Weed Hosts of Beet Western Yellows Virus and Potato Leafroll Virus in British Columbia

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ABSTRACT

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The vegetable production areas of British Columbia were surveyed to determine weed hosts of beet western yellows virus (BWYV) and potato leafroll virus (PLRV). More than 10,000 plant samples were tested for BWYV and PLRV; the enzyme-linked immunosorbent assay was used. Twelve species from five families were infected with BWYV. Four species, *Cardamine oligosperma*, *Matricaria maritima*, *Polygonum lapathifolium*, and *Raphanus raphanistrum*, had not previously been identified as hosts. PLRV was found in *Capsella bursa-pastoris* and *Solanum nigrum*, but neither of these hosts is considered an important reservoir of this virus in British Columbia.

Beet western yellows virus (BWYV), a member of the luteovirus group (27), occurs in a wide range of crop and weed hosts in the United States (4,24) and has been implicated as an important component of potato leafroll disease (5,6). Potato leafroll virus (PLRV), another luteovirus (27), has a narrow natural host range confined primarily to the Solanaceae (11,16). In Canada, the importance of weeds as reservoirs of viruses has not been closely studied (19). Native and naturalized flora and volunteer or abandoned cultivated crop plants were considered weeds. Because of the known wide host range of BWYV and its potential threat to seed and table potato crops (5,6), this research was undertaken to determine the occurrence of BWYV and PLRV in weeds in the vegetable-producing areas of British Columbia. A preliminary report has been published (7).

MATERIALS AND METHODS

Collection of samples. Foliage samples of common weeds and some volunteer crop plants were collected within fields of seed and table potatoes, in nearby fence rows and in irrigation ditches. The sampled plants ranged in growth stage from four expanded true leaves to maturity. Symptoms were not used as a criterion for selection of samples, because symptoms of virus infection may be easily confused with those of drought, senescence, waterlogging, nutritional imbalance, or herbicide injury (4). Each sample consisted of a stem and leaves from the middle of the plant canopy. Samples were kept, usually not longer than 1 wk, in plastic bags at 4 C until they were used. Collection sites were selected at random from a list of potato producers. The authority for weed names used in this paper was Alex et al (1).

Serology. Each sample was tested twice with the triple-antibody sandwich enzyme-linked immunosorbent assay (TAS-ELISA) procedure as previously described (9). Positive and negative controls consisted of BWYV-infected ground cherry (*Physalis pubescens* L.), PLRV-infected potato and virus-free potato, and healthy plants of the species being tested. Infection with either BWYV or PLRV was indicated when absorbance readings (A_{405}) of sample wells were greater than twice the mean absorbance reading of five healthy controls (24) or 0.05, whichever was greater. To check the validity of ELISA results, plant samples rated positive by TAS-ELISA were further tested by aphid transmission to indicator plants.

Aphid transmissions. For aphid transmission tests, about 20 virus-free green peach aphids (*Myzus persicae* (Sulzer)) were allowed a 48-hr access to leaf samples in sealed petri dishes. After acquisition, the aphids were placed on healthy indicator plants (*P. pubescens*) for an inoculation access period of 72 hr. The aphids were then killed with pirimicarb at 0.25 g a.i./L (Pirimor 50WP; Chipman, Inc., Stony Creek, Ontario). The plants were kept in an aphid-free greenhouse and checked for symptoms during 6 wk. Leaf samples were taken from the indicator plants after 6 wk and assayed for BWYV and PLRV by TAS-ELISA.

RESULTS

A total of 10,067 weed samples, representing 96 species in 22 families, were tested by ELISA for virus infection. The vast majority of these proved to be uninfected with either virus. No evidence of virus was found in 82 of the species that were tested (Table 1).

In those species in which virus infection was detected, BWYV was far more prevalent than PLRV. BWYV was found in 101 (1.0%) of the samples and 12 of the 96 species, whereas PLRV was found in only six samples (0.06%) representing three species (Table 2). Four species had not previously been identified hosts of BWYV: *Cardamine oligosperma* Nutt., *Matricaria maritima* L., *Polygonum lapathifolium* L., and *Raphanus raphanistrum* L.

The ELISA tests done in 1986 used the double-antibody sandwich procedure (DAS-ELISA) and polyclonal antisera of dubious quality. Under these conditions, the optical density (OD) readings from infected samples were often less than twice that of the negative controls. In later tests (1987–1990), a better quality polyclonal antiserum was available for coating, and monoclonal antibodies were used for detection. Further, the TAS-ELISA protocol was substituted for the DAS-ELISA. These modifications resulted in a much higher signal-to-noise ratio, typically in the order of 10–20 times (Table 2). Even with these improvements, samples collected under cold growing conditions (late fall to early spring) had a low virus titer and consequently gave a low OD reading. The readings obtained from healthy control plants, on the other hand, did not vary appreciably with the season. The range of ELISA readings given in Table 2 represents the complete range of growing conditions. Some species, particularly those belonging to the Compositae, show up to a 10-fold difference in specific reading depending on the growing conditions.

