EVALUATION OF FUMIGANT AND NON-FUMIGANT NEMATICIDES FOR THE CONTROL OF *MELOIDOGYNE CHITWOODI* ON POTATO

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Summary. In two experiments conducted in Parma, Idaho, U.S.A. to study the efficacy of fumigant and non-fumigant nematicides on *Meloidogyne chitwoodi* infesting potato, there was a significant reduction in the number of root knot nematode infected tubers in treated plots compared to the untreated control. In the first experiment, maximum marketable yield and minimum percentage of nematode infected tubers were observed in a combined treatment of metam sodium (351 l/ha) with fosthiazate (5 kg/ha). Total tuber yield was significantly increased by application of metam sodium and fosthiazate, singly or in combination. The percentage of nematode infected tubers in treated plots ranged from 11.4-29.9%. In the second experiment, marketable yield was significantly increased by application of ethoprop or metam sodium or by two rates (140 and 187 l/ha) of 1,3-D compared to the untreated control. Total tuber yield was significantly increased by the application of the highest rate of 1,3-D and by metam sodium treatment. The percentage of nematode infected tubers in treated plots ranged from 18.7 to 28.0%, with the lowest number of parasitized tubers occurring in the 1,3-D (187 l/ha) treatment.

Key words: Columbia root-knot nematode, control, *Solanum tuberosum*.

The Columbia root knot nematode, *Meloidogyne chitwoodi* Golden, O'Bannon, Santo *et* Finley, is one of the major nematode pests on potato in the Pacific Northwest region of the United States of America (U.S.A.). Damage caused by this nematode to potato (*Solanum tuberosum* L.) and the resulting yield loss is a serious concern to growers in this region. Several management tactics, such as chemical (Hafez and Sundararaj, 2001a; 2002a, b) and cultural practices such as planting of green manure crops (Hafez and Sundararaj, 2000, 2001b), have been developed to reduce the damage caused by this nematode to potato. However, due to environmental concerns and to the stringent regulations for nematicide registration, availability of nematicides for use on potato is scarce. Results of previous studies indicated that fosthiazate is effective for the control of nematodes on Bermuda grass (Giblin-Davis *et al*., 1993), potatoes (Hafez and Sundararaj, 2003; Kimpinski *et al.,* 1997), tobacco (Pullen and Fortnum, 1999; Johnson, 1993) and banana (Gonzalez *et al*., 1994; Chabrier *et al*., 2002). In field experiments, metam sodium gave the best control of *Meloidogyne* spp. on potato and the greatest increase in tuber yield (Widijaja, 1979). The fumigant 1,3-D is a commonly used nematicide that reduces the number of tubers infested by the root knot nematode and increases the marketable yield of tubers; it is also used against nematodes on other crops. Ethoprop is also effective in root-knot nematode management strategies on many crops, including potato. In this study, the organophosphates fosthiazate and ethoprop and the fumigants metam sodium and 1,3-D were evaluated for the control of *M. chitwoodi* on potato in Idaho.

MATERIALS AND METHODS

Two field experiments were conducted at the University of Idaho, Idaho, U.S.A.

In the first experiment the efficacy of metam sodium or fosthiazate alone was compared with that of combinations of the two nematicides (see Table I for the rates used). A sandy field with an indigenous population of Columbia root-knot nematode (430 juveniles/500 cm^3 soil) was selected. Treatments were broadcast onto individual plots (15 × 50 ft) in a randomized complete block design with six replications. Metam sodium (42%) was broadcast on the soil surface at rates of 281 or 351 l/ha by a fumigation bar on 28 October 2002. The liquid formulation of fosthiazate 900 EC was applied on 16 April 2003 using a hand held sprayer with flat fan nozzles at 50 psi calibrated to deliver 323 l/h. Within one hour of application, plots were disked three times to incorporate the chemicals in the top 20 cm of soil. Potato cv. Russet Burbank seed tuber pieces were planted on 23 April 2003 in five rows, three feet apart. Standard cultural practices were followed. Potato tubers were hand-harvested on 18 September 2003 from the middle two rows of each plot and weighed. All tubers were graded and evaluated for nematode infection based on the external symptoms observed on the surface of the tubers.

In the second experiment, the efficacy of the two fumigants and ethoprop, applied singly, was investigated (Table II). The experiment was prepared as before in a randomized complete block design with five treatments, each with six replications, in a sandy loam field with a nematode population of 390 juveniles/500 cm^3 soil. The

Table I. Efficacy of different rates of metam sodium and fosthiazate, alone and in combination, on the control of *Meloidogyne chitwoodi* in potato (first experiment).

