MANAGEMENT OF THE COLUMBIA ROOT-KNOT NEMATODE AND CORKY RINGSPOT DISEASE ON POTATO, 1996

by
G. S. Santo, J. H. Wilson, and H. Mojtahedi[1]
Irrigated Agriculture Research and Extension Center
Washington State University, Prosser, WA 99350

Columbia Root-Knot Nematode

The Columbia root-knot nematode (*Meloidogyne chitwoodi*) is one of the most serious problems to potato production in the Pacific Northwest. This nematode blemishes tubers and renders them unmarketable. The northern root-knot nematode (*M. hapla*) commonly occurs in potato growing areas but is not as important as *M. chitwoodi*. The principal reason is that soil temperatures during the growing season favors *M. chitwoodi* than *M. hapla* (7). With favorable soil temperatures and a long growing season *M. chitwoodi* can produce 4-5 generations during the season compared to 2-3 for *M. hapla* (2). Thus, *M. chitwoodi* will attack tubers earlier and more severely than *M. hapla*. Significant tuber damage late in the season can be caused by *M. hapla* if conditions (unusually warm and long growing seasons) allow the nematode to complete three generations.

Management strategies for *M. chitwoodi* include nematicides, green manure crops, crop rotation, and early harvest. Soil fumigation with Telone II™ and metham sodium remains the most common means for controlling *M. chitwoodi* (4). Generally, Telone II™ has provided more consistent control of *M. chitwoodi* than metham sodium. In certain fields metham sodium applied in 1-inch of water is unable to control nematodes below 12 inches. This problem has been overcome with application of metham sodium in a broadcast spray at 14 inches deep with sweep shanks attached with spray nozzles followed by a broadcast surface incorporated application of metham sodium or Mocap™. In our studies the best treatments for controlling *M. chitwoodi* have been the combination of Telone II™ with either metham sodium or Mocap™ (4). Telone II™at 15 gal/A shank-injected 18 inches deep followed by 30 gal/A of Vapam HL™ applied as a broadcast spray and incorporated or in ½-inch of water is registered for control of *M. chitwoodi*. Another excellent treatment has been Telone II™ 20 gal/A followed by Mocap™ at 12 lb. ai/A. Studies with green manure crops show that rapeseed consistently provides 80-90% control of *M. chitwoodi*, and sudangrass 50-80% (6). When these green manure crops have been used in combination with Mocap™ control have been comparable to Telone II™ (6). Crop rotation is used to suppress nematode soil populations (6), and early harvest is a strategy used to escape severe nematode damage (3).

[1]Nematologist, Agriculture Research Technologist, and Research Associate, respectively.

This Presentation is part of the 1997 Proceedings of the Washington State Potato Conference and Trade Show

Nematicide trials were conducted at WSU-Prosser to evaluate several nematicides and a bionematicide for control of *M. chitwoodi* on Russet Burbank potato. Treatments included different rates, methods of application, and combination treatments. The fungal bionematicide showed good activity against *M. chitwoodi*, providing about 50% less tuber damage compared to the untreated plots in 1995. In 1996 similar control was achieved but only a month before harvest (Table 1). At harvest tubers in the bionematicide treated plots were severely damaged by *M. chitwoodi* (Table 1). The benefits of this material may be limited. However, it could play a role in combination with other nematicides or management practices.

Several new chemistry nematicides were evaluated for control of *M. chitwoodi*. Four of these compounds were comparable to Telone II™ in reducing tuber damage (2 to 6% culls compared to untreated with 92%). Another experimental compound applied as a foliar spray showed very good activity by itself (23% culls). When this foliar material followed a preplant incorporated treatment of another experimental compound control was excellent (6% culls). Alone these two compounds provided only 77 (23% culls) and 42% (58% culls) control, respectively. The results obtained with these new and less toxic nematicides are very encouraging, and research will continue to determine the best means to use these materials.

