THE ABILITY OF WHEAT PLANTS TO RECOVER
FROM DIFFERING AMOUNTS OF FEEDING INJURY
CAUSED BY THE GREENBUG (TOXOPTERA GRAMINUM ROND.)

by

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INTRODUCTION

The results of many studies, observations, and tests have been recorded in the literature regarding the injury to wheat and other of the small grains caused by the feeding of colonies of the greenbug (Toxoptera graminum Rond.). Most of these studies have been concerned with injury to the plants as it occurs in the spring. Few observations have been made regarding the varying degrees of damage to which the few plants are subjected. Data taken in this study were primarily of field observations on fall injury to wheat plants that was caused by feeding activity of a natural-occurring fall infestation of T. graminum.

Although a problem of this type offers many complexities, an attempt was made to find concrete evidence, both in the field and in the greenhouse, permitting a comparison between the varying amounts of insect injury and the subsequent ability of the affected plants to recover, at least in part, from the effects of the feeding injury to the plants. Injury to plants was a result of the feeding of the greenbugs and was caused by the removal of plant juices from the mesophyll of the leaf tissue. Further injury to the parenchymatous tissue is probably the result of enzymatic action of the insect's saliva. This feeding injury to the plants varies somewhat depending upon the variety of plant upon which the insect feeds. The usually observed damage to wheat plants is a yellowing of areas about the place of feeding which may increase in size to include the entire leaf. Further yellowing and withering of the leaves generally resulted in death of the plant.

It has been observed that when such conditions as severe winter weather, application of insecticides, or perhaps other natural causes singly or in combination have stopped the feeding of the greenbug, the plants may recover in varying degrees. Other wheat plants because of the severe attack were weakened and failed to survive.

To make this study, advantage was taken of a situation that occurred in the wheat plots of the Kansas State College Entomology Department. A natural fall infestation of greenbugs occurred in a plot of Cheyenne wheat. The uniformity of the infestation gave an excellent opportunity to make the observations reported here. As there was little infestation of greenbugs the following spring, these observations pertained only to fall injury and, therefore, gave an excellent opportunity to determine the relationship between classified amounts of damage and the resultant recovery of the plants the following spring and summer.

Following application of different insecticides to classified plants in three different plots, comparisons were made between classes and plots of these three and a fourth untreated control on relative degree of recovery and subsequent yield at harvest.

REVIEW OF LITERATURE

Specimens of the greenbug (Toxoptera graminum Rond.) were first reported in the United States in 1882 (Webster and Phillips 1912). Since the first general outbreak in 1890, there have been serious recurrences at various times and localities throughout the central and southeastern United States and parts of southern Canada. The latest outbreak appeared in 1950 in northern Texas, western Oklahoma, and in parts of Kansas, Colorado, and Nebraska. (Dahms 1951). The fact has been established that plants vary in their degree of resistance to spring attacks by this aphid pest (Atkins 1945); however, little was known about the ability of the plant to recover from prolonged feeding injury caused by this insect, or to the ability of the plant to produce further growth of tillers with the addition of new tillers. There were rather distinct degrees of infestation and injury that could be classified (Fenton and Whitehead 1944). These degrees of injury have been observed when examination of damaged plants in the field were made. Injury to plants by the feeding of T. graminum was observed by Wadley (1929), and the method of penetration and formation of stylet sheaths in the feeding on phloem elements was described by Tate (1937), and Chatters and Schlehuber (1951). Studies of ecological factors and their relation to the greenbug have been reported by Wadley (1931). Observation and studies of this insect pest in its relation to other of the cereal crops were also being made at many experiment stations in the United States and abroad. Argentina had experienced serious damage to their cereal crops as a result of heavy infestations of this aphid (Tapia 1950).

The complexities of this problem are many and varied, and the aspects of tillering need study both by the agronomist and by the entomologist in those aspects in which the problem concerns him. An early review of the growth capacity of wheat and the ability to make new growth was presented in detail in a monograph on wheat

(Percival 1921). Such variables as soil fertility, soil and air temperature, humidity, density of planting, and of light intensity affect tillering and all need be held at or as near constant as possible.

Fall infestation of greenbugs have generally been known to occur following a summer of below normal temperatures and favorable moisture conditions (Fenton and Dahms 1951). Quite early Webster (1909) observed that severe spring infestations were often initiated by the greenbugs that had overwintered in the field or surrounding areas. As this winged aphid may often travel for miles on prevailing winds, control should be practiced by all within the threatened area. General good farming practices and proper time of planting in well prepared seed beds containing adequate moisture and fertility determine to an extent some resistance the plants may have to the greenbug attack.

Parasites and predators as a source of greenbug control has been tried with varying amounts of success (Hunter 1909).

MATERIALS AND METHODS

Materials

Insect. The greenbug (*Toxoptera graminum* Rond.), also called spring grain-aphis, is classified in the family Aphididae of the order Homoptera. This plant louse occurs on various grasses including wheat, oats, and barley, and often causes severe damage to these crops. The greenbugs observed in this study were either alate or apterous parthenogenic viviparous females. Repeated collections of aphids were made during the time of the fall infestation and no alate males were taken.

