Distribution of *Plum pox virus* in Residential Sites, Commercial Nurseries, and Native Plant Species in the Niagara Region, Ontario, Canada

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ABSTRACT

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Extensive surveys of native weed populations in peach orchards heavily infected with *Plum pox virus* strain D (PPV-D) in the Niagara Region quarantine area, Ontario, Canada, failed to identify natural infection in any of the species examined. Surveys of rural and urban residential properties within areas of high PPV incidence did not detect widespread infection of susceptible hosts, with infected *Prunus glandulosa* (dwarf flowering almond) being found only at one site. The prominent color-breaking observed in blossoms of PPV-infected *P. glandulosa* would make this an excellent sentinel species for early detection of virus in *Prunus* orchards. Surveys of susceptible ornamental *Prunus* spp. in Niagara nurseries failed to demonstrate PPV infection in any of the nursery field plantings.

Additional keywords: host range

Plum pox virus (PPV) is a devastating disease of stone fruits including peaches, apricots, plums, nectarines, and almonds. Wild and ornamental *Prunus* species have also been shown to be susceptible to the virus (17,18,20–25). Four PPV strains have been described to date: PPV-D and PPV-M, the two most common strains, originally in apricot trees from southeastern France and from peach trees from Greece, respectively, PPV-EA in apricots in Egypt, and PPV-C in sour cherry from Moldova (7). Economic losses from these strains can be catastrophic to stone fruit production in large geographic areas (1). Yield loss and reduction in fruit quality and size have resulted in the removal of large areas of stone fruit production (9).

The Dideron strain (PPV-D) is the only strain known to occur in North America. First reported in Adams County, PA, in 1999 (15), it was later reported in southern Ontario and Nova Scotia, Canada, in 2000 (3). The heaviest concentration of infection was found in the Niagara Region of southern Ontario. National surveys of commercial *Prunus* orchards were initiated by the Canadian Food Inspection Agency (CFIA) in 2000 to delimit the extent of infection

and establish quarantine zones to control the spread of the disease.

In addition to ornamental *Prunus* species, a large number of native and introduced weed species have been shown to be susceptible (3). It should be noted, however, that while several dozen weed species have been shown to be susceptible to PPV in laboratory studies, limited information is available on whether natural infection occurs in the field and the role of these species in PPV survival and spread in orchards (3). Natural spread of PPV occurs in a nonpersistent manner by several species of aphids, although the PPV-D group is not as efficiently transmitted as other strains and tends to spread more slowly (3). Further, many of the reports on susceptible weed hosts of PPV fail to mention which strain of the virus was examined. Long-distance spread occurs largely through the movement of infected nursery stock.

This study reports on surveys made within the Niagara quarantine area to identify the distribution of PPV in non-stone fruit species in commercial orchards, ornamental nurseries, and rural and urban residential properties. These surveys were structured and implemented in cooperation with the CFIA to provide a more complete picture of the extent of PPV infection to complement eradication measures.

MATERIALS AND METHODS

Native plant surveys. Surveys were made between June and October 2001 and 2002 in 76 peach orchards with greater than 3.5% infection incidence of PPV-D within the Niagara quarantine area (Fig. 1).

Infection incidence (%) at each site was based on surveys conducted by the CFIA using the hierarchical survey method (12). Due to the expanse of the area surveyed, it was necessary to continue surveys over a 5-month period each year. Sampling of known PPV-infected peach trees at each site was also done over the survey period to monitor virus detection.