Research continues to determine the most efficient methods in using available nematicides. Multiple applications of Vydate ™ alone and in combination with Mocap™ were evaluated for added benefits of control of *M. chitwoodi*. Vydate™ gave excellent control of *M. chitwoodi* (Table 2). Results obtained were not expected. In previous studies Vydate™ alone applied at planting has failed to provide adequate control. The timing and rate of application may be a critical factor. In this study three applications of Vydate™ were made. The first application was made between emergence and tuber initiation followed by two more applications 3 weeks apart. Vydate L™ is registered for use on potato at a total dosage of 4.5 gal/A during the season with a 7 day preharvest interval. The results obtained with Vydate™ were very encouraging. However, this is only a one year study and need to be repeated. In 1997 these studies will be repeated along with lower rates of Vydate™.

For the second consecutive year, excellent control was obtained with Vapam™ 55 gal/A shank-spray followed by preplant incorporation of Mocap at 12 lb. ai/A, and a tank mixed treatment of Vapam™ and Mocap™ applied as a shank-spray and surface broadcast-incorporated (Table 3). Vapam™, Telone II™ and Mocap™ alone also gave excellent control of *M. chitwoodi*. However, only trace or no nematode infection was detected whenever Vapam™ was used in combination with either Telone II™, Mocap™, or Temik™. The split application of Vapam™ (35 gal shank-spray + 20 gal surface spray and incorporated) had significantly more infection than the other combination treatments. Vapam™ + Mocap™ need to be further evaluated in commercial fields with high and deep nematode populations. In our research plots at Prosser Vapam™ shank and Mocap™ alone have provided excellent control of *M. chitwoodi*. However, in a commercial field with high and deep populations these treatments by themselves did not provide adequate control (5).

A green manure/cover crop trial was established in the spring of 1995 to evaluate sudangrass-sorghum hybrid Sordan 79, Martigena white mustard, bitter lupin 562P (Resource Seeds, Inc., Visalia, CA), and Crackerjack marigold for managing *M. chitwoodi* populations.

Sordan 79, white mustard, and lupin were evaluated as green manure, and marigold as a cover crop and green manure. Marigolds contain within their root exudates compounds that may be toxic to nematodes. Sordan 79, white mustard, and lupin produce hydrogen cyanide, isothiocyanate, and alkaloid compounds, respectively that are toxic to nematodes. Treatments included white mustard seeded in August, white mustard plus Mocap™, Sordan 79 seeded in August, Sordan 79 plus Mocap™, and lupin and marigold seeded in June and August. All green manure treatments were incorporated 6 inches deep with a rototiller in October, except the June planted lupin incorporated in July. The June planted lupin was mistakenly killed with a herbicide when only a few inches tall. Russet Burbank potato was planted the following spring 1996. Telone II™ and Mocap™ served as standard nematicide controls. Results showed that all, except one, of the cover crops were comparable to Telone II™ and Mocap™ in reducing % culls by *M. chitwoodi* (Table 4). Only the June seeded lupin treatment did not provide adequate control. Results presented here are very encouraging, but note that this is only the first year of a 3-year study. Also, the % culls in the untreated plots were low (65%) compared to other studies in the same field. Additional studies are needed to determine if these treatments will do as well under higher nematode population pressure.

Corky Ringspot Disease

The corky ringspot (CRS) disease can be as important on potato as root-knot nematodes. This disease is caused by the tobacco rattle virus that causes internal damage and renders the tubers unmarketable. The virus is dependent on the stubby-root nematode *Paratrichodorus allius* that acts as a vector and injects the virus into the tubers during tuberization. Thus, the disease can be effectively controlled by protecting the tubers from nematode feeding during tuberization. By themselves both the virus and nematode are not a problem on potato. The typical tuber symptoms are brown necrotic concentric rings and arcs that extend deep into the flesh and frequently break through the skin producing finely-fissured, corky, surface areas (9). However, in recent years tuber symptoms observed in the Pasco, WA. area have not been typical. The typical necrotic concentric rings and surface symptoms are seldom observed. Instead, internal symptoms appear as diffuse brown to black spots that may be confused with internal brown spot (IBS). This may be a more virulent strain of the virus.

