UPDATE ON MANAGEMENT OF MELOIDOGYNE CHITWOODI, AND EPIDEMIOLOGY OF CORKY RINGSPOT DISEASE ON POTATO, 1998

by
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Management of *Meloidogyne chitwoodi* on Potato

The Columbia root-knot nematode, *Meloidogyne chitwoodi* is one of the most serious problems affecting potato production in Washington. Continued research efforts are needed to develop the most efficient and economical management strategies for control of *M. chitwoodi*. It is important to provide the grower with additional and improved management options to keep a step ahead of the problem. In this paper we will report on the progress of the following research objectives: determine the efficacy of non-registered and new chemistry nematicides for control of *M. chitwoodi*, and determine the most efficient methods in using these compounds, including available nematicides; and evaluate organic amendments, and green manure and cover crops for control of *M. chitwoodi*.

Nematicide trials were conducted at WSU-Prosser to evaluate registered and non-registered nematicides for control of *M. chitwoodi* on Russet Burbank potato. For the fourth consecutive year, Mocap™ was evaluated as a tank mix with Vapam™ HL. The tank mix was applied 50% as a broadcast spray 10 inches deep, and 50% broadcast on the surface, 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. In all four years, the tank mix gave excellent control of *M. chitwoodi* (Table 1). In 1998, lower rates of both Vapam™ and Mocap™ also gave excellent control. Further tests need to be done with the lower rates. It should be cautioned that the nematode population in the field plots where these studies were conducted are concentrated in the top 2 ft. Studies need to be conducted in commercial fields with high and deep populations. Vapam™ shank only treatments have given excellent control in plots at Prosser; however, Vapam™ shank only treatment is not recommended. Previous field trials show that shank only treatment is not adequate for soils with high and deep nematode populations. Mocap™ was evaluated in combination with Telone II™ at 10 gallon/A (Table 2). All treatments, except Mocap™ alone gave excellent control. In this trial, Telone II™ 10 gallon gave excellent control. Thus, the additional benefit of control with Mocap™ was not observed. In 1997, Telone II™ 10 gallon did not provide adequate control, and the benefit of Mocap™ was evident (Table 2). These studies will be continued in 1999. For the past three years, multiple post plant broadcast spray treatments of Vydate L ™ were evaluated. In 1996 and 1997 Vydate™ was sprayed on the foliage and followed immediately by 1-inch of sprinkler applied water. In 1998, Vydate™ was applied with 1-inch of water through a sprinkler simulator.

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The first application was made between emergence and tuber initiation followed by none to two more applications three weeks apart. In 1998, Vydate™ gave excellent control of *M. chitwoodi* (Table 3). Similar results were obtained in 1996 but not 1997, although tuber infection was significantly ($P < 0.05$) reduced (Table 3). These results are significant because Vydate™ is the only nematicide currently registered for in-season use. Vydate™ application via sprinklers will be repeated in 1999.

Fosthiazate, an experimental material, which has shown to be very effective against *M. chitwoodi* in previous field trials was evaluated (Table 4). Two of the higher rates tested gave excellent control comparable to Telone II™. Fosthiazate is an organophosphate similar to Mocap™, and has been submitted by ISK Biosciences to EPA for registration. Further studies need to be conducted under commercial field conditions with high and deep populations of *M. chitwoodi.*

A 3-year study, to evaluate bitter lupin, white mustard cv. Martigena and Sordan 79™ (sudangrass-sorghum hybrid) as green manure, and marigold cv. Crackerjack as a cover crop for managing *M. chitwoodi* on Russet Burbank potato was completed. Results showed that over the 3-year period the green manure or cover crops suppressed tuber infection, however, in 1997 and 1998 control was not adequate (>10% culls) (Table 5). Only in 1966 were adequate control achieved with most of the treatments. Even Telone II™ in 1997 did not provide adequate control. Mocap™ alone gave the most consistent control. In 1998, Mocap™ in combination with white mustard and Sordan 79™ did not provide adequate control. This was unexpected, since Mocap™ in combination with green manure crops has consistently given adequate control (4, 5). These results show that the green manure and cover crops evaluated in these studies will reduce *M. chitwoodi* tuber infection but not at acceptable levels.

