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A Study of the Spotted Alfalfa Aphid and the Potato leafhopper and Their Abundance in Relation to Certain Climatic Condition in Five Specific Areas in South Dakota

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A STUDY OF THE SPOTTED ALFALFA APHID AND THE POTATO LEAFHOPPER AND THEIR ABUNDANCE IN RELATION TO CERTAIN CLIMATIC CONDITION IN FIVE SPECIFIC AREAS OF SOUTH DAKOTA

By

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A STUDY OF THE SPOTTED ALFALFA APHID AND THE POTATO LEAFHOPPER AND THEIR ABUNDANCE IN RELATION TO CERTAIN CLIMATIC CONDITIONS IN FIVE SPECIFIC AREAS OF SOUTH DAKOTA

This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

The movement of the economically important spotted alfalfa aphid, *Therioaphis maculata* (Buckton), into South Dakota in August of 1956 provided the basis for an ecological study of this insect during the growing season of 1957.

Because of the uncertainty of the aphid's reappearance in such northern areas as South Dakota, it was decided to outline a thesis study program to include a study of the potato leafhopper, *Empoasca fabae* (Harris). Many of the habits of the potato leafhopper correspond with the habits of the spotted alfalfa aphid. There are also considerable differences in the activities of these two insects. The potato leafhopper is also an important pest of alfalfa. The appearance of the leafhopper in the study area has been shown to be an annual occurrence.

Ecological studies pertaining to the spotted alfalfa aphid and the potato leafhopper were conducted in four specific areas of four southeastern counties of South Dakota. Simultaneous studies were conducted on the East Dairy Farm and the Agronomy Farm of South Dakota State College.

The objectives of this ecological study were to discover, if possible, how temperature, wind, humidity and barometric pressures affect the abundance of the spotted alfalfa aphid and the potato leafhopper. To aid in these studies, an electric light trap was erected in the area of the irrigated legume grazing plots on the East Dairy Farm to collect certain night-flying insects. Emphasis was placed on the spotted alfalfa aphid and the potato leafhopper populations.

To facilitate in the orientation of this project, the introduction is further sub-divided into two catagories.

SPOTTED ALFALFA APHID.— One of the outstanding biological phenomena of the past 30 years has been the sudden and nearly complete drying out of alfalfa in the south-central and south-western parts of the United States. This near catastrophy of alfalfa has been attributed to the introduction of the spotted alfalfa aphid into the United States.

The sudden appearance of this insect on alfalfa has once again emphasized the value of alfalfa as a agricultural crop.

Interest in the spotted alfalfa aphid on this continent dates from 1954 when the aphid was first found in New Mexico. By the end of 1954, the spotted alfalfa aphid had spread into California, Nevada, Colorado, and Oklahoma where it destroyed vast acres of alfalfa. As of January 1, 1957, the aphid had been found in 30 states including South Dakota. See figure 1. Many scientists, such as Dickson of California and Dieter-dorf of Oklahoma, have described the spotted alfalfa aphid as having shown the fastest rate of spread of any insect ever introduced into the United States.

The appearance of the spotted alfalfa aphid has forcefully and abruptly called to the attention of entomologists and others concerned with alfalfa production the need for basic research regarding the characteristics of this economic pest of alfalfa. That this need can not be emphasized too much is evidenced by the aphid's ability to spread so rapidly and the potential damage that the aphid can do to alfalfa.

Early spotted alfalfa aphid investigations conducted in the southcentral and southwestern United States were aimed at determining the characteristics and habits of the aphid, the results of which were used as a basis for establishing control methods. Chemical control programs were given priority because of the immediate need for an effective control measure.

While researchers in the heavily infested areas were concentrating their efforts on chemical control, researchers in the areas of lesser known concentrations initiated studies relating to the basic ecology of the aphid. With additional information of this type available, entomologists will be better able to relate how far north the aphid can overwinter, how varying climatic conditions will affect the seasonal abundance of the aphid, and at what particular time during the growing season the aphid can be expected to make its appearance.

The purpose of the portion of this paper pertaining to the spotted alfalfa aphid is to present the results of an ecological study dealing with the distribution and seasonal abundance of the insect. This study was conducted in four specific areas of four southeastern counties of South Dakota. Observations included the varying weather conditions and their effect on the aphid.

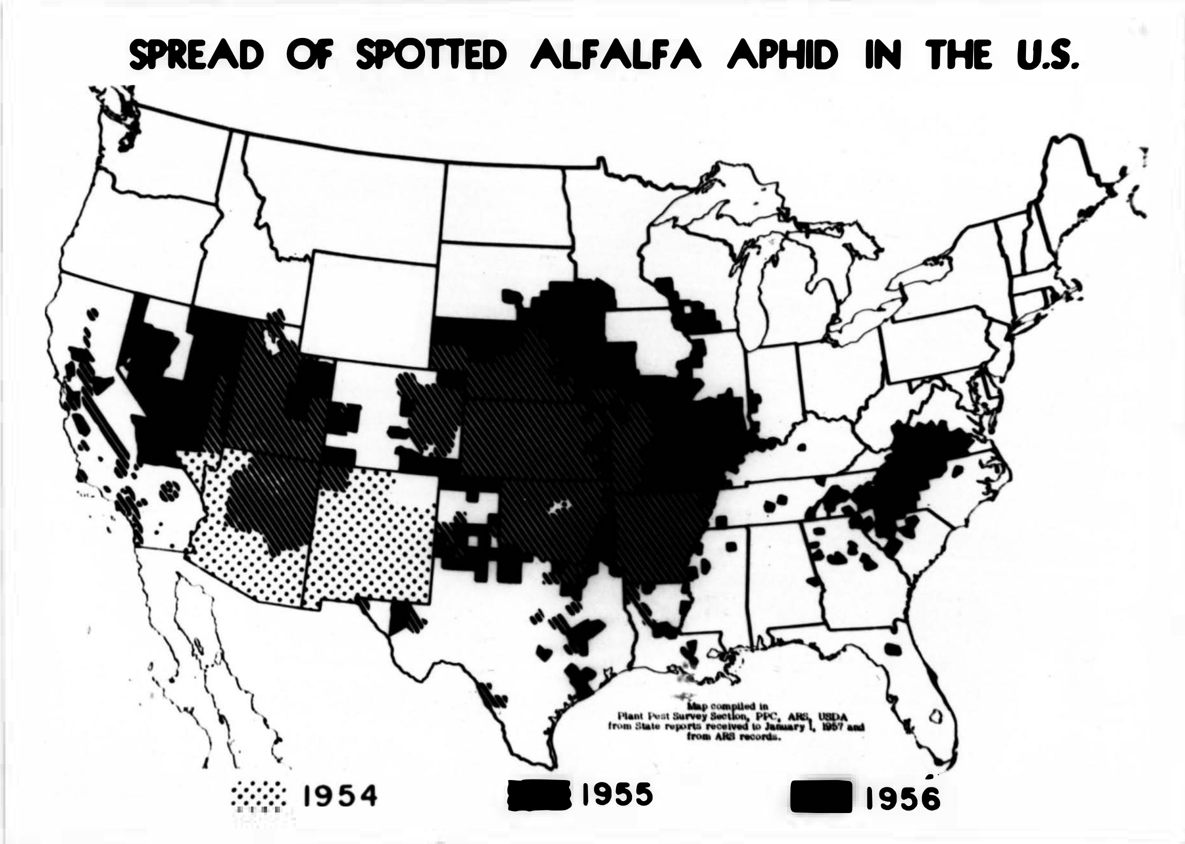

Figure 1.—— A map of the United States showing the areas inhabited by the spotted alfalfa aphid, as well as the spread of this insect for the years 1954, 1955, and 1956.

POTATO LEAFHOPPER.--- Entomologically speaking, the potato leafhopper, _Empoasca fabae_ (Harris), has been in the news for many decades. The leafhopper's first important appearance as a economic pest was in the summer of 1916. It was in this particular year that E. D. Ball of the University of Wisconsin associated the leafhopper with the potato injury called tipburn. Ball also suspected the potato leafhopper of causing similar damage to alfalfa. The first authentic report of the potato leafhopper causing damage to alfalfa came from R. A. Blanchard in 1929 in California. Mr. Blanchard reported that the _E. fabae_ was responsible for a yellowing and a dwarfing of alfalfa in his laboratory plat. This yellowing was later termed alfalfa yellow.

This invasion of the potato leafhopper into the potato fields of northern United States in 1918 caused much concern among the potato growers and scientists alike. Preliminary studies of this insect were begun at once.

The results of these early investigations were made and varied. This was especially true for life history studies. The majority of the workers assumed the potato leafhopper hibernated as an adult or an egg in the northern regions of the United States. Many of these conclusions, which were later found to be false, were derived from the fact that the adult potato leafhoppers were present in fields prior to killing frosts in the fall and during the early growing season in the spring. Green house hibernation studies also supported the fact that the potato leafhopper outwintered as an adult.

These erroneous conclusions were based on a hasty identification of the involved species at the time the studies were conducted.

Confusion of this type emphasizes how essential it is to know the correct identity of any species in order to ascertain its correct economic status.

Other preliminary studies conducted by DeLong and Poos, to mention only a few, did not support the above observations. These workers confirmed the fact that leafhoppers were present in the fields in April or early May. However, they found that the species of leafhopper involved was not the potato leafhopper. It was identified as *Empoasca maligna* (Walsh), a close relative of *Empoasca fabae*. DeLong and Poos also found *E. fabae* in the field, but this insect was never present before late May or early June.

Poos (1932) also made careful studies on hibernating leafhoppers but failed in his attempts to secure hibernating potato leafhoppers in his field cages. In view of the fact that no evidence could be obtained regarding a winter egg stage, Poos, DeLong, and others strongly favored the possibility that the insect passed the winter in a milder climate and migrated north.

Actual proof of the potato leafhopper migratory theory was not forthcoming until 1951 when entomologists of the North Central States, with the aid of entomologists in certain Southern States, voluntarily collected the needed data in a cooperative survey. One of the steps outlined by the North Central States was the need for quantitative collections of the potato leafhopper along with notes on temperature, wind, and other weather conditions present at the time of collections.

With these thoughts in mind, a study of this type was begun by this author on May 1, 1957, in those areas already discussed.

REVIEW OF LITERATURE

SPOTTED ALFALFA APHID.—— Insect ecological studies have been conducted for many years, however, prior to 1947, there had been very little information available regarding the attraction of aphids to light. It was generally believed that aphids were day-flying insects and that they did not respond to light. Broadbent (1947) was the first to reveal that aphids fly throughout the night and that they are freely attracted to lights. He also noted that wind during the day or evening affected aphid collections more than wind during the night. Corresponding collections were larger on windy nights than they were during windy days or evenings. These investigations, however, were conducted seven years before the spotted alfalfa aphid, *Therioaphis maculata* (Buckton), was first noticed on this continent. Very little is known about the spotted alfalfa aphid and its attraction to lights.

Smith (1952) indicated that wind currents in the atmosphere have a direct bearing on flying insects and their migrations.

The spotted alfalfa aphid was first noticed in the United States in New Mexico early in 1954. In the short space of three years, it has spread into 30 states of the United States (Davis, et al., 1957).

