nor in increasing the plant growth parameters. Diallate which resulted in higher percentage of mortality of second stage larvae, reduced the population in soil as well as in root, decreased root-knot index and increased growth parameters of plant suggesting high nematicidal properties against *M. incognita*.

INTRODUCTION

Chemical control of *Meloidogyne incognita* with nematicides is very much limited due to high cost and unavailability

of the products in the market. Various other chemicals such as insecticides and herbicides have been tried by several workers (Witkowski, 1971, 1973, Frey, 1976, Johnson, *et al.*: 1975, 1981, Schmitt, *et al.* 1981, 1983 and Osman and Viglierchio, 1981) to suitably control plant parasitic and other nematodes. Very few of the herbicides have been systematically tested against nematodes. The present investigation undertakes 13 herbicides commonly used against weeds of vegetables along with two nematicides for assessing their effectiveness in direct exposure as well as in pots with tomato plants inoculated with *M. incognita*.

MATERIALS AND METHODS

Thirteen herbicides viz. alachlor, glyphosate, thiobencarb, diphenamid, monolinuron, paraquat, diquat, MCPA, diallate, oxyfluorfen, 2,4-D, amitrole and dichloromate, including two nematicides such as furadan and nequon, were tested at 250, 500 and 1000ppm for direct contact mortality of *M. incognita* larvae. Stock solutions of each chemical was prepared with distilled water and was further diluted. Each test chemical was filled in transparent homoeopathic tube at 2ml of the double strength as per desired concentration and approximately 100 freshly hatched second stage larvae in 2ml of suspension were released into each homoeopathic tube. Mortality after 24 and 48 hours were recorded and expressed as corrected percentage over control. The nematicidal activity was subsequently tested by inoculating

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1500 larvae per 1.5 kg of soil in pots at three different doses viz., 1, 1.5 and 2 kg a.i./ha. One week old tomato seedlings were transplanted seven days after the application of chemicals. Both the experiments were carried out in a complete randomized block design with two replications. The data on root-knot index (1-5 scale, Taylor, 1971), population of nematodes (Soil + root), root and shoot weight and length were recorded at 60 DAT

RESULTS AND DISCUSSIONS

Direct Contact Mortality

Varying degree of larval mortality was obtained due to exposure in herbicides (Table I). Thiobencarb, 2,4-D and furadan resulted in reduced percentage of mortality as compared to control. Neguvon, dichloromate, diphenamid and diallate showed increased mortality in 24 hours. The other chemicals did not show significant mortality of larvae. After 48 hours, monolinuron, dichloromate, diallate and neguvon were found to be most effective in the increasing order. Monolinuron, after 24 hours, showed a negligible percentage of mortality but after 48 hours recorded higher percentage of mortality in all the three concentrations. Diphenamid, which resulted in higher percentage of mortality after 24 hours, was not effective after 48 hours, indicating less persistency of the chemical in the active form. Dichloromate and diallate consistently resulted in higher percentage of mortality both in 24 and 48 hours along with neguvon. These two herbicides resulted in increased mortality with the corresponding increase in the concentration and time even at their lower concentration. Furadan treated larvae in all concentrations tried, noted very much negligible effect on the mortality of larvae.

Frey (1976, 1979) observed a higher

percentage of kill of *Acrobelloides butschlii* in paraquat, diquat and amitrole which is in contradiction to the present findings and may be explained in terms of differential behaviour of the nematodes used, the former being a plant parasite whereas the latter is a predatory one. Krishnaprasad and Rao (1980) observed ineffectiveness of furadan in direct contact method against *M. graminicola* which is in agreement with the present findings and hence is not effective as a direct toxicant.

Pot Experiment

Observations on various plant growth parameters such as shoot and root length (Table 2), shoot and root weight (Table 3) indicated significant differences among various treatments except in shoot weight. Alachlor, monolinuron, paraquat, diquat, MCPA, oxyfluorfen, 2,4-D, amitrole, dichloromate and neguvon applied plants had comparatively a reduced shoot length over control. Thiobencarb, diallate and furadan at all the three doses exhibited increased shoot length.

The highest root length was observed at lowest dose of these chemicals. Data on root length indicated monolinuron and 2,4-D to be the most ineffective one, exhibiting a reduced root length. Rest of the chemicals showed increased root length over control. Furadan, diallate, thiobencarb, alachlor and glyphosate showed comparatively higher root length than others.

Shoot weight as influenced by the application of different herbicides showed statistically non-significant differences. However, furadan and diallate-treated plants at all the three doses exhibited a comparatively higher mean shoot weight. Root weight in furadan, diallate and thiobencarb was higher than others and all these chemicals at lower

TABLE 1 Effect of various herbicides on percentage mortality of *M. incognita* larvae.

