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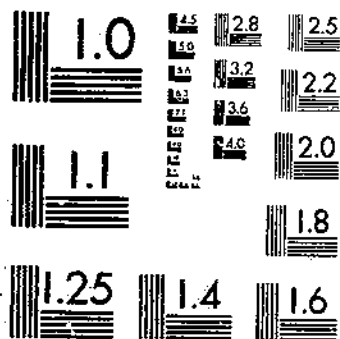
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REACTION OF SMALL-GRAIN VARIETIES TO GREEN BUG ATTACK

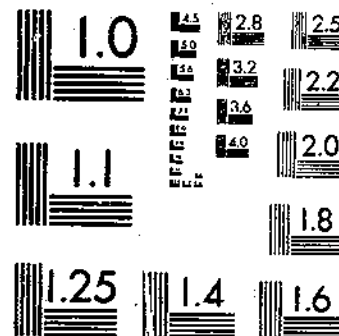
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**UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.**

Reaction of Small-Grain Varieties to Green Bug Attack¹

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THE green bug (*Toxoptera graminum* (Rond.)) is a member of the aphid, or plant louse, group of insects, which attack a wide range of host plants. Several members of the group may attack small grains, the more important being the green bug, the English grain aphid (*Macrosiphum granarium* (Klby.)), the apple grain aphid (*Rhopalosiphum prunisfoliae* (Fitch)), and the corn leaf aphid (*Aphis maidis* Fitch). In the southern part of the middle western winter wheat belt of the United States the green bug often attacks the small-grain crops in fall or early in spring, spreading rapidly from infestation centers and finally dispersing widely as the winged forms appear in spring.

Damage to the small-grain crop is caused by the insects sucking the plant juices, which results in a yellowing of the leaves. In heavy infestations the leaves soon wither and the plants die, whereupon the insects move to new plants at the edge of the infested area. This results in definite spots of dead plants in the early stages of infestation. Later, as the winged forms appear, the insects scatter and the damage may become more general. Destruction of these early infestation spots by burning straw on them, or plowing them under, offers some measure of control in the early stages, but once infestation becomes general no known control is effective or practical. Under such conditions the only controls are through natural agencies — parasites, predators, and unfavorable weather.

It is the purpose of this bulletin to record some of the factors responsible for the widespread serious infestation of the green bug in

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REPRODUCTION

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Texas and Oklahoma in 1942, and to bring to the attention of other workers the reactions to it of some varieties of small grain, especially the high resistance to attack observed in certain barley varieties, some of which may be useful in breeding desirable adapted varieties that are resistant. It may be summarized as follows.

SUMMARY

A severe attack of the green bug caused widespread damage to barley, oats, and wheat in central Texas, Oklahoma, and southern Kansas in the winter and spring of 1942. The damage in Texas and Oklahoma is estimated at more than 61 million bushels of grain, valued at current prices at more than 38 million dollars. Oats and barley were damaged more severely than wheat and over a larger area.

Opportunity was afforded to observe varietal resistance in wheat, oats, and barley on a more extensive scale than has been previously reported. These included observations at Denton and Chillicothe, Tex., and Lawton, Okla., where extensive experimental plantings were grown.

Under heavy infestations at Denton and Chillicothe, the most resistant strains of wheat were selections from the cross Marquillo \times Ore, which are also resistant to the Hessian fly. These strains were developed by the Kansas Agricultural Experiment Station. Other wheats showing some resistance included Denton, Early Blackhull, Wichita, Blackhull and Blackhull crosses, and several Chinese and Russian strains, but none of these appears to have sufficient resistance to withstand heavy attack.

A considerable number of barley varieties, mostly from the Orient (chiefly China and Chosen), showed very high resistance to attack, surviving and maturing a crop when all surrounding strains were killed. Several other strains that originated from crosses on oriental barleys also showed high resistance. Bulk hybrids growing at Denton showed resistance among the segregates when one parent included was a resistant strain, suggesting that the resistance of these strains can be transferred to adapted varieties by crossing.

Among the oat varieties and strains there were included most of the commercial red oat varieties and hybrid strains. None showed outstandingly high resistance, although some differences in susceptibility were observed at Lawton. Wintok, a common winter oat, was much more susceptible to attack than the varieties Fulwin and Tennex. Further testing of oat varieties from world-wide sources is needed before any conclusions regarding resistance can be made.

REVIEW OF LITERATURE

The first reported specimens of the green bug in the United States were found in 1882, according to Webster and Phillips (11).² The first general outbreak was in 1890, when damage to small grain occurred in Texas, Oklahoma, Indiana, Illinois, Kentucky, and North Carolina. In 1901, an outbreak occurred in central Texas and spread from McLennan County northward through Oklahoma and into southern Missouri, causing an estimated damage of several million dollars. Probably the most widespread and serious outbreak was in 1907. It started in central Texas, spreading into a fan-shaped area extending northward through Oklahoma, Kansas, Missouri, Arkansas, and into Illinois to within 60

²Italic numbers in parentheses refer to Literature Cited, p.30.

miles of Chicago. Damage was reported the same year from North Carolina and South Carolina. Walton (10) estimated the loss in the outbreak to exceed 50 million bushels of grain. In Texas, 70 percent of the wheat acreage was abandoned.

An outbreak in Kansas and Oklahoma in 1916 caused an estimated loss of 600,000 acres of oats and 260,000 acres of wheat, according to Kelly (6). Kelly states that each of the serious outbreaks, including that of 1916, was preceded by seasons of excessive precipitation with excessive growth of volunteer grain during the summer and fall, followed by a mild winter; this in turn was followed by cool, dry, backward spring weather favorable for the insect but not for its natural enemies.

More recently less extensive outbreaks have occurred. Hyslop (5) reports that in 1922 one in Texas damaged grain from Bell County in central Texas to Bryan County, Okla. In 1926 an outbreak in Minnesota caused the loss of 15 million bushels of oats (7). Outbreaks each year from 1934 to 1939 threatened the small-grain crops in Oklahoma, according to Fenton and Fisher (2), but only in 1934 and 1939 did these develop into serious general infestations.

Studies of environmental conditions in relation to green bug outbreaks have been made by Wadley (9), Glenn (3), Fenton and Fisher (2), and others. All found that the green bug can reproduce normally at considerably lower temperatures than its principal enemies. Fenton and Fisher (2) studied population trends of both under natural conditions in the field and found that whereas the insect increased normally over a rather wide range of temperature, the parasites did not increase rapidly until daily minimum temperatures were above 50° F.

Few attempts have been made to control the insect with sprays or dusts, because such methods are difficult and impractical in the extensive plantings and with the low acre value of the grain crops. Whitehead and Fenton (12) suggest stamping out the early infestation centers through cooperative effort of growers by plowing under the crop or burning the areas. Spreading the parasitic wasp *Lysiphlebus testaceipes* (Cresson) forward to the advanced margins of infested areas has been attempted by Hunter (4). Webster and Phillips (11), however, found attempts to spread the parasite useless because of its wide natural occurrence and its ability to increase rapidly without assistance whenever weather conditions or abundance of host aphids are favorable to it.

Observations of varietal resistance among the small-grain crops have been limited. Webster and Phillips (11) mention wheat, oats, barley, and related grasses as food plants of the insect. Fenton and Fisher (2) reported that barley was preferred, followed by oats and then wheat. They noted some varietal differences in susceptibility to attack among oat varieties, Lee, Nortex, and Red Rustproof being more seriously damaged than Kanota, Coker Fulghum No. 4, or Columbia. They also observed that fall-sown barley following grain sorghum was more severely damaged than when following soybeans.

WEATHER CONDITIONS IN RELATION TO THE 1942 GREEN BUG OUTBREAK

As with many outbreaks of diseases or insects generally, weather conditions have an important bearing on the abundance of green bugs. Because of this, weather data for Texas for the period June 1941 to May 1942 are given in detail, with some comments on earlier conditions.

As previously mentioned, Fisher and Fenton (2) reported losses from the green bug in 1939. The presence of the insects was noted in north-central Texas the same year, although they did only minor damage. In 1940 and 1941 the green bug caused localized losses in north-central Texas, and as conditions were favorable it seems probable that populations of the aphid were built up over a large area during this period.

The average precipitation, number of rainy days, number of clear days, mean temperature, and humidity for the 11 months June 1941 to April 1942 and comparisons with long-time averages are given in table 1 for Abilene, Dallas, Temple, and Wichita Falls, Tex. In figure 1, monthly precipitation for the same period in comparison with the normal long-time averages is shown for the four stations.

Excessive precipitation over a large area in the summer of 1941 caused serious losses in quantity and quality of grain through delayed

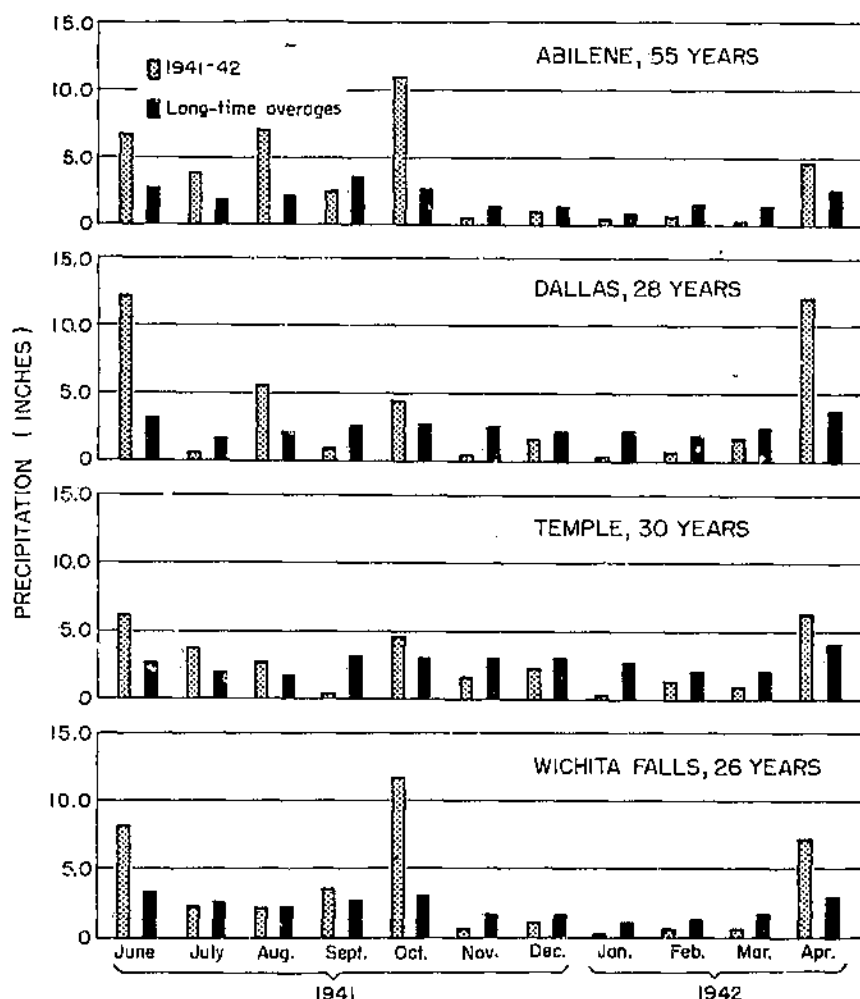


FIGURE 1.—Monthly precipitation compared with long-time averages at selected stations in Texas.