Most of the species that tested positive for BWYV or PLRV (Table 2), with the exception of *Cardaria draba* (L.) Desv., *Senecio vulgaris* L., and *Lactuca scariola* L., did not exhibit diagnostic symptoms. The diagnostic symptoms of luteovirus infection, stunting, reddening of the lower leaves, and interveinal chlorosis, are often easily confused with stress symptoms caused by abiotic factors such as drought, excess moisture, nutrient deficiency, and herbicide injury (4). The wide range in A_{405} values for samples of the same species may have been because of the range of growth stages sampled or because not all samples would have been infected at the same time. The most

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recently infected plants would have the lower absorbance values.

The TAS-ELISA protocol, with purified BWYV and PLRV, did not reliably detect the viruses at concentrations below 1 ng/ml.

Aphid transmissions. Aphid transmission tests were attempted on samples that tested positive by ELISA, except for a few samples that had become desiccated. Aphid transmission experiments confirmed the TAS-ELISA results in all cases, except for the transmission of BWYV from two of three samples of prickly lettuce (*L. scariola*) and five of seven samples of scentless chamomile (*M. maritima*).

DISCUSSION

The identification of weed hosts of plant viruses can help in understanding the ecological relationships that contribute to disease outbreaks. In Canada, more than a thousand different plants can be regarded as weeds, but only about 230 species are considered economically important (10). Most of the weeds infected with BWYV are in the Cruciferae or Compositae and are common here. Those that are winter annuals (fall-sprouted annuals) or perennials may serve as overwintering sources of BWYV. When these plants grow in protected areas near the Pacific Coast, they also serve as overwintering plants for the summer form of vector aphids, mostly the green peach aphid.

BWYV is of considerable economic importance (4,17). Its presence in weeds in agricultural areas of British Columbia indicates that a source of inoculum is usually present. In years when green peach aphids are abundant, BWYV probably is a threat to many susceptible vegetable crops. MacCarthy (15) has shown that garden beet, spinach, lettuce, pea, broccoli, cauliflower, turnip, and Chinese cabbage are all susceptible to a local isolate of BWYV. The presence of BWYV in weeds is not surprising considering the wide host range of this virus and its occurrence in the province for at least 20 yr. Weeds are important reservoirs of vectors and viruses of several important crops, especially for BWYV in California and the Pacific Northwest (3,25,26). The results show that BWYV is present in the vegetable-producing areas of British Columbia. The presence of BWYV in samples of potato showing symptoms of potato leafroll disease has not been confirmed in Canada (8). Weeds are likely to be important sources of BWYV because many weeds are also good hosts for the green peach aphid, recognized as the most efficient vector of BWYV. BWYV was first recorded in British Columbia by MacCarthy (15) who isolated this virus from sugarbeet. Although sugarbeets are no longer grown commercially in British Columbia, the virus has survived in the weed population in the area surveyed.

Infected volunteer potatoes have long been considered the most important source of inoculum of PLRV (2,22). Finding a few *S. nigrum* and *C. bursa-pastoris* plants naturally infected with PLRV (Table 2) suggests that weeds may occasionally play some part in the epidemiology of potato leafroll disease. *S. nigrum* is an annual and, although not an overwintering host for either virus or vector, is a preferred host of the green peach aphid (20) and may be a reservoir of virus and vectors for the spread of current season leafroll. Klein (14) also reported *S. nigrum* as a natural host for PLRV in a weed survey of the San Luis Valley of Colorado. *C. bursa-pastoris* has been reported as an experimental host of PLRV, but this is the first report of the natural occurrence of PLRV in this host. *C. bursa-pastoris* is a winter annual that could be an overwintering host of PLRV. Thomas and Kaniewski (23) reported that PLRV could overwinter in cruciferous weeds.

Table 1. Weed species not naturally infected with beet western yellows virus (BWYV) and potato leafroll virus (PLRV) when tested by triple-antibody sandwich enzyme-linked immunosorbent assay