Since 1989, the number of potato crops damaged by CRS has increased (8). This coincided with the temporary withdrawal of Temik for use on potatoes in 1989. Temik is effective against the stubby-root nematodes, and effectively controls CRS (10). The extensive use of Temik for insect control has probably suppressed the occurrence of this disease in many potato fields in the Pacific Northwest. Temik was reinstated for use on potatoes in 1996 with several restrictions including an at plant in-furrow treatment with the seed-piece and a 150 day preharvest interval. Previously applications were commonly made 3-4 weeks after planting. Telone II has been effective in controlling CRS in the Pacific Northwest (1).

In 1996 a nematicide trial was conducted at Balcom and Moe Farms, Inc. near Pasco, WA. for control of CRS on Norkotah potato. The experimental plot was infested with *P. allius* harboring the tobacco rattle virus. Plots were six rows wide and 35 ft. long. Each treatment was replicated twice with five subsamples per replicate.

Treatments included Telone II 20 gal/A, Telone II 20 gal + Temik 15G 3 lb. ai/A, Telone II 10 gal + Vapam HL 30 gal applied as a surface broadcast spray (BS), Vapam HL 24.6 gal shank + 16.4 gal (BS), Vapam HL 24.6 gal shank + 16.4 gal (BS) + Temik 3 lb., Temik 3 lb., and Mocap 6EC 12 lb. + Temik 3 lb. Untreated plots served as controls. Telone II was applied as a broadcast by tractor-drawn chisels 18 inches deep, spaced 18 inches apart, and Vapam shank treatments were applied with sweep shanks 14 inches deep as a broadcast spray band. Mocap and Vapam (BS) were applied as broadcast surface spray and incorporated 6 inches deep, and Temik was applied with the seed-piece. Certified Norkotah potato seed-pieces were planted May 3. Plots were irrigated with sprinklers and maintained with standard cultural practices. At harvest twenty tubers were peeled by hand and examined for corky ringspot disease symptoms. Tubers were rated for corky ringspot disease symptoms in terms of % infection and a tuber rating index where 0 = no disease symptoms, 1 = slight (1-10%), 2 = moderate (11-25%), 3 = heavy (26-50%), and 4 = severe (>50%).

Initial soil populations of *P. allius* were low, and remained low throughout the study. Midseason and after harvest samples showed that no nematodes were detected in plots that received Telone II. Only Telone II alone and in combination with Vapam or Temik effectively controlled the Corky Ringspot disease (Table 5). Vapam and Temik significantly ($P < 0.05$) reduced tuber infection, but did not provide adequate control in this trial. Processors may reject or severely downgrade potato fields with more than 10% infection. The primary reason for the lack of control with Temik is probably 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 nematode feeding. Studies in 1997 will include comparison of at plant and postplant Temik applications.

Literature cited

1. Ingham, R.E. 1993. Corky ringspot - What control measures are available? Proceedings 32nd Washington State Potato Conference February 2-4, 1993, Moses Lake, WA., pp. 95-102.
2. Pinkerton, J.N., G.S. Santo, and H. Mojtahedi. 1991. Population dynamics of *Meloidogyne chitwoodi* on Russet Burbank potatoes, *Solanum tuberosum*, in relation to degree-day accumulation. Journal of Nematology 23:283-290.
3. Santo, G.S., H. Mojtahedi, and J.H. Wilson. 1996. Root-knot nematode management: early harvest & storage. Spud Topics Vol. XXXXI, No. 28, 2p.
4. Santo, G.S., H. Mojtahedi, and J.H. Wilson. 1994. Nematicide treatments and cost for managing root-knot nematodes on potato. Spud Topics Vol. XXXIX, No. 23, 2p.
5. 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 2-4, 1993, Moses Lake, WA., pp. 107-115.
6. Santo, G.S., H. Mojtahedi, and J.H. Wilson. 1992. Management of root-knot nematodes on potato in Washington. Proceedings 31st Annual Washington State Potato Conference February 4-6 1992, Moses Lake, WA., pp. 7-14.
7. Santo, G.S., and J.H. O'Bannon. 1981. Effect of soil temperature on the pathogenicity and reproduction of *Meloidogyne chitwoodi* and *M. hapla* on Russet Burbank potato. Journal of Nematology 13:483-486.
8. Thomas, P.E., G.S. Santo, and C.R. Brown. 1993. Corky ringspot in the Columbia Basin. Spud Topics Vol. XXXVIII, No. 24, 2p.
9. Weingartner, D.P. 1990. Tobacco rattle virus, pp. 80-82. *In:* Compendium of Potato Diseases, W. J. Hooker [Ed.]. American Phytopathological Society Press, St. Paul, Minnesota.
10. Weingartner, D.P., J.R. Shumaker, and G.C. Smart, Jr. 1983. Why soil fumigation fails to control potato corky ringspot disease in Florida. Plant Disease 67:130-134.