During this same period of time and in particular, 1953 to 1956, Frost and Pepper (1957) collected a total of 4390 aphids at light traps. It should be mentioned that these aphids were collected in areas in which the spotted alfalfa aphid had not yet appeared. Best collecting results were obtained by using low intensity 15 watt black fluorescent lights (Frost and Pepper, 1957).

In Oklahoma, Bieberdorf (1956) recovered spotted alfalfa aphids from the crown or debris area of alfalfa when temperatures were as low as 10 degrees Fahrenheit. Aphid activities at this temperature were very much restricted. Consequently mild winters and prevailing southernly winds seemed to favor the overwintering and spread of the insect the following spring. At temperature below 45 degrees Fahrenheit, growth and reproduction of the spotted alfalfa aphid ceased (Davis, et al., 1957). Frost and Pepper (1957) also indicated that spotted alfalfa aphid's activities became greatly reduced below 47 degrees Fahrenheit.

During the past few years spotted alfalfa aphid population trends have followed different seasonal patterns in the several climatic and geographical areas in which they are found. There seasonal variations are apparently a result of the interaction of climate, aphid reproduction, and predator populations. The climate, or more specifically the microclimate of the alfalfa field, directly affects the reproduction of the aphid (Davis, et.al., 1957).

Cooperative Economic Insect Reports indicate that spotted alfalfa aphid activities for the year 1957 commenced in the southeastern tip of South Dakota and then progessively worked northwest along the Missouri river and north along the South Dakota-Iowa border. The Survey Entomologist reported the aphid in Yankton county on May 27 (Anonymous, 1957).

Nielson and Barnes (1957) conducted life history studies of the spotted alfalfa aphid under Arizona climatic conditions. These individuals found the reproductive potential of this aphid to be greatest in the first 16 days of adult life. The number and rate at which the nymphs were produced were in close association with temperature variations.

POTATO LEAFHOPPER.—— The successful understanding of an insect is based on the biology of the insect or insects involved and of the various environmental factors that either favorably or unfavorably affect the species in question (Michelbacher, 1945).

Ball (1919) found that leafhopper outbreaks had occurred with little regard to temperature or moisture conditions and that the appearance of leafroll on potatoes had been entirely with reference to time of planting of the potatoes and the occurrence of the flights of the leafhopper, rather than to varieties or characteristic soil or moisture conditions.

During the 1920 growing season, Hartzell (1921) noted that the fore part of the season with its unusually low temperatures was unfavorable for the development of the leafhoppers. Other experiments conducted by Hartzell indicated that some of the females of the summer generation overwinter in the Ames, Iowa area. This conclusion was shown to be false by Ball (1934) as he proclaimed that there has been great confusion and misunderstanding with respect to the scientific and common names applied to three species of leafhoppers infesting apple and potato. Ball explained that Hartzell (1924) in his "The Genus _Empoasca_ in North America" followed Gillette in the use of color characters for the separation of species and also failed to recognize any of the earlier described injurious species. Ball found that the use of color characteristics was very unreliable when used exclusively.

Further ecological studies were also being conducted by Carter (1930) in the western part of the United States. Carter's studies, however, were primarily concerned with the beet leafhopper, but he did observe leafhoppers of other species. One phase of Carter's studies involved light trap collections of leafhoppers. It was learned from these studies that leafhoppers show a definite relationship between light intensity and phototropism.

DeLong (1931) indicated that at least 12 species of leafhoppers may become important pests of apple in one or more areas of the United States. They can be distinguished by color markings and male genital characters. The biology and overwintering stage will vary with the species. Some pass the winter as adults in hibernation and some as eggs in the plant tissue. The life cycle of Empoasca fabae (Harris) strongly indicates that this insect migrates north in the spring from its Gulf States breeding grounds.

In 1931 Pooe (1932) failed to find or rear the potato leafhopper during the winter and suggested that this leafhopper migrates north in the spring. He did observe the leafhopper to be present late in the fall even after killing frosts and then again as fertile females on alfalfa in the spring around May 10 and 16 each year. The leafhopper was observed as staying on the alfalfa until it was removed or until the alfalfa became too mature to be succulent.

Searls (1934) contends that the cutting of the alfalfa may be synchronized with the life cycle of the potato leafhopper so as to suppress leafhopper infestions. Searls goes on to say that properly timed cuttings will destroy a large part of the eggs and/or nymphs present in the field. Recommendations given by Searls indicate that the first cutting of alfalfa should be rather late in June (25th); this would rid the alfalfa of nymphal and egg stages which were laid sometime after June 13.

DeLong and Caldwell (1935) conducted investigations to support or disprove the fact that E. fabae passes the winter as an adult in northern regions. These workers searched for the potato leafhopper for eight consecutive years prior to releasing their conclusions. Their failure to find the potato leafhopper overwintering in the north led them to support the migration theory.

Frost (1953) in his research at Pennsylvania State College learned that when lights of equal wattages were compared the total light trap catches of insects were slightly greater at white lights of 100 watts. The Hemiptera and Cicadellidae (leafhoppers) responded more freely to black lights. The term black light is used to refer to lights that are almost invisible to man.

Frost went on to say that many species of Cicadellidae were taken, but E. fabae predominated throughout July. Frost concluded that black light is not superior to white lamps in collecting most insects (excluding Lepidoptera); however, black lights might be used advantageously in areas where bright lights are objectionable.

The taxonomy of the leafhopper was not clearly known until DeLong (1931) studied the male genitalia. A proper knowledge of the species enabled DeLong to point out that no authentic records of

E. fabae overwintering in northern states were available (Medler, 1957).

Although Ball, DeLong and others had reported that *E. fabae* did not overwinter in the northern United States, the proof of a definite seasonal migration of this insect was not forthcoming until entomologists in the North Central States with the aid of entomologists in certain Southern States voluntarily collected the needed data in a cooperative survey over the years of 1951 to 1954 (Medler, 1957).

MATERIALS AND METHODS

This study of some of the ecological aspects of the spotted alfalfa aphid and the potato leafhopper involved several factors. These were the use of a light trap, the analysis of field populations of the two insects, and the observation of caged specimens of the aphid. These will be discussed in that order.

LIGHT TRAP INVESTIGATIONS.—— The insect light trap used in this study is known as a Turntable or Multiple Type Light Trap (Granovsky, 1947). This light trap is distinguished by having a rotating turntable which exposes nine collecting jars under the receiving funnel for a period of one hour each. The attracting device of this trap consists of a standard 15 inch, 15 watt black light (Bl.) fluorescent bulb radiating energy around 3500 Angstroms. This type of light is nearly invisible to man. With a light trap of this type operating between the hours of 8 P.M. and 4 A.M. June 1, 1957 through October 31, 1957, spotted alfalfa aphid and potato leafhopper attraction to this light was tabulated. A diagrammatic section through the light trap is shown in figure 2.

Certain deviations from Granovsky's trap facilitated these studies. Briefly, they were the addition of eight galvanized metal channel bars fastened to the upper surface of the receiving funnel and to the underside of the funnel hood at right angles to the fluorescent bulb. This assured the baffles of remaining in their proper positions during high winds. The shaft upon which the turntable was mounted was screw threaded half its entire length so that the distance between the lip

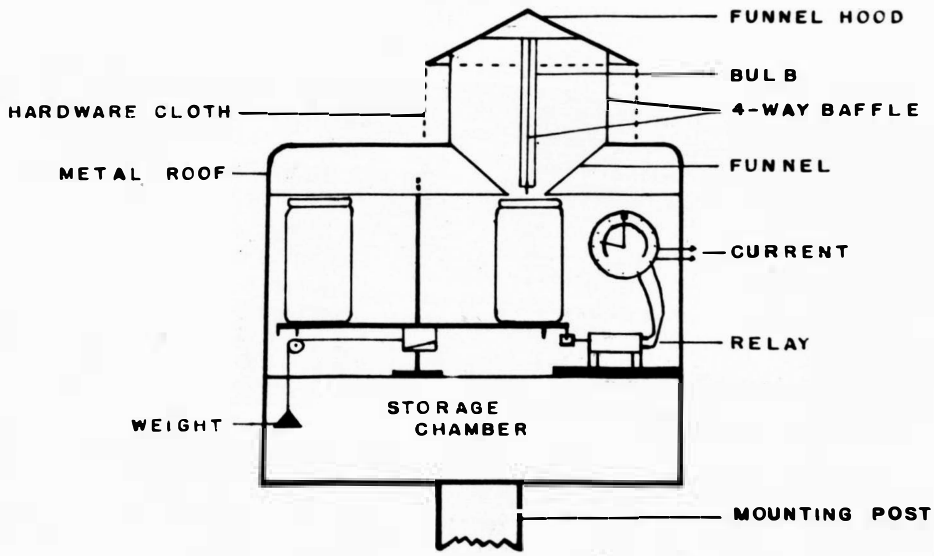

Figure 2.—— A diagrammatic section drawing showing the multiple-type light trap used in population studies of the spotted alfalfa aphid and the potato leafhopper on the South Dakota State College East Dairy Farm, Brookings, South Dakota, 1957.

of the collecting jar and the opening of the receiving funnel could be more precisely regulated. Hardware cloth with one-eigth inch mesh was erected around the attracting light and the baffles. A screen of this type was used to prevent the larger insects from entering the receiving funnel. These were excluded to eliminate possible damage to the spotted alfalfa aphid and potato leafhopper collections.

The light trap was erected on the legume grazing plots of the East Dairy Farm at South Dakota State College. The extreme height of the attracting light of the light trap was 87 inches above the surface of the ground. Each grazing plot consisted of approximately one acre. The exact measurements of the plots were 400 feet long by 101.2 feet wide. Sprinkler irrigation of these plots assured the alfalfa of receiving sufficient moisture to offset the effects of rotated grazing of the East Dairy Farm dairy herd. The combined effects of the irrigation and grazing seemed to stimulate plant growth. By rotating the dairy herd from grazing plot to grazing plot every seven or eight days, the height of the alfalfa was maintained at approximately 6 to 12 inches. This rather uniform height was desirable to sweep with the collecting net.

For these collections, a standard 15 inch insect collecting net was used. The bag of the net was constructed of muslin cloth. The muslin used for these studies was dyed black to facilitate finding the cream colored spotted alfalfa aphid and the yellow potato leafhopper.

In making a collection, the collector walked in an arbitrary straight line, swinging the collecting net before him through the alfalfa. One sweep refers to the movement of the net through one 180 degree arc. The height of the collecting net was maintained at approximately 2 to 3 inches above the ground. The swinging of the net was coordinated with the collector's normal pace through the alfalfa.

Insect collections from the grazing plots were taken beginning May 1, 1957, and were continued Monday through Friday until October 31, 1957. These collections were made in the five grazing plots surrounding the light trap. Sampling of the population in each of the five plots consisted of taking 20 random sweeps. Each daily collection consisted of the insects from 100 sweeps. The contents of the collecting net for each plot were emptied into a separate cyanide killing jar. Insects from each daily collection were then emptied into one receptacle and labelled for time, date and location. Weather data pertaining to each day's collection were obtained from the graphs of weather recording instruments housed in a louvered chamber 100 feet from the light trap.

