AN ASSESSMENT OF APPLE VIRUS INDEXING RESULTS~

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Abstract

Assessments have been made of the results of indexing apple trees in British Columbia plantings, and of observations in virus-diseased orchards. The viruses responsible for stem pitting of Virginia crab, decline of Virginia crab, and rubbery wood in Lord Lambourne can occur independently. The virus responsible for flute fruit of Virginia crab can occur in the absence of those causing rubbery wood, and decline of Virginia crab. Prunus tomentosa, Russain apple seedling R12740-7A, Hopa crab, and Bedford crab have displayed symptoms when topworked on Malling II rootstocks although Lord Lambourne and Virginia crab topworked on the same rootstocks display no symptoms. Stem pitting and dwarf fruit can occur separately on Hyslop crab, and either can occur on trees that do not show decline symptoms. Virginia crab has displayed no symptoms in the season following inoculation from Hyslop crab displaying dwarf fruit, stem pitting, and decline symptoms. These results suggest need for caution in interpreting results from indexing on a limited range of indicators.

Introduction

During the first few years in which viruses are investigated in a plant genus, there is an expectation that a number of indicator hosts will be found, and that confusion will surround the identities and relationships of the viruses to which these indicator hosts are sensitive.

Usually successions of cross transmissions among carefully selected and systematically employed indicator hosts provide gradual clarification. However the planning of such an indexing program must depend on the assessment of data arising incidentally from earlier investigations of known diseases.

Useful information has been assembled during the investigation, initiated in 1955, of viruses occurring in British Columbia apple plantings. A major part of the original project was intended to determine the prevalence of stem pitting and rubbery wood viruses in orchard trees and scibn source trees. The indicator hosts used most consistently have been Virginia crab and Lord Lambourne. Results of this indexing to 1958 (15) demonstrated that at least four viruses can occur as latent infections in the trees of British Columbia apple plantings. The 1958 report can now be augmented by additional readings in the indexing of the listed source trees, and results from the indexing of additional trees.

Selected source trees, for which indexing on Virginia crab and Lord Lambourne have indicated differences in virus content, have been indexed

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also seedlings of Prunus tomentosa Thunb.

Since 1958 the occurrence of other viruses has been demonstrated, in orchard surveys, and in the course of attempts to establish test trees of additional indicator hosts when Malling II was used as a standard rootstock. The varying behaviour of some of the indicator varieties when topworked on the supposedly virus-free Malling II has revealed the presence of a virus, or viruses, to which a number of these varieties are sensitive.

This paper presents data derived from these observations, and an assessment of their significance in cataloguing viruses that can occur as latent infections in apple.

Materials and Methods

The materials and methods used for all indexing on Virginia crab, **Lord** Lambourne and P. tomentosa were those described in an earlier report (15). All test trees were grown on Malling II rootstocks derived from indexed stoolbeds at East Malling Research Station. All test trees were paired in orchard plots with an uninoculated test tree, the latter growing between the two inoculated trees. For all reported results the two test trees gave identical readings, and the check tree remained healthy.

The additional indicator hosts that have been assembled are Hopa crab, Bedford crab, Columbia crab, Transcendent crab, Hyslop crab, and the Russian apple seedling R12740-7A introduced as an apple virus indicator by Mink and Shay (11). All have been grafted to Malling II rootstocks derived from the same stoolbeds that provided rootstocks for the Virginia crab and Lord Lambourne test trees, Indexing at East Malling had shown Malling II to be free from all viruses of apple recognized before 1958. The rootstocks were grafted to variety while growing in one-gallon cans in the greenhouse, and have been retained in the greenhouse during the full period that they have been under observation,

Results and Discussion

The results of indexing on Virginia crab, Lord Lambourne and **P.** tomentosa from 1955 to 1960 are summarized in Table 1.

The reactions of various Malus species and varieties, when attempts were made to propagate them on Malling II rootstocks, are described in Table 2.

Orchard observations on a block of Hyslop crab trees are reported in Table 3.

An evaluation of the results recorded in Tables 1, 2 and 3 suggests that there are numerous viruses, or strains of viruses, occurring commonly in apple, and characteristically latent in commercial apple varieties. The manifestations, of virus action that have been recorded at Summerland and elsewhere in these test plants include: stem pitting of Virginia crab (6, 7, 15, 17); decline of Virginia crab (15, 17); flute fruit of Virginia crab (17); stem pitting of Hyslop crab (2, 4, 7); decline of Hyslop crab (2, 15, 17); dwarf fruit of Hyslop crab (2, 3, 5, 17); rubbery **wood** of Lord Lambourne and other apple varieties (9, 15, 17); leaf flecking of Hopa crab (14, 17); stem pitting of Hopa

crab (1); leaf necrosis of Bedford crab (17); chlorotic leaf spot of Russian apple seedling R12740-7A (11); and foliage mottling of P. tomentosa (10, 15).