Table 1. Evaluation of ABG bionematicide for control of *Meloidogyne chitwoodi* on Russet Burbank potato, Prosser, WA. 1996.

Treatment (rate ai/A)	September 19	October 24
	% culls	% culls
Untreated	71 a	92 a
Telone II 20 gal	--	1 b
Mocap 6EC 12 lb	1 b	2 b
ABG-9017 100 lb	32 ab	84 a
ABG-9017 50 + 50 lb (1000 DD)	24 ab	91 a
Mocap 12 + 9017 50 lb (1000 DD)	9 b	5 b
ABG-9008 100 lb	28 ab	92 a

Values are means of five replicates. Values in each column not followed by the same letter differ at $P < 0.05$, according to Least Significant Difference test. Data were transformed to Arcsin[sqrt(x)], analyzed, and transformed back to real numbers. Telone II shank injected 18 inches deep; Mocap and ABG broadcast sprayed before planting and incorporated 6 inches deep with a rototiller; At 1000 DD (degree days at base 5 C from time of planting) ABG applied as a broadcast spray and incorporated with 1-inch water. Percent culls = any tuber with six or more infection sites were graded as culls.

Table 2. Evaluation of Vydate L on yield and tuber infection of Russet Burbank potato by *Meloidogyne chitwoodi*, Prosser, WA. 1996.

Treatment (rate ai/A)	Yield (T/A)	% inf.[1]	% culls[2]	Inf. Index[3]
Untreated	21.1 c	98 a	92 a	4.18 a
Telone II 20 gal	35.3 a	5 b	1 b	0.21 b
Mocap 6EC 12 lb	27.7 ab	4 b	2 b	0.18 b
Vydate L 2 lb (3x)[4]	26.0 bc	6 b	2 b	0.38 b
Vydate L 4 lb (3x)[4]	28.3 ab	0.2 b	0 b	0.01 b
Mocap 12 lb + Vydate 1 lb (3x)[4]	31.8 ab	0 b	0 b	0.00 b

Values are means of five replicates. Values in each column not followed by the same letter 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 shank injected 18 inches deep; Mocap broadcast sprayed before planting and incorporated 6 inches deep with a rototiller; Vydate broadcast sprayed and incorporated with ½-inch water.

[1] % infection: any tuber infected with *M. chitwoodi*.

[2] % culls: any tuber with 6 or more infection sites were graded as culls.

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

[4] The first application was made between emergence and tuber initiation followed by two more applications 3 weeks apart.

Table 3. Evaluation of Telone II, Vapam, and Mocap alone and in various combinations on tuber yield and tuber infection of Russet Burbank potato by *Meloidogyne chitwoodi* , Prosser, WA. 1996.

Treatment (rate ai/A)	Yields (T/A)	% inf.[1]	% culls[2]	Inf. Index[3]
Untreated	21.1.e	98 a	92 a	4.17 a
Telone II 20 gal	35.3 abc	5 c	1 bc	0.21 bcd
Mocap 6EC 12 lb (PPI)	27.7 d	4 c	2 bc	0.18 bcd
Vapam 55 gal Fall	37.2 a	3 cd	2 bc	0.20 bcd
Vapam 55 gal Spg	36.5 a	2 cd	2 bc	0.44 bc
V55 + M12 (tank mix)[Fall]	30.5 cd	0 d	0 c	0.00 d
V55 + M12 (tank mix)[Spg]	37.3 a	0 d	0 c	0.00 d
V55 (Fall) + M12 PPI	38.5 a	0.2 cd	0 c	0.01 d
V55 (Spg) + M12 PPI	36.1 ab	0.2 cd	0 c	0.01 d
V55 (Spg) + Temik 10G 3 lb (IF)	30.8 bcd	1 cd	0.2 c	0.05 cd
Tel 10 + V40 (PPI)	35.5 abc	0.2 cd	0 c	0.01 d
Tel 10 + V30 (PPI)	36.1 ab	0 d	0 c	0.00 d
Tel 10 + V20 (PPI)	35.5 abc	1 cd	0 c	0.03 d
V35 (Shank) + 20 (PPI)	36.6 a	17 b	7 b	0.53 b

