Association of *Xiphinema* Species with Soil Type and Grapevines Infected with Tomato Ringspot Virus in Ontario, Canada

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ABSTRACT

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Xiphinema rivesi was recovered from all nematode-containing samples taken from the root zone of grapevines either healthy or infected with tomato ringspot virus (TmRSV) in 21 European hybrid vineyards in the Niagara Peninsula. *X. americanum* was found in one of those samples. TmRSV-infected vineyards occurred on all soil types, and the virus was transmitted to bait plants grown in soil from infected vines. The results indicated that *X. rivesi* is the principal vector of the virus in the area studied and that this nematode is associated with a wider variety of soil types than was previously reported.

Tomato ringspot virus (TmRSV) causes significant losses in tree fruit, berry, and grape crops in the United States (8,10,12). *Xiphinema americanum* Cobb was the only known vector of the virus until about 1981 (14), when a newly recognized but similar species, *X. rivesi* Dalmasso, also was shown to be a vector (7). The efficiency of transmission of TmRSV by both nematode species was similar in tests with dandelion (4). *X. rivesi* is now reported to occur in at least 11 eastern states, whereas *X. americanum* occurs in most if not all states of the United States (11). Survey data from Pennsylvania indicated that both nematode species were associated with TmRSV-infected apple, blueberry, and peach, whereas only *X. rivesi* was found in limited samples from grape and raspberry (8).

TmRSV also is widespread in the fruit-growing region of the Niagara Peninsula in Ontario, where it is responsible for significant losses in grape, peach, cherry, and raspberry (2; W. R. Allen, *unpublished*). Until about 1982, *Xiphinema* species associated with TmRSV-infected plants in Ontario were identified as *X. americanum*. The taxonomic revision of the *X. americanum* species group (9), however, prompted a reexamination of the *X. americanum* collection in the Canadian National Collection of Nematodes. Three species were subsequently identified, viz., *X. rivesi, X. americanum*, and *X. occiduum* n. sp. (5). In all cases, *X. americanum* was reportedly recovered from "well-drained soils with a high sand content," while *X. rivesi* tended to be found in "less well-drained soils with higher clay and lower sand content." The specific composition of the soils was not recorded.

The wide distribution of *X. rivesi* in Ontario, as indicated by the Canadian National Collection, led us to suppose that this species, rather than *X. americanum*, might be solely or predominantly responsible for transmission of TmRSV in fruit-growing areas. However, because of the diversity

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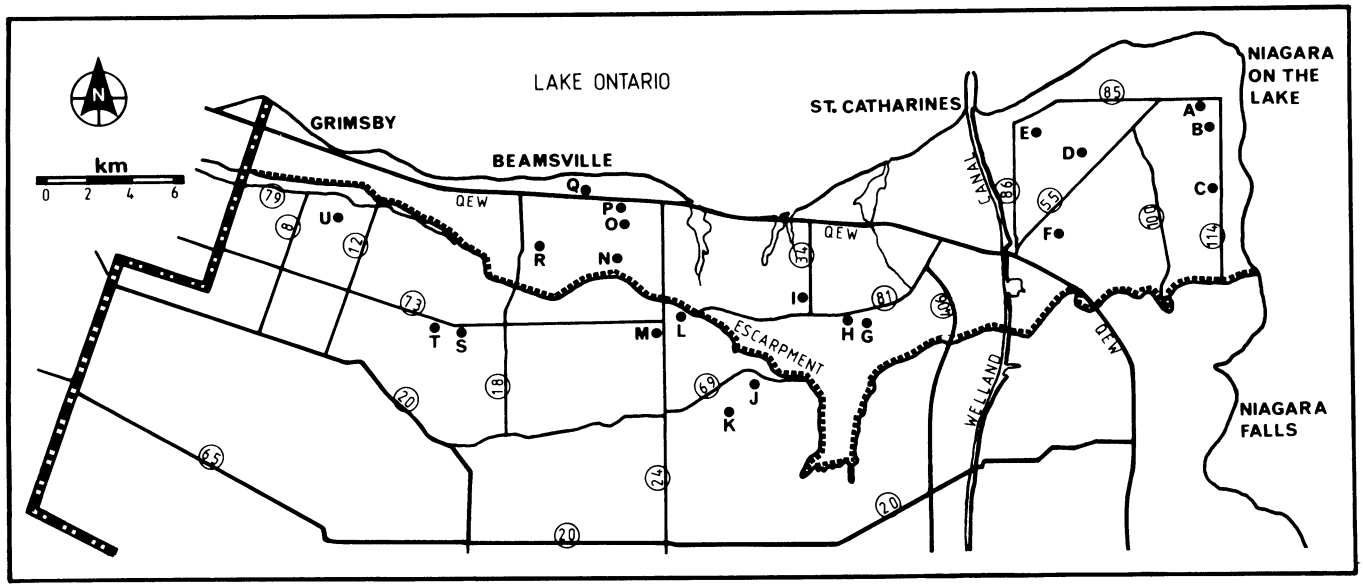

Fig. 1. Location of vineyards (solid circles with letters; circled numbers identify highways) in Lincoln County, Ontario, Canada, from which *Xiphinema* species were collected.

