

Anatomical Studies of Injury to Sugar Beets Induced by Three Strains of the Curly-Top Virus

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The object of these studies is to determine the tissues affected, the amount of tissue involved and the general histological or internal effects induced in susceptible sugar beets by curly-top virus strains 1, 6 and 22, obtained from N. J. Giddings. All three strains cause severe injury to susceptible sugar beets.

In Figure 1A are shown healthy checks of beets the same age as the infected ones. In 1B is shown a vascular bundle in a healthy beet petiole. Figure 1C is a cross section of a healthy root tip. Strain 1 produces rather severe symptoms on susceptible beets. It kills some beets *in* the very young stage but most of the beets infected when older live, although showing severe symptoms, and there are many cases of partial recovery observed. Figure 1D shows susceptible beets with the severe symptoms induced by strain 1.

In Figure 1E and 1F internal symptoms of curly-top are shown. In the root tips there is degeneration and necrosis of cells surrounding the sieve tubes as in Figure 1F. One or all may be involved. There is no uniformity in the degree of infection produced in these root tips. Figure 1E shows a cross section of a beet petiole with distinct areas of degeneration and necrosis in the phloem of the vascular bundles. Many times the phloem cells are regenerated so that the beet continues to grow in spite of the infection but will not make a very large root.

Virus strain 6 produces much less veinlet clearing or vein distortion than do the other virus strains but does dwarf the entire plant and is more lethal than virus 1, as shown in Figure 2A. It produces only small, inconspicuous necrotic areas in the phloem of beet petioles (Figure 2B); but it does cause severe necrosis in many cells in the sieve tube areas in root tips, as shown in Figure 2C. This strain is quite destructive to susceptible beets. While virus strain 1 usually causes necrosis and degeneration to only the cells surrounding the sieve tubes in root tips, virus 6 causes a great many other cells outside this area to become severely necrotic. This causes a rapid death of the root tips and dwarfs the top before killing it without affecting its tissues directly.

Strain 22, the most recent of the three to be selected, was obtained from a virus collection near Jerome, Idaho. It produces the most unusual symptoms of all strains tested and is the most injurious to both susceptible and resistant sugar beets. This strain produces very severe symptoms on the leaves of beets as shown in Figure 2D. It causes the greatest injury to the vascular

Figure 1. (See page 533.) Healthy checks and symptoms produced by virus strain 1. A. Healthy checks, same age as D; B, vascular bundle healthy beet petioles; C, cross-section healthy root tip; D, infected sugar beets; E, vascular bundle in petiole of infected beet showing necrosis and degeneration of phloem tissue; F, necrosis and degeneration of cells surrounding sieve tube in infected root tips.

