MANAGEMENT OF ROOT-KNOT NEMATODES ON POTATO IN WASHINGTON

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Despite costly chemical control practices, the northern root-knot nematode (*Meloidogyne hapla*) and especially, the Columbia root-knot nematode (*M. chitwoodi*) remain a serious problem to potato production, and appear to have increased over the past several years. This is due, in part, to inadequate fumigation practices, and the build-up of nematode population densities resulting from mild winters, unusually warm growing seasons, and poor cropping sequences.

The principal reason *M. chitwoodi* is more important than *M. hapla* is the ability of *M. chitwoodi* to reproduce at lower soil temperatures than required by *M. hapla* (10). This is significant because potatoes in the northwestern U.S. are planted in the spring when soil temperatures range between 40 and 55 F at 6 inches deep. Therefore, *M. chitwoodi* is able to penetrate and reproduce on potato roots earlier in the season than *M. hapla*. Consequently, *M. chitwoodi* will have more generations (4-5) during the growing season than *M. hapla* (2-3) (6). An extra generation, especially late in the season, will result in a tremendous increase in nematode population densities. The more nematodes present will result in increased tuber damage.

MANAGEMENT STRATEGIES

There are several strategies that may be used to manage root-knot nematodes before planting potatoes. Management strategies may include prevention of spread, crop rotation, early harvest, nematicides, and green manure cover crops. The best means to suppress nematode populations would be to employ a combination of these management practices.

Prevention Of Spread

Nematodes under their own power move very short distances. Spread of nematodes from infested to noninfested areas is by means of soil carried on sampling tools, boots, hoofs of animals, and farm equipment, infected plant material, and in reused irrigation water.

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Clean boots, tools and equipment between nematode infested and noninfested fields to prevent moving contaminated soil. Settling ponds will minimize the spread of nematodes through reused irrigation water. Nematodes in the settling ponds will settle to the bottom and eventually die.

A common means of spreading root-knot nematodes is by infected seed potato tubers. M. chitwoodi and (or) M. hapla have been reported from most of the seed potato growing areas in the western U.S. and Canada. However, it is very difficult to detect root-knot nematode infection in seed potato tubers. Seed potatoes are usually not as severely damaged by root-knot nematodes as are potatoes grown for processing and fresh market. The environmental conditions in seed production areas are generally not optimal for root-knot nematode development. These areas usually have cooler soil temperatures, finer textured soils, and a shorter growing season resulting in 1-2 generations compared to 2 or more in commercial production areas. Consequently, symptoms and damage by root-knot nematodes on seed potato are not evident. Although external symptoms of M. chitwoodi may be evident, it is often very difficult to detect any internal tuber damage because the females are immature and brown spots have not yet developed. Probably the best means to determine if a seed-lot is infested with root-knot nematodes is to obtain soil samples from the field in question or to sample the tare soil.

Crop Rotation

The crops most commonly grown in rotation with potato in the Pacific Northwest are alfalfa, (corn Zea mays) and wheat (Triticum aestivum). Corn and wheat are hosts for M. chitwoodi, but not for M. hapla (1,5). Thus, corn and wheat (and other cereals) would be excellent crops to rotate with potato to suppress M. hapla populations. Although both field corn and wheat are suitable hosts for M. chitwoodi, field corn is a longer season crop then wheat and M. chitwoodi is able to complete more generations on field corn than wheat. Thus, wheat would be a better rotational crop than field corn to minimize M. chitwoodi populations. Sweet corn is preferred as a rotational crop to field corn because it is a less suitable host to M. chitwoodi. Super sweet corn cultivars Sweet Tooth and Kandy Kiss have been demonstrated to be resistant to both races of M. chitwoodi. Alfalfa is an excellent crop to suppress M. chitwoodi race 1 populations. However, race 2 and M. haplapopulations will increase to high population densities on alfalfa. Studies indicate that alfalfa germ plasms Nevada Synthetic XX and W12SR2W1 exhibit high degree of resistance to M. chitwoodi race 2 and M. hapla. However, both germ plasms are poor yielders and lack resistance to Verticillium wilt. An important factor in a crop rotation program is proper weed control in the rotational crop. Many weeds are suitable host for M. chitwoodi and M. hapla (1,5).

Crops that are not suitable host to both M. chitwoodi races include asparagus (Asparagus officinalis), cowpea (Vigna unguiculata), fodder radish (Raphanus sativus), lima bean (Phaseolus limensis), Scotch spearmint (Mentha cardiaca), and several cultivars of rapeseed (Brassica napus and B. campestris, sudangrass (Sorghum bicolor), popcorn and super sweet corn (4,5).