TABLE 1.—*Meteorological data for 1941-42 compared with long-time averages, 1885 to 1943, at selected stations in Texas*ABILENE, 55 YEARS, 1885-1930¹

Month	Mean temperature		Relative humidity		Total precipitation		Days with more than 0.01 inch precipitation		Clear days	
	1941-42	Average	1941-42	Average	1941-42	Average	1941-42	Average	1941-42	Average
	°P.	°F.	Percent	Percent	Inches	Inches	Number	Number	Number	Number
June.....	77.8	80.0	67	55	6.60	2.68	11	7	8	14
July.....	82.7	83.0	63	54	3.59	1.90	5	5	13	15
August.....	82.8	83.0	62	51	7.01	2.10	11	7	9	14
September.....	76.0	76.0	69	58	2.30	2.69	7	6	13	15
October.....	68.4	66.0	70	50	10.28	2.32	13	5	3	17
November.....	55.3	54.0	60	50	.50	1.36	4	5	12	14
December.....	49.2	46.0	67	60	.03	1.22	4	5	12	9
January.....	43.0	45.0	58	50	.08	.67	3	5	8	10
February.....	49.3	48.0	50	56	.54	1.06	5	4	13	12
March.....	56.6	56.0	41	50	.47	1.25	5	5	13	12
April.....	66.1	65.0	46	50	4.65	2.55	10	6	13	12

DALLAS, 28 YEARS, 1914-41¹

June.....	78.0	80.5	75	67	12.18	3.45	14	7	5	14
July.....	84.4	84.2	67	62	.76	1.81	7	5	16	16
August.....	84.4	84.1	69	60	5.54	2.29	12	6	12	16
September.....	79.0	78.1	67	61	1.22	2.61	3	5	14	16
October.....	71.3	68.0	78	63	4.57	2.63	12	6	1	19
November.....	55.2	55.9	65	60	.67	2.69	4	6	13	13
December.....	49.9	47.7	73	70	1.97	2.47	9	7	7	12
January.....	42.8	45.8	63	70	.47	2.40	4	8	14	12
February.....	48.4	46.5	64	67	.86	2.04	4	8	7	10
March.....	56.6	56.0	53	61	1.94	2.63	6	7	14	12
April.....	65.4	65.0	74	64	12.37	3.91	15	8	4	11

TEMPLE, 30-YEAR PERIOD:²

June.....	79.1	80.8	81	71	6.25	2.81	14	6	1	13
July.....	82.5	83.7	78	68	3.80	2.06	5	5	2	14
August.....	83.6	83.9	79	67	2.70	1.90	7	5	6	14
September.....	80.9	78.4	79	71	.44	3.49	5	5	2	13
October.....	74.5	69.2	83	72	4.64	3.07	14	6	1	14
November.....	57.6	59.6	75	70	1.54	3.04	4	7	8	10
December.....	54.0	50.4	71	77	2.49	3.05	8	8	8	10
January.....	48.3	48.3	70	77	.37	2.54	3	9	11	11
February.....	51.9	52.2	72	75	1.48	2.21	6	8	4	9
March.....	60.0	59.0	71	69	.87	2.16	3	7	10	10
April.....	67.5	65.5	80	71	6.38	4.16	14	7	7	11

WICHITA FALLS, 26 YEARS, 1916-43³

June.....	76.9	81.5			5.22	3.49	12		3	
July.....	83.5	85.0			2.42	2.80	3		6	
August.....	84.0	85.5			2.29	2.35	8		7	
September.....	77.0	78.4			3.53	2.71	4		7	
October.....	68.4	68.0			11.77	3.01	12		0	
November.....	53.9	54.5			.60	1.83	4		15	
December.....	47.4	46.3			1.12	1.63	3		8	
January.....	41.6	42.6			.13	1.00	3		13	
February.....	46.3	48.0			.59	1.23	3		11	
March.....	56.3	55.5			.50	1.65	5		12	
April.....	65.8	66.1			7.35	2.98	11		7	

¹ U. S. Weather Bureau data.² Data from Texas Substation No. 5, at Temple; Data on relative humidity and clear days for 28 and 29-year periods, respectively.³ No data for 1921 and 1922.

harvest, lodging, and shattering. This resulted in an enormous volunteer grain crop, which emerged early and continued growth through the summer and early fall. Under these conditions, abnormally large populations of the green bug lived through the summer and with favorable fall weather increased rapidly.

Weather conditions during November and December 1941 continued favorable, with subnormal precipitation and open weather and no great extremes in temperature. One severe cold snap from January 1 to 8, with a minimum of 8° F., killed many insects, but large numbers survived under a light snow cover. Weather during the rest of January

and throughout February and March was characterized by moderate to subnormal temperatures, strong winds, and cloudy skies, but with little precipitation. Temperatures were not sufficiently low to retard the green bug, but were too low for normal development of its parasites and predators. Under these conditions, small-grain crops grew slowly and the insect increased rapidly. Small-grain crops deteriorated rapidly during February and March. Spring-planted grain was destroyed as soon as it emerged. By March 15, temperatures were more favorable for parasitic insects and they increased rapidly. During the last week of March and the first week of April, the green bug in north-central Texas was brought under control by its parasitic and predaceous enemies and other factors. Winged forms appeared, and a general migration occurred. This carried the insect throughout most of the small-grain area of Oklahoma and into southern Kansas. Also, general rains occurred the first week in April, destroying many green bugs and reviving the small stand of surviving grain.

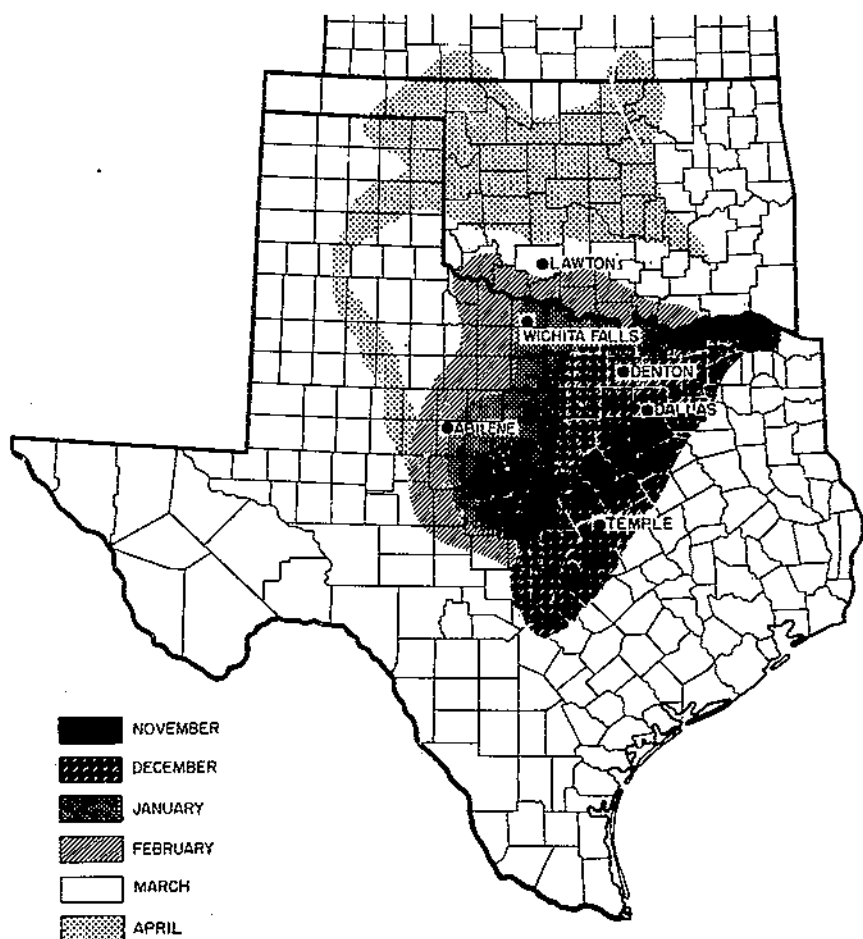


FIGURE 2.—Spread of green bug in Texas and Oklahoma shown by monthly periods, 1941-42.

The approximate spread of appreciable damage by the green bug is shown by monthly periods in figure 2. Reports obtained from each county indicate that damage was observed as early as November 1941 in two areas in central Texas, followed by initial damage over a rather wide area in December. The insect continued to migrate throughout the winter, the greatest spread occurring with the appearance of winged forms in March and April.

CROP LOSSES FROM THE 1942 ATTACK

Any attempt to estimate the loss from an insect outbreak is naturally subject to many errors and assumptions. A record of the best estimate of the loss caused by the widespread infestation of 1942, however, may be of value in indicating the serious damage this insect can do and serve to encourage further work on control measures. Estimates were obtained from the county agricultural agents in each county of Texas and Oklahoma of the damage to each of the small-grain crops. From these estimates figure 3 for wheat and figure 4 for oats and barley were prepared, showing the areas affected and the approximate damage

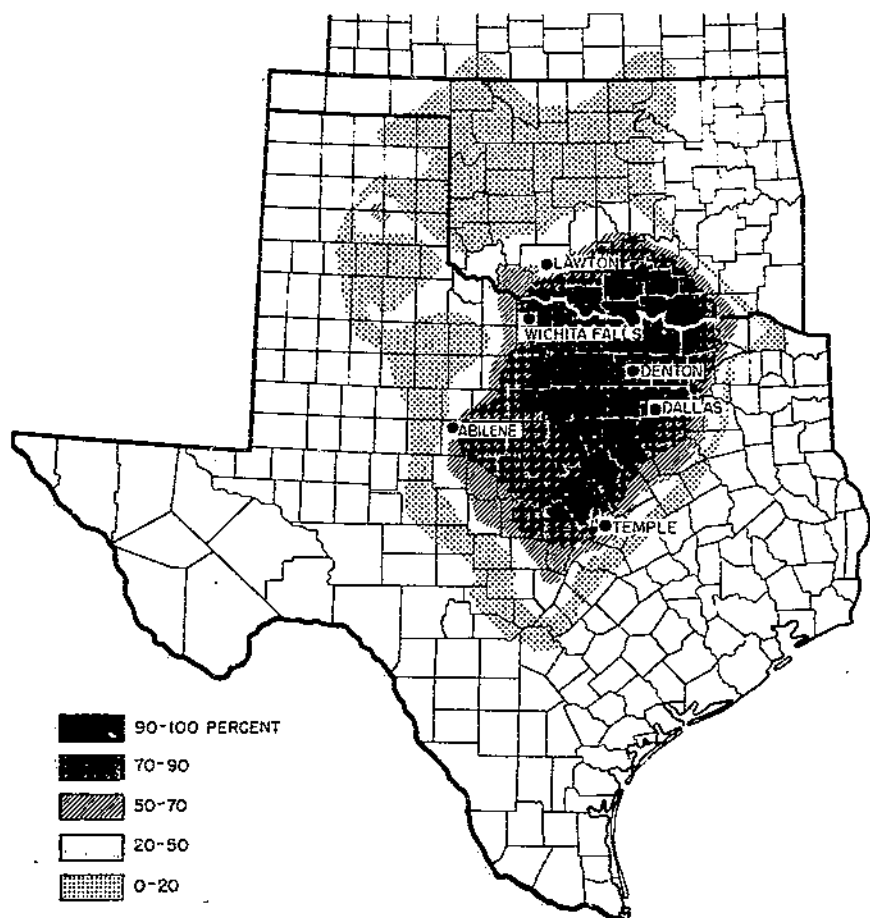


FIGURE 3.—Green bug damage to wheat in Texas and Oklahoma, 1942.

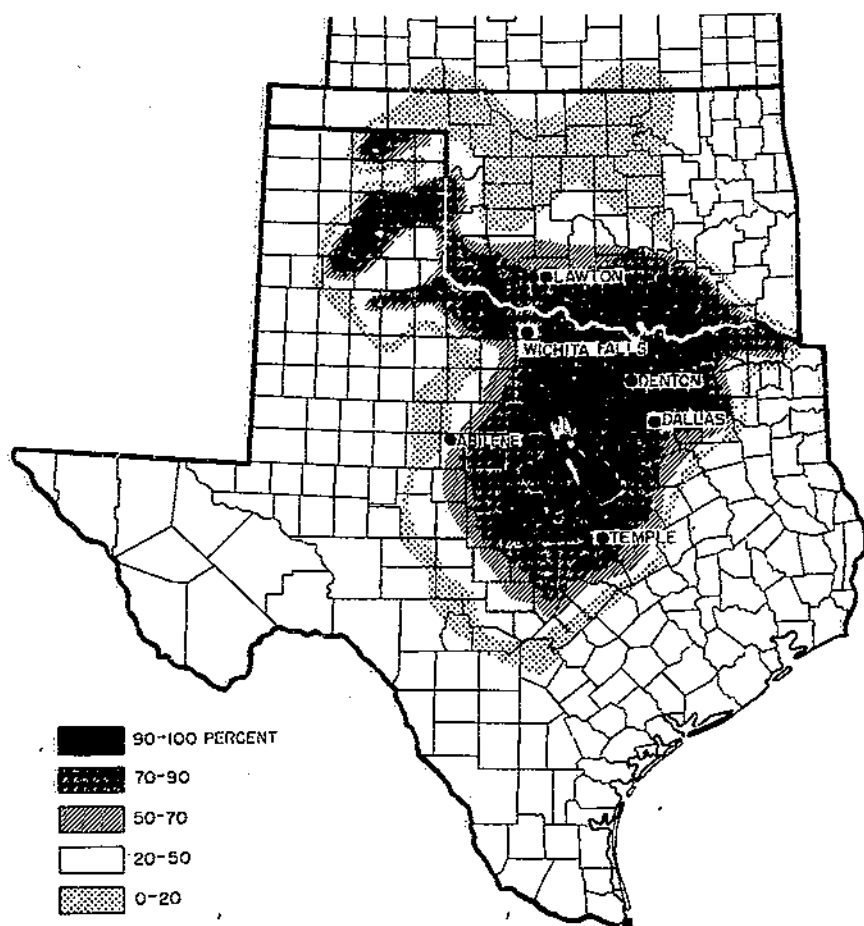


FIGURE 4.—Green bug damage to oats and barley in Texas and Oklahoma, 1942.

in each State. As will be observed the extent of damage was nearly the same for both oats and barley.