Plants. The variety of wheat used in this study was Cheyenne, C. I. 8885. This variety was the result of a plant selection made at the Nebraska Agricultural Experiment Station in 1922 from Crimean wheat, C. I. 1435. While Cheyenne showed some tolerance to Hessian Fly (*Phytophaga destructor* Say) it was a good host for fly and was quite susceptible to attacks by the greenbug. Cheyenne was thus planted to provide plants for any late oviposition of the fly and also to provide plants for the subsequent greenbug studies. However, as most of the fly had emerged and layed eggs before the wheat germinated, fall injury to the plants by Hessian Fly was not a factor in these observations. Those plants that showed any evidence of fly infestation were not used in the greenbug tests.

Greenhouse. The greenhouse tests were made in the Entomology section of the Kansas State College greenhouse. Full winter sunlight conditions could not be maintained as this section was shaded a part of each day by a taller building to the south. Temperature in the greenhouse fluctuated between 50°-85°F; however the thermostat control was set for 75°F. The plants were placed on well-lighted benches in the south end of the greenhouse so that they could receive all possible available light. In addition, the potted wheat plants were changed in position on the bench every third day to eliminate any light-gradient factor that might have been present.

Nursery Plots. The field observations of this experiment were made on the Cheyenne wheat planted at the wheat nursery plot located just south of the College Apiary. The rows of wheat in this plot were planted in an east-west direction. Soil throughout the test plots of this experiment was of uniform consistency and fertility.

Miscellaneous Equipment. The pictures of these plants were taken in color with 35mm Kodak cameras; however the picture showing the stunted plant was taken with a regular studio camera. The cages that were used in the greenhouse were of two types. A lumite-covered cage was used to cage insects on wheat plants that were grown in the six-inch clay pots. These cages were five inches in diameter and twelve inches in height. A fine-mesh cheese cloth was used to cover the top of the cages. Other cages consisted of large glass cylinders, eight inches in diameter by twelve inches in height. These were covered with cheese cloth and also a screen-covered frame made for each cage. The grain was threshed by hand or by means of an electrically driven laboratory thresher.

Methods

In the Field. This project began October 2, 1951 when an area of the entomology wheat nursery was planted with several rows of Cheyenne wheat. The wheat was drilled in rows one foot apart by means of a single-row garden seed drill. The planter was adjusted to space the kernels about two inches apart within the rows. When the plants had developed in size to a growth of four or five leaves, a natural greenbug infestation was observed to have been established on the plants. These aphid colonies on the plants soon increased in size and numbers and the resulting injury to the wheat plants became more apparent. Several stunted plants, probably the result of the insects' feeding, were also noted at this time.

November 20, 1951, four plots each twelve rows wide and twelve feet in length were measured and the perimeter of each staked. With one of these plots designated as untreated control, each of the other plots was sprayed with a different application of insecticide as follows: Plot II, was sprayed with Systox at the rate of 1.05 pounds per acre of the actual ingredient; Plot III, received an application of Metacide at rate of 0.845 pounds of actual ingredient per acre; and Plot IV was sprayed with Parathion at the application rate of 0.612 pounds per acre.

November 21, 1951, the plants were classified in regard to different degrees of feeding injury of the greenbugs and labeled by means of numbered stakes denoting class of injury. One hundred plants were staked in each plot with twenty-five plants being placed in each degree of injury classification. Labels were marked with numbers 0, 1, 2, or 3 and classification made by choosing those plants which corresponded as nearly as possible with the following description of classes:

Class 0. No greenbug feeding injury to the plant.

Class 1. Slight feeding injury to one entire leaf, or with the tips of two or three leaves injured.

Class 2. More than half the leaves of each plant injured, or with fifty per cent of the plant showing yellowing leaves.

Class 3. Feeding injury to all leaves of the plant and leaves beginning to wither.

Class three plants had very little green color showing in the leaves and some of the plants showed evidence of stunted growth resulting from the insect feeding. (Plate I.)

To make the four classifications, plants were selected at random and with reference to distance between plants taken into consideration. This ruled out the variable that closeness of plants can cause by affecting the number of tillers formed. No plants were chosen that appeared to be infested with Hessian Fly or damaged by any other insect activity. The number of tillers that wheat plants are able to produce is determined by any or a combination of several variables. Variables concerned with tillering are temperature, rainfall, humidity, distance between plants, relative size of seed, fertility of the soil, and the source of the seed planted.

No greenbugs were observed to cause further injury to the treated plots after spray application; however, feeding continued on plants of the untreated control until the aphids were inactivated or killed by the winter weather.

Two periods of cold weather, one the middle of December and the other the first week of the following March terminated feeding activity and killed the greenbugs that were still present from the fall infestation. Climatological data are shown in Table 1.

On April 1, 1952, data were taken on degree of tillering for each living plant. Classification of the plants corresponded with the following description:

Degree 1. One live tiller per plant.

Degree 2. Two live tillers per plant.

Degree 3. Three live tillers per plant.

Degree 4. Four live tillers per plant.

EXPLANATION OF PLATE I.

Wheat plants representative of each of the four classes of fall injury to Cheyenne wheat that was caused by feeding activity of the greenbug (Toxoptera graminum Rond.) as indicated by stakes in the pots and as described below:

Class 0. No greenbug feeding injury to the plant.

Class 1. Slight feeding injury to one entire leaf, or with the tips of two or three leaves injured.

Class 2. More than half the leaves of each plant damaged, or with fifty per cent of the plant showing yellowing leaves.

