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RESISTANT VARIETIES OF SORGHUM AND CORN IN RELATION TO CHINCH BUG CONTROL IN OKLAHOMA

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RESISTANT VARIETIES OF SORGHUM AND CORN IN RELATION TO CHINCH BUG CONTROL IN OKLAHOMA[1]

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INTRODUCTION

The chinch bug is one of the most destructive of all insects attacking cereal crops in Oklahoma. This pest occurs in damaging numbers in the State each year, and in outbreak proportions in much of the State during many years. It is often a limiting factor in the production of sorghums, corn and spring barley. Methods of control used in some of the northern states have been found ineffective under Oklahoma conditions. Experimental results and observations indicate that the most promising method of reducing chinch bug damage in Oklahoma is by the development of resistant varieties of plants adapted to regions in the State that are frequently and heavily infested with chinch bugs. The progress that has been made in developing chinch bug resistant varieties of sorghums is discussed in this bulletin. The data were collected in the field from 1930 to 1936 and in the laboratory during 1935 and 1936 at the United States Dry Land Field Station, Lawton, Oklahoma. Observations also were made on many farms throughout the State. Although the results obtained from these experiments and observations are promising it must be pointed out that the development of a variety of corn or sorghum entirely immune to chinch bug damage does not appear likely. When the plants are small or the infestation is extremely heavy, all varieties will be damaged. The resistant varieties suffer less damage, however, than those which are more susceptible.

Distribution of the Chinch Bug in Oklahoma

Chinch bugs occur in greatest numbers in the southwestern, central, and northeastern parts of the State (fig. 1). They are seldom injurious in the southeastern, northwestern, or panhandle sections of Oklahoma. Very little injury from chinch bugs occurs west of the 25-inch rainfall line.

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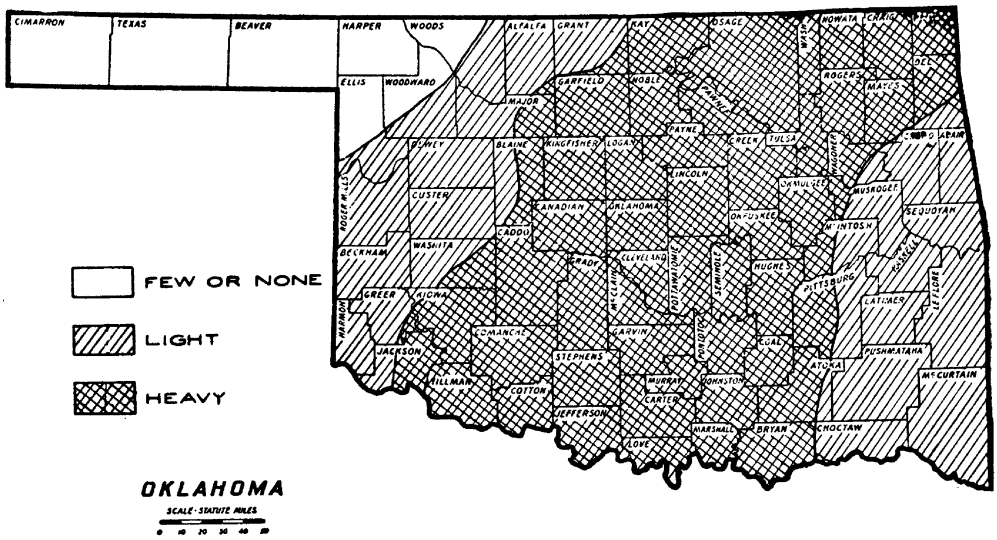
[1] Cooperative project between the Divisions of Cereal Crops and Diseases, and Dry Land Agriculture, Bureau of Plant Industry; Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture; and the Departments of Entomology and Agricultural Chemistry Research, Oklahoma Agricultural Experiment Station. The Kansas Agricultural Experiment Station participated through informal cooperation, 1930-1934. Results obtained during this period were included in a manuscript which will be published as a U. S. D. A. Technical Bulletin entitled "Sorghum Varieties Resistant to the Chinch Bug," by R. O. Snelling, R. H. Painter, J. H. Parker and W. M. Osborn, which is in press.

[2] The authors are indebted to the following men for valued assistance in the execution of the work and the preparation of this manuscript. Dr. F. A. Fenton, Entomology Department, Oklahoma Agricultural Experiment Station, Mr. W. M. Osborn, Division of Dry Land Agriculture, Bureau of Plant Industry, U. S. Department of Agriculture, Dr. John H. Martin, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and Dr. P. N. Annand, Division of Cereal and Forage Insects, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Fig. 1.—Intensity of chinch bug infestation in Oklahoma.



