MANAGEMENT OF MELOIDOGYNE CHITWOODI USING GREEN MANURE AND COVER CROPS AND NEMATICIDES, AND CONTROL OF THE CORKY RINGSPOT DISEASE ON POTATO, 1997

by
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The Columbia root-knot nematode, *Meloidogyne chitwoodi* is one of the most important factors affecting potato production in Washington. We have developed management strategies best to deal with this nematode. Despite these research efforts *M. chitwoodi* continues to be a problem, especially if proper control measures are not administered. Continued efforts are needed to give the grower additional and improved management options to keep a step ahead of the problem. Several promising management tools are available that need to be looked at in more detail. Recently, several new chemistry nematicides developed to be less toxic and more environmentally friendly have shown promise. These new nematicides are different in chemistry from the more common organophosphates (Mocap™) and carbamates (Temik™, Vydate™). The organophosphates and carbamates are currently going through a reassessment with EPA, and the availability of these groups of nematicide-insecticides is a major concern to agriculture.

We have shown that rapeseed and sudangrass and sudangrass-sorghum hybrids used as green manure can be effective in reducing damage caused by *M. chitwoodi*. Studies show that white mustard and lupin are toxic to nematodes and weed seeds. The toxic compounds released by white mustard and lupin are butyl isothiocyanate and derivatives of alkaloid, respectively. The advantage of these green manure crops is that only 6-8 weeks growth is required compared to 6-7 months for rapeseed. Marigolds release compounds in root exudates that are toxic to *M. chitwoodi*. Field studies show that marigold may be an effective cover crop in suppressing *M. chitwoodi*. Preliminary field studies show that Crambe and Meadowfoam meals incorporated into soil reduce damage by *M. chitwoodi*. The toxic compounds are similar to those released by rapeseed and mustard.

Nematicide trials were conducted at WSU-Prosser to evaluate registered and non-registered new chemistry nematicides different from the organophosphates [Mocap™] and carbamates [Temik™, Vydate™]. Mocap™ 6EC was evaluated as a tank mix with Vapam™ HL, and in combination with Telone™ II at 10 gal/A (Table 1). The tank mix was applied 50% as a broadcast spray 10 inches deep, and 50% broadcast on the surface and incorporated 6 inches deep with a rototiller and packed. Telone™ II was applied 18 inches deep, spaced 18 inches apart and packed immediately with a cultipacker. Mocap™ was applied as a broadcast spray and incorporated 6 inches deep with a rototiller. Both combination treatments gave excellent control of *M. chitwoodi*.

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This was the third consecutive year that the Vapam™ + Mocap™ treatment has given excellent control at the Prosser field site (1). This combination treatment needs to be further evaluated in commercial fields with high and deep nematode populations. Vapam™ alone at 41 gal/A applied with sweep shanks as a broadcast spray at 14 inches deep also gave excellent control. However, shank only treatment with Vapam™ is not recommended. Previous field trials show that shank only treatment is not adequate for soils with high and deep nematode populations (2). Telone™ II at 20 gal/A gave adequate control with < 10% culls, but Telone™ II 10 gal, and Mocap™ 6EC at 12 lb ai/A did not. Multiple post plant broadcast spray treatments of Vydate™ L were evaluated. Vydate™ was sprayed on the foliage and incorporated into the soil with 1-inch of water. The first application was made between emergence and tuber initiation followed by none to two more applications 3 weeks apart. Results showed that Vydate™ significantly ($P < 0.05$) reduced tuber infection but did not provide adequate control (Table 2). These results were contrary to the excellent results obtained in 1996 (Table 2) [1]. In 1998 Vydate™ will be applied with water through a sprinkler simulator. Vydate™ is currently the only nematicide that can be used in-season to protect tubers from nematode infection.

Several new chemistry nematicides were evaluated for control of *M. chitwoodi*. Results for the second consecutive year were very encouraging. Several of these nematicides and formulations were comparable to Telone™ II in reducing tuber damage. In all 10 treatments had < 10% culls ranging from 0.2 to 7.5%. In particular, a compound applied as a foliar spray and translocated downwards through the plant to protect the roots from nematode attack provided excellent control when used in combination with a pre plant experimental nematicide. This is very encouraging because currently only Vydate™ L is available for in-season control of *M. chitwoodi*. The results obtained with these, new environmentally friendly nematicides are very encouraging, and research will continue to determine the best means to use these compounds.

