A COMPARISON OF CERTAIN FEATURES OF THE BIOLOGIES OF GREENBUGS, *TOXOPTERA GRAMINUM* (ROND.), ON THE RECOMMENDED KANSAS WINTER WHEAT AND BARLEY VARIETIES

by

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INTRODUCTION

Insect control is generally divided into the cultural, biological, and chemical phases. Host plant resistance to insects is related to all three phases, but is mainly a biological phenomenon. Chemical and cultural control have made rapid advances in the past decades and will, no doubt, always be needed for some types of control. Host plant resistance will always be a preferred method of control since it is more economical and lasting.

The bionomics of the greenbug, Toxoptera graminum (Rond.), (Homoptera, Aphididae), in Kansas would indicate that host plant resistance, where possible, is a preferred and often the only practical means of control. One reason why this is true is that the Kansas wheat crop, especially in western Kansas, is a gamble where there is not a large per-acre profit and where there are many adverse factors such as drought and wind erosion which threaten the crop. The potentialities of greenbug population increase on susceptible varieties are astronomical when not retarded or controlled by parasites and predators, or unfavorable climatic conditions. All these factors make it difficult to determine when chemical control should be applied. If spraying is postponed until the damage is seen, the farmer has suffered loss or if spraying is done before it is warranted in a year of low yields the added operation may result in the crop showing a net loss instead of a small profit.

The resistance of plants to insect attack is generally a matter of degree as well as kind of resistance. The number of young produced by a specific insect when feeding on a certain variety may influence the amount of damage done to that variety. The death rate of the adults or their relative size are also factors that may produce varying degrees of damage.

It is the purpose of this research to study the reaction of greenbugs to small grains, particularly the principal wheat and barley varieties recommended for Kansas. A few other wheat and barley varieties, especially some known to carry resistance or susceptibility were also studied. Most of the varieties studied were those that have been bred or selected for other factors than greenbug resistance. It was therefore of interest to determine whether any of these showed marked differences in effect on the biology of the greenbug. While various factors of resistance were considered, the main emphasis of the study was on variations in the fecundity rate of the greenbugs when feeding on different varieties.

The resistance factors reported in this thesis are only a part of the resistance mechanism known as antibiosis. Antibiosis studies were chosen since much of the previous work in greenbug resistance has been in the area of tolerance. The factors within antibiosis were chosen both for their importance and for the possibility of working out a method for evaluating the relative expression of these resistance factors.

The methods used in evaluating these factors of resistance were either entirely new or needed considerable adaptation. Therefore, much of the experimental work involved the perfecting of procedures that would eliminate all sources of variability except those inherent in the plant itself. The general method used was to sprout the seeds in petri dishes and then transfer the sprouts to shell vials for infestation with fourth instar nymphs.

REVIEW OF LITERATURE

The Bionomics of the Greenbug

The greenbug was first described by Rondani in 1852. It was placed in the genus Toxoptera by Passerini in 1863. Passerini mentions as its food plants, Triticum, Hordeum, Avena, Zea, and Sorghum. Webster and Phillips (1912) listed about sixty host species, almost all from the grass family. Pergande (1902) reports that the earliest record of this insect in the United States occurred in June, 1882. Kelly (1917) lists the major outbreaks 1890, 1901, 1907, and describes the outbreak of 1916. Ainslie (1926) describes the severe outbreak that occurred in Minnesota that year. Dahms (1951) states that there have been fourteen major outbreaks in the United States. Painter et al. (1954) list severe outbreaks of greenbugs in 1907, 1916, 1934, 1939, 1949, and 1950. The greenbug is listed by Dietz (1953) as one of the five major insects attacking wheat.

The biology has been described by Webster and Phillips (1912). An early comprehensive study of the greenbug parasites and predators was made by Hunter (1909). The ecological studies have been summarized by Wadley (1931). Lowe (1952) notes the overwintering of the greenbug in southwestern Kansas and also the possibility of recurrent infestations by flights of greenbugs carried north on the prevailing winds.

The seasonal cycle and its effect upon the fecundity and length of life of the greenbug are discussed by Luginbill and Beyer (1918). Wadley (1923) has recorded some of the factors affecting the proportion of apterous or alate adults. The loss of chlorophyll and other effects of feeding are reported by Wadley (1929). A thorough study of the effects of temperature on the development of the greenbug was made by Wadley (1935).

The Greenbug and Resistance

Studies of insect resistance in crop plants have been compiled and summarized by Painter (1951). He divides the resistance phenomena into three mechanisms. These mechanisms are preference, tolerance and antibiosis. Painter also discusses the various ramifications and possibilities of resistant varieties of crops. Dahms (1948) studied some of the antibiotic effects on chinch bugs by varieties of sorghum. He found differences in number of eggs laid, longevity, body length, and mortality. Harrington (1945) found a positive correlation between adult weight and birth rate in pea aphids.

Sajo (1894) was the first to indicate possible differences in tolerance among oat varieties to the greenbug. Wadley (1931) reported the reactions of greenbugs to several varieties of common, durum and emmer wheat. On Vernal, a variety of emmer Triticum dicoccum, the aphids did not thrive. Fenton and Fisher (1940) in general field observations found winter barley to be more susceptible than winter wheat, and spring oat varieties were injured the most of all. Atkins and Dahms (1945) in observing the reaction to greenbugs of a large number of varieties of wheat, oats, and barley, found significant differences in the amount of damage done to the wheat and barley varieties. Omugi barley from Korea was reported to show exceptional resistance to greenbugs in Oklahoma by Blizzard (1948). Arriaga (1950) in Argentina, reported some progress in his studies of ryes resistant to greenbugs. In Uruguay, Silveiria and Conde (1946) reported some differences in susceptibility among varieties of wheat and rye. Dahms et al. (1955) reported a selection of the Dickinson wheat variety to be resistant. Chatters and Schlehuber (1951) state, "On the basis of cytological,

entomological, and agronomic observations the implications are that resistance and susceptibility are expressions of physiological differences".

MATERIALS AND METHODS

Materials

The materials used were those necessary for the caging and growing of greenbugs on wheat and barley sprouts and for controlling or evaluating the known variables related to the various tests. The methods used were a type of microevaluation in that the reactions of individual aphids or small groups of aphids were measured. Due to the intrinsic difficulties involved no large scale field experiments were attempted. The materials are described first to facilitate more continuity in the description of methods.

The greenbugs used in Experiments I through IX were from a stock culture maintained in the greenhouse. The aphids used for infesting in Experiments V through VIII were grown under artifical light in the basement of Insectary No. 2. In September, 1954, a pure strain was started from the original stock culture in the greenhouse; the greenbugs of this strain were supposedly all the progeny of one female. There were no known sources from which this culture might have been contaminated. Greenbugs from the pure strain were used in the weight experiments and in Experiment X. The aphids used for infesting were usually chosen from a single pot or flat in order to insure homogeneity of environment.

Different forms and instars of greenbugs were used in the various tests. Alate fourth instar nymphs were generally used. Alate and apterous forms of adults or apterous nymphs did not give as uniform results, because it was more difficult to select those of about the same age. The alate

nymphs could be more readily selected because their wing pads could be distinguished without the aid of a microscope.

The greenbugs used in the second generation tests were apterous adults. This was because, as reported by Wadley (1923), the majority of young produced by alate parents on succulent growth are apterous. Apterous adults can be distinguished from large nymphs by the exsertion of the cauda which occurs at the fourth molt. The apterous adults used in the weight tests were also selected by using this character.

A total of eleven varieties or selections of wheat were used in the experiments. Most of the seed of the varieties Pawnee, C.I. 11669; Ponca, C.I. 12128; Comanche, C.I. 11673; Concho, C.I. 12517; Wichita, C.I. 11952; Triumph, C.I. 12132; and Kiowa, C.I. 12133, was obtained from E. G. Heyne of the Agronomy Department. The seed of these varieties used in the first four tests was from the 1953 Entomology Nursery. The above varieties are recommended and grown commercially in Kansas. The variety, Red Chief, C.I. 12109, was also included in the tests. The packet of Red Chief obtained from E. G. Heyne was marked "not too pure". This seed was used in Experiments VI, VII, and VIII. In the other experiments the Red Chief seed was from the 1953 Entomology Nursery. Red Chief is not recommended in Kansas, but is grown to considerable extent in southwestern Kansas. An unnamed selection, C.I. 12804, Med-Hope-Pawnee x Oro-Ill.#1-Comanche, was also included because it has a favorable leaf and stem rust reaction and also hessian fly resistance and was being considered for release to farmers. The seed sources of C.I. 12804 were the same as for the recommended varieties. Denton, a selection of Mediterranean, C.I. 8265, was included in the early tests because it was the best known greenbug resistant variety. The Denton seed used was from the 1953 Entomology Nursery. A selection of the variety

known as Dickinson, C.I. 3707, replaced Denton after Experiment IV. This selection was found to be resistant to greenbugs by R. G. Dahms at Oklahoma Agricultural and Mechanical College. The original seed used was supplied by Dahms. The seeds of the Dickinson selection used in Experiments VI to IX were supplied by D. J. Ward, United States Department of Agriculture, Agricultural Research Service, Field Crops Research Branch, Beltsville, Maryland. The seed for Experiment X was from plants of the selection grown at Manhattan in 1954. These plants had been naturally infected by stem and leaf rust, and seed from them was shriveled.

Seven varieties of barley were used one or more times in the experiments. Most of the seed was obtained from the Department of Agronomy. Dobaku, C.I. 5238, was obtained from the Fort Hays Branch Experiment Station and Omugi, C.I. 5144, from R. G. Dahms. The varieties Reno, C.I. 6561; Dicktoo, C.I. 5529; and Beecher, C.I. 6566; are recommended for growing in Kansas. Dobaku and Omugi were included because, according to the report of Atkins and Dahms (1945), they had shown tolerance to greenbugs. Kearney, C.I. 7580, was included in the early tests, but was dropped because of its similarity to Dicktoo in reaction to greenbugs. Kearney had slightly less of an antibiotic effect on greenbug fecundity than Dicktoo. Ward, C.I. 6007, was included in the first few tests, but it is quite similar to Reno and therefore its use was discontinued.

Beginning with Experiment V, all the wheat seeds were screened so that the size of kernels would be similar for all varieties. The wire screens used had 64 and 100 square meshes per square inch. After the seeds were screened a definite number from each variety was counted and weighed on a Roller-Smith Precision balance. Weighings were to the nearest milligram.

In Experiment V, three sizes of seed were used. The ratio of their weights followed a 1:2:3 ratio. This was not entirely due to differences in size, as the heavy seeds had been selected for their plumpness and the light seeds from those that were very shriveled. In the variety tests the average weight of one kernel was 25.9 mg.

After Experiment II, all seeds were treated with a one or two per cent solution of Vancide 51 before soaking. Vancide 51 (30 per cent sodium salts of dimethyl dihiocarbamic acid and 2-mercaptobenzothiazole) is produced by the R. T. Vanderbilt Company. Petri dishes with a sheet of filter paper or toweling on the bottom were used to sprout the seeds for the first several days. The name of the variety was written on these sheets with a soft lead pencil.