Crambe and Milkweed seedmeal were evaluated as organic amendments. They were broadcast and incorporated by rototilling 6 inches deep. The toxic compound released by Crambe seedmeal is a derivative of isothiocyanate, which is similar to rapeseed and mustard. The toxic compound in Milkweed is not known. All treatments significantly ($P < 0.05$) reduced tuber infection, except Mocap™ alone and Milkweed 5 T/A (Table 6). Excellent control was achieved with Milkweed at 10 T/A, and Mocap™ 12 lb. ai/A in combination with Crambe at five and 10 T/A. Crambe alone at five and 10 T gave good control with slightly more than 10% culls. Crambe at 10 T has been consistent in reducing tuber infection the last two years (Table 6). Results obtained with Milkweed seedmeal were encouraging.

Epidemiology of Corky Ringspot Disease on Potato

The corky ringspot disease (CRS) can be a severe problem to potato production by blemishing tubers and rendering them unmarketable (3). This disease is caused by the tobacco rattle virus (TRV) which is transmitted by the stubby-root nematode *Paratrichodorus allius*. Both the virus and nematode vector have a wide host range between cultivated crops and weeds (2). Crops that are non-host for the virus include alfalfa, corn, and wheat that are commonly rotated with potato. We have shown in the greenhouse that on Vernema alfalfa the virus is not detected after allowing viruliferous *P. allius* to feed for three months.

Thus, maintaining an alfalfa field weed-free for 2-3 years will reduce the impact of TRV on the subsequent potato crop. Although, corn and wheat are reported to be non-host for TRV, we have detected the virus using PCR in roots fed on by nematodes carrying the virus. Also, TRV was detected in leaves of Stephens wheat grown in soil from a nematode-virus-infested field in Pasco, WA. This indicates that the virus may have multiplied and become systemic in the plant. However, detection of the virus in roots and leaves have not been confirmed by ELISA, suggesting that either the titer of the virus is very low or the TRV strain does not produce nucleoprotein particles. It is important to decide if P. *allius* can acquire the virus from corn and wheat roots and transmit it to potato tubers.

There are several ways a field may become infested with the virus. One is by planting infected potato seed-pieces. However, the role of potato seed-pieces for spreading this disease within a field has not been thoroughly investigated. Preliminary results show that about 18% of the daughter plants from infected tubers became infected with TRV, and <1% of the daughter tubers became infected (1). We need to determine if *P. allius* can acquire the virus from roots of infected potato seed-pieces and transmit it to the daughter tubers.

TRV is vectored by several *Paratrichodorus* spp. However, the known species in Washington and Oregon is *P. allius*. We have shown that *P. allius* from a field in Umatilla, OR. and Pasco, WA. behave differently on potato cultivars. The virus isolates are serologically similar but differ in their short particle sizes. The severity of disease and symptomology also differs from these two locations. CRS disease is more severe and the symptoms are more intense on potato cultivars planted at the Pasco site compared with the Umatilla site. These virus isolates may have a specific relationship with its nematode vector in the CRS disease complex. A similar interaction between European isolates of TRV and their vectors have been demonstrated. Understanding the interrelationship between microorganisms in a disease complex is crucial to a successful management program, including selecting and breeding for resistance.

In 1998 the research objectives were to (a) determine the transmission of TRV by *P. allius* to corn and wheat, and reacquisition of TRV from corn and wheat roots by virus-free *P. allius*; (b) determine the frequency of systemic virus transfer from the mother tuber to daughter plants of Russet Burbank, Ranger Russet and Norkotah potato; (c) determine the ability of *P. allius* to acquire TRV from roots of infected potato seed-pieces and transmission to daughter tubers; and (d) compare the pathogenicity and disease expression of two TRV isolates on Norkotah potato.