Conditions in southwestern Oklahoma are so favorable to the chinch bug that it is present in large numbers nearly every year at some time during the growing season. The Lawton station was established in 1915 and since that time chinch bugs have been present in more or less injurious numbers every year. The practice of isolating sorghums and corn from small grain crops is commonly used in the southwestern section. In the central and northwestern sections, however, a few years of successive light infestation results in the planting of sorghums and corn adjacent to small grains. A rather sudden outbreak under these conditions causes greater and more spectacular damage than if the sorghums and corn had been isolated from the small grain crops.

Life History of the Chinch Bug

Three complete generations of chinch bugs occur each year in the region of Lawton, Oklahoma, as reported by Snelling,[3] and illustrated in fig. 2. Studies at Stillwater by the junior author also indicate this to be true in the northern part of the State. The over-wintered adults usually leave winter quarters, such as native grass, Johnson grass, and sorghum stubble, during the last half of March and the first part of April. They fly to small grain crops, especially barley and winter wheat, where eggs for the first generation are deposited duing the latter half of April. Young nymphs of this generation usually appear early in May and feed on wheat or barley, and to some extent on oats, until they have become adults. They usually reach this stage about the time the small grain crops mature, or during the first half of June; at that time these adults are forced to seek another source of food. In the southwestern part of the State, and to some extent in the central and northeastern parts, this migration is accomplished by flight. This differs from the habit of the insect farther north where migration usually is by crawling. In the northern states, small grain crops usually become mature sometime before the bugs reach the winged or adult

[3] Snelling, R. O., Third Generation and Method of Migration of Chinch Bugs in Southwestern Oklahoma, Jour. Econ. Ent. *29*:797-803, 1936.

