Beet Leafhopper Populations In Southern Idaho and Northern Utah During the Seasons of 1940 and 1941[1]

J. R. DOUGLASS, H. K. DORST, AND W. K. PEAY[2 3]

In 1940 curly-top-resistant varieties of sugar beets grown in some areas of northern Utah suffered severe damage from curly-top diseases transmitted by the beet leafhopper, *Eutettix tenellus* (Bak.). Then during the 1941 season, severe injury to curly-top-resistant varieties occurred in the Jerome and Buhl-Castleford areas of southern Idaho. Although the damage was local in extent, it dealt hard blows to farmers in affected areas. These growers seriously questioned the degree of curly-top resistance of the varieties planted.

Information in the files of this bureau shows that the magnitude and time of spring movement of the leafhoppers into beet fields are important factors in determining the extent of curly-top epidemics, since small sugar-beet plants are more susceptible to injury by the curly-top disease transmitted by the leafhopper than are the larger plants. Large populations of the summer generation which enter the beet fields later in the season are relatively unimportant in causing damage by curly top, since the older plants, especially those of the curly-top-resistant varieties, are more resistant to the disease. With this thought in mind we shall confine our discussion to the important spring populations.

Life History of the Beet Leafhopper

In southern Idaho and northern Utah the beet leafhopper passes through the winter in the adult stage. Females are fertilized in the fall and live until spring; males die during the winter. Egg laying normally begins in March, and adults of the first or spring generation appear in May or June. The second or summer generation appears during July and early August, and the third or overwintering generation in September or October. There is considerable overlapping of generations, especially during the summer and early fall. This insect requires a sequence of host plants for its development, which has been discussed before.[4]

[1]The work In Idaho was carried on in cooperation with the Bureau of Plant Industry, U. S. Department of Agriculture, the Idaho Agricultural Experiment Station and the Leafhopper Control Administration, State of Idaho, and in Utah in cooperation with the Utah Agricultural Experiment Station.

[2]U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

[3]H. C. Hallock, R. N. Hofmaster, D. E. Fox, H. C. Bennion, A. L. Burroughs, and E. R. Janes assisted in obtaining the field notes.

[4]Piemeisel, R. L., and Chamberlin, J. C, Land-improvement Measures in Relation to a Possible Control of the Beet Leafhopper and Curly Top. U. S. Dept. Agr. Cir. 416, 24 pp., illus. 1936.

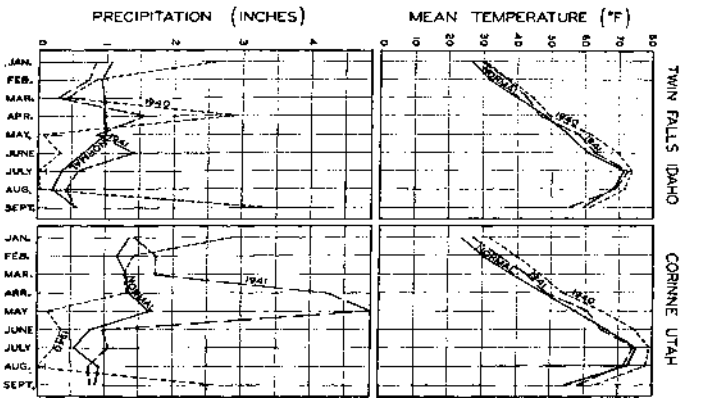

Figure 1.—Monthly mean temperatures find precipitation **with** the normal for Twin Falls, Idaho, and Corinn**e,** Utah, for the seasons of 1940 and **1941.**

Climatological Conditions

The climatological data presented in figure 1 for January to September, inclusive, show that monthly mean temperatures for the season of 1940 in both the Idaho and Utah areas were slightly greater than in 1941, although both seasons were above normal in temperature. The total precipitation recorded at Twin Falls, Idaho, for the 2-year period was 10.01 and 7.34 inches for 1940 and 1941, respectively. At Corinne, Utah, the total precipitation for the period was 10.08 and 17.54 inches for 1940 and 1941. During the 1940 season, at both stations, January, February, and September were the only months with excessive precipitation, whereas in 1941 all the months except August and September showed excessive moisture.

Varieties Planted

In the affected area of southern Idaho the curly-top-resistant varieties U. S. 12, U. S. 22, A-635, and A-735 were planted in practically the same general localities both years, except that in 1941, U, S, 22 was used more extensively than U. S. 12.