Asparagus, lima bean, sudangrass and sweet corn are also unsuitable hosts for M. hapla (1). The use of appropriate potato rotational crops to reduce nematode populations will greatly aid in the performance of a nematicide.

Early Harvest

The severity of tuber damage to M. chitwoodi and M. hapla is greatly increased the longer the tubers remain in the ground. Thus, by harvesting tubers as early as possible damage will be lessened. Early maturing potato varieties, which are harvested by early August usually escape damage by root-knot nematodes. Early harvest is especially beneficial for fields infested with M. hapla, because severe tuber damage is usually not observed until late September to early October. On the other hand, severe tuber infection by M. chitwoodi may be evident by mid-August. Even if nematicide treatments were made for M. chitwoodi, tubers should be harvested as soon as possible. Tubers infected with M. chitwoodi should be processed immediately and not stored. At storage temperatures of 46-48 F, M. chitwoodi continues to develop and tuber damage becomes more pronounced. M. hapla is not known to increase tuber damage at these storage temperatures.

Nematicides

The most common method used to control root-knot nematodes on potatoes in the northwestern U.S. is by soil fumigation with Telone II or metham sodium (7,9). Telone II has been more consistant in controlling M. chitwoodi than metham sodium. Metham sodium is an excellent nematicide, however, in certain soils the desired depth of control is not achieved. Metham sodium is applied in water with sprinklers and is dependent on water for movement into the soil profile.

In fields with high and deep populations of M. chitwoodi soil fumigation alone may not be adequate. Of the nonfumigant nematicides, Mocap has been the most effective in suppressing root-knot nematodes on potatoes. Laboratory and greenhouse studies have demonstrated the excellent nematicidal properties of ethoprop in controlling M. chitwoodi and M. hapla (3). However, because Mocap does not move readily with water its effectiveness in the field is limited to the depth of mechanical incorporation. Mocap is most effective when applied as a broadcast and incorporated 4-6 inches by disking or rototilling just before planting (9). Mocap is registered for control of M. hapla and suppression of M. chitwoodi on potatoes. The best treatment for controlling M. chitwoodi has been the combination of Telone II with Mocap applied as a broadcast-incorporated treatment just before planting (7). Excellent control of M. chitwoodi has also been achieved with the combination of lower rates of Telone II and metham sodium (11). Telone II is injected 18 inches deep followed by metham sodium in ½-inch of water instead of the normal 1-inch of water. Telone II provides control of the deeper placed nematodes, and metham sodium controls nematodes and certain diseases near the surface. In 1991 metham sodium shanked 18 inches deep and applied as a broadcast spray was evaluated in two field trials. In both trials shank-injected metham sodium at 55 gal/A was comparable to Telone II at 20 gal/A (Tables 1 & 2).

Green Manure

Control of root-knot nematodes on potatoes in the northwestern U.S. is heavily dependent on soil fumigation. The continued availability of these nematicides is of major concern to potato growers. Thus, the search for alternative measures to manage root-knot nematodes on potatoes and other vegetable crops has become increasingly important. Rapeseed and sudangrass may provide an alternative method for managing nematodes. Rapeseed and sudangrass contain glucosinolate and cyanogenic glycoside compounds, respectively, which have pesticidal effects when the plants are incorporated into the soil as green manure. Following incorporation, enzymic hydrolysis produces isothiocyanate from glucosinolates and hydrogen cyanide from cyanogenic glycosides. These compounds are toxic to certain insects, fungi, nematodes, and weeds. Within the potato rotational scheme rapeseed and sudangrass can be planted in early August after harvest of wheat or sweet corn rotation crops and incorporated as green manure either in the fall (sudangrass) or following spring (rapeseed).

Greenhouse and field studies show that rapeseed and sudangrass are toxic to *M. chitwoodi* (2,8). Field plots in 1989-90 with sudangrass cv. Piper incorporated in the fall and winter rapeseed cv. Jupiter incorporated in the spring prior to planting potatoes reduced tuber infection comparable to Mocap at 12 lbs a.i./A with about 20% cullage (8). Similar results with Jupiter rapeseed were obtained in 1990-91 field trials (Table 3). However, sudangrass cv. Trudan 8 did not reduce tuber infection compared to the previous year. This was probably due to the extremely cold temperatures in the fall of 1990 that hindered the growth of sudangrass. Only 0.8 ton/A of green tissue was incorporated in 1990 as compared to 8 tons/A in 1989. Excellent control of *M. chitwoodi* was obtained when rapeseed and sudangrass green manure treatments were followed with a preplant incorporated Mocap treatment (Table 3). The green manure plus Mocap treatments were comparable to Telone II.

LITERATURE CITED

1. Faulkner, L. R., and F. D. McElroy. 1964. Host range of northern root-knot nematode on irrigated crop plants and weeds in Washington. Plant Disease Reporter 48:190-193.