From figures 3 and 4 it is apparent that the green bug infestation covered most of the small-grain areas of Texas and Oklahoma and extended into southern Kansas. Wheat was damaged over a smaller area than oats and barley. A considerable part of the main wheat belt of Texas was damaged only slightly, and as a very favorable season followed, the total production for the State in 1942 was above average.

Losses were calculated with the help of C. A. Bonnen.² The following method was used for Texas. The average annual harvested acreage for the State was determined for the period 1939-41, inclusive, rather than for longer periods, because of the rapid increase in oat and barley acreages in recent years. Reports of the 1942 planted acreage could not be used, as they are subject to normal abandonment and include that planted for pasture only. County acreages were then proportioned

² Farm management specialist, Division of Farm and Ranch Economics, Texas Agricultural Experiment Station.

on the basis of the 1939 census, which is the latest record on a county basis. Normal yields for each county were taken from the crop yields by type-of-farming areas (1) used in arriving at wartime farm-production adjustments. These normal yields were based on information from a number of sources and were agreed upon by committees set up for each area to make recommendations of wartime adjustments. From these data the normal acreage and production for each county were computed and then the loss determined, using the estimate of damage supplied by the county agent in each county.

For Oklahoma the same method was used, except that no average yields by type-of-farming area were available; and the average yield per acre for the 1939 crop was used to compute the expected yield after acreages for each county were proportioned. The losses as estimated by these methods are presented in table 2. The percentage of the crop lost as given in table 2 is based on a normal crop represented by the 3-year average previously noted.

TABLE 2.—*Estimated losses of small grain in Texas and Oklahoma caused by the green bug in 1942*

State	Wheat			Oats			Barley			Total	
	Crop lost	Grain lost	Value (at 92 cents per bushel)	Crop lost	Grain lost	Value (at 54 cents per bushel)	Crop lost	Grain lost	Value (at 51 cents per bushel)	Grain lost	Value
	Per cent	Bushels	Dollars	Per cent	Bushels	Dollars	Per cent	Bushels	Dollars	Bushels	Dollars
Texas	10	5,707,404	5,250,811	87	36,891,902	10,489,027	07	3,395,375	1,731,041	45,194,081	26,472,079
Oklahoma	11	7,189,275	6,614,133	22	6,701,178	3,651,036	36	2,631,021	1,341,320	16,581,474	11,606,080
Total		12,896,679	11,864,944		42,593,080	23,140,063		6,026,396	3,072,361	61,775,555	38,078,058

The total estimated loss in the two States in 1942 thus exceeds the estimated 50-million-bushel loss in 1907 and may be considered the most serious outbreak of green bugs in history, even though it did not cover so large an area as that of 1907. In addition to the value of the grain, there must be included such additional losses as the value of winter pasture to stockmen, the loss of adapted seed stocks, and the cost of shipping in new seed for planting. The amount of these additional items would be hard to estimate, but certainly they are sufficiently heavy that they must be considered.

REACTION OF SMALL GRAINS TO GREEN BUG ATTACK

Breeding for resistance to insect attack is one of the more promising new fields of plant breeding. This work has recently been summarized by Snelling (8). One of the chief purposes of this bulletin is to report the outstanding differences in resistance to green bug attack observed in certain small-grain varieties and to record certain observed differences due to cultural practices.

INFLUENCE OF CULTURAL PRACTICES

Although it could hardly be expected that any method of seedbed preparation or any differences in type of fertility of soil or rate of seeding would serve as a control for the green bug, information on the effects of certain of these factors is of importance. County agents reported that land highly fertile, such as that on which cowpeas had been turned under or land fertilized with barnyard manure, showed

materially less damage than less fertile fields. The influence of previous crops on infestation by green bugs in wheat was also observed by Fenton and Fisher (2). At the United States Dry Land Field Station, Lawton, Okla., opportunity was afforded to observe differences in reaction of Turkey wheat where seedbeds had been prepared in several different ways. The results are shown in table 3.

TABLE 3.—Green bug injury to Turkey wheat grown in field plots with different methods of seedbed preparation, Lawton, Okla., 1942

Method of seedbed preparation	Leaves damaged	Method of seedbed preparation	Leaves damaged
	Percent		Percent
Basin-listed:		Early fall-plowed:	
Manured.....	34	With moldboard plow.....	40
Not manured.....	39	And sub-soiled.....	47
Disked:		Deep.....	56
As needed to keep down weeds.....	54	Shallow.....	58
At seeding time.....	72	Late fall-plowed, shallow.....	60
As needed, plowed alternate years.....	45		

Observations in these experimental plots agree with those previously mentioned in that plants produced by the more desirable cultural practices were injured less than those on poorly prepared ground. While these practices offer no hope of complete control they may reduce the damage where infestation is moderate.

The influence of rate and date of seeding on green bug damage to oats was observed at Lawton. The data are presented in table 4.

TABLE 4.—Leaf injury¹ by green bugs to Fulghum oats in a rate-and-date-of-seeding test, Lawton, Okla., 1942

Rate per acre (pecks)	Injury to leaves on oats planted —					Average injury
	January 26	February 5	February 14	February 25	March 10	
	Percent	Percent	Percent	Percent	Percent	Percent
4.....	60	56	57	70	78	65.8
6.....	57	52	49	46	66	54.0
8.....	55	44	45	53	60	51.4
10.....	46	44	46	52	54	48.4
Average.....	54.5	49	51.8	55.3	64	

¹ Notes on leaf injury were taken April 3, when plants in the January 26 planting were 67 days old and those of the March 10 planting 18 days old.

It is of value to note that plots having the lower rates of seeding were more severely injured in all instances. The greater injury on the late-seeded plots was to be expected, as the insect population increased during the period.

WHEAT VARIETIES

The green bug attack at Denton, Tex., started soon after fall emergence of grain. Infestation centers developed throughout the fields so that the severity of attack was not uniform in the experimental plantings or fields. For this reason dependable comparisons were difficult to make except where the strains were located in relatively small areas.

A group of 30 varieties and strains of winter wheat in the Uniform Rust Nursery of the United States Department of Agriculture at Denton, Tex., offered an opportunity to observe varietal differences

among wheats of rather wide sources and seeded in a small area uniformly infested. Plantings were made in single 10-foot rows, and the varieties are listed in planting order so that varietal differences may be better observed. Data on the reaction of these varieties to green bug attack are given in table 5. The estimates are of total damage to the

TABLE 5.—Green bug damage to winter wheat varieties in the United States Department of Agriculture Uniform Rust Nursery grown at Denton, Tex., 1942
(Superscript (in *italics*) indicates number of times recurrent variety was used as parent)

Variety or strain	C. I. ¹ No.	Estimated damage		Variety or strain	C. I. ¹ No.	Estimated damage	
		March	May 1			March	May 1
		<i>Percent</i>	<i>Percent</i>			<i>Percent</i>	<i>Percent</i>
Michigan Amber.....	5620	5	40	Hope X Hussar.....	11682	5	20
Trumbull.....	5657	5	40	Cheyenne X Tenmarq.....	11972	5	30
Denton.....	8265	(²)	10	Marquillo X Tenmarq.....	12113	5	45
Fulcaster.....	0471	5	65	Kanred.....	5146	5	30
Mediterranean.....	3332	5	50	Tenmarq.....	6036	5	30
Minardi.....	5149	5	50	Klarkof.....	1442	5	30
Trumbull X Fultz.....	12220	5	20	Malakof.....	4808	5	20
Wabash.....	11384	5	20	Comanche.....	11673	5	30
Trumbull X Fultz.....	12217	5	20	Pawnee.....	11669	10	60
Fultz sel. X Hungarian.....	11850	5	20	Kawvale X Tenmarq.....	11955	5	30
Do.....	12017	(²)	10	Do.....	11992	5	50
Wabash X Trumbull.....	12216	10	50	Marquillo X Oro.....	11070	(²)	10
Hussar.....	4843	5	50	Hope X Turkey.....	11904	(²)	10
Kawvale.....	8180	5	50	Hope X Cheyenne.....	11909	(²)	10
Minturki.....	6155	5	50	U-44 X Minturki.....	12022	5	30

¹ C. I. in this table and subsequently refers to accession number of the Division of Cereal Crops and Diseases.

² Trace.

variety as compared with normal growth and include leaf injury as well as some killing of plants.

The data in table 5 indicate some marked differences in resistance to green bug attack, although no variety showed sufficient resistance to survive severe attacks. Strains showing greatest resistance included Denton, Marquillo X Oro, Hope X Turkey, and Hope X Cheyenne. Fulcaster, Pawnee, and Kawvale were more susceptible than most other varieties. The resistance of Denton wheat and other Mediterranean strains was apparent in commercial fields in Denton County, Tex., as a few fields survived to produce a small crop when adjoining fields of Tenmarq and other varieties were killed. On many other farms, Denton and Mediterranean, as well as other varieties, were completely destroyed.

Another group of winter wheat strains, including domestic and foreign varieties being tested in preliminary trials, gave opportunity for observation on resistance and susceptibility. Data for these are given in table 6. The varieties are listed in planting order to show varietal differences on adjoining plots. Here also the estimates are of total damage as compared with normal growth and include leaf injury as well as killing of plants.

In this group of strains, Denton wheat again showed considerable resistance to green bug attack. Strains of Marquillo X Oro were the most resistant of any in the nursery, and this was observed in other plantings as will be noted later. Several Chinese wheat varieties showed little injury, which may have been due to their extremely early maturity. The foreign strains, such as P. I. Nos. 94454 and 94462 from the Union of Soviet Socialist Republics (Russia) and P. I. 109585 from Turkey, were considerably more resistant than Tenmarq.

TABLE 6.—Green bug damage to miscellaneous winter wheat varieties grown in single 10-foot nursery rows, Denton, Tex., 1942

Variety or strain	Origin of seed	Selection No.	P. I. ¹ No.	C. I. No.	Estimated damage	
					March 1	April 15
					Percent	Percent
Denton (check)				8205	5	20
Hope X Mediterranean sel.		41-33-1-119-4			5	50
Do.		41-33-1-113-4			5	40
Do.		41-26-1-11-4			5	20
Alabama Bluestem				6976	10	80
Thorne				11850	10	80
Leap selection				12185	30	90
Wabash				11384	10	40
Tennmarq (check)				6936	10	40
Illinois No. 2				11537	5	40
Sanett				12224	20	90
Maretta Blue Straw 2-A					15	90
Maretta-Boggs Purple Straw No. 3						
Kanred-Hard Federation X Tennmarq		37-34-54-1			15	98
Marquillo X Oro				11851	(2)	30
Do.				11980	(2)	10
Do.				11978	(2)	10
Oro X Cerus-Hope-Florence		Ks. 73-2			(2)	45
Denton (check)				8205	(2)	15
Mentana	Italy		132856		95	100
Reusante	Armenia		91344		5	40
No. 22	do.		91340		5	40
No. 88	Bulgaria		94407		10	90
No. 92	do.		94411		10	85
No. 12-13	China		118720		5	20
Tennmarq (check)				6936	15	70
Nanking No. 25	China		124370		5	15
Nanking No. 268	do.		124322		5	20
Nanking No. 393	do.		124310		5	20
No. 6446	U.S.S.R.		92378		25	80
32 r/s 34	do.		94454		5	10
37 r/s 34	do.		94402		5	10
Ukrainka 9246	do.		113912		5	10
No. 1037-30 (No. T-533) ²	Turkey		100583		5	30
No. 11-20 (No. T-535) ²	do.		100585		5	10
Denton (check)				8205	5	10
No. 1419-32 (No. T-539) ²	Turkey		100580		15	60
S. A. B. 129	China		117748		5	10
No. 124	do.		118727		5	10
Akagawa Ako Ichigo	Japan		81793		10	60
No. 11388	U.S.S.R.		94559		10	80
No. 22233	do.		94574		25	80
No. 21-29 (No. T-534) ²	Turkey		100584		15	80
Kanred-Hard Federation 142 X Tennmarq		33-38-109			5	30
Tennmarq (check)				6936	5	25

¹ P. I. refers to accession number of the Division of Plant Exploration and Introduction (formerly Foreign Plant Introduction).

² Trace.

³ Durum.

In several instances there were indications of segregation for moderate resistance among pure line segregates of wheat crosses. An example of this is given in table 7, where the reaction of a few selections from the cross Mediterranean, T. S. 5933-23⁴ - Hard Federation X Hope - Mediterranean selection 41-8-3 is shown in comparison with check plots of Denton and Tennmarq. These strains were grown in duplicate 4-row 10-foot nursery plots and were a part of a much larger group. Estimates of damage are made as described above.