In northern Utah the varieties used were U. S. 12, U. S. 22, U. S. 33, and A-735. These varieties were planted in the same general localities both years, except that in 1941, U. S. 33 and A-735 were largely replaced by U. S. 22 and U. S. 12, respectively.

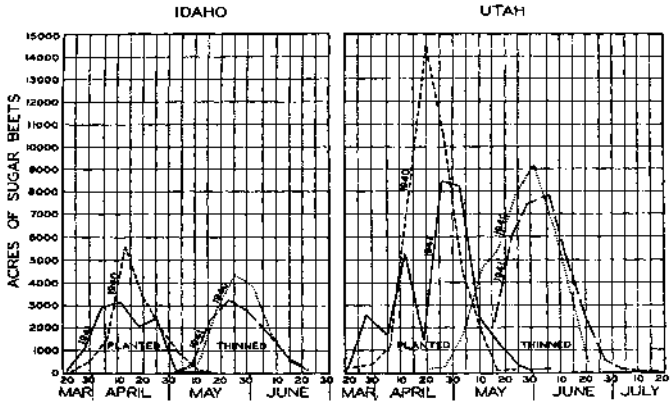

Figure 2.—Dates of planting and thinning sugar beets for southern Idaho and northern Utah for the seasons of 3940 and 1041.

Dates of Planting and Thinning

The data on time of planting and thinning sugar beets for the Idaho and Utah areas are given in figure 2.[5] This figure shows that planting in the Idaho area for the 2 years started the last half of March, reached its peak about the middle of April, and ended about the middle of May. Thinning started the first week of May, reached its peak during the fourth week of May, and was completed during the last 10 days of June.

In Utah the planting began the latter part of March in both years. The peak of planting was reached during the week ending April 20 in 1940 and the week ending April 26 in 1941. It was completed during the latter part of May in 1940 and in the first part of June in 1941. Thinning started during the latter part of April in 1940 and in the middle of May in 1941. The peak was reached during the last of May in 1940 and in the first week of June in 1941. It was completed during the third week of June in 1940 and in the last of July in 1941.

Spring Migration

With the maturity of the spring generation, which develops on wild host plants in the breeding areas, the adults disperse to the summer hosts, and the progress of this movement coincides with the maturation of the insect.

[5]These data were furnished by The Amalgamated Sugar Company and the Utah-Idaho Sugar Company.

Idaho.—In order to determine the time and magnitude of the spring-generation movement into the cultivated area, beet fields on the western edge of the irrigated tract near Buhl and Castleford, Tdaho, were selected for this study. The population counts of adults were made by means of the Hills square-foot sampler.[6] Before the beets were thinned a total of 100 square-foot samples, taken at random, were examined in the rows of beets in each field, and after thinning, a total of 100 beets or a fraction thereof, depending upon the density of the leaf hopper population, were sampled in each field. Each of these beets was included in a square-foot sample, corresponding to the square-foot samples taken in the beet rows before thinning.

Figure 3 shows that in 1940 there were a few beet leafloppers in the fields when the first samples were taken on May 2. These were females that had overwintered in the cultivated areas and had moved into the sugar-beet fields soon after the plants appeared above ground. The migration of the spring generation into the beet fields started on May 20, and the peak of this movement was reached on June 17, when an average of 1,090 beet leafloppers per 100 square-foot samples was recorded. A period of 28 days was required for the movement to reach its peak.

Tn 1941 the population counts were repeated in the Buhl and Castleford. Idaho, districts, using the same methods as in 1940. A few overwintered females were noted in the beet fields before the initial spring movement, began. The spring migration started on May 3 2, which is the earliest movement of the spring generation into the cultivated area since 1934. Following the initial spring movement there was a gradual increase in the rate of migration until May 23, when on an average 734 leafloppers per 100 square-foot samples were recorded, as shown in figure 4. The population decreased during a period of rainy weather from May 25 to June 3. No precipitation occurred on June 4 and 5, and a slight increase in number of leafhoppers was recorded on June 6. Further precipitation occurred on June 6, 7, and 8, and the population again was reduced on June 9. This rainy period evidently resulted in some mortality of leafhoppers in beet fields and was distinctly unfavorable for movement of the insects from breeding grounds into the cultivated area. During this period an accumulation of adult leafloppers was noted on spring hosts in the breeding grounds. Immediately following the period of inclement weather, the population increased from 560 on June 9 to 1,206 on June 11 and 1,496 per 100 square-foot samples on June 13, when the peak was reached. A period of 32 days was required for the movement to reach its peak.