Class 3. Feeding injury to all leaves of the plant and leaves beginning to wither.

PLATE I

Table 1. Climatological data for the Manhattan, Kansas area for the period, six months prior to planting the wheat until the end of the month of harvest or April 1, 1951 to June 30, 1952.

	April 1951	May	June	July	August	September	October	November
Precipitation in inches.							Planted oct 2	
Average	2.75	10.29	11.12	15.32	6.32	6.13	2.70	0.61
Departure from Normal	+0.09	+ 5.86	+ 6.51	+11.59	+2.08	+2.20	+0.45	-1.16
Temperature (o F.)								
Average	50.0	64.8	69.2	76.0	77.3	64.0	55.0	37.7
Departure from Normal	-5.2	0.0	-5.5	-4.2	-1.2	-6.5	-3.1	-6.3

Table 1. (Concl.)

	December	January 1952	February	March	April	May	June
Precipitation in inches.							
Average	0.40	0.17	0.35	2.94	3.47	4.33	0.31
Departure from normal	-0.46	-0.54	-0.87	+1.32	+0.81	-0.10	-4.31
Temperature (o F.)							
Average	29.6	31.6	38.4	37.4	51.8M	63.5	81.7
Departure from normal	-2.6	+2.4	+6.0	-6.6	-3.4	-1.3	+7.0

M. One or more days' record missing.

Degree 5. Five or more living tillers per plant. There had been some winter killing of plants which may have been the result of weakening of the plants because of the fall insect feeding.

The labeled plants in the four test plots were harvested individually, the heads cut from each plant, counted, and placed in separate envelopes. The harvest date was June 24-25, 1952. The label denoting the class of fall injury was also placed in the envelope and the plant data, number of heads, class of injury, and date written on the front of each envelope. The notations on the envelopes were written with a different colored pencil for each of the four plots.

When a sufficient number of the plants had been harvested so that the plants that had been photographed in April were clearly differentiated from the surrounding plants, Kodachrome pictures were taken to make a pictorial record of the plant differences.

The second planting of Cheyenne wheat made October 12, 1951, was also harvested at this time and data taken in the manner previously described. The only two comparisons made on this later planted wheat consisted of a comparison between a Metacide-treated plot and an untreated control plot.

The heads from each of the harvested plants were threshed by hand or with a small mechanical separator and the seed cleaned. The grain from each head was weighed and the weight recorded in grams.

In the Greenhouse. One hundred pots were planted with Cheyenne wheat October 14, 1952, with two kernels of wheat in each four-inch clay pot and placed on a well-lighted bench in the entomology greenhouse. The soil in which the wheat was planted consisted of a mixture of six parts prairie sod, two parts river sand, and one part dry powdered sheep manure. The plants showed green leaves above the ground after six days and were grown free from insect infestation until the two-leafed stage was reached. The plants were infested with greenbugs by brushing the aphids from heavily infested culture pots onto the young plants. Other pots containing infested wheat plants were placed near the test plants to further the infestation. Three-fourths of the plants were infested in this manner. The remaining twenty-five pots were set aside in another section of the greenhouse so that these plants would not become infested and thus could be designated as Class 0.

Infestation and injury of the plants soon progressed to such a degree that some of the plants began to show extreme yellowing of the leaves. At this time it was also noted that a few of the plants began to show a definite stunting from the feeding damage. Two plants were particularly noted which showed a definite stunting of the central shoot which was free of infestation, while a colony of greenbugs was feeding out from the plant on one of the larger and older leaves. Such stunted plants had a short broad central leaf much resembling the typical plant damage that occurs after infestation by the Hessian Fly. A picture of this damage was made by the station photographer. (Plate II.)

On November 20, 1952, the pots of infested wheat plants were

EXPLANATION OF PLATE II

The stunted central shoot of the plant on the right is the result of greenbug feeding on the other leaves of that plant. The plant on the left is normal.

PLATE II

classified in comparative degrees of damage. Classification of injury was made to most nearly equal those that had been used to denote class of injury to plants in the field (Plate I). The following day, fifteen plants from each classification were placed in flats to differentiate the four classes and all given an application of Systox to stop all feeding of the insects. Each plant received a 50cc soil application of the Systox solution. The solution was a mixture of one part Systox to one thousand parts water. The plants were placed outside the greenhouse in glassed-in cold frames and the frames covered with glass sash. After twenty-four hours, the plants were examined for live greenbugs. The application of Systox had resulted in a kill of 100 per cent of the insects and the aphids had all released their hold on the plants and dropped to the soil in the top of the pots.

The plants were left in the cold frames until December 12, 1952, at which time they were returned to the greenhouse. Little difference in injury could be noted between the classes zero and one at that time; however, some injured plants of the class three group were soon dead and others were slow in recovering.

All the plants received two applications of a commercial fertilizer, "Hyponex", with the regular watering. The stock solution was made by mixing one teaspoon full of the prepared powder with one gallon of water. Each plant received about 200cc. at each application. The wheat plants were grown in the greenhouse until the readings were made January 19, 1953, at which time the final tiller count was made. The previous tiller count was recorded at the time of application of the insecticide, November 20, 1952.