Corn and wheat, which are commonly used in rotation with potato, were evaluated as possible hosts for TRV and sources for *P. allius* to acquire TRV. Stephens and Pennewawa wheat, Stylpak and Miracle sweet corn, Pioneer 3489 field corn, and Pioneer 3335 silage corn were inoculated with 150 viruliferous *P. allius*. Samsun NN tobacco served as a control treatment for the virus. After a month, viruliferous *P. allius* were eliminated from the root system by bleaching, and root samples were examined for the presence of TRV using ELISA and PCR. The bleached plants freed of nematodes were repotted and inoculated with 100 virus free *P. allius* and maintained for another month. The nematodes then were extracted and inoculated on Samsun NN tobacco plants. The nematodes that acquired TRV from wheat, corn and tobacco roots transmitted it to tobacco plants and caused visual symptoms.

The asymptomatic tobacco plants were tested for presence of TRV using ELISA or PCR. Results showed that *P. allius* transmitted TRV readily to wheat and corn plants (Table 7). Virus free *P. allius* reacquired the virus from Samsun NN tobacco and transmitted it readily to indicator tobacco plants (Table 8). However, the acquisition of the virus by *P. allius* from wheat and corn was low. This could be due to low titer of virus in these plants. The results of some of the ELISA tests indicate that the virus had not lost the coat protein in wheat and corn, which is essential to be acquired by *P. allius*. Presently, we are testing the significance of wheat and corn in serving as a source of inoculum in field microplots.

CRS diseased potato tubers of Russet Burbank, Ranger Russet, and Norkotah were collected in 1997 from an experimental plot in Pasco, WA. Eyepieces from symptomatic regions of diseased tubers were cut and planted. The results showed that relatively high percentage (25-42%) of plants grown from CRS diseased tubers produced potato plants systemically infected with TRV (Table 9). Since the number of test tubers was limited, these percentages should be viewed with caution. Presently, a much larger population of tubers from the 1998 crop from Pasco is being tested to obtain a more reliable database. Norkotah potatoes grown from diseased tubers produced daughter tubers. Only a few daughter tubers were produced from Russet Burbank or Ranger Russet. Five percent (4/82) of daughter tubers of Norkotah exhibited primary infection of CRS. The symptoms from primary infection were different from nematode vectored symptoms. Primary infection resulted in brown flecks scattered throughout the tuber, and the nematode vectored symptoms originated from the tuber surface extending internally in concentric rings. We plan to collect similar data in 1999 for Russet Burbank and Ranger Russet potatoes. These types of data will determine the potential importance of planting potato seed-pieces infected with TRV.

An experiment was conducted to determine if P. *allius* could acquire the virus from roots of infected potato and transmit it to tobacco indicator plants. Eyepieces from symptomatic regions of CRS diseased Russet Burbank, Ranger Russet, and Norkotah tubers were cut and planted, and after rooting inoculated with 150 virus free *P. allius*. After three months *P. allius* was extracted and inoculated to tobacco indicator plants and maintained for two months. Results showed that *P. allius* could acquire TRV from infected roots of all three potato cultivars and transmit it to indicator tobacco plants (Table 9). In one case, *P. allius* extracted from TRV infected tobacco and added to healthy Russet Burbank potato caused typical CRS symptoms on tubers. These preliminary results suggest that planting infected potato seed-pieces in the presence of *P. allius* could result in higher incidences of tuber infection.

The intensity of CRS disease symptoms observed in the field was much higher in Pasco than in Umatilla. Also, tuber symptoms at Pasco consisted of large brown-black defused spots, whereas, in Umatilla the symptoms were more typical and consisted of concentric rings. In both sites, the vector was *P. allius* with different reproductive potentials on selected plants (2). The pathogenicity of TRV isolates from Pasco, WA and Umatilla, OR was compared on Norkotah potato. The Pasco virus was maintained on Samsun tobacco by inoculation with viruliferous *P. allius* from Pasco. The Umatilla virus was originally isolated from an infected tuber in 1995, and mechanically introduced and maintained on Samsun tobacco. Virus free *P. allius* from Pasco and Umatilla were established on tobacco infected with the viruses isolated from Pasco or Umatilla.