In the second year of a 3-year study, a green manure and cover crop trial was established in the spring of 1996 to evaluate bitter lupin and white mustard cv. Martigena as green manure, and marigold cv. Crackerjack as a cover crop for managing *M. chitwoodi* on Russet Burbank potato. Results showed that only the Mocap™ alone and in combination with white mustard and Sordan 79 showed < 10% culls (Table 3). In this trial Telone™ II did not provide adequate control. The reason for this lack of control may have been due to high moisture levels at 2 ft. depth. The marigold seeded in June had less ($P < 0.05$) tuber damage than the untreated and did not differ from Telone™ II. The other treatments did not differ ($P < 0.05$) from the untreated plots. These results were contrary to the excellent results obtained in 1996 (Table 3) [1]. In previous field trials Sordan 79 and white mustard have significantly ($P < 0.05$) suppressed tuber damage. These studies will continue in 1998. Except for the Meadowfoam 5 T/A, all of the other organic amendment treatments significantly ($P < 0.05$) reduced tuber damage compared to the untreated (Table 4). Crambe meal at 10 T/A did not differ statistically from Telone™ II. Studies with Crambe meal will continue in 1998.

The corky ringspot disease is a serious problem on potato causing internal tuber damage. This disease is caused by the Tobacco Rattle virus. However, for the virus to enter the tuber it is dependent on the stubby-root nematode *Paratrichodorus allius* that acts as a vector and injects the virus into the tuber during tuberization. Thus, control of the nematode or protecting tubers during tuberization will control this disease.

Typical symptoms produced in tubers consist of necrotic concentric rings. Recently, a more severe strain of the virus has been discovered in Washington. Symptoms produced by this strain consist of diffuse brown to black spots resembling heat necrosis that may result in tissue breakdowns. In cooperation with Balcom & Moe Farms a nematicide trial was conducted for control of the corky ringspot disease on Norkotah potato near Pasco, WA. The plot area was infested with *P. allius* harboring the severe strain of the virus. Treatments included Telone™ II at 10, 15 and 20 gal/A and in combination with Vapam™ HL and Temik™ 15G, Vapam™ HL 24.6 gal/A applied 14 inches deep as a broadcast spray and 16.4 gal sprayed on the surface and incorporated 6 inches deep, and Temik™ 15G applied at plant and 4 weeks after plant. Results showed that except for Telone™ II 10 gal alone, all of the Telone™ II alone or in combination with Vapam™ HL or Temik™ effectively (< 10% infection) controlled the corky ringspot disease (Table 5). Vapam™ alone did not provide adequate control. Temik™ applied 4 weeks after plant provided adequate control compared to the at plant treatment which did not. The primary reason for the lack of control with the at plant Temik™ treatment is due to the timing of application. In the past Temik™ was normally applied approximately 3-4 weeks after planting, however, the new label requires that it be applied at planting time. Thus, the dose of Temik™ remaining at tuberization was probably too low to adequately protect the tubers from nematodes injecting the virus into the tubers. Note that in this study the at plant treatment was applied 5 days after plant. Thus, it is conceivable that the disease incidence may have been even greater if Temik™ was applied in-furrow with the seed-piece. In 1996 in plots adjacent to this trial Telone™ II, Vapam™, and Temik™ applied at plant gave similar results (1). In field trials conducted by Dr. Russ Ingham at Oregon State University in Hermiston, OR. Temik™ applied at plant has provided adequate control of the less severe strain of the virus. Thus, it may be more difficult to control the severe strain of TRV than the mild strain.

Reference:

1. Santo, G. S., J. H. Wilson, and H. Mojtahedi. 1997. Management of the Columbia root-knot nematode and corky ringspot disease on potato, 1996. Proceedings 36th Annual Washington State Potato Conference February 4, 5, 6, 1997, Moses Lake, WA.

2. Santo, G. S., H. Mojtahedi, J. H. Wilson, and J. Huan. 1993. Current status of root-knot, root-lesion and stubby-root nematodes on potatoes. Proceedings 32nd Annual Washington State Potato Conference February 1, 2, 3, 1993, Moses Lake, WA, pp 107-115.