FIELD POPULATION INVESTIGATIONS.--- Similar sweeping procedures and field observations were also begun May 1, 1957, on four alfalfa fields located in Yankton, Bon Homme, Charles Mix and Gregory counties in southeastern South Dakota. The exact location of these fields is as follows:

Field 1 - Seven miles west of Yankton, South Dakota, on highway 50. (Yankton county)

Field 2 - Three miles west of Tyndall, South Dakota on highway 50. (Bon Homme county)

Field 3 - Five miles east of Wagner, South Dakota, on highway 50. (Charles Mix county)

Field 4 - Six and one-half miles west of Picketown, South Dakota on highway 50. (Gregory county)

Insect collections during May in these regions varied somewhat from the standard procedure mentioned above. Early collecting efforts were concentrated near fence rows, weedy and brush areas, especially willow, lining the edge of the alfalfa, as well as the alfalfa field. By sweeping these outlying sections and the alfalfa, it was possible to determine which areas were visited first by the investigated insects.

Sweeping operations in the southern study area were completed October 28, 1957. It should be noted, however, that the results of these collections were tabulated only to October 14, even though the aphid and the leafhopper continued to be present in the fields until October 28. Collections following October 14 were heavily contaminated with weed seeds which made the accuracy of the counts for both insects questionable. Therefore, these results were omitted from the graphs but are included in the appendix. See table 19.

Another field observation completed in the southern study area included the taking of soil samples. These samples were taken November 4 and were analyzed by the South Dakota State College Soils Laboratory the following month.

REARING CAGE INVESTIGATIONS.—— These ecological studies included the cage rearing of the spotted alfalfa aphid. This study was confined to a field of randomly planted plots of alfalfa varieties on the Agronomy Farm at South Dakota State College. Here an attempt was made to plot the life cycle and the reproductive ability of this insect under climatic conditions found in eastcentral South Dakota between July 8 and October 26.

To do this, two and seven-eighths by one and three-sixteenth by one inch clear Polystyrene plastic boxes were converted to insect rearing cages by cutting one-half inch holes in the top and bottom of each box. These holes were covered with Lumite woven saran fabric No. 1032-000 to prevent the escape of the aphid and at the same time admit ventilation. Before the aphids were placed in the rearing cages, they were examined under a binocular microscope to determine their maturity. These determinations were based on the degree of development of the spots found on the dorsal surface of the aphid as is shown in figure 3. This data, along with the date, was recorded for each insect upon its admittance to its respective cage. Each of these cages contained one fourth instar aphid and was attached to various areas of the alfalfa plants by passing a stem through a small notch on one or both ends of the cage. For example, one cage might have been attached to a lower trifoliate leaf while another cage might have a stem passing through it. The openings through which the alfalfa passed were sealed by wrapping cotton around the stem and then closing the rearing cage around the stem. This also prevented the escape of any aphids. Only one cage was attached to a plant. Daily examinations of these cages were necessary to plot the progress of each individual.

The initial population housed in the rearing cages was obtained by sweeping alfalfa fields in the Vermillion, South Dakota area. These aphids were transported to Brookings on a screen enclosed potted alfalfa plant. Further aphid brood stock was reared from one individual transferred from the field collection to a potted alfalfa plant in the laboratory.

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Figure 3.—— The first, second, third and fourth instar stages of the spotted alfalfa aphid, *Therioaphis maculata* (Buckton) on the alfalfa leaf.

Soil and air temperatures were obtained from a thermograph operating in the alfalfa field. The amount of precipitation and the wind direction were recorded in a louvered chamber located two blocks from the rearing cages.

RESULTS AND DISCUSSION

SPOTTED ALFALFA APHID.— The economically important spotted alfalfa aphid made another appearance into South Dakota in 1957. Its arrival into the state this year was much earlier than anticipated and suggests the possibility that this insect could someday build up to economic important numbers in this state whereby control measures must then be applied. Summer investigations of this insect were successful in that population curves were established in four specific southern areas.

Light Trap Investigations.— During the 1957 growing season, the spotted alfalfa aphid was not attracted to the light trap used in this study. And only once, August 16, was it found in the grazing plots surrounding the light trap.

Field Population Investigations.— Spotted alfalfa aphid activity in the southern study area was first noticed June 18, in Field 2. Aphid activity in Fields 1, 3, and 4 was first noticed on June 28 and 25 and July 12 respectively. After the initial population was present in all four study areas, it continued to be present throughout the remainder of the season until October 27. Aphid populations never reached economic proportions in which control measures had to be applied. On the whole, the activities of this insect varied from field to field; therefore, the results of each study field will be discussed separately except for a few details.

Checks for the spotted alfalfa aphid in Field 1 were negative until June 28, one month after its initial appearance in Yankton county and ten days after its appearance in Field 2. The early appearance of the aphid in Yankton county and the fields close to the study area, while remaining absent in Field 1, suggested that possibly the condition of Field 1 might have been responsible for the aphid's late appearance. Inquiries revealed that the field had a low supply of subsoil moisture going into the fall of 1956. Very little moisture fell during the winter and spring, and much of that which did fall was lost through excessive runoff. Consequently, the quality of the alfalfa in Field 1 in early June was excessively woody and spindly. The minimum average temperature for this field was 55.4 degrees Fahrenheit. This figure was compiled from a Weather Report furnished by the United States Corps of Engineers located three miles south of this field on the Missouri river. Low temperatures of this degree may have also had some effect on aphid reproduction potentials in this particular field. According to Frost and Pepper (1957) spotted alfalfa activities become greatly reduced below 47 degrees Fahrenheit.

The initial recovery of the aphid here averaged 0.06 insects per net sweep based on 100 net sweeps. Aphid populations during the next 30 days declined to 0.00 per sweep except for one collection when 0.02 aphids were taken and then began to increase on July 23. This figure was also based on 100 net sweeps. A population build-up to 4.10 aphids per sweep continued until September when this field was mowed. See figure 4. This mowing combined with lower temperatures resulted in a continuous drop in the aphid population during the remainder of the season. Alfalfa growth throughout September and October was slight and afforded very little protection for the aphid.

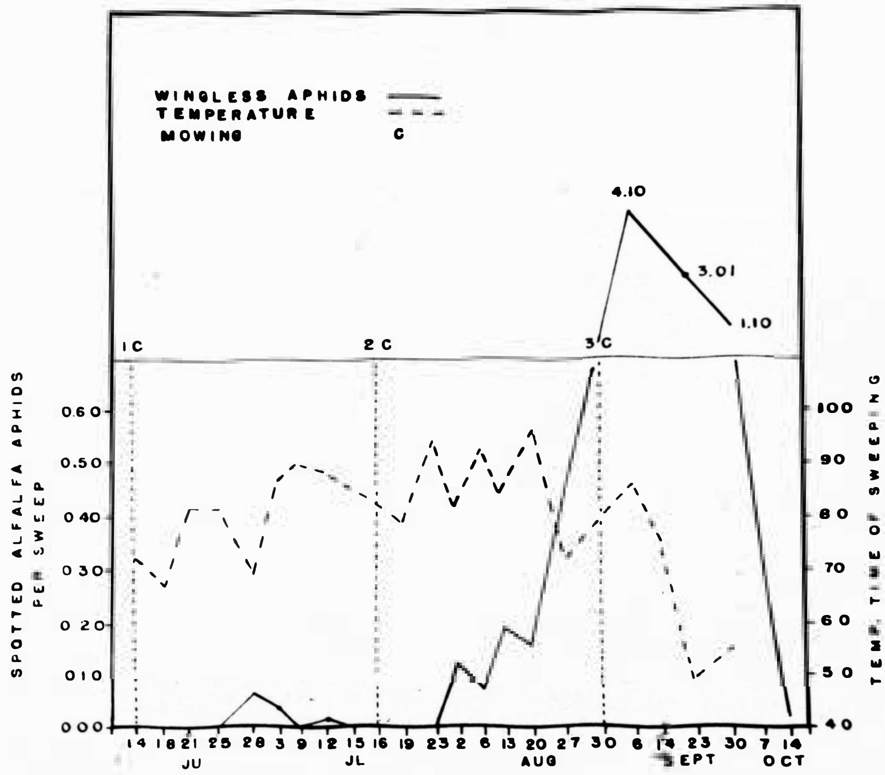

Figure 4.—— Spotted alfalfa aphid populations, based on 100 net sweeps, in Field 1 in southeastern South Dakota with temperatures recorded at collecting time. 1957.

Unusual climatic conditions prevailed in the immediate area of Field 2 during the 1957 growing season. This field received considerably more moisture than did any of the other three study areas. The topography of this field was rather flat and afforded no spring thaw run-off. This field was in excellent condition and produced succulent growth once temperatures were suitable. The condition of this field was never straggly or weedy during the entire growing season.

Aphids were first observed in this field on June 18. Population fluctuations remained about the same until July 12 when there was a slight increase to 0.05 aphids per sweep. For the next 30 days, aphid abundance was twice that of June, and then on August 20, a very sharp increase occurred raising the population to 1.01 per sweep. The aphid population continued to increase to a high of 4.10 per sweep on September 6. This increase paralleled a noticeable temperature increase. Later, as the temperature began to fall, the aphid population declined. This decrease in aphids was noted on the 11th of September, the same day the alfalfa was cut for the fourth time. Populations continued to drop until September 14 when the trend reversed itself. By September 28, the aphid population was near the peak it had reached on September 6. The remainder of the season found the population dwindling. See figure 5.

The exceptional condition of this field produced a heavy stand of alfalfa during the entire growing season. This prime growth shows up in the tabulated analysis of the population curve of the spotted alfalfa aphid in figure 5. The population trend in this field had a definite pattern. Prior to the third cutting, the population fell off and then began to build up shortly after haying operations were completed.

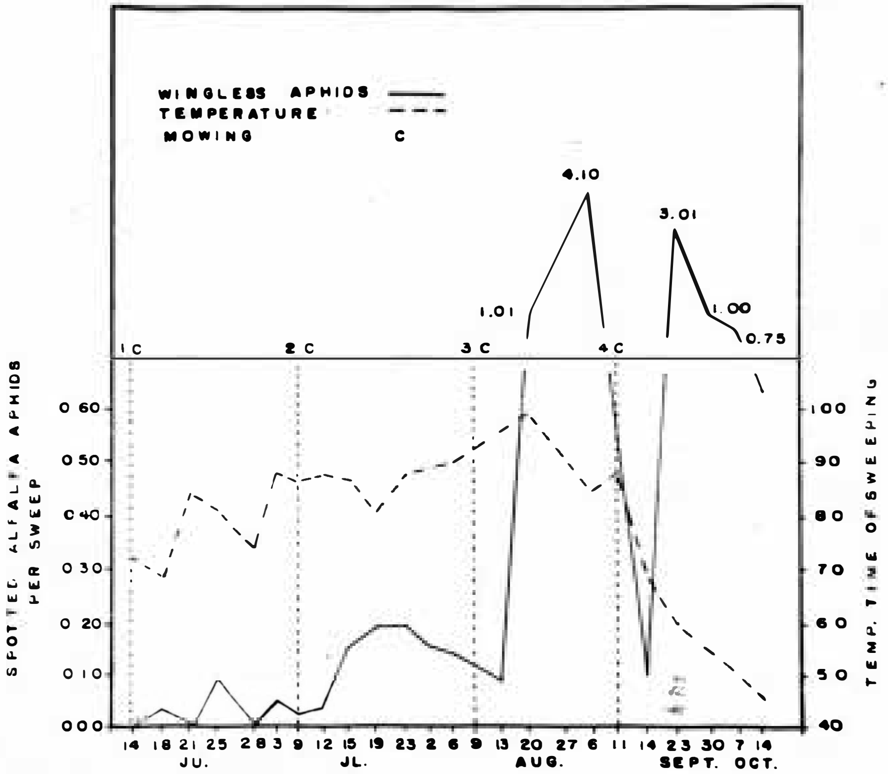

Figure 5.— Spotted alfalfa aphid populations based on 100 net sweeps, in Field 2 in southeastern South Dakota with temperatures recorded at collecting time. 1957.