RESULTS

In the Field

Results of data taken in this study show that when comparisons were made of growth, development, and yield between classes and plots, there was a direct relationship between the class of injury and the resulting degree of recovery of the plants. There were differences in the number of plants in each plot that produced grain. Fifty-six of the sixty-two surviving plants of the control plot produced heads with grain. The Parathion treated plot had ninety-two remaining plants at harvest time; however, seven of these produced no grain. The Metacide and Systox plots carried eighty-seven and eighty-eight plants respectively; each plot with five plants produced no grain. (Table 2.)

Records taken April 1, 1952, showed no loss of Class 0 plants in any of the four plots. There was little difference between plots when relative average degree of tillering was compared. A comparison between control plots of the October 2, 1951 and the October 12, 1951 plantings showed there were fewer tillers present on plants from the later planted wheat. (Table 3). Plants from classes 0, 1, and 2, in the insecticide treated plots showed a high degree of tillering; however, a significant difference in tillering was noted when classes two and three were compared. Data in Table 3 shows also that with the higher class of injury to plants of the control there were fewer numbers of tillers. There were no plants classified in Class 3 in the younger wheat as the colonies of greenbugs had not built up to sufficient strength at time of

Table 2. This indicates the original number of plants in each class of fall injury in each plot, the number of plants harvested that produced heads, the plants that survived but produced no heads, and the total plants that survived until harvest.

Plot	Class of Injury	Number of Plants: At beginning of experiment	With heads at harvest	Without heads at harvest	Surviving until harvest
Control	0	25	25	0	25
	1	25	21	0	21
	2	25	9	3	12
	3	25	1	3	4
Parathion					
	0	25	23	0	23
	1	25	24	1	25
	2	25	25	0	25
	3	25	13	6	19
Metacide					
	0	25	25	0	25
	1	25	25	0	25
	2	25	22	0	22
	3	25	10	5	15
Systox					
	0	25	25	0	25
	1	25	25	0	25
	2	25	24	1	25
	3	25	9	4	13
Totals		400	307	23	330

Table 3. Data showing average degree of tillering of plants in the spring, April 1, 1952, of those plants in the field that had received insecticide application and were classified for insect injury the preceding fall, November 21, 1951. Department of Entomology Nursery, Manhattan, Kansas.

Treatment of Plants	Condition of Plants							
	Class 0		Class 1		Class 2		Class 3	
	Mean /Degree of Tillering	Plants Alive %	Mean Degree of Tillering	Plants Alive %	Mean Degree of Tillering	Plants Alive %	Mean Degree of Tillering	Plants Alive %
Planted Oct. 2, 1951.								
Check (No treatment)	4.95	100	3.08	96	1.56	76	0.25	25
Parathion	4.92	100	4.74	100	4.32	100	1.63	75
Metacide	4.96	100	4.88	100	4.04	96	1.52	64
Systox	4.88	100	4.78	100	4.48	100	1.57	62
Planted Oct. 12, 1951.								
Check (No treatment)	4.46	100	2.90	95	0.76	60	*	*
Metacide	‡	‡	4.71	100	4.13	100	*	*

* No plants this class.
‡ Data not taken.
/ Degree of tillering is nearly equivalent to number of tillers; see explanation p 11.

classification. In comparing plants of the control with those of a treated plot, Plates III and IV, the observations, with the exception of Class 0, showed fewer tillers on plants that grew in the control area, while plants that matured in the Parathion treated plot showed a greater total number of heads at time of harvest. Comparison between plants from the control and plants from the other treated plots gave parallel results. A count of grain-producing heads at harvest showed that the greater the class of injury the preceding fall, the lower the average number of heads produced per plant in the spring. Plants of Classes 0, 1, and 2, of the Systox plot produced a greater average number of heads per plant than did any of the other plots. A comparison of the average number of heads per plant for each class of injury within the plot is shown in Plate V. A similar comparison of average weight per plant, Plate VI, shows corresponding evidence.

An analysis of variance was made to test differences between total heads harvested per class and between plots. Results showed significant differences prevailed between all classes of injury and between all plots with the exception of Class 3 plants in the treated plots. Differences between the plots for Class 3 were not significant. Analysis of the yields showed no significant differences between Classes 0, 1, and 3 when Parathion and Metacide were compared. (Table 4).

The average weight per head of plants in each injury class was calculated. Injured plants of the control plot produced heads of less weight than plants that had not been infested. Considerable differences in weight were noted between plants of the

EXPLANATION OF PLATE III.

The survival and character of some of the original one hundred plants of the untreated control plot at harvest. Note loss of plants by some of the stakes labeled class 2 and 3.

PLATE III

EXPLANATION OF PLATE IV.

