Highly Virulent Strains of Curly Top Virus in Sugar Beet in Western United States

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Introduction

It has been known for more than 30 years that beet curly top virus is a complex of strains that vary in virulence, induced symptoms, host range, and perhaps other characteristics. Giddings (2,3,5)[2] described 12 strains of this virus. One strain obtained from Idaho was highly virulent on sugar beet and was designated "Strain 11" (5). This strain is capable of causing marked injury even on resistant varieties of sugar beet.

During the season of 1960 curly top caused considerable damage to individual plants in some fields in central San Joaquin Valley, but no special study was made of strains of the virus involved. In 1961, curly top symptoms were so severe on plants in certain fields near Shandon, Los Banos, and Tracy that it was thought advisable to compare the virulence of the virus strains involved with that of strains previously isolated. Results of these tests are presented in this report.

Method of Testing

Beet plants affected with curly top were selected from fields near Shandon, Los Banos, and Tracy, and planted in pots at the U. S. Agricultural Experiment Station at Salinas, California. Also, beets received from Wyoming and Colorado were potted and included in the tests. After sufficient top growth was produced on the potted beets, nonviruliferous beet leafhoppers were allowed to feed on the diseased plants 3 days or more and then caged singly on seedling sugar beet plants. To determine the relative virulence of virus from different field beets, tests were made using the susceptible selection SL 742, the resistant variety US 75, and the very resistant selection SL 68. Additional tests and subtransfers were made on US 75 and on hybrid varieties with high degrees of resistance.

Only plants with very severe symptoms were selected from fields in California. Therefore, the virus recovered from these plants probably represents strains with the highest virulence to be found in the respective fields and the results are not necessarily representative of the fields as a whole.

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[2] Numbers in parentheses refer to literature cited.

Results were compared with those obtained with strain 11 on the different varieties and selections used in testing the field beets. Strain 11 was chosen because it is the most virulent of the curly top virus strains described up to the present. This strain was tested at Jerome, Idaho, in 1956 and 1957, on 4 varieties of beets growing in field plots (7). In both years, strain 11 caused substantially greater losses on all varieties than was caused by natural infection. This was true even in 1957 when plots naturally infected yielded only 2.47 to 5.20 tons per acre, and plots inoculated with strain 11 yielded 1.16 to 3.42 tons per acre.

Severity of injury on the test plants by virus from different field plants was estimated on the basis of stunting, leaf curling, and plant survival. A numerical grading system, ranging in ascending order of severity from 1 to 5, inclusive, was used in estimating relative virulence of virus from the different sources.

Results of Transfers of Virus from Field Beets

The results of tests of representative beets from different areas are shown in Table 1. As would be expected, a range of severity of symptoms was produced by virus from different sources. Highly virulent strains were obtained from beets from Shandon, Los Banos, Tracy, and Wyoming. Some of these were obviously more virulent than strain 11 with which they were compared. The

Table 1.—Relative virulence of curly top virus strain 11 and isolates from beets from different areas of western United States, indicated by tests on US 75 sugar beet.

Source of beets from which virus transfers were made	Number of plants of 20 inoculated showing indicated grade of severity					Average severity
	1	2	3	4	5	
Shandon, Calif.	0	0	2	9	7	4.3
Shandon, Calif.	0	3	6	7	2	3.4
Shandon, Calif.	3	2	5	2	4	3.1
Shandon, Calif.	0	0	0	3	11	4.8
Shandon, Calif.	0	0	0	10	7	4.4
Shandon, Calif.	0	0	0	7	7	4.5
Shandon, Calif.	0	1	1	5	11	4.4
Tracy, Calif.	0	0	0	0	11	5.0
Tracy, Calif.	0	0	1	3	13	4.7
Tracy, Calif.	0	2	5	5	0	3.2
Los Banos, Calif.	0	0	0	1	11	4.9
Los Banos, Calif.	0	0	0	1	12	4.9
Los Banos, Calif.	0	0	1	8	9	4.4
Wasco, Calif.	0	2	12	0	0	2.8
Wyoming	0	2	11	0	0	2.9
Wyoming	0	1	1	3	13	4.6
Wyoming	0	6	10	0	0	2.6
Salinas, Calif.-st. 11	0	0	6	11	2	3.8
Salinas, Calif.-st. 11	0	0	2	9	4	4.1
Salinas, Calif.-st. 11	0	0	5	10	2	3.8

relative amounts of dwarfing by an isolate from Shandon and by strain 11 on a hybrid variety (1 × 3) and on US 75 are shown in Figure 1. Several other isolates appeared also to be more virulent than strain 11 when tested on US 75 (Table 1).

Figure 1.—Beet plants inoculated with curly top virus in the cotyledon stage. Top, Selection 1 × 3 inoculated with isolate from Shandon (left) and strain 11 (right). Bottom, US 75 inoculated with isolate from Shandon (left) and strain 11 (right).

Transfers from some of the field beets gave uniformly severe effects. Transfers from others gave a range of severity of symptoms on US 75, indicating that the plants were infected with a mixture of strains. Subtransfers from mildly affected test plants gave predominantly mild symptoms, whereas transfers from severely affected plants gave severe symptoms only or a range of severity of symptoms, indicating that more than one strain of virus had

been transmitted. These results supply further evidence that field beets often are infected with a mixture of curly top virus strains.