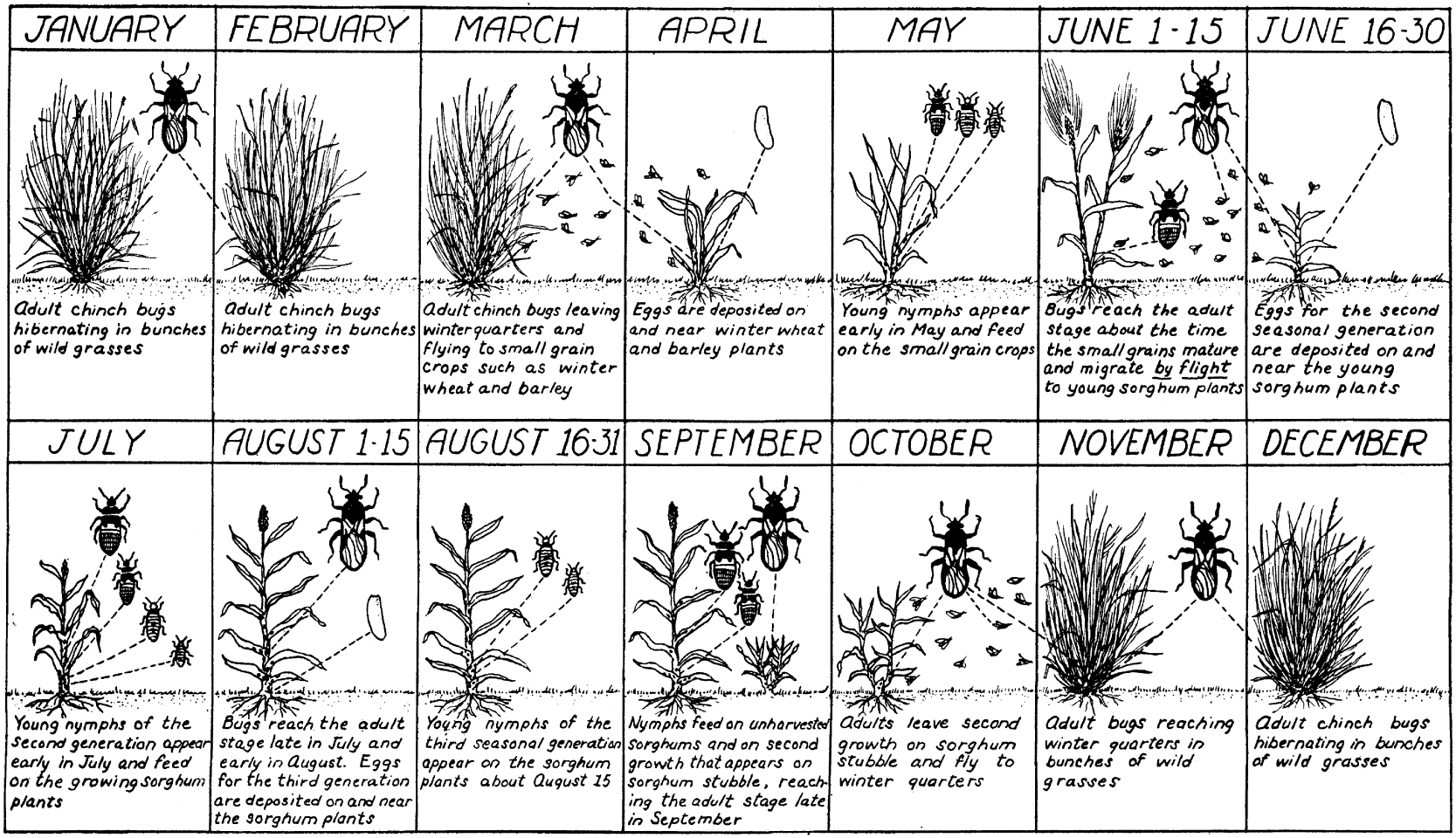


Fig. 2.—Life cycle of the chinch bug in Oklahoma.

stage, thus forcing them to migrate to a new source of food by crawling. In Oklahoma, because of high soil temperatures, at the time of migration, the bugs tend to migrate by flight also.

Eggs for the second generation are deposited on and near young sorghum and corn plants during the last part of June. Young nymphs of this generation usually appear early in July. They feed on the sorghum and corn plants until they become adults in late July and early August. Eggs for the third generation are deposited on and near sorghum plants during the first half of August. Young nymphs of this generation appear about August 15. They feed on late sorghums, and on second growth where the main crop has been harvested, until they become adults. The third generation adults may either hibernate in sorghum stubble or fly to nearby grass land for hibernation. The principal places of hibernation are sorghum stubble, Johnson grass, and native grasses such as Little Blue Stem or Big Blue Stem that have a bunch habit of growth.

Plants Attacked by the Chinch Bug

So far as known, the chinch bug injures only plants belonging to the grass family, and many species serve as host plants. This family includes small grains, corn, millet, Johnson grass, sorghum (grain and forage sorghums, Sudan grass and broom corn), and many of the native grasses. All of these hosts are common in Oklahoma and their periods of growth are such that ample food for this insect is always available. Of the small grain crops, barley is a favorite food plant, while wheat is preferred to oats. Susceptible sorghum varieties seem to be preferred to all corn varieties that have been tested at Lawton when the bugs had a chance to choose between them.

Character of Injury Caused by the Chinch Bug

Chinch bugs feed on plants during any stage of growth by sucking the sap from the plant and such feeding is an important factor in causing injury. It is not believed, however, that the removal of the sap alone accounts for all the injury that results. After the withdrawal of the mouthparts some injury results by exudation of plant juices through the puncture. The opening left in the plant also permits entrance of disease organisms. The red, injured condition that appears at the feeding places on sorghum plants probably results from a clogging of certain plant tissues. The injection of toxic substances by the insect may also be a factor.

Natural Control Not Dependable in Oklahoma

Very few natural conditions seem to play a consistent part in the control of chinch bugs in Oklahoma, and especially in the southwestern part of the State. One of the chief natural controls of importance is the occurrence of damp, relatively cold weather during May while the young nymphs of the first generation are appearing. Very heavy infestations of overwintering adults that deposit many eggs in the spring do not necessarily result in serious damage. Cases have been observed where damp, cool weather prevailed while these eggs were hatching and the young nymphs perished in such numbers that the crops suffered as little summer damage as any on record.

Another factor in natural control is the destruction of chinch bug eggs by drought and high temperatures. Conditions have been observed in

which a heavy summer infestation has been greatly reduced because the eggs failed to hatch. This has been especially noticeable in eggs laid by second generation females in seasons when drought and high temperatures prevailed during their oviposition period. This condition does not materially reduce the damage during the current season, but does reduce the numbers of bugs for hibernation, which may result in less damage the following year.