Midway between each of the cuttings, a peak was reached and irregularly maintained, it seemed possible, that this apparent population decline on August 6 might have resulted from the inability of the collector to maintain his net at the base of the plants when sweeping. When alfalfa is tall and in a heavy stand, seldom is a collector successful in penetrating more than the upper 8 to 10 inches of a 20 to 28 inch plant with the sweep net. Collecting insects under these conditions decreases the possibility of collecting insects from the bottom two-thirds of the plant. Because a large proportion of the spotted alfalfa aphid population is found on the lower portions of alfalfa, the smaller number of aphids collected just before mowing is understandable.

The topography of Field 3 was similar to that of Field 1. They were both located on land that has a gravelly subsurface. Soil of this type requires frequent precipitation to remain productive. Like Field 1, Field 3 went into the dormant stage in 1956 with low subsoil moisture. This field did receive two early spring and summer showers amounting to a total of about three inches which stimulated rapid growth in the first cutting alfalfa.

The spotted alfalfa aphid was detected in this field on June 25, four days after the second cutting of alfalfa. Sweepings at this time were averaging 0.03 aphids per sweep. This average aphid count prevailed until July 23, and then on August 2, the average number of aphids per sweep rose to 2.04, then dropped off only to rise again after August 20. These fluctuations did not parallel any evident climatic change. See figure 6.

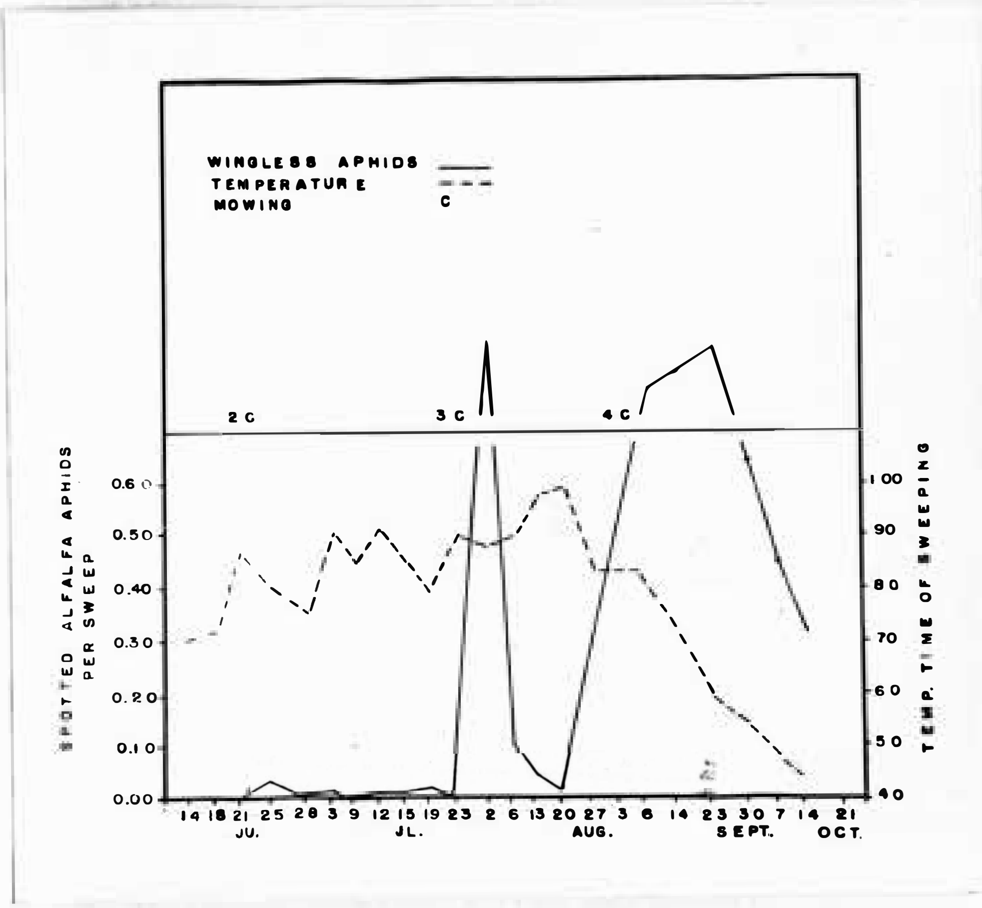

Figure 6.—— Spotted alfalfa aphid populations, based on 100 net sweeps, in Field 3 in southeastern South Dakota with temperatures recorded at collecting time. 1957.

As the summer continued the plants in this field began blooming when they were only 6 to 8 inches high. These stunted plants were quite woody and apparently undesirable to the aphid as evidenced by this insects decrease in population.

Ecological observations in Field 4 were almost at a minimum because of the late appearance, July 12, of the spotted alfalfa aphid. The only climatic factor that seems to have a bearing on the aphid population in this field was rain.

The alfalfa in this field was cut for the first time on June 14. During the next two days, one and one-half inches of rain fell on the mowed hay. This hay remained on the ground, drying for the next six days, and at the same time it prevented any appreciable growth of the underlying alfalfa. Approximately ten days after the hay was cut, it was bucked with a tractor into small stacks. This operation required three days. The activity of the farm equipment in the hayfield and the fact that the mowed hay remained on the ground so long may have been responsible for the delayed collection on the aphid in this field.

Even though the aphid was first found on July 12, the next three collecting dates revealed negative results. The next appearance of the aphid wasn't until August 2. The following 32 days found the aphid population increasing until it reached a peak of 10.10 aphids per sweep on September 6. With the onset of cooler weather, this peak fell to 1.01 aphids per sweep and then rose again to 3.05 aphids per sweep on September 23. The aphid population decreased continually during the remainder of the season. See figure 7.

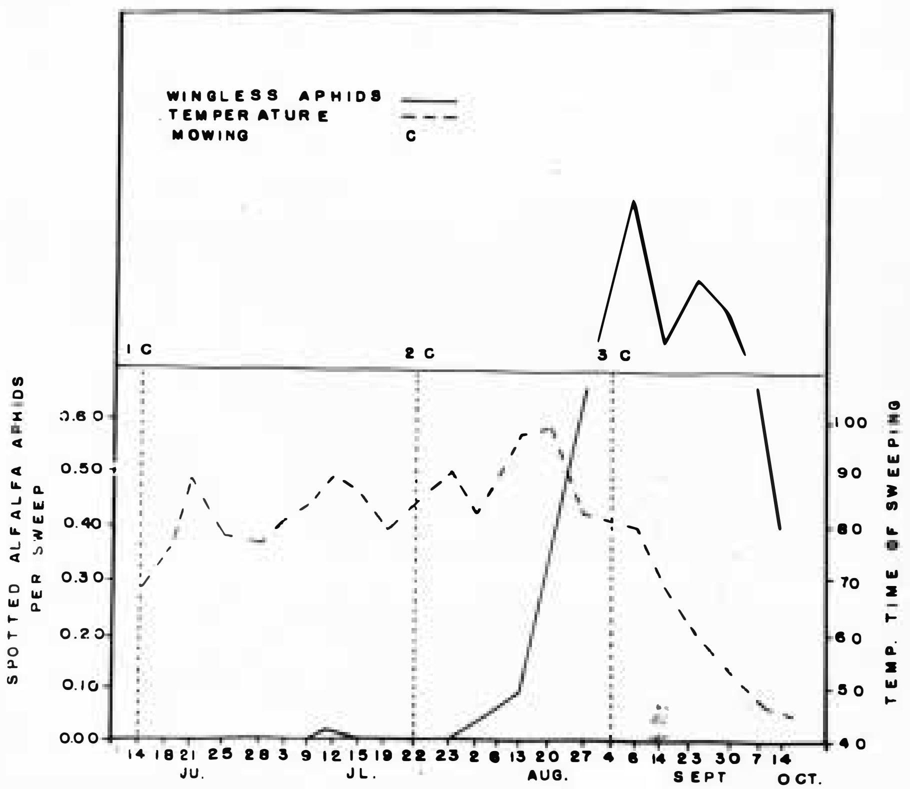

Figure 7.—— Spotted alfalfa aphid populations, based on 100 net sweeps, in Field 4 in southeastern South Dakota with temperatures recorded at collecting time. 1957.

Rearing Cage Investigations.—— Rearing cage studies of the spotted alfalfa aphid indicate that the aphid is capable of successful reproduction under summer climatic conditions found in the Brookings area. However, the rate at which the aphid reproduces seems to be affected by the variations in field temperatures. Other climatic factors may have also affected the aphid's reproduction, but observations at the site of the experimental cages failed to produce any other significant information.

The aphid reproduces by parthenogenesis and gives birth to living young. The number of young produced by these caged females varied from 15 to 75 individuals. These variations seemed to parallel temperature fluctuations.

In warm weather, with maximum temperatures between 85 and 95 degrees Fahrenheit, females produced a nymph every 7 to 8 hours. See tables 1 and 2. Almost 50 per cent of the nymphs produced in this temperature range failed to survive in the plastic cages.

The rate of reproduction gradually decreased with declining temperatures. Between maximum temperatures of 75 to 85 degrees Fahrenheit, young aphids appeared at approximately 11 hour intervals, and between maximum temperatures of 65 and 75 degrees Fahrenheit, nymphs appeared about every 21 hours. Reference is made to tables 3, 4, 5, and 6. Aphid reproduction below 65 degrees Fahrenheit was very low. See tables 7 and 8.

Table 1.—— Spotted alfalfa aphid cage tests for population potential, South Dakota State College Agronomy Farm, Brookings, South Dakota, July 8-31, 1957.

VARIETY	TOTAL POPULATION	AVERAGE PER DAY	MORTALITY	PER CENT MORTALITY
Ranger				
Cage 1.	60.0	2.6	26	43.3
Cage 2.	67.0	2.9	31	46.2
Cage 3.	61.0	2.6	30	49.1
Cage 4.	68.0	3.0	30	44.1
Cage 5.	63.0	2.7	28	44.4
Average	63.8	2.8	29	45.4
Buffalo				
Cage 1.	59.0	2.5	34	57.6
Cage 2.	65.0	2.8	34	52.3
Cage 3.	71.0	3.1	36	50.7
Cage 4.	79.0	3.4	37	52.1
Cage 5.	69.0	3.0	32	46.3
Average	68.8	3.0	35	51.8

Table 2.—— Weather data for spotted alfalfa aphid cage test area, South Dakota State College Agronomy Farm, Brookings, South Dakota, July 1957.