Table 1. Russet Burbank potato tuber % infection, % culls, and infection index of *Meloidogyne chitwoodi* from Mocap and Vapam plots, Prosser, WA., 1997.

Treatment (rate ai/A)	% Infection[1]	% Culls[2]	Infection index[3]
Untreated	95 a	89 a	4.62 a
Telone II 20 gal	20 bc	7 bc	0.68 bc
Telone II 10 gal	42 b	27 b	1.51 b
Mocap 6EC 12 lb	29 b	24 b	1.53 b
Telone II 10 gal + Mocap 6EC 12 lb	2 cd	0.2 c	0.07 c
Vapam HL 41 gal	2 cd	1 c	0.19 c
Vapam 41 + Mocap 12 (tank mix)	0.2 d	0 c	0.01 c

Values are means of five replicates. Values in each column followed by the same letter do not differ at $P < 0.05$, according to Least Significant Difference test. Percent data were transformed to Arcsin[sqrt(x)], analyzed, and transformed back to real numbers. Telone II was applied 18 inches deep, spaced 18 inches apart and packed immediately with a cultipacker. Vapam was applied with sweep shanks as a broadcast spray at 14 inches deep. The tank mix was applied 50% as a broadcast spray 10 inches deep, and 50% broadcast on the surface and incorporated 6 inches deep with a rototiller and packed. Mocap was applied as a broadcast spray with a CO_2 pressurized backpack sprayer and incorporated 6 inches deep with a rototiller.

[1] % infection = any tubers infected with *M. chitwoodi*.

[2] % culls = tubers with six or more infection sites.

[3] Infection index: 0 = no nematode infection; 1 = 1-3; 2 = 4-5; 3 = 6-9; 4 = 10+; 5 = 50+; and 6 = 100+ = infection sites.

Table 2. Percent culls of Russet Burbank potato tubers due to *Meloidogyne chitwoodi* from Vydate plots, Prosser, WA., 1996-97.

Treatment (rate lb ai/A)	Percent culls	
	1996	1997
Untreated	92 a	89 a
Telone II 20 gal	1 b	7 c
Mocap 6EC 12	2 b	23 bc
Vydate L 1 (3x)	--	50 b
Vydate L 2 (3x)	2 b	24 bc
Vydate L 2 (2x)	--	44 b
Mocap 6EC 12 + Vydate L 1 (1x)	--	45 b
Mocap 6EC 12 + Vydate L 1 (3x)	0 b	--

Values are means of five replicates. Values in each column followed by the same letter do not differ at $P < 0.05$, according to Least Significant Difference test. Percent data were transformed to Arcsin[sqrt(x)], analyzed, and transformed back to real numbers. Telone II was applied 18 inches deep, spaced 18 inches apart and packed immediately with a cultipacker.

Mocap was applied as a broadcast spray with a CO_2 pressurized backpack sprayer and incorporated 6 inches deep with a rototiller. Vydate was sprayed on the foliage and incorporated into the soil with 1-inch of water. The first application of Vydate was made between emergence and tuber initiation followed by none to two more applications 3 weeks apart. Tubers with six or more infection sites were graded as culls.

Table 3. Percent culls of Russet Burbank potato tubers due to *Meloidogyne chitwoodi* from green manure/cover crop plots, Prosser, WA. , 1996-97.

Treatment (rate/A)	Percent culls	
	1996	1997
Untreated	65 a	66 a
Telone II 20 gal	6 b	25 cde
Mocap 6EC 12 lb ai	4 b	9 def
White Mustard	10 b	55 abc
Mustard + Mocap 12 lb	9 b	7 ef
Sordan 79	3 b	70 a
Sordan 79 + Mocap 12 lb	2 b	2 f
Marigold (June 96)	1 b	32 bcd
Marigold (August 96)	1 b	54 abc
Lupin (June 96)	46 a	62 ab
Lupin (August 96)	10 b	69 a

Values are means of five replicates. Values in each column followed by the same letter do not differ at $P < 0.05$, according to Least Significant Difference test. Percent data were transformed to Arcsin[sqrt(x)], analyzed, and transformed back to real numbers. Telone II was applied 18 inches deep, spaced 18 inches apart and packed immediately with a cultipacker. Mocap was applied as a broadcast spray with a CO_2 pressurized backpack sprayer and incorporated 6 inches deep with a rototiller. Sordan 79 and white mustard were planted August 1996, and all green manure crops were incorporated October 1996 with a rototiller. Marigold was not incorporated and served as a winter ground cover. Potato was planted May 1997. Tubers with six or more infection sites were graded as culls.