Treatment	t/ha			% nematode infected tubers
	Marketable yield	Total yield	Nematode infected tubers	
Control	0.0 d*	31.4 b	31.4 a	100.0 a
Metam sodium 351 l/ha, in autumn	26.3 b	40.2 a	8.0 bcd	20.1 c
Metam sodium 351 l/ha, in autumn + fosthiazate 5 kg/ha in spring	28.0 a	41.8 a	4.7 d	11.4 e
Metam sodium 281 l/ha, in autumn + fosthiazate 5 kg/ha in spring	26.1 b	40.2 a	5.9 cd	14.8 d
Fosthiazate 5 kg/ha in spring	24.3 c	38.3 a	11.3 b	29.9 b
Fosthiazate 6.7 kg/ha in spring	25.2 bc	39.0 a	10.5 bc	27.1 b

* Fisher's protected least significant difference test

Table II. Effect of two rates of 1,3-D, ethoprop and metam sodium on potato tuber yield and infection in a field infested with *M. chitwoodi* (second experiment).

Treatment	t/ha			% nematode infection
	Marketable yield	Total yield	Infected tubers	
Control	0.0 b*	32.1 d	32.1 a	100.0 a
1,3-D 187 l/ha in autumn	15.6 a	43.9 a	8.2 d	18.7 e
1,3-D 140 l/ha in autumn	15.8 a	34.8 c	9.5 c	28.0 c
Ethoprop 19 l/ha in spring	15.2 a	36.1 c	13.3 b	37.0 b
Metam sodium 351 l/ha in autumn	16.2 a	39.8 b	9.3 cd	23.3 d

* Fisher's protected least significant difference test

liquid formulation of ethoprop (69.6% a.i.) was broadcast on the soil surface on 21 April 2003, using a hand-held plot sprayer with flat fan nozzles calibrated to deliver 323 l/h. Within one hour of application, all plots were disked twice to incorporate the chemical in the top 20 cm of soil. The fumigants 1,3-D (94%) and metam sodium (42%) were broadcast on 24 October and 28 October 2002 by fumigation bar and ripper, respectively. Potato cv. Russet Burbank seed tuber pieces were planted on 23 April 2003 in rows three feet apart. Potato tubers were hand-harvested on 17 September 2003 from the middle two rows of each plot and weighed. Tubers were graded and evaluated for nematode infection based on the external symptoms observed on the surface of the tubers.

As both females and egg masses of *M. chitwoodi* remain completely embedded within potato tubers, the soil population of the nematode at harvest is not usually a good indication of the efficacy of the nematicides. Therefore, no soil samples were collected after harvest of potatoes.

Data were statistically analyzed and mean values compared by means of least significant differences (LSD).

RESULTS AND DISCUSSION

In the first experiment, maximum marketable yield and a reduced number and percentage of nematode infected tubers occurred in the metam sodium and fosthiazate treatment combinations (Table I). These studies are in agreement with Hafez and Sundararaj (2003) that applications of metam sodium with fosthiazate on potato significantly reduced the percentage of tubers infected by *M. chitwoodi*. There was no significant difference in marketable yield between application of the higher rate of metam sodium alone and the lower rate of metam sodium along with fosthiazate. Application of fosthiazate alone at both rates used gave significantly higher marketable yields than the control but lower than the combination of the highest rate of metam sodium with a low rate of fosthiazate.

Total tuber yields were significantly increased by all treatments compared to the control. Kimpinski *et al.* (1997) concluded that fosthiazate should be useful for potato production in the Maritime region of Canada, though yields of plots treated with fosthiazate did not differ consistently from yields of plots treated with aldicarb. All tubers produced in the control plots were

infected by *M. chitwoodi*, while the proportion of infected tubers in the different treatments ranged from 11.4% to 29.9%, with the least infection of 11.4% occurring in plots treated with a combination of the highest rate of metam sodium with a low rate of fosthiazate (Table I).

The second experiment (Table II) also resulted in significant reductions in the number and percentage of nematode infected tubers in all treatments. Also, there was an increase in marketable yield and total yield in all treatments as compared to control plots. Gill *et al.* (1980) and Santo *et al.* (1985) found that application of ethoprop significantly increased the population of *M. incognita* followed by increased tuber yield. However, Santo and Wilson (1990) reported no effect of ethoprop on either soil population densities of *M. chitwoodi* or tuber infection. Marketable yield in our experiments was significantly increased by application of ethoprop or metam sodium or both rates of 1,3-D compared to the untreated control. Total yields were increased most by application of the highest rate of 1,3-D, followed by the metam sodium treatment. There was no significant difference in the total yield of tubers between the low rate of 1,3-D and application of ethoprop. The number of nematode infected tubers was reduced most by the higher rate of 1,3-D, and the percentage of tubers infected by nematodes was in the range of 18.7-28% in the treated plots, compared with 100% in the control plots.

In conclusions, the results of both experiments offer promise for the control of *M. chitwoodi* on potato as all treatments greatly reduced tuber infection and increased tuber yield.

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