Giddings (4) showed that a single beet leafhopper is able to carry a combination of at least 3 strains of virus. When such leafhoppers were allowed short feeding periods on seedling beets, they introduced the strains into the plants singly and in all possible combinations. The beet leafhopper, therefore, may infect beets with more than one strain of virus in a single feeding. Also, plants infected with one strain remain susceptible to infection by other strains. If the second strain is more virulent than the strain already present, symptoms of curly top are increased by the second strain.

Four of the most virulent isolates—one from Shandon, two from Los Banos, and one from Wyoming—were selected for making a series of transfers to different varieties and selections of sugar beets and other plants. These isolates have continued to produce very severe symptoms on resistant varieties and selections, such as US 75 and SL 68. Infected plants of US 75 produced curled and dwarfed leaves, and little growth was produced after the plants showed first symptoms of disease. High percentages of plants inoculated in the cotyledon stage with the 4 virus selections were killed. The virus isolates have maintained their relative degrees of virulence, as compared to strain 11, through 3 or more transfers on US 75. Each of the 4 isolates has appeared to be more virulent than strain 11 on sugar beet.

Damage by Virulent Strains of Virus

It is not possible to assess accurately the damage produced in 1961 by virulent strains of curly top virus in any specific area because injury varied in different fields depending on the time of infection, vigor of plants, and other factors. It was evident, however, that in certain fields yields were greatly reduced.

In the Shandon and Los Banos areas, beet leafhoppers moved into the beet fields a month to six weeks earlier than usual, owing to the earlier drying of desert vegetation which forced the leafhoppers to migrate. In certain areas there also was overwintering of leafhoppers on the floor of the valleys close to beet fields. In some fields leafhoppers were present at thinning time. Where conditions were unfavorable for very rapid growth, leafhoppers multiplied in the beet fields and produced high percentages of infection. In some fields the leafhoppers continued to multiply through the summer. Fields that had 50 or more leafhoppers per plant in June and July were found near Los Banos and Shandon.

Plants in these fields did not attain sufficient size for the foliage to cover the rows. Thus, they were exposed to direct sunlight throughout the summer and remained favorable hosts for multiplication of leafhoppers.

The high summer populations of leafhoppers probably account for the severe damage noted in some fields. The leafhoppers that initially invaded the beet fields from the desert areas undoubtedly carried many different strains of curly top virus ranging in virulence from mild to very severe. Tests over a period of years have indicated that leafhoppers from desert areas predominantly carry mild strains of virus. Giddings (6) suggested that this is due to the fact that virulent strains of virus kill most desert host plants. If this is true, virulent strains of virus that may be developed in the natural breeding grounds of the beet leafhopper tend to be self-eliminating.

After virus is carried from the desert breeding grounds to beet fields by the beet leafhopper, factors involved in strain selection change radically. In beets, the highly virulent strains of virus are best equipped to survive.

The sugar beet plant is an excellent host for increase of the beet leafhopper if plants are small and exposed to full sunlight. If the plants are large and the foliage covers the rows so that shade and high humidity prevail, little leafhopper increase occurs. By stunting the beet plants virulent strains of virus provide more favorable conditions for leafhopper increase. Also, since strains of curly top virus do not afford cross-protection against each other, plants infected with a mild strain of virus remain susceptible to infection with more virulent strains. Where high populations of leafhoppers are present in a field they may continue to spread more virulent strains throughout the season. Curly top, therefore, may become progressively more severe as the season advances. By the end of the season, most of the plants may be infected with the most virulent strains of virus along with any less virulent strains that may be present.

Evidence of progressive spread of more virulent strains of curly top virus in fields already 100% infected was noted in beet fields near Los Banos as late as November 2. Older leaves of many plants showed mild vein swelling, indicating that they had first been infected with a mild strain of virus. On November 2, some of these plants had badly curled young leaves, indicating that the plants had been reinfected with a more virulent virus strain.

As already stated, the strain complex in desert areas apparently has remained more or less stable for many years. No new factors that would change this condition are known to have been introduced. However, if conditions which would permit perpetuation of virus on beets through the year should arise, the percentage of beet plants infected with the more virulent strains would be expected to increase.

Summary and Conclusions

Tests of isolates from field beets in 1961 indicate that strains of the curly top virus capable of causing appreciable damage to resistant varieties of sugar beets were present in widely separated areas of western United States. Some of these isolates have higher degrees of virulence than any of the strains previously described, indicating that strains of increased virulence are being evolved. The findings emphasize the desirability of maintaining and increasing the curly top resistance of new varieties of sugar beets developed for use in areas of western United States where curly top virus and the beet leafhopper are prevalent.

Literature Cited

(1) BENNETT, C. W. 1957. Interaction of sugar-beet curly top virus and an unusual mutant. Virology 3: 322-342.

(2) GIDDINGS, N. J. 1938. Studies of selected strains of curly top virus. J. Agr. Res. 56: 883-894.

(3) GIDDINGS, N. J. 1944. Additional strains of the sugar-beet curly top virus. J. Agr. Res. 69: 149-157.

(4) GIDDINGS, N. J. 1950. Combination and separation of curly-top virus strains. Proc. Am. Soc. Sugar Beet Technol. 6: 502-507.

(5) GIDDINGS, N. J. 1954. Two recently isolated strains of curly top virus. Phytopathology 44: 123-125.

(6) GIDDINGS, N. J. 1959. The stability of sugar beet curly-top virus strains. J. Am. Soc. Sugar Beet Technol. 10: 359-363.

(7) MURPHY, ALBERT M., C. W. BENNETT, and F. V. OWEN. 1959. Varietal reaction of sugar beets to curly top virus strain 11 under field conditions. J. Am. Soc. Sugar Beet Technol. 10: 281-282.