PLANT PATHOLOGY AND ENTOMOLOGY

Movement's of Spring-Generation Beet Leafhoppers Into Beet Fields of South-Central Idaho[1]

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Questions repeatedly asked about the spring movement of the beet leafhopper *(Eutettix tenellus* (Bak.)), the vector of the virus of curly top disease, from its spring-breeding host plants in the desert to the beet fields arc : (1) When does the movement start? (2) How long is the period of movement? (3) What is its magnitude? (4) At what time of the season do leafhoppers enter the cultivated fields?

In an endeavor to answer these questions the study of the movement of the beet leafhopper into cultivated fields was begun several years ago in south-central Iraho. Annand e*t al.* (1)[3] delt with the movements in 1930 and pointed out that the flight was not completed in a few days but was continuous. Hills (9) studied the movement of the spring generation in the central Columbia River breeding area for 1031-33 and concluded: "The leafhopper usually disperses from this breeding area between May 20 and June 30, movements being more or less continuous during this period." Douglass e*t al. (4),* working in southern Idaho, compared the spring movement of the leafhoppers into untreated experimental plots with the movement into commercial fields in 1937, and later *(5)* discussed the movements into cultivated fields in this area and in northern Utah during the seasons of 1940 and 1941. Fox e*t al.* (6) presented similar data for the period 1930-37, giving dates of initial movements, populations at intervals and at the peak, and the date on which the peak was reached. Movements of the beet leafhopper in southern Idaho are from local spring breeding areas and do not involve long-distance movements.

Small sugar beet plants are more susceptible to injury by curly top than are the larger plants. This holds true even for curly-top-resistant varieties, although they are less subject to injury than European varieties formerly grown (Giddings, 7). Hence the magnitude and

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[3]Italic numbers in parentheses refer to literature cited.

time of the spring movement of the leafhopper into beet fields are important factors in determining the extent of curly top epidemics. If the lessened injury to older plants and the wide-spread use of curly-top-resistant varieties are taken into account, large populations of the summer generations, which enter the beet fields later in the season, may be relatively unimportant.

Life History of **the Beet Leafhopper.**—In southern Idaho the beet leafhoppers pass the winter in the adult stage. Females are fertilized in the fall and live until spring, but 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 adults of the second, or summer, generation appear in July and the early part of August, and those of the third, or overwintering, generation in September or October. There is considerable overlapping of generations, especially during the summer and early in the fall. The sequence of host plants required for the development of this insect has been discussed by Carter *(2).* Cook *(3),* and Piemeisel and Chamberlin *(10).*

Methods of Investigation.—In order to determine the time and magnitude of the spring-generation movement of the beet leafhoppers into the cultivated area, six sugar beet fields on the western edge of the Twin Falls irrigated tract near Buhl and Castleford, Idaho, were selected for study each year from 1935 to 1944, inclusive. These fields were chosen because they are close to the spring breeding grounds that lie to the west of the cultivated area. The density of the leafhopper population decreases as the distance from the breeding grounds increases. In general the beet leafhopper moves with the wind, but occasionally, when the velocity is very low, the insect travels against the wind. Since the prevailing wind direction in the spring over the Snake River Plains is from the west, the movement is from the breeding grounds eastward up the Snake River Valley.. The tributary breeding grounds being warmer than the local areas, the spring immigrants begin to move into the beet fields before the local insects mature.

Leafhopper populations were determined by the method described by Hills (8), with the use of Hills' sampler, which traps the insects in circular areas containing 1 square foot. In unthinned fields the sampling areas were located at random on the rows of beet plants, but in thinned fields the sampler was placed over random plants. In practice, beet plants are usually thinned to about one plant per foot of row, A total of 100 sampling areas were examined **in** each field, except in heavily infested fields, where smaller members were used.

Most of the studies were begun in the first half of May but all of them several days in advance of the anticipated appearance of the

incoming spring leafhoppers, and they were continued until after the peak of infestation was reached. During most seasons the fields were examined every 2 or 3 days, but occasionally weather conditions interfered and the intervals between examinations were longer.