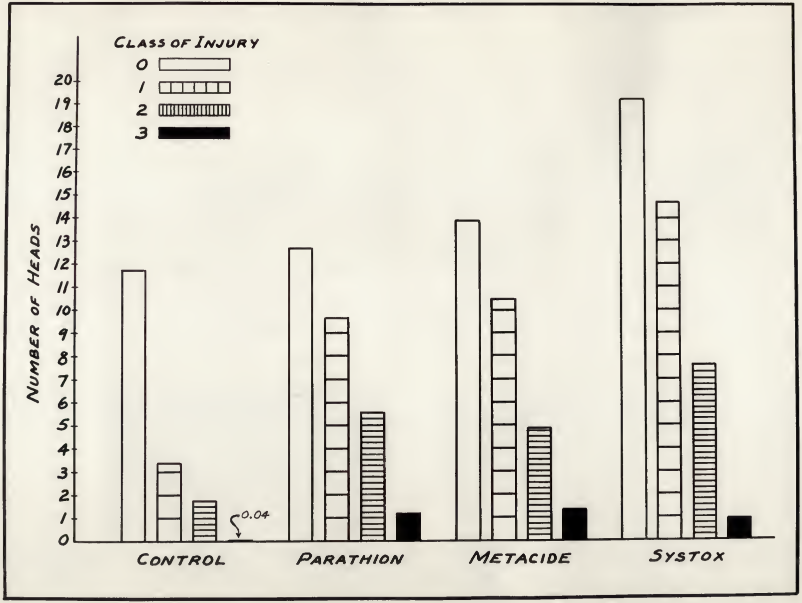
The survival and character of some of the original one-hundred plants of the Parathion treated plot at harvest. Note the survival of the plants in class 2 and 3 although reduced in size and number of tillers. The appearance of plants of the other insecticide treated plots were similar.

PLATE IV

EXPLANATION OF PLATE V.

Diagram showing average number of heads harvested per plant for each class of fall insect injury in each of the four plots. Averages were figured on number of heads produced from each group of the twenty-five original plants in the class. Clear bars represent no fall insect injury at time of observation. Widely cross-hatched bars represent class 1 injury. Close cross-hatched bars equal class 2 injury and the solid black bars represent class 3 injury.

PLATE V


Class of Injury
0
1
2
3
Number of Heads
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.04
Control
Parathion
Metacide
Systox

EXPLANATION OF PLATE VI.

Diagram showing average yield of wheat per plant for each class of injury in each of the four plots. Averages were figured on yield of grain (grams) produced for each group of twenty-five original plants in the class. Clear bars represent no fall insect injury at time of observation. Widely cross-hatched bars represent class 1 injury. Close cross-hatched bars equal class 2 injury and the solid black bars represent class 3 injury.

PLATE VI


CLASS OF INJURY
0
1
2
3
WEIGHT OF GRAIN (GRAMS)
10
9
8
7
6
5
4
3
2
1
0
0.003
CONTROL
PARATHION
METACIDE
SYSTOX

Table 4. Total number of wheat heads harvested from plants surviving from the 25 plants marked in each injury class in each plot the preceding fall.

Plot	Class of Fall Injury			
	Class 0	Class 1	Class 2	Class 3
Control	293	85	43	1
Parathion	316	243	138	30
Metacide	346	262	121	32
Systox	480	366	190	21

Least significant difference at 5% level: 16.8

Total yield of wheat (grams) harvested from plants surviving from the 25 plants marked in each injury class in each plot the preceding fall.

Plot	Class of Fall Injury			
	Class 0	Class 1	Class 2	Class 3
Control	120.18	17.35	12.05	0.07
Parathion	173.01	110.52	54.96	10.30
Metacide	176.83	108.19	43.11	6.98
Systox	213.21	165.74	57.77	4.79

Least significant difference at 5% level: 10.04

control and plants of the treated plots. (Table 5.) With increase in class of fall insect feeding injury to the plants, the average weight per head decreases. Heads from plants that had been sprayed with Parathion to kill the greenbugs had slightly higher average weights than those of other plots.

Table 5. Comparison of the average weight of the grain in grams from heads of plants which had injury in each of the injury classes in the various plots under observation.

Insecticide Treatment	Fall Class of Insect Injury			
	Class 0	Class 1	Class 2	Class 3
Control (No treatment)	0.41	0.20	0.28	0.07
Parathion	0.55	0.45	0.40	0.34
Metacide	0.51	0.41	0.36	0.22
Systox	0.44	0.45	0.30	0.23

In the Greenhouse

Observations on plants grown in the greenhouse showed results similar to those observations made on field-grown plants. The application of Systox, a systematic insecticide, killed all insects on the plants. An aphid count made twenty-four hours following the application showed no live greenbugs on any of the plants, as the aphids had all fallen from the plants. There was no apparent injury to the plants caused by the insecticide. No greenbugs were observed to establish colonies or reproduce young on these plants for five weeks following application of this insecticide.

Of the fifteen original plants per each class of injury, only six plants failed to survive and these were all in Class 3. All the plants in Classes 0, 1, and 2, made an increase in number of tillers during the two month growing period. Four of the Class 3 plants produced no new tillers and one other plant had one less tiller than it did at time of insecticide application. At the time the plants were sprayed, both Class 1 and 2 had the same average number of tillers; however, at the end of the growing period Class 1 had an average of eleven tillers while Class 2 averaged only nine. (Table 6.) Four plants from Class 3 showed a definite stunted appearance to the central shoot.

A comparison between the tiller averages of the greenhouse plants and the field grown plants is illustrated by Plate VII.

DISCUSSION

Results of the observations and analysis of data obtained from this study provided new information on certain aspects of greenbug injury to wheat. The feeding of the aphids on a plant did not always kill the plant, but rather affected it in varying degrees depending upon the amount of feeding that occurred. It was observed that greenbug feeding can result in greater destruction to wheat in less time, and as a result of fewer insects, than that of any of the other aphids commonly found feeding on wheat. Obvious injury to wheat was rarely seen as the result of the feeding of such aphids as *Rhopalosiphum prunifoliae*, *R. subterranum*, *Aphis maidis*, and *Macrosiphum granarium*. In the greenhouse with

Table 6. Number of tillers taken at beginning and end of a two month growing period in the greenhouse, November 2, 1952 to January 19, 1953, for plants which had different classes of injury.