Conc./Chemical	24 hrs			48 hrs		
	250ppm	500ppm	1,000ppm	250ppm	500ppm	1000ppm
Alachlor	8.45 (16.89)	52.26 (46.30)	44.40 (41.79)	49.21 (44.54)	22.27 (28.19)	63.50 (52.83)
Glyphosate	73.42 (58.92)	7.98 (16.42)	13.09 (21.13)	6.06 (14.24)	43.85 (41.46)	27.05 (31.34)
Thiobencarb	3.45 (10.67)	2.20 (8.43)	3.01 (10.04)	-5.47 (-13.50)	0.64 (4.59)	1.35 (6.66)
Diphenamid	95.83 (78.26)	94.67 (76.66)	96.68 (79.49)	8.70 (17.15)	6.25 (14.48)	14.32 (22.28)
Monolinuron	1.00 (5.74)	21.74 (27.78)	81.57 (64.57)	83.76 (66.21)	95.17 (77.30)	96.53 (79.26)
Paraquat	0.45 (3.84)	5.45 (13.50)	0.35 (3.38)	0.45 (3.38)	0.46 (3.89)	7.50 (15.88)
Diquat	1.50 (7.04)	4.00 (11.53)	6.00 (14.13)	3.00 (9.98)	5.50 (13.53)	8.50 (16.94)
MCPA	3.60 (10.92)	23.89 (29.24)	55.96 (48.43)	35.14 (16.34)	60.97 (51.34)	83.82 (66.28)
Diallate	82.16 (65.01)	92.71 (74.34)	98.43 (82.79)	96.65 (79.45)	99.45 (85.75)	100.00 (90.00)
Oxyfluorfen	20.15 (26.66)	62.44 (52.20)	87.65 (69.42)	43.61 (41.32)	33.50 (35.38)	79.10 (62.79)
2,4-D	-2.16 (-8.45)	3.98 (11.72)	28.79 (33.48)	18.04 (25.13)	79.60 (63.15)	87.17 (69.02)
Amitrole	9.65 (18.10)	18.59 (25.52)	73.75 (59.13)	69.82 (56.67)	82.60 (65.34)	93.25 (74.94)
Dichloromate	94.58 (76.53)	98.33 (82.58)	99.71 (86.97)	94.78 (76.77)	97.65 (81.18)	99.73 (87.02)
Furadan	-0.49 (-4.01)	3.19 (10.20)	2.25 (8.61)	0.21 (2.63)	3.25 (10.38)	4.15 (11.75)
Neguvon	97.92 (81.71)	99.79 (87.66)	100.00 (90.00)	99.86 (87.91)	100.00 (90.00)	99.90 (88.19)

Figures in the parenthesis indicate angular transformed values

Chemical	SEM ±	CD at 5%	SEM ±	CD at 5%
Concentration	0.44	8.89	3.95	7.97
Chem. x Conc.	0.19	0.40	1.76	3.56
	0.77	1.55	NS	NS

Table 2 Effect of various herbicides on growth of tomato infected by *M. incognita*.

Dose/ha Chemicals	Shoot length (cm)			Root length (cm)		
	1.0kg	1.5kg	2.0kg	1.0kg	1.5kg	2.0kg
Alachlor	20.00	16.50	18.25	19.25	26.00	26.25
Glyphosate	25.75	23.75	25.75	29.25	28.50	25.50
Thiobencarb	31.75	26.50	28.00	23.50	23.00	16.25
Diphenamid	25.00	25.75	29.00	20.00	21.00	23.00
Monolinuron	14.50	14.50	23.50	9.50	10.50	12.50
Paraquat	21.75	23.25	24.00	15.50	29.50	13.00
Diquat	22.75	17.75	22.50	20.00	16.50	28.00
MCPA	14.25	15.75	23.00	11.25	13.00	19.00
Diallate	30.00	29.25	27.50	19.00	21.75	28.25
Oxyfluorfen	13.00	15.00	22.00	19.50	16.00	19.00
2,4-D	14.50	14.25	16.50	16.00	12.50	25.75
Amitrole	16.00	21.75	10.25	15.75	13.50	12.50
Dichloromate	18.25	24.50	16.25	18.75	21.00	11.50
Furadan	36.75	27.00	20.00	22.00	22.50	17.50
Neguvon	11.00	14.25	12.50	19.00	14.50	22.75
Check	23.25	—	—	18.41	—	—

	SEM +	CD at 5%	SEM +	CD at 5%
Chemical	0.20	0.41	0.22	0.45
Dose	0.09	0.18	0.10	0.20
Chem x Dose	0.36	0.72	0.39	0.79

Table 3 Effect of various herbicides on growth of tomato infected by *M. incognita*.