The appearance of males in the beet fields is an excellent criterion of the start of the spring movement, and since 1937 it has been used in these studies to mark the beginning of the movement. Females cannot be used satisfactorily for this purpose, because when the weather is cool during the latter part of the nymphal period, dark-colored forms similar to overwintered individuals are produced.

To determine how long overwintered females were present in beet fields, all beet leafhoppers collected in 1939 were brought to the laboratory for examination. The overwintered forms were distinguished from the spring generation by their coloration, as described by Severin *(11),* and by general appearance. The peak of overwintered population was recorded on May 3, and was followed by a gradual decrease. In 1939 overwintered females were present in beet fields from April 17 to June 21, or over a period of 65 days. April 2 was the earliest date that overwintered females were found in beet fields during the 30-year period.

The term "winter annuals" in this paper refers to weeds, chiefly mustards. The more important are flixweed *(Descurainia sophia* (L.) Prantl), green tansymustard *(D. pinnata* spp. *filipes* (A.Gray) Detling), perfoliate peppergrass *(Lepidium perfoliatum* L.), and tumblemustard *(Sisymbrium altissimn L.).* Under favorable conditions the seeds of these weeds usually germinate in the fall. The young plants develop small rosettes of leaves, remain alive throughout the winter, and complete their growth the following spring.

Spring Movement.—Some beet leafhoppers overwinter on winter annuals found growing in patches along canal banks, fence rows, railroads, roadsides, in fields and overgrazed pastures, and on idle, reverted, and waste lands within and adjoining the cultivated areas. The spring generation develops on Aveed host plants in the breeding areas, and then the adults disperse to summer hosts; therefore, the progress of this movement coincides with the maturation of the insect. Charts were prepared to illustrate this movement into beet fields each spring during the period of study. The charts for 1935, 1937, 1938, 1940, and 1941 are presented in this paper. The populations.in the other years were low, and charts are not shown for them, since the spring movement followed the same general pattern as in 1940.

There were a few beet leafhoppers in the fields when the first samples were taken in May of the years 1935, 1937, 1940, and 19.41.

These were overwintered females that had moved into the sugar beet fields, either from weed-host patches nearby or from the desert breeding grounds, soon after the beet plants appeared above ground. The highest population of overwintered females found during the period of this study was recorded in June 1938.

Wallace and Murphy *(12)* have shown that overwintered beet leafhoppers are very important in starting new curly top infection centers. The overwintered viruliferous females infect a small percentage of the plants throughout the Fields, from which the virus is spread to other plants by the incoming spring generation.

Table 1 shows the dates of the initial spring movement, the dates on which the highest populations were recorded, the period between each initial movement and its peak, and the density of the leafhopper populations for the 10-year period.

It is impossible to determine the period between the peak and the end of the spring movement, since there is no practical method of distinguishing incoming leafhoppers from those already Ihere and from those that develop from eggs deposited in beets by overwintered females. The decrease in population after the peak is reached is due to a redistribution of the leafhoppers and to natural mortality. It is safe to assume that this period extends over 2 to 3 weeks, depending on the season. The magnitude and rate of movement may also vary, depending on the cardinal factors governing the reproduction, maturation, and activity of the leafhopper. These factors are host-plant conditions, temperature, moisture, and. during movement, other weather conditions.