The reactions of the segregates from this cross indicate that differences in resistance are inherited. Reactions in the two replications agree rather closely. Strain 124-40-130 was damaged only 27.5 percent, while strains 124-40-122 and 124-40-135 growing adjacent to it were damaged 96.5 and 72.5 percent, respectively. The high resistance of

⁴ Accession number, Texas Agricultural Experiment Station.

TABLE 7.—Reactions to green bug attack among segregates of the cross *Mediterranean, T. S. 5933-23-Hard Federation* × *Hope-Mediterranean* selection 41-8-3 and of Denton and Tenmarq check plots grown in duplicate 4-row 10-foot nursery plots, Denton, Tex., 1942

Strain or check variety	Estimated damage			Strain or check variety	Estimated damage		
	Replication 1	Replication 2	Average		Replication 1	Replication 2	Average
	Percent	Percent	Percent		Percent	Percent	Percent
Tenmarq (check).....	100	85	92.5	124-40-100.....	95	85	90.0
124-39-350-3.....	100	98	99.0	124-40-111.....	95	90	92.5
124-40-27.....	100	50	75.0	124-40-120.....	95	90	92.5
124-40-31.....	100	30	65.0	124-40-122.....	95	98	96.5
124-40-64.....	40	40	40.0	124-40-130.....	25	30	27.5
124-40-67.....	90	70	80.0	124-40-135.....	70	75	72.5
124-40-70.....	85	85	90.0	124-40-145.....	90	70	80.0
124-40-78.....	65	75	70.0	124-40-140.....	90	80	85.0
124-40-82.....	80	60	70.0	124-40-153.....	95	85	90.0
124-40-102.....	60	30	45.0	Tenmarq (check).....	100	75	87.5
Denton (check).....	20	30	25.0				

Denton wheat compared with many other strains is again indicated in the table and is shown in figure 5.

Replicated nursery tests of winter wheat arranged in a modified Latin square design, consisting of 97 varieties and 11 check plots in each replication, were grown at Denton and Chillicothe, Tex., in 1942. Al-

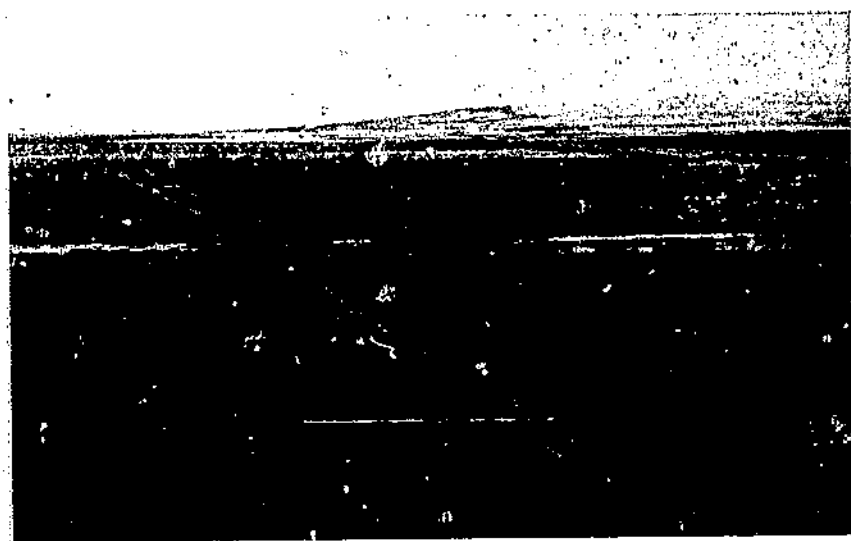


FIGURE 5.—The illustration shows the comparatively high resistance of Denton wheat to green bug attack, while strains from the cross *Mediterranean, T. S. 5933-23-Hard Federation* × *Hope-Mediterranean* selection 41-8-3, adjoining and in the foreground, were injured more seriously; Denton, Tex., 1942.

though the varieties in the tests were not identical, they were nearly so. At Denton the green bug damage was not uniform, owing to localized infestation centers, and notes on damage were taken on only one replication. At Chillicothe the infestation resulted largely from migrating green bugs, so all strains had equal opportunity to be damaged. Parasites and other factors brought the aphids under control before the crop was entirely destroyed, so that a small crop matured. Estimates of

TABLE 8.—Green bug damage to varieties and strains of winter wheat grown in nursery plots, Denton and Chillicothe, Tex., 1942

(Superscript (in *italics>*) indicates number of times recurrent variety was used as a parent)

Variety or strain	Selection No.	C. I. No.	Date headed	Estimated damaged at —	
				Chillicothe, average of 4 replications	Denton, 1 replication
Tenmarq X Blackhull	Wd. ¹ 36h29157		May	Percent	Percent
Marquillo X Oro	Ks. F. N. ² 790-1		4	11.2	
Do.	Ks. F. N. ² 1433-16		12	15.0	5
Cheyenne X Blackhull		12112	5	21.2	29
Kanred-Hard Federation 254887 X Tenmarq	37-37-57		12	21.2	20
Blackhull			5	21.2	40
Kanred-Hard Federation X Minhardi-Minturki		6251	12	22.5	19
Marquillo X Oro	Ks. F. N. ² 797-1	11970	12	23.8	20
Kanred-Hard Federation 254887 X Tenmarq	37-35-3		4	23.8	5
Wichita			5	25.0	
Kanred-Hard Federation 254887 X Tenmarq	37-37-16	11952	4	25.0	20
Denton			8	25.0	30
Cheyenne X Early Blackhull		8205	14	27.5	5
Hope X Turkey		11990	5	27.5	10
Cheyenne X Early Blackhull		11964	15	28.8	10
Cheyenne X Tenmarq		12114	9	28.8	10
Kanred X Clarkan	74-37-37	12104	5	30.0	10
Kanred-Hard Federation 142 X Tenmarq	33-37-40		12	30.0	20
Kanred X Clarkan	74-37-29		4	30.0	30
Kanred-Hard Federation 142 X Tenmarq	33-38-88		13	32.5	
Marquillo X Oro			5	32.5	30
Cheyenne X Early Blackhull		11979	12	33.8	10
Marquillo X Tenmarq		12000	5	33.8	15
Red Chief		12113	11	33.8	30
Martin X Tenmarq ³	50-37-121	12109	9	35.0	90
Kanred-Hard Federation 142 X Tenmarq	33-37-07		12	35.0	
Early Blackhull			5	36.2	30
Martin X Tenmarq ³	50-37-92	8856	4	36.2	40
Kanred X Blackhull			12	37.5	5
Kanred-Hard Federation 142 X Tenmarq	33-37-30	11844	14	37.5	20
Kanred X Hope-Hard Federation			4	37.5	40
Kanred X Hard Federation 142 X Tenmarq	33-37-89	11975	9	40.0	10
Do.	33-34-303		5	40.0	20
Do.	33-35-26	12105	5	40.0	30
Clarkan			5	41.2	
Chiefkan		8858	12	41.2	30
Kanred-Hard Federation 142 X Tenmarq	33-38-27	11754	12	42.5	10
Martin X Tenmarq ³	50-37-109		5	42.5	30
Do.	50-33-63		5	42.5	
Blackhull X Tenmarq		11508	9	42.5	70
Martin X Tenmarq ³	50-37-130	12102	5	43.8	30
Tenmarq X Oro	70-38-44	12111	12	45.0	
Nebred		10094	14	45.0	20
Kanred-Hard Federation 142 X Tenmarq	33-34-271		5	45.0	30
Do.	33-37-31		5	46.2	20
Tenmarq X P. 1066-Prelude	20-34-76		5	46.2	20
Blackhull X Cheyenne		12101	12	47.5	20
Cheyenne		8885	12	47.5	
Tenmarq X P. 1066-1-Prelude	20-38-56		4	47.5	60
Do.	20-35-10		12	48.8	40
Kanred-Hard Federation 254887 X Tenmarq	37-35-2		12	48.8	
Blackhull X Hard Federation	Wd. ¹ 1133-9		9	48.8	
Tenmarq X Oro	70-36-1		12	50.0	
Kanred-Hard Federation 142 X Tenmarq	33-35-27		12	50.0	50
Hope X Cheyenne		11969	12	51.2	
Tenmarq X P. 1066-1-Prelude	20-34-165		5	52.5	10
Kanred-Hard Federation 142 X Tenmarq	33-35-31		6	52.5	
Kanred-Hard Federation 25007 X Tenmarq	25-34-32		5	53.8	40

Least significant difference between the estimated damage of two varieties at Chillicothe at 0.05 point = 14.6 percent.

¹ Wd. = Woodward, Okla.² Ks. F. N. = Kansas Fly Nursery.

TABLE 8.—Green bug damage to varieties and strains of winter wheat grown in nursery plots, Denton and Chillicothe, Tex., 1942—Continued

Variety or strain	Selection No.	C. I. No.	Date headed	Estimated damage at—	
				Chillicothe, average of 4 replications	Denton, 1 replication
Tenmarq X P. 1086-1-Prelude	29-34-153		May 5	Percent 53.8	Percent 50
Vaughn Turkey (average of 24 checks)	T. S. ¹ 15133			55.4	
Kanred-Hard Federation 142 X Tenmarq	33-38-20		5	56.2	
Hope X Mediterranean	41-121		14	56.2	5
Tenmarq X P. 1066-1-Prelude	29-34-113		12	56.2	20
Martin X Tenmarq ¹	56-37-85		12	56.2	50
Comanche		11673	11	57.5	10
Tenmarq X Oro	70-38-112		12	57.5	
Tenmarq X P. 1086-1-Prelude	29-36-44		12	57.5	20
Austin		12346	17	58.8	40
Cheyenne X Tenmarq		12103	12	58.8	40
Kanred-Hard Federation 25007 X Tenmarq	25-34-115	12110	12	58.8	80
Turkey		1558	8	60.0	30
Tenmarq		6936	12	60.0	40
Tenmarq X P. 1066-1-Prelude	29-34-141		12	60.0	
Kanred-Hard Federation 142 X Tenmarq	33-24-274		15	60.0	70
Vaughn Turkey	T. S. ¹ 15133		14	61.2	
Kanred-Hard Federation 25007 X Tenmarq	25-34-44	12106	12	61.2	50
Kanred-Hard Federation 142 X Tenmarq	33-37-90	12115	4	63.8	20
Kanred-Hard Federation 25007 X Tenmarq	25-34-74		5	63.8	50
Kanred-Hard Federation 142 X Tenmarq	33-37-36		5	63.8	60
Tenmarq (average of 20 checks)		6936		64.5	40
Kanred-Hard Federation 25007 X Tenmarq	25-34-135		12	65.0	40
Kawvale X Tenmarq		11992	12	66.0	20
Kanred		5146	15	66.2	10
Tenmarq X Oro	70-36-3		12	67.5	
Do	70-38-83		12	67.5	20
Do	70-38-91		12	68.8	70
Do	70-37-38		12	70.0	10
Kanred-Hard Federation 254887 X Tenmarq	37-34-54	11974	12	70.0	
Cheyenne X Tenmarq		11072	12	70.0	80
Kawvale X Tenmarq	35-34-117	11956	15	71.2	20
Kawvale		8180	13	71.2	60
Kanred-Hard Federation 142 X Tenmarq	33-37-87		8	72.5	
Kharkof		1442	12	73.8	30
Tenmarq X Oro	70-38-125		12	75.0	40
Do	70-38-54		12	77.5	
Kawvale X Tenmarq		11050	12	78.8	90
Pawnee		11600	15	82.2	20
Tenmarq X Oro	70-38-147		15	82.5	60
Kanred-Hard Federation 142 X Tenmarq	33-34-111		12	87.5	30

¹ T. S. = Texas station.

damage at Chillicothe are averages of four replications, detailed data for each of which are on file. The analysis of variance test indicates that at the 0.05 point the least significant difference between the means of two varieties is 14.6 percent. Data on damage observed in the tests are presented in table 8 in order of increasing damage to varieties rather than in planting order, as was done in previous tables. Estimated damage is total injury, as in previous tables.⁵

Some rather marked differences in green bug damage were observed in the above tests. In general, the observations on resistance at the two stations are in agreement, as they also are with the data previously presented in tables 5 and 6. Among the most susceptible varieties may be mentioned the Kawvale X Tenmarq strains, including Pawnee.

⁵ Data presented through the courtesy of J. R. Quinby, Superintendent, Texas Substation No. 12, Chillicothe, Tex.

