Virginia Crab Apple Decline

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ABSTRACT

The Virginia Crab apple decline agent was detected in 13 apple introductions from European countries and Australia. It incited a conspicuous yellowing of the foliage of Virginia Crab, but not of other apple virus indicator varieties. Trees that decline over a 2- to 3-year period usually bear a premature crop of small fruit on a stunted tree. Golden Delicious and *Malus platycarpa* (Long Ashton clone) were stunted and fruited precociously. The Virginia Crab scions were swollen immediately above the graft union, and necrotic phloem tissue developed at the interface of stock and scion. Most of the isolates that induced decline of Virginia Crab also induced stem pitting or stem grooving in this indicator.

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Virginia Crab stem pitting (6) and stem grooving (3) are well-known virus-incited diseases of Virginia Crab apple. However, only seven reports—from the USA (1), Canada (10, 11, 12, 13, 14), and France (5)—have mentioned a Virginia Crab yellows and decline (VCD) syndrome. Welsh & Keane (10) briefly described this syndrome for the first time in 1959. Later they demonstrated that the causal agent was latent in several apple sources (11), and that it was distinct from the agent which incited stem pitting in Virginia Crab (2). Welsh & Spangelo (15) also described a bud-transmissible disease which incited a decline and death syndrome in *Malus robusta* No. 5 rootstocks similar to the disease of Virginia Crab described here. We do not know whether the causal agents of these diseases are related in any way. This report provides additional information on the etiology, symptoms, and distribution of the Virginia Crab yellows and decline disease.

MATERIALS AND METHODS.—The indexing experiments were conducted in the field by a double-budding technique. Indicators were established by placing two buds on an apple seedling stock 8 inches aboveground. The two test or inoculum buds were inserted below the indicator buds 2 to 4 weeks later, and after another week the seedlings were cut back to the upper indicator bud. We usually inoculated two trees with each virus source. The inoculum buds were rubbed off if they grew. Most of the budding was done during June.

Inocula were from apple tree introductions from several countries now on the grounds of the station. When possible, inoculum buds were taken from 2- to 3-year-old wood in preference to younger tissue. Several of the infected sources were simultaneously indexed on apple varieties Lord Lambourne, Gravenstein, Virginia Crab K-6, Spy 227, Russian R-12740-7A, Golden Delicious, *Malus platycarpa* Rehd., and Jay Darling. These indicators were observed for leaf and bark, and, when present, for fruit symptoms during the 2- to 6-year period of the tests. Pitting of the xylem and stock-scion union abnormalities were observed by peeling off one or more strips of the bark.

RESULTS.—Thirteen of 127 virus sources incited yellows and decline of the Virginia Crab indicator within 1 to 5 years after inoculation. The progression of the disease varied among the inoculum sources. Affected trees became conspicuously yellow (Fig. 1). Some trees were dead within 1 year after initial symptoms appeared, whereas others declined over a period of 3 years. Some Virginia Crab indicators produced small yellowish leaves during the year before they died similar to those seen on Spy 227 affected with epinasty decline virus. Dieback or winter kill was evident in varying degrees. Most of the affected trees flowered before leafing out in the spring and bore a prematurely heavy crop of slightly smaller but otherwise normal-appearing fruit (Fig. 1-C). Some affected trees were appreciably stunted; others were not. There was also extreme variation in the strength of the graft union.

While there was variation in some of the symptoms among the Virginia Crabs infected with the various virus sources, other symptoms were always present. The foliage throughout the tree became uniformly yellow and dropped prematurely (Fig. 1-B). The chlorosis drew initial attention to diseased trees. The scion was always swollen immediately above the juncture with the stock (Fig. 1-D). We always observed necrotic phloem tissue at the interface of scion and stock. (Fig. 2-A). This may be what has been referred to as brownline in the literature. On those trees where the bark could be removed, the xylem was pitted at the juncture.

In three instances, only one of the two Virginia Crab trees inoculated became diseased, suggesting that the causal virus was unevenly distributed in the source tree or that the graft union developed sufficiently well, in spite of the causal virus, to preclude the development of symptoms.