Values are means of five replicates. Values in each column not followed by the same letter 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 shank injected 18 inches deep; Except where noted, all Vapam and Vapam-Mocap tank mix treatments applied as a broadcast spray 14 inches deep with sweep shanks; PPI = applied as a broadcast spray and incorporated 4-6 inches deep by rototilling; IF = in-furrow with the seed piece; Fall = fall application; Spg = spring application.

[1] % infection: any tuber infected with *M. chitwoodi*.

[2] % culls: any tuber with 6 or more infection sites were graded as culls.

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

Table 4. Evaluation of green manure and cover crops for control of *Meloidogyne chitwoodi* on Russet Burbank potato based on tuber yields and tuber infection, Prosser, WA. 1996.

Treatment (rate ai/A)	Yield (T/A)	% inf[1]	% culls[2]	Inf. Index[3]
Untreated	22.1 dc	97 a	65 a	3.14 a
Telone II 20 gal/A	23.3 bc	12 cde	6 b	0.48 c
Mocap 6EC 12 lb	21.1 cde	13 cde	4 b	0.43 c
White mustard (August)	21.4 cde	32 c	10 b	0.84 c
White mustard (August) + Mocap 12 lb	21.3 cde	24 cde	9 b	0.79 c
Sordan 79 (August)	19.8 def	15 cde	3 b	0.49 c
Sordan 79 (August) + Mocap 12 lb	25.3 ab	8 de	2 b	0.24 c
Marigold (June)	18.0 f	5 de	1 b	0.26 c
Marigold (August)	19.1 def	4 e	1 b	0.32 c
Lupin (June)	28.0 a	70 b	46 a	2.27 b
Lupin (August)	18.7 ef	25 dc	10 b	1.01 c

Values are means of five replicates. Values in each column not followed by the same letter 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 shank injected 18 inches deep; Mocap broadcast sprayed before planting and incorporated 6 inches deep with a rototiller; Months in parenthesis indicates planting date; All green manure treatments were incorporated 6 inches deep with a rototiller in October, except for the June planted lupin which was incorporated in July.

[1] % infection: any tuber infected with *M. chitwoodi*.

[2] % culls: any tuber with 6 or more infection sites were graded as culls.

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

Table 5. The effect of various nematicide treatments on Norkotah potato yield, percent and intensity of infection corky ringspot disease caused by tobacco rattle virus and vectored by *Paratrichodorus allius*. Balcom & Moe Farms, Inc., Pasco, WA. 1996.

Treatments (rate/A)	Yield (T/A)	Tuber Rating[1]	Infection (%)[2]
Untreated	19.4 ab	2.300 a	75.5 a
Telone II 20 gal	20.3 ab	0.005 c	0.5 d
Telone II 20 gal + Temik 3 lb ai	18.4 bc	0.000 c	0.0 d
Telone II 10 gal + Vapam HL 30 gal	21.2 a	0.000 c	0.0 d
Vapam 24.6(S) + 16.4 gal (SB)	15.9 d	1.175 b	48.0 b
Vapam 24.6(S) + 16.4 gal (SB) + Temik 3 lb ai	16.2 cd	1.170 b	50.5 b
Temik 15G 3 lb ai	18.4 bc	1.705 b	59.5 b
Mocap 6EC 12 lb ai + Temik 3 lb ai	20.6 ab	0.495 c	22.0 c

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 original means used. S = Shank-spray injected 14 inches deep. SB = surface broadcast spray. Temik applied in the furrow with the seed piece. Mocap and 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%).

[2] Any tuber exhibiting symptoms of corky ringspot disease.