Heavy, dashing rains while the nymphs of any generation are relatively small destroy sufficient numbers to result in satisfactory control. When these natural factors operate they are of considerable value in reducing chinch bug damage, but they do not occur often enough to afford dependable control, thereby making other methods necessary.

Artificial Controls Limited in Oklahoma

Control measures generally recommended for reducing damage caused by the chinch bug consist of the use of mechanical barriers, particularly creosote, the burning of grasses that harbor the pest during the winter season, and the planting of immune crops. The creosote barrier, used rather successfully in the northern States in reducing the number of chinch bugs that enter sorghums and corn, is ineffective in southwestern Oklahoma and is not always effective in the central and northeastern parts of the State. The migration of bugs from small grain crops to the sorghums and corn usually is accomplished by flight because the bugs have reached the adult or winged stage when the small grains ripen. High temperatures dry the creosote quite rapidly, rendering its repellent qualities less effective; and high winds blow litter and soil across the barrier, forming bridges over which the bugs can cross. Even when the insects have not attained wings, high temperatures force them to remain under non-host weeds and stubble until they have developed wings. In laboratory experiments it has been found that it is possible for an occasional chinch bug to pass entirely through its fifth nympal instar in the absence of food, although this is rather unusual. In general, therefore, the use of the creosote barrier is not recommended as a control measure under southwestern Oklahoma conditions. Elsewhere in the State, however, if conditions exist where good judgment indicates that it might be of value, its use is recommended.

The practice of winter burning of hibernation places is not generally recommended in Oklahoma. Cold weather, which should follow burning to make it successful, cannot be depended upon during the winter months, particularly in the southwestern part of the State. Furthermore, large numbers of bugs hibernate in sorghum stubble and other places where burning cannot be done. The burning, moreover, destroys grass often badly needed for livestock feed during the winter months. Burning does not improve pasture conditions the year following, and it does encourage soil erosion.

Legumes such as clover, alfalfa, lespedeza, vetch, cowpeas, soy beans, peanuts, velvet beans, and others are recommended in many States as crops which will not be attacked by the chinch bug. This cropping method of control cannot be recommended for Oklahoma conditions in general because some of these crops are not adapted to southwestern Oklahoma conditions. On some of the bottom lands in central and western Oklahoma, alfalfa can be grown to a fair advantage, but it is not adapted to most upland soils.

Cowpeas seem to be the legume best adapted to a wide range of conditions that exist in central and western Oklahoma, but they cannot compete there with chinch bug resistant sorghum varieties in the production of livestock feed. Fortunately, cotton is immune and is a cash crop that is adapted to the chinch bug infested sections of central and western Oklahoma. This crop, however, is not adapted to conditions in the chinch bug infested areas of northeasten Oklahoma.

CHINCH BUG RESISTANCE IN CORN

The relative inefficiency of methods of artificial control in sections of Oklahoma that are persistently and heavily infested with chinch bugs has led to an attempt to combat such crop injury by breeding corn and sorghums for varietal resistance to this insect. Chinch bugs injure corn directly by feeding on the plants and indirectly by causing lodging of the injured plants. In the latter respect corn differs from the sorghums, which do not lodge so easily when attacked by these insects.

The adaptation of a corn variety to Oklahoma conditions is an important factor in the chinch bug resistance of the variety. Corn is more sensitive to changes in environment than are sorghums, and this fact should be given consideration when discussing chinch bug resistance. A variety that is not well adapted will be more susceptible to chinch bug attack than one that is well adapted. This was apparent in several varieties of flint corn that were tested at Lawton during the two-year period of 1933-1934. Although inherently susceptible to some extent, these varieties of flint corn suffered much injury because of their extremely poor adaptation to Oklahoma conditions. Flint corn is adapted to the northern part of the United States where environmental conditions such as length of day, temperature, and moisture conditions are much different than in Oklahoma.

It must also be pointed out that chinch bug resistance in corn does not have the same relative importance as it does with sorghums. Corn usually is planted earlier than sorghums and the plants have attained greater size when the bugs migrate from the small grain crops. At this time, sorghum plants usually are much smaller, causing them to suffer more injury than corn. This does not necessarily lessen the importance of chinch bug resistance in corn, but it does permit more attention to other factors of adaptation, such as drought resistance, earliness, and ability to produce a fair yield of high quality corn. Such factors are responsible for the good showing that Hays Golden has made at Lawton as well as in several other parts of the State.