The vials in which the plants were grown were six-dram shell vials with a diameter of 23 mm. and height of 85 millimeters. The variety contained and vial number was marked on the side of each vial with a red, glass-marking pencil.

The vials were covered with caps made from regenerated zephyr dialyzing tubing. These caps are transparent and also allow for some passage of gases, and possibly some moisture. The caps were made by cutting two inch squares of the tubing and moistening these in water. After the squares were soaked they were stretched over the top of the vials. A rubber band was wrapped tightly around the cap and then when the caps were almost dry the rubber bands were removed. This drying time varied with the humidity in the room, but averaged about an hour. After another hour of drying the caps were removed from the vials by pressing upward along the bottom edge of the cap with the thumb and forefinger. This initial

removal was tedious. Subsequent removals of the caps caused no difficulties. The one disadvantage of this type of cap was that it was very brittle and must be handled with caution.

As substrata for growing the seedlings, bits of cellucotton were used. The advantages of using cellucotton were that it was easy to form into uniform plugs in the bottoms of the vials and to soak the plugs with enough water to maintain three sprouts for at least ten days under normal conditions. The cellucotton plugs were usually five to eight millimeters in thickness. Since the cellucotton was white it was much easier to find any aphids that fell to the bottom of the vials than it would have been were the sprouts in soil. There were little or no known nutrients in the substrata or water used; thus the edaphic variables were believed to have been eliminated.

No light was necessary for sprouting the seeds, but they were usually grown in semidarkness. Efforts were made to maintain a fifty foot candle reading with a Kodak light meter, when the meter was held just above the top of the vials. In Experiments II and III this amount of light was furnished by two 15 watt standard white fluorescent bulbs. In the later experiments two 40 watt standard white fluorescent bulbs were used. In Experiment II the lights were on for ten hours per day. In all other experiments the lights were kept burning continuously. A Friez thermograph was used to record the temperature during the time the greenbugs were in the vials.

In all experiments after Experiment IV a daily count was made of the number of living adults in each vial. From these counts it was possible to determine the average number of nymphs produced by the adults each

day, and to determine the number of adults that died each day. At the end of the infesting period, which was usually six days at 80° F., the plants were taken out of the vials and placed on white paper. The total number of nymphs produced was then counted. A camel's hair brush was used for infesting the plants and also for removing the aphids from the leaves.

The arrangement of the vials of the different varieties under the light was randomized. The vials were placed in trays of various capacities, but the arrangement for varietal tests usually had five columns and twenty-eight rows. This assortment, of course, varied with the number of varieties tested and the number of vials per variety. In the apterous fecundity test of Experiment X a modified 10 x 10 Latin Square was used.

It was necessary to use five different locations for the fecundity experiments. Experiment I was run in a General Electric refrigerator with the thermostat set to maintain a temperature of about 60° F. when a 30 watt incandescent light bulb was kept burning in place of the usual regrigerator light. Experiments II and III with the various contemporary experiments on methods were carried on under a florescent desk lamp. The room under the north steps of Fairchild Hall was utilized for Experiment IV. The electricity was unavoidably shut off in this room on the evening of the fifth day, thus leaving the plants in darkness for the last fifteen hours of the experiment. Experiments V to VIII were run in the basement of Insectary No. 2. Due to cold temperatures in the basement, Experiment X was run in the third floor laboratory room of Fairchild Hall. The average temperature in all these places was about 80° F. during the experiments.

In Experiment VII the materials and methods used were similar to those used by R. G. Dahms when at Oklahoma Agricultural and Mechanical College.

These materials will be described under the methods. In the weight experiments the plants were grown in twelve inch pots. All the soil used was a mixture of six parts black bottom land clay, one part fine sand, and one part sheep manure. The plants of each pot were caged in glass cylinders that were eight inches in diameter and twelve inches high. The cylinders were covered with fine mesh cheese cloth. When enough time had elapsed after infestation of the pots to be reasonably certain that the adults were those that had been born on the plants, twenty or thirty greenbugs were removed and weighed. These greenbugs were examined with a binocular microscope at ten diameters magnification to definitely identify them as adults. A binocular microscope was used to select apterous forms in all the experiments where they were used. The aphids in the weight experiments were weighed on a Roller-Smith balance calibrated to .002 mg.

Methods

Varietal Fecundity Tests. The varietal effect on fecundity tests all followed a general pattern. As in all research there were tangible and intangible improvements, the latter were possible due to becoming more familar with the materials and more efficient in timing the steps of the method. Improvements in method did not give greater differences between varieties, but apparently showed that the differences present were due to varietal causes. The chronological order of the final method will be followed in reporting the method. The experiment number when each step was added will be given for all steps not followed in Experiment II. Once included in a variety test a step was usually maintained with the one exception that the number of water rinsings was reduced from two to one in Experiment V and those following.

In Experiment V and all following experiments the first step was to screen the wheat with a sixty-four square mesh per inch wire screen. Forty or fifty of the seeds that passed through this screen were weighed in lots of ten or twenty and the weights recorded to the nearest milligram. These kernels were placed into $2\frac{1}{4}$" x $3\frac{1}{2}$" kraft envelopes on which the name of the variety, number of kernels, and weight of kernels was recorded.

Seed treatments were started in Experiment II to inhibit fungus growth. A series of tests were run to determine which fungicide to use and at what dilution. The dilution must be emphasized for some fungicides impair, if not destroy, germination. Vancide 51 at dilutions of one and two per cent was chosen. These dilutions were made by mixing one milliliter of full strength solution with nine milliliters of water and then taking one milliliter of the mixed ten per cent solution and mixing it with nine milliliters of water. If a two per cent solution was desired the last dilution was changed to two milliliters of ten per cent solution and eight milliliters of water.

In treating the seed, the kernels from each variety were poured into an eight dram shell vial that contained at least five milliliters of the Vancide 51 solution. The vial was shaken vigorously for about a minute and then the Vancide solution was poured off and five milliliters of distilled water were poured into the vial. The vial was shaken until the seeds appeared to be rinsed and then the water was poured out. Another five milliliters of water were added and the seeds and water poured into a clean petri dish. A piece of filter paper or toweling with the variety name written on it with a soft lead pencil had been placed into the petri dish just before the seed was added. The second rinsing with distilled water was discontinued after Experiment V, and the first rinse water used to soak the seeds.

From thirty-six to forty-eight hours after the seeds were placed in the petri dishes the plants were of the best size for transferring to the vials. Transferring to the vials could be done as soon as the pericarp had ruptured and the plumule and primary root begun to elongate. Three sprouts per vial were used in order to reduce the effect that a single aberrant sprout might produce.

After Experiment IV, the cellucotton substrate in the vials was boiled either fifteen minutes with fifteen pounds pressure or in an open kettle for thirty minutes or more. After boiling the substrate material was immediately placed into a quart jar and left there until needed. The substrate was placed into the vials just before the sprouts were ready to be transferred. This was accomplished by tearing bits of the wet cellucotton from the jar and tamping the wad with an inverted cork that fitted snugly into the vial. The wad was tamped until it assumed the shape of a thick disc in the bottom of the vial.

The vials were covered with caps of dialyzing tubing as soon as the sprouts had been placed on the wet cellucotton substrata. A test of cork stoppers, cotton plugs, and caps formed from various types of dialyzing tubing resulted in the choice of the regenerated zephyr dialyzing tubing as being the most practical. After the vials were capped they were placed under the lights for two or three days until the sprouts had elongated enough to be infested. In Experiment II it was found that sprouts that were three or four centimeters in length were of the best size for infesting when the maximum number of nymphs produced was used as the criterion.

In the first four experiments leaves with heavy colonies of greenbugs on them were cut in the greenhouse and placed in a quart jar and carried to the place where the vials were being kept. In Experiments II, III, and IV

the aphids were anesthetized with CO_2 and spread out on 5" x 7" sheets of white paper in order to select the desired form. The forms were selected under a binocular microscope with magnifications of ten or thirty diameters. The selection of vials for infestation was random with care taken not to infest all the vials of one variety before most of the other vials of other varieties had been infested.

In Experiment V and those following the vials were taken to where the aphids were cultured. The pots containing heavy colonies were placed on the work table and some greenbugs shaken onto a white sheet of paper, from which the desired ones were immediately transferred to the vials. As soon as all the vials were infested the vials were arranged under the light in an order that would allow approximately equal amounts of light to enter each vial. In Experiment X, a modified Latin Square arrangement was followed for one series of the wheat variety tests. It was not possible to detect any differences in fecundity of the greenbugs due to the position of the vials within the Latin Square.

At the end of a given number of days, usually six, the plants were removed and the number of nymphs produced were counted. These counts included both live and dead nymphs with no effort being made to take separate counts of either because of the large number of nymphs that needed to be counted in a short period of time. During these counts notes were also taken of any abnormal conditions of the plants or the aphids.

In order to get a comparison with the method used by Dahms (unpublished data) for determining the fecundity of greenbugs a test similar to his was followed with six of the wheat varieties and the four barley varieties. In this test six inch flower pots containing soil of the usual mixture were used. In each pot three kernels were planted in each of three rows that

radiated out from the center of the pot. Each variety was planted in two such pots. When the seedlings emerged they were thinned to one plant in each of the rows or three plants per pot. Cages were placed over each plant. These cages were glass cylinders 1½ x 6 inches, with a cap made of dialyzing tubing formed in the same manner as described for the vial caps. The barley seedlings were infested eight days after planting and the wheat seedlings at nine days after planting. The average temperature in the basement during this test was 80° F. The height of the seedlings at infesting was at least five inches. One fourth instar alate nymph was placed in each cage. Counts of live adults were taken each day and the number of nymphs produced was counted after seven days on barley and after six days on wheat. It was difficult to find all the aphids because of the abundance of plant material and the black color of the soil.

Varietal Effects on Adult Mortality. In the first few tests the live adults were counted on the third or fourth day and at the end of the test. In these early tests it was sometimes difficult to determine the number of the original adults alive at the end of the test because in a few instances when apterous adults were used some of the nymphs produced had become apterous adults before the test was terminated. This source of error was eliminated by infesting with alate nymphs and terminating the test at the end of six days.

In order to get a better estimate of adult mortality, daily counts of live adults were begun with Experiment V. These counts were made without opening the vials whenever possible in order not to disturb the aphids. The danger in disturbing the aphids came from a few becoming entangled among the roots that grew above the cellucotton.

In Experiment VIII the original adults were maintained for twelve days by transferring them to new vials of the same varieties on the seventh day. In Experiment X the original adults were maintained for twenty days by transferring them on the fourth, ninth, and fifteenth day after infesting. By the end of the fifteenth day most of the original adults had died and therefore the results of the last four days are not included in the death rate table.

The tabular summary of the various materials and methods used in the principle fecundity and mortality experiments is given in Table 1. Most of the modifications were made in an effort to minimize the variability, particularly among the results with wheat. Plate I illustrates the arrangement of the vials in a tray under the lights and also the petri dishes after most of the seeds have been transferred to the vials.