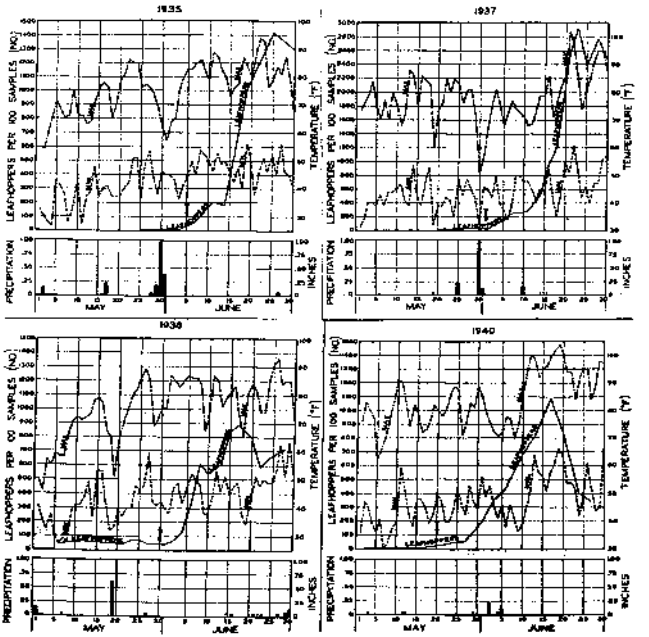
Table 1.—Beet leafhopper movements into six representative beet fields of the Buhi-Castleford area during the seasons of 1935-44.

Year	Date of spring movement		Time required to reach peak	Average population per 100 samples at peak
	Initial	Peak		
1935	June 5	June 25		1,416
1936	May 25	June 29		232
1937	Juno 2	June 23		2,939
1938	May 30	June 17		889
1939	May 17	June 14		85
1940	May 20	June' 17		1,089
1941	May 12	June 13		1,496
1942	June 1	June 29		169
1943	May 26	July 7		79
1944	May 15	July 10		270
Average	May 25	June 24		

Discussion

The chart for 1935 shows that in that year a few beet leafhoppers were in the fields in May before the spring movement began. These were the overwintered females discussed earlier in this article. Each year the population in the fields remained low for a few days after the movement of the spring generation began, and then the rate of movement gradually increased until the peak of population was reached. After the peak was reached the rate of movement decreased gradually.

Meteorological conditions affect the flight activity of the beet leafhopper. From information at hand the writers have attempted to determine what some of these conditions are. The infestation curve



Spring movement of beet leafhoppers into beet fields as related to the temperature and precipitation, Buhl and Castleford, Idaho. Arrows point to the dates the first spring-generation leafhoppers appeared in the fields.

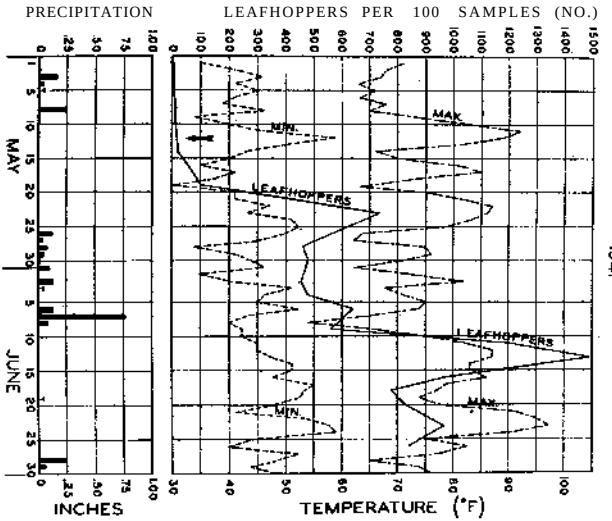
for 1935 is not always smooth, and at intervals decreases in population were recorded. These decreases are readily understood, because cool, cloudy, rainy, and windy weather affects the activity of this leafhopper and may also affect the accuracy of the counts. During adverse weather leafhoppers hide under clods and trash and between beet-leaf petioles, where they are often overlooked. Population counts are often made in fields that are being cultivated, but such counts are less satisfactory than those made in areas that are not being disturbed. Observations have shown that during light sprinkles of rain in warm weather the leafhoppers are not confined to the beet plants but are found scattered throughout the field.

Unfavorable weather affects not only the accuracy of the population counts but also the movement of the leafhopper from the breeding grounds into the cultivated area. A good example is presented in the chart for 1941. The spring movement started on May 12 in that year. There was a gradual increase in the rate of movement until May 23, when an average of 734 leafhoppers per 100 samples was recorded. The population decreased during the period of rainy weather and low temperature from May 24 to June 3. No precipitation occurred on June 4 and 5 and a slight increase in population was recorded on June G. After further precipitation on June (i, 7, and 8 the population again was reduced on June 9. This rainy period evidently caused some mortality of leafhoppers in beet fields and was distinctly unfavorable for movements of the insects. During this period an accumulation of adult leafhoppers was noted on spring hosts in the breeding grounds, which is a rare occurrence. Immediately following the period of inclement weather the population increased to the peak on June 13.