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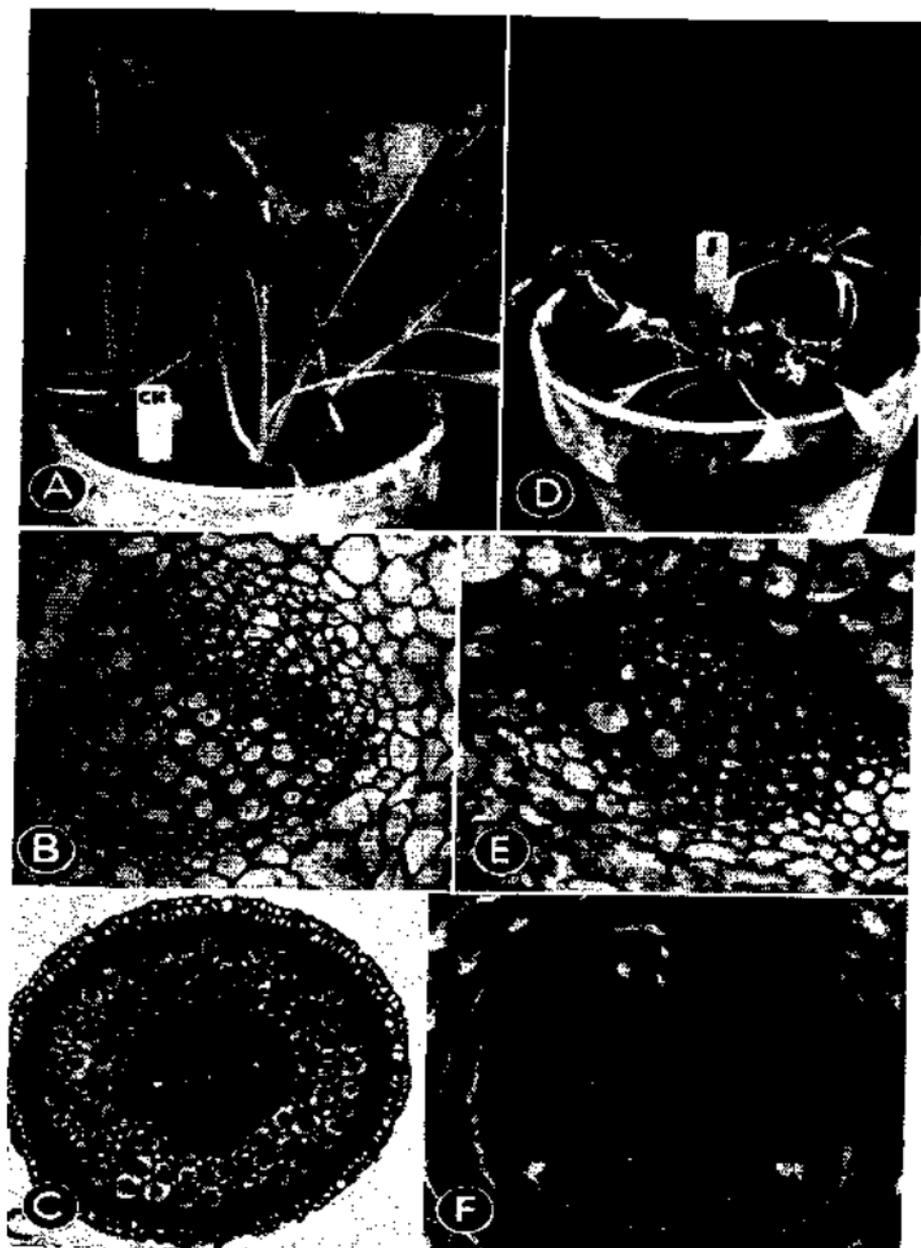


Figure 1.