The record of chinch bug injury to 30 varieties of corn which are of interest to Oklahoma farmers is shown in Table 1. Additional varieties were tested, but since they are not likely to be of interest in Oklahoma the results are not presented. This table shows that the percentage of killed plants, of corn varieties commonly grown in the State, ranges from very small to very large. The corn under the tests presented here was about 3½ feet tall when the first generation bugs flew into the nursery. Damage was done by these bugs and by their offspring, which were nymphs of the second generation. Yield and quality of grain are valuable indications in determining the degree of chinch bug damage, but because of the drought that occurred later in the season these records were not obtained. Data were obtained, however, on the lodging and percentage of plants killed; and these

TABLE 1.—Injury done by chinch bugs to open-pollinated varieties of corn at Lawton, Oklahoma, 1933-1934.*

Variety	PERCENTAGE OF DEAD PLANTS		
	1933	1934	Average
Harmon White	12.0	22.2	17.1
Pride of Saline	26.0	19.3	22.7
Midland	12.0	34.0	23.0
Big Red	18.4	31.3	24.9
Mexican June	14.0	38.0	26.0
Franklin Yellow Dent	28.6	26.7	27.7
Calico	33.3	22.2	27.8
Red June	44.0	12.5	28.3
Black Hawk	36.0	28.0	32.0
Hays Golden	29.5	34.7	32.1
Surcropper	36.0	32.7	34.4
Champion White Pearl	31.9	44.9	38.4
Southwestern Yellow Dent	42.0	45.7	43.9
Kaw Chief	46.8	41.0	43.9
Improved Leaming	47.8	40.8	44.3
Krug	35.4	56.0	45.7
Oklahoma Silvermine	56.0	36.7	46.4
Nicholson Drought Resistant	44.0	51.0	47.5
Honey June	61.0	40.0	50.5
Hastings Prolific	52.0	52.2	52.0
Freed White	54.0	55.3	54.7
Reid Yellow Dent	44.9	64.6	54.8
Pride of the North	47.9	64.0	56.0
Iowa Silvermine	54.0	58.1	56.1
Iowa Goldmine	62.0	57.4	59.7
Squaw Corn	68.0	60.0	64.0
Improved Squaw Corn	72.0	58.0	65.0
Cassell White	68.0	63.4	65.7
Hickory King	87.8	48.9	68.4
Neal Paymaster	72.0	65.1	68.6

* Varieties are arranged in the order of decreasing resistance as an average of the two years.

two records were highly correlated. Mexican June, Red June, Surcropper, Southwestern Yellow Dent, Improved Leaming, Oklahoma Silvermine, Reid Yellow Dent, Squaw corn, and Neal Paymaster are all grown rather widely in Oklahoma, and it is seen that their susceptibility to chinch bug damage varied greatly. Some of these varieties such as Mexican June and Red June are grown because they can be planted rather late and make a crop in some sections of the State. Others are grown because of their adaptation to drought conditions, but undoubtedly their ability to withstand chinch bugs plays a part in their popularity. Varieties such as Reid Yellow Dent, Squaw corn, and Neal Paymaster, which proved susceptible, are grown rather extensively because of the popularity they have attained in years when chinch bugs were not so much of a limiting factor in their produc-

tion. Reid Yellow Dent has been popular over a wide section of the country for many years, and this is probably responsible to some extent for a greater acreage being grown in Oklahoma. Squaw corn has been grown in Oklahoma a long time; and, because of its earliness, it escapes enough chinch bug injury to make probable its continued popularity. Neal Paymaster is lacking in ability to withstand chinch bug injury, but is well adapted to other environmental conditions common in the State. It is grown chiefly in eastern Oklahoma, where it is better adapted than in the western counties.

Hays Golden ranked tenth in susceptibility to chinch bug damage among the 30 varieties tested (Table 1). This variety, however, is drought resistant and matures early enough to enable it to escape some drought, and this is mainly responsible for its increasing popularity in southwestern Oklahoma. It has been producing fair yields of good quality corn on both bottom and upland farms, in contrast to low yields of poor quality corn and complete failures of many of the later varieties that are not so well adapted. These later varieties, however, in some cases showed a higher degree of chinch bug resistance. Hays Golden is recommended as a dependable variety of corn to meet a wide range of conditions encountered over a period of years in various parts of the State. Some varieties may produce slightly higher yields in some of the better growing seasons, but

