

Outbreaks of Beet Leafhoppers North and East of the Permanent Breeding Areas¹

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The occurrence of the beet leafhopper (*Circulifer tenellus* (Bak.)) in the sugar beet-producing areas of southwestern Kansas in 1953, together with the resulting curly top outbreak, has created considerable interest by the beet sugar industry in the leafhopper problem east of the Continental Divide.

The beet leafhopper was first recorded on sugar beets in 1895 by Gillett and Baker (1)³ at Grand Junction, Colorado. The insect was originally described by Baker (2) in 1896 as *Thaninotettix tenellus* from a single female taken at Las Cruces, New Mexico, on *Sisymbriu?n*, a species of mustard; he noted that "It is quite a common insect in various parts of Colorado and will undoubtedly be found widely distributed in the West." In 1909 Ball (3) wrote that this leafhopper had been collected from near Denver, Colorado, and south along the edge of the mountains through New Mexico. He stated, "It was taken at Fort Collins and Lamar, Colorado, in 1901—in one case 100 miles north of its known habitat, on wild plants and in the other an equal distance east, but was rare in both situations."

In 1908 Townsend (4) wrote that George G. Hedgecock of the Bureau of Plant Industry found distinct cases of curly top in garden beets in Nebraska more than 20 years previously, which would have been before 1888. In discussing the distribution of curly top, referred to as "curly leaf," in 1917, Ball (5) gave the following occurrence in the Colorado-Nebraska-Kansas region:

The Grand Island, Nebraska, factory started in 1890 and shipped beets from the northern Colorado districts until the Loveland factory was built in 1901. Hedgecock reports (in correspondence) that blight appeared in the Grand Island region in 1900 and again in 1901, in the latter year occurring over a wider area, but not so serious as at Grand Island the year previous.

The factory at Rocky Ford was built in 1900 and the next year a small amount of curly-leaf appeared in the Arkansas Valley region. In 1903 the disease was quite serious in the whole southern Colorado section, extending down into Kansas.

In 1908 curly-leaf started very early in the Arkansas Valley region and finally spread to include the entire Colorado-Nebraska-Kansas district, being very severe in the Arkansas Valley and lighter in the northern part of the state. The average production of the state was the lowest yet recorded.

In 1920 Lawson (6), in his study of the Cicadellidae of Kansas, reported the beet leafhopper from Clark County and remarked that it probably oc-

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³ Numbers in parentheses refer to literature cited.

curred in other southwestern counties. Scverin and Severin (7) reported curly top at Belle Fourche, South Dakota, during the summer of 1926, but did not collect any beet leaf hoppers. In 1927 Carter (8) reported the beet leafhopper and curly top from Billings, Bitterroot Valley, and Flathead Lake, Montana, and from Green River and Rock Springs, Wyoming.

Until 1953 the beet leafhopper had been reported only twice from east of the Mississippi River. DeLong (9) found it reproducing abundantly on sea purslane (*Sesuvium portulacastrum* L.) at Miami, Florida, in 1921. On October 6, 1936, he and Kadow (10) collected many specimens of this leafhopper from horseradish plants at Collinsville, Illinois, that were apparently infected with curly top. Since other leafhoppers were on the plants, the disease was not definitely identified but was later verified as curly top. On July 10, 1947, L. L. Dean of the Idaho Agricultural Experiment Station noted curly top in tomatoes at Lafayette, Indiana. These plants had been grown as seedlings in Moapa Valley, Nevada, and shipped to Indiana for transplanting. They could have been infected with curly top before shipping.

In 1953 Decker (11) reported that this leafhopper had been collected at several points in Illinois and that it was abundant in Madison County, and H. B. Petty reported collections in Champaign, Cook, Peoria, and St. Clair Counties. A. R. Downie reported finding curly top in sugar beets at Waseca, Minnesota, and Mason City, Iowa, in 1953, and the diseased plants were sent to N. J. Giddings (12), who confirmed their identification in his manuscript entitled "Curly Top Moves East." In 1953 R. M. Takeshita collected some sugar beet plants at Des Plaines, Illinois. They were sent to Dr. Giddings, who found one to be infected with curly top. C. A. Lavis reported an occasional curly top-diseased beet in exploratory trial plantings in Douglass, Geary, Riley, and Wyandotte Counties in eastern Kansas.

Breeding Areas

The only known breeding area of any size east of the Continental Divide is located in southern New Mexico and western Texas. Romney (13) concluded that the spring migrants from the permanent breeding areas in New Mexico and Texas infested the agricultural districts as far north as Alamosa and Lajunta, Colorado, and as far east as Hereford and Plainview, Texas. Figure 1 shows these breeding areas and other places east of the Continental Divide where beet leafhoppers or curly top have been reported.