DATE	TEMPERATURE MAXIMUM	TEMPERATURE MINIMUM	PRECIPITATION
8.	83	63	0
9.	87	54	0
10.	90	60	0
11.	95	65	0
12.	95	66	0
13.	88	63	0
14.	89	60	0
15.	88	64	0
16.	90	67	0
17.	99	75	0
18.	100	69	0
19.	98	64	0
20.	90	64	0
21.	84	64	0
22.	85	56	.36
23.	86	57	0
24.	84	63	0
25.	82	63	0
26.	82	54	0
27.	92	64	0
28.	89	70	0
29.	91	65	0
30.	93	62	0
31.	92	63	0
Average	89.7	63.1	---
Total			.36

Table 3.—— Spotted alfalfa aphid cage tests for population potential, South Dakota State College Agronomy Farm, Brookings, South Dakota, August, 1957.

VARIETY	TOTAL POPULATION	AVERAGE PER DAY	MORTALITY	PER CENT MORTALITY
Ranger				
Cage 1.	77.0	2.5	34	44.5
Cage 2.	83.0	2.7	40	45.7
Cage 3.	86.0	2.8	42	48.8
Cage 4.	83.0	2.7	36	43.4
Cage 5.	77.0	2.5	34	44.1
Average	81.2	2.6	37	45.3
Buffalo				
Cage 1.	71.0	2.3	40	56.3
Cage 2.	74.0	2.4	38	51.3
Cage 3.	89.0	2.9	45	50.5
Cage 4.	96.0	3.1	47	48.9
Cage 5.	77.0	2.5	38	49.3
Average	81.4	2.2	41	51.2

Table 4.— Weather data for spotted alfalfa aphid cage test area, South Dakota State College Agronomy Farm, Brookings, South Dakota, August, 1957.

DAY OF WEEK	TEMPERATURE MAXIMUM	MINIMUM	PRECIPITATION
1.	98	62	0
2.	96	68	0
3.	83	59	.03
4.	76	49	0
5.	80	40	0
6.	88	57	0
7.	91	66	0
8.	86	65	.04
9.	82	63	.03
10.	88	51	0
11.	90	55	0
12.	93	60	0
13.	90	67	.22
14.	90	55	0
15.	88	53	0
16.	81	52	0
17.	80	55	.13
18.	76	48	.02
19.	82	42	0
20.	78	57	.16
21.	82	56	.17
22.	80	58	0
23.	74	58	.95
24.	76	45	0
25.	84	53	0
26.	80	49	0
27.	60	50	0
28.	61	51	.04
29.	72	54	0
30.	82	57	.11
31.	91	63	0
Average	82.4	55.4	---
Total			1.90

Table 5.—— Spotted alfalfa aphid cage tests for population potential, South Dakota State College Agronomy Farm, Brookings, South Dakota, September, 1957

VARIETY	TOTAL POPULATION	AVERAGE PER DAY	MORTALITY	PER CENT MORTALITY
Ranger				
Cage 1.	36.0	1.2	16	44.4
Cage 2.	30.0	1.0	13	43.3
Cage 3.	39.0	1.3	18	46.1
Cage 4.	33.0	1.1	14	42.4
Cage 5.	42.0	1.4	18	42.8
Average	36.0	1.2	15	43.8
Buffalo				
Cage 1.	39.0	1.3	19	48.7
Cage 2.	36.0	1.2	18	50.0
Cage 3.	39.0	1.3	17	43.6
Cage 4.	36.0	1.2	16	44.4
Cage 5.	42.0	1.4	19	45.2
Average	38.0	1.3	18	46.3

Table 6.—— Weather data for spotted alfalfa aphid cage test area, South Dakota State College Agronomy Farm, Brookings, South Dakota, September, 1957.

DAY OF WEEK	TEMPERATURE MAXIMUM	TEMPERATURE MINIMUM	PRECIPITATION
1.	85	64	.13
2.	73	55	0
3.	71	56	0
4.	72	48	0
5.	71	44	0
6.	72	39	0
7.	75	40	0
8.	78	46	0
9.	69	48	.36
10.	71	45	0
11.	76	40	0
12.	74	46	0
13.	66	32	0
14.	67	33	0
15.	66	40	0
16.	66	40	0
17.	64	31	0
18.	81	48	0
19.	75	53	.59
20.	68	28	0
21.	64	36	.11
22.	65	40	.09
23.	64	34	.07
24.	74	40	0
25.	74	35	0
26.	68	38	0
27.	66	39	0
28.	73	45	0
29.	80	47	0
30.	78	43	0
Average	71.5	42.4	--
Total			1.35

Table 7.—— Spotted alfalfa aphid cage tests for population potential, South Dakota State College Agronomy Farm, Brookings, South Dakota, October 1-28, 1957.

VARIETY	TOTAL POPULATION	AVERAGE PER DAY	MORTALITY	PER CENT MORTALITY
Ranger				
Cage 1.	28.0	1.0	12	42.8
Cage 2.	25.0	0.9	11	44.0
Cage 3.	14.0	0.5	6	42.8
Cage 4.	19.0	0.7	8	42.1
Cage 5.	16.0	0.6	7	43.7
Average	20.0	0.7	8	43.0
Buffalo				
Cage 1.	30.0	1.1	14	46.6
Cage 2.	28.0	1.0	13	46.4
Cage 3.	11.0	0.4	5	45.4
Cage 4.	14.0	0.5	6	42.8
Cage 5.	19.0	0.7	8	42.1
Average	20.0	0.7	9	44.6

Table 5.—— Weather data for spotted alfalfa aphid cage test area, South Dakota State College Agronomy Farm, Brookings, South Dakota, October 1-26, 1957.

DAY	TEMPERATURE		PRECIPITATION
	MAXIMUM	MINIMUM	
1.	78	38	0
2.	77	42	0
3.	77	44	0
4.	73	48	0
5.	75	47	0
6.	67	50	.29
7.	63	51	.10
8.	59	41	0
9.	44	38	0
10.	44	33	0
11.	51	38	0
12.	54	44	0
13.	69	47	0
14.	58	46	0
15.	65	54	.12
16.	57	42	.11
17.	57	29	0
18.	68	24	0
19.	57	26	0
20.	55	30	0
21.	50	41	.17
22.	62	44	0
23.	51	38	.34
24.	40	36	0
25.	29	16	0
26.	38	22	0
27.	50	18	0
28.	53	25	0
Average	51.5	37.5	—
Total			1.13

POTATO LEAFHOPPER. — Potato leafhopper investigations in the widely separated areas of Brookings and the southern study areas revealed population patterns that were surprisingly uniform. Even though this leafhopper appeared first in the southern counties, its activities in the Brookings area resembled those of the other four fields. The major difference between the Brookings populations and the others was the occurrence of the various population peaks. The population peaks in the Brookings area followed those of the other areas by 2 to 5 days. This characteristic was no doubt due to the insect's northern migratory habit.

Light Trap Investigations. — Light trap studies of the potato leafhopper on the East Dairy Farm proved successful in determining the relative abundance of this insect between the hours of 7 P.M. and 4 A.M. This study points out that this insect had a rather uniform pattern of night-time activity, which usually began sometime between 8 and 9 P.M. The activities of this insect did not seem to be hindered by precipitation and/or wind velocities except for a few isolated instances when velocities reached 15 to 20 miles per hour during the collecting hours. For the most part, the high winds subsided prior to the collecting hours.

The population abundance patterns established as a result of these collections were similar throughout the collecting periods. The first indication of the leafhopper's attraction to the 15 watt Bl. light on the light trap was on June 19, one day after the leafhopper first appearance in the adjacent grazing plots. See table 9. This first trapped leafhopper was taken between 9 and 10 P.M.

Table 9.—— Potato leafhopper hourly light trap collections on the grazing plots of the South Dakota State College East Dairy Farm, Brookings, South Dakota, June 19-28, 1957.

HOURS		JUNE *							
		19	20	21	24	25	26	27	28
7-8	P.M.	0	0	0	0	0	0	0	0
8-9	P.M.	0	0	1	3	0	5	4	0
9-10	P.M.	1	0	3	6	1	6	4	5
10-11	P.M.	3	2	2	11	3	13	5	8
11-12	P.M.	4	2	3	9	0	11	8	7
12-1	A.M.	0	2	0	8	0	6	7	5
1-2	A.M.	0	0	0	0	0	0	1	0
2-3	A.M.	0	0	0	0	0	0	0	0
3-4	A.M.	0	0	1	0	0	0	1	0
Precipitation				.1		.3			

* June 1-18 Catches were negative.

Only one adult was found during this period. During the remainder of the night, seven more adults were trapped, three between 10 and 11 P.M., and four between 11 and 12 P.M.

Leafhopper activity at the light trap began to increase on July 21. The result of the collecting on this evening was typical for the entire four months collecting period. Major leafhopper activity was concentrated between 9 and 12 P.M. when a total of eight adults was collected. There were a few instances in which leafhoppers were collected prior to 9 P.M. and after 12 P.M., but for the most part, activities ceased after 12 P.M. Reference is made to tables 10, 11, 12, and 13. Table 13 reveals that the leafhopper activity was fairly heavy between the hours of 7 and 8 P.M. This particular phase of activity paralleled the onset of shorter days and the longer periods of darkness that is common in South Dakota during the fall and winter seasons.

Light trap collections between July 22 and 29 were interrupted when the Bl. bulb burned out. The Bl. bulb was temporarily replaced with a common 15 watt Daylight Desk bulb. This light appeared to be less attractive to the potato leafhopper as is indicated by the collecting results for this period on table 10.

Table 10.— Potato leafhopper hourly light trap collections on the grazing plots of the South Dakota State College East Dairy Farm, Brookings, South Dakota, July, 1957.

	JULY																						
HOURS	1	2	3	4	5	8	9	10	11	12	15	16	17	18	19	22*	23*	24*	25*	26*	29*	30*	31*
7 - 8 P.M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 - 9 P.M.	8	1	0	0	1	2	5	4	3	1	4	5	7	5	6	1	2	1	2	2	3	9	6
9 -10 P.M.	9	1	0	1	2	5	7	6	5	4	4	7	8	8	9	2	4	2	4	3	3	7	9
10-11 P.M.	13	3	1	1	4	8	9	7	6	5	3	4	9	12	13	2	4	4	5	4	4	7	9
11-12 P.M.	15	0	1	0	1	11	10	11	9	6	10	11	16	16	17	1	3	2	1	3	4	0	7
12- 1 A.M.	9	0	0	0	0	1	0	0	0	0	1	2	3	4	0	3	0	0	0	1	0	1	0
1- 2 A.M.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2- 3 A.M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
3- 4 A.M.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Precipitation	T*															.4							

* A 15 watt Daylight bulb was substituted for the burned out Bl. bulb.

* T - Trace

Table 11.—— Potato leafhopper hourly light trap collections on the grazing plots of the South Dakota State College East Dairy Farm, Brookings, South Dakota, August, 1957.