There is an inclination to assume that these disease manifestations can be grouped, and each group attributed to the action of one virus. This leads to the assumption that a selected indicator can serve to indicate freedom from the viruses to which the other hosts are sensitive. An examination of the data recorded in Tables 1, 2 and 3 suggests that considerable caution must be exercised in attributing to single viruses the responsibility for causing more than one of the reactions that have been observed in the range of apple virus indicators. Most of the virus manifestations in the indicators used have been induced by one or more sampled apple sources that failed to induce the other virus manifestations.

Stem pitting of Virginia crab and rubbery wood of Lord Lambourne.

When indexing was initiated at Suminerland, there existed a possibility that stem pitting was a manifestation of the rubbery wood virus in Virginia crab. The indexing results recorded in Table 1 and elsewhere (13, 15) have shown that rubbery wood virus and stem pitting virus can occur independently.

Stem pitting of Virginia crab and decline of Virginia crab.

Decline of Virginia crab has occurred, so far, only after inoculation with sources carrying both stem pitting and rubbery wood (Table 1). However, decline was not induced by sources 9D-90910, Evans 1, Skelly H-20 and Splett 1, which carried both stem pitting and rubbery wood, by GG-13 which carries rubbery wood but not stem pitting, and by 6 sources that carry stem pitting but not rubbery wood. This justifies the conclusion that decline is not caused by the stem pitting virus or rubbery wood virus alone, or by combined action of the two viruses.

Stem pitting of Virginia crab and chlorotic leaf spot.

Russian apple seedling R12740-7A has displayed chlorotic leaf spot when propagated on Malling II rootstocks (Table 2). Over 200 Virginia crab trees have been propagated on these stocks, and none has shown stem pitting unless it was used to index diseased apple clones. Source 9D-90514 (Table 1), that has induced stem pitting in Virginia crab, has not caused chlorotic leaf spot symptoms in Russian apple seedling R12740-7A in 2 seasons following inoculation. Thus, although many apple sources induce both stem pitting and chlorotic leaf spot, it appears possible for the viruses responsible for these reactions to occur independently. Cation and Carlson (4) have reported a similar demonstration of independent occurrence of these viruses. The stem pitting symptom on Russian apple seedling R12740-7A recorded by other workers (11) has not been found on this host when propagated on Malling 11.

Stem pitting of Virginia crab and the reactions of Hopa and Bedford crabs.

Hopa and Bedford crabs have developed foliage flecking and necrosis, and tip dieback symptoms, when propagated on Malling II rootstocks (Table 2). As Virginia crab is symptomless when grown on this rootstock, the stem pitting of Virginia crab is apparently not caused by the virus responsible for the foliage symptoms on Hopa and Bedford crab. Stem pitting symptoms (1)

have not been observed on Hopa and Bedford crabs propagated on Malling II. Tests to compare the reactions of Malus platycarpa Rehd., described by Luckwill and Campbell (8) with those of Hopa, Bedford, and Virginia crab are incomplete.

Decline of Virginia crab and decline of Hyslop crab.

The symptoms of decline in Virginia crab and in Hyslop crab are similar, and both have been invariably accompanied by stem pitting symptoms (2, 15). However, Virginia crab test trees that in 1959 received buds from sources Walburn B-69 and Walburn B-71 (Table 1), both of which are Hyslop trees in advanced state of decline, have shown no evidence of decline in 1960. As Virginia crab test trees characteristically show severe decline in the season following inoculation with Virginia crab decline virus, this test suggests that the virus causing decline of Hyslop crab does not induce decline in Virginia crab.

Stem pitting of Hyslop crab and decline of Hyslop crab.

The trees B-25, B-31, B-43, B-63, B-69 and B-71 (Table 3) are part of a commercial Hyslop planting, Trees B-69 and B-71, which have been topworked to Jonathan, show severe symptoms of both stem pitting and decline. Trees B-25, B-31, B-43 and B-63, have not been topworked. Tree B-43 displays severe stem pitting, and trees B-25, B-31 and B-63 display moderate stem pitting, but these trees show no evidence of decline, Other trees in the block and in other surveyed blocks display mild stem pitting, but no decline. Thus it is possible for stem pitting to occur on Hyslop crab with or without the onset of decline.

Flute fruit of Virginia crab, and stem pitting and decline of Virginia crab.

Flute fruit characteristically occurs on Virginia crab trees that display stem pitting symptoms (Table 1). So far there have been no exceptions to the co-occurrence of these two types of symptoms on this host. Flute fruit 'and decline also appear to be distinct. All trees affected by decline that have fruited have displayed flute fruit symptoms. However flute fruit has been observed on many orchard and test trees not affected by decline.

Dwarf fruit of Hyslop crab, and stem pitting and decline of Hyslop crab.

Dwarf fruit characteristically occurs on Hyslop crab trees that display stem pitting. However, their co-occurrence has not been invariable (Table 3). In the Walburn orchard, trees B-31 and B-63, which display moderate stem pitting, have borne normal fruits in 2 successive seasons. Trees B-15 and B-31, which are free from stem pitting, have borne fruits with mild dwarf fruit symptoms in these two seasons. Surveys of a second orchard have provided a similar example of general but not invariable co-occurrence, Dwarf fruit and decline also appear to be distinct. Trees B-69 and B-71, suffering severe decline, have displayed severe dwarf fruit symptoms. However fruits with mild to severe symptoms have been borne by trees that do not show decline, in the two surveyed orchards.