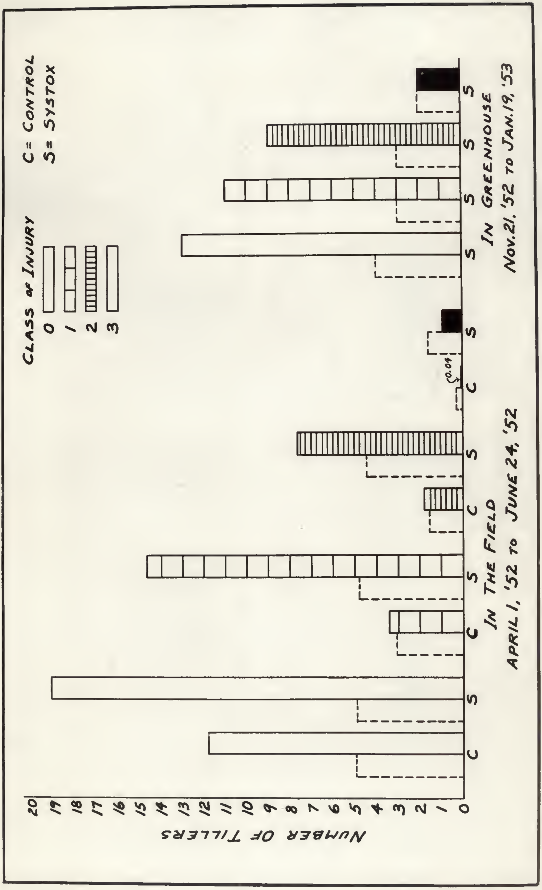
Plant No. in Each Class	Classes of Feeding Injury Showing Number of Tillers of Each Plant							
	Class 0		Class 1		Class 2		Class 3	
	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.
1	5	13	4	11	2	5	2	3
2	4	10	4	11	2	7	3	0
3	3	13	3	9	4	12	1	0
4	4	10	3	9	4	13	1	0
5	4	13	4	11	4	12	1	1
6	5	14	4	9	2	6	1	0
7	3	13	5	15	4	16	3	0
8	3	10	2	9	3	12	3	3
9	5	16	3	11	2	8	2	2
10	3	12	4	10	4	10	3	4
11	3	14	2	10	2	8	2	2
12	4	14	3	10	4	9	3	3
13	6	16	4	11	3	5	2	0
14	4	14	2	10	4	14	2	1
15	4	14	4	14	2	4	1	1
Totals	60	196	51	160	46	141	30	20
Average	4	13	3	11	3	9	2	2*

*Of those remaining plants.

EXPLANATION OF PLATE VII.

A diagram showing average number of tillers produced by plants in the untreated control and in the Systox treated plot in the field for comparison with growth of plants in the greenhouse. Plants in greenhouse show addition of tillers during two-months growing period following insecticide application. The bars with dash outlines represent degree of tillering April 1, 1952 of the field grown plants. Dash-outlined bars of greenhouse plants represent initial tiller count at time of insecticide application. Bars with no cross-hatching represent no feeding injury to plants. Class 1 injury is represented by the widely cross-hatched bars, Class 2 designated by the close cross-hatched bars and the solid black bars represent the severe injury of Class 3 plants. Each bar represents an average from 25 plants in the field and an average from 15 plants of those grown in the greenhouse.

PLATE VII


Class of Injury
0
1
2
3
C = Control
S = Systox
Number of Tillers
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
C S C S C S C S S S S S
0.04
In The Field
April 1, '52 to June 24, '52
In Greenhouse
Nov. 21, '52 to Jan. 19, '53

temperatures of about 75°F a plant of 3-4 leaves was killed in about ten days as the result of greenbug feeding; however such a plant continued to grow in spite of heavy infestation of other species.

Insecticide applications were made to three of the test plots so that insect feeding would be halted at a time earlier than normal winter conditions would do so; however, greenbugs feeding on control plants that had received no insecticide treatment caused continued injury to the plants until the insects were inactivated by low temperatures of mid-December. In this study there were two separate periods of winter weather with temperatures at or below 0°F that reduced feeding and killed most of the insects. The first cold period of the winter was mid-December and was followed by a second cold wave the first week of March, 1952. No live greenbugs were observed feeding on wheat plants in the plots after the second cold wave, March 4-5, 1952.

Injury to plants under observation in this study all occurred during a fall infestation of the insect. No infestation was seen the following spring; spring injury as a result of greenbug feeding was not a factor in these observations. Insect injury to plants in the fall was much the same in appearance as that which occurred in the spring; however, field infestations of greenbug in the spring either killed the plant or if the insects were suddenly removed by insect enemies or insecticides, there was fairly prompt recovery. Aphids may be controlled somewhat in the warmer spring months by parasites and predators. Fall infestation consisted of alate agamic females which appeared on the plants when a two to three leaf stage had been reached. Thereafter reproduction and increase in numbers of the aphids was rapid. The areas of feeding on the leaves showed a yellowing and after more prolonged exposure to the feeding activity the leaves withered and died. This feeding occurred during the cool weather of fall and destruction of the plants was not as rapid as that occurring in the spring when temperatures are normally higher. Feeding was observed to occur on any of the leaves and on the leaf sheath. Some feeding was also noticed in the crown of the plant at the level of the soil surface.