Symptoms were seen in other apple virus indicators also (Table 1). Infected *M. platycarpa* trees were appreciably smaller than control trees or trees

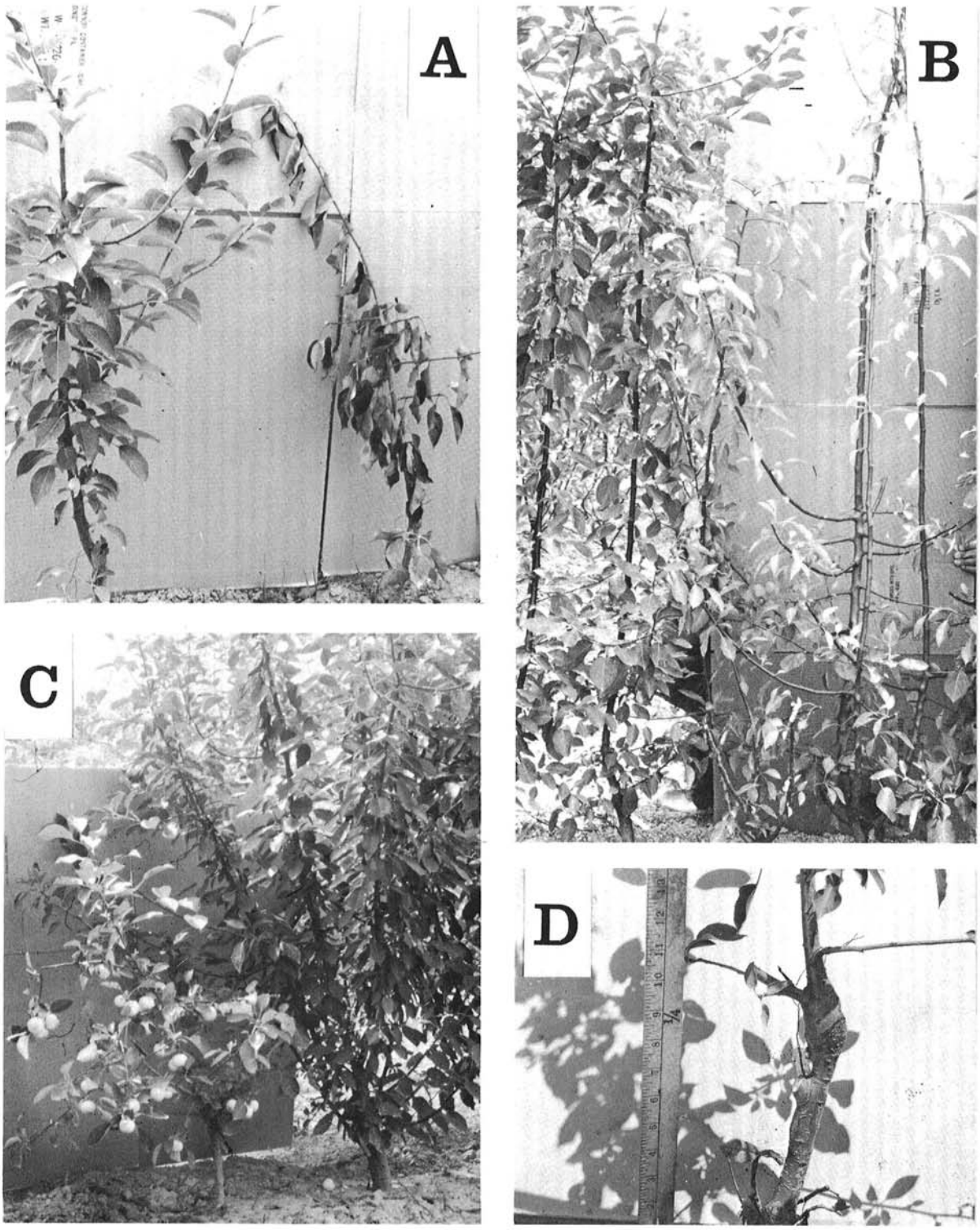

Fig. 1. Apple variety Virginia Crab on seedling rootstocks infected with three different cultures of Virginia Crab yellows decline (VCD) virus: **A, B)** on the right; **C)** on the left. Note variation in symptoms: **A)** tree with quick decline; **B)** tree with fruit but without stunting; **C)** slow decline, stunted. All affected trees were dead after 4 years. The other tree in A, B, C is infected with apple chlorotic leaf spot and Spy 227 epinasty decline viruses. **D)** Close-up of tree in C showing swelling of the stock-scion region.