Varietal Effects on Fecundity of Apterous Progeny. In order to determine whether there was any effect of the feeding of the greenbugs from one generation to the next, fecundity tests were run using apterous adults reared from alate adults when both were feeding on the same variety of wheat or barley. Two such tests were made using greenbugs on wheat and one on barley.

In Experiment VIII, twelve of the largest nymphs produced on each variety were transferred to four vials containing five day old sprouts of the same variety. The transfers were made eight days after the alate parents had been placed in the vials; therefore, none of the nymphs or adults were over eight days old. Daily counts were taken of the number of adults in each vial during the following five days to determine how many actual adult days were responsible for the number of nymphs produced.

In Experiment X the alate parents were moved from the first set of wheat vials after four days. The nymphs produced during these first four

Table 1. Summary of various materials and methods used in the principal fecundity and mortality experiments.[1]

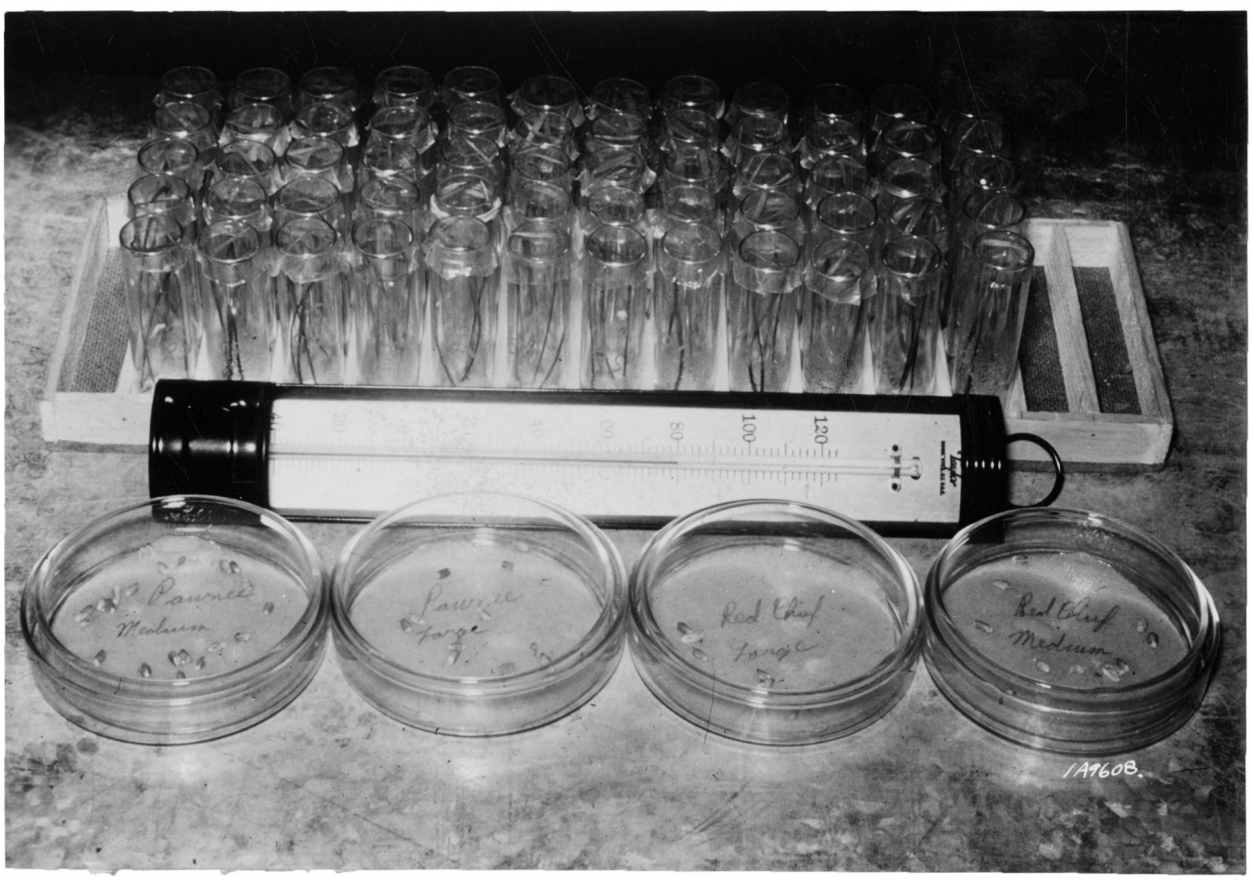
Experiment number / Conditions of experiments :	I	II	III	IV	V[2]	VI	VII[3]	VIII	Xa	Xb
No. of days aphids were in vials	7	7	6	6	6	6	6[4]	6	4	5
No. of vials per variety	9[5]	4	4	4	30	10	6[6]	10	8	4-5
No. of seedlings per vial	3[5]	1	3	3	3	3	1	3	3	3
No. of greenbugs per vial	3 or 5	1 or 3	3	3	3	3	1	3	3	3
Form of greenbugs used[1]	N	N,AA,WA	WN,AN	WN,AN	WN	WN	WN	WN	WN	WA
Immediate source of infesting material	Jar	Jar	Jar	Jar	Plant	Plant	Plant	Plant	Plant	Plant
Greenbugs cultured on	Wheat	Wheat	Wheat	Wheat	Barley	Barley	Barley	Wheat	Barley	[7]
Date vials were infested	12-8-53	1-21-54	3-5-54	4-6-54	8-6-54	8-13-54	8-21-54	10-8-54	1-4-55	1-8-55
Daily counts made of live adults	yes	no	no	no	yes	yes	yes	yes	yes	yes
Per cent Vancide 51 solution used in seed treatment	none	1%	1%	1%	1%	1%	1%	2%	2%	2%
Total Number of adults used	89	104	156	360	180	405	60	420	550	326
Total No. of nymphs produced	231	1352	808	2032	1531	1736	726	2124	2524	1983
No. of nymphs per adult female	2.7	13.0	5.2	5.6	8.5	7.2	12.1	5.1	4.6	6.1

[1] The following symbols were used: N-large nymphs, AA-apterous adults, AN-apterous adult producing nymphs WA-winged adults, and WN-winged adult producing nymphs.
[2] Experiment of size of seed effect on fecundity.
[3] Experiment using method similar to that used by Dahms in testing greenbug fecundity.
[4] The barley varieties were infested seven days.
[5] Petri dishes were used in this test instead of vials.
[6] Glass cages were used in this test instead of vials.
[7] These greenbugs were cultured on the same variety as in Experiment Xa.

EXPLANATION OF PLATE I

The arrangement of the vials in a tray under the lights and the petri dishes used in sprouting the seeds after most of the seeds have been moved from the dishes to the vials.

PLATE I


Pawnee Medium
Lawrie Large
Red Chief Large
Red Chief Medium
1A9608.

days were kept in these vials for five more days. They were then transferred to six or eight vials containing five day old seedlings of the same varieties. Because of the low humidity in the room some of the plants in the old vials were dry before the transfers could be made and therefore the aphids did not do well. The apterous nymphs of the barley varieties were transferred to new vials at the end of seven days after the original infestation. Five vials of Reno and three of each other variety were infested. These were all vigorous nymphs, that had not suffered from a food scarcity. The usual counts were taken for the next six days for both the wheat and barley test.

Tests to Determine Weight Differences. A simple test was developed in the greenhouse to determine whether there were any weight differences between apterous greenbug adults when raised on Pawnee or Dickinson wheat. This test was modified slightly and the weight differences caused by Reno, Dicktoo, and Kearney barley and the ten wheat varieties were determined. About fifty kernels of each variety of wheat were planted in a twelve inch flower pot and the pots placed in a large metal tray to be thoroughly soaked. The soil in these pots was of the same mixture described previously. The plants were caged in glass cylinders. These cylinders were eight inches in diameter and twelve inches high. The tops are closed with fine mesh cheese cloth.

After nine days the pots were each infested with an equal number of greenbugs. For the first test of Pawnee and Dickinson these were alate adults collected from the ceiling of the greenhouse, and most of these were removed after two days. In the test of the eight wheat varieties the infestation was from a small number of nymphs and adults. After eight days in the first test thirty apterous adults from each variety were weighed.

In the test of the eight wheat varieties thirty alate adults from each variety were weighed. The aphids were removed from the leaves with a camel's hair brush and the individual weights recorded to the nearest .002 milligram. The distribution of these weights was plotted and the group means compared by the "F" test.

The weight tests on barley were made on the three varieties mentioned above by caging plants of Dicktoo and Kearney that were growing in a flat, and a pot of Reno. The aphids were already on these varieties when they were caged. The cages were left on the plants for ten days and then twenty alate and twenty apterous adults of each variety were weighed as described above.

RESULTS

Non-Varietal Effects on the Biology of the Greenbug

Before the varietal effect on the biology of the greenbug could be evaluated properly, it was necessary to get some idea as to what effects environment would have on the biology. Also our methods needed to be evaluated. The purpose of Experiment I was to obtain answers to some of these problems. Table 2 summarizes the comparisons of lighting, number of females per dish used for infesting, and the differences in the two varieties, Pawnee and Denton. Extensive statistical evaluation of the data were not attempted because of the small number of samples in each group. The temperature during this test was lower than that used in subsequent experiments. It was observed that increasing the temperature to about 80° F. also increased the differences between the reaction of the varieties.

Table 2. Number of nymphs produced per introduced female, per day, over a period of seven days at 48° to 63° F. on Pawnee and Denton under various conditions of light and initial number of aphids.

Reared in	Original No. of aphids	Pawnee: Number of dishes	Pawnee: N/A/D	Denton: Number of dishes	Denton: N/A/D	Total: Number of dishes	Average: N/A/D[1]
Light	five nymphs	4	0.81	4	0.93	8	0.87
	three nymphs	2	1.16	2	0.95	4	1.06
	average	6	0.93	6	0.94	12	0.93
Dark	five nymphs	1	0.40	1	0.39	2	0.40
	three nymphs	2	0.49	2	0.17	4	0.33
	average	3	0.46	3	0.24	6	0.35
Grand Total or Avg.		9	0.77	9	0.71	18	0.74

[1] N/A/D is the number of nymphs produced per adult female per day.

In Experiment I petri dishes were used throughout the experiment. The reason for using vials instead of petri dishes in later experiments was that more vials could be placed in a smaller area and when capped with the transparent dialyzing tubing caps, the vials would each recieve approximately the same amount of illumination. Plant growth seemed to be more natural in vials. Another reason for using vials instead of petri dishes was that moisture condensed on the tops of the dishes where it presented a mechanical hazzard to the greenbugs and also encouraged the growth of microorganisms.