[6]HilIs, O. *A., 1933. A* New Method for Collecting Samples of Insect Populations Jour. Econ. Ent. 20: 906-910, illus.

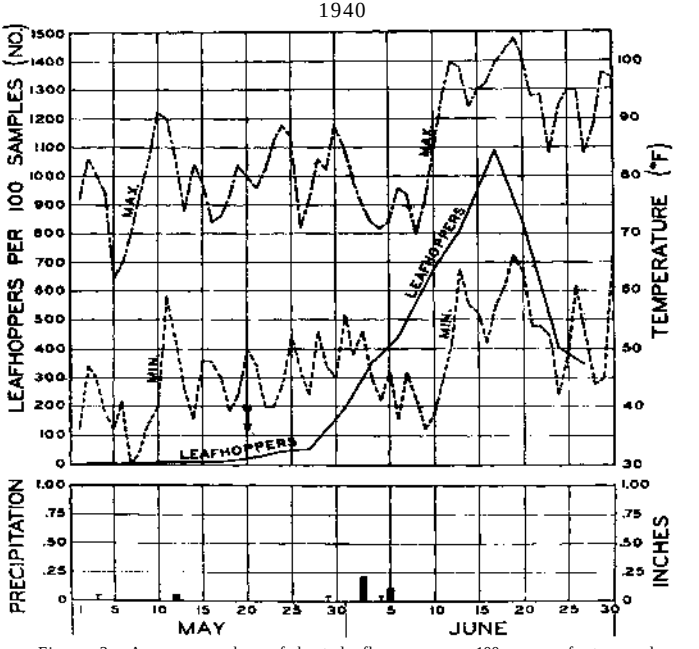

Figure 3.—Average number of beet leafhoppers per 100 square-foot samples. Arrow points to the date the initial spring-generation leafhoppers appeared in beet fields. Buhl and Castleford, Idaho. 1040.

The movement of the spring generation into beet fields of southern Idaho in 1940 and 1941, in comparison with the average movement for the past 7 years, is presented in figure 5. This shows that the 1940 movement was earlier than the average and that the magnitude was slightly lower. A glance at the figure will show that the movement in 1941 was early and the rate was very fast until May 23, when unfavorable weather conditions, as pointed out above, delayed the migration until June 9. A comparison of the populations will show that in 1941 there was an average infestation of 734 leafhoppers, per 100 samples, over 17 days earlier than in 1940 and 21 days earlier than the average.

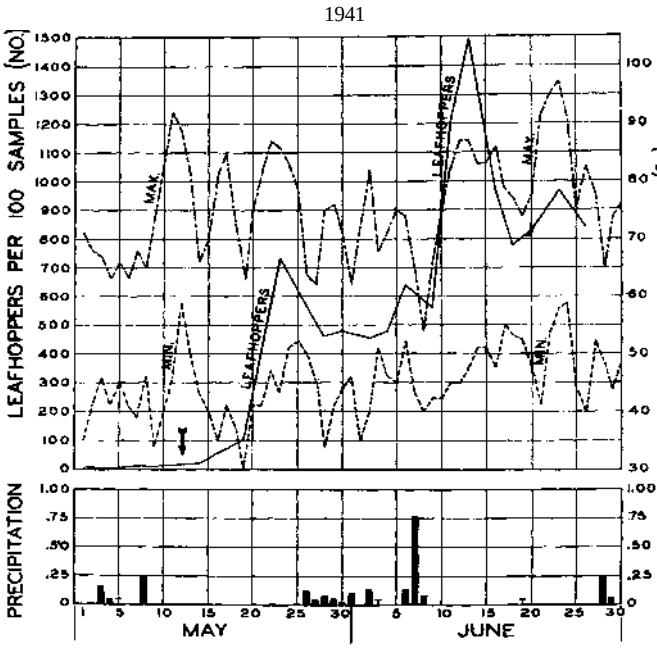

Figure 4.—Average number of beet leafhoppers per 100 square root samples. Arrow points to the date the initial spring-generation leafhoppers appeared in beet fields. Buhl and Castleford. Idaho. 1941.