April 1, 1952, a record was made of the degrees of tillering that the plants had made, and results were observed to be similar for all classes containing plants that had previously been sprayed with insecticides. All plants previously classified Class 0 survived. There was, however, a marked downward gradient in degree of tillering that showed a decrease in tillers for each greater amount of fall insect injury.

Plants from the October 12, 1951, planting gave evidence of being more susceptible to injury; probably because of the age of the plants. This agreed with the common observation that the later planted spring crops were the most susceptible to greenbug damage. The age and vigor of plants at time of infestation determined to a great extent the varied reactions to insect attack. There were no plants chosen in Class 3 of the later planted wheat as feeding activity had not been sufficient to produce this class of injury by the time the insecticide applications were made. Comparisons between control and Metacide plots for Classes 1 and 2 both gave a significant difference in degree of tillering.

A count of plants from the earlier seeded plots that survived at harvest showed few differences occurring between any of the treated plots; however, in the control only two-thirds as many plants remained as in any of the other plots. Plants of the control had received greater fall injury as the feeding had continued until terminated by lower temperatures.

The total yield of grain from surviving plants of the original four hundred was 1,275 grams. Plants that survived in the control produced only about 12 percent of the total yield. The surviving plants of the Systox plot gave the highest yield, about 35 percent of the total yield. Plants of the Parathion plot produced about 27 percent and those of the Metacide plot produced about 26 percent of the total yield. Thus, the lowest yield from a treated plot was 14 percent greater than the yield of the control, while plants of the Systox plot gave 23 percent more grain than the control.

Application of the insecticides accounted for about 90 percent kill of all greenbugs in the treated plots and resulted in no further observed feeding injury to the plants. The low temperatures inactivated further feeding at this time.

Records taken April 1, 1952, showed that all plants that had not been injured survived the winter. Little difference could be observed between plants of Class 0 and Class 1 of the treated plots. There was a slight decline in numbers of tillers in Class 2 and a significant drop in degree of tillering on plants in Class 3. Only 25 percent of the plants in Class 3 of the control plot were alive on April 1, 1952. Data in Table 3 show also that the more seriously injured plants, those of Class 2 and 3, had a definitely lower degree of tillering. The plants from the October 12, 1951, seeding showed a greater irregularity in degrees of tillering. This probably was due in part to a shorter feeding time for the insects and in part to the fact that the younger plants were more susceptible to injury than those of the earlier planting.

Comparisons of the average number of heads produced and the average weights of grain per plant were made. Again, the plants from the Systox plot returned higher averages for Class 0, 1, and 2. Plants of the Metacide and Parathion plots that had received only slight fall injury (Class 1) produced about the same average yield; both, however, gave less grain than Class 1 plants of the Systox plot. (Plates V and VI). There was little difference between plots when a comparison of yields of Class 2 plants was made.

An analysis of the average heads per plant, per class from the plots showed that there was a significant difference between all plots and all classes within the plots with the exception of the Class 3 plants among the treated plots. (Table 3). This was evidence that this manner of assigning classes of injury to the plants was a valid way of making comparisons of degrees of damage.

Control plants could not be maintained in the greenhouse where near optimum temperatures for greenbug activity were maintained. If the aphids were allowed to feed for prolonged periods on plants in the greenhouse, the plants very rapidly turned yellow, withered and died. Damage to the plants in the greenhouse was more rapid than to plants in the field as the greenhouse temperatures were more nearly optimum for the greenbug than the cooler field temperatures. While plants in the greenhouse also had better growing temperatures, the rapidity of reproduction of the greenbug soon resulted in such a large number of insects that the plant could not maintain growth.

The Systox used in the greenhouse to terminate feeding damage gave a kill of 100 percent. This was a systemic insecticide that had a longer residual action than the other insecticides used in this study. When killed, the apids fell from the plant and did not remain hanging to the leaves as they sometimes did when killed by means of other poisons. The plants in this experiment gave results that paralleled those already seen in the field observations. The gradient of a decrease in number of tillers as the class of injury increased was also illustrated in this test. Those plants with the most severe injury made very little growth and few tillers were added during the two month growing period after insect feeding had been stopped. Six of the original fifteen plants of Class 3 did not survive the injury of the insects' feeding. Winter conditions could not have been an important factor in the death of these plants as they were outside in cold frames and there protected by the sash covers.

In both greenhouse and field the soil moisture was favorable to the growing plant and fall temperatures were optimum for both wheat and insect growth. Table 1 gives the climatological data for a period of six months before seeding dates of the plants tested in the field. The average rainfall was well above normal for the summer months prior to seeding; however below normal amounts of moisture were experienced throughout the winter months.

It can therefore be concluded from the data presented, that there was a distinct relationship between the amount of fall injury to the wheat plant, the degree to which it will recover, and the amount of yield at maturity. The greater the class of injury that the plants receive as a result of greenbug feeding in the fall, the lower will be the yield the following harvest. Plants may be infested and receive minor feeding injury and grow to produce near normal yields; however there is a class of injury to the plant that once the plant is injured to this extent, recovery and growth is doubtful. It is highly probable that most fall infestations of greenbugs should receive some adequate insecticide application before fifty percent of the leaves of each of the infested plants have begun to turn yellow as the result of feed injury. Hence, a careful survey, made at regular intervals, by the wheat growers would determine the time of application of insecticides and thus limit fall injury to plants and perhaps aid in preventing spring infestations.