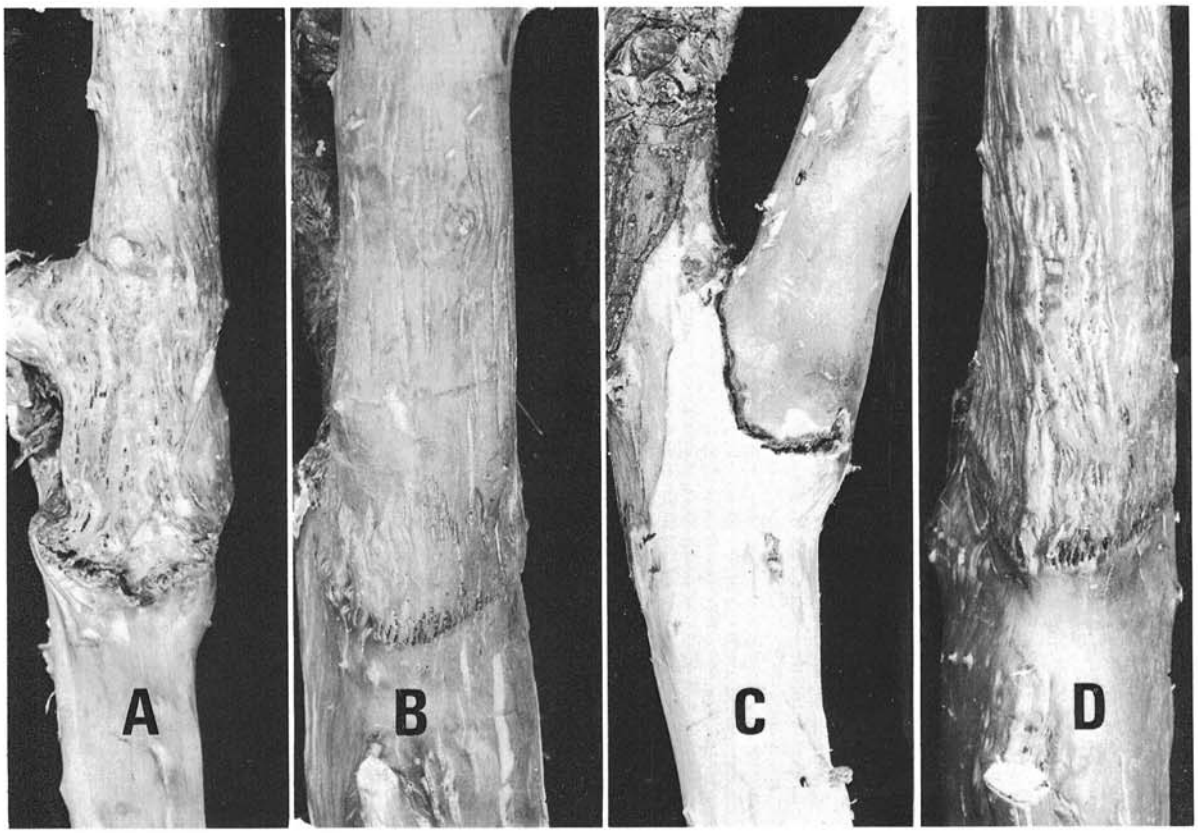

Fig. 2. Apple variety Virginia Crab on seedling stocks showing usual range or combinations of symptoms in the xylem 3 years after inoculation with virus(es) in four apple introductions. Trees are infected with **A)** VCD; **B)** stem grooving; **C)** Type 2 apple virus (a strain of stem grooving virus; and **D)** stem pitting and stem grooving virus. Each of these trees was also infected with chlorotic leaf spot virus.

infected with chlorotic leaf spot alone, and trees infected with four of six sources of VCD virus bore prematurely heavy crops of slightly smaller-than-normal fruit (Table 1).

