Occurrence of mottle and redleaf components of carrot motley dwarf disease in British Columbia

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Carrots showing symptoms of motley dwarf disease were found in the lower Fraser Valley in British Columbia in 1974. Incidence of the disease and of the vector aphid Cavariella aegopodii was low in several commercial crops examined but was high in a field experiment plot. Tests by manual and aphid inoculation showed that the affected plants contained both components of the disease, carrot mottle virus and carrot redleaf virus. This is the first record of the disease in Canada and the first evidence that both of the component viruses occur in North America.

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Les carottes presentant des symptômes de nanisme bigarre ont ete decouvertes en 1974 dans la vallee inferieure du Fraser, en Colombie-Britannique. La frequence de la maladie et de son agent de transmission, le puceron *Cavariella aegopodii,* etait faible dans plusieurs des cultures commerciales examinees mais elle etait elevee en parcelle experimentale. L'inoculation a la main et par puceron a revele que les plantes atteintes hebergent les deux facteurs de la maladie, le virus de la marbrure et celui du roussissement des feuilles de la carotte. Cette maladie n'a aucun antecedent au Canada et il s'agit de la premiere manifestation simultanée des deux facteurs viraux en Amérique du Nord.

Motley dwarf disease of carrot *(Daucus carota* L. var. *sativa* DC.) was first described by Stubbs (1948; 1952) in Australia, where it caused serious damage to table and seed crops. It has since been reported from New Zealand (Anon. 1959), Japan (Komuro & Yamashita 1956), the U.K. (Watson 1960), Germany (Heinze 1968), and the U.S.A. (Stubbs 1956, Howell & Mink 1974). The disease is characterized by reddening or yellowing of the foliage, accompanied by stunting and loss of yield (Stubbs 1948, 1952; Watson 1960; Watson & Serjeant 1964). In seed crops the disease causes the roots of transplanted stecklings to rot, and the surviving plants yield small amounts of seed with reduced germination (Stubbs 1948).

Watson et al. (1964) showed that affected plants in the U.K. contain two persistent, aphid-borne viruses. One, called carrot redleaf virus (CRLV), is transmissible on its own by the aphid *Cavariella aegopodii* Scop., but the other, carrot mottle virus (CMotV), is transmitted only in the presence of CRLV. However, CMotV is transmissible by inoculation of sap, whereas CRLV is not. It is obvious from the descriptions given by Stubbs (1948, 1952) that both viruses were present in the Australian material, but there is no published evidence to show clearly whether the same two virus components are present in North America. This note reports that both occur in British Columbia.

Methods and results

Carrot crops on 10 farms or smallholdings in the lower Fraser Valley area of British Columbia were inspected in September 1974. Most were late-sown crops planted in late May or June and were substantially healthy, but each contained a few plants (less than 0.1%) showing symptoms typical of motley dwarf disease. These crops had been treated with diazinon or parathion against the carrot rust fly *Psila rosae* Fabr. and were almost free of aphids. In contrast, a small plot of carrots sown in June 1974 in an experimental field of the University of British Columbia (UBC) was heavily infested with *Cavariella aegopodii* and all the plants showed typical symptoms of the disease.

C. aegopodii from symptom-bearing carrots in the UBC plot were placed in groups of five on healthy carrot or coriander *(Coriandrum sativum* L.) seedlings for 1 day and then removed by fumigation with nicotine or methyl bromide. The test plants developed symptoms typical of infection with CRLV after 10 days. The carrots showed slight reddening or yellowing and noticeable retardation of growth; the corianders showed obvious yellowing, stunting, and distortion. To show whether CMotV was also present, leaves from the aphid-inoculated test plants were ground in 0.05 M phosphate buffer, pH 7.0, and the extract was used to inoculate carborundum-dusted leaves of *Chenopodium quinoa* Willd. and *Nicotiana clevelandii* Gray. *C. quinoa* showed minute necrotic local lesions after 4-7 days with no systemic symptoms; *N. clevelandii* developed systemic necrotic vein-etching after 9 days. Both symptoms are characteristic of infection with CMotV (Murant, 1974).