In Experiment II the length of sprouts that would favor the production of the maximum number of aphids and the form of greenbugs that might be used

as parental material were studied. The parental form producing the maximum number of nymphs with a minimum amount of variability was desired. The lengths of the sprouts, ranging from one to six centimeters, were recorded just after the parental aphids were placed in the vials. A scatter diagram of the number of nymphs produced on eight varieties of wheat and five varieties of barley indicated that sprouts of three to four centimeters in length at infestation produced a maximum number of nymphs. Alate and apterous adults used as infesting parents produced more young than did fourth instar nymphs, although these molted in less than twenty-four hours after being placed in the vials. When adult greenbugs were used as parental material, the number of nymphs produced in each vial varied greatly. This was sometimes due to some of the first nymphs produced becoming reproducing adults before the test was ended.

It had been suggested that the size of seed might influence the fecundity rate. Table 3 summarizes the data of Experiment V in which different sizes of seed of Pawnee and Red Chief were used. The weight of these seeds had an approximate 1:2:3 ratio. Differences in the number of nymphs produced per adult day were not significant. It was interesting to note that the trend was towards more nymphs being produced on sprouts of the smaller seed size.

Varietal Effects on the Fecundity of the Greenbug

There were only small differences in fecundity between the wheat varieties studied. Table 4 illustrates the type of differences observed. The arrangement of the table is according to the rank of the average number of nymphs produced per adult day for each variety. The variety, Dickinson, had the lowest rate. The average for each variety was obtained

Table 3. The effect of differing kernel weights of Pawnee and Red Chief wheat upon greenbug fecundity for the first six adult female days with a constant light source and an approximate temperature of 80° F.

Variety	Wt. of 50 ker.	Articles in rows	Vial 1	Vial 2	Vial 3	Vial 4	Vial 5	Vial 6	Vial 7	Vial 8	Vial 9	Vial 10	Total	Average
Pawnee	1723	Nymphs	21	5	16	28	35	18	26	25	17	35	226	22.6
		Adult days	12	9	11	16	18	12	15	18	13	17	141	14.1
		N/A/D[1]	1.75	0.56	1.45	1.75	1.94	1.50	1.73	1.39	1.31	2.06	15.4	1.54
Pawnee	1101	Nymphs	19	21	31	[2]	25	33	42	44	[2]	17	232	29.0
		Adult days	18	18	16	—	12	16	18	16	—	18	132	16.5
		N/A/D	1.06	1.17	1.94	—	2.08	2.06	2.33	2.75	—	0.94	14.3	1.79
Pawnee	560	Nymphs	38	24	37	25	28	42	39	16	30	26	305	30.5
		Adult days	14	18	18	13	15	18	16	14	18	17	161	16.1
		N/A/D	2.71	1.33	2.06	1.92	1.87	2.33	2.44	1.14	1.67	1.53	19.0	1.90
Red Chief	1773	Nymphs	26	9	11	38	21	16	20	38	50	29	258	25.8
		Adult days	16	14	12	18	12	8	17	17	18	16	148	14.8
		N/A/D	1.63	0.64	0.92	2.11	1.75	2.00	1.18	2.24	2.78	1.81	17.1	1.71
Red Chief	1100	Nymphs	16	30	18	37	[2]	17	28	23	30	20	219	24.3
		Adult days	15	15	16	18	—	9	15	18	18	10	134	14.9
		N/A/D	1.07	2.00	1.13	2.06	—	1.89	1.87	1.28	1.67	2.00	15.0	1.66
Red Chief	631	Nymphs	34	37	34	34	26	25	36	20	34	22	292	29.2
		Adult days	15	14	18	17	16	14	18	15	16	15	158	15.8
		N/A/D	2.27	1.93	1.89	2.00	1.63	1.79	2.00	1.33	2.13	1.47	18.4	1.84

[1] Nymphs produced per adult per day.
[2] Data lacking because of the development of microorganisms in vial.

by totaling the nymphs per adult day ratio for each vial and dividing the total by the number of vials of the variety. This generally gave a lower ratio than dividing the total number of nymphs produced on a variety by the total number of adult days, but did not effect the rank of the varieties, and allowed the ratio to be evaluated statistically. The "F" test for this experiment indicated significance. The least significant difference at the .05 level indicated that Dickinson had a lower fecundity rate than Red Chief, Triumph, and Kiowa, and that Kiowa had a significantly higher rate than all the other varieties except Red Chief and Triumph. Ponca and C.I. 12804 had a significantly lower fecundity rate than Triumph in this test.

The summary of greenbug fecundity on wheat for the principle experiments is given in Table 5. As can be seen in Table 1, daily counts of live adults were not made in Experiments III and IV; therefore, the nymphs per adult day ratio had to be estimated and no allowance was made for varying mortality rates. In these two experiments both the nymphs per female and the nymphs per adult day ratios are a combination of fecundity and adult mortality factors. The estimates were lower than the actual ratios because the maximum number of adult days was used in the estimate. Much of the difference in the nymphs per adult day ratios in the various experiments is due to differences in methods used from one experiment to another. As far as was otherwise known the nymphs per adult day ratio measured only fecundity.

The arrangement of the varieties in Table 5 is by average rank of the fecundity ratio in all the experiments. Dickinson had the lowest fecundity ratio and was given the highest rank. Statistical evaluation of this table was not attempted since no suitable method was known. The

Table 4. Fecundity of greenbugs on ten wheat varieties for the first six days in Experiment VI.[1]

Variety	Wt. of 40 ker. in mg.	Number in rows	Vial 1	Vial 2	Vial 3	Vial 4	Vial 5	Vial 6	Vial 7	Vial 8	Vial 9	Vial 10	Total	Average
Dickinson	885	Nymphs	9	17	23	16	26	21	31	17	6	30	196	19.6
		Adult days	13	17	15	18	13	18	18	15	7	18	152	15.2
		N/A/D	0.7	1.0	1.5	0.9	2.0	1.2	1.7	1.1	0.9	1.7	12.7	1.27
C.I. 12804	822	Nymphs	6	28	21	8	32	22	23	25	25	32	222	22.2
		Adult days	11	16	14	10	17	13	17	16	17	18	149	14.9
		N/A/D	0.6	1.8	1.5	0.8	1.9	1.7	1.4	1.6	1.5	1.8	14.6	1.46
Ponca	893	Nymphs	10	7	[3]	[3]	32	20	17	32	15	15	148	18.5
		Adult days	12	12	—	—	13	13	9	18	11	13	101	12.6
		N/A/D	0.8	0.6	—	—	2.5	1.5	1.9	1.8	1.4	1.2	11.7	1.46
Pawnee	834	Nymphs	7	[3]	24	32	27	28	17	27	23	30	215	23.9
		Adult days	14	—	14	18	15	18	14	15	18	18	144	16.0
		N/A/D	0.5	—	1.7	1.8	1.8	1.6	1.2	1.8	1.3	1.7	13.3	1.48
Concho	831	Nymphs	36	28	28	28	22	13	26	27	15	22	245	24.5
		Adult days	18	15	15	17	14	16	13	17	18	14	157	15.7
		N/A/D	2.0	1.9	1.9	1.7	1.6	0.8	2.0	1.6	0.8	1.6	15.9	1.59
Wichita	896	Nymphs	21	[3]	26	[3]	26	26	24	20	22	17	182	23.5
		Adult days	13	—	13	—	16	16	15	13	13	15	114	16.0
		N/A/D	1.6	—	2.0	—	1.6	1.6	1.6	1.5	1.7	1.1	12.7	1.59
Comanche	843	Nymphs	20	35	2	29	22	33	35	26	16	29	247	24.7
		Adult days	17	16	5	15	16	16	17	14	12	17	145	14.5
		N/A/D	1.2	2.2	0.4	1.9	1.4	2.1	2.1	1.9	1.3	1.7	16.2	1.62
Red Chief	864	Nymphs	8	28	35	42	2	26	36	47	11	37	272	27.2
		Adult days	14	15	18	18	5	16	17	16	8	18	145	14.5
		N/A/D	0.6	1.9	1.9	2.3	0.4	1.6	2.1	2.9	1.4	2.1	17.2	1.72
Triumph	860	Nymphs	26	32	7	[3]	35	25	25	44	20	38	252	28.0
		Adult days	16	17	8	—	16	15	14	16	12	18	132	14.7
		N/A/D	1.6	1.9	0.9	—	2.2	1.7	1.8	2.8	1.7	2.1	16.7	1.86
Kiowa	916	Nymphs	24	22	[3]	13	56	35	63	32	51	32	328	36.4
		Adult days	15	18	—	18	16	18	18	18	18	15	154	17.1
		N/A/D	1.6	1.2	—	0.7	3.5	1.9	3.5	1.8	2.8	2.1	19.1	2.13
												L. S. D. at .05 =		0.38

[1] See Table 1 for additional conditions of experiment.
[2] Nymphs produced per adult day.
[3] Data lacking because of the development of microorganisms in vial.

Table 5. Summary of nymphs per adult day data for the principal experiments involving greenbug fecundity on eleven varieties of wheat.[1]

Variety	Number in row	Experiment Number III	IV	VI	VII	VIII	Xa	Xb[2]	Average of Variety named	Average of Ponca in same tests
Dickinson	Females in test[3]		27	30	6	30	40	20		
	Nymphs per female		3.11	6.53	8.83	3.27	2.58	3.45		
	Nymphs/adult/day		0.52*	1.27	1.69	1.27	1.25	1.55	1.26	1.27
Denton	Females in test	12	30							
	Nymphs per female	2.67	4.40							
	Nymphs/adult/day	0.44*	0.73*						0.59	0.67
Ponca	Females in test	12	30	24	6	30	40	21		
	Nymphs per female	4.08	3.93	6.17	9.67	3.83	3.38	2.14		
	Nymphs/adult/day	0.68*	0.66*	1.46	1.67	1.36	1.46	1.00	1.18	1.18
C.I. 12804	Females in test	12	27	30	6	30	40	29		
	Nymphs per female	3.17	5.74	7.40	8.50	5.67	3.92	1.34		
	Nymphs/adult/day	0.53*	0.96*	1.46	1.77	1.48	1.29	1.37	1.26	1.18
Pawnee	Females in test	12	30	27		30	35	22		
	Nymphs per female	4.17	6.63	7.96		4.57	4.29	3.77		
	Nymphs/adult/day	0.69*	1.11*	1.48		1.32	1.50	1.10	1.20	1.10
Comanche	Females in test	12	24	30		27	40	27		
	Nymphs per female	5.17	4.79	8.23		3.59	4.83	4.22		
	Nymphs/adult/day	0.86*	0.81*	1.62		1.38	1.74	1.56	1.33	1.10
Triumph	Females in test			27	6	30	40	17		
	Nymphs per female			9.33	8.00	5.27	3.13	4.76		
	Nymphs/adult/day			1.86	1.71	1.60	1.55	1.30	1.60	1.39
Concho	Females in test	12		30		30	40	22		
	Nymphs per female	4.75		8.17		5.27	3.00	4.45		
	Nymphs/adult/day	0.79*		1.59		1.61	1.18	1.73	1.38	1.19
Wichita	Females in test	12	30	24		30	35	30		
	Nymphs per female	6.92	5.57	7.58		6.43	4.31	5.97		
	Nymphs/adult/day	1.15*	0.93*	1.59		1.69	1.41	1.48	1.38	1.10
Red Chief	Females in test	9		30	6	30	40	27		
	Nymphs per female	6.56		9.07	10.17	4.57	5.15	5.52		
	Nymphs/adult/day	1.09*		1.72	2.08	1.38	1.82	1.56	1.63	1.27
Kiowa	Females in test			27	6	30	40	17		
	Nymphs per female			12.15	12.00	5.10	3.18	5.88		
	Nymphs/adult/day			2.13	2.28	1.75	1.38	1.85	1.84	1.39

[1] See Table 1 for conditions of experiments. * estimated by using total possible adult days.
[2] These are the same females as in Experiment Xa for the period from the fifth to tenth day.
[3] Only females from vials where there was reproduction were counted.

variances for Experiments VI, VIII, Xa, and Xb were .316, .301, .277, and .276 respectively. It might be possible to divide the wheat varieties into three groups in relation to their effect on fecundity. Dickinson, Denton, and Ponca would be in the first group having a low fecundity rate. Pawnee, C.I. 12804, Comanche, Triumph, Concho, and Wichita would be in the group with an intermediate effect on fecundity. Greenbugs feeding on Kiowa and Red Chief seem to have an above average fecundity.

