Beet curly top virulence increased

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Recent curly top isolates from San Joaquin Valley sugar beet fields and the foothills are more virulent than those collected in the 1950s and 1960s. The beet leafhopper (shown below, 48 times life size) carries the disease between crops and weed plants.

Curly top disease of sugar beet and other crops, including tomatoes, melons, beans, and spinach, is one of the oldest known and is unique among leafhopper-transmitted maladies. The only known vector of the disease in North America is the beet leafhopper *Circulifer tenellus* (Baker). The characteristic symptoms of the phloem-inhabiting disease are roughening and clearing of veins and curling of leaves. Since the appearance of curly top virus in California in about 1899, a wealth of data has accumulated on the complex and controversial nature of its epidemiology.

During the last 20 years, numerous changes have occurred in the San Joaquin Valley ecology. Irrigation canals have been completed; more than 500,000 acres of uncultivated land have been brought under cultivation; and new agricultural chemicals, particularly herbicides, have been introduced. The entire cropping pattern of the valley has changed.

In light of these ecological changes, a reinvestigation of some aspects of the epidemiology of curly top disease has been long overdue. Studies on these areas were suggested and supported by the Curly Top Virus Control Board, which is responsible for the control program and represents growers of crops susceptible to curly top disease. Our main concern during this investigation was to determine whether the isolates found today cause more or less damage to agricultural crop plants than the isolates collected many years ago, and to test a premise of self-elimination of damaging strains in the foothill region.

Experimental observations were made on the west side of the San Joaquin Valley and in the canyons of the foothills ranging from Taft to Los Banos. For an evaluation of the severity of isolates, 22 plants with typical signs of curly top disease were collected from each randomly selected sugar beet field and from breeding grounds of the vector. Healthy beet leafhoppers that had fed for five days on cuttings of these plants were placed on young sugar beet test plants. The severity of infection as the disease progressed was recorded.

Control isolates—Strain 11 and Los Banos—collected in the 1950s and 1960s and maintained in Salinas were also compared and rated for severity of infection of sugar beets. There has been no experimental evidence in our studies or in the studies of other researchers that the curly top virus isolates decline or attenuate in severity during prolonged maintenance in sugar beet under greenhouse conditions.

TABLE 1. Average Severity of Sugar Beet Curly Top Virus Isolates Found in the San Joaquin Valley and Foothills in 1974 and 1975

Sampling area and isolate*	Severity of isolate on sugar beets† US 75 (resistant) 1974	1975	742 (susceptible) 1974	1975
San Joaquin Valley				
Fresno I	7.1	7.1	10	10
Fresno II	7.0	7.0	10	10
Westside (Five Points)	6.2	7.0	10	10
Coalinga I	6.3	6.8	9.3	9.4
Foothills				
Taft	4.8	3.0	6.3	6.9
Bakersfield	4.0	3.0	6.3	5.0
Coalinga III	3.1	3.0	6.9	6.9
Coalinga IV	3.0	2.9	7.0	7.0
Control isolates				
Los Banos (1963)	4		7	
Strain 11 (1954)	0		5	

*Twenty-two plants from each area studied for evaluation of isolate severity based on reactions of susceptible (742) and resistant (US75) sugar beet varieties. Most severe isolate from each location is compared with similarly selected severe isolates from other areas.
†Values represent average of nine experiments with four replications. Severity index: 0 = little damage; 10 = death of plants.

The most important finding of our study (table 1) was that the current isolates of curly top virus in California are far more severe than were Strain 11 and Los Banos, the damaging isolates of many years ago. At present there is no theory to explain this observation. Conceivably, the lack of cross-protection among curly top isolates could account for the observed increase in severity of isolates.

It has been found, in agreement with earlier findings, that isolates obtained in the spring from the vicinity of the foothills are less damaging than those collected from agricultural areas. In assessing the meaning of this observation, it is essential to understand that migrating beet leafhoppers carry severe strains from agricultural areas and then feed on various weed plants, such as *Atriplex* and *Salsola*, in the fall until the winter annuals germinate in the breeding grounds. During this period, strains could be either attenuated or self-eliminating, and, as a result, only mild isolates would be found in the spring.

N.J. Giddings in the 1940s suggested that severe strains tend to be self-eliminating in the spring, because the germinating winter annuals are killed when inoculated with the severe isolates. Observations during our epidemiological study have cast some doubt on this theory. We therefore conducted field and greenhouse experiments to rank the germinating winter annuals for susceptibility to the disease, i.e., the number of days to death after inoculation with different isolates.

Table 2 shows that young winter annuals are not killed readily in the greenhouse or in the foothill region after inoculation with the damaging isolates. If Giddings' assumption were correct, the isolates collected today from the foothill area would be little changed in severity from that of Strain 11 collected 20 years ago. We have no evidence to support this conclusion. Our data indicate that the isolates of curly top virus collected from the breeding grounds were far more severe than was Strain 11, an isolate which would never have occurred in the foothills according to Giddings' theory.

In conclusion, the isolates damaging susceptible crops in California are more virulent than those collected during the 1950s and 1960s. We believe, in light of our data, that another alternative must be sought to explain the observed lack in virulence of curly top isolates during the spring.

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TABLE 2: Effect of Beet Curly Top Isolates on Young Germinating Host Plants under Natural Conditions in San Joaquin Valley Foothills and under Greenhouse Conditions

Weed species	Natural conditions, Fresno II: Curly-top-infected plants* (%/sq meter)	Natural conditions, Fresno II: Days to death†	Greenhouse conditions, Days to death‡: Fresno II (severe)	Greenhouse conditions, Days to death‡: Strain 11 (mild)
Capsella bursa-pastoris	2	31	28	over 60
Erodium cicutarium	3	24	30	over 60
Lepidium nitidum	10	20	21	over 60
Plantago lanceolata	1	21	29	over 60
Salsola iberica and *paulsonii*	1	40	over 60	over 60

*Five hundred viruliferous leafhoppers (Fresno II, 1974) were caged on a 1-square-meter area and kept for 10 days. Insects were killed by spraying the area, and the percentage of infected plants was estimated.
†Number of days to death after inoculation. Value represents the mean of two cages. Numbers are rounded off to the nearest day.
‡Number of days to death after inoculation with two isolates of beet curly top virus.