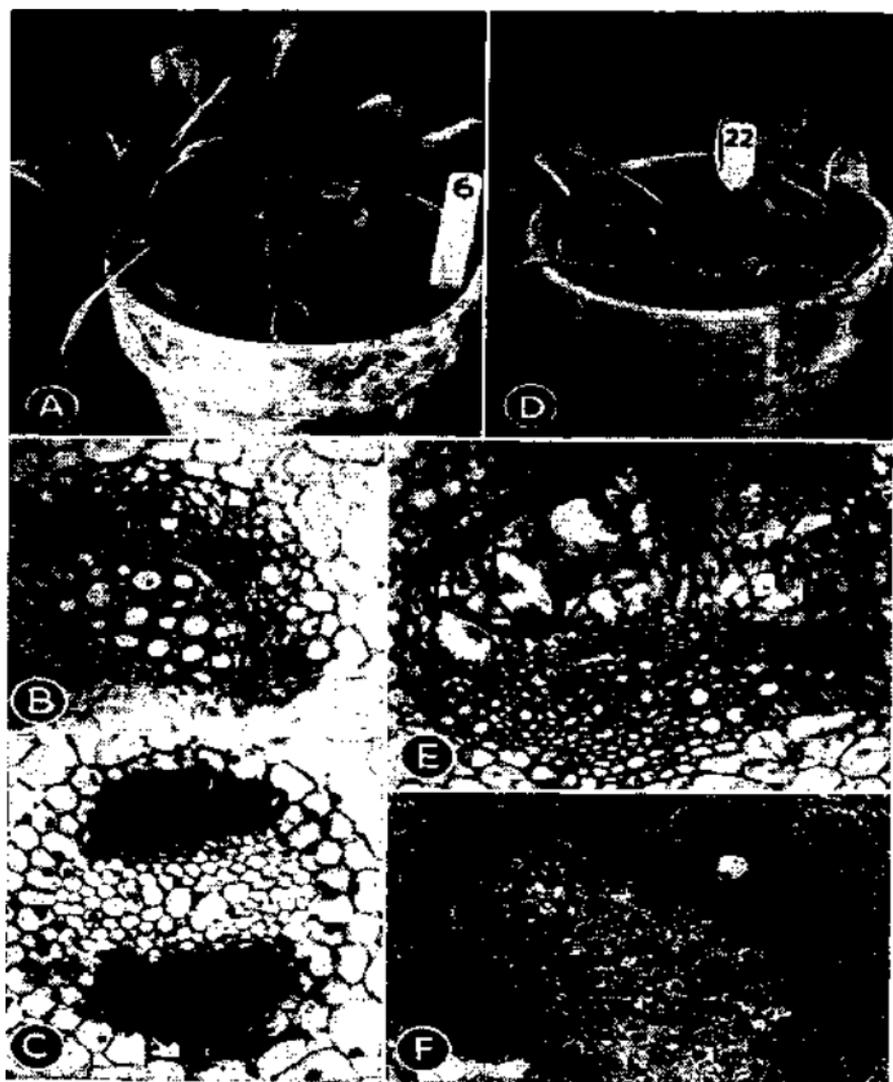


Figure 2.

bundles of the petioles of sugar beets. This injury consists of extreme hypertrophy of phloem cells with extensive necrosis and complete disorganization of the vascular bundles as shown in Figure 2E. This is a cross-section through a vascular bundle in a susceptible beet petiole.

Very mild strains of virus often cause hypertrophy in the phloem area of root tips and petioles without any degree of necrosis. Virulent strains like strain 1 will cause considerable necrosis but very little hypertrophy. Strain 22 produces both kinds of symptoms in the petioles of sugar beets and these prove to be the most destructive. However, extensive examinations of sectioned root tips from soil and nutrient solutions show few symptoms of curly-top in the tips of infected beets and these consist of only a few cells adjacent to the sieve tubes showing mild forms of degeneration (Figure 2F), in contrast to virus 6. Strain 22 does produce some bending and curling of root tips similar to that of virus strains 1 and 6. These latter strains produce root distortion by phloem necrosis. Strain 22 distorts by hypertrophy of cells surrounding sieve tubes and involving some tissue outside the pericycle.

Since virus strains 1 and 6 have been collected from two widely separated areas in California and strain 22 from Idaho, it indicates a widespread distribution of them.

Summary

Histological studies were made to determine tissues affected and degree of injury produced by three very virulent strains of curly-top virus.

Virus strain 1 causes rather severe injury to beet tops with vein roughening and distortion of leaves. In petioles it causes necrosis and degeneration of phloem tissue.

Virus strain 6 causes very little vein roughening or leaf distortion but does severely dwarf the entire beet plant. In petioles only a few small necrotic areas are produced, in the phloem tissue. The root tips are severely injured by extensive necrosis and degeneration of many cells in addition to those adjacent to sieve tubes.

Virus strain 22 produces very severe *vein* roughening and leaf distortion. In the vascular bundles of the petioles there is extremely severe hypertrophy and necrosis of the phloem and complete disorganization of the bundle. In contrast to virus 6 there are occasionally only a few cells surrounding sieve tubes in root tips which show mild degeneration.

Figure 2. (See page 534). Symptoms produced by virus strains 6 and 22 on susceptible sugar beets. A. Beets infected with virus 6 showing very little leaf distortion or vein roughening but severe dwarfing; B. vascular bundle in infected beet petiole showing only small necrotic areas; C, cross-section infected root tip showing severe necrosis and degeneration, involving many more cells than those adjacent to sieve tubes; D, beets infected with virus 22 showing severe top symptoms; E, cross-section vascular bundle in infected petiole, severe hypertrophy and necrosis of phloem tissue; F, cross-section of root tips showing only mild degeneration of a few cells surrounding sieve tube.