Utah.—The spring migrations of beet leafhoppers in northern Utah come from two main sources. These are the long-distance and local migrations, each being independent of the other. The long-distance migrants come from Arizona, son thorn Utah, and Xevada. The local migrants come from breeding areas principally around Utah Lake and the Great Salt Lake.

Figure 6 shows the populations of long-distance migrants present in beet fields about the time the peak of the migration was reached in 1940 and 1941 from Cache Valley, in the north, to Elsinore, Utah, in the south. This shows a much higher population in southern than in northern Utah, an indication that the movement comes from

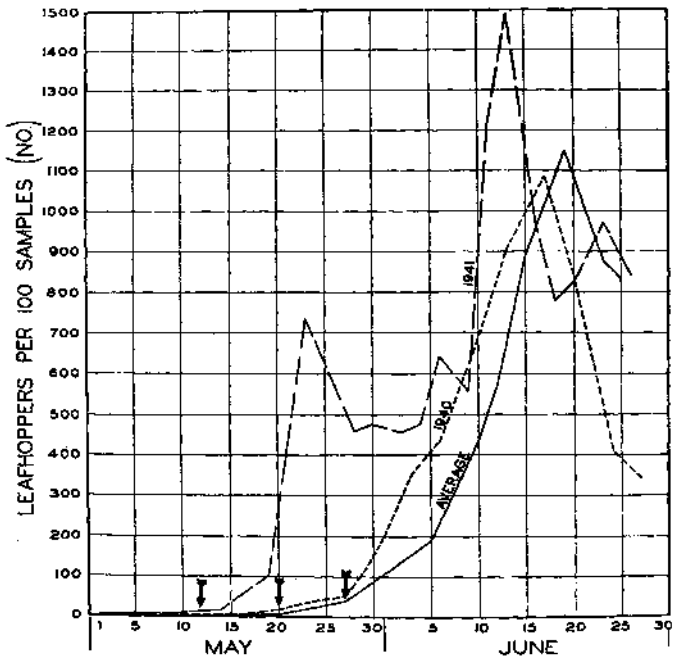

Figure 5,—Comparison of the average number of beet leafhoppers, per 100 square-foot samples, in southern Idaho for 1940 and 1941 with the average for 1935-41, Arrows point to the dates the initial spring-generation leafhoppers appeared in the beet fields.

the south. The cardinal factors governing the production and maturation of the beet leafhopper are temperature, moisture, and host-plant conditions. Since the long-distance migrants come from sections having higher temperatures than the local areas, these leafhoppers move into beet fields of northern Utah before the maturation of the local insects. In 1940 long-distance migrants first were collected in beet fields on April 23 and increased in number until reaching a peak about May 15. At this time on an average 136 beet leafhoppers, per 100 square-foot samples, were present. The first evidence of the local migration into beet fields was between May 17 and 20, a peak being

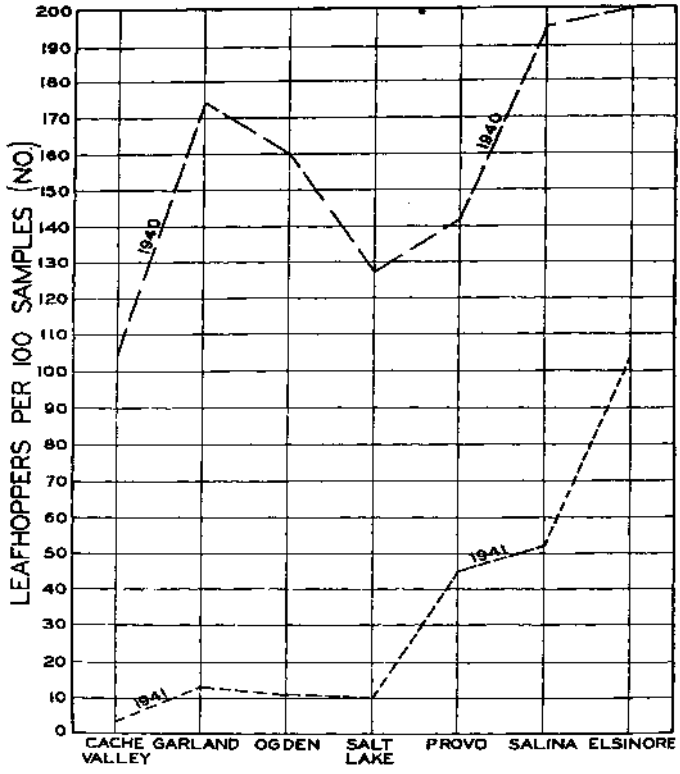

Figure 6.—Average number of long-distance migrant beet leafhoppers per 100 square-foot samples for 1940 and 1941 from Cache Valley, in the north, to Elsinore, Utah, in the south.