Native plant species were sampled within a 30-m radius of each infected tree, and the location was mapped. A representative sample of the weeds within this area was taken, including about 5% of the total population of each species. Based on other studies in which susceptibility of weed hosts to various strains of PPV was demonstrated experimentally, a number of plant species were targeted and sampled more extensively than other species when present at the various sites. These included bellflower (*Campanula* sp.) (6), bird's-eye speedwell (*Veronica persica* Poir.) (16), bishop's weed (*Amni majus* L.) (7,10,16), black medic (*Medicago lupulina* L.) (14), black nightshade (*Solanum nigrum* L.) (9), chicory sp. (*Cichorium* sp.) (9), bluewings (*Torenia fournieri* L.) (7,10), bladder campion (*Silene vulgaris* (Moench) Garcke) (4), buttercup (*Ranunculus* sp.) (2,5), Canada thistle (*Cirsium arvense* (L.) Scop.) (9), chickweed (*Stellaria media* (L.) Cyrill.) (16), clover sp. (*Trifolium* sp.) (14), dandelion (*Taraxacum officinale* Weber) (9), field bindweed (*Convolvulus arvensis* L.) (9), ground cherry (*Physalis* sp.) (5), groundsel (*Senecio sylvaticus* (L.) Ann.) (10,16), henbit sp. (*Lamium* sp.) (6,16), lamb's-quarters sp. (*Chenopodium* sp.) (16), shepherd's-purse (*Capsella bursa-pastoris* (L.) Medik.) (16), vetch sp. (*Vicia* sp.) (14,15), thistle sp. (*Sonchus* sp.) (9), and white lupine (*Lupinus albus* L.) (6,14). Leaves from four plants of each species from each site were composited into one sample, sealed in a labeled plastic bag, and stored in a Styrofoam cooler with ice packs pending transport to the laboratory. The relative number of samples collected at each site was generally weighted on the prevalence of the species, with typically 10 or more composited samples of each species being taken.

Residential surveys. Rural and urban residential properties were surveyed in Niagara and East Grantham townships, which represented the highest level of PPV infection within the quarantine area. Sur-

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veys were made between May and September 2001 and 2002. Domestically grown *Prunus* fruit trees (excluding cherry varieties, not considered susceptible to PPV-D) and landscaping plants were surveyed at each site. Non-*Prunus* species, identified as PPV susceptible by other researchers, were targeted and included euonymus sp. (*Euonymus* sp.) (12), walnut sp. (*Juglans* sp.) (1,11), and privet (*Ligustrum vulgare* L.) (13). In most cases, plants were sampled individually, with 8 to 16 leaves (or approximately 10 g of leaf tissue) being arbitrarily selected from each plant. Privet and euonymus growing in hedges were compositely sampled with four plants constituting one sample. Samples were collected and shipped as previously described. When enzyme-linked immunosorbent assay (ELISA) results were inconclusive (within 10% of the detection threshold) or positive, individual plants were resampled and tested by both ELISA and polymerase chain reaction (PCR) (Centre for Plant Health, CFIA, Sidney, B.C.).

Nursery surveys. Nine commercial nurseries were targeted for surveys within the Niagara quarantine area in 2001 (Fig. 1). Ornamental *Prunus* spp. used in landscaping and walnut spp. were targeted at each nursery (Table 1). *Prunus* fruit nursery stock was not surveyed, as it was included in the CFIA national surveys. Generally, second year nursery stock was surveyed in the field, with leaf samples being composited from four plants into one sample. In most cases, all the nursery material described was sampled at each site.

PPV testing. In the laboratory, 0.5 g of tissue was subsampled from each composited field sample, placed in a 12 × 14 cm BioReba universal extraction bag (Bioreba, Reinach, Switzerland), and shipped with ice packs in a cooler to the Laboratory Services Division, University of Guelph, Guelph, Ontario, for double-antibody sandwich (DAS)-ELISA. Samples were tested for PPV using the Durviz polyclonal 5B-IV for coating, and the monoclonal PPV 96IVIA conjugate (C. E. Durviz, S. L., Valencia, Spain) within 7 days of field collection. PPV-infected and healthy peach leaves were used as controls. Any samples considered suspect or positive for PPV were resampled from the field within 2 weeks and retested by ELISA and PCR at the Southern Crop and Food Research Center, AAFC, Vineland Research Station, and in some cases by the Center for Plant Health, Canadian Food Inspection Agency (CFIA), Sidney, B.C. Strain identification of positive isolates was made by D'Ann Rochon, Pacific Agriculture Research Centre, Agriculture and AgriFood Canada, Summerland, B.C.

RESULTS

Native plant surveys. A total of 99,328 plant specimens were collected over the 2

years of the survey, representing 188 species from 53 plant families (Table 2). Samples were collected from 76 sites within the quarantine zone across Lincoln County, including Niagara, Grantham, Louth, Clinton, and North Grimsby townships (Fig. 1).