Highest resistance to attack was shown by the Marquillo \times Oro strains, Denton, Hope \times Turkey (C. I. 11964), and the Blackhull wheat group. Several hybrid strains involving Blackhull or Early Blackhull also showed high resistance, indicating that these hybrid strains may have inherited the resistance of the Blackhull group. In commercial plantings in the Chillicothe area, Early Blackhull was damaged much less than other varieties. Whether earliness directly influenced resistance has not been determined. The data in table 8 indicate no very definite relationship between earliness and resistance, but there is a slight tendency for the later maturing lines to show heavier damage. Selections from the cross Kanred-Hard Federation 254887 \times Tenmarq were among the more resistant strains, while selections from two similar crosses, Kanred-Hard Federation 25007 \times Tenmarq and Kanred-Hard Federation 142 \times Tenmarq, were nearly all very susceptible.

Several varieties of winter wheat were grown in replicated field plots at Chillicothe and Denton, Tex., and Lawton, Okla. All plantings at Denton were killed, but at both Chillicothe and Lawton partial survival permitted good observations on reaction to attack. The varieties included in the tests were the same for the most part. Data on reactions of these varieties are given in table 9. Estimates of damage are total injury and include injured leaves as well as killing, as in other tables.

The results were similar to those in the nursery tests. At Lawton the range in damage was rather small, but in general the more resistant strains were the same as at Chillicothe, where the damage was severe.

TABLE 9.—Green bug damage to winter wheat varieties grown in field plot tests, Chillicothe, Tex., and Lawton, Okla., 1942

[Superscript (in *italic*) indicates number of times recurrent variety was used as a parent]

Variety or strain	C. I. No.	T. S. No.	Chillicothe, Tex.			Lawton, Okla.		
			Estimated damage		Yield of grain	Estimated damage		Yield of grain
			Average, 4 replications	Rank		Average, 3 replications	Rank	
Wichita	11952	26984	<i>Percent</i>		<i>Bushels</i>	<i>Percent</i>		<i>Bushels</i>
Red Chief	12109		36.3	1	12.9	27.3	6	26.5
Early Blackhull	8656	15838	45.0	2	11.1	26.7	5	13.5
Denton	8265	9236	53.8	3	9.3	23.3	2	24.2
Kanred-Hard Federation 142 \times Tenmarq	12105		58.8	4	7.9			
			62.5	5	7.3			
Comanche	11673	24951	63.8	6	7.8	34.0	16	20.9
Chiefkan	11754	23276	65.0	7	6.9	22.0	1	11.6
Blackhull	6251	7172	66.3	8	7.1	20.3	10	18.0
Martin \times Tenmarq	11805		72.5	9	5.2			
Kanred-Hard Federation 25007 \times Tenmarq	12106		76.3	10	4.6			
Tenmarq	6936	12578	77.5	11	4.3	27.7	7	16.9
Kawvale \times Tenmarq	11956		78.8	12	4.2	29.0	9	24.8
Turkey	1558		81.3	13	3.5	43.3	21	11.0
Choyenne	8885	18506	83.8	14	3.2	33.0	15	14.9
Pawnee	11600		83.8	14	3.0	30.3	13	15.4
Mediterranean	11687		80.3	16	2.7			
Kanred	5146	11730	86.4	17	2.5	31.7	14	19.5
Kharkef	1442	16830	87.5	18	2.3	38.3	18	12.9
Kawvale \times Tenmarq	11750		92.5	19	1.7	34.7	17	20.6
Turkey \times Kawvale, La. 35-93						25.7	3	12.3
Clarkan	8839	20400				25.7	3	15.1
Harvest Queen	6109					28.7	8	11.4
Penquite	11745	23243				30.7	11	13.8
Kawvale	8180	12577				30.0	12	20.5
Sibley 62	11523	20481				39.0	19	18.9

In both tests Pawnee and other Kawvale \times Tenmarq strains were among those more seriously damaged. The relative damage was reflected in final yields of grain.

BARLEY VARIETIES

As noted previously, barley is one of the favored host plants of the green bug in this region. Opportunity to observe the reaction of a very large number of varieties from world-wide sources was afforded by the extensive plantings at Denton, Tex., and Lawton, Okla. The high resistance and survival of some strains under heavy infestation give encouragement to the project of breeding adapted resistant varieties.

For several years, a study of winter hardiness of barley varieties has been conducted by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering. Usually 40 varieties are included, these being grown at all experimental stations in the winter barley area. This group of varieties was grown at both Denton, Tex., and Lawton, Okla., where notes on reaction to attack were recorded. The data are given in table 10. Estimates of damage are the average of two replications, the varieties being arranged in order of increasing injury as observed at Denton. Estimates given are total injury to the plot compared with normal growth and include leaf injury as well as killing of plants. Observations at Lawton are expressed both as percentage of injury to the variety and as percentage of the nearest Tennessee Winter check plot.

TABLE 10.—Green bug damage to winter barley varieties in the United States Department of Agriculture Uniform Winter-Hardiness Nursery, grown at Denton, Tex., and Lawton, Okla., 1942

Variety	C. I. No.	Estimated damage ¹ at Denton, Tex.	Estimated damage, ² Lawton, Okla.		
			Named variety	Percentage of nearest Tennessee Winter (check)	Rank
		Percent	Percent	Percent	
Nu Er Ta	7411	7.5	34.0	78.2	3
Esaw	4690	7.5	35.5	81.0	5
Smurise	6272	12.5	29.5	67.8	1
Smooth Awn 86	6268	20.0	33.5	70.5	2
Wong	6728	25.0	33.5	79.8	4
Iredell	6571	37.5	43.0	90.5	13
Davidson	6373	60.0	38.5	85.5	11
Randolph	6372	60.0	39.0	89.7	12
North Carolina 11	6594	92.5	39.5	90.8	14
Tennessee Winter (checks)	6034	94.3	43.9	100.0	25
Ward	6007	95.0	42.0	81.6	7
Reno	6561	95.0	43.5	84.5	8
Clemson Hooded	7042	95.0	45.5	95.8	20
Jackson 1	7045	95.0	46.5	97.9	24
Marnobarb	6120	95.0	46.0	103.1	29
Texan	6499	95.0	49.5	104.2	31
Poland	6280	97.5	47.5	92.9	16
Wisconsin Winter	2150	97.5	45.5	95.8	20
Tennessee Beardless 6	2746	97.5	45.5	95.8	20
Missouri Early Beardless	6051	97.5	46.0	96.8	22
Tenkow	646	97.5	44.5	102.3	28
Manchuria	245	97.5	46.0	105.5	30
Wintex	6127	97.5	46.0	105.5	30
Santiam	6367	99.0	44.0	101.2	27
Ohio 1	7072	100.0	34.0	81.0	5
Mercer	7071	100.0	35.5	84.5	8
Polders	3213	100.0	38.0	87.4	10
Jackson	6569	100.0	43.5	91.6	15
Purdue 2815A3-1-1-6	7067	100.0	39.0	92.9	17
Kentucky 1	6050	100.0	46.0	93.9	19
Purdue 21	4581	100.0	47.5	96.6	23
Purdue 1101	4582	100.0	49.0	100.0	25
Trebi	936	100.0	46.0	107.0	33

¹ Average of 2 replications.

At Denton, Tex., where the insect population was very great, most varieties were soon killed. The resistance of Smooth Awn 86, Esaw, Sunrise, Wong, and Nu Er Ta was outstanding. These varieties survived and produced a good crop when all strains surrounding them were killed. At Lawton, Okla., the attack was of shorter duration, so that damage was not so severe, but the same varieties showed high

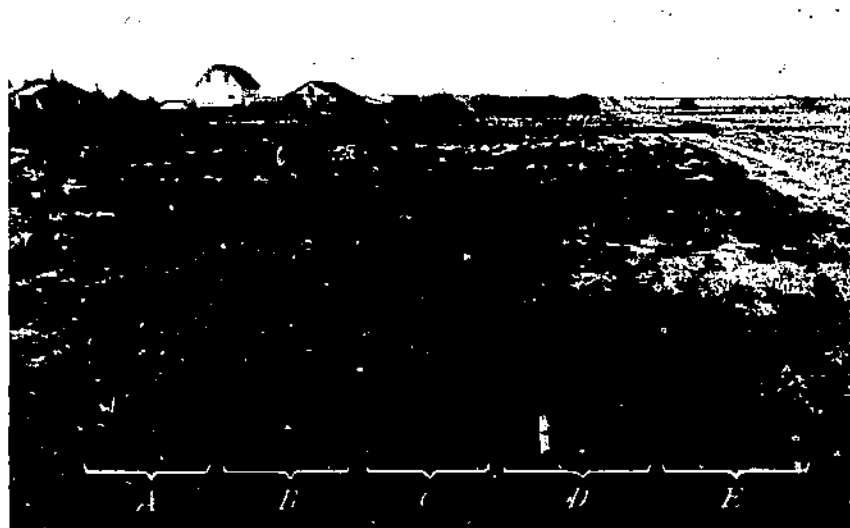


FIGURE 6.—Survival of barley varieties following attack of the green bug at Denton, Tex., 1942, in 2-row 12-foot plots: A, Iredell; B, Tennessee Winter; C, Clemson Hooded; D, Esaw; E, Sunrise. In the next block in the background may be seen Nu Er Ta and Wong, which survived the attack.



FIGURE 7.—Smooth Awn 86 barley survived when all surrounding strains were killed by the green bugs; Denton, Tex., 1942.

resistance. The resistant varieties Esaw and Sunrise are selections from a natural cross of Nakano Wase, a Japanese variety. Esaw is also one of the parents of Smooth Awn 86. The high resistance of these strains is shown in figures 6 and 7.

Another group of foreign and domestic barley varieties were grown in single 2-row 12-foot plots at Denton in comparison with check plots of Wintex and Texan. The data from this test are recorded in table 11, the varieties being listed in order of severity of damage.

TABLE 11.—Green bug damage to miscellaneous winter barley varieties grown in single 2-row 12-foot nursery plots, Denton, Tex., 1942

Variety	C. I. No.	Estimated damage	Rank	Origin or source
		Percent		
Peru.....	707	5	1	North Africa.
Kunshan.....	1005	5	1	China.
Malwet.....	2459	5	1	Do.
Omugi.....	5144	5	1	Chosen.
Sonbaku.....	5151	10	5	Do.
Nipa.....	2471	20	6	China.
Hoodless Beardless.....	1803	35	7	Saskatchewan.
Pidor.....	901	80	8	Tennessee Winter X Hankow.
Kinroku.....	5265	85	9	Chosen.
Arabel.....	896	85	9	Tennessee Winter X Black Arabian.
Temple.....	1046	90	11	China.
Unnamed.....	2420	90	11	California.
Texan (check).....	0490	90	11	Selection from Composite Cross, C. I. 5530.
Unnamed.....	3883	90	11	Kashmir.
Dobadak.....	5187	90	11	Chosen.
Nipa.....	2471	90	11	China.
Maretts Awnless 1.....	7073	95	17	South Carolina.
Wintex (check).....	0127	100	18	Selection from farmer's field in Texas.
Telli.....	194	100	18	North Africa.
Argentine.....	223	100	18	Argentina.
Santizo.....	1049	100	18	China.
Michigan Winter.....	7032	100	18	Oklahoma.
Orkoo.....	2465	100	18	China.
Maynang.....	2429	100	18	Do.
Maretts Hooded 4.....	7074	100	18	South Carolina.
Zehra.....	5180	100	18	Chosen.

Extreme differences in susceptibility to green bug attack were observed in this group of varieties. Omugi was damaged only 5 percent, maturing a good crop while the adjoining plot of the Unnamed strain (C. I. 3883) from Kashmir was damaged 90 percent. The varieties Peru, Kunshan, Malwet, and Omugi all showed high resistance, being damaged only 5 percent each, while the standard varieties Wintex, Texan, and Michigan Winter were almost completely destroyed. The resistance and susceptibility of a number of varieties included in this test are shown in figure 8.

At Lawton, Okla., a group of 91 varieties of winter barley was grown from fall seeding in single 5-row 10-foot nursery plots. Check plots of Michigan Winter were spaced at intervals of 10 plots. The test included most of the commercial winter barleys grown in the United States, as well as many winter types from widely separated parts of the world. As mentioned previously, the green bug infestation at Lawton was largely the result of migration, and the insects were brought under control by parasites and other factors before complete killing occurred. The first notes on injury were taken April 3 to 7 at each of four places in each plot. About 10 days later, April 17, a second note was taken to indicate the percentage of the leaves infested. The

final note, taken April 30, was an estimate of the total injury to the entire plot, including leaf injury and killing of plants. The first two observations are recorded as percentages for the named variety, while the last is in proportion to the nearest Michigan Winter check plot, in order to overcome any possible variation due to location. Data for the 91 strains are presented in table 12 and are arranged in order of increasing injury to the variety.