The differences in effect of greenbug fecundity was greater among the barley varieties studied. Table 6 gives the results of the barley varieties studied in Experiment VIII. The nymphs per adult day ratio for all the barley varieties was the lowest in this experiment. The arrangement of Table 6 is comparable to Table 4. In most experiments the nymphs per adult day ratio for Dicktoo and Omugi were lower than for any of the wheat varieties in the same experiment, and the same ratio for Reno and Beecher were higher than any of the wheat varieties. The difference between the fecundity on these two groups of barley varieties is highly significant for Table 6, and the same is true for most of the other experiments.

Table 7 summarizes the fecundity on different varieties of barley in a similar manner to that of Table 5 for the wheat varieties. It was not possible to demonstrate a significant difference between Dicktoo, Kearney, or Omugi. The high estimated fecundity ratio for Kearney in Experiment III was attributed to a much lower mortality rate than either Dicktoo or Omugi had in the same experiment as can be seen in Table 12. Kearney was not included after Experiment IV because it was felt that Kearney was so nearly like Dicktoo in its reaction to greenbugs that the space and time could be more profitably spent in studying some other variety. The same was true of the relationship between the reactions of Reno and Ward. It was not possible

to find significant differences in the fecundity rates among the varieties Ward, Reno, and Beecher. Dobaku was known to have tolerance to greenbugs and its fecundity ratio in Experiment IV was more nearly like the resistant varieties than like Reno. The barley varieties formed two distinct groups with the results of the fecundity rate differences being significant in all the experiments summarized in Table 7.

Table 6. Fecundity of greenbugs on four barley varieties for the first six days in Experiment VIII.[1]

Variety	Articles in rows	Vial 1	Vial 2	Vial 3	Vial 4	Vial 5	Vial 6	Vial 7	Vial 8	Vial 9	Vial 10	Total	Average
Dicktoo	Nymphs	10	18	1	10	11	14	18	23	5	10	120	12.0
	Adult days	10	15	7	17	11	10	16	18	13	14	131	13.1
	N/A/D[2]	1.0	1.2	0.1	0.6	1.0	1.4	1.1	1.3	0.4	0.7	8.8	0.88
Omugi	Nymphs	19	14	14	4	20	4	24	36	11	8	154	15.4
	Adult days	17	10	15	9	17	6	16	18	7	11	126	12.6
	N/A/D	1.1	1.4	0.9	0.4	1.2	0.7	1.5	2.0	1.6	0.7	11.5	1.15
Reno	Nymphs	40	34	30	10	19	7	24	18	21	10	213	21.3
	Adult days	17	12	11	18	12	6	18	11	11	5	121	12.1
	N/A/D	2.4	2.8	2.7	0.6	1.6	1.2	1.3	1.6	1.9	2.0	18.1	1.81
Beecher	Nymphs	35	55	16	16	3	25	33	35	3	[3]	221	24.6
	Adult days	18	18	12	11	1	15	18	17	6	—	116	12.9
	N/A/D	1.9	3.1	1.3	1.5	3.0	1.7	1.8	2.1	0.5	—	16.9	1.88
											L.S.D. at .05 =		0.56

[1] See Table 1 for additional conditions of experiment.
[2] Nymphs produced per adult per day.
[3] Data lacking because of the development of microorganisms in vial.

Table 7. Summary of nymphs per adult day for principal experiments involving greenbug fecundity on seven varieties of barley.

Variety	Number in Row	Experiment Number III	IV	VI	VII[1]	VIII	Xa	Average of Variety named	Average of Reno in same tests
Dicktoo	Females in test[2]	12	27	24	6	30	35		
	Nymphs per female	1.92	7.56	5.13	9.83	4.00	5.97		
	Nymphs/adult/day	0.32*	1.27*	1.03	1.48	0.88	1.23	1.03	2.29
Omigi	Females in test	9	30	12	6	30	40		
	Nymphs per female	1.33	4.57	5.08	14.33	5.13	6.98		
	Nymphs/adult/day	0.22*	0.76*	1.15	2.07	1.15	1.50	1.14	2.29
Kearney	Females in test	12	30						
	Nymphs per female	9.00	7.00						
	Nymphs/adult/day	1.50*	1.17*					1.33	1.66
Dobaku	Females in test		30						
	Nymphs per female		7.90						
	Nymphs/adult/day		1.32*					1.32	1.69
Ward	Females in test	12							
	Nymphs per female	9.83							
	Nymphs/adult/day	1.64*						1.64	1.63
Beecher	Females in test			15	6	27	15		
	Nymphs per female			8.33	19.50	8.19	12.60		
	Nymphs/adult/day			2.08	3.04	1.88	2.67	2.42	2.60
Reno	Females in test	12	27	27	6	30	20		
	Nymphs per female	9.75	10.15	13.04	20.17	7.10	11.35		
	Nymphs/adult/day	1.63*	1.69*	2.46	3.39	1.81	2.73	2.29	2.29

[1] Experiment VII had only one female per cage and the plants were growing in soil for eight days before being infested.
[2] Only females from vials where there was reproduction were counted.
[3] In Experiment Xa there were five female adults per vial.
* Estimated by dividing the number of nymphs by the total possible adult days.

It was felt that the varietal effect on fecundity might be cumulative. Two approaches to this idea were investigated: (1) the fecundity rate of apterous females reared from alate parents feeding in vials on the same variety of wheat and barley were studied: and (2) alate adult fecundity on wheat was studied for most of the life span and on barley for eighteen days.

Table 8 summarizes the results for the first part of this approach. The experiment numbers are the same as for those in which the alate parents were studied. The apterous fecundity Experiment Xa was an anomaly. Plans had been made to transfer the apterous parental nymphs or adults eight days after the alate infestation, but the writer was too ill to make the transfers until late on the ninth day. Be the ninth day some of the aphids were obviously undernourished, and to further complicate matters the humidity in the room had gone down enough to dry out some of the vials. The Dickinson vials had fewer nymphs to begin with and therefore were not effected as much as some of the other varieties. The wheat results for Experiment Xa were included for completness and present little proof of the hypothesis. Headlee (1914) gave the daily fecundity rate of apterous females on wheat as 3.1 at 80° F. The apterous fecundity rate in Experiment Xa was generally lower than the expected fecundity rate of such females. The apterous female producing nymphs used in Experiment VIII on wheat and in Experiment X on barley were apparently all of equal vigor.

The following comparisons were made from the results of Experiment VIII. Dickinson has a lower apterous fecundity rate than all the varieties studied except Ponca, Concho, and Red Chief. Ponca, Concho, Red Chief and Comanche have significantly lower fecundity rates than Triumph and Kiowa. In general the results obtained for the apterous females feeding on the same wheat variety for their entire life span would indicate that varietal effects

Table 8. Fecundity of apterous greenbugs for the first six adult days on different varieties of wheat and barley sprouts. These apterous females were reared in vials from alate parent females feeding on sprouts of the same variety.[1]

Wheat varieties	Experiment VIII[2] Females in test	Nymphs produced per Female	Nymphs produced per Female day	Experiment Xa Females in test	Nymphs produced per Female	Nymphs produced per Female day	Barley varieties	Experiment Xa Females in test	Nymphs produced per Females	Nymphs produced per Female day
Dickinson	12	7.25	1.98	24	14.83	2.38[3]	Dicktoo	9	19.44	3.23
Ponca	12	6.08	2.73	21	5.67	1.80	Omugi	9	22.44	3.73
Comanche	12	9.83	3.25	24	6.83	1.64	Reno	15	26.00	4.74
Pawnee	12	15.75	3.50	18	6.94	1.55	Beecher	9	26.56	4.90
Red Chief	12	10.83	3.03	18	11.72	2.03				
Concho	6	11.83	2.55	21	13.19	2.73				
Wichita	6	19.00	3.80	12	5.58	1.75				
C.I. 12804	12	17.67	3.98	24	9.29	2.08				
Triumph	12	23.00	4.68	21	5.90	1.67				
Kiowa	12	22.83	4.58	18	14.50	3.05				
	L.S.D. = 1.21 at .05			L.S.D. = 1.04 at .05				L.S.D. = 1.01 at .05		

[1] In all three experiments three apterous females were placed in each vial and the conditions were similar to those used for alate females in comparable tests.

[2] This experiment lasted only five days.

[3] Part of the differences in this column may be due to the condition of the plants on which the parental females were reared.

are similar to those of their alate parents feeding on the same variety during the adult period only. Possible exceptions to this rule were noted in the fecundity rates of C.I. 12804 and Red Chief.

The differences among the barley variety results were significant. The distinct differences indicate that the barley varieties have a comparable effect on greenbug fecundity for both the first and second generation. A small number of parental apterous nymphs were used, but the variance was relatively small and therefore the differences could be shown.

The approximate life time greenbug fecundity on wheat was summarized in Table 9. The arrangement of the varieties is according to the fecundity rate when calculated by dividing the total number of nymphs produced by the total number of adult days for the variety. Significant differences among the varieties occurred only in the second period. The first period was the one in which most of the nymphs were produced. The effects of this period on the final results can be seen by observing the number of nymphs produced by Kiowa and Comanche in the first period. The mortality rate naturally tends to complicate these results. The fecundity rate decreased sharply after the second period and in the fourth period only eight nymphs were produced in thirty-five adult days. The reaction of Concho should be attributed to a higher mortality rate than it usually had. Other varietal evaluations will be made in the discussion.