Testing by ELISA failed to demonstrate the presence of PPV in any of the samples, and no symptoms consistent with PPV infection were seen. *Ribgrass mosaic virus*, a tobamovirus, was infrequently found in both *Plantago lanceolata* L. (narrow-leaved

Fig. 1. Native plant survey and nursery sites within the Niagara quarantine area. Top: Louth, Clinton, and North Grimsby townships. Bottom: Niagara and Grantham townships. Native species and nursery sample sites are represented by circles and rectangles, respectively.

Table 1. Survey of known *Plum pox virus* (PPV) hosts^a for PPV infection in commercial nurseries in the Niagara quarantine zone

Species	Common name	# Plants sampled	# Nursery sites sampled
<i>Prunus americana</i>	American plum	9,096	5
<i>P. cistena</i>	Purple-leaved sandcherry	33,696	7
<i>P. nigra</i>	Canada plum	152	3
<i>P. triloba</i>	Flowering almond	9,640	6
<i>P. virginiana</i>	Chokecherry	262	1
<i>Juglans nigra</i>	Walnut	2,984	5

^a Species that have been shown to be susceptible to one or more strains of PPV in scientific studies.

Table 2. Survey of native plant species for susceptibility to *Plum pox virus*^a

Family/species	Common name	SC ^b	SS ^c
Aceraceae			
<i>Acer negundo</i> L.	Manitoba maple	108	10
Amaranthaceae			
<i>Amaranthus graecizans</i> L.	Prostrate pigweed	483	28
<i>A. retroflexus</i> L.	Redroot pigweed	11,615	49
Anacardiaceae			
<i>Rhus typhina</i> L.	Staghorn sumac	194	12
Apocynaceae			
<i>Apocynum androsaemifolium</i> L.	Spreading dogbane	38	4
<i>A. medium</i> Greene	Intermediate dogbane	42	6
<i>A. cannabinum</i> L.	Indian hemp	20	1
Asclepiadaceae			
<i>Asclepias incarnata</i> L.	Swamp milkweed	12	2
<i>A. syriaca</i> L.	Common milkweed	338	27
Balsaminaceae			
<i>Impatiens pallida</i> Nutt.	Jewelweed	53	5
Berberidaceae			
<i>Berberis vulgaris</i> L.	Common barberry	4	2
Boraginaceae			
<i>Borago officinalis</i> L.	Borage	29	2
<i>Echium vulgare</i> L.	Vipers bugloss	24	1
Campanulaceae			
<i>Galinsoga ciliata</i> (Raf.) Blake	Hairy galinsoga	360	14
Caprifoliaceae			
<i>Sambucus canadensis</i> L.	American elder	2	2
<i>S. nigra</i> L.	European elder	3	1
Caryophyllaceae			
<i>Cerastium arvense</i> L.	Mouse-ear chickweed	1,110	19
<i>Silene cucubalus</i> Wibel	Bladder campion	23	1
<i>Stellaria graminea</i> L.	Grass-leaved stichwort	20	3
<i>S. media</i> (L.) Cyrill.	Common chickweed	3,719	49
Chenopodiaceae			
<i>Atriplex patula</i> L.	Spreading atriplex	15	4
<i>Chenopodium album</i> L.	Lamb's-quarters	2,877	42
Compositae			
<i>Achillea millefolium</i> L.	Yarrow	80	7
<i>Ambrosia trifida</i> L.	Great ragweed	15	1
<i>A. artemisiifolia</i> L.	Common ragweed	703	23
<i>Anthemis cotula</i> L.	Stinking mayweed	16	1
<i>Arctium minus</i> (Hill) Bernh.	Common burdock	362	24
<i>Artemisia vulgaris</i> L.	Mugwort	2	1
<i>Aster novae-angliae</i> L.	New England aster	59	7
<i>A. vimineus</i> Lam.	Small white aster	35	4
<i>Bidens cernua</i> L.	Nodding beggarticks	11	2
<i>Carduus nutans</i> L.	Nodding thistle	36	3
<i>C. nigra</i> L.	Black knapweed	12	1
<i>Cichorium intybus</i> L.	Chicory	242	17
<i>Chrysanthemum leucanthemum</i> L.	Ox-eye daisy	11	3
<i>Cirsium arvense</i> (L.) Scop.	Canada thistle	102	7
<i>C. vulgare</i> (Savi) Tenore.	Bull thistle	23	3
<i>Erigeron annuus</i> (L.) Pers.	Annual fleabane	149	11
<i>E. canadensis</i> L.	Canada fleabane	909	34
<i>E. strigosus</i> Muhl.	Rough fleabane	310	15
<i>Hieracium aurantiacum</i> L.	Orange hawkweed	30	2
<i>Lactuca serriola</i> L.	Prickly lettuce	610	23
<i>Matricaria matricarioides</i> (Less.) Porter	Pineapple-weed	1,611	14
<i>M. perforata</i> Merat.	Scentless chamomile	8	1
<i>M. recutita</i> L.	Wild chamomile	31	2
<i>Onopordum acanthium</i> L.	Scotch thistle	32	4
<i>Senecio vulgaris</i> L.	Common groundsel	3,572	32
<i>Solidago canadensis</i> L.	Canada goldenrod	1,092	62
<i>S. graminifolia</i> L.	Narrow-leaved goldenrod	24	3
<i>Sonchus arvensis</i> L.	Perennial sow thistle	119	18

