

The differences between young plants and comparatively old plants, or those between the resistant and susceptible beet were so great in both 1939 and 1941 that statistical analyses hardly seemed necessary. Such analyses were made, however, and all such differences were shown to be highly significant.

It is clearly evident from these experiments that, in general, early planting of sugar beets in the curly-top areas is a highly desirable practice. The important factor is to have the plants as well advanced as possible at the time of infestation by viruliferous leafhoppers. It is also clear that the resistant varieties of sugar beet, even in the very early stages of growth, are far more resistant to curly-top injury than are varieties, such as Old Type.

Production of Heavy Curly-Top Exposures in Sugar-Beet Breeding Fields

ALBERT M. MURPHY¹

Curly top formerly was the worst trouble with which the beet-sugar industry had to cope in practically all areas of the far-western United States. Farmers occasionally had crop failures and in many places sugar factories had to be abandoned on account of the disease. Then curly-top epidemics seemed entirely evil but now we can see that good comes out of them. Without curly-top epidemics, naturally and artificially produced, we could not have bred curly-top-resistant sugar beets. And probably we would not now have a well-established sugar-beet seed industry adequate to meet all our own needs and part of the requirements of our friends and allies.

Natural, drastic curly-top epidemics do not occur in the same area every year and therefore do not meet the needs of a program of breeding for curly-top resistance. The severest possible curly-top exposure must come regularly in order to make possible the most rapid advance in breeding resistant varieties. It takes very severe exposure to bring out small differences in resistance between resistant individual beets and between resistant varieties. Such small differences must be evident to the plant breeder if the right selections are

¹Assistant Pathologist, Division of Sugar Plant Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.

to be made. By having a drastic exposure each season for 6 consecutive years, progress has been about 3 times as great as it would have been if a severe epidemic had occurred only once in 3 years; that is, twice in the same 6-year period. The foregoing discussion should make clear why so much study and effort has been devoted to producing curly-top epidemics artificially.

The purpose of this paper is to present and discuss the methods used and being studied by the Bureau of Plant Industry to insure a drastic curly-top exposure in the breeding plots every year.

Experimental Procedure

Five general methods of inducing curly-top epidemics in the breeding field have been employed; (1) Caging viruliferous leafhoppers on individual beets, (2) planting diseased mother beets as a source of virus for invading leafhoppers, (3) releasing viruliferous leafhoppers in the field, (4) planting a susceptible variety to be infected and then serve as a source of virus, and (5) late planting. Modifications of some of these measures are being tried and additional methods are being tested or planned.

Caging Leafhoppers on Beets.—The earliest method used to produce an artificial curly-top epidemic was to confine one or more viruliferous leafhoppers on individual plants. Small, specially constructed glass cages were used and the operation involved a great deal of hand work. It was laborious, expensive, and slow; therefore only a limited number of beets could be inoculated. Since the number of beets that could be handled by this method was small, progress was retarded.

Planting Diseased Mother Beets. — Numerous observations revealed that when diseased beets from the previous season were saved as mother beets for seed and transplanted in or adjacent to a spring-planted field, these diseased mother beets served as a source of virus for invading leafhoppers.

This led to the method of transplanting diseased mother beets to the breeding plots which has proved effective in helping to hasten the development of epidemics. This plan is most useful when the leafhopper invasion is heavy and early. One danger in the procedure is that the mother beets may have other diseases, such as mosaic, which will spread to the breeding plots and interfere with the work.

Releasing Viruliferous Leafhoppers. — Viruliferous leafhoppers bred in the insectary or collected from natural breeding grounds have been released in large numbers in the breeding plots early in the spring. The principal contribution this makes is to infect a small percentage of the plants throughout the plots so that when the natural leafhopper infestation occurs there is an ample source of virus. The chief limitation of the method is the difficulty in obtaining adequate numbers of the insects.

Planting a Susceptible Variety.—A susceptible variety when planted in blocks in the field or in rows alternating with rows of resistant varieties serves as a good source of virus. The beets of such a variety contract curly top quickly and then, as long as they survive, supply virus for such non-viruliferous leafhoppers as may enter the field and feed on them. When the movement of leafhoppers was expected to be heavy, it was found that it was better to plant some area with a variety of intermediate resistance. Such a variety will persist and continue to supply virus after the susceptible variety has been almost completely wiped out.

Late Planting.—One of the early recommendations for curly-top control was to plant early enough to get the crop advanced as far as possible before the movement of the spring generation of leafhoppers into the field. Obviously, when severe exposure is wanted the recommendation would be reversed. Manipulation of planting date so that the varieties to be tested would be very young, and therefore relatively susceptible when very heavily exposed, has been found highly effective.

An added reason for using this method of late planting is that it permits testing of progeny of beets selected the previous season. Seed of such mother beets can be grown in the greenhouse in the winter and early spring. Plants so tested, of course, are not large enough for sugar analysis and can be selected only for resistance and root shape.

Other Methods.—Another method is now being tried to increase the curly-top exposure, namely, to provide suitable host plants, either wild or cultivated, to harbor the leafhoppers over the winter. The seed of weed hosts, such as the mustards, is planted in the fall in or near the field to be used next for the breeding plots. The seed must be planted early enough to germinate and become established so that the leafhoppers will have an opportunity to move to these hosts before the weather becomes too unfavorable.

Preliminary tests with spinach have indicated that it is quite satisfactory as a cultivated host plant. It will grow at somewhat lower temperatures than beets and, therefore, if planted in the fall, it will generally live over the winter under field conditions in southern Idaho. Spinach is susceptible to the curly-top disease and seems to be a favorable host plant for the beet leafhopper.

A plan is being worked on involving the use of a large area of desert land where the weed hosts of the leafhopper can be manipulated or in effect cultivated to maintain a small permanent breeding ground for the leafhopper. The beet-breeding plots will be planted adjacent to or in the midst of the permanent breeding ground.

Discussion and Conclusions

Great progress has been made in breeding for curly-top resistance, as shown in table 1.

Table 1.—Comparative yields of varieties under drastic curly-top exposure, Buhl, Idaho, 1941.

Variety	Tons per acre
R. & G. Old Type	.73
U. S. 1 (0137)	6.31
U. S. 33 (833)	8.40
U. S. 12 (018)	11.25
U. S. 22 (922)	14.32
Improved U. S. 22 (97)	16.61

In spite of the progress that has already been made in the development of sugar-beet varieties resistant to early top losses of importance are still occasionally sustained and greater resistance is therefore needed. As the severity of curly-top damage fluctuates widely from year to year it is unwise to depend entirely upon the natural infestation if the greatest progress is to be made.

A General Appraisal of Plant Cover in Relation to Beet Leaf Hoppers, Forage Production, and Soil Protection

R. L. PIEMEISEL¹

The semi-arid lands of the northern portion of the intermountain region at one time were covered with bunch grass or with widely spaced sagebrush where bunch grass and other perennials occurred between the shrubs. Today, very little of the sagebrush-grass vegetation remains, and instead there are weedy areas composed almost entirely of annuals, or if sagebrush remains, the spaces between the shrubs are largely weeds. Such weedy vegetation now covers most of the dry lands that stretch from the irrigated portions of the valleys to the wooded mountain slopes. In southern Idaho alone there are approximately 2 1/2 million acres of weedy lands and several million more of the sagebrush and weed type.

¹Physiologist, Division of Sugar Plant Investigations, Bureau of Plant Industry, United States Department of Agriculture.