The fecundity of alate greenbug females on the four barley varieties for eighteen days is given in Table 10. There was poor germination of seed of some of the varieties and therefore eight vials were not used for each variety. The experiment was not continued for the entire life time of the adults because of intrinsic difficulties. Forty-three of the original 110 females were still alive at the end of the eighteenth day. The varietal

Table 9. Fecundity of greenbugs on ten wheat varieties for a period approximating the adult life span.[1]

Adult days:	First to fourth			Fifth to tenth			Eleventh to Fifteenth			Sixteenth to twentieth			Total		
Wheat varieties	No. of young	Adult days	N/A/D[2]	No. of young	Adult days	N/A/D[2]	No. of young	Adult days	N/A/D[2]	No. of young	Adult days	N/A/D[2]	No. of young	Adult days	N/A/D[3]
Dickinson	103	83	1.25	69	45	1.55	12	24	0.50	0	5	0.00	184	157	1.17
C. I. 12804	157	124	1.29	39	26	1.37	21	28	0.70	4	5	0.50	221	183	1.21
Ponca	135	92	1.46	45	43	1.00	1	13	0.06	0	0	0.00	181	148	1.22
Pawnee	152	90	1.50	83	75	1.10	10	34	0.28	0	0	0.00	245	199	1.23
Triumph	125	84	1.55	81	61	1.30	2	14	0.17	0	0	0.00	208	159	1.31
Wichita	159	102	1.41	179	119	1.48	21	49	0.38	0	1	0.00	359	264	1.36
Kiowa	127	96	1.38	100	56	1.85	32	33	0.93	1	2	0.50	260	189	1.38
Concho	120	97	1.18	98	52	1.73	4	9	0.50	0	0	0.00	222	158	1.41
Comanche	193	111	1.74	114	70	1.56	44	49	0.77	2	10	0.15	353	240	1.47
Red Chief	206	110	1.82	149	94	1.56	65	62	1.00	1	12	0.15	421	278	1.51

[1] Only one female was alive on Comanche and three on Red Chief at the end of the twentieth day. Conditions are those given for Experiment X, in Table 1.

[2] Average of nymphs produced per adult day for all vials of the variety.

[3] Total number of nymphs produced on the variety divided by the total number of adult days on the variety.

Table 10. Fecundity of greenbugs on four barley varieties for up to eighteen adult days.[1]

Adult days[2]	First to sixth			Seventh to twelveth			Thirteenth to Eighteenth			Total		
Barley varieties	Nymphs produced	Adult days	N/A/D[3]	Nymphs produced	Adult days	N/A/D[3]	Nymphs produced	Adult days	N/A/D[3]	Nymphs produced	Adult days	N/A/D[4]
Omugi[5]	279	186	1.50	236	133	1.86	78	52	1.40	593	371	1.60
Dicktoo[6]	209	164	1.23	264	101	2.76	131	61	2.10	604	326	1.85
Beecher[7]	189	73	2.67	178	65	2.77	93	39	2.37	460	177	2.60
Reno[8]	227	82	2.73	269	103	2.50	212	82	2.45	708	267	2.65

1 See Table 1 for conditions of Experiment X.
2 A few of the vials were transferred a day early or late.
3 Average of nymphs produced per adult day for all vials of the variety.
4 Total number of nymphs produced on the variety divided by the total number of adult days.
5 There were 40 females on Omugi at the beginning of the test.
6 There were 35 females on Dicktoo at the beginning of the test.
7 There were 15 females on Beecher at the beginning of the test.
8 There were 20 females on Reno at the beginning of the test.

differences in fecundity rate are significant for only the first period. The lack of significance in the following periods was attributable to the increased fecundity of the females on Dicktoo. When the fecundity rates on the various barley varieties was compared with that of the wheat varieties for similar periods it was observed that there was not as noticable a decline in the fecundity rate among the barley varieties as among the wheat varieties.

Varietal Effects on Greenbug Mortality

Table 11 lists the number of parent females alive for each variety for the first fifteen days in Experiment X. In all experiments where this phenomenon was studied it was difficult to interpret the results for the different varieties. No defect in the methods used was found to explain the differences in rank of some of the wheat varieties from one test to another, although the influence of microorganisms sometimes appeared to be the cause. A chi-square test comparing the effects of the wheat and barley varieties on greenbug mortality in this experiment was highly significant. Similar results have been obtained for most of the experiments as may be seen by studying Table 12.

Table 12 summarizes the per cent of adult females dying during the first six days after infestation on the different varieties of wheat and barley. The number of females in the test was actually the number placed in the vials minus those apparently dying from the effect of microorganisms on the plant or on the aphids.

The high percentage dying in Experiment III was probably attributable to not sterilizing the substrate. The parental females used in Experiment VI were cultured on barley and this might explain the lower overall

Table 11. Daily counts taken during Experiment X of live alate greenbugs on varieties of wheat and barley. Numbers are total living adults left each day from an original infestation of eight vials per variety and five last instar nymphs per vial.

Variety	Days after infestation 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Concho	39	27	24	22	17	12	11	7	5	3	2	2	1	1	0	173
Ponca	38	33	28	21	13	9	8	7	6	5	3	3	2	0	0	176
Dickinson	34	28	26	20	15	10	9	6	6	5	5	4	4	4	2	178
Triumph	36	28	22	17	14	12	12	12	11	7	4	1	1	1	0	178
Kiowa	40	28	21	17	13	12	12	10	9	9	9	6	4	3	2	195
Pawnee	36	32	25	22	16	15	15	15	14	13	9	5	3	2	2	224
C.I. 12804	39	38	36	29	17	11	10	9	9	7	6	4	4	4	3	226
Comanche	39	38	33	27	20	15	13	12	10	10	10	8	8	7	6	256
Red Chief	36	30	28	27	25	20	19	16	14	14	11	10	10	9	8	277
Wichita	37	32	30	30	27	27	26	22	22	16	15	6	5	4	3	302
Wheat Total	374	314	273	232	177	143	135	116	106	89	74	49	42	35	26	2185
Dicktoo[1]	34	34	34	34	28	22	19	19	17	17	15	14	14	14	13	328
Omugi	40	37	36	31	29	27	26	23	23	23	16	16	14	14	14	369
Beecher[2]	13	13	12	12	12	12	11	11	11	11	11	10	8	8	8	163
Reno[3]	20	18	16	15	15	15	15	15	15	15	15	15	14	14	14	231
Barley Total	107	102	98	92	84	76	71	68	66	66	57	55	50	50	49	1091

[1] Only seven vials.
[2] Only three vials.
[3] Only four vials; reduced number of replications in some barley varieties due to poor germination.

Table 12. Percent of adult females dying by the sixth day after infestation on the different varieties.

Experiment No.	III		IV		VI		VII		VIII		X	
Wheat varieties	females in test	% dying	females in test	% dying	females in test	% dying	females in test	% dying	females in test	% dying	females in test	% dying
Comanche	12	83	30	67	30	47			30	77	40	63
Ponca	12	83	30	57	24	54	6	0	30	70	40	75
Denton	12	92	30	57								
Dickinson			30	70	30	27	6	0	30	70	40	75
C.I. 12804	12	83	30	50	30	43	6	33	30	67	40	73
Concho	12	75			30	33			30	63	40	70
Wichita	12	83	30	60	30	57			30	53	40	35
Triumph					30	37	6	17	30	57	40	70
Kiowa					27	15	6	0	30	80	40	70
Pawnee	12	83	30	30	27	30			30	57	40	63
Red Chief	12	58			30	33	6	0	30	63	40	50
Barley varieties												
Omugi	12	92	30	47	21	71	6	17	30	43	40	33
Dicktoo	12	92	27	41	27	44	6	33	30	30	35	37
Beecher					27	63	6	0	30	37	15	20
Kearney	12	50	30	40								
Reno	12	67	30	27	30	27	6	33	30	30	20	25

percentage in this test as compared to Experiments IV and VIII. The source on which the parental aphids were cultured seems to influence the fecundity and mortality rate even after the aphids are transferred to another variety. The number of females in Experiment VII was too small to produce an adequate distribution. The females in Experiment X were transferred to different vials on the fourth day and this increased the mortality slightly.

The arrangement of the varieties in Table 12 was made by averaging the per cent dying for each experiment and placing the varieties in the order of their decreasing mortality rates. Comanche had the highest average percentage. The barley varieties were arranged separately, but with the exception of Omugi all had a lower rate than any of the wheat varieties. The higher rate for the barley varieties in Experiment VI was attributed to a higher incidence of seed borne microorganisms that were not killed as effectively by the seed treatment. It was observed that the hulls over the barley caryopsis made it more difficult to do a thorough job of killing all the microorganisms.

Varietal Effects on Adult Greenbug Weight

In the first weight test, apterous adult females reared on Pawnee and Dickinson were compared. These females were between six and eight days old. The mean weight of the apterous females reared on Dickinson was .163 mg. and the mean of the females reared on Pawnee was .230 mg. The "t" test indicated that the differences between the two means was highly significant. The apterous aphid weight variance was much less among the females o wheat than it was among the females on barley.

In another weight test both apterous and alate adults feeding on Reno, Dicktoo, and Kearney were compared. The weight distributions in

.04 mg. classes were graphed in Fig. 1. Twenty females of each form were weighed from each of the varieties. Both the alate and apterous adults on Reno were significantly heavier than both the alate and apterous adults on either Dicktoo or Kearney. There was only a small difference between the mean weights of the alate and of the apterous females reared on Dicktoo and Kearney. The variance of the apterous weights was about six times as great as the variance of the alate weights. The greater apterous variance was, no doubt, attributable in part to the extremely large females that were part of the sample. There was no way of determining the age differences of the females in the sample. The large ones were darker green than the rest of the females. They may have been old or not normally reproductive.

An effort was made to determine the weight of alate female adults on ten of the wheat varieties. The mean weights of females from eight of the varieties were plotted in Fig. 2. The other two varieties, Triumph and Wichita, had not produced enough alate forms to be compared with the other varieties before the plants were killed by the greenbugs. The alate females on Dickinson, Ponca, and Pawnee weighed significantly less than those of the other varieties. The females on Kiowa weighed more than those of any of the other varieties. The few alate females which were weighed from the Wichita and Triumph plants appeared to have about the same weight distribution as the females on Concho or Red Chief.