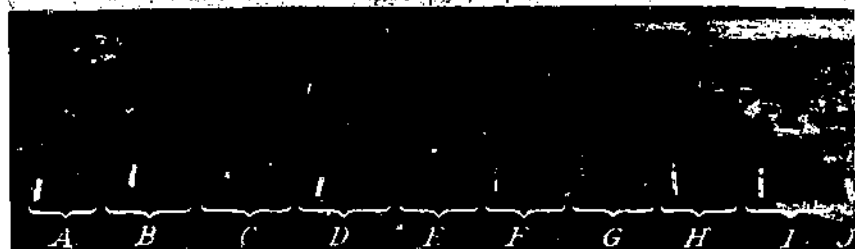


FIGURE 8.--Reaction of barley varieties to green bug attack, Denton, Tex., 1942: A, Hooded Beardless, 35 percent damaged; B, Unnamed strain (C. I. 2420), 90 percent; C, Texan, 90 percent; D, Maynang, 100 percent; E, Malwet, 5 percent; F, Nipa, 20 percent; G, Unnamed strain (C. I. 3883), 90 percent; H, Omugi, 5 percent; I, Sonbaku, 10 percent; and J, Dohadak, 90 percent.

The data indicate that some varieties are rather resistant to green bug attack and that the reaction at Lawton, Okla., was similar to that at Denton, Tex., where infestation was even greater. Total damage to the plots ranged from 15.6 percent (based on percentage of the nearest Michigan Winter check plot) for Rufino to 135.8 percent for Composite Cross selection (Okla. 39-5267). The varieties Omugi, Esaw, and Dobaku were highly resistant at both stations, while Wintex, Texan, and all Tennessee Winter strains, including Ward, Reno, and Michigan Winter, were seriously damaged or completely killed.

Differences in the nature of reaction to attack also are indicated. For example, Rufino was damaged only 15.6 percent in spite of 50 percent infestation of the leaves and 34 percent of the leaves showing injury at the early inspections, whereas Dorshu was damaged 25 percent, with only 12 percent of the leaves infested and 23 percent of the leaves injured. Also, White Catami (Oklahoma 39-8027), with 93 percent of the leaves infested, was damaged about 29 percent, while Kipo, with only 16 percent of the leaves infested, was damaged almost 35 percent.

For the purpose of studying resistance to chinch bug attack, a group of 99 varieties and strains, some winter and some spring types, were spring-seeded in 5-row 10-foot nursery plots in a triple-lattice design at Lawton. This test offered a valuable opportunity to study the reaction of these varieties to green bug attack. Detailed notes were taken for each replication and are on file at Lawton, and only the averages

TABLE 12.—Green bug damage to fall-sown barley varieties grown in single 5-row 10-foot nursery plots at Lawton, Okla., 1942

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Leaves infested April 17 ²	Total injury to plot ³ April 30 ³
			Percent	Percent	Percent
Rufino	2475	China	34	50	15.0
Dorshu	6154	Chosen	23	12	25.0
Shumaki	5222	do.	34	25	25.3
Seibaku	5220	do.	25	32	26.3
Dobaku	5238	do.	16	32	26.3
White Gatami	920		18	93	29.4
Unnamed	5087	China	34	80	29.4
Shonan	5255	Chosen	24	21	32.3
Unnamed	5092	China	41	57	32.3
Kipo	5242	Chosen	32	16	34.9
Omugi	5144	do.	34	26	38.5
Rangubori	5239	do.	30	35	39.0
Mignon	999	U. S. S. R.	32	69	42.9
Borido	5230	Chosen	40	35	42.9
Ghest	979	U. S. S. R.	41	77	42.9
Fesun	2463	China	38	48	44.1
Esaw	4690	Nakano Wase X Unknown	28	82	45.5
Naver	737	China	37	62	45.5
Warabe	5205	Chosen	36	45	45.5
Lopat	2477	China	32	65	46.2
Orkoe	2465	do.	31	87	46.9
Pontius	731	do.	48	62	50.0
Tenkow	646	Tennessee Winter X Hankow	46	90	53.3
Kinroku	5265	Chosen	31	73	53.3
An arillo	1073	China	20	43	53.6
Nangmay	2428	do.	37	70	53.6
Ruble	870	Venezuela Winter	36	82	54.1
Arlington Awiless	702	Tennessee Winter X Black Arabian	31	55	55.6
Peru	707	North Africa	44	72	56.3
Composite Cross selection (Oklahoma 30-5255)		Selection from Composite Cross, C. I. 5530	50	82	56.8
Composite Cross selection (Oklahoma 30-5240)		do.	44	70	57.2
Black Smyrna	191	do.	42	85	57.2
Bakson	5244	Chosen	38	75	57.2
Gumshu	5217	do.	49	55	58.0
Composite Cross selection (Oklahoma 39-5250)		Selection from Composite Cross, C. I. 5530	46	38	50.7
Iredell	6571	North Carolina selection from Tennessee Headless G.	48	34	60.6
Saniol	2488	China	35	85	60.6
Brando	5210	Chosen	39	86	61.7
Loelink	2460	China	42	88	62.5
Nu Er Ta	741	do.	55	92	63.5
Horsford	2324	do.	55	98	64.5
Ton Pori	5150	Chosen	45	70	65.8
Unnamed	5088	China	50	93	69.0
Han River	205	do.	51	80	69.4
Argentine	223	Argentina	52	87	69.4
Quast	626	do.	56	93	71.4
Telli	104	North Africa	55	83	71.4
Abyssinian	1231	Abyssinia	44	82	71.5
Composite Cross selection (Oklahoma 35h0-9)		Selection from Composite Cross, C. I. 5461	46	97	71.5
Sonbaku	5151	Chosen	54	97	71.5
Black Smyrna	191	Asia Minor	46	85	71.5
Composite Cross selection (Oklahoma 35h10-3)		Selection from Composite Cross, C. I. 5461	49	97	71.5
Kotau	5161	Chosen	38	96	71.5
Composite Cross selection (Oklahoma 39-5242)		Selection from Composite Cross, C. I. 5530	38	72	72.5
Wisconsin Winter	510	Europe	60	74	73.2
Missouri Early Headless	6051	Selection from Missouri farmer's field	44	37	74.1
Davidson	6373	Selection from Composite Cross, C. I. 5461	47	85	76.9
Hooded 10	6563	Selection from Tennessee Headless G.	59	50	76.9
Bodau	753	Japan	35	73	76.9
Lico		Lion X Coast	50	83	78.1
Oni	5188	Chosen	45	80	80.6
North Carolina 11	6564	Selection from Composite Cross, C. I. 5461	40	84	82.0
Tongukotau	5211	Chosen	34	61	83.3

¹Percentage of leaves injured, determined from inspection of 25 plants at 4 locations in each plot.²Percentage of leaves infested, determined from inspection of 100 plants in center row of each plot.³Estimate of injury to entire plot, converted to percentage of nearest check plot.

TABLE 12.—*Green bug damage to fall-sown barley varieties grown in single 5-row 10-foot nursery plots at Lawton, Okla., 1942—Continued*

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Leaves infested April 17 ²	Total injury to plot April 30 ³
Composite Cross selection	6502	Selection from Composite Cross, C. I. 5530.	Percent 40	Percent 96	Percent 83.3
Moldavia	392	Rumania	26	77	85.7
Composite Cross selection	6500	Selection from Composite Cross, C. I. 5530.	44	92	85.7
Odessa	182	U. S. S. R.	48	87	85.7
Keiroku	5240	Chosen	48	82	85.7
Dohaduk	5187	do.	60	98	85.7
Rice	742	China	55	78	86.2
Porcu	2428	Japan	63	98	89.7
Tennessee Winter	3546	Selection from Tennessee Winter	54	83	80.7
Composite Cross selection (Oklahoma 39-5264).		Selection from Composite Cross, C. I. 5530.	40	94	92.0
Santaku	5130	Chosen	44	71	95.2
Reno	6561	Farm in Kansas	40	97	100.0
Ward	6007	Farm in Oklahoma	44	92	100.0
Luth	908	Selection from farmer's field in Minnesota	45	98	100.0
Unnamed	2420	California	47	80	100.0
Trebi	936	Asiatic Turkey	50	97	100.0
Composite Cross selection (36Ab0308).		Selection from Composite Cross, C. I. 5461.	46	89	100.0
Composite Cross selection (Oklahoma 39-5245).		Selection from Composite Cross, C. I. 5530.	52	90	100.0
Michigan Winter (check)	7032	Oklahoma	56	90	100.0
Composite Cross selection (Oklahoma 35h10-2)		Selection from Composite Cross, C. I. 5461.	37	92	100.0
Composite Cross selection (Oklahoma 39-5268).		Selection from Composite Cross, C. I. 5530.	54	68	102.0
Texas	6490	do.	68	94	108.1
Tennessee Winter X Smooth Awn	6565	Tennessee Winter X Smooth Awn	76	95	100.6
Santian	6367	Selection from Composite Cross, C. I. 5530.	43	95	114.3
Wintex	6127	Selection from farmer's field in Texas	59	100	121.6
Composite Cross selection (Oklahoma 35h6-12).		Selection from Composite Cross, C. I. 5461.	67	100	123.6
Unnamed	3883	Kashmir	38	98	133.3
Composite Cross selection (Oklahoma 39-5267).		Selection from Composite Cross, C. I. 5530.	70	100	135.8

¹ Percentage of leaves injured, determined from inspection of 25 plants at 4 locations in each plot.² Percentage of leaves infested, determined from inspection of 100 plants in center row of each plot.³ Estimate of injury to entire plot, converted to percentage of nearest check plot.

are presented here. As in the fall-sown test, three notes were taken: (1) Percentage of leaves injured on April 7; (2) estimated injury to the entire plot on April 25, which included leaves injured and plants killed; and (3) a final note on April 30, with counts of the percentage of plants killed. These notes were slightly different from those on the fall-sown tests, where the second note was one of the percentage of leaves infested with green bugs and the final note one of the general injury to the plot.

The average for each of the three notes is given in table 13, with the varieties arranged in order of increasing injury, as indicated by the total injury note on April 25. An analysis of variance of the data on leaf injury from the first note taken shows that the standard error of an adjusted mean difference between varieties located together in a block is 5.86 percent and for those not together in a block 5.96 percent. The adjustments are not large. For unadjusted means, given in table 13, a difference of 14 percent or more would be significant.

Many varieties included in the fall-sown test reported in table 12 were included also in the spring-planted group reported in table 13. In general their reaction was the same. Among the more resistant

TABLE 13.—Green bug injury to winter barley varieties spring-seeded in 5-row 10-foot nursery plots in a triple-lattice design, Lawton, Okla., 1942

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 25 ²	Plants killed April 30 ³
			Percent	Percent	Percent
Mignon.....	009	U. S. S. R.....	24.7	10.0	0
Dobaku.....	5238	Chosen.....	23.7	13.3	0
Omugi.....	5144	do.....	24.3	13.3	.6
Felix.....	1457	Mesopotamia.....	27.7	13.3	3.3
Ruffino.....	2476	China.....	25.3	10.7	2.0
Kumfide.....	730	do.....	20.7	20.0	0.9
Hoodless Beardless.....	1803	Saskatchewan, Canada.....	33.3	25.7	13.1
Gatani (Oklahoma 30-8004).....			30.0	26.7	8.5
Nunca.....	2473	China.....	32.2	30.0	7.3
Turkestan.....	712	Turkestan.....	35.7	30.0	12.8
Kinroku.....	5285	Chosen.....	30.0	30.0	3.8
Pannier.....	1330	Kashgur.....	40.0	30.0	15.7
Uncle John.....	2471	China.....	35.7	35.7	8.0
Good Delta X Flynn (40Ab578).....		Good Delta X Flynn.....	37.0	35.7	10.0
Quinn.....	1024	Australia.....	38.3	36.7	17.3
Horsford.....	2324	China.....	40.3	36.7	4.5
Wanfat.....	2161	do.....	30.7	40.0	12.5
Flynn X Stavropol (H. C. 37-3046).....		Flynn X Stavropol.....	37.7	43.3	10.0
Niver.....	737	China.....	38.3	43.3	18.1
Loelink.....	2460	do.....	41.0	40.7	22.7
White Gatani.....	920	do.....	28.7	45.7	3.3
Olonets.....	198	U. S. S. R.....	42.3	45.7	34.0
Stavropol (H. C. 246).....	5013	do.....	43.7	45.7	30.0
Horido.....	5236	Chosen.....	44.0	46.7	12.8
Ton Port.....	5150	do.....	45.0	46.7	4.0
Venus.....	730	China.....	38.7	50.0	13.0
Esau.....	4090	Nakano Wave X Unknown.....	42.3	50.0	10.4
Beecher.....	6566	Atlas X Vaughn.....	44.0	50.0	50.5
Malwet.....	2450	China.....	41.3	53.3	22.2
Composite Cross selection (Oklahoma 35h0-5).....		Selection from Composite Cross, C. I. 5461.....	42.0	55.3	67.8
Vaughn.....	1367	Club Maricot X Lien.....	42.0	53.3	25.0
Nu Er Tu.....	741	China.....	43.3	53.3	24.5
Davidson.....	0373	Selection from Composite Cross, C. I. 5461.....	43.7	53.3	48.1
Vaughn X Stavropol (H. C. 304).....		Vaughn X Stavropol.....	44.0	53.3	24.2
Black Smyrna.....	191	Asia Minor.....	45.7	53.3	32.3
Leb.....	700	India.....	47.3	53.3	53.3
Nungui.....	2426	China.....	45.3	56.7	30.0
India Hall-less.....	008	India.....	47.7	56.7	23.7
Unmated.....	497	Egypt.....	50.3	56.7	32.8
Turhot.....	1254	do.....	51.0	56.7	61.2
Composite Cross selection (Oklahoma 35h0-0).....		Selection from Composite Cross, C. I. 5461.....	41.7	60.0	55.8
Vance.....	4585	Selection from Smyrna, C. I. 2642.....	44.7	60.0	60.6
Yatlong.....	2464	China.....	45.3	60.0	23.0
Gunshu.....	5217	Chosen.....	47.3	60.0	13.5
Reed Triumph.....	880	Highland Chief X Mensury.....	47.7	60.0	60.7
Atlas X Vaughn (Moscow 33-31). ⁴	0075	Atlas X Vaughn.....	48.0	60.0	78.0
Han River.....	206	China.....	40.0	60.0	45.2
Olonets.....	198	U. S. S. R.....	49.3	60.0	66.8
Bozu.....	749	Japan.....	50.3	60.0	12.0
Khamaka.....	743	Turkestan.....	60.0	60.0	84.1
Atlas X Vaughn (Moscow 33-44).....	0070	Atlas X Vaughn.....	46.3	63.3	67.5
Atlas.....	4118	Selection from Const.....	47.3	63.3	40.7
Heron.....	1299	U. S. S. R.....	50.0	63.3	51.1
Composite Cross selection (Texas 1-33-170).....	0500	Selection from Composite Cross, C. I. 5530.....	50.3	63.3	69.8
Composite Cross selection (Oklahoma 30-5254).....		do.....	45.3	60.7	62.7
Kusan.....	1315	Egypt.....	48.3	66.7	57.5
Tenkow.....	040	Tennessee Winter X Hankow.....	48.7	66.7	50.5