The charts show a tendency for the population to decrease when the maximum temperature for the day was 74° F. or below. In some years there were exceptions, but it appears that counts were not made on those days. This tendency indicates that leafhopper flights took place on days when the maximum temperature was above 75°, but this is not the minimum threshold of flight[4].

The population curves show that during the periods when spring-generation leafhoppers are moving there are times when the rate of movement is great. The curves also show that some of the movements were continuous for several days, as from June 14 to 23, 1937, when 83 percent of the incoming leafhoppers moved into the cultivated area in 9 days. There were also heavy flights of short duration, such as occurred from June 4 to 8, 1938, and from June 9 to 11, 1941, when 52 and 44 percent of the incoming leafhoppers entered the fields

[4]F. R. Lawson, J. C. Chamberlain, and G. York. Unpublished manuscript.



Spring movement of beet leafhoppers into beet fields as related to the temperature and precipitation. Buhl and Castleford, Idaho. Arrows point to the dates the first spring-generation leafhoppers appeared in the fields.

in 4 and 2 days, respectively. During years of comparatively high populations most of the incoming leafhoppers entered the beet fields during periods of intensive movement. In 1935, 1987, 1940, and 1941 most of the leafhoppers entered the fields during continuous movements extending over several days, and during these continuous movements there were periods when the rate was more intensive than at other times. For example, in 1935 during the 5-day period. June 15 to 19, 58 percent of the leafhoppers entered the fields, as compared with 29 percent for the 6-day period immediately following, and in 1937 during the 3-day period June 19 to 21, 45 percent of the leafhoppers entered the fields, as compared with 25 percent during the preceding 4-day period, and 13 percent for the 2-day period immediately following the period of intensive movement.

Data on wind direction and velocity, obtained by means of self-recording instruments located at Twin Falls, were studied during the periods of intensive leafhopper movements. The prevailing wind during these periods was from the west and the northwest. No correlation

was shown between the velocity of the wind and the leafhopper movements, because population counts were not made often enough.

Summary

Questions repeatedly asked about the spring movement of the beet leafhopper, the vector of the virus of curly top disease, from its spring-breeding host plants in the desert to the beet fields are: (1) When does the movement start? (2) How long is the period of movement? (3) What is its magnitude? (4) At what time of the season do leafhoppers enter the cultivated fields? In an endeavor to answer these questions the study of the movement of the beet leafhopper into cultivated fields was begun several years ago in south-central Idaho. Various authors have published on the movement in different years.

Leafhopper populations were determined with the use of the Hills' sampler, which traps the insects in a circular area containing 1 square foot. Both unthinned and thinned beet fields were sampled, the samples being taken at random.

Upon reaching maturity adult beet leafhoppers of the spring generation disperse to their summer hosts, and the progress of this movement coincides with the maturation of the insect. The date of the initial spring movements in southern Idaho has ranged from May 12 to June 5, with May 25 as the average for the 1935-44 period. The date for the peak of movement has ranged from June 13 to July 10, with June 24 as the average. The period between the initial movement and its peak has ranged from 18 to 56 days, with 31 days as the average. The magnitude of the population at its peak has ranged from 79 adults per 100 square feet in 1939 to 2,939 in 1937, with an average of 866, or 8.7 leafhoppers per beet. Adverse meteorological conditions affect flight after the movement has started and also affect the accuracy of population counts.

Leafhopper flights took place on days when the temperature was above 75° F., but this is not the minimum threshold of flight.

Most of the incoming beet leafhoppers entered the cultivated areas during continuous movements over a period of several days or during heavy flights of short duration. During these continuous movements there were times when the rate was higher than at other times.

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