An Investigation on Plant-Parasitic Nematodes in Horseradish Fields in Illinois

by

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INTRODUCTION

Horseradish, *Armoracia rusticana* P. Gaertn., B. Mey. Scherb, is grown for its white, fleshy, and pungent roots. Approximately, half of the total commercial horseradish in the United States is produced in Mississippi River Valley, near East St. Louis, Illinois (10). Over the past 20 years, the horseradish growers in the area have experienced internal discoloration in horseradish roots and a significant reduction in the marketable yields (4).

Root deterioration of horseradish was observed in Germany as early as in 1860 and the word "Schwarzwerden," or black discoloration, was used to describe a condition of horseradish in 1895 and 1899 (11). Percich and Johnson (9) investigated horseradish root rot in Wisconsin and reported that root deterioration of horseradish was caused by a complex of organisms including *Fusarium roseum* 'Accumunatum', *Verticillium dahliae*, and *Pseudomonas fluorescence*. Gerber, et al. (6) indicated that the internal discoloration of horseradish roots in Illinois was a soil related problem and sterilization of the soil would alleviate the problem. Jacobson and his coworkers (7) investigated the root discoloration of horseradish in the Mississippi River Valley area during 1984-1986. They assayed horseradish roots from 12 fields and isolated 25 different fungi and bacteria from the roots with brown-black vascular discoloration. The results of their studies on the pathogenicity of the isolated organisms show that *Verticillium albo-atrum*, *Fusarium oxysporum*, *F. roseum* 'Accumunatum', an unidentified "curly green fungus," a *Pseudomonas* species, and an *Erwinia* species caused internal root discoloration in horseradish. During 1990s, Eastburn and Chang (4) studied the discoloration of horseradish roots from the area and reported that *V. dahliae* was the primary pathogen associated with symptoms of the root discoloration.

Failure in controlling the discoloration problem of horseradish by soil fumigation (1, 7) and fungicide treatment of plant stocks (1) resulted in making attempts to control *V. dahliae* by using plant resistance (1). To find resistance sources, 113 horseradish cultivars from the University of Illinois germ plasm collection were evaluated and six cultivars were identified as resistant to *V. dahliae*. However, commercially-acceptable horseradish cultivars resistant to the internal discoloration of roots are not yet available.

During various meetings, the growers have expressed their concerns on the lack of effective methods to control the discoloration of horseradish roots. Also, they have repeatedly urged the university scientists to carry out an appropriate investigation to determine if there is any involvement of plant-parasitic nematodes in the root discoloration of the plants. Although in 1940 Kadow and Anderson (8) discussed diseases caused by nematodes in horseradish plants, there is no recently published report on the interactions between plant-parasitic nematodes and horseradish plants. The purpose of this study was to determine the presence of plant-parasitic nematodes in horseradish fields in the Mississippi River Valley area by assaying soil and plant root samples.

MATERIALS AND METHODS

Based on the soil types, field locations, and cropping history, 10 horseradish fields in the Mississippi River Valley area (Table 1) were selected for studying. Soil types on the selected fields varied in texture with sandy loam, silt loam, silty clay loam, and clay loam soils being represented. Soil and root samples were collected on August 16, 1999, by walking across the longest diagonals in the fields. In each field, 10 locations were selected and one plant in each location was dug out. Soil around the roots and the roots were collected. The collected soil samples from each field were mixed and a sample of approximately three pounds was placed in a plastic bag. The collected roots from each field were also placed in a separate plastic bag. All bags, containing soil samples and the roots, were kept in coolers during transportation and at 4 C in the laboratory until processing.

The soil samples were assayed for the presence of plant-parasitic nematodes using sieving and sugar-flotation methods. A set of sieves, ranging from 30 mesh on the top to 325 mesh on the bottom, was used to extract nematodes from the soil samples. Recovered plant-parasitic nematodes form 100 cc of the soil samples were identified and the exact number of the nematodes in each genus was determined.

The roots were washed with tap water and examined for the presence of the nematodes and any symptom that might had been caused by the plant-parasitic nematodes, using a dissecting microscope. Also, sections of various parts of the roots, particularly lateral and internally-discolored roots, were cut in pieces of 1-3 mm. From each field, 300 cc of the cut roots were assayed for the presence of nematodes using the mist-extraction method. The mist-extraction of nematodes was achieved during a 10-day period. Plant-parasitic nematodes extracted from the root samples were identified. The root samples used for nematode extraction were dried at 80 C for 48 h and the dry weight of the roots was determined. Number of nematodes per gram of dried roots was calculated.

