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Control of Root-Knot Nematode on Tomato Seedlings by Chemical Root-Dipping or Soil Application

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Abstract: Treatment of tomato seedlings with oxamyl significantly reduced their root-knot multiplication when inoculated with second stage juveniles of *Meloidogyne javanica* before or after root-dipping. A negative relationship between increasing oxamyl concentrations and number of root-galls/plant was observed and there were no remarkable differences amongst various concentrations of oxamyl-dipping periods. Oxamyl at 5 k ha^{-1} was more effective than aldicarb in suppressing multiplication of *M. javanica* when infested tomato seedlings were planted in soil treated with these chemicals. Application of chemical root-dipping technique in root-knot nematodes control especially in tomato transplants is discussed.

Key words: *Meloidogyne javanica*, root-knot nematodes, root-dipping, oxamyl, aldicarb, tomato seedlings, Sudan

INTRODUCTION

Root-knot nematodes are considered to be one of the most devastating agents affecting vegetable crops grown in Sudan (Yassin, 1974, 1978, 1979, 1984; Yassin and Zeidan, 1979, 1982). At present, nematicides use to control these pests are very frequent and stressed. The problem confronted with is how to apply these chemicals without any health hazard to develop the most appropriate method. The present resaerch is an attempt to search for such effective control measures and was undertaken to determine the efficacy of chemical root-dipping or soil application against *Meloidogyne javanica* a root-knot nematode infesting tomato seedlings.

MATERIALS AND METHODS

Studies were conducted at the Botany and plant pathology laboratory, Gezira Research Station (GRS), Wad Medani, Sudan. The chemicals used were oxamyl (Vydate 24% active ingredient liquid) for root-dipping treatment while oxamyl and aldicarb (Temik) 10% granules were employed for soil application. Tomato (*Lycopersicon esculentum* Mill. cultivar super Marmande) seedlings were grown in 20 cm diameter plastic pots containing steam- sterilized soil-compost mixture (3:1). Some seedlings 2 weeks old were transferred singly and grown in small plastic pots (7.5 cm diameter) containing the same soil-compost mixture and each pot was inoculated with 1000 freshly hatched second stage juveniles (J2) of the root-knot nematode, *Meloidogyne javanica* (Treub) Chitw. At the 4 weeks age, all the seedlings grown whether inoculated or uninoculated received root-dipping treatments in different concentrations of chemicals for the different exposure times. Two experiments were designed in a way that some pots received nematodes before root-dipping treatment (infested seedlings), while remaining others received inoculation after root-dipping treatment. In the third set of experiments, the multiplication of *M. javanica* in the infested tomato seedlings when planted in the treated soil was also studied. The description and experimental protocol of the 3 experiments are as follows:

Experiment 1: The nematode-infested tomato seedlings (in 7.5 cm diameter pots) of uniform size and same degree of galling were washed free of adhering soil particles and the whole root system was dipped (submerged) in aqueous solution of oxamyl for 10, 20 min, 1 and 6 h at the different concentrations of 1000, 5000, 10000 and 15000 μg a.i. mL^{-1}. Water dips without any added chemical were used as controls. Upon the completion of each dip treatment, the dipped seedlings were transplanted to 20 cm diameter plastic pots containing 1 kg steam-sterilized soil-compost mixture. Eight weeks later, the plants were uprooted, washed free of soil and multiplication of root galls was bioassayed.

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Experiment 2: Roots of the uninoculated tomato seedlings, which were originally raised in 20 cm diameter pots were separately dipped in oxamyl for the same periods and using the same different concentrations as mentioned in experiment 1. After the dip treatment the roots were thoroughly washed in running water and the seedlings were transplanted to 20 cm diameter plastic pots containing 1 kg steam-sterilized soil-compost mixture. Each seedling was then inoculated with 1000 J2 per pot. The water dip seedlings served as controls. Eight weeks after inoculation the plants were examined for the root-knot infestation.