(continued)

^a Samples were collected from sites with >10% infection.

^b Number of samples collected of each species.

^c Number of sites from which samples were collected.

Table 2. (continued)

Family/species	Common name	SC	SS
<i>S. asper</i> (L.) Hill	Annual sow thistle	37	9
<i>Tanacetum vulgare</i> L.	Common tansy	18	4
<i>Taraxacum officinale</i> Weber	Dandelion	13,620	69
<i>Tragopogon dubius</i> Scop.	Goat's-beard	21	3
<i>Xanthium strumarium</i> L.	Cocklebur	21	3
Convolvulaceae			
<i>Convolvulus arvensis</i> L.	Field bindweed	2,321	26
<i>C. sepium</i> L.	Hedge bindweed	194	34
Cornaceae			
<i>Cornus racemosa</i> Lam.	Gray dogwood	16	4
<i>C. alternifolia</i> L.	Pagoda dogwood	4	1
<i>C. stolonifera</i> Michx.	Redosier dogwood	32	4
Cruciferae			
<i>Alliaria petiolata</i> (bieb.) Cavara	Garlic mustard	76	8
<i>Barbarea vulgaris</i> R. Br.	Yellow rocket	20	2
<i>Brassica kaber</i> (D.C.) L.C.Wheeler	Wild mustard	36	3
<i>Capsella bursa-pastoris</i> (L.) Medik.	Shepherd's-purse	268	17
<i>Cardamine pennsylvanica</i> Mulh.	Pennsylvania bitter cress	39	1
<i>Erucastrum gallicum</i> (Willd.) Schulz	Dog mustard	28	1
<i>Lepidium campestre</i> (L.) R.Br.	Field peppergrass	20	3
<i>L. densiflorum</i> Schrad.	Common peppergrass	79	9
<i>Nasturium officinale</i> R. Br.	Water cress	22	3
<i>Rorippa islandica</i> (Oeder) Borb.	Yellow marsh cress	45	4
<i>R. sylvestris</i> (L.) Bess.	Creeping yellow cress	4	1
<i>Raphanus raphanistrum</i> L.	Wild radish	42	6
<i>Sisymbrium altissimum</i> L.	Tumbling mustard	15	1
<i>S. officinale</i> (L.) Scop.	Hedge mustard	122	13
<i>Thlapsi arvense</i> L.	Stinkweed	18	2
Cucurbitaceae			
<i>Echinocystis lobata</i> (Michx.) T. & G.	Wild cucumber	16	1
Dipsacaceae			
<i>Dipsacus sylvestris</i> Huds.	Teasel	8	3
Ericaceae			
<i>Rhododendron nudiflorum</i> L.	Honeysuckle	12	1
Equisetaceae			
<i>Equisetum arvense</i> L.	Common horsetail	38	8
Euphorbiaceae			
<i>Euphorbia esula</i> L.	Leafy spurge	7	1
<i>E. glyptosperma</i> Engelm.	Thyme-leaved spurge	26	4
<i>E. nutans</i> Lag.	Spotted spurge	139	3
<i>E. peplus</i> L.	Petty spurge	48	3
Fabaceae			
<i>Lotus corniculatus</i> L.	Bird's-foot trefoil	429	12
<i>Medicago lupulina</i> L.	Black medick	957	22
<i>Melilotus alba</i> Desr.	White sweet clover	3,067	6
<i>Trifolium pratense</i> L.	Red clover	1,027	45
<i>T. repens</i> L.	White clover	3,118	60
Fagaceae			
<i>Fagus grandifolia</i> Ehrh.	American beech	5	2
<i>Quercus rubra</i> L.	Red oak	29	4
Hypericaceae			
<i>Hypericum perforatum</i> L.	St. John's wort	38	7
Juglandaceae			
<i>Carya cordiformis</i> K. Koch	Bitternut hickory	4	1
<i>Juglans cinerea</i> L.	Butternut	23	2
<i>J. nigra</i> L.	Black walnut	358	19
<i>J. regia</i> L.	English walnut	61	9
Labiatae			
<i>Glechoma hederacea</i> L.	Ground ivy	1,276	13
<i>Lamium amplexicaule</i> L.	Henbit	466	11
<i>Leonurus cardica</i> L.	Motherwort	31	4
<i>Nepeta cataria</i> L.	Catnip	61	8
<i>Lycopus virginicus</i> L.	Bugleweed	12	2