RESULTS AND DISCUSSIONS

Five genera of plant parasitic nematodes, including *Pratylenchus* (lesion), *Tylenchorhynchus* (stunt), *Helicotylenchus* (spiral), *Xiphinema* (dagger), and *Hoplolaimus* (lance), were identified in the extractions from the soil samples (Table 2). The number of nematodes in the genera *Pratylenchus*, *Tylenchorhynchus*, *Helicotylenchus*, *Xiphinema*, and *Hoplolaimus* extracted from 100 cc of the soil samples ranged 14-135 (ave = 44), 31-266 (ave = 107), 6-371 (ave = 62), 0-11 (ave = 3), and 0-12 (ave = 2), respectively. Plant-parasitic nematodes extracted from the mist-extraction of root samples belonged to the genera *Pratylenchus*, *Tylenchorhynchus*, and *Helicotylenchus* (Table 3). The number of nematodes in the genera *Pratylenchus*,

Table 1. Horseradish fields assayed for presence of plant-parasitic nematodes.

Field code	Field location	Grower's name	Cropping history					
			99	98	97	96	95	94
99-HR-11	Edwardsville	George Willaredt	HR*	FC	WH,SB	SB	HR	**
99-HR-12	Granite City	John Relleke	HR	SC	Pump	HR	SC	Pump
99-HR-13	Granite City	Craig Engeling	HR	SB	FC	FC	HR	SB
99-HR-14	St. Jacob	Don Smith	HR	FC	SB	Pump	HR	SB
99-HR-15	Collinsville	Craig Keller	HR	SC,SB	FC	HR	**	**
99-HR-16	Collinsville	Craig Keller	HR	SC	FC	HR	**	**
99-HR-17	Caseyville	Barry McMillen	HR	SB	SB	FC	HR	FC
99-HR-18	Washington Park	Bratsch/Weissert (Exp)	HR	SB	HR	SB	FC	HR
99-HR-19	Fairview Hts.	Carl Weissert	HR	FC	SB	HR	FC	SB
99-HR-20	Collinsville	Robert Fournie	HR	FAL	SC	HR	SC	HR

* Codes: SC = sweet corn, FC = field corn, SB = soybean, HR = horseradish, FAL = fallow, WH = wheat, and Pump =pumpkin.
** Not known

Table 2. Plant-parasitic nematodes recovered from soil samples collected from horseradish fields in Illinois in 1999.

Field	Number of nematodes recovered from 100 cc of soil				
	Lesion (*Pratylenchus*)	Stunt (*Tylenchorhynchus*)	Spiral (*Helicotylenchus*)	Dagger (*Xiphinema*)	Lance (*Hoplolaimus*)
99-HR-11	14	99	19	11	0
99-HR-12	36	131	8	0	0
99-HR-13	22	39	113	4	12
99-HR-14	19	198	11	0	0
99-HR-15	135	34	15	7	0
99-HR-16	38	266	13	0	0
99-HR-17	28	52	54	0	0
99-HR-18	72	64	6	1	1
99-HR-19	36	31	371	4	2
99-HR-20	40	156	8	0	0

Average	44	107	62	3 2

Table 3. Plant-parasitic nematodes recovered from horseradish roots collected from horseradish fields in Illinois in 1999.

	Number of nematodes recovered from roots (based on 1 g dry roots)			
Field	Lesion (*Pratylenchus*)	Stunt (*Tylenchorhynchus*)	Spiral (*Helicotylenchus*)	
99-HR-11	12	0	<1	
99-HR-12	8	<1	0	
99-HR-13	0	0	<1	
99-HR-14	<1	0	0	
99-HR-15	2	0	0	
99-HR-16	<1	1	0	
99-HR-17	0	<1	0	
99-HR-18	<1	<1	0	
99-HR-19	<1	<1	<1	
99-HR-20	47	0	0	
Average	7	<1	<1	

Tylenchorhynchus, and *Helicotylenchus* per gram of the dried roots ranged 0-47 (ave = 7), 0-1 (ave <1), and 0-1 (ave <1), respectively.

There was no significant correlation between the number of the plant-parasitic nematodes found in the soil samples and soil type or the cropping history. Also, numbers of plant-parasitic nematodes extracted from the soil samples and the root samples were not correlated. This could be explained, in part, by the fact that nematodes extracted from the soil may have reproduced on weed hosts rather than in or around horseradish roots or on previous crops used in the rotation.

There is no established quantitative level to determine threshold levels for damage caused by plant-parasitic nematodes in horseradish as there is for field crops such as corn and soybean. However, based on the generalized population threshold for damage by plant-parasitic nematodes in other crops in Illinois, it appears that horseradish should not be significantly affected by dagger and lance nematode populations encountered in the soil or by root extractions (Tables 2 and 3). For the spiral nematode, only one soil sample (sample # 99-HR-19) contained nematode population above the threshold for severe damage as determined for corn and soybean. In the other nine samples, spiral numbers ranged from 6 to 113, which is considered as insignificant and/or of minor importance. The number of spiral nematodes obtained from root mist-extraction is considered to be extremely low and insignificant.