Table 1. Association of *Xiphinema* species with soil type and grapevines infected with tomato ringspot virus (TmRSV) in Lincoln County, Niagara Peninsula, Ontario, Canada

Soil type	Vineyard[a]	*Xiphinema* spp.	TmRSV-infected[b] Vines	TmRSV-infected[b] Cucumber bait plants
Haldimand clay-loam	I,J,K	*X. rivesi*	I,J,K	I,J,K
Jeddo clay-loam	A,B,D,Q,U	*X. rivesi*	A,B,D,Q,U	A,B,D,Q,U
	B	*X. americanum*		
Lincoln clay	F,S,T	*X. rivesi*	F	F
Oneida loam	L,M	*X. rivesi*	L	L
Smithville loam	G,H	*X. rivesi*	H	H
Trafalgar silty clay-loam	N,P,R	*X. rivesi*	P,R	P,R
Vineland fine sandy-loam	C,E,O	*X. rivesi*	E	E

[a] Figure 1 shows location of vineyards, each designated by a different letter.
[b] TmRSV was detected in vines and cucumber by mechanical transmission to *Chenopodium quinoa*. Virus was identified by serology.

Table 2. Soil composition at 90 nematode collection sites in vineyards in Lincoln County, Niagara Peninsula, Ontario, Canada[a]

Soil type	Parent soil	Sand (%)	Silt (%)	Clay (%)	pH	Organic matter (%)
Haldimand clay-loam	Calcareous clay till	44	23	33	6.6	0.9
Jeddo clay-loam	Calcareous clay till	29	20	51	6.8	1.0
Lincoln clay	Calcareous clay till	20	31	49	5.2	5.3
Oneida loam	Calcareous clay till	27	39	34	4.6	1.7
Smithville loam	Calcareous clay till, overlain by lacustrine silt sediment	31	40	29	5.7	0.6
Trafalgar silty clay-loam	Calcareous silty clay loam till	10	45	45	5.5	3.0
Vineland fine sandy-loam	Calcareous medium and fine sand	64	23	13	5.6	1.8

[a] Values taken from Lincoln County soil survey data (13).

in soil types in which TmRSV-infected crops have been found, and because the Niagara Peninsula had not been widely surveyed for *Xiphinema* species, it could not be assumed that *X. americanum* was an insignificant vector in all areas of the region. To obtain additional information on both the distribution of *Xiphinema* species and the association of these nematodes with soil type and TmRSV-infected crops, a survey was conducted in vineyards for which the virus disease incidence was known (2) and for which information on soil classification was available. The results of the survey are presented here.

MATERIALS AND METHODS

Soil samples were collected near the roots of at least three grapevines in each of 27 vineyards in the Niagara Peninsula of Ontario, specifically in Lincoln County. Vineyards were selected on the basis of soil type and the presence or absence of TmRSV-infected vines. The location of soil types was determined from a soil map of Lincoln County (13). The vineyards were 10 or more years old and consisted mostly of cv. De Chaunac (Seibel 9549). All selected vines in 14 of the vineyards tested positive for TmRSV by the enzyme-linked immunosorbent assay (ELISA) procedure performed, as reported (2), with antiserum prepared to a De Chaunac isolate of the virus (1). The vines also were tested for virus by mechanical inoculation to *Chenopodium quinoa* Willd., as reported (2). Isolated viruses were tested against the TmRSV antiserum by the gel double-diffusion procedure (2). The bioassay and ELISA results were in agreement.

At least 10 kg of soil was removed from the root zone of each vine and stored at 5 C in plastic bags. Each soil sample was mixed by tumbling and then divided into two lots. Nematodes were extracted from one lot by water-flotation and wet-screening through stacked screens (0.25- and 0.149-mm mesh) (6). At least 50 *Xiphinema* specimens were collected from each soil lot and fixed in hot 4% formaldehyde for identification by one of the authors (BAE), according to published morphometric indices (5,9,14). The other soil lot was added to sterile 12-cm clay pots that were planted to *Cucumis sativus* L. cv. Windermoor Wonder and maintained as reported (3). Five weeks after plants emerged, leaves and washed roots of each plant were tested for virus by mechanical inoculation to *C. quinoa*.

Isolated viruses were tested against TmRSV antiserum by the gel double-diffusion procedure.

RESULTS AND DISCUSSION

Xiphinema species were recovered from 21 (Fig. 1) of the 27 vineyards surveyed and from 71 of the 90 sites sampled. *X. rivesi* occurred in all 71 samples and in all seven soil types surveyed and *X. americanum* occurred in one sample, a clay-loam (Table 1). These results appear contrary to those (5) derived from specimen data in the Canadian National Collection of Nematodes, which indicated that *X. rivesi* occurred most commonly in less well-drained soils having high clay and low sand content. Table 2 lists the approximate soil composition at the sites sampled in the current study. Those soils ranged from heavy clay to fine sandy-loam.

X. rivesi was found in soil taken from all TmRSV-infected vines, and *X. americanum* occurred in one of those samples (Table 1). Coincidentally, at least one of 16 *C. sativus* bait plants became infected with TmRSV when grown in soil collected from the root zone of two virus-infected vines in each vineyard.

The predominant association of *X. rivesi* with TmRSV-infected vines and the apparent general presence of this species in vineyards suggest that it is the principal vector of the virus in the area studied. More extensive sampling is required, however, to determine if *X. americanum* has the limited occurrence indicated by the present results and the records from the Canadian National Collection of Nematodes.

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