Table 4. Tuber infection of Russet Burbank potato tubers by *Meloidogyne chitwoodi* from Meadowfoam and Crambe meal plots, Prosser, WA., 1997.

Treatment (rate/A)	% Infection[1]	% Culls[2]	Infection index[3]
Untreated	95 ab	89 a	4.62 a
Telone II 20 gal	20 d	7 d	0.68 d
Mocap 6EC 12 lb ai	38 cd	34 bc	2.03 bcd
Meadowfoam 5T	98 a	96 a	4.85 a
Meadowfoam 10T	64 bc	46 b	2.61 bc
Crambe 5T	65 bc	53 b	2.67 b
Crambe 10T	19 d	16 cd	1.01 cd

Values are means of five replicates. Values in each column followed by the same letter do not differ at $P < 0.05$, according to Least Significant Difference test. Percent data were transformed to Arcsin[sqrt(x)], analyzed, and transformed back to real numbers. Telone II was applied 18 inches deep, spaced 18 inches apart and packed immediately with a cultipacker. Mocap was applied as a broadcast spray with a CO_2 pressurized backpack sprayer and incorporated 6 inches deep with a rototiller. Meadowfoam and Crambe meal were broadcast on the soil surface and rototilled 6 inches deep 3 weeks before planting.

[1] % infection = any tubers infected with *M. chitwoodi*.

[2] % culls = tubers with 6 or more infection sites.

[3] Infection index: 0 = no nematode infection; 1 = 1-3; 2 = 4-5; 3 = 6-9; 4 = 10+; 5 = 50+; and 6 = 100+ = infection sites.

Table 5. The effect of various nematicide treatments on Norkotah potato yield, percent and intensity of infection by Tobacco Rattle virus vectored by *Paratrichodorus allius*. Corky ringspot disease plots, Balcom & Moe, Pasco, WA. 1997.

Treatments (rate/A)	Yield (T/A)	Tuber Rating[1]	Infection (%)
Untreated	15.8 de	2.76 a	97 a
Telone II 20 gal	20.2 abc	0.00 e	0 d
Telone II 15 gal	23.0 a	0.07 e	3 d
Telone II 10 gal	22.8 ab	0.92 c	31 bc
Telone II 15 gal + Vapam HL 30 gal (SB)	21.8 ab	0.02 e	1 d
Telone II 10 gal + Vapam HL 30 gal (SB)	20.6 ab	0.00 e	0.05 d
Vapam 24.6 gal (S) + 16.4 gal (SB)	17.8 cd	1.64 b	54 b
Temik 15G 3 lb ai (AP)	13.6 e	0.68 d	22 c
Temik 15G 3 lb ai (PP)	20.0 bc	0.21 de	5 d
Telone II 20 gal + Temik 3 lb (AP)	18.4 cd	0.00 e	0 d
Telone II 20 gal + Temik 3 lb (PP)	21.9 ab	0.00 e	0.05 d

Values are means of two replicates with five subsamples per replicate. Values in each column not followed by the same letter differ at $P < 0.05$, according to Least Significant Difference test. Percent infection data were transformed to Arcsin[sqrt(x)], analyzed, and transformed back to real numbers. S = applied as a broadcast spray with sweep shanks 14 inches deep. SB = surface broadcast spray. AP = shanked on both sides of the seed-piece 5 days after plant. PP = surface broadcast 4 weeks after plant. Vapam surface broadcast treatments were incorporated by rototilling 6 inches deep. Telone II shank-injected 18 inches deep.

[1] Tuber rating: 0 = no internal necrosis; 1 = slight (1-10%); 2 = moderate (11-25%); 3 = heavy (26-50%); 4 = severe (>51%).