The virus and nematode combinations allowed us to compare the pathogenicity of the two virus isolates regardless of vector influence. Norkotah potato plantlets were inoculated with 240 nematodes in all virus-vector combinations, and maintained in 5-gallon plastic containers in the greenhouse for four months to obtain tubers for symptom evaluation. The results showed that despite nematode sources, TRV from Umatilla seldom caused symptoms on potato and never on tobacco. On tobacco, it was not detected even by PCR. Lack of efficiency in *P. allius* to transmit Umatilla TRV may be associated with the loss of the particle 2 RNA virus genome. This RNA particle is responsible for production of the coat protein that attaches the virus to the lumen of the nematode esophagus. The virus particles are ingested into roots or tubers when the nematode inserts its' stylet into plant cells during feeding. The Pasco virus caused symptoms on tubers, and tobacco leaves and stems despite the nematode vector (Table 10). In a second experiment, the effect of nematode density on disease severity was tested on Norkotah and Russet Burbank using the Pasco virus isolate. Potato seedlings were grown from eyepieces of healthy tubers. *P. allius* carrying the virus was inoculated at 100 and 500 per pot and maintained for four months before tubers were harvested and evaluated for CRS symptoms. The severity of CRS was proportional to inoculum density, and Norkotah was more severely diseased than Russet Burbank (Table 11).

References:

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Table 1. Effect of Vapam-Mocap tank mix on *Meloidogyne chitwoodi* tuber infection (percent culls) of Russet Burbank potato, Prosser, WA., 1995-98.

Treatment (rate ai/A)	Percent culls			
	1995	1996	1997	1998
Untreated	74 a	92 a	89 a	61 a
Telone II 20 gallon	0.2 b	1 b	7 bc	0 b
Mocap 6EC 12 lb	4 b	2 b	24 b	32 a
Vapam 55 gallon (shank)	5 b	2 b	--	--
Vapam HL 41 gallon (shank)	--	--	1 c	1 b
Vapam HL 24.6 (shank) + 16.4 (surface)	--	--	--	0.2 b
Vapam 55 + Mocap 12 (mix)	0.4 b	0 b	--	--
Vapam HL 41 + Mocap 12 (mix)	--	--	0 c	1 b
Vapam HL 41 + Mocap 6 (mix)	--	--	--	0 b
Vapam HL 30 + Mocap 6 (mix)	--	--	--	0.2 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 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. Vapam™ was applied with sweep shanks, as a broadcast spray at 14 inches deep, and surface treatment was broadcast and rototilled 6 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. All fumigant treatments were immediately followed by a cultipacker. Mocap was applied as a broadcast spray with a CO_2 pressurized backpack sprayer and incorporated 6 inches deep with a rototiller. Tubers with six or more infection sites were graded as culls.

Table 2. Percent culls of Russet Burbank potato tubers due to *Meloidogyne chitwoodi* from Mocap™ and Telone II™ plots, Prosser, WA, 1997 &1998.

Treatment (rate ai/A)	Percent culls	
	1997	1998
Untreated	89 a	61 a
Telone II 20 gallon	7 bc	0 b
Telone II 10 gallon	27 b	4 b
Mocap 6EC 12 lb	24 b	32 a
Telone II 10 gallon + Mocap 6EC 6 lb	--	1 b
Telone II 10 gallon + Mocap 6EC 12 lb	0.2 c	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. 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 plots, Prosser, WA, 1996-98.

Treatment (rate lb ai/A)	Percent culls		
	1996	1997	1998
Untreated	92 a	89 a	61 a
Telone II 20 gallon	1 b	7 c	0 b
Mocap 6EC 12	2 b	23 bc	32 a
Vydate L 1 (3x)	--	50 b	0.5 b
Vydate L 2 (3x)	2 b	24 bc	0.1 b
Vydate L 2 (2x)	--	44 b	--
Mocap 6EC 12 + Vydate L 1 (1x)	--	45 b	--
Mocap 6EC 12 + Vydate L 1 (3x)	0 b	--	0.8 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. The first application of Vydate™ was made between emergence and tuber initiation followed by none to two more applications three weeks apart. Tubers with six or more infection sites were graded as culls.