2. Mojtahedi, H., G. S. Santo, A. N. Hang, and J. H. Wilson. 1991. Suppression of root-knot nematode populations with selected rapeseed cultivars as green manure. Journal of Nematology 23:170-174.

3. Mojtahedi, H., G. S. Santo, J. N. Pinkerton, and J. H. Wilson. 1988. Effect of ethoprop on *Meloidogyne chitwoodi* and *M. hapla*. Journal of Nematology 20:649.

4. Mojtahedi, H., G. S. Santo, and J. H. Wilson. 1988. Host test to differentiate *Meloidogyne chitwoodi* race 1 and 2 and *M. hapla*. Journal of Nematology 20:468-473.

5. O'Bannon, J. H., G. S. Santo, and A. P. Nyczepir. 1982. Host range of the Columbia root-knot nematode (Meloidogyne chitwoodi). Plant Disease 66:1045-1048.

6. 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.

7. Pinkerton, J. N., G. S. Santo, R. P. Ponti, and J. H. Wilson. 1986. Control of Meloidogyne chitwoodi in commercially grown Russet Burbank potatoes. Plant Disease 70:860-863.

8. Santo, G. S., H. Mojtahedi, A. N. Hang, and J. H. Wilson. 1991. Control of the Columbia root-knot nematode using rapeseed and sudangrass green manure. Proceedings of the 30th annual Washington State Potato Conference, Moses Lake, Wa. Pp 41-46.

9. Santo, G. S., H. Mojtahedi, and J. H. Wilson. 1988. Biology and control of root-knot nematodes on potatoes, 1987. Proceedings of the 27th annual Washington State Potato Conference, Moses Lake, Wa. Pp 67-70.

10. 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.

11. Santo, G. S., J. H. Wilson, and H. Mojtahedi. 1991. Control of Meloidogyne chitwoodi on potato with 1, 3-dichloropropene and metham sodium alone and in combinations. American Potato Journal 68:632.

Table 1. Russet Burbank potato yields, % culls, and infection index from *Meloidogyne chitwoodi* nematicide plots, Prosser, Wa. 1991.

Treatment (rate/A)	Yields (T/A)	Infection Index†	% culls‡
Untreated	23.2 a	4.16 a	81 a
Telone II 20 gal	27.6 a	0.41 c	6 b
Metham 55 gal (1-inch water)	21.6 a	2.86 b	57 a
Metham 55 gal (shank)	29.6 a	0.79 c	13 b
Metham 55 gal (shank) + Metham 40 gal (½-inch)	26.2 a	0.15 c	2 b
Telone II 10 gal + Metham 40 gal (½-inch)	26.9 a	0.20 c	2 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 Duncan's multiple range test.

†Tubers with 6+ infection sites were graded as culls.

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

Table 2. Russet Burbank potato yields, % culls, and infection index from Meloidogyne chitwoodi nematicide plots, Ringold, Wa. 1991.

Treatment (rate/A)†	Yields (T/A)	Infection Index‡	% culls§
Untreated	19.7 a	3.19 a	65 a
Telone II 20 gal	21.0 a	1.20 b	22 b
Telone II 20 gal + Mocap 10G 12 lb a.i.	21.0 a	0.52 b	10 b
Metham 55 gal (1-inch water)	24.8 a	1.38 b	28 b
Metham 55 gal (shank)	22.1 a	1.40 b	30 b
Mocap 10G 12 lb a.i.	18.4 a	1.62 b	35 b
Metham 55 gal (shank) + Mocap 12 lb a.i.	22.6 a	0.61 b	10 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 Duncan's multiple range test.

†Telone II and metham sodium treatments were applied 2-3 weeks before planting, and Mocap was applied as a broadcast incorporated treatment just prior to planting.

‡Tubers with 6+ infection sites were graded as culls.

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

Table 3. Yield and Meloidogyne chitwoodi infection on Russet Burbank potato tubers from soil amended with green manure of Jupiter rapeseed and Trudan 8 sudangrass, 1990-91.

Treatments	Yield (T/A)	Infection index†	% culls‡
Untreated	23 a	4.13 a	91 a
Rapeseed	24 a	0.93 c	14 b
Rapeseed + Mocap	22 a	0.10 c	0.02 c
Sudangrass	24 a	2.68 b	55 b
Sudangrass + Mocap	21 a	0.34 c	5 c
Mocap 10G 12 lb ai/A	25 a	1.11 b	21 b
Telone II 20 gal/A	25 a	0.00 c	0 c

Values are means of five replicates. Means in each column followed by the same letter do not differ significantly at $P < 0.05$, according to Duncan's multiple range test.

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

‡Tubers with 6+ infection sites were graded as culls.