(continued on next page)

plantain) and *P. major* L. (common plantain) by ELISA and did not demonstrate any cross-reactivity with PPV in ELISA. Aphid species were present on many of the weed samples, and peach trees at most collection sites demonstrated leaves and fruit symptomatic of PPV infection.

Residential surveys. A total of 19,519 samples were collected from 3,745 sites within the quarantine zone. (Table 3, Fig.

2). In Niagara township, five *Prunus glandulosa* were found at one site in one landscape bed. The location was within 0.5 km from the nearest known PPV-infected orchard. All plants were infected with PPV and were believed to have been propagated from a single plant in the Beamsville area over 30 years previously. The parent tree was no longer present, and the site had been replaced by an urban subdivision.

The homeowner reportedly propagated from this parent tree as he liked the color variegation present in the flowers. This variegation may have been caused by the presence of PPV infection. Infected plants all demonstrated pronounced color-breaking symptoms in the blossoms. Confirmation of the isolate was made by both AAFC and the CFIA using PCR and sequencing data. Sequencing demonstrated

Table 2. (continued from previous page)

Family/species	Common name	SC	SS
<i>Marrubium vulgare</i> L.	Horehound	3	2
<i>Mentha arvensis</i> L.	Field mint	4	1
<i>M. piperita</i> L.	Peppermint	25	1
<i>M. spicata</i> L.	Spearmint	24	2
<i>Prunella vulgaris</i> L.	Heal-all	271	9
Leguminosae			
<i>Coronilla cracca</i> L.	Tufted vetch	1,469	38
<i>C. varia</i> L.	Crown vetch	71	10
<i>Robina pseudoacacia</i> L.	Black locust	8	3
Lilaceae			
<i>Asparagus officinalis</i> L.	Common asparagus	17	2
<i>Hemerocallis fulva</i> L.	Daylily	4	2
Lobeliaceae			
<i>Lobelia inflata</i> L.	Indian tobacco	8	2
Malvaceae			
<i>Abutilon theophrasti</i> Medik.	Velvetleaf	39	8
<i>Althaea rosea</i> Cav.	Hollyhock	8	2
<i>Geranium robertianum</i> L.	Herb-robert	28	2
<i>Geranium</i> spp.	Wild geranium	20	1
<i>Hibiscus trionum</i> L.	Flower-of-an-hour	72	3
<i>Malva neglecta</i> Wallr.	Common mallow	1,213	25
Moraceae			
<i>Morus alba</i> L.	White mulberry	544	38
<i>M. pendula</i> L.	Weeping mulberry	1,415	6
Oleaceae			
<i>Fraxinus americana</i> L.	White ash	38	7
<i>F. pennsylvanica</i> Marsh.	Green ash	251	13
Onagraceae			
<i>Epilobium coloratum</i> Biehler.	Purple-leaved willow herb	15	4
<i>E. glandulosum</i> L.	Northern willow herb	171	20
<i>E. hirsutum</i> L.	Hairy willow herb	13	3
<i>Oenothera biennis</i> L.	Yellow evening primrose	79	8
Oxalidaceae			
<i>Oxalis corniculata</i> L.	Creeping wood sorrel	154	25
<i>O. dillenji</i> Jacq.	Common wood sorrel	1,450	23
<i>O. stricta</i> L.	European wood sorrel	164	25
<i>Rumex acetosella</i> L.	Sheep sorrel	17	3
Papaveraceae			
<i>Chelidonium majus</i> L.	Greater celandine	4	2
Phytolaccaceae			
<i>Phytolacca americana</i> L.	Pokeweed	38	2
Plantaginaceae			
<i>Plantago lanceolata</i> L.	Narrow-leaved plantain	1,872	29