DISCUSSION

In the studies of greenbug fecundity and mortality there was a considerable amount of variability of results. Some of this variability was, no doubt, attributable to the method used. Edaphic factors were

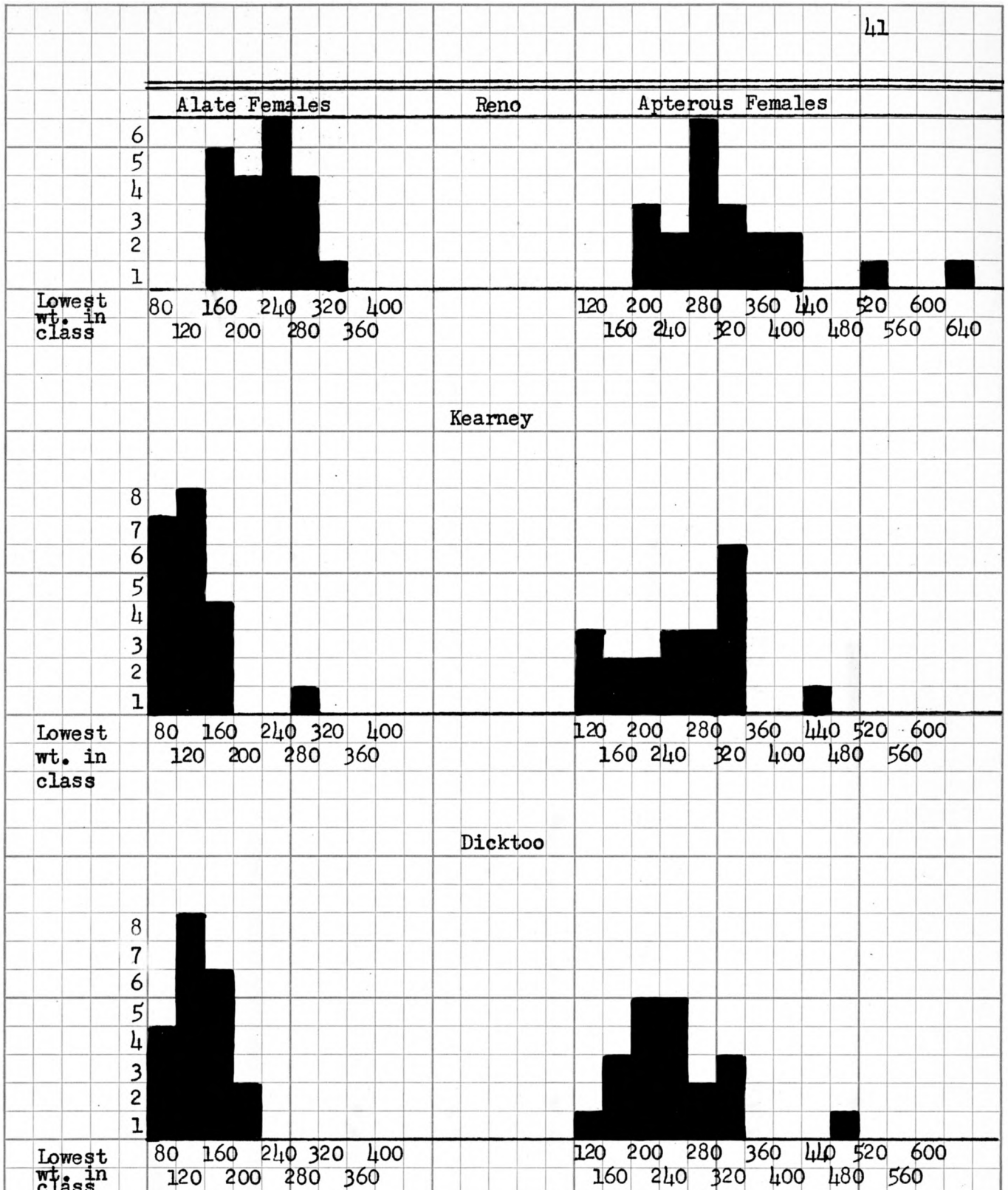
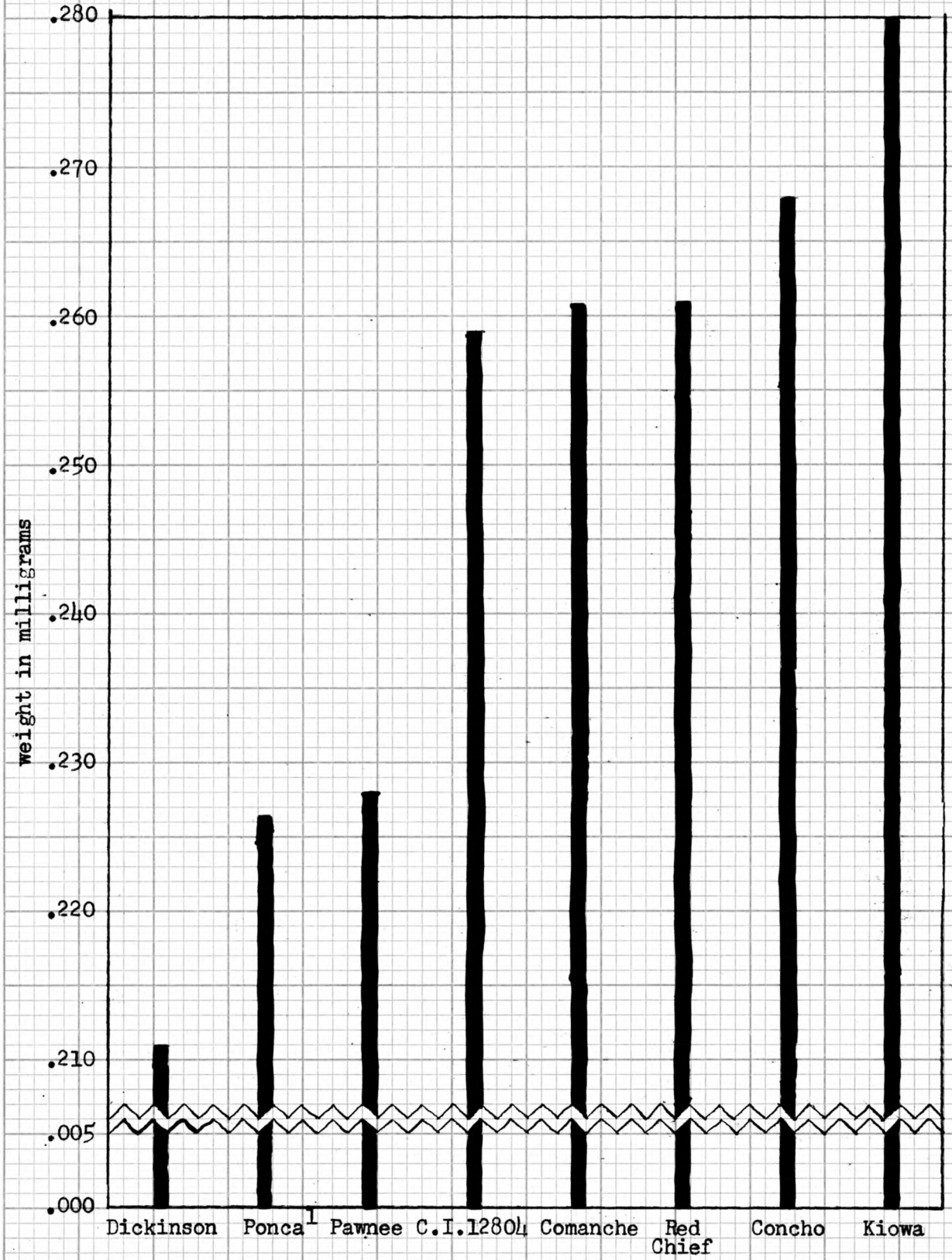


Fig. 1. Weight distribution in .04 mg. classes of apterous and alate greenbug female adults feeding on Reno, Dicktoo, and Kearney barley plants.



[1] Only twenty greenbugs were weighed on Ponca.

Fig. 2. Mean weight of thirty alate female adults on eight wheat varieties.

eliminated so that the effects of the seed contents alone could be studied, but the abnormal environment necessary to accomplish this may have increased the variability of results. Dahms (1948) has compared the tolerance of small grains to greenbugs from Oklahoma and Mississippi, but no studies of the variability within the local population were known. Such variability was considered to be small since parthenogenetic vivparous females make up almost the entire population. Another possible source of variability was the seed. Only Omugi has been selected for its greenbug resistance. Even though the seeds used were all from apparently pure self-pollenated varieties, it is still possible to have mixtures derived either from natural hybrids or mechanical mixtures. It might be that there are several genes that influence the physiology of the plant in such a manner as to produce antibiotic effects on the greenbug.

The effect of light on greenbug fecundity was noted in Experiment I, but whether it is the physiology of the plant or the activity of the aphid that results in the difference was not determined. Greenbugs caged on albino barley seedlings appear to feed and reproduce normally until the endosperm is depleted and the seedling dies. This might indicate that the immediate products of photosynthesis or the chlorophyll that is broken down are not essential in the cereal hosts of the greenbug. Although no significant differences were observed in the size of seed experiment summarized in Table 3, the tendency for more nymphs to be produced on less vigorous plants needs further investigation. It may be that there is a need for a definite concentration of salivary secretion from the aphid colony into the plant before the optimum nourishment can be acquired.

When statistical methods were used, they were those described by Snedecor (1953). Table 13 summarizes the statistical results of the

principle mortality and fecundity experiments. Some of the variations in the significance of the tests were related to changes in methods. Among the varieties of wheat and barley studied it would seem that there were greater differences in fecundity among the barley varieties, and in mortality among the wheat varieties. The chi square test of mortality gave rather crude results since only homogeneity could be tested.

A total of 3,613 parental greenbug females were placed into 1,136 vials during this study. These females produced a total of 23,714 nymphs while in the vials. To determine the death rate, 10,305 adult day counts were taken on 2,756 of the parental females in the vials. Individual weighings of 480 apterous and alate adult females were made during the weight studies.

No statistical constant was found to compare the varieties in all the tests in relation to the mortality rate, but the wheat varieties could be divided into three possible groups: Comanche, Ponca, Denton, and Dickinson might be placed in the first group causing an above average greenbug mortality rate; C.I. 12804, Concho, Wichita, and Triumph in the average group; and Pawnee, Kiowa, and Red Chief in the third group causing a lower than average mortality rate. The mortality rate of Omugi was usually the highest and that of Reno the lowest among barley varieties studied. The differences among the mortality rates of greenbugs on barley were not significant in most tests. A significantly lower mortality of greenbugs when feeding on barley as compared with wheat was observed and may be part of the reason why susceptible varieties of this crop are sometimes more severely damaged than the wheat crop in the same area. A well planned and executed procedure to study this phenomenon in more detail is needed.

Table 13. Statistical evaluation of greenbug fecundity and mortality data.[1]

Experiment Number	Number of varieties of: Wheat	Barley	Chi square value of 6 day adult mortality on: Wheat	Barley	"F" test value of number of nymphs produced or N/A/D[2] on: Wheat	Barley
I	2	4	.94	4.98	—	—
II	8	5	6.11	7.67	.22	.93
III	8	5	5.15	10.00*	.72	5.52**
IV	7	5	12.61*	2.72	2.25*	2.86*
V	2	0	5.81		1.02	
VI	10	4	21.19**	13.24**	2.05*	11.47**
VII	6	4	13.34*	3.18	.44	4.33*
VIII	10	4	9.06	1.62	1.05	6.15**
VIII[3]	10	0	23.59**		4.27**	
Xa	10	4	29.20**	2.21	1.13	13.76**
Xb	10	4			1.20	1.06
Xc	10	4			.79	1.49
X[3]	10	4	30.33**	7.80	2.05*	6.29*

[1] See Table 1 for conditions of experiments.
[2] Nymphs produced per adult day.
[3] Test of apterous adults produced by alate adults in same experiment.

The greenbug fecundity rate on Dicktoo and Omugi was significantly lower than that on Reno and Beecher. Kearney and possibly Dobaku would belong in the low fecundity group of barleys. Ward had a fecundity rate similar to that of Reno in the tests where both varieties were studied. The fecundity rate of Dicktoo and Omugi was usually lower than that of any of the wheat varieties and that of Reno and Beecher generally higher than the fecundity rate of the highest wheat variety.