When a group of 40 viruliferous *C. aegopodii* were transferred daily to fresh carrot or coriander seedlings they retained ability to transmit both viruses for at least 4 days (the longest period tested). Four insects that moulted during this period transmitted both viruses

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Table 1. Host range and symptom expression of carrot mottle virus isolates

Plant species	Scottish isolate	B.C. isolate 1	B.C. isolate 2
Apium graveolens L. cv. Utah (celery)	–	–	–
Brassica pekinensis Rupr. (Chinese cabbage)	–	–	–
Brassica rapa L. (turnip)	–	–	–
Capsicum frutescens L. (pepper)	–	–	–
Chenopodium amaranticolor Coste & Reyn.	L	L	L
Chenopodium capitatum (L.) Asch.	L	L	L
Chenopodium quinoa Willd.	L	L	L
Cucumis sativus L. (cucumber)	–	–	–
Datura stramonium L.	–	–	–
Gomphrena globosa L.	–	–	–
Lycopersicon esculentum Mill, cv. Rutgers (tomato)	–	–	–
Nicotiana clevelandii Gray	LS	LS	LS
Nicotiana glutinosa L.	–	–	–
Nicotiana rustica L.	–	–	–
Nicotiana tabacum L. (tobacco)			
cv. Haranova	–	L(S)	–
cv. Havana 425	–	–	–
cv. White Burley	–	–	–
cv. Xanthi-nc	–	L(S)	–
Petunia hybrida Vilm.	–	–	–
Phaseolus vulgaris L. cv. Topcrop (French bean)	–	–	–
Vigna sinensis (Torner) Savi cv. Blackeye (cowpea)	–	–	–

L Necrotic local lesions.

S Systemic necrotic vein-etching,

(S) A few necrotic spots on upper leaves; not fully systemic.

– No symptoms.

afterwards, showing that the viruses resembled other isolates of CMotV and CRLV (Watson et al. 1964) in being persistent (circulative) in the vector. On each day of this test, the larvae that were produced were transferred to celery (*Apium graveolens* L.) to establish a culture of virus-free aphids. Celery appears immune to both viruses and is a good host for the aphid.

Sap-transmission tests and aphid-transmission tests using virus-free C. *aegopodii* showed that similar viruses were present in symptom-bearing plants from each of five of the commercial crops inspected.

Three of the sap-transmissible isolates, after inoculation into coriander plants, ceased to be transmissible by *C.*

aegopodii. This behaviour is typical of CMotV. In host range comparisons (Table 1), two of the B.C. isolates and an isolate of CMotV originally obtained from carrot in Angus, Scotland, (Murant et al. **1969**) appeared almost identical. One of the B.C. isolates induced necrotic local lesions in ***Nicotiana tabacum*** L. cv. Xanthi-nc and ***N. tabacum*** cv. Haronova; the other did not. This variation is also found with U.K. isolates. In these tests none of the isolates induced symptoms in ***Datura stramonium*** L.. ***N. glutinosa*** L., ***Petunia hybrida*** Vilm., or ***Phaseolus vulgaris*** L., although these species can sometimes be infected by some U.K. isolates in winter.

No virus-like particles were seen when sap from infected carrot or ***N. clevelandii*** was examined in the electron microscope using potassium phosphotungstate or uranyl acetate negative stains. This too is typical of CMotV and CRLV, although membrane-bound particles, which are possibly virus, have been seen in ultrathin sections of ***N. clevelandii*** infected with CMotV (Murant et al., **1969, 1973**). No attempt was made to see whether such particles were associated with the sap-transmissible isolates from B.C.

Discussion

The symptoms produced by the B.C. carrot viruses in various test plants and their transmission in the persistent (circulative) manner by *C. aegopodii* leave no doubt that they are CMotV and CRLV. In addition, the sap-transmissible component resembled CMotV in losing aphid-transmissibility after being transmitted by inoculation of sap, However, in the absence of reliable antisera the identity of these viruses cannot be confirmed serologically.

The importance of the disease in B.C. may be slight at present because all commercial crops examined seemed substantially free from the viruses and from the aphid vector. However, the high level of infection in the U.B.C. plots suggests that the disease could be a potential problem; the low incidence of the disease in commercial crops is probably due to the general use of insecticides against carrot rust fly.

In Britain the viruses overwinter in wild umbelliferous plants, such as cow parsley, ***Anthriscus sylvestris*** (L.) Bernh., and wild carrot; carrot motley dwarf disease is therefore especially troublesome following mild winters when *C. aegopodii* can survive as adult aphids on wild umbellifers instead of passing the winter in the egg stage on willow ***(Salix*** spp.), which is immune to the viruses. In B.C., wild carrot is prevalent (Dale, **1974**) and could provide an alternate host for the viruses. It also occurs in Ontario and other parts of eastern Canada and it is possible that the viruses occur there too.

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