	AUGUST																
HOURS	5	6	7	8	9	15	16	19	20	21	22	23	26	27	28	29	30
7 - 8 P.M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 - 9 P.M.	9	8	9	8	7	5	5	3	0	0	0	0	4	5	1	0	5
9 -10 P.M.	10	13	12	11	10	7	6	3	1	1	0	1	2	2	1	1	4
10-11 P.M.	10	15	14	14	12	8	5	1	0	1	3	0	5	4	2	1	1
11-12 P.M.	11	16	15	12	12	6	7	1	0	1	1	0	1	3	0	0	3
12- 1 P.M.	6	6	0	5	4	1	0	0	0	0	0	0	0	0	0	0	0
1 - 2 A.M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2 - 3 A.M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 - 4 A.M.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Precipitation				T*	T*				.2	.2		.9			.T*		.T*

* T = Trace.

Table 12.—— Potato leafhopper hourly light trap collections on the grazing plots of the South Dakota State College East Dairy Farm, Brookings, South Dakota, September, 1957.

	SEPTEMBER																				
Hours	2	3	4	5	6	9	10	11	12	13	16	17	18	19	20	23	24	25	26	27	30
7 - 8 P.M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 - 9 P.M.	0	6	4	3	5	0	1	4	3	0	5	3	4	2	1	1	1	3	2	0	0
9 -10 P.M.	3	5	4	2	3	2	3	6	4	1	3	2	0	4	2	3	1	3	3	1	1
10-11 P.M.	4	1	3	3	5	1	2	2	1	1	1	1	0	3	1	6	3	2	2	0	1
11-12 P.M.	1	3	3	1	2	3	1	4	1	0	1	1	1	0	1	1	1	4	1	1	0
12- 1 P.M.	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
1 - 2 P.M.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 - 3 P.M.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 - 4 P.M.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Precipitation						.4						[illegible]		.6		.1					

Table 13.—— Potato leafhopper hourly light trap collections on the grazing plots of the South Dakota State College East Dairy Farm, Brookings, South Dakota, October 1-11, 1957.

	OCTOBER *							
HOURS	1	2	3	4	7	8	9	10	11
7 - 8 P.M.	0	0	0	1	2	1	1	1	1
8 - 9 P.M.	1	2	4	3	3	3	1	2	0
9 -10 P.M.	1	4	3	1	2	1	0	0	0
10-11 P.M.	1	3	1	1	1	0	0	0	0
11-12 P.M.	0	0	1	1	0	0	0	0	0
12- 1 A.M.	0	0	0	0	0	0	0	0	0
1 - 2 A.M.	0	0	0	0	0	0	0	0	0
2 - 3 A.M.	0	0	0	0	0	0	0	0	0
3 - 4 A.M.	0	1	0	0	0	0	0	0	0
Precipitation					.1				

* October 12-31 Catches were negative.

Field Population Investigations.—— The appearance and activity of the potato leafhopper in the southern study area showed remarkable similarities in Fields 1, 3, and 4. The discussion of these fields will be considered together, while highlights of the individual fields will be pointed out separately. Leafhopper activities in Field 2 followed a different trend that necessitates separate consideration. Potato leafhopper counts in Fields 1, 2, 3, and 4 were negative until June 14. The June 14 collections produced the adult leafhopper from all study areas. The initial recovery from Fields 1, 2, 3, and 4 averaged 0.10 insects per sweep. See figures 8, 9, 10, and 11. During the next 14 days, the adult leafhopper population trends in all four fields gradually increased and came to simultaneous peaks on June 28. Leafhopper collections from these fields on this date averaged 0.23 adult leafhoppers per sweep. The next collecting date, July 3, revealed parallel population decreases from 0.19 to 0.10 in Field 1, 0.39 to 0.15 in Field 3, and 0.26 to 0.14 in Field 4. The decrease in leafhoppers in Field 2 was slight, 0.17 to 0.16.

The July 3 collections were also the first time in which the potato leafhopper nymphs were collected in the study area. These collections recovered nymphs from all four fields and averaged 0.07 nymphs per sweep.

The adult populations in Field 1 continued to decrease following the July 3 collection and reached a new low of 0.01 insects on July 9. Immediately following the July 9 collecting date, the adult population began its build up to the season's highest peaks. These peaks fluctuated from the July 15 level of 1.19 to the all time high of 2.31 adult insects on August 2. The remainder of the collecting season found the adults dwindling to the 0.02 level on October 14. Reference is made to figure 8.

Simultaneous adult peaks also occurred in Fields 3 and 4. Adult populations in Field 3 rose from the July 3 level of 0.15 to 1.41 leafhoppers on July 23 at which time the alfalfa was cut for the third time. The next collecting date, August 2, showed a decided drop in adult leafhoppers. This reduction was attributed to the haying operations. During the remainder of the season, the leafhoppers gradually increased to the 0.16 level on September 6 and then fell to the 0.02 level on September 23. This level was maintained for the remainder of the season. This particular decrease paralleled colder weather as is shown in figure 9.

The adult population trends in Field 4 reached their peak on July 19, with 1.01 insects per sweep being the high. The alfalfa in this field was cut for the second time on July 23, which also resulted in a population decrease to 0.10 on August 2. The next collecting date, August 6, found an increase to 0.20 insects per sweep. This figure gradually decreased to the 0.05 level on October 14. See figure 10.

Activities in Field 2 varied only slightly from the other three fields. The outstanding difference between Field 2 and the others was the length of time in which the adult population remained at a relatively high level. See figure 11. The initial high peak of 0.75 occurred on July 9, the same day the field was mowed for the second time. Following this mowing, the population fell to 0.21 insects on July 12 and then increased to 1.04 on July 15. This peak was irregularly maintained

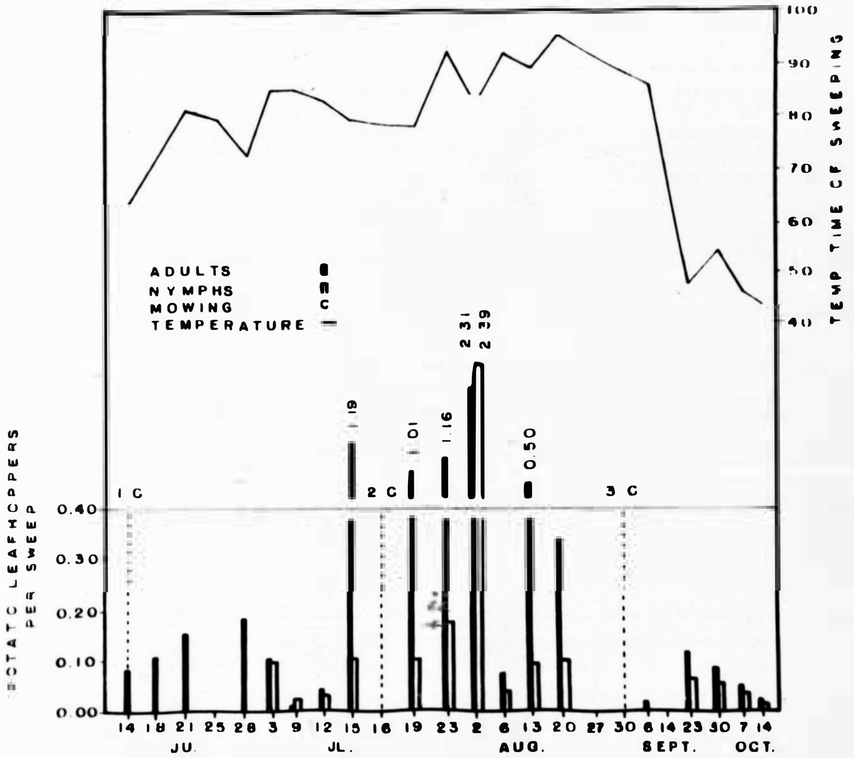

Figure 8.—— Potato leafhopper populations, based on 100 net sweeps in Field 1 in southeastern South Dakota with temperatures recorded at collecting time. 1957.

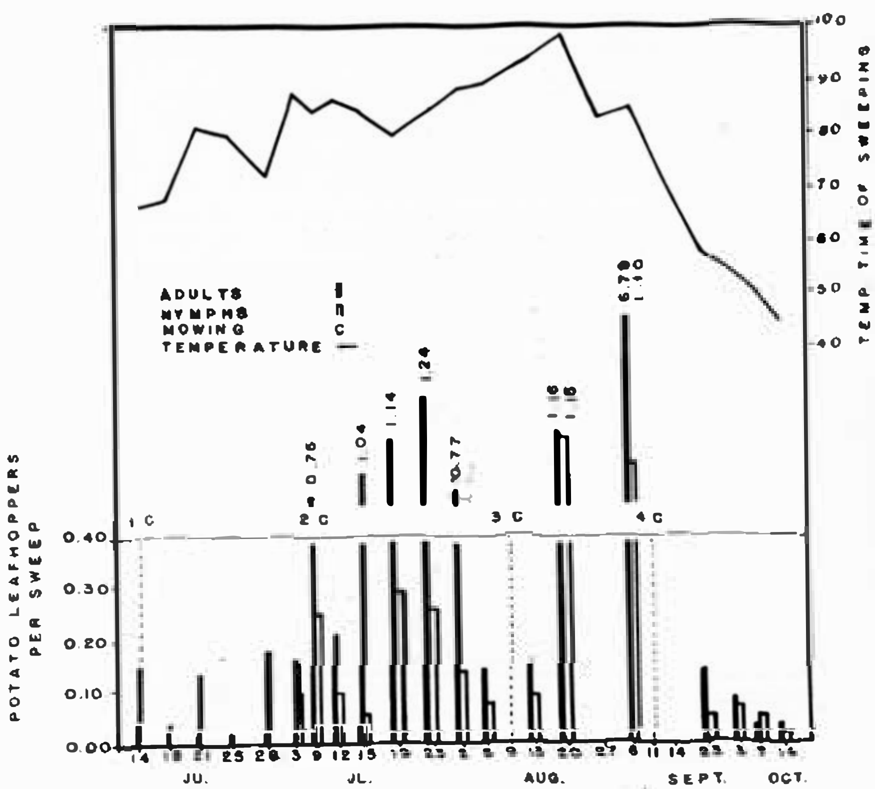

Figure 9.—— Potato leafhopper populations, based on 100 net sweeps, in Field 2 in southeastern South Dakota with temperatures recorded at collecting time. 1957.