Dose/ha Chemicals	Shoot weight (g)			Root weight (g)		
	1.0kg	1.5kg	2.0kg	1.0kg	1.5kg	2.0kg
Alachlor	8.62	6.09	7.65	1.27	1.15	2.65
Glyphosate	9.95	9.05	8.65	1.55	2.25	2.65
Thiobencarb	9.77	9.30	7.97	3.87	1.45	1.95
Diphenamid	6.07	8.40	9.07	0.85	1.75	1.30
Monolinuron	1.75	1.70	5.50	0.70	0.75	1.70
Paraquat	4.17	5.75	7.32	1.45	0.85	2.15
Diquat	5.90	3.55	5.50	2.30	1.50	1.60
MCPA	4.00	4.07	8.80	1.45	2.05	2.95
Diallate	17.75	11.50	11.12	3.85	2.95	2.85
Oxyfluorfen	7.65	6.35	9.95	1.75	1.10	1.65
2,4-D	5.75	5.12	13.15	2.05	2.25	2.55
Amitrole	6.80	1.30	4.35	1.70	2.45	1.05
Dichloromate	8.07	13.25	7.12	0.95	3.70	2.00
Furadan	21.05	14.80	10.25	3.95	4.15	2.90
Neguvon	1.75	5.52	5.65	1.95	2.90	2.65
Check	11.32	—	—	2.45	—	—

	SEM +	CD at 5%	SEM +	CD at 5%
Chemical	NS	NS	0.04	0.08
Dose	NS	NS	0.01	0.03
Chemical x Dose	NS	NS	0.07	0.14

dose resulted into a better root weight. Alachlor, diphenamid, monolinuron, paraquat, diquat, and oxyfluorfen had reduced root weight than control.

All the chemicals at three different doses exhibited lower root-knot index than the control except thiobencarb at 2 kg a.i./ha. However, the root-knot index for chemicals and doses were not significantly different from each other. Alachlor, monolinuron and diallate at all the doses exhibited lower root-knot index consistently. However, paraquat at the lowest dosages recorded the lowest root-knot index and at increased dosages there was a corresponding increase in the root-knot index (Table 4).

Final nematode count (soil + root) in all the chemicals indicated lower population level than control. The final nematode population in thiobencarb, diphenamid, monolinuron, paraquat, MCPA, diallate, oxyfluorfen, amitrole, dichloromate, furadan and nequvon was lower than the initial inoculated population (1500 larvae/1.5 kg soil). At 1 kg a.i./ha diallate had lowest recorded population next to furadan (Table 4).

Schmitt (1972) reported MCPA to be effective against *Heterodera avenae* and *Pratylenchus* sp. in reducing the infestation which is in contradiction to the present findings. King, *et al.*, (1977) reported a similar trend by using some thiocarbamate herbicides which were not effective against *M. arenaria*. Osman and Viglierchio (1981) recorded reduced number of galls by application of glyphosate which is in agreement with the present findings.

Out of the tested herbicides, dichloromate and monolinuron caused direct mortality of *M. incognita* larvae significantly

higher than the other herbicides including furadan and hence possessed nematicidal properties. But these chemicals were not effective in reducing the root-knot index, final nematode population as well as in increasing plant growth parameters. All these properties were found only in diallate proving it to be a better nematicidal compound against *M. incognita* which can be used to control this nematode effectively.

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Table 4. Effect of various herbicides on root knot index and population development of *M. incognita* in tomato.

Dose/ha Chemical	Root knot index			Nematode population		
	1.0kg	1.5kg	2.0kg	1.0kg	1.5kg	2.0kg
Alachlor	2.0	2.0	2.0	1550.00 (3.190)	1276.50 (3.105)	1638.50 (3.214)
Glyphosate	2.5	3.0	3.5	693.50 (2.845)	2832.00 (3.451)	2430.00 (3.385)
Thiobencarb	4.0	2.5	3.0	352.00 (2.546)	626.00 (2.796)	1025.00 (3.010)
Diphenamid	2.0	2.5	2.5	901.00 (2.954)	462.00 (2.662)	550.00 (2.739)
Monolinuron	2.0	2.0	2.0	842.50 (2.924)	804.00 (2.905)	485.00 (2.685)
Paraquat	1.0	3.0	3.5	495.00 (2.694)	854.00 (2.931)	1370.00 (3.136)
Diquat	2.0	3.5	3.5	561.00 (2.748)	666.50 (2.829)	569.50 (2.754)
MCPA	2.0	2.5	3.5	1023.50 (3.009)	457.00 (2.607)	545.00 (2.736)
Diallate	2.0	2.0	2.0	416.60 (2.619)	1102.00 (3.041)	1203.00 (3.800)
Oxyfluorfen	1.5	2.0	1.0	676.50 (2.835)	196.50 (2.293)	707.50 (2.849)
2,4-D	3.5	3.0	2.0	807.00 (2.906)	2242.00 (3.350)	700.00 (2.845)
Amitrole	3.0	3.0	3.5	1182.00 (3.072)	760.00 (2.880)	653.00 (2.814)
Dichloromate	2.0	2.5	2.5	551.00 (2.740)	1257.00 (3.099)	518.00 (2.714)
Furadan	2.5	3.0	3.0	281.30 (2.447)	306.00 (2.485)	777.00 (2.890)
Neguvon	3.0	2.0	1.0	615.00 (2.788)	721.00 (2.857)	595.00 (2.777)
Check	4.0	—	—	4138.00 (3.616)	—	—

Figures in parenthesis indicate log transformed values:

	SEM +	CD at 5%	SEM +	CD at 5%
Chemical	NS	NS	0.011	0.023
Dose	NS	NS	0.005	0.010
Chemical x Dose	0.41	0.84	0.020	0.040

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