<i>P. major</i> L.	Common plantain	11,259	53
Polygonaceae			
<i>Polygonum achoreum</i> Blake	Striate knotweed	275	13
<i>P. arenastrum</i> Jord. ex. Borg.	Common knotweed	4,177	15
<i>P. ariculare</i> L.	Prostrate knotweed	2,272	40
<i>P. cuspidatum</i> Sieb. & Zucc.	Japanese knotweed	16	1
<i>P. convolvulus</i> L.	Wild buckwheat	775	35
<i>P. pennsylvanicum</i> L.	Smartweed	28	4
<i>P. persicaria</i> L.	Lady's thumb	1,280	30
<i>Rumex crispus</i> L.	Curled dock	1,309	56
<i>R. obtusifolius</i> L.	Broad-leaved dock	18	2
Portulacaceae			
<i>Portulaca oleracea</i> L.	Purslane	3,109	48

(continued)

Table 2. (continued)

Family/species	Common name	SC	SS
Primulaceae			
<i>Anagallis arvensis</i> L.	Scarlet pimpernel	8	1
Ranunculaceae			
<i>Ranunculus acris</i> L.	Tall buttercup	4	1
<i>R. repens</i> L.	Creeping buttercup	17	3
Rhamnaceae			
<i>Rhamnus cathartica</i> L.	European buckthorn	9	5
Rosaceae			
<i>Crataegus mollis</i> Scheele	Downy hawthorn	21	3
<i>Fragaria</i> spp.	Wild strawberry	12	3
<i>Geum aleppicum</i> Jacq.	Yellow avens	22	2
<i>Potentilla argentea</i> L.	Silvery cinquefoil	6	1
<i>P. norvegica</i> L.	Rough cinquefoil	12	2
<i>P. recta</i> L.	Sulphur cinquefoil	132	12
<i>Prunus avium</i> L.	Sweet cherry	86	15
<i>P. serotina</i> Ehrh.	Black cherry	89	10
<i>P. virginiana</i> L.	Chokecherry	213	4
<i>Rosa</i> spp.	Wild rose	53	4
<i>Rubus allegheniensis</i> Porter	Blackberry	34	12
Rubiaceae			
<i>Galium aparine</i> L.	Cleavers	16	2
<i>Galium</i> spp.	Madder	38	14
<i>Mitchella repens</i> L.	Wild raspberry	23	2
Salicaceae			
<i>Populus deltoides</i> Bartr. ex. Marsh.	Eastern cottonwood	20	4
<i>Salix babylonica</i> L.	Weeping willow	10	2
<i>S. coloratum</i> Biehler	Purple willow herb	15	4
<i>S. purpurea</i> L.	Purpeosier willow	4	1
Scrophulariaceae			
<i>Linaria vulgaris</i> Hill.	Toadflax	268	14
<i>Verbascum blattaria</i> L.	Moth mullein	33	3
<i>V. thapsus</i> L.	Common mullein	457	12
<i>Veronica arvensis</i> L.	Corn speedwell	1,044	2
<i>V. filiformis</i> Sm.	Creeping speedwell	4	1
<i>V. officinalis</i> L.	Common speedwell	228	7
<i>V. perigrina</i> L.	Purslane speedwell	358	11
<i>V. persica</i> Poir.	Bird's-eye speedwell	104	2
<i>V. serpyllifolia</i> L.	Thyme-leaved speedwell	170	3
Solanaceae			
<i>Physalis virginiana</i> Mill.	Smooth ground cherry	196	19
<i>Solanum americanum</i> Mill.	American bittersweet	6	3
<i>S. dulcamara</i> L.	Climbing nightshade	96	11
<i>S. nigrum</i> L.	Black nightshade	15	3
<i>S. ptycanthum</i> Dun.	Eastern black nightshade	435	24
<i>S. sarachoides</i> Sendt.	Hairy nightshade	18	2
Ulmaceae			
<i>Ulmus americana</i> L.	American elm	22	4
Umbelliferae			
<i>Daucus carota</i> L.	Wild carrot	763	35
<i>Heracleum lanatum</i> L.	Cow parsnip	36	4
Urticaceae			
<i>Urtica dioica</i> L.	Stinging nettle	87	6
Verbenaceae			
<i>Verbena hastata</i> L.	Blue vervain	11	4
<i>V. urticifolia</i> L.	White vervain	16	4
Violaceae			
<i>Viola</i> spp.	Wild violet	24	5
Vitaceae			
<i>Parthenocissus</i> spp.	Virginia creeper	397	12