Table 4. Effect of Fosthiazate on *Meloidogyne chitwoodi* tuber infection (percent culls) on Russet Burbank potato tubers, IAREC, Prosser, WA, 1991-94 & 1998.

Treatment (rate lb ai/A)	Percent culls				
	1991	1992	1993	1994	1998
Untreated	93 a	100 a	91 a	100 a	61 a
Telone II 20 gallon	7 bc	0.1 c	0.2 b	0 c	0 d
Mocap 6EC 12	21 b	4 b	0.7 b	3 b	32 ab
Fosthiazate 900 EC 2.25	0 c	--	--	--	--
Fosthiazate 900 EC 3.0	--	--	0.04 b	--	26 abc
Fosthiazate 900 EC 4.5	1 c	1.5 bc	0.04 b	0 c	2 d
Fosthiazate 900 EC 6.0	--	0.2 c	0 b	0 c	3.5 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™ and Fosthiazate were applied as a broadcast spray with a CO_2 pressurized backpack sprayer and incorporated 6 inches deep with a rototiller. Tubers with six or more infection sites were graded as culls.

Table 5. Effect of green manure (white mustard cv. Martigena, Sordan 79 sudangrass-sorghum hybrid, and bitter lupin) and cover (marigold cv. Crackerjack) crops on *Meloidogyne chitwoodi* tuber infection (percent culls) on Russet Burbank potato, IAREC, Prosser, WA, 1996-98.

Treatment (rate ai/A)	Percent culls		
	1996	1997	1998
Untreated	65 a	66 a	95 a
Telone II 20 gallon	6 b	25 cde	0 d
Mocap 6EC 12 lb	4 b	9 def	2 d
White Mustard	10 b	55 abc	75 ab
Mustard + Mocap 12 lb	9 b	7 ef	22 c
Sordan 79)	3 b	70 a	29 c
Sordan 79 + Mocap 12 lb	2 b	2 f	30 c
Marigold (Spring)	1 b	32 bcd	77 ab
Marigold (Fall)	1 b	54 abc	23 c
Bitter Lupin (Spring)	46 a*	62 ab	19 c
Bitter Lupin (Fall)	10 b	69 a	64 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. Sordan 79™ and white mustard were planted August, and all green manure crops were incorporated 6 inches deep with a rototiller in October. Marigold was not incorporated and served as a winter ground cover. Tubers with six or more infection sites were graded as culls. * Plants when incorporated were dead.

Table 6. Percent culls of Russet Burbank potato tubers infected with Meloidogyne *chitwoodi* from Crambe and Milkweed seed meal plots, IAREC, Prosser, WA, 1997 &1998.

Treatment (rate ai/A)	Percent culls	
	1997	1998
Untreated	88.9 a	61.2 a
Telone II 20 gallon	6.7 d	0.0 c
Mocap 6EC 12 lb	33.9 bc	32.2 ab
Crambe 5 T	52.6 b	11.1 bc
Crambe 10 T	16.5 cd	10.3 bc
Crambe 5 T + Mocap 12 lb	--	0.2 c
Crambe 10 T + Mocap 12 lb	--	3.3 c
Crambe 10 T + Mocap 6 lb	--	11.4 bc
Milkweed 5 T	--	37.6 ab
Milkweed 10 T	--	3.2 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. Mocap ™ was applied as a broadcast spray with a CO_2 pressurized backpack sprayer and incorporated 6 inches deep with a rototiller. Crambe and Milkweed seed meal were broadcast on the soil surface and rototilled 6 inches deep three weeks before planting. Tubers with six or more infection sites were graded as culls.

Table 7. Detection of Tobacco Rattle Virus (TRV) in tobacco, wheat, and corn roots inoculated with viruliferous *Paratrichodorus allius* (PA).