¹ Estimate of leaves injured taken on 100 plants, 25 plants in each of 4 locations in plot.² Estimate of total injury of entire plot, including leaves injured and plants killed, by general observation of entire plot, based on percentage of nearest check plot.³ Estimate of plants killed, taken on 100 plants in center row of plots, after green bugs had disappeared and growth was resumed.⁴ Nursery number, in this table and subsequently, at Moscow, Idaho.

TABLE 13.—Green bug injury to winter barley varieties spring-seeded in 5-row 10-foot nursery plots in a triple-lattice design, Lawton, Okla., 1942—Continued

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 25 ²	Plants killed April 30 ³
			Percent	Percent	Percent
Trebi	936	Asiatic Turkey	46.0	66.7	75.4
Composite Cross selection (Oklahoma 35b9-12)		Selection from Composite Cross, C. I. 5461	53.3	66.7	83.7
Zamugi	5178	Chosen	53.7	66.7	69.1
Atlas X Vaughn (Moscow 33-11) ⁴	6072	Atlas X Vaughn	54.7	66.7	74.3
Blackhull	878	Abyssinia	56.7	66.7	65.4
Lion	6270	Lion X Coast	51.3	76.0	60.1
Weider	1021	Australia	51.7	70.0	65.2
Italiana 62 (Oklahoma 37-4342)			52.0	70.0	48.0
Blackhull 1180	6069	Selection from Blackhull, C. I. 878	53.3	70.0	63.8
Cape	567		54.6	70.0	55.8
Composite Cross selection (Oklahoma 39-5255)		Selection from Composite Cross, C. I. 5530	55.3	70.0	60.3
Perth	6025	Australia	56.7	70.0	71.7
Coast	626		60.0	70.0	74.6
Tennessee Winter 52	3543	Selection from Tennessee Winter	62.3	70.0	78.7
Wisconsin Winter	519	Europe	62.3	70.0	62.2
Do	2159	Selection from Wisconsin Winter, C. I. 510	65.0	70.0	82.1
Rice	742	China	54.0	73.3	80.4
Atlas X Vaughn (Moscow 33-27)		Atlas X Vaughn	55.0	73.3	77.6
Maison Carre X Flynn (36Ab5179)		Maison Carre X Flynn	55.7	73.3	63.9
Texas	6499	Selection from Composite Cross, C. I. 5530	58.3	73.3	72.2
Tong	2462	China	59.0	73.3	74.4
Composite Cross selection (Oklahoma 39-5257)		Selection from Composite Cross, C. I. 5530	60.3	73.3	56.7
California Marriot	1455	North Africa	61.7	76.7	82.5
Randolph	6372	Selection from farm field in North Carolina	63.3	76.7	82.8
Lion	923	U. S. S. R.	65.6	76.7	77.5
Phoebe	1305		65.7	76.7	90.4
Oderbrucker	940		72.7	76.7	86.8
Tennessee Winter 66	3546	Selection from Tennessee Winter	76.7	76.7	72.6
Ramadan	2478	Algeria	55.3	80.0	89.1
Iredell	6571	North Carolina selection from Tennessee Beardless 6	63.0	80.0	83.3
Unnamed	5088	China	63.3	80.0	88.1
Wintex	6127	Selection from farmer's field in Texas	64.3	80.0	80.8
Tennessee Winter	6034	Virginia seed service	66.3	80.0	97.2
Composite Cross selection (Oklahoma 39-5245)		Selection from Composite Cross, C. I. 5530	66.3	80.0	84.2
California Marriot X Lyallpur (36Ab5092)		California Marriot X Lyallpur	71.3	80.0	79.3
Zehra	5189	Chosen	75.3	80.0	88.4
Silver King	800	Manchuria	83.3	80.0	97.4
Reno	6561	Farm in Kansas	65.0	83.3	85.8
Missouri Early Beardless	6051	Selection from farmer's field in Missouri	68.7	83.3	89.2
Keiroku	5240	Chosen	71.0	83.3	80.9
Michigan			71.7	83.3	82.1
Golden Phasant X Hannchen (36Ab3896)		Golden Phasant X Hannchen	88.3	90.0	98.6

¹ Estimate of leaves injured taken on 100 plants, 25 plants in each of 4 locations in plot.² Estimate of total injury of entire plot, including leaves injured and plants killed, by general observation of entire plot, based on percentage of nearest check plot.³ Estimate of plants killed, taken on 100 plants in center row of plots, after green bugs had disappeared and growth was resumed.

strains grown at Denton, Tex., and from both spring and fall seedings at Lawton, Okla., were Dobaku, Omugi, and Hoodless Beardless. Strains showing high resistance at Lawton from both fall and spring seedings but not grown at Denton include Rufino, Mignon, Borido, Niver, and White Gatami. That green bug resistance is inherited and may be transmitted in crosses is evidenced by the high resistance of

Esaw, Sunrise, and Smooth Awn 86, all of which have a common parent, Nakano Wase, a Japanese barley. Several Gatami strains were highly resistant, and third generation bulk hybrids of Black Gatami \times Winter and Black Gatami \times Texan grown at Denton showed segregation for resistance, many plants surviving to mature normally.

For a study of resistance to chinch bugs, a spring planting of 136 varieties of barley was made at Lawton, Okla. This test consisted largely of spring barleys but included some winter types. Data on the reaction of these spring-sown strains to green bug attack are given in table 14. As with previous data, notes were taken on three dates,

TABLE 14.—Green bug damage to spring-seeded barley varieties grown in single 6-row 10-foot nursery plots, Lawton, Okla., 1932

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 17 ²	Plants killed April 30 ³
			Percent	Percent	Percent
Hankow	192	China	23.4	11.1	0
Arlington Awnless	792	Tennessee Winter \times Black Arabian	41.7	17.0	0
Unnamed	5087	China	35.7	17.5	0
Do	5092	do	30.4	17.9	0
Tori	5246	Chosen	42.2	18.5	0
Dorshu	5154	do	38.5	18.9	0
Saibaku	5220	do	50.0	20.0	0
Pera	707	North Africa	35.0	22.2	4.8
Leonid	1057	China	33.3	24.6	11.1
Abyssinian	1231	Abyssinia	45.8	20.4	0
Telli	104	North Africa	44.8	33.3	61.2
Shonan	5255	Chosen	44.9	34.5	0
Waseh	1044	China	54.3	36.1	46.3
Yang Chung	1048	do	30.4	36.0	14.8
Amarillo	1073	do	38.6	30.5	7.1
Atlas \times Vaughn (Moscow 33-13)	0078	Atlas \times Vaughn	55.8	40.4	78.0
Tripeh	1115		41.0	42.1	72.1
Hell Hanna 4	677	Germany	55.1	43.5	78.0
Argentine	223	Argentina	55.7	44.4	74.5
Coast	601	North Africa	65.2	45.5	61.6
Atlas \times Vaughn (Moscow 33-13)	0073	Atlas \times Vaughn selection	37.4	46.5	68.2
Colby 28445 \times Flynn (U. C. 35-2034)	0083	Colby 28445 \times Flynn selection	50.6	51.0	79.1
Chukiang	1009	China	46.4	51.3	14.0
Hansee Hull-less	703	Hankow \times hooded "b."	60.4	61.7	120.1
Peruvian	1131	Selection from Composite Cross, C. I. 5530	36.7	53.2	62.8
Canada Winter	713	Europe	50.2	53.6	5.6
Composite (Oklahoma 30-5200)			45.0	55.6	95.3
Huan	734	India	74.5	55.6	71.1
Ghest	979	U. S. S. R.	58.3	58.1	11.0
Moldavia	302	Rumania	66.0	58.1	100.4
Monte Cristo	1017	India	60.3	59.5	82.3
Lion \times Muttan (30Ab5670)		Lion \times Muttan	62.9	62.5	90.0
Karin-Gre	604	Japan	61.8	63.5	95.9
Italian 65 (Oklahoma 38-4360)			57.1	64.5	80.0
Composite Cross selection (Oklahoma 30-5242)		Selection from Composite Cross, C. I. 5530	63.0	65.2	83.0
Composite Cross selection (Oklahoma 30-5247)		do	55.0	65.9	91.3
Menesh	593	China	72.9	66.7	81.8
Hooded 10	6563	Selection from Tennessee Beardless 6, C. I. 2746	77.5	66.7	82.6
Saitama-Nishiki	752	Japan	63.2	67.4	101.3
Oleass	182	U. S. S. R.	67.7	68.5	87.0
Unnamed	671	Abyssinia	101.7	69.4	136.6
Santal	2408	China	58.1	70.2	30.8
Woodrow	686	U. S. S. R.	70.2	70.6	78.3
Atlas \times Vaughn (Moscow 33-8)	0071	Atlas \times Vaughn	75.1	71.4	93.2

¹ Percentage injury based on inspection of 25 plants at each of four places in each plot, converted to percentage of nearest Michigan Winter check.

² Percentage of injury based on general appearance of entire plot, converted to percentage of nearest Michigan Winter check.

³ Percentage of injury based on inspection of 100 plants in center row of each plot, then converted to percentage of nearest Michigan Winter check.