no major differences in the sequence with the Canadian isolate of strain D (D. Rochon, *personal communication*). The isolate had some minor nucleotide sequence differences from other Canadian fruit tree isolates when expressed phylogenetically, and in this regard it is somewhat distinctive from the other Canadian PPV isolates (D. Rochon, *personal communication*). ELISA false positives were infrequently reported in *Euonymus* spp., *Ligustrum* spp., and *Juglans nigra*. Subsequent resampling and testing by ELISA and PCR by both AAFC and CFIA failed to identify the presence of PPV in these hosts. An unidentified potex-virus detected by electron microscopy was infrequently found in privet, but it did not demonstrate any serological cross reactivity with PPV antiserum.

In general, homeowner cooperation was excellent, with approximately 95% of homeowners in 2002 agreeing to have their properties surveyed.

Nursery surveys. Suspected hosts of PPV were surveyed at nine nursery sites (Fig. 1). A total of 55,830 nursery plants were sampled, representing six species (Table 1). Testing by ELISA failed to demonstrate the presence of PPV in any of the plants. No symptoms associated with virus infection were found in any of the plants in the field nursery sites. All nursery sites were within 1 km of PPV-infected peach orchards. Various aphid species were present at low numbers at the time of sample collection.

DISCUSSION

None of the native plant species surveyed were shown to be naturally infected

by PPV in orchards exhibiting moderate to high levels of PPV infection. This is consistent with other studies in Pennsylvania, where PPV strain D was not found to occur naturally in native weed populations (5). Weeds do not appear to represent a significant reservoir of PPV and as such are not prominent in the etiology of the disease. The extensive multispecies sam-

pling done in heavily infected areas where aphid species were present failed to show any natural infection over the 2 years of the survey.

Residential surveys did not demonstrate the widespread presence of PPV in landscaping or susceptible *Prunus* stone fruit trees on rural residential properties. Such sites do not appear to represent a signifi-

Fig. 2. Rural residential survey sites in Niagara and Grantham townships. Dots represent one or more sample sites.

Table 3. Residential surveys conducted over 2001 to 2002 in Niagara on the Lake and West Lincoln townships for *Plum pox virus*