Table 1. Results of the indexing of apple source trees on Virginia crab, Lord Lambourne apple, and Prunus tomentosa.

Source	Flute fruit	Virginia crab stem pitting	Rubbery wood	Virginia crab decline	P. tomentosa mottle
E.F. 9J-P30	-	-	-	-	-
Malling II	-	-	-	-	t
E. F. 9D-91708	-	-	-	-	no index
Hait BB-22	-	-	-*	-	t
Hait U-17	+	t	-	-	no index
E. F. 9D-91912	t	t	-	-	no index
Hait V-12	t	t	-	-	no index
E.F. 96-7349	t	t	-	-	no index
E. F. 9D-90514	t	t	-	-	no index
Q-7	t	t	-	-	no index
Walburn B-69	?	-*	-*	-*	no index
Walburn B-71	?	-*	-*	-*	no index
Walburn B-43	?	-*	-*	-*	no index
Hait GG-13	-	-	+	-	t
Evans 1	+	t	+	-	+
Splett 1	+	?	+	-	t
Skelly H-20	+	t	+	-	no index
E. F. 9D-90910	+	t	+	-	t
Q-13	?	t	+	+	no index
WP-1	+	t	+	+	no index
E.F. 3-17-7	+	t	+	+	t

? Indexing incomplete
* Readings for one season only

Table 2. Symptoms displayed by apple virus indicator hosts when propagated on E. M. II rootstocks.

Russian Seedling R12740-7A	- High percentage scions remained dormant, eventually died. Dwarfed shoots. Chlorotic leaf spot.
Bedford crab	- High percentage scions remained dormant, eventually died. Dwarfed shoots. Leaf necrosis, defoliation. Tip dieback.
Hopa crab	- High percentage scions remained dormant, eventually died. Dwarfed shoots. Purple leaf flecking.
Virginia crab	- No symptoms. Vigorous growth.
Hyslop crab	- No symptoms., Vigorous growth.
Transcendent crab	- No symptoms. Vigorous growth.
Columbia crab	- All scions remained dornant, eventually died.
Prunus tomentosa	- Foliage mottling.

Table 3. Occurrence of stem pitting, dwarf fruit, and decline of Hyslop crab in Walburn orchard, Kelowna. B. C.

	Stem pitting	Dwarf fruit	Decline
B15	none	mild	none
B17	none	none	none
B19	none	none	none
B21	trace	none	none
B23	trace	mild-moderate	none
B25	moderate	mild-moderate	none
B31	moderate	none	none
B33	none	mild	none
B35	mild	none	none
B37	mild	none	none
B41	mild	none	none
B43	severe	moderate-severe	none
B47	mild	mild-moderate	none
B63	moderate	none	none
B67	mild	mild-moderate	none
B69*	severe	moderate-severe	severe
B71*	severe	severe	severe

* Topworked to Jonathan.

Significance of P. tomentosa leaf mottling,

Transmission results (Table 1) have demonstrated that leaf mottle of P. tomentosa can be induced by apple sources free from the viruses that cause stem pitting (3 trees), flute fruit (3 trees), rubbery wood (2 trees) and Virginia crab decline (6 trees). Moreover, P. tomentosa has displayed foliage mottling when used to index Malling II, which has not induced decline of Hyslop crab. So far, results have not been obtained from tests in which P. tomentosa has been used for the indexing of materials known to be free from chlorotic leaf spot, or the viruses that cause symptoms in such crab varieties as Hopa and Bedford. At present it seems safe to conclude that P. tomentosa is not a differential indicator for the viruses causing stem pitting, decline, or flute fruit of Virginia crab, or for those causing decline of Hyslop crab, or rubbery wood. However, its status as an indicator for chlorotic leaf spot and the leaf flecking diseases of species and varieties of crabapple, has not been demonstrated.

Conclusions

The results of transmission tests at Summerland and elsewhere have demonstrated that viruses are prevalent in apple plantings, and that a number of viruses or virus strains are involved, Their designation either as viruses or virus strains is considered academic until information is available on their interactions in their hosts, and their chemical, physical, and serological characteristics. At present the significance of their differences is in their impact on the assessment of indexing results.

Obviously the results that have been recorded are not sufficiently comprehensive to justify a'ssumption of unique etiology for all of the disease manifestations that are described and assessed., They do provide justification for extreme caution in assuming that the symptoms displayed by any one indicator host used in apple indexing are attributable to the viruses responsible for either the same or different symptoms in other indicators. They suggest equal caution in categorical assumption of virus freedom on the basis of indexing on a limited range of indicators. They emphasize the need for expanded indexing of apple trees and rootstock clones in an effort to elucidate the relationships of the viruses to which the indicator hosts are sensitive. Such tests are now in progress at Summerland, with a wider range of test plants employed for indexing of all apple sources that have differed significantly in their effects on one or more of the indicator hosts used so far.

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