reached about June 10. The long-distance migration started on May 11 or 12 in 1941 and gradually increased and merged with the local migration which started about May 25. At that time there was an average of 14 beet leafhoppers, per 100 square-foot samples, as coinpared to 136 in 1940. The local migration in 1941 reached a peak about June 12.

Usually the progeny of migrants from more distant sources are maturing to the adult form in the beet fields before the movement of adults from local areas reaches its peak, and it is therefore necessary to adopt artificial methods to isolate the local from the long-distance populations in order to determine the magnitude of the former. To accomplish this objective and also to determine the percentage of leafhoppers carrying the virus, a series of small plots was planted in 1940 and 1941 along the edge of Great Salt Lake from Bear River City south to Kaysville. These plots were covered with cheesecloth until the local migrations started, in order to exclude the long-distance migrants and prevent their breeding in the plots. An average of 93 and 2 beet leafhoppers, per 100 square-foot samples, was collected from these plants in 1940 and 1941, respectively.

Percentage of Viruliferous Leafhoppers

In order to determine the percentage of viruliferous beet leafhoppers and the virulence of the curly-top virus in spring-generation leafhoppers, tests were conducted in cooperation with the Bureau of Plant Industry in Idaho and independently in Utah with leafhoppers from the desert-breeding areas and from beet fields. The results of the Idaho tests showed that an average of 35.8 and 61.1 percent of the spring-generation insects were viruliferous for the years of 1940 and 1941, respectively. Utah tests showed that 77.3 and 33.3 percent of the spring generation were viruliferous for 1940 and 1941.

Curly-Top Infection

During the middle of the seasons in 1940 and 1941 representative sugar-beet fields in the affected areas of Idaho and Utah were examined for curly-top infection, as an indication of comparative beet-leafhopper infestations and the resulting curly-top disease produced. No study was made by bureau representatives of the seasonal development of curly top. In each field included in this survey a total of 500 beet plants taken at random were examined and the grade of disease severity recorded according to Giddings' system.[7]

The results of the surveys show that in the affected area of Idaho, 88.4 percent of the beets were infected in 1940 and 99.9 percent in 1941. A comparison of the infected plants showing grades of severity, which is an excellent criterion of the severity of the curly-top epidemic, shows that 9.5 as compared with 52 percent were in grades 3, 4, and 5 for 1940 and 1941, respectively. Grades 3, 4, and 5 show increased dwarfing with an increase in grade.

Curly-top surveys of the beet areas in northern Utah showed that an average of 62 percent of the beets were diseased in 1940. In some areas as high as 90 percent of the plants, on an average, were

[7]Giddings, N. J. 1938. Studies of Selected Strains of Curly-Top Virus. Jour. Agr. Res. 56: 883-894, illus.

Figure 7.—Curly-top injury to sugar beets, northern Utah, 1940. Photographed August 24, 1940, a few days after weeding.

Figure S.—Curly-top injury to sugar beets, southern Idaho, 1941. Photographed August 4, 1941.

infected by curly-top disease, and many individual fields showed practically 100-percent infection. A large percentage of the diseased beets was in grades 3, 4, and 5. Since the survey was made after the more severely affected fields were abandoned and plowed out, the average percentage undoubtedly is under-estimated. An average of 12.3 percent of the beets in northern Utah was diseased in 1941, 0.4 percent of these being in grades 3, 4, and 5.

Since there is a tendency to forget the severity of infection from one curly-top epidemic to another, figure 7 is presented to recall the 1940 outbreak in northern Utah and figure 8 to visualize the 1941 curly-top situation in southern Idaho.

Sugar-Beet Yields

The average yield of sugar beets[5] in the affected area of southern Idaho (Castleford, Cedar, Gooding, Jerome, Richfield, Shoshone, and Wendell) in 1940 was 16.82 tons per acre compared with 8.97 tons in 1941, or a difference of 7.85 tons per acre (fig. 9). In the northern Utah area the average yields for Cache Valley, Garland, Ogden, Salt Lake and Spanish Pork were 10.60 and 14.82 tons per acre for 1940 and 1941, respectively, or a difference of 4.22 tons.