Genus/species	Common name	# Plants collected [# sites] (# positives)		2001-2002 totals	
		2001	2002		
<i>Prunus americana</i>	American plum	43 [12]	445 [215]	488	[227]
<i>P. brigantina</i>	Apricot	423 [173]	183 [100]	606	[273]
<i>P. cerasifera</i>	Myrobalan (flowering) plum	137 [112]	153 [70]	290	[182]
<i>P. cistena</i>	Purple leaved sand cherry	867 [410]	698 [348]	1,565	[758]
<i>P. domestica</i>	European plum	527 [126]	647 [243]	1174	[369]
<i>P. dulcis</i>	Almond	4 [3]	-	4	[3]
<i>P. glandulosa</i>	Dwarf flowering almond	58 [37] (5)	50 [29]	108	[66] (5)
<i>P. insititia</i>	Damson plum	40 [30]	-	40	[30]
<i>P. japonica</i>	Japanese almond cherry	3 [1]	-	3	[1]
<i>P. mahaleb</i>	Mahaleb cherry	2 [1]	-	2	[1]
<i>P. persica</i>	Peach	436 [120]	226 [85]	662	[205]
<i>P. persica</i> var. <i>nucipersica</i>	Nectarine	25 [14]	27 [19]	52	[33]
<i>P. pumila</i>	Sand cherry	10 [5]	-	10	[5]
<i>P. salicina</i>	Japanese plum	181 [41]	123 [36]	304	[77]
<i>P. serotina</i>	Black cherry	25 [12]	-	25	[12]
<i>P. serrulata</i>	Japanese flowering cherry	97 [82]	-	97	[82]
<i>P. tomentosa</i>	Nanking cherry	6 [4]	4 [1]	10	[5]
<i>P. triloba</i>	Flowering almond	84 [59]	69 [55]	153	[114]
<i>P. virginiana</i>	Chokecherry	111 [43]	25 [14]	136	[57]
<i>Euonymus</i> spp.	Euonymus species	3,909 [908]	3,622 [702]	7,531	[1,610]
<i>E. alata</i>	Burning bush	-	703 [311]	702	[311]
<i>Juglans cinerea</i>	Butternut	533 [163]	-	533	[163]
<i>J. nigra</i>	Black walnut	360 [96]	1,200 [250]	1,560	[346]
<i>Ligustrum</i> spp.	Privet species	-	3,505 [269]	3,505	[269]
Totals:		7,881 - (5)	16,030 -	19,519	- (5)

Total sites surveyed = 3,674

cant reservoir of PPV infection, and do not present any constraints to the current suppression and containment program. The only ornamental *Prunus* found to be infected with PPV may have originated from a propagative link to a parent plant grown in a different area 30 years earlier. This clade, being distinct from the peach strain present in Niagara, is likely unrelated to the introduction of the peach strain. The strong color-breaking symptoms on flowers of *P. glandulosa* make infection very easy to identify. This species could be used as a sentinel species in orchards as an early indicator of the presence of PPV, particularly if *P. glandulosa* was a preferential feeding host of PPV aphid vector species. Further studies in this laboratory are presently examining this possibility.

Surveys of non-stone fruit *Prunus* species and black walnut in commercial nurseries similarly failed to demonstrate the presence of PPV infection. Most of the nursery stock was second-year material or mother plants and had undergone at least one cycle of dormancy required for symptom or virus expression in some species. While this does not provide conclusive proof about the susceptibility of these species to PPV, it does indicate that virus was undetectable in all of the Niagara nursery plantings in 2001.

Certain limitations associated with field surveys must be considered. Distribution of PPV in infected woody species is often uneven, and virus levels fluctuate over the year (4,19). The reliability with which PPV is detected depends largely on virus concentration, host species, time of year, and location from which the sample was collected on the plants (11). Further, it is usual for there to be a several-year delay between introduction of virus and systemic expression on many hosts (8). While this survey represented an extensive examination within the quarantine area, some error associated with the above factors is likely to occur in some species. Composite leaf sampling of individual plants was used to reduce sampling error due to variance in virus distribution within plants. Monitoring of PPV-infected peach trees throughout

the survey demonstrated the continued detectability of virus by ELISA. Resampling where possible was done from the original plants to reduce sampling error.

The overall findings of these surveys are very encouraging and should not present any constraints to achieving eradication within the quarantine area. Ongoing studies in this laboratory with T. Lowery (PARC, AAFC, Summerland) are examining susceptibility of ornamental and other native plant species through natural infection by aphid species under heavy inoculum loading in containment facilities. These trials are being complemented by graft transmission trials conducted by D. Thompson (CFIA, CPH, Sidney, B.C.).

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