Experiment 3: In this experiment, infested tomato seedlings with uniform size and number (11-20 galls/seedling) of root-knot galling were transplanted singly in 7.5 cm diameter plastic pots containing steam-sterilized soil-compost mixture already mixed with granular formulations o f oxamyl and aldicarb at 5 and 10 kg a.i. ha^{-1}. Infested seedlings were then transplanted in untreated soil and served as controls. Eight weeks later, the plants were washed free of soil and number of root-galls multiplied on the roots were recorded. In all these experiments, there were five replicate pots for each treatment and all arranged on a green house bench in a randomized manner with temperature maintained at 28± 2°C during the entire period of study.

RESULTS

Experiment 1: Root-dipping in various oxamyl concentrations significantly eliminated the multiplication of *M. javanica* from the roots of infested tomato seedlings (Table 1). It was shown that the numbers of root galls were suppressed with the increase in oxamyl concentrations. There were no differences between various root-dipping periods in each tested concentration of the chemical. The eradication was observed even in the lowest concentration of oxamyl (1000 µg mL^{-1}) for 10 min. exposure period. This indicated that the nematodes did not multiply further after root-dipping treatment. There was a highly significant difference ($p<0.01$) between 1000 µg mL^{-1} oxamyl concentration as compared to 5000, 10000 or 15000. On the other hand, insignificant differences were detected between 5000, 10000 and 15000 concentrations. Root-dipping for 10, 20 min or 1 in 1000, 5000 or 10000 µg mL^{-1} oxamyl concentration was not injurious to tomato seedlings. However, exposure time of 6 h in 15000 µg mL^{-1} oxamyl solution caused severe injury and was considered to be phytotoxic. Thus, the growth of all treated tomato plants improved with the concentration 1000, 5000 and 10000 µg mL^{-1} and this well correlated with the degree of root galls reduction. Seedlings dipped in 15000 µg mL^{-1} oxamyl for 6 h showed somewhat stunted growth despite the good reduction in root galls. In the undipped inoculated plants (controls), the nematodes multiplied and caused severe galling associated with death of the plants.

Experiment 2: The results of this experiment indicate that inoculation of the seedlings after root-dipping treatment also protected tomato plants against *Meloidogyne javanica* (Table 2). There were a highly significant differences ($p<0.01$) between the 1000 µg mL^{-1} oxamyl concentration compared to 5000, 10000 or 15000 µg mL^{-1} concentrations. The differences amongst 5000, 10000, 15000 µg mL^{-1} concentrations for 10 min root-dipping were insignificant.There was little difference between these different oxamyl concentrations for various exposure times, though there was high degree of eradication as compared to the untreated controls. However, there was no complete protection in any of the treatments. Therefore, it can be concluded that the lowest concentration of oxamyl (1000 µg mL^{-1}) and the shortest period of exposure (10 min) were optimum to exert protection against *Meloidogyne javanica*. The phytotoxic effects in this series of experiments was negligible as compared to the one in infested tomato seedlings shown in the previous experiment.

Table 1: Effects of different oxamyl concentrations and time of root-dipping on root-galls of tomato seedlings infested by *Meloidogyne javanica*, 5 weeks after planting (Number of galls at transplanting 11-20/seedling)

		Average number of root-galls/plant*				
		Time of root-dipping				
Treatment	Concentration (µg a.i. mL^{-1})	0	10 min	20 min	1 h	6 h
Control (undipped)	-	126.63	-	-	-	-
Oxamyl	1000	-	8.38a**	9.26a	9.59a	7.29a
	5000	-	5.08b	6.20b	5.52b	5.13b
	10000	-	4.80b	4.05c	4.75c	3.65c
	15000	-	3.13c	4.00c	4.65c	3.62c

*Means of 5 replicates/treatment; ** Values in column followed by the same letter are not significantly different at p>0.05 according to an LSD mean separation testS

Table 2: Effects of different oxamyl concentrations and time of root-dipping on root-galls of tomato seedlings uninfested by *Meloidogyne javanica*, 5 weeks after planting

		Average number of root-galls/plant*				
		Time of root-dipping				
Treatment	Concentration (μg a.i. mL^{-1})	0	10 min	20 min	1 h	6 h
Control (undipped)	-	86.66	-	-	-	-
Oxamyl	1000	-	9.72a**	10.76a	8.11a	7.00a
	5000	-	4.00ab	5.00 ab	4.85 ab	3.43ab
	10000	-	3.68ab	3.58 b	3.68c	2.00c
	15000	-	3.00ab	2.00 b	1.55a	1.00a