Spring Migrations

Glick (14), who over a 5-year period in Louisiana collected insects in the upper air with an airplane at different elevations and at different times of day and night, took the six-spotted leafhopper (*Macrostelus divisus* (Uhl.) = *fascifrons* (Stal.)) from 20 to 13,000 feet, 85 percent of them in the daytime. He found temperature to be the most important factor regulating the density of insects in the air at any given time, but that their distribution and dispersal is influenced by the air currents. The direction of the wind affects the migration of insects, and convection and turbulence play an

important role in determining the insect population in the upper air. As the air becomes rougher, a greater proportion of the insects are found at the higher elevations. When insects are in calm air and caught in strong ascending and horizontal currents of air, they are carried upwards.

We know that beet leaf hoppers in flight come to the ground whenever the temperature becomes unfavorable. Those not landing on host plants will again take to the air when weather conditions become favorable. Leaf-hoppers are often forced down when they fly into air of low temperature.

The length of life of this insect without food is a factor in its long range migrations. Apparently airborne insects live longer than those near the ground. Harries and Douglass' (15) found the average life of unfed

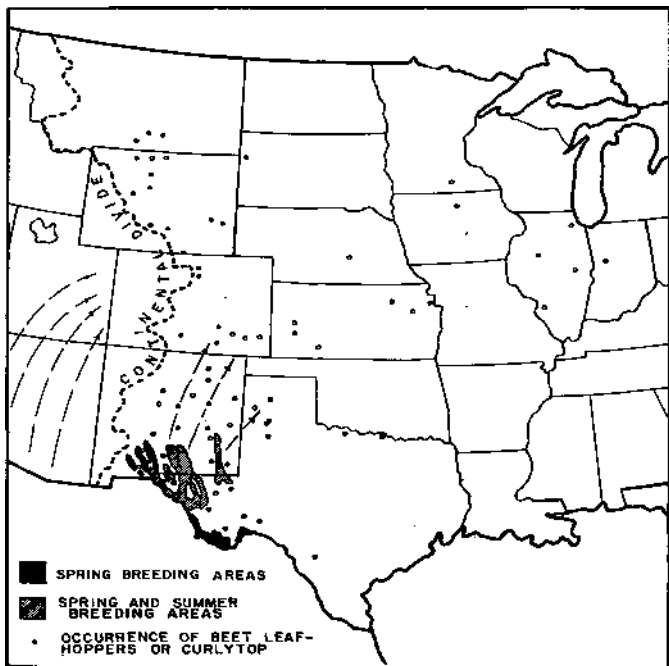


Figure 1.—Breeding areas in New Mexico and western Texas and occurrence of beet leaf hoppers or curly top east of the Continental Divide.

females in the laboratory at approximately 50 percent relative humidity to be about 1 day at 90° F. and 3 days at 60°. Elton (16) reported that large numbers of the aphid *Dilachmus picea* (Panzer) were found on fresh snow after a strong wind at Nordaust Landet, Vest Spitsbergen, and concluded that they must have been carried by the wind from the spruce forests of northern Europe, at least 800 miles.

During years of large beet leafhopper populations combined with an early migration of the spring generation in southern Idaho, curly top has appeared in sugar beet areas east of Idaho. The prevailing winds across the Snake River plains of southern Idaho are from west to east, and since this leafhopper moves with the wind, the migration should be eastward. In 1926 a heavy movement of spring migrants occurred in southern Idaho between May 3 and 6, which is 21 days earlier than the average initial movement. In correspondence, Asa C. Maxson⁴ wrote in 1940: "The first noticeable attack of curly top in Great Western territories occurred in the Wheatland, Wyoming, section in 1926. There has been no repetition of this outbreak in the Wheatland area since."

In 1934 a heavy spring migration of beet leafhoppers began in southern Idaho on April 27, the earliest on record. The first curly top epidemic occurred near Billings, Montana, in 1934. In 1941 a similar migration began on May 12, the earliest since 1934. Practically all the nonresistant sugar beets grown near Shell, Wyoming, in 1941 were affected by the disease late in the season. The leafhoppers which entered the area were able to produce a large population during the remainder of the season. Excessive precipitation fell in the Big Horn Basin that September and October, which was favorable for the early germination of the winter annual weed hosts. November and December were above normal in temperature, but January and February 1942 were below normal with an excess of precipitation. During this cold period the ground was covered with snow, which protected the leafhoppers from subzero temperatures, as shown by Douglass *et al.* (17).