Golden Delicious was similarly affected (Fig. 3). One of 22 apple introductions double budded onto Virginia Crab in 1968 incited decline symptoms in 1970. None of the other 21 introductions incited this syndrome in Virginia Crab, even though 11 were infected with combinations of chlorotic leaf spot, Spy epinasty decline, stem pitting, and apple mosaic viruses. The two Golden Delicious trees budded with this single positive VCD source were the only trees in the row which bore heavy crops of small fruit in 1971. These trees were about one-half the size of most of the trees. Neither the *M. platycarpa* nor the Golden Delicious exhibited any obvious leaf, bark, or graft union abnormalities.

The Russian indicator appeared to be affected by the VCD virus as well. In another experiment initiated in 1968, 55 apple introductions were double budded onto Virginia Crab and the Russian indicators. Six incited VCD in the crab in 1970. The Russian indicators inoculated with three of these six sources remained dormant but otherwise normal in appearance in 1969 for about 3 weeks in the spring after all other 104 trees were leafed out. Two months later, these six 18-inch trees were dead.

Table 2 lists the varieties which were infected with VCD and the country of origin of the introduction. These varieties were read for necrosis and swelling at the graft union, for pitting, and for yellows. All were infected also with combinations of other latent viruses. The trees ranged from 4 to 10 years old. None showed obvious yellows disease symptoms.

We graft-inoculated McIntosh, Hopa, and Hyslop crab apples to see if the VCD disease was similar to any of the reported diseases of these varieties. Keane & Welsh (2) and Welsh & Keane (11) had noted a similar decline syndrome in Virginia Crab and Hyslop Crab. We grafted two of our VCD virus sources to Hyslop Crabs in 1969. Neither source incited decline after 2 years. Our results agree with those of Welsh and Keane in that Virginia Crab decline and Hyslop Crab decline apparently are caused by different agents. Likewise they reported on a dieback-delayed foliation condition of Spartan apple inoculated with the McIntosh leaf pucker virus. Our two VCD virus sources, which did not cause leaf pucker in McIntosh trees, induced a delay in leafing out of Spartan apple.

TABLE 1. Apple varieties which react to the Virginia Crab yellows and decline agent (VCD)

Variety[a]	Symptoms[b]	No. times observed per total number of VCD cultures inoculated
Virginia Crab	Death	13/13
Russian R-12740-7A	Delayed leafing and death	3/6
Malus platycarpa	Premature fruiting and stunting	4/6
Golden Delicious	Premature fruiting and stunting	1/1
Jay Darling	Union necrosis and dieback	1/1

[a] Several trees of each variety were inoculated as controls with various combinations of chlorotic leaf spot, Spy epinasty decline virus, stem pitting, flat limb, and rubbery wood viruses without inciting the symptoms in column 2.

[b] Most conspicuous symptoms associated with infection by the VCD virus.

However, some isolates that did not induce VCD also caused delayed leafing of Spartan.

DISCUSSION.—Although the Virginia Crab indicator responds to inoculation with many decline isolates with definite yellows symptoms, there is a likelihood that other isolates of the VCD virus remain undetected. Indicators inoculated with several sources of unknown virus content exhibited various combinations of the symptoms associated with this disease, such as union swelling and necrosis, but the Virginia Crab trees did not decline and die (Table 3). Perhaps less virulent strains, or cultures of low concentration, will not cause yellows or kill the indicator, at least not within 5 years.

A mechanically transmissible virus of Type 2 (3, 7) which was latent in pear introductions (9) was graft-transmitted to Virginia Crab where it caused union necrosis and swelling of the scion but without pitting, grooving, or tree decline (8). Even though it failed to incite these symptoms in this indicator, evidence suggests that this pear virus is closely related to the Virginia Crab decline virus. On the other hand, other distinct viruses may cause union swelling and necrosis without yellowing and tree decline (Fig. 2-C).