SUMMARY

A study was made on the relationship between classes of fall greenbug feeding injury to Cheyenne wheat plants and the resulting ability of the plants to tiller and produce grain at harvest. This study was made in the field between October 2, 1951 and June 25, 1952. Data taken were primarily from field observations

on inury to plants resulting from a naturally-occurring fall infestation of Toxoptera graminum Rond., with no subsequent infestation or plant injury the following spring. Three of the four plots were sprayed with insecticies and a classification of insect injury made which placed twenty-five plants in each of four classifications within each of the plots. The insecticides killed the aphids in the treated plots; however, the injury continued in the control until low mid-December temperatures terminated feeding. Data were taken April 1, 1952, for a comparison of degrees of tillering and survival of the plants under study. Comparisons were made again at harvest between survival of plants of each plot, average number of heads, and average yield per plant for each previously classified fall injury to plants within the plots, and the difference in the total yield from each plot. The experiment was repeated in part under greenhouse conditions with results paralleling those found under field conditions.

Interpretation of the data showed that under the conditions of this experiment, wheat plants go into the winter with recognized different amounts of greenbug feeding injury. The yield at harvest is largely determined by the amount of fall injury the plants receive. There was also a critical class of injury beyond which there is little probability of recovery of the plant. Those plants that had the highest class of fall injury and grew to maturity produced on the average of only two heads per plant, while those plants that received lower classes of feeding injury in the fall averaged as much as fourteen heads per plant. Plants that had been sprayed with an insecticide in the fall consistently produced more tillers than plants of the same injury classification in the untreated control. This study has indicated that fall injury to wheat plants as the result of greenbug feeding activity may reduce to a considerable extent the resulting yield unless the damage can be terminated before plants in the field begin to turn yellow as a result of the feeding. Timely application of proper insecticides may increase the yield as much as twenty percent over that received from an equal number of plants not treated.

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THE ABILITY OF WHEAT PLANTS TO RECOVER
FROM DIFFERING AMOUNTS OF FEEDING INJURY
CAUSED BY THE GREENBUG (TOXOPTERA GRAMINUM ROND.)

by

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ABSTRACT OF THESIS

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A study was made on the relationship between classes of fall greenbug feeding injury to Cheyenne wheat plants and the resulting ability of the plants to tiller and produce grain at harvest. This study was made in the field between October 2, 1951 and June 25, 1952. Data taken were primarily from field observations on injury to plants resulting from a naturally-occurring fall infestation of Toxoptera graminum Rond., with no subsequent infestation or plant injury the following spring. The fact has been known for some time that plants of wheat varieties differ in their degrees of resistance to attacks by this aphid pest. However, little is known of the ability of wheat plants to recover from prolonged feeding injury and the ability of the plants to recover and make additional growth of tillers once the feeding of the insect has been stopped. The insect feeding may be stopped either by temperatures unfavorable to the greenbug, by parasites and predators, or by the application of insecticides.

Three of four experiment plots were sprayed with insecticides and a classification of insect injury made which placed twenty-five plants in each of four classifications within each of the plots. Class designations were made to correspond to the following descriptions: Class 0, no injury to the plant; Class 1, feeding injury to one leaf; Class 2, injury to at least half the leaves of the plant; and Class 3, all leaves injured and a yellowing and stunting evident. The insecticides killed the aphids on the plants of the treated plots; however, injury continued in the control until low mid-December temperatures terminated the insects' feeding. Data were taken April 1, 1952, for a comparison of degrees of tillering and survival of the plants under study. Those plants that had received the least amount of injury had produced the highest degree of tillering and had more plants surviving. Comparisons were made again at harvest between survival of plants of each plot, average number of heads, and the average yield per plant for each previously classified fall injury to plants within the plots. The total yield of grain from the surviving plants of the original four hundred was 1,275 grams. Those plants that survived in the control plot produced only 12 percent of this total. Plants of the Systox plot gave a yield of 35 percent of the total, while those of the Parathion and Metacide treated plots produced 27 and 26 percent respectively.

Interpretation of the data showed that under the conditions of this experiment, wheat plants go into the winter with recognized different amounts of greenbug feeding injury. The yield at harvest is largely determined by the amount of fall injury the plants received, and that there was a critical class of injury beyond which there was little probability of recovery of the plant. Those plants that had the highest class of fall injury and grew to maturity produced on the average of only two heads per plant, while those plants that received lower classes of feeding injury in the fall averaged as much as fourteen heads per plant. Plants that had been sprayed with an insecticide in the fall consistently produced more tillers than plants of the same injury classification in the untreated control.

This study indicated that fall greenbug injury to wheat plants as the result of feeding activity may reduce to a considerable extent the resulting yield unless the damage can be terminated before plants in the field begin to turn yellow as a result of the feeding. Timely application of proper insecticides may increase the yield as much as 20 percent over that received from an equal number of plants not treated.

The experiment was repeated in part under greenhouse conditions with results paralleling those found under field conditions.