March, April, and May were above normal in temperature and deficient in precipitation, which was favorable for leafhopper survival and for the early development of the spring generation. With the approach of spring, some of the overwintered leafhoppers moved into the beet fields, where they infected the young plants. These early cases of curly top served as infection centers from which the spring generation leafhoppers spread the disease to other plants. Low temperatures in June retarded curly top, but hot, dry weather in July and August stimulated its development. As the season advanced, curly top increased beyond expectations. There was some injury to sugar beets in the Big Horn Basin in 1943, but since that time this disease has not been of any economic importance.

Beet Leafhoppers and Curly Top In Billings, Montana, and Big Horn Basin, Wyoming

Spring studies were made in the Billings area from 1936 to 1941 and again in 1951 to determine the abundance and distribution of the over-

⁴ Formerly, with the Great Western Sugar Company and author of "Insects and diseases of the sugar beet."

wintered beet leaf hoppers. Their numbers varied in these years from 0 to 87 per 1,500 square-foot samples, which are low compared with the overwintered population in southern Idaho. These studies showed seven winter annuals on which this leafhopper can survive to produce a spring generation. Four of the most important summer hosts occur in the area. Although the number of spring and summer weed hosts is large, the acreages of these plants are small and often intermixed with nonhost grasses, which reduce their suitability for producing large numbers of leafhoppers.

The average annual precipitation for Billings is 14.38 inches, as compared with 9.81 at Twin Falls, Idaho. The normal precipitation at Billings for September and October is 2.62 inches, which is favorable for germination and fall growth of grasses. The April, May and June precipitation is 6.46 inches, which is favorable for the continued good growth of these grasses so that weed hosts on disturbed and overgrazed lands are replaced more rapidly than in southern Idaho, where the precipitation for the same period is 2.95 inches. This spring moisture promotes rank growth of annual weeds and thus reduces their suitability as hosts for the leafhoppers. The curly top injury to sugar beets at Billings persisted until 1941. The amount of injury caused by this disease varied from year to year and from locality to locality.

Studies conducted in the Big Horn Basin showed eight winter annuals which are spring hosts and five summer annuals which are hosts of this leafhopper. A total of 2, 45, 51, and 106 overwintered leafhoppers were found during the spring studies of 1943, 1944, 1945, and 1951. The number of square-foot samples taken ranged from 1,700 to 3,050 per year. Summer or fall studies made in 6 years showed low populations on summer weed hosts. The largest populations were found in a small patch of Russian thistle near Basin, Wyoming, on September 12, 1951, when 257 leafhoppers were recorded per square foot of weed host. Two small breeding areas were found near Basin and Shell in the Big Horn Basin, but no large host plant areas. The low annual rainfall is not favorable for the growth of the weed host plants in the desert area.

Curly Top in Other Areas

Curly top was reported on sugar beets in the Arkansas Valley of Colorado in 1901, 1903, 1908, 1926, 1928-31, 1933, 1937, 1938, 1945, and 1950-53, and in the San Luis Valley in 1928-31, 1933, 1939, 1940, 1943, 1945, 1947, 1950, and 1953. On September 22-23, 1927, Carter (18) made eight collections of leafhoppers in the Arkansas Valley of Colorado in locations where large populations would be expected from the presence of suitable host plants. Only a few beet leafhoppers were found at six of the locations.

Although curly top had previously been reported from the Arkansas Valley of Kansas, it was not until 1953 that serious curly top injury to sugar beets occurred. From our present knowledge of the breeding areas, the spring migrants which infected sugar beets in Illinois, Iowa, Kansas and Minnesota evidently came from southern New Mexico and western Texas. Reports from New Mexico show serious curly top injury to tomatoes in that state in 1953, which indicates a large leafhopper population. The

occurrence of the beet leafhopper or curly top over such a wide area in the middle west indicated an abnormally high movement of leafhoppers from their southwestern breeding grounds in 1953, but yearly that repetitions of such movements would be unlikely.

The writer visited the sugar beet-producing area of Kansas from September 12 to 14, 1953, and, with John R. Latta of the Garden City Company and others, made a study of that company's Garden City and Scott City territories. Few beet leafhoppers were found on either sugar beets or Russian thistle, although the incidence of curly top was high in most of the fields examined. In bionomic studies of the beet leafhopper, Harries and Douglass (15) have shown that the length of life of the adults decreased to a few days at temperatures above 110° F., that egg-laying begins to decrease above 90° and ceases in about 1 day at 115°, that mortality in both the egg and nymphal stages increases at high temperatures, and that the development of this insect is retarded at temperatures above 95°. The low population of beet leafhoppers found in southwestern Kansas in 1953 may have been the result of a long hot, dry period in the summer.