*Means of 5 replicates/treatment; ** Values in column followed by the same letter (s) are not significantly different at p>0.05 according to an LSD mean separation test

Table 3: Effects of oxamyl and aldicarb on root-knot nematode *Meloidogyne javanica* in infested tomato seedlings planted in treated soil* (Number of galls at transplanting 11-20/seedling)

Treatment	Dose (Kg a.i. ha^{-1})	Average number of galls/plant**
Control	-	366.95
Oxamyl	5	7.46
Oxamyl	10	9.33
Aldicarb	5	11.75
Aldicarb	10	13.17
SE±		0.29
LSD (p = 0.01)		70.17

*Assays were carried out 5 weeks after planting; ** Mean of 5 replicates/treatment

Experiment 3: In this experiment, a highly significant difference ($p<0.01$) was observed between oxamyl and aldicarb when they were used for soil treatment (Table 3). Oxamyl in both the doses was much more effective against *Meloidogyne javanica* than aldicarb ($p<0.01$). Practically, there was no further multiplication of the nematode in infested tomato seedlings planted in the treated soil with both chemicals. The efficacy of oxamyl was better and the dose 5 kg ha^{-1} was good enough to eliminate *Meloidogyne javanica* from soil. Phytotoxic effects were not observed with the doses used for both the chemicals.

DISCUSSION

Our findings in both root-dipping experiments (Table 1 and 2)indicate that control of *Meloidogyne javanica* can be achieved even with low concentration of oxamyl i.e., 1000 μg mL^{-1} with 10 min exposure time of root-dipping. By increasing oxamyl concentration up-to 15000 μg mL^{-1}, the nematode multiplication was though very significantly suppressed but the plants at such enhanced concentration showed high degree of phytotoxic effects in addition to the residuals might be expected later. The fact that there were no differences between various exposures times to offer the protection, suggests that 10 min exposure was sufficient for the roots to be saturated with the chemical tested. Any additional time for root exposure therefore, is unnecessary. It would be safer to use the lower oxamyl concentrations of 1000 μg mL^{-1} or 5000 μg mL^{-1} for 10 min since, they offer protection without importing any injurious effects on their seedlings. The inhibition of root-knot development was found to be greater in previously infested and subsequently treated tomato seedlings (Table 1), than in those inoculated (infested) with the nematode after root-dipping treatment. This indicates that the chemicals absorbed by the roots have instantaneously acted against the nematodes already present in the roots. This is in agreement with the logic data interpretation presented by Akhtar and Alam (1990), who mentioned that when the nematodes were inoculated (infested) after the root-dipping treatment, the potentiality of the chemicals might have reduced to some extent by the time the nematodes have established an effective host-parasite interactions.

From the present, as well as from the earlier investigations in line with our data (Miller and Perry, 1965; Harlan and Jenkins, 1967; Colon *et al.*, 1972; Khair and Mc Leod, 1974; Singh, 1975; Reddy and Seshadri, 1975; Khan, 1981; Haq *et al.*, 1984, 1987; Stephan *et al.*, 1990; Owino *et al.*, 1993; Sunil and Khanna, 2005; Rao, 2005; Mohanty and Mahapatra, 2005) it would be easy and safer to use low oxamyl concentrations as root-dipping treatment under green house temperature conditions in order to give a high performance to overcome root-knot nematode on tomato seedlings. Similarly, the low cost and simplicity involved in preparing dipping solution before and/or after transplanting offer a possible utilization of this method of application to be incorporated with other integrated pest control strategies.

Our findings also showed that there was no further multiplications of *Meloidogyne javanica* when the infested tomato seedlings were planted in the soil treated with oxamyl and aldicarb (Table 3).This was quite similar to the results of Wright *et al.* (1980) and Mateeva and Ivanova (2000), who obtained considerable control of root-knot nematodes by oxamyl and aldicarb soil treatment in tomato seedlings. Therefore, any potentially infested tomato seedlings originated from uncertified seeds, when transplanted in oxamyl or aldicarb treated field and/or green house will be of practical significance in preventing nematodes population build-up.

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