Gilmer et al. (1) and Welsh & Nyland (14) reported that the Virginia Crab brownline decline syndrome developed more quickly and was more pronounced under the higher Illinois or California temperatures than those at more northern locations. If this is the case, we may be detecting milder strains at Glenn Dale, which incite union swelling and necrosis, but which do not kill the indicator, because our maximum temperatures are in the 90- to 95-F range during 25 to 35 days each summer.

Identification of legitimately different causal organisms with the Virginia Crab indicator is further complicated by the fact that one does not know how many viruses a given culture contains. Hence, it is not

TABLE 2. Sources of apple plant introductions infected with Virginia Crab yellows and decline virus[a]

P.I. No.[b]	Variety	Origin	Abnormalities in the variety tree
131102	Cravert	France	None
131283	Dr. Clifford	England	Sw[c]
131561	Reinette Jaeghers	Belgium	Sw[c]
132225	Gewurzluiken	Germany	Sw[c]
136268	Tardive de la Sarthe	France	None
137094	Notaire	Belgium	None
158731	Bramtot	France	None
307380	Nubeena	Australia	None
307381	Rokewood	Australia	Stunt
307383	S.T.P. Scarlet Pearmain	Australia	Sw[c]
307519	Suislepper	Poland	Sw[c]
312488	Bankroft	Poland	None
312489	Malinowa Oberlandzka	Poland	None

[a] Chlorotic leaf spot virus was detected in each of these; Spy epinasty decline was detected in all except 131102, 137094, and 158731. The last six numbers indexed negative for flat limb, rubbery wood, apple mosaic, and platycarpa scaly bark viruses after 3 years.

[b] One hundred twenty-seven variety-introductions were indexed; Virginia Crab reacted with yellows and death to inoculation with 10.2% of the P.I.'s.

[c] Swelling above the graft union; no necrosis observed. This condition not necessarily due to the disease agent.

Fig. 3. Row of Golden Delicious apple trees infected with combinations of apple viruses with one tree (arrow) infected also with VCD. Note stunting and precocious fruiting. The other healthy-appearing trees are infected with chlorotic leaf spot virus.

TABLE 3. Frequency of occurrence of various symptoms in Virginia Crab indicator trees double-budded with 127 apple Plant Introductions

Observation[a]	No. times
SP (Fig. 1-D)	27
SG (Fig. 1-B)	1
SG + BL	2
BL + swelling (Fig. 1-C)	9
SP + swelling	2
BL + swelling + SP	3
Swelling only	2
BL + swelling + VCD + SP	13
No symptoms	59
Experimental trees failed	9
Total	127

[a] SP = stem pitting; SG = stem grooving; BL = brown lines; VCD = Virginia Crab yellows and decline.

possible to associate a specific symptom with a specific virus. The Virginia Crab stem pitting virus is present in many of the cultures of VCD virus. Our experience indicates that stem pitting virus alone does not cause necrosis or swelling at the graft union (Fig. 2-B, D).

Virginia Crab has been shown to display two distinct syndromes: the stem pitting syndrome caused by an agent that so far has not been isolated or characterized, and the stem-grooving syndrome caused by a flexuous rod virus (3). Some strains of the so-called stem grooving virus have not induced stem grooving (8, 9). Because of this variability and the difficulties in isolating virus in herbaceous species from infected apple trees, we have not been able to directly correlate the disease symptoms in Virginia Crab with the known host range of Type 2 virus cultures. We have isolated Type 2 virus on *Chenopodium quinoa* Willd. from dozens of apple varieties, some of which incited VCD disease; some, the grooving symptom; and others, only a brown line at the stock-scion interface. Consequently, there is inadequate evidence to demonstrate whether Virginia Crab decline is a manifestation of infection by some cultures of stem grooving virus, or whether additional viruses are involved in production of this syndrome.

Finally, although VCD virus caused stunt without foliage symptoms in *M. platycarpa* as does the platycarpa dwarf virus (4), it probably is not related to the latter virus. Many non-VCD cultures have also stunted this indicator in our nurseries.

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