In a study of beet leafhopper populations on summer hosts in the San Joaquin Valley of California, W. C. Cook (unpublished data) from 1930 to 1940 found that the populations on Russian thistle decreased considerably from June to September because of the high temperatures of July and August. Although high temperature was detrimental for the leafhopper, it was very favorable for the development of curly top.

Precipitation is the most important single limiting factor in controlling the distribution of the beet leafhopper. The total precipitation at Garden City from April 1 to August 31 was 12.36 inches, which was unfavorable for the reproduction and development of the beet leafhopper in that area.

Curly top occurred in sugar beets in western Texas in 1906, 1930, 1931, 1938-40, 1943, and 1945-53. In the fall of 1935 spinach near Crystal City was severely injured. A study indicated that the leafhoppers from the breeding areas of western Texas moved southeastward into that area with storm winds during the fall. In 1953 Richardson (19) reported widespread infestations in tomatoes and canning beets in Zavala County. In the same year Dobson (20) reported early in July that 20 percent of the tomato fields in Lee County, New Mexico, had been plowed up because of curly top and that the beet leafhopper was continuing to invade tomato fields in several counties.

Large populations of beet leafhoppers and serious losses to curly top-susceptible crops occurred in southcentral Idaho in 1919, 1921, 1924, 1926, 1930, 1931, 1934, 1935, 1937, 1941, and 1947, and probably would have occurred in 1950 and 1953 if the most productive spring breeding areas had not been sprayed. Injurious populations occurred in 13 of the 34 years, but only twice did they occur in two consecutive years, which were in the early 30's. Therefore, a serious curly top epidemic in one season does not mean that there will be another one the succeeding season.

Curly top is common in various areas in New Mexico where sugar beets are grown, but the percentage of plants infected has varied from

year to year and from locality to locality. The nearest known permanent breeding areas of the beet leafhopper at this writing are in southern New Mexico and western Texas. Since the prevailing summer winds across the Arkansas Valley blow from the south or southeast and those across New Mexico from the west, southwest and south, the leafhoppers which move into the sugar beet areas of southern Colorado and Texas must come from these breeding areas.

On the eastern slope of the Rocky Mountains in northern Colorado, a small amount of curly top has been observed nearly every year since 1910. Evidently the center of the infection is near La Porte, west of Fort Collins. Probably a study of that area would show a small leafhopper-breeding area. In conversation Asa C. Maxson in 1942 stated that he believed that there was a small local breeding area in one of the canyons near Fort Collins. For several years there has been a light curly top infection near Wheatland, Wyoming, and there may be a small leafhopper-breeding area nearby.

A large spring population of the leafhoppers was produced in southern Idaho in 1937, but the spring movement was late. Early in September Russian-thistle patches growing near U. S. Highway 30 between Lava Hot Springs, Idaho, and Laramie, Wyoming, were sampled for leafhoppers. The first five samples were taken approximately every 12.5 miles and the remaining samples every 20 miles. Beet leafhoppers were found at every collecting point except just west of Laramie. The largest population in Wyoming, which averaged 2.8 leafhoppers per square foot of weed host, was found near Rock Springs. The population was low throughout eastern Idaho and southern Wyoming.

The beet leafhopper weed-host complex has changed in favor of the insect in many areas during the last 30 years, and there is more than a bare possibility that this leafhopper is becoming acclimated to new areas. Therefore, we must be prepared for major changes over a longer period of years.

Summary

The occurrence of beet leafhoppers (*Circulifer tenellus* (Bak.)) in the sugar beet producing areas of southwestern Kansas in 1953, with the resulting curly top outbreak, has created considerable interest by the beet sugar industry in the leafhopper problem east of the Continental Divide. From our present knowledge of their breeding areas, the leafhoppers which moved into the Kansas area were migrants from southern New Mexico and western Texas.

Outbreaks of economic importance also occurred at Billings, Montana, in 1934 and in the Big Horn Basin, Wyoming, in 1941. These areas were infested during the spring by long range migrations of this leafhopper from, apparently, the breeding areas of southern Idaho.

The occurrence of this insect or of curly top in areas far removed from the permanent breeding grounds shows that the beet leafhopper is a migratory insect which occasionally extends its normal range into areas where it cannot survive because of the climate. The occurrence of curly top out of its normal economic range during a certain season does not indicate that it will be followed by another epidemic during the succeeding one.

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