TABLE 14.—Green bug damage to spring-seeded barley varieties grown in single 5-row 10-foot nursery plots, Lawton, Okla., 1942—Continued

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 17 ²	Plants killed April 30 ³
Composite Cross selection (36Ab4961).		Selection from Composite Cross, C. I. 5461.	Percent 60.9	Percent 72.1	Percent 89.3
Abyssinia.....	362	Abyssinia.....	95.6	73.2	124.2
Club Mariout.....	261	Egypt.....	50.7	73.2	92.2
Sonbaku.....	5151	Ohosen.....	64.2	74.1	10.6
Flynn 1.....	5911	Selection from Flynn, C. I. 1311.	77.3	75.0	102.0
Bano.....	2472	China.....	59.0	75.5	17.8
Glabron.....	4577	Smooth Awn X Manchuria.	60.6	76.0	80.5
Yanchudaka.....	580	Japan.....	78.5	70.9	101.6
Lopat.....	2477	China.....	80.8	70.9	54.1
Smooth Awn 86.....	6208	Tennessee Winter X Smooth Awn X Esaw.	79.4	70.9	81.0
Mensury.....	170	Manchuria.....	75.5	77.8	70.0
Tennessee Winter X Smooth Awn B5-14.	0570	Tennessee Winter 52 X Lion.	82.7	77.8	100.3
Composite Cross selection (Oklahoma 39-5285).		Selection from Composite Cross, C. I. 5530.	82.8	77.8	71.9
Jackson.....	6509	Tennessee Winter 52 X Lion.	86.8	77.8	102.2
Salamanca.....	089	Spain.....	96.7	77.8	100.0
Spartan.....	5027	Michigan 2 - Row X Black Barbless.	73.3	77.6	77.0
Eurylops.....	2209	China.....	70.2	78.1	114.0
Unnamed.....	3883	Kashmir.....	77.1	78.4	110.0
Glacier.....	0976	Atlas X Vaughn.....	40.2	79.5	94.8
Banado.....	5210	Chosen.....	66.1	80.0	37.8
Bakson.....	4244	do.....	69.0	80.0	37.7
Warabo.....	5205	do.....	71.4	80.0	81.3
Shumaki.....	8222	do.....	75.0	80.0	39.2
Bulu.....	1022	Australia.....	63.6	80.0	82.8
Nakano Wase.....	704	Japan.....	85.7	80.5	94.2
Caucasian.....	90	Caucasus.....	80.8	80.6	149.0
Composite Cross selection (Oklahoma 35h10-3).		Selection from Composite Cross, C. I. 5461.	67.0	81.1	90.5
Composite Cross selection (36Ab6398).		do.....	90.5	83.3	104.0
Kentucky 11.....	6021	Tennessee Winter X Smooth Awn.	73.3	86.0	103.9
Unnamed.....	3921-2	Abyssinia.....	101.4	86.2	106.9
Turkestan (Winter).....	711	Turkestan.....	78.5	87.7	144.5
Composite Cross selection (Oklahoma 39-5288).		Selection from Composite Cross, C. I. 5530.	90.2	88.6	103.1
North Carolina 11.....	6564	Selection from Composite Cross, C. I. 5461.	103.4	88.9	103.2
Reverse.....	2409	China.....	83.1	89.3	117.3
Caucasian.....	714	Caucasus.....	78.8	90.9	60.1
Santaku.....	5139	Chosen.....	82.8	90.9	101.2
Bodai.....	763	Japan.....	111.1	90.9	100.0
Nipa.....	2471	China.....	81.1	92.6	67.0
Kentucky 2.....	0148	Selection from local Kentucky barley.	78.0	92.8	102.0
Union Winter.....	583	Europe.....	82.1	93.8	103.4
Michigan Winter.....	2030	Indiana Agricultural Experiment Station.	90.6	94.7	104.3
Kotsu.....	5161	Chosen.....	102.1	96.2	63.3
Wansnipe.....	2356	China.....	75.3	96.8	61.0
Composite Cross selection (Oklahoma 35h10-2).		Selection from Composite Cross, C. I. 5461.	114.0	97.2	124.2
Marnobarb.....	0120	Smooth Awn X Tennessee Winter.	85.4	97.8	99.9
Hero.....	1286	Lion X Club Mariout.....	83.2	98.0	114.7
Cape.....	557	South Africa.....	111.7	98.8	124.1
Santiam.....	6367	Selection from Composite Cross, C. I. 5530.	111.5	100.0	111.0
Michigan Winter (21 checks).....	7032	Oklahoma.....	100.0	100.0	100.0
Composite Cross selection (Texas 1-32-103).	6502	Selection from Composite Cross, C. I. 5530.	94.1	100.0	111.4
Kip.....	5242	Chosen.....	71.4	100.0	17.6
Rangburi.....	5239	do.....	80.4	100.0	101.4
Composite Cross selection (Oklahoma 39-5067).		Selection from Composite Cross, C. I. 5530.	92.0	100.0	112.2

¹ Percentage injury based on inspection of 25 plants at each of four places in each plot, converted to percentage of nearest Michigan Winter check.² Percentage of injury based on general appearance of entire plot, converted to percentage of nearest Michigan Winter check.³ Percentage of injury based on inspection of 100 plants in center row of each plot, then converted to percentage of nearest Michigan Winter check.

TABLE 14.—Green bug damage to spring-seeded barley varieties grown in single 5-row 10-foot nursery plots, Lawton, Okla., 1942—Continued

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 17 ²	Plants killed April 30 ³
			Percent	Percent	Percent
Purdue 21.....	4581	Mass selection from Tennessee Winter.	104.1	101.0	100.8
Unnamed.....	3010-2	Abyssinia.....	127.6	101.7	171.0
Ward.....	0007	Local farm in Oklahoma.....	93.3	102.0	101.0
Blackhull 1178.....	5079	Selection from Blackhull C. I. 8737.	74.6	102.6	102.0
Milan.....	424	Asia.....	117.6	103.4	110.0
Minsturd.....	1650	South African X Manchuria.	104.0	105.3	112.0
Bremo.....	2230	India.....	91.2	100.1	154.1
Tennessee Winter X Smooth Awn.....	5565	Tennessee Winter X Smooth Awn.	93.8	106.4	105.2
Peru.....	653	North Africa.....	113.1	100.7	124.6
Princess.....	520	Sweden.....	116.0	107.1	117.0
Pitler.....	6036	Selection from farmer's field in Michigan.	73.4	108.1	114.8
Ruble.....	870	Venezuela.....	95.0	108.7	102.7
Tambis.....	2470	China.....	84.6	100.1	172.4
Clemson Hooded.....	7042	South Carolina.....	115.9	111.1	111.0
Carytid.....	1108	Switzerland.....	119.4	111.1	132.8
Andie.....	728	India.....	117.6	113.2	248.4
Winter Club.....	1707	Europe.....	120.1	113.0	203.6
Hanna.....	226	Moravia.....	116.7	114.3	131.2
Poppenheim.....	314	Central Asia.....	126.3	115.4	132.1
Dinar.....	720	Tunis.....	99.0	115.1	266.7
Pontius.....	731	China.....	109.0	117.6	71.0
Winter Club.....	592	Europe.....	91.7	118.4	117.9
Barbery.....	095	North Africa.....	98.0	119.0	142.3
Tongkatou.....	5211	Chosen.....	85.7	120.0	207.8
Dohndak.....	6187	do.....	112.5	120.0	203.6
Baku.....	253	Central Asia.....	122.3	121.6	120.0
Dehra.....	1085	India.....	130.7	121.6	130.0
Canadian Thorpe.....	740	England.....	101.4	125.0	322.1
Sopchow.....	867	China.....	115.6	127.7	273.7
Lokiang.....	2457	do.....	92.6	134.4	178.0
Porce.....	2428	Japan.....	119.9	135.0	178.6
Nugent.....	176	Swedish X Baxter.....	139.5	136.4	165.4
Manchuria.....	2330	Manchuria.....	111.9	139.5	160.2
Kharaila.....	733	Abyssinia.....	125.3	142.0	142.5
Abyssinian.....	1216	do.....	141.8	146.3	328.0
Kopeck.....	860	North Africa.....	104.0	155.0	361.8
Luth.....		Selection from farmer's field in Minnesota.	240.2		
Galangatch.....	008	Chinese Turkestan.....	181.8	188.7	268.7
Pori.....	5184	Chosen.....	150.0	176.5	340.4

¹ Percentage injury based on inspection of 25 plants at each of four places in each plot, converted to percentage of nearest Michigan Winter check.

² Percentage of injury based on general appearance of entire plot, converted to percentage of nearest Michigan Winter check.

³ Percentage of injury based on inspection of 100 plants in center row of each plot, then converted to percentage of nearest Michigan Winter check.

recording (1) percentage of leaves injured on April 7, (2) total injury to the plot on April 17, by observation, and (3) percentage of plants killed on April 30, taken from a count of 100 plants as before. As not all these strains were located on the same area but were exposed to varying degrees of green bug infestation, all notes are expressed in percentage of the nearest Michigan Winter check plots.

The percentage of plants injured in the spring-sown test ranged from 11 of Michigan Winter check for Hankow to 176.5 of Michigan Winter check for Pori. It will be noted that some strains that showed high resistance when fall-seeded likewise showed high resistance when spring-seeded. Among those are Peru, Telli, Amarillo, and Argentine. Smooth Awn 86, which showed high resistance when fall-seeded, was damaged rather severely when spring-sown, although not so severely as many surrounding strains. The very high resistance of Hankow in comparison with several other varieties is shown in figure 9.



FIGURE 9.—High resistance of Hankow barley in comparison with other strains, Lawton, Okla., 1942: *a*, Mensury; *b*, Hankow; *c*, Hero; *d*, Composite Cross selection (36Ab6308); *e*, Odessa; *f*, Philer; *g*, Michigan Winter; *h*, Jackson; *i*, Tennessee Winter \times Smooth Awn B5-14; *j*, Hooded; *k*, North Carolina 11; *l*, Santiam.

OAT VARIETIES

At Denton, Tex., where the green bug population was extremely large, no oat varieties were found that showed marked resistance to attack. The experimental tests included most of the commercial red oat strains in addition to many of hybrid origin.

At Lawton, Okla., where the insect population was the result of migration and the injury to the crop not so severe, some differences in injury were observed. Data on the reaction of varieties grown in field plots at Lawton are given in table 15.

TABLE 15.—Green bug leaf injury to oat varieties grown in triplicate field plots, Lawton, Okla., 1942

Variety	C. I. No.	Leaves injured			
		Replication			Average
		A	B	C	
		Percent	Percent	Percent	Percent
Tennex	3160	19	16	8	14.3
Pulwin	3168	22	14	12	16.0
Coker 33-47	3176	20	18	10	16.0
Pulgrain	3253	21	18	10	16.3
Coker 32-1	3026	25	20	9	18.0
Pultex	3531	17	21	17	18.3
Pulghum (winter type)	2198	28	30	26	28.0
Do	2500	36	35	30	33.7
Whitok	3421	70	58	45	51.0

SPRING-SEEDING					
Columbia	2820	40	39	43	40.7
Ferguson 922	2170	46	51	52	49.7
Frazier	2381	39	50	56	51.3
Pulghum (Lawton seed)		43	61	66	56.7
Texas Red Rustproof (T. B. 1415-12)		48	65	62	58.3

From the data in table 15 it appears that there are some small differences among varieties of oats in their reaction to attack. The resistance observed is not of such a high order as was found in certain barley varieties, and under heavy infestation at Denton these same varieties were killed. Among the five varieties spring-seeded, the differences are relatively small and probably not significant. As some small differences were observed and as most of the varieties grown were of one type, it is possible that by growing a large number of varieties from world-wide sources greater resistance among oat varieties may be found.

ORIGIN OF RESISTANT VARIETIES

In recording the origin of varieties of barley grown at Denton, Tex., and Lawton, Okla., in 1942, it soon became apparent that the majority of the strains showing high resistance to green bug attack originated in the Orient, and by far the greater proportion of these came either from east-central China or from Chosen. The most resistant varieties reported in tables 10 to 14, inclusive, are grouped according to sources as follows:

- China:* Rufino*,^a unnamed (C.I. 5087)*, unnamed (C.I. 5092)*, Kunshan, Malwet, Nipa, Kumfide, Ninea, Hankow, Leopold, Nu Er Ta.
Chosen: Omugi*, Dorshu*, Seibaku*, Dobaku*, Sonbaku, Shunaki, Shonan, Kipo, Tori.
North America: Hoodless Beardless*, Wong, Esaw, Smooth Awn 86, Sunrise, Arlington Awnless, White Gatami, Gatami (Okla. 39-8004).
Union of Soviet Socialist Republics: Mignon.
Mesopotamia: Felix.
Abyssinia: Abyssinian (C.I. 1231).
Turkestan: Turkestan.
North Africa: Peru*.

In addition to the fact that the majority of the varieties showing high resistance originated in the Orient, it will be observed by studying the parentage of the North American resistant varieties in the original tables that oriental barleys appear as one of the parents in nearly all instances. Wong barley originated from the cross between Ore! and a Chinese barley; Esaw, Sunrise, and Smooth Awn 86 all have a common parent in Nakano Wase from Japan. The Gatami strains are selections from Gatami barleys introduced from the Orient. From these facts it seems that resistant varieties must have been developed by natural selection over long periods in central China. The exact area where many of these originated is not known, but it is possible that many are related.

The fact that most of the resistant varieties of barley came from east-central China lends support to the moderate resistance observed in certain Chinese wheats reported in tables 5 and 6. Although it was thought that earliness of these wheats may have accounted for some of their resistance, nevertheless they survived much better than Tenmarq and other common varieties. Nanking No. 25 (P. I. 124270), Nanking No. 268 (P. I. 124322), Nanking No. 393 (P. I. 124340), and No. 12-13 (P. I. 118726) from China all were injured approximately 20 percent when adjoining plots of Tenmarq were injured 70 percent. By further testing of varieties from the Orient, as well as other world sources, it seems possible that high resistance to the green bug may be found in all the small grains.

^a Varieties marked with an asterisk (*) appear twice in tables 10 to 14 as high-ranking varieties.

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