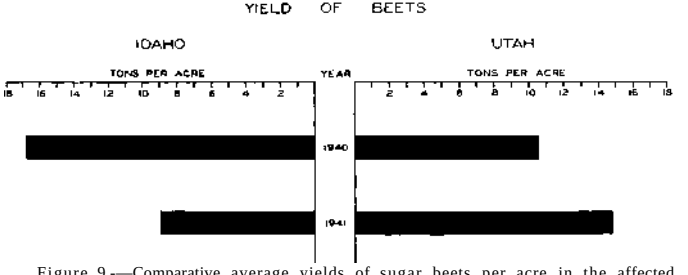

Figure 9.—Comparative average yields of sugar beets per acre in the affected curly-top area of southern Idaho and northern Utah for 1940 and 1941.

Discussion

In the interpretations of the data and conditions presented in this discussion one finds that the spring seasons of 1940 and 1941 were above normal in temperature for southern Idaho and northern Utah. In 1941 a total of 9.09 inches of precipitation fell at Corinne, Utah, during April and May. These 2 months are the critical period in the development of the spring-generation leafhoppers. Excessive precipitation occurring as it did created such unfavorable physical and environmental conditions in northern Utah that the leafhopper populations were reduced far below the expectancy.

[5]These data were furnished by The Amalgamated Sugar Company and the Utah-Idaho Sugar Company.

On the west end of the cultivated areas of southern Idaho, which normally receives a heavy infestation of beet leafhoppers, improved curly-top-resistant sugar-beet varieties were planted in 1940 and 1941. These varieties were damaged severely by the curly-top exposure in 1941, especially on fields of low soil fertility and those not receiving proper cultural care. Following the severe curly-top epidemic in Utah in 1940, varieties not extremely resistant to the disease were replaced in certain areas by superior improved curly-top-resistant varieties in 1941.

The planting and thinning dates for the 2 seasons were practically the same in Idaho but were 6 days later in Utah in 1941 than in 1940.

After a glance at figure 5 one wonders why southern Idaho did not have a serious curly-top epidemic in 1940. A survey of the affected area did show that 88.4 percent of the beets were infected, but only 9.5 percent showed severe curly-top symptoms. A non-resistant variety, R. and G. Old Type, planted April 10 by the Bureau of Plant Industry[8] in their trial plots north of Buhl, Idaho, showed 100 percent severe curly-top symptoms and yielded 6.63 tons per acre as compared with 29.39 tons for Improved U. S. 22, a highly resistant curly-top variety. R. and G. Old Type was completely destroyed by curly top in a similar test, but planted at the extremely late date of June 6, while the highly resistant variety Improved U. S. 22 yielded 11.58 tons per acre.

A glance at figure 3 will show that these beets were probably in the seedling stage, or the period of greatest susceptibility, when the peak of the movement was reached on June 17. A study of figures 2 and 5 shows that in 1940 the spring migration did not start until May 20, when approximately 27.0 percent of the beets were thinned. A magnitude of 700 beet leafhoppers, per 100 square-foot samples, was not reached until after June 10 when thinning was practically completed. By this time the improved curly-top-resistant varieties had acquired sufficient resistance to withstand a population of approximately 11 leafhoppers per beet on June 17. It must also be remembered that only 35.8 percent of those leafhoppers were viruliferous.

The initial spring movement of leafhoppers into the cultivated area of southern Idaho in 1941 occurred on May 12. This was 8 days ahead of the 1940 migration and 15 days earlier than the average. The 1941 movement started when approximately 7.0 percent of the beets were thinned and reached a magnitude of 734 leafhoppers, per 100 square-foot samples, on May 23, when thinning was at its peak. Of these incoming insects 61.1 percent were viruliferous. The time of the initial migration is not so important as the magnitude and rate,

[8]Unpublished data by Albert M. Murphy, Bureau of Plant Industry.

especially if larger numbers enter the fields early. The spring migration of large numbers in 1941 was over 17 days earlier than in 1940. Although inclement weather delayed the spring migration for about 17 days during the movement, the peak was reached 4 days earlier than in 1940, and 6 days ahead of the average peak. This early migration, coming as it did when the beets were at the most suspectible stage, was one of the major factors in creating the curly-top epidemic in Idaho during 1941. Tt is evident that, if weather conditions in Idaho in 1941 had not interfered with the spring migration, the peak of movement would have been much earlier and the curly-top epidemic evidently would have been much more serious.