Plant family and species	Number of samples
Amaranthaceae	
Amaranthus retroflexus	290
Boraginaceae	
Lappula echinata	2
Caryophyllaceae	
Spergula arvensis	364
Chenopodiaceae	
Beta vulgaris	7
Chenopodium album	26
Spinacia oleracea	3
Compositae	
Achillea millefolium	12
Arctium minus	6
Aster sp.	5
Bellis perennis	6
Chrysanthemum leucanthemum	9
Cirsium arvense	260
C. vulgare	3
Erigeron canadensis	5
Gnaphalium uliginosum	1
Hypochaeris radicata	230
Lactuca muralis	6
L. sativia	3
Matricaria matricarioides	65
Senecio jacobaea	9
Solidago canadensis	8
Sonchus arvensis	3
S. asper	13
S. oleraceus	22
Tanacetum vulgare	7
Taraxacum officinale	456
Convolvulaceae	
Convolvulus arvensis	10
Cruciferae	
Alyssum alyssoides	1
Rorippa armoracia	1
Brassica oleracea var. *botrytis*	1
B. oleracea var. *capitata*	8
B. pekinesis	1
Camelina microcarpa	64
Descurainia pinnata	125
Lepidium perfoliatum	1
Nasturtium officinale	177
Nestlia paniculata	2
Rorippa sylvestris	190
Sinapis arvensis	255
Sisymbrium altissimum	9
Thlaspi arvense	653
Geraniaceae	
Geranium molle	2
Labiatae	
Galeopsis tetrahit	194
Lamium amplexicaule	7
Melissa officinalis	6
Mentha arvensis	9
Prunella vulgaris	3
Leguminosae	
Medicago lupulina	10
M. sativa	23
Pisum sativum	5
Trifolium pratense	213
T. repens	125
Vicia sp.	2
Malvaceae	
Malva neglecta	102
M. parviflora	3
Onagraceae	
Epilobium angustifolium	25
E. minutum	15
Oenothera erythrosepala	1
Papaveraceae	
Papaver nudicaule	1
P. somniferum	8
Plantaginaceae	
Plantago lanceolata	158
P. major	63
Polygonaceae	
Polygonum aviculare	12
P. convolvulus	106
P. persicaria	221
P. scabrum	8
Rumex acetosella	190
R. crispus	335
Portulacaceae	
Montia perfoliata	8
Portulaca oleracea	101
Ranunculaceae	
Ranunculus repens	199
Rosaceae	
Fragaria vesca	73
Geum macrophyllum	40
Rosa sp.	2
Rubus hispidus	2
Rubiaceae	
Galium aparine	56
G. boreale	16
Scrophulariaceae	
Digitalis purpurea	4
Verbascum thapsus	2
Solanaceae	
Lycopersicon esculentum Mill.	4
Umbelliferae	
Coriandrum sativum	2
Daucus carota	1

Table 2. Natural hosts of beet western yellows virus (BWYV) and potato leafroll virus (PLRV) in British Columbia

Virus and host plant	Infected/ sampled	ELISA A_{405} positive samples[a]	ELISA A_{405} negative controls[b]
BWYV			
Brassica napus var. *napobrassica*	1/49	0.149	0.015
Capsella bursa-pastoris	5/1,309	0.096–0.272	0.008
Cardamine oligosperma	2/100	0.082–0.812	0.022
Cardaria draba	1/31	0.353	0.014
Erodium cicutarium	2/174	0.285–0.436	0.010
Lactuca scariola	3/297	0.114–0.528	0.034
Matricaria maritima	7/209	0.111–0.538	0.010
Polygonum lapathifolium	2/264	0.610–1.187	0.030
Raphanus raphanistrum	1/35	0.264	0.022
Senecio vulgaris	75/459	0.051–1.570	0.004
Sisymbrium officinale	1/233	0.218	0.008
Stellaria media	1/626	0.213	0.005
PLRV			
Capsella bursa-pastoris	2/1,309	0.244–0.513	0.015
Solanum nigrum	1/393	0.205	0.013
S. tuberosum	3/212	1.996–2.478	0.001

[a] ELISA, enzyme-linked immunosorbent assay.
[b] Mean of five healthy control samples of the species tested.

The report of PLRV transmission to Cruciferae by Salaman and Wortly (18) was not confirmed by the experiments of Helson and Norris (13). Even as recently as 1981, *C. bursa-pastoris* was thought to be a host for BWYV but not for PLRV (5,6). Thomas (21) and Hassan et al (12) have also demonstrated that PLRV and the tomato strain of PLRV, tomato yellow top virus, cause symptomless infection of *C. bursa-pastoris*. Nevertheless, in much of Canada and the United States, most authorities would agree that PLRV-infected volunteer potato plants are the most important sources of primary inoculum of PLRV (2,22). Low grade potatoes for planting material are another source. In the densely settled Fraser Valley of British Columbia, backyard gardens are almost certainly the most important reservoir of PLRV-infected potato. Many home gardeners plant noncertified potatoes, do not apply insecticides, and are not aware that their potatoes are infected with a virus.

The results presented here represent a conservative estimate of virus infection because, under the conditions of our testing, ELISA is not sensitive enough to detect virus at concentrations below 1 ng/ml. If the virus concentration in some of the samples was below this limit, because of recent infection, time of year, or restricted multiplication of the viruses in some hosts, the sample would have been scored falsely negative.

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