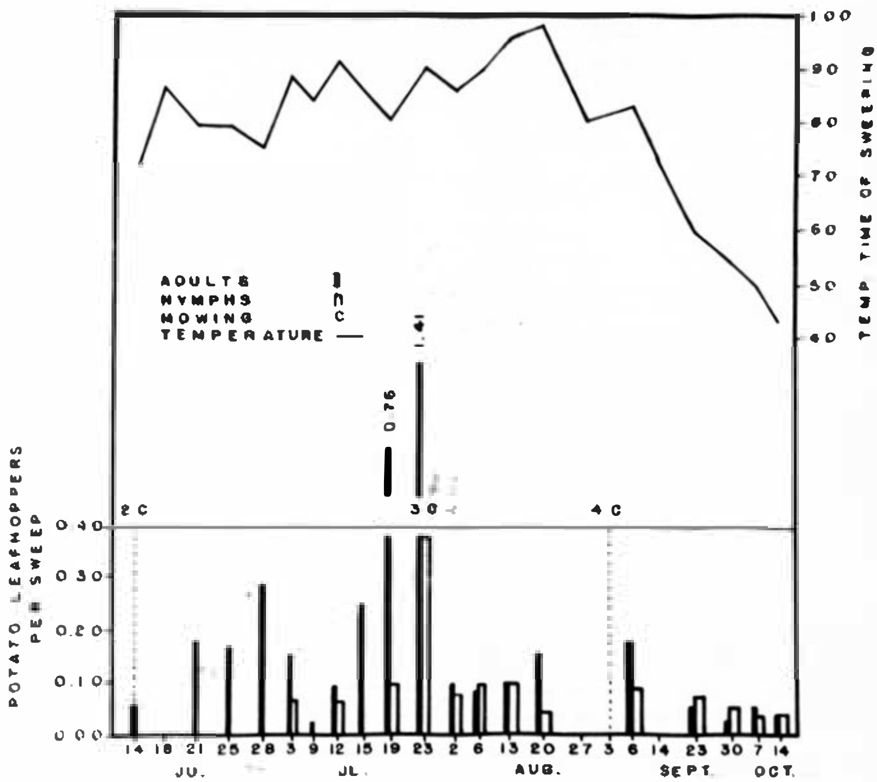

Figure 10.—— Potato leafhopper populations, based on 100 net sweeps, in Field 3 in southeastern South Dakota with temperatures recorded at collecting time. 1957.

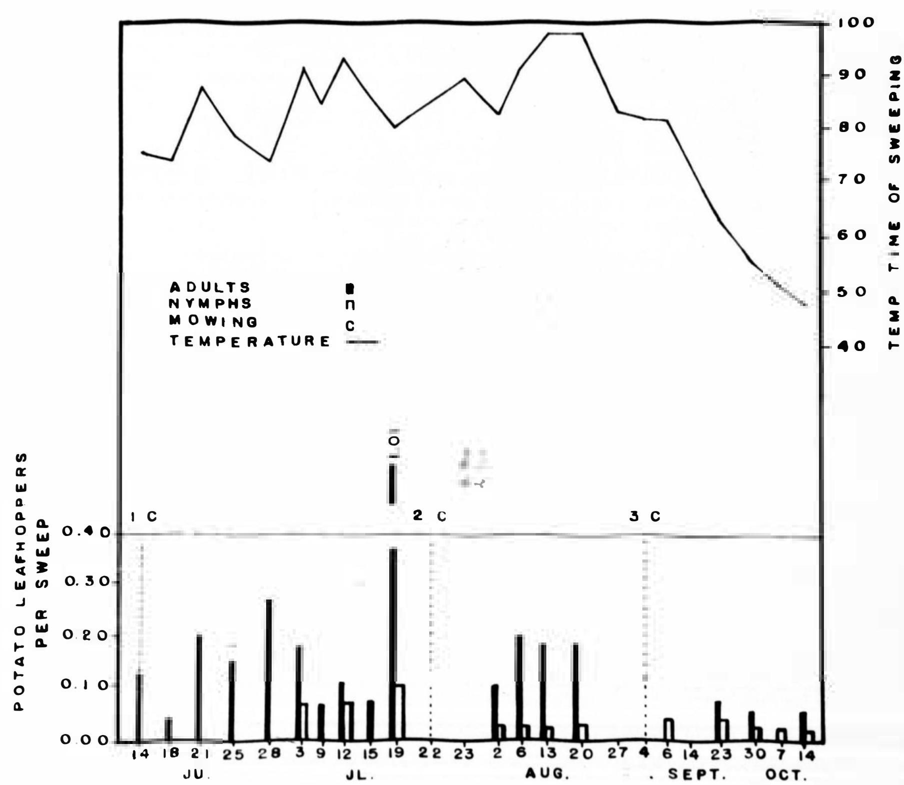

Figure 11.—— Potato leafhopper populations, based on 100 net sweeps, in Field 4 in southeastern South Dakota with temperatures recorded at collecting time. 1957.

until August 2 at which time there appeared a slight reduction in insects. This decline was gradual and might have resulted from the collector's inability to obtain an accurate sample due to the unusually heavy stand of alfalfa.

Another increase was noted on August 13 and 20, with a peak being reached on September 6 when the count was 6.79 adult leafhoppers per sweep. Five days later, the alfalfa was cut for the fourth time and immediately following this cutting, cold weather set in. As the weather became progressively colder, the population fell from 0.14 insects per sweep on September 23 to 0.04 adults on October 14.

Seasonal population trends for the potato leafhopper nymphs in all four fields increased and decreased with the adult populations, only at a more conservative level. Both the adults and nymphs were present in all fields at a non-economic level throughout the season. There was no indication of alfalfa yellowing due to leafhopper populations. Frost occurring on October 25 terminated these studies.

It is interesting to note the sequence of the adult potato leafhopper population increases as they are represented in the June collections of this insect in figures 8, 9, 10, and 11. The population variations, as they are represented in these graphs, might well correspond with a phase of the migratory habits of this insect. Each year, the potato leafhopper migrates from its southern breeding grounds on the Gulf coast into our section of the country. Insect collections in the southern study area give indications that the bulk of the migration into these areas required a few days after the initial appearance of the insect. This particular trend was apparently indicated by the gradual build up of the leafhopper in the June 14 through 28 collecting dates. Reference is made to figures 8, 9, 10 and 11. The initial appearance of the leafhopper into the study area could very well be the early migrants. These collections were low. As the migration intensified, so did the numbers of leafhoppers collected. The peak of the migration could very well be represented by the June 28 peak in the collections.

Immediately following the population peak on June 28, there was a distinct reduction in adults and a simultaneous appearance of the leafhopper nymph for the first time. It is believed that the sudden reduction in the adult population was due to the dying of the migratory leafhoppers after they completed their reproduction phase of their life cycle upon their arrival in the study areas. The egg laying habits of the migratory leafhopper would account for the appearance of the nymphs at this time. The second build up phase of the adults might be due to the maturing of the early nymphs. These peaks were maintained with the continued development of the nymphs and began to fall off after that generation had completed its life cycle. See figures 8, 9, 10, and 11.

There is a possibility that the spotted alfalfa aphid and potato leafhopper populations found in these study areas were somewhat affected by a physical condition present in all four fields. The soil analysis of these fields revealed that there was a deficiency of phosphorous in all four fields. See table 18. Fields 1, 3, and 4, were classified as being very low in phosphorus, while Field 2 was considered as being low. And according to Lyon (1950), such a deficiency will produce poor, spindly growth as well as make the plants more suscept-ible to insect attacks.

It should be noted that the high insect populations occurred after the first cutting and during a growing season having less than a normal amount of rainfall. It seems possible then, that alfalfa in such a condition might be more susceptible to insects such as the spotted alfalfa aphid and the potato leafhopper.

Potato leafhopper collections in the Brookings area followed a pattern similar to those in the Yankton area. There was, however, a much more gradual build-up populations in the Brookings collections as is indicated in figure 12. These collections failed to produce extreme highs or lows in the population trends. The high in the adult population which did occur apparently resulted from the normal maturing of the nymphs. Such uniformity in the population curves may have resulted from the uniform height of the alfalfa. The height of this particular field was maintained between 6 and 12 inches by rotating the dairy herd from plot to plot every few days. This consistant growth enabled the collector to maintain his sweep net 2 to 3 inches above the ground for all collections. This condition eliminated an important variable in the sweeping methods.

The leafhopper was first noticed in the grazing plots on July 18, four days after it was recovered in the southern study area. There is a possibility that the leafhopper's migration to the grazing plots may have been hindered by the west-northwest winds blowing in the Yankton area between June 14 and 16. Weather observations in the Yankton area recorded 12 mile per hour winds blowing out of thenorth-

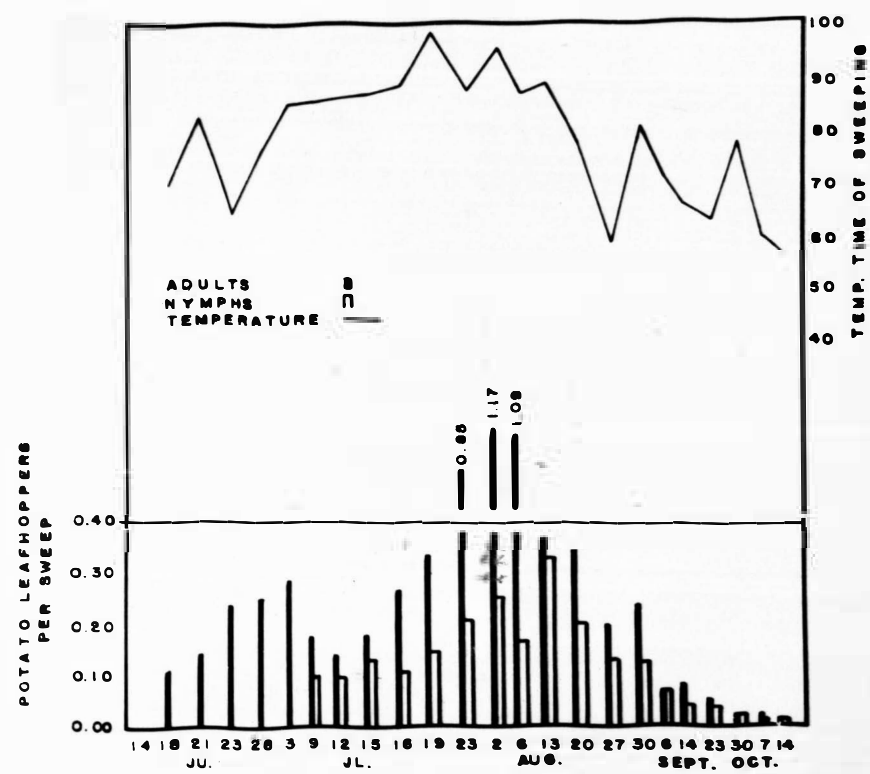

Figure 12.—— Potato leafhopper populations, based on 100 net sweeps, on the grazing plots of the South Dakota State College East Dairy Farm, Brookings, South Dakota with temperature recorded at collecting time. 1957.

west on June 14. These ground winds continued to be unfavorable for the northward migration of the leafhopper the following day. June 15 winds came out of the west at six miles per hour. Climatic conditions in the Yankton area changed somewhat on June 16 and 17 as warm southerly winds prevailed and blew at 6 and 10 miles per hour respectively. If the leafhoppers had been carried by the ground winds at six miles per hour, they would have been transported the 132 intervening air miles in about 19 hours. This would bring the first collection records within one day of coinciding with the calculated first arrival of the leafhopper at the Brookings plots. It was also interesting to note that there were 0.11 leafhoppers per sweep taken in the first collections in the Brookings area as compared to the initial recoveries of 0.08 in Field 1, 0.15 in Field 2, 0.05 in Field 3 and 0.12 leafhoppers in Field 4.

The initial recovery of 0.11 insects from the grazing plots showed a extremely uniform build-up to 0.28 leafhoppers on July 3. This peak occurred five days after similar peaks in the southern areas. And, in accordance with figures 8, 9, 10, and 11, the next collecting date in the grazing plots revealed a decisive drop to 0.17 adults. During the remainder of the season, the leafhopper gradually increased to the seasons high of 1.17 insects on August 2 and then tapered off to 0.01 leafhoppers on October 14.