In northern Utah the planting, thinning, and spring migration of beet leafhoppers occurred earlier in 1940 than in 1941. Even though the relative time elapshig between migration and thinning was approximately the same for both years, the magnitude of the beet-leafhopper population was much larger in 1940 than in 1941. The magnitude of the long-distance movement was 9.7 times larger in 1940 than in 1941. Owing to overlapping of the local and long-distance migrations, it is difficult to determine the exact size of the local movement. Records show, however, that the local movement was much larger in 1940 than in 1941. Thus, the magnitude of the migration in 1940 was more responsible for the outbreak in northern Utah than the time of its occurrence. In this section 44 percent more leafhoppers carried the virus in 1940 than in 1941. The percentage of leafhoppers carrying curly-top virus is evidently a factor in creating curly-top epidemics, especially since curly-top-resistant varieties acquire far more resistance as they advance in age than do the curly-top-susceptible varieties.

Records from the Twin Falls, Idaho, and Logan, Utah, laboratories show that the spring-breeding areas contributing beet leafhoppers to southern Idaho and northern Utah are entirely separate and independent of each other.

In southern Idaho the curly-top infection records showing the grade of severity disclose that 9.5 percent of the diseased beets were in grade 3 or higher during 1940 as compared with 52 percent in grade 3 or better during 1941. This indicates the severity of the curly-top epidemic in southern Idaho during 1941 as compared with the 1940 record.

The average beet yields in the affected area of southern Idaho for 1940 and 1941 were 16.82 and 8.97 tons per acre, respectively, or a difference of 7.85 tons per acre. The high yields produced in southern Idaho in 1940 evidently were influenced by late-season weather conditions. Above-normal temperature combined with excessive precipitation in September occurred at both Twin Falls, Idaho, and Corinne, Utah, during this year, while delayed killing frost prolonged the growing season until October 4 in both areas. In

southern Idaho during 1940 the curly-top infected plants were able to take advantage of this favorable growing weather and produce the highest average tonnage on record, but in the northern Utah area the intermediate curly-top-resistant variety was so severely damaged by curly top that it was unable to recover when more favorable growing conditions occurred. In northern Utah the average yield was about 40 percent higher in 1941 than in 1940,

Summary and Conclusions

Information presented in this paper shows that the seasonal temperatures for both southern Idaho and northern Utah were above normal for 1940 and 1941.

Excessive precipitation occurring in northern Utah in 1941 at the critical period in the development of the spring-generation leafhoppers reduced the populations of these insects below the level that was expected.

Curly-top-resistant varieties were planted extensively in southern Idaho and northern Utah in 1940 and in 1941.

There was little difference in the planting and thinning dates for the 2 seasons in the southern Idaho area, but the peaks of planting and thinning in the northern Utah area were about 6 days later in 1941 than in 1940.

In southern Idaho in 1940 the migration of the spring generation into the beet fields started on May 20, reaching the peak on June 17, when an average of 1,090 beet leafhoppers, per 100 square-foot samples, was recorded. In 1941 the initial spring movement occurred on May 12, reaching the peak on June 13, when an average of 1,496 leafhoppers was recorded in 100 square-foot samples.

In northern Utah the long-distance spring migration was 9.7 times larger in 1940 than in 1941. The local migration was also many times larger in 1940. These migrations occurred 19 and 10 days, respectively, earlier in 1940 than in 1941.

There were 25.3 percent more of viruliferous spring-generation leafhoppers in southern Idaho in 1941 than in the preceding year, whereas in northern Utah, 44.0 percent more of leafhoppers were carrying the virus in 1940 than in 1941.

In 1940 and 1941 a serious curly-top epidemic occurred in northern Utah and southern Idaho, respectively.

With improved curly-top-resistant varieties of sugar beets, serious epidemics of curly top are dependent upon several contributing factors: (1) Magnitude of the movement of spring-generation leafhoppers, (2) time of their movement into the beet fields, (3) percentage of leafhoppers carrying curly-top virus, (4) size and condition of beets at the time of infection, and (5) weather conditions.

A serious curly-top epidemic one season is no criterion that it will be followed by another epidemic during the succeeding season.