The differences in fecundity on the wheat varieties observed were small, but it must be remembered that with a field infestation as light as ten aphids per foot of drill row a unit increase in the second decimal of the average nymphs per adult day ratio, would increase the population by over a million greenbugs per day in a 160 acre field. Such apparently small differences could in a few generations be the difference between the total loss or survival of a crop. Although it was impossible definitely to establish the greenbug fecundity rate on the wheat varieties used, there was an apparent pattern in the results. Dickinson usually had the lowest fecundity. Ponca had the lowest fecundity rate of the commercial wheats and Pawnee the next higher rate. Kiowa generally had the highest fecundity rate, but Triumph and Red Chief were also high in the number of nymphs produced. The results of the study of second generation greenbugs would also substantiate these ideas. It was also observed that when the parental greenbug females were obtained from wheat plants instead of from susceptible barley plants the fecundity was lower and the mortality rate higher. This was a major factor in the results obtained in Experiment VIII and would add more proof to the idea of the cumulative effects of differences in antibiosis among the varieties studied.

Changes in the biology of the greenbug due to antibiotic effects were also observed in a single generation of the aphids. When fourth instar nymphs were used to infest the vials, it was assumed that they would molt at about the same rate on all the varieties. This was not always true. In Experiment X the chi square test of this phenomenon did not support the hypothesis of homogeneity. It might be that this difference in the length of the last stadium holds true for the preceeding periods as well. This point needs further investigation.

The aphid fecundity on wheat for the first period in Table 9 might be interpreted to mean that a period longer than four days is necessary for the varietal effects on fecundity to be seen. A daily count of nymphs produced might show more clearly how long this period of no difference lasts.

Table 9 needs careful consideration. The combination of the fecundity and mortality factors would seem to produce geometric results. A few aphids produced daily for many days may or may not be as destructive to the crop as many greenbugs produced in a short period of time. The many possible combinations of the factors and the environmental influences on these factors merit further study.

Greenbug host preference studies have not been emphasized since the methods for efficiently evaluating this mechanism are not know. It might be that preference or nonpreference have a part in the increased fecundity of alate greenbugs feeding on Dicktoo as seen by the results of the second period of Table 10. Plant age preference might also furnish valuable research information that might be of economic importance.

Differences in weight of adults have intrinsic importance and if the relationship to fecundity, shown by Harrington (1945) for the pea aphid,

holds true in the greenbug then weight differences must be considered a major factor. This factor would be useful in studying a segregating population of a cross for greenbug resistance since the methods could be readily adjusted to such a program.

The rank correlation between the averaged results of the different antibiotic characters observed on the wheat varieties studied were tabulated in Table 14. They might be interpreted to mean that either a few genetic factors seem to have several different types of antibiotic effects on the greenbug or that many factors are involved. Rank correlations among the averaged results indicate highly significant relationships between the six day alate fecundity rate with the alate life time fecundity and with alate weight. The correlation between alate weight and apterous fecundity was highly significant. A highly significant correlation was calculated between apterous fecundity and differences in the length of the molting time, but the reason for this is not understood and may be only a chance combination. Significant correlations were also observed between six day alate fecundity and alate mortality; six day alate fecundity and apterous fecundity; and six day alate fecundity and differences in the length of the molting time. Weight of alate greenbug adults was significantly correlated with molting time and also with life time alate fecundity. Six day alate fecundity was significantly correlated with all the other criteria studied, which might mean that it is the most useful; however, more intensive study of the other factors is necessary before this can be proven.

Table 14. Correlations of average rank of the ten wheat varieties between the antibiotic factors studied.

Antibiotic factor	Six day alate fecundity	Life time fecundity	Alate[1] Weight	Apterous Fecundity	Molting time	Six day alate Mortality
Six day alate fecundity	—	.794**	.952**	.655*	.676*	.636*
Life time fecundity	.794**	—	.714*	.224	.318	.321
Alate weight[1]	.952**	.714*	—	.869**	.804*	.429
Apterous fecundity	.655*	.224	.869**	—	.961**	.491
Molting time	.676*	.318	.804*	.961**	—	.561
Six day alate mortality	.636*	.321	.429	.491	.561	—

[1] Only aphids from eight varieties were weighed.

SUMMARY

The purpose of this problem was to determine whether it was possible to demonstrate any differences in the biology of the greenbug, Toxoptera graminum (Rond.), when feeding on different varieties of wheat and barley. This was an approach to the question "What effect would the planting of large acreages to new and different varieties of cereals have on the greenbug population potential?". Most of the varieties tested were those grown and recommended for Kansas.

Since no previous work of this type had been reported it was necessary to spend a considerable amount of time in developing a method that would tend to give uniform results. In the method developed, shell vials with caps formed from dialyzing tubing and a substrata of wet cellucotton were used. Three sprouted seeds were placed in each vial and when the sprouts

were five or six days old they were usually infested with three, fourth instar, alate female producing nymphs per vial. The greenbugs were left in the vials for six days and then the number of nymphs produced in each vial were counted. Daily counts of the live adults in each vial were also taken for six or more days in order to determine whether there were any differences in the death rate of the parental aphids on the various varieties. Greenbug adults feeding on young wheat and barley plants growing in the greenhouse were weighed to determine weight differences. The following conclusions and suggested trends were drawn from the data accumulated.

Significant differences occurred in the fecundity of alate adults among the varieties of barley studied. The varieties, Reno and Beecher, had a consistently higher fecundity rate than Dicktoo and Omugi. It is probable that Kearney would have given results similar to Dicktoo and Ward similar to Reno, judging from the preliminary results obtained for these varieties which were included in the early tests.

There were definite patterns in the fecundity rate of alate greenbugs feeding on different varieties of wheat. It was not possible to prove consistently significant differences in the several tests although such varieties as Dickinson, Ponca, and Pawnee were usually low in fecundity rate.

It was not possible to demonstrate consistent differences between the number of adult females alive after six days when they were feeding on barley varieties although there were some indication of differences.

It was possible to demonstrate significant differences between the number of adult aphids alive after six days when they were feeding on different wheat varieties. These differences occurred in four of the eight experiments.

The chi square test comparing the number of adult greenbugs alive after six days indicated a highly significant number of adults alive on all barley varieties as compared to all wheat varieties.

The greenbug fecundity rate when feeding on the resistant barleys was lower than the fecundity rate on any of the wheat varieties and the rate on the susceptible barleys was usually higher than that on any of the wheat varieties tested.

When the apterous progeny of alate females feeding in the vials on the various varieties were moved to other vials containing the same varieties it was possible to demonstrate significant differences in the fecundity rates of the apterous adults on both wheat and barley varieties.

It was possible to demonstrate significant weight differences between alate adults that had fed on the several wheat varieties for their entire nymphal period, and among apterous and alate females feeding on Reno, Kearney and Dicktoo barley.

It would seem that when the greenbugs had been cultured on susceptible barley instead of generally susceptible wheat prior to introduction into the vials, the fecundity rate was higher and the adult death rate was lower.

It was not possible to demonstrate any effect on greenbug fecundity rate by using different sizes of kernels of the Pawnee and Red Chief varieties.

In reaching these conclusions a total of 3,613 greenbugs were placed into 1,136 vials and while in the vials produced 23,714 nymphs. To determine the death rate, 10,305 adult day counts were made on 2,756 of the greenbugs used for infesting the vials. Individual weighings of 480 apterous and alate adult females were made during the weight studies.

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A COMPARISON OF CERTAIN FEATURES OF THE BIOLOGIES OF GREENBUGS, TOXOPTERA GRAMINUM (ROND.), ON THE RECOMMENDED KANSAS WINTER WHEAT AND BARLEY VARIETIES

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AN ABSTRACT

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The purpose of this problem was to determine whether it was possible to demonstrate any differences in the biology of the greenbug, Toxoptera graminum (Rond.), when feeding on different varieties of wheat and barley. This was an approach to the question "What effect would the planting of large acreages to new and different varieties of cereals have on the greenbug population potential?". Most of the varieties tested were those grown and recommended for Kansas.

Since no previous work of this type had been reported it was necessary to spend a considerable amount of time in developing a method that would tend to give uniform results. In the method developed, shell vials with caps formed from dialyzing tubing and a substrata of wet cellucotton were used. Three sprouted seeds were placed in each vial and when the sprouts were five or six days old they were usually infested with three, fourth instar, alate female producing nymphs per vial. The greenbugs were left in the vials for six days and then the number of nymphs produced in each vial were counted. Daily counts of the live adults in each vial were also taken for six or more days in order to determine whether there were any differences in the death rate of the parental aphids on the various varieties. Greenbug adults feeding on young wheat and barley plants growing in the greenhouse were weighed to determine weight differences. The following conclusions and suggested trends were drawn from the data accumulated.

Significant differences occurred in the fecundity of alate adults among the varieties of barley studied. The varieties, Reno and Beecher, had a consistently higher fecundity rate than Dicktoo and Omugi. It is probable that Kearney would have given results similar to Dicktoo and Ward similar to Reno, judging from the preliminary results obtained for these varieties which were included in the early tests.

There were definite patterns in the fecundity rate of alate greenbugs feeding on different varieties of wheat. It was not possible to prove consistently significant differences in the several tests although such varieties as Dickinson, Ponca, and Pawnee were usually low in fecundity rate.

It was not possible to demonstrate consistent differences between the number of adult females alive after six days when they were feeding on barley varieties although there were some indication of differences.

It was possible to demonstrate significant differences between the number of adult aphids alive after six days when they were feeding on different wheat varieties. These differences occurred in four of the eight experiments.

The chi square test comparing the number of adult greenbugs alive after six days indicated a highly significant number of adults alive on all barley varieties as compared to all wheat varieties.

The greenbug fecundity rate when feeding on the resistant barleys was lower than the fecundity rate on any of the wheat varieties and the rate on the susceptible barleys was usually higher than that on any of the wheat varieties tested.

When the apterous progeny of alate females feeding in the vials on the various varieties were moved to other vials containing the same varieties it was possible to demonstrate significant differences in the fecundity rates of the apterous adults on both wheat and barley varieties.

It was possible to demonstrate significant weight differences between alate adults that had fed on the several wheat varieties for their entire nymphal period, and among apterous and alate females feeding on Reno, Kearney and Dicktoo barley.

It would seem that when the greenbugs had been cultured on susceptible barley instead of generally susceptible wheat prior to introduction into the vials, the fecundity rate was higher and the adult death rate was lower.

It was not possible to demonstrate any effect on greenbug fecundity rate by using different sizes of kernels of the Pawnee and Red Chief varieties.

In reaching these conclusions a total of 3,613 greenbugs were placed into 1,136 vials and while in the vials produced 23,714 nymphs. To determine the death rate, 10,305 adult day counts were made on 2,756 of the greenbugs used for infesting the vials. Individual weighings of 480 apterous and alate adult females were made during the weight studies.