Stunt nematode populations were the highest among the ten soil samples collected from the horseradish fields. However, it is common to find high stunt populations in soil types typical of those collected from horseradish fields under study. Threshold numbers for stunt nematodes per 100 cc of soil for degrees of severity are as follows: 1-10, insignificant; 11-50, minor; 51-100, moderate; 101-200, severe; above 200, very severe. Again these threshold numbers are based on potential damage to corn and soybean and no correlation can be made for damage to horseradish. Stunt nematode populations encountered could have resulted from the carry-over from a previous susceptible crop or have the build-up on weed hosts in the fields.

Lesion nematode populations were high in only two of the ten soil samples (99-HR-15 and 99-HR-18, Table 2). In the other eight soil samples, lesion nematode populations per 100 cc of soil are considered to be insignificant, minor, or moderate importance for degrees of problem severity. Again, these numbers are based on thresholds for corn and soybean. Since the lesion nematode is an endo-parasite (feeds internally on root cortex tissue), the root mist-extraction was performed. Normally, the mist-extraction would reveal more lesion nematodes within the roots than found in the soil. This was not the case in this study and suggests that horseradish is not a preferred host for the lesion nematode involved.

The senior author of this study examined horseradish roots collected from the fields, using a

dissecting microscope, and found no particular root symptoms typical for those caused by the plant parasitic nematodes encountered.
It is the opinion of the extension nematologist author (D. I. Edwards) that the plant-parasitic nematodes found in this study are not the causal agents of the internal root discoloration of horseradish. It is possible that the higher populations of the stunt and lesion nematodes may be causing some damage in horseradish; however, it is doubtful that the use of a nematicide would have an economical return in yield increases.

The interactions of plant-parasitic nematodes with other organisms in plant disease complexes have been investigated and synergisms of plant-parasitic nematodes and soil-borne fungi, particularly *Verticillium* species, in the disease complexes have been reported (2, 3, 5). The objective of this study was to determine the presence of plant-parasitic nematodes in soil and horseradish roots in the fields. Further studies may reveal interactions of plant-parasitic nematodes with other pathogens in causing the root discoloration of horseradish in the area.

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LITERATURE CITED

1. Atibalentja, N., and Eastburn, D. M. 1997. Evaluation of inoculum methods for screening horseradish cultivars for resistance to *Verticillium dahliae*. Plant Disease 81: 356-362.

2. Beute, M. K., and Benson, M. D. 1979. Relation of small fauna to plant disease. Pages 485-502, in: Annual Review of Phytopathology, Vol. 17, ed. R. G. Grogan, G. A. Zentmeyer, and E. B. Cowling. Annual Reviews Inc., Palo Alto, California.

3. Bowers, J. H., Nameth, S. T., Riedel, R. M., and Rowe, R. C. 1996. Infection and colonization of potato roots by *Verticillium dahliae* as affected by *Pratylenchus penetrans* and *P. crenatus*. Phytopathology 86: 614-621.

4. Eastburn, D. M., and Chang, R. J. 1994. *Verticillium dahliae*: a causal agent of root discoloration of horseradish in Illinois. Plant Disease 78: 496-498.

5. Endo, B. Y. 1975. Pathogenesis of nematode-infected plants. Pages 213-238, in: Annual Review of Phytopathology, Vol. 13, ed. B. F. Kenneth, G. A. Zentmeyer, and E. B.

Cowling. Annual Reviews Inc., Palo Alto, California.

6. Gerber, J. M., Doll, C. C., Simons, R. K., and Fillingim, K. E. 1983. Internal discoloration of horseradish-development of symptoms. Univ. Ill. Veg. Res. Rep. Hortic. Ser. 47: 34-37.

7. Jacobson, B. J. ..... Draft of Final Report to Tri-County Vegetable Growers Association on Investigations of Vascular Internal Discoloration Problems of Horseradish.

8. Kadow, K. J., and Anderson, H. W. 1940. A study of horseradish diseases and their control. Univ. Ill. Agric. Exp. Stn. Bull. 496: 530-583.

9. Percich, J. A., and Johnson, D. R. 1990. A root rot complex of horseradish. Plant Disease 74: 391-393.

10. Rhodes, A. M. 1977. Horseradish-Problems and Research in Illinois. Pages 137-147 In: Crop Resources. Academic Press, Inc., New York.

11. Sorauer, P. 1899. Kernfaule und Schwarzwerden des Meerrettich. Ztschr. f. Pflanzenkrank. 9: 132-137.