Leafhopper population curves in the Brookings area showed little association with existing weather conditions. Natural climatic conditions surrounding the grazing plots were interrupted somewhat by the application of sprinkler irrigation. This, and the presence of the dairy herd in the plots may also have had some affect on the population. Such combinations of irrigation and grazing also stimulated continuous succulent alfalfa growth. Artificial conditions such as these could have then played an important role in the production of these population curves on the East Dairy Farm.

SUMMARY AND CONCLUSIONS

Ecological studies of the spotted alfalfa aphid, Therioaphis maculata (Buckton), and the potato leafhopper, Empoasca fabae (Harris), under South Dakota climatic conditions were successful in establishing seasonal population curves of these two insects.

SPOTTED ALFALFA APHID.—— This aphid reached its peak abundance during the latter part of August and early September.

Light Trap Investigations.——The aphid was not recovered at the Bl. light of the light trap located at Brookings.

Field Investigations.—— Field surveys were conducted in five specific areas to determine population curves if and when the aphid appeared in the study areas. The aphid was found only once on the East Dairy Farm at Brookings. In the southeastern areas the initial recovery of this insect in Fields 1, 2, and 3, was during the second and third weeks of June, while in Field 4, it was July 12. Populations seemed to increase following temperature rises.

Rearing Cage Studies. ——The reproductive potential of the spotted alfalfa aphid under caged conditions on the alfalfa varieties of Ranger and Buffalo also paralleled temperature variations. The average number of aphids produced per day varied from 0.7 to 3.0. These studies indicate that the Buffalo variety is more susceptible to aphid build-ups than is the Ranger variety.

POTATO LEAFHOPPER. ——Potato leafhopper activities during 1957 followed similar patterns in the two widely separated study areas.

Light Trap Investigations. —— Leafhopper activity at the light trap between the hours of 7 P.M. and 4 A.M. was concentrated between 9 P.M. and 12 P.M.

Field Investigations. --- The potato leafhopper population surveys in all fields revealed that a uniform population curve occurred in the southeastern and Brookings study areas. North and northwest winds occurring for a period of a few days seemed to hinder the northward migration of this insect from southern South Dakota to Brookings. In 1957, population peaks occurred the latter part of July. Climatic conditions seemed to have little effect on the leafhopper activities.

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APPENDIX

APPENDIX

Table 14.—— Spotted alfalfa aphid rearing cage records showing daily population increases for all cages on the alfalfa varieties of Ranger and Buffalo, located on the South Dakota State College Agronomy Farm, Brookings, South Dakota, July 8-31, 1957

	VARIETY									
	RANGER					BUFFALO				
Cage:	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.
July 8.	3	3	2	4	3	2	3	3	4	2
9.	3	4	4	4	3	3	4	4	5	3
10.	4	4	3	4	4	2	3	3	3	2
11.	2	3	3	3	2	2	3	4	3	4
12.	3	2	2	4	3	3	2	3	4	4
13.	3	3	3	2	3	4	4	2	3	3
14.	1	2	2	3	2	2	3	5	6	4
15.	2	3	2	2	3	3	1	5	8	5
16.	5	6	4	5	3	2	3	3	3	3
17.	4	4	3	4	3	1	4	3	4	4
18.	3	3	3	4	2	3	3	4	3	4
19.	4	2	5	2	4	1	2	3	4	3
20.	2	3	3	2	3	2	4	2	3	2
21.	1	3	2	3	3	4	3	3	2	3
22.	2	1	3	2	2	3	2	2	4	2
23.	3	4	2	3	3	4	4	3	4	3
24.	1	3	2	2	3	3	3	2	2	3
25.	2	3	2	2	1	4	1	3	3	2
26.	2	2	1	3	2	3	3	4	1	3
27.	3	2	2	3	3	2	3	4	2	3
28.	0	0	0	0	0	0	0	0	0	0
29.	2	3	2	2	2	1	2	2	3	3
30.	3	3	3	4	3	2	3	3	2	3
31.	2	1	3	1	3	3	2	1	3	2

Table 16.—— Spotted alfalfa aphid rearing cage records showing daily population increases for all cages on the alfalfa varieties of Ranger and Buffalo, located on the South Dakota State College Agronomy Farm, Brookings, South Dakota, August, 1957.

		VARIETY								
	RANGER					BUFFALO				
Cage:	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.
August 1.	4	3	4	4	3	2	3	3	4	3
2.	3	5	3	3	2	3	2	3	3	3
3.	1	4	5	4	3	2	3	5	4	3
4.	1	3	5	4	3	1	2	4	4	1
5.	2	3	4	3	2	2	3	3	3	2
6.	4	2	2	3	4	2	3	3	3	3
7.	3	3	2	2	3	5	4	3	3	3
8.	3	2	3	2	2	2	3	3	3	2
9.	2	2	2	2	2	3	2	3	3	2
10.	3	3	2	2	1	2	4	4	3	4
11.	2	2	4	3	1	1	3	5	4	3
12.	2	3	3	3	4	2	3	3	4	3
13.	3	2	2	2	3	3	2	3	3	2
14.	3	2	1	3	3	4	2	2	5	3
15.	3	3	3	2	3	3	3	2	4	2
16.	3	4	4	4	2	2	3	3	2	3
17.	2	3	3	4	3	3	3	2	3	3
18.	3	2	3	3	3	2	3	3	3	2
19.	3	4	3	2	2	2	2	3	4	3
20.	2	3	4	3	1	2	2	2	3	2
21.	3	3	2	1	1	3	3	3	4	2
22.	2	3	3	3	3	2	2	2	2	3
23.	3	3	3	3	4	2	2	2	3	2
24.	1	3	1	2	3	2	1	1	2	2
25.	2	1	3	3	2	3	1	3	2	2
26.	3	2	2	3	3	2	1	2	2	2
27.	1	3	2	1	1	0	0	1	2	2
28.	1	2	1	2	2	0	1	1	1	3
29.	2	1	3	2	3	1	0	2	0	1
30.	3	1	1	2	3	3	3	3	2	3
31.	3	3	3	3	2	3	3	4	4	3

Table 16.—— Spotted alfalfa aphid rearing cage records showing daily population increases for all cages on the alfalfa varieties of Ranger and Buffalo, located on the South Dakota State College Agronomy Farm, Brookings, South Dakota, September, 1957.

	VARIETY									
	RANGER					BUFFALO				
Cage:	1.	2.	3.	4.	5.	Cage: 1.	2.	3.	4.	5.
September 1:	3	3	3	2	3	3	3	3	2	3
2.	2	1	3	2	3	2	2	2	2	2
3.	1	1	2	2	1	2	2	1	2	3
4.	1	1	1	1	1	1	1	2	1	2
5.	1	1	1	1	2	1	1	1	1	2
6.	1	1	1	1	1	1	1	1	1	1
7.	1	1	1	1	1	1	1	1	1	1
8.	2	1	1	1	1	2	1	1	1	1
9.	1	1	0	0	1	1	1	1	1	1
10.	1	1	1	1	2	1	1	1	2	2
11.	1	1	1	2	1	2	1	2	1	1
12.	1	1	2	2	1	1	1	2	1	1
13.	1	0	0	1	1	1	1	1	1	2
14.	1	0	1	0	1	1	1	1	1	1
15.	1	1	1	1	1	1	1	1	1	1
16.	1	0	1	2	1	1	0	1	1	1
17.	1	0	1	0	1	1	1	1	1	1
18.	1	1	2	2	1	2	1	2	1	2
19.	1	1	2	1	1	1	1	1	1	1
20.	1	1	1	1	2	2	1	1	1	1
21.	0	1	1	1	1	1	1	1	1	1
22.	1	0	1	1	1	1	1	1	0	1
24.	1	1	0	1	0	0	2	1	1	1
25.	1	1	1	1	1	1	1	1	1	1
26.	1	2	2	1	1	1	1	1	0	1
27.	1	1	1	1	1	1	1	1	1	1
28.	2	1	1	1	2	2	1	1	2	2
29.	2	2	3	1	3	1	2	2	3	1
30.	2	2	2	1	3	2	2	2	2	2

Table 17.— Spotted alfalfa aphid rearing cage records showing daily population increases for all cages on the alfalfa varieties of Ranger and Buffalo, located on the South Dakota State College Agronomy Farm, Brookings, South Dakota, October 1-26, 1957.

		VARIETY									
		RANGER					BUFFALO				
	Cage:	1.	2.	3.	4.	5.	Cage: 1.	2.	3.	4.	5.
October	1.	3	2	1	2	1	2	2	1	1	1
	2.	2	2	1	2	1	2	2	1	1	1
	3.	2	1	1	1	1	2	1	1	1	1
	4.	1	1	0	1	1	1	1	1	1	2
	5.	1	1	0	1	1	2	1	1	1	1
	6.	1	1	1	1	1	1	2	1	1	1
	7.	1	1	1	1	1	2	1	1	1	1
	8.	1	1	0	1	1	1	1	0	1	1
	9.	0	1	0	1	0	1	1	0	1	1
	10.	1	0	0	0	1	2	2	1	1	1
	11.	1	1	1	0	0	1	1	0	1	1
	12.	2	1	1	1	1	1	1	0	1	1
	13.	1	1	0	1	1	1	1	0	0	1
	14.	2	1	1	1	1	1	1	1	0	1
	15.	1	1	1	1	0	1	1	0	0	1
	16.	1	1	1	1	1	1	1	0	1	0
	17.	1	1	0	1	1	1	1	0	0	0
	18.	1	1	1	1	0	1	1	0	0	1
	19.	1	1	0	0	0	1	1	0	0	0
	20.	1	1	1	0	0	1	1	1	1	0
	21.	1	1	1	0	0	1	1	0	0	1
	22.	1	1	0	1	1	1	1	0	0	1
	23.	1	1	1	0	1	1	1	1	0	1
	24.	0	1	0	0	0	1	1	0	0	0
	25.	0	0	0	0	0	0	0	0	0	0
	26.	0	0	0	0	0	0	0	0	0	0

Table 18.—— Soil analysis report for fields 1, 2, 3, and 4, located in south eastern South Dakota, for 1957.

FIELD NO.	#1A NO.3	AVAIL. P. #1A	AVAIL. K. #1A	pH*	SALINITY**	ORGANIC MATTER	TEXTURE
1.	5	1.4	292	7.8	0.6	Medium	Silt Clay Loam
2.	10	8.8	800	7.2	0.5	Medium	Clay Loam
3.	5	2.0	800	7.8	0.6	Medium	Sandy Clay Loam
4.	5	4.9	700	7.6	0.4	Medium	Silt Loam

* Paste Test of Saturated Soil

** Per Cent Saturation

Table 19.—— Spotted alfalfa aphid and Potato Leafhopper population counts in Fields 1, 2, 3, and 4, in south eastern South Dakota for October 21 and 28, 1957.

SPOTTED ALFALFA APHID*		
October	21	28
Field 1.	0.01	0
Field 2.	0.10	0
Field 3.	0.05	0
Field 4.	0.07	0
POTATO LEAFHOPPER*		
Field 1.	0.01	0
Field 2.	0.03	0
Field 3.	0.03	0
Field 4.	0.02	0

*Number Per Sweep