Test plants	No. of TRV^+ plants/no. of plants tested
Tobacco cv. Samsun NN	10/10
Winter wheat cv Stephens	26/34
Spring wheat cv. Pennewawa	18/20
Sweet corn cv. Miracle	24/28
Sweet corn cv. Stylpak	12/14
Field corn cv. Pioneer 3489	11/11
Silage corn cv. Pioneer 3335	9/9

Initially, the test plants were inoculated with 150 viruliferous *P. allius* and maintained on greenhouse bench for one month before a small root sample of treated plants were tested for presence of TRV using PCR.

Table 8. Acquisition of Tobacco Rattle Virus (TRV) by *Paratrichodorus allius* (PA) from tobacco, wheat and corn roots and subsequent transmission of virus to indicator tobacco plants.

Test plants	No. of infected plants	No. of PA recovered	Visual symptoms
Tobacco cv. Samsun NN	10	54	10
Winter wheat cv. Stephens	26	62	2
Spring wheat cv. Pennewawa	18	30	0
Sweet corn cv. Miracle	24	164	1
Sweet corn cv. Stylpak	12	254	0
Field corn cv. Pioneer 3489	11	52	0
Silage corn cv. Pioneer 3335	9	71	0

The infected plants were inoculated with 100 virus free *P. allius* and maintained in the greenhouse for one month before the nematodes were extracted and added around the root system of Samsun NN tobacco that served as indicator plants to detect TRV by visual symptoms.

Table 9. Acquisition of Tobacco Rattle Virus (TRV) by *Paratrichodorus allius* (PA) from three potato cultivars and subsequent transmission of virus to indicator plants.

			No. of TRV^+ tobacco determined by		
Potato cultivars	No. of TRV^+ potato/no. tested	No. of PA recovered	Visual symptoms	ELISA	PCR
Russet Burbank	11/40	119	9	2	-
Ranger Russet	10/24	107	5	4	1
Norkotah	21/82	125	21	-	-

Potato seedlings were grown from corky ringspot diseased tubers. Roots and (or) leaves of daughter plants were tested for TRV using ELISA and (or) PCR. The TRV positive plants were inoculated with 100-300 virus free *P. allius*, and maintained in the greenhouse for one month before the nematodes were extracted and added to Samsun NN tobacco indicator plants.

Table 10. Incidence and severity of corky ringspot disease (CRS) affecting Norkotah potato five months after inoculation with *Paratrichodorus allius* isolated from tobacco roots infected with tobacco rattle virus (TRV) from Pasco, WA and Umatilla, OR.

Sources of TRV	% of tubers with CRS	Disease severity
Umatilla, OR	8 a	0.7 a
Pasco, WA	52 b	3.6 b

The means are average for vectors from Pasco, WA and Umatilla, OR combined, and values not followed by the same letter differ at $P < 0.05$ according to Student "t" test. For disease severity, rating tubers were cut in four wedges and based on presence of CRS symptoms on eight cut surfaces, they were rated 0 to 8.

Table 11. Incidence and severity of corky ring spot disease affecting two potato cultivars four months after inoculation with 100 and 500 viruliferous *Paratrichodorus allius* from Pasco, WA.

Potato cultivars	Disease incidence		Disease severity
	% of tubers with CRS	% of pots with at least one affected tuber	
	100 *Paratrichodorus allius*		
Norkotah	17 a	40 a	0.27 a
Russet Burbank	16 a	27 a	0.30 a
	500 *Paratrichodorus allius*		
Norkotah	67 b	93 b	2.15 b
Russet Burbank	45 c	80 b	1.27 b

Fifteen 13-cm-d clay pots per cultivar were filled with methyl bromide treated field soil and maintained very wet on the greenhouse bench. The tubers were collected and evaluated for CRS symptoms, and presence of tobacco rattle virus in the representative tuber samples was confirmed by PCR. The values in the first and last columns were subjected to Student "t" test and means followed by the same letters do not differ at $P < 0.05$. The data in middle column were subjected to categorical analysis, and means were discriminated by using 2 values. For disease severity, the tubers were cut in four wedges and based on presence of corky ring spot symptoms on eight cut surfaces, they were rated 0 to 8.