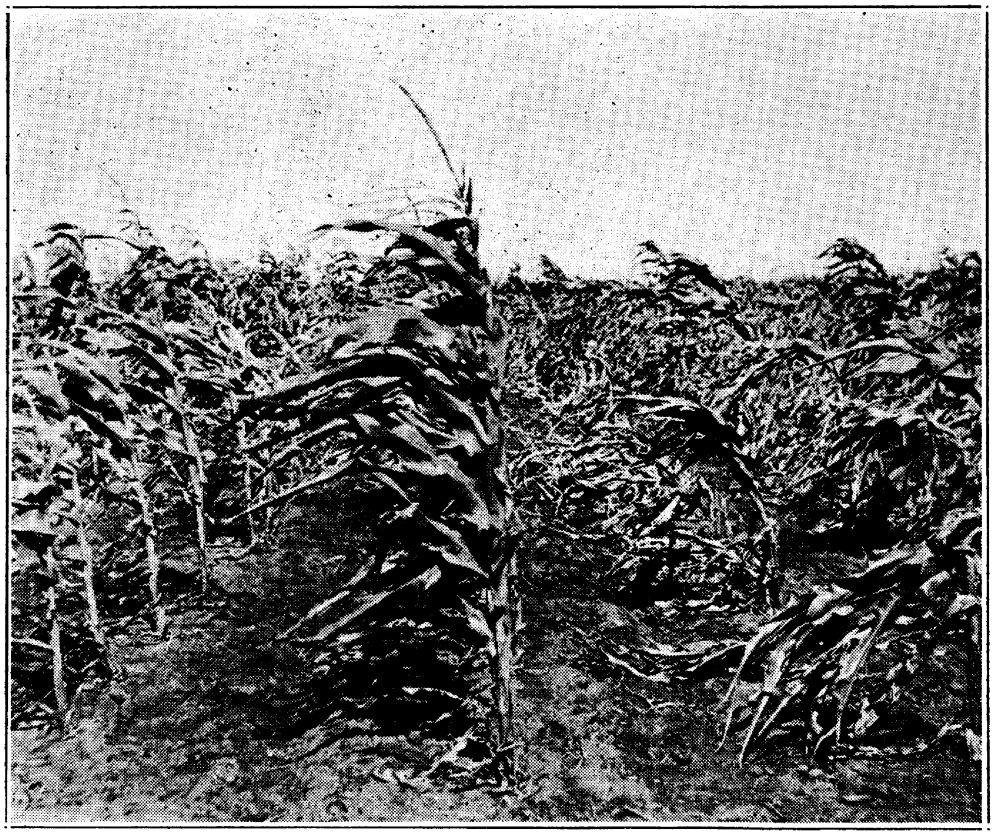


Fig. 3.—Chinch bug injury to hybrid corn and its inbred parents. Left, inbred WF9, center hybrid WF9 x PR, and right, inbred PR, Lawton, Oklahoma, 1934.

over a period of years which includes adverse seasons, Hays Golden has been found fairly consistent and dependable in grain production. This recommendation is not based entirely on the resistance of this variety to chinch bugs but on a combination of factors which enable it to produce fair yields of good quality grain when other varieties fail. Corn is not sufficiently dependable in most parts of the State to make recommendations on the basis of high yields. A variety should be recommended, rather, because it is able to produce a fair amount of grain most of the time.

In most of the Corn Belt States, considerable attention has been given to the production of hybrid corn. Interest in hybrid corn has been shown in Oklahoma, and it was thought that the chinch bug response of a few corn hybrids, in comparison with their inbred parents, might be of interest. In the experiments at Lawton, the hybrids have suffered less injury by chinch bugs than their parents, and in some cases much less. An average of 61 percent of all of the inbred parents were killed, while only 17 percent of the hybrid plants were killed. Pride of Saline, a resistant variety, suffered a loss of 39 percent of the plants in the same test. The hybrids were bred in four different Corn Belt States and were not necessarily adapted to Oklahoma climatic conditions. One of these hybrids, WF9 x PR, and its inbred parents are illustrated in fig. 3.

CHINCH BUG RESISTANCE IN SORGHUMS

Investigations designed to determine the variation in sorghum varieties to chinch bug injury and the possibility of the development of resistant types of sorghums were started at Lawton in 1930. Since then, the number of strains in the chinch-bug nursery has been increased each year from about 60 varieties, selections, and crosses in 1930, to more than 2,000 in 1936. A test of this kind, where a number of new varieties are grown, is always complicated by such factors as the adaptation of a variety to the region, and especially to drought conditions. As is true of their response to chinch bug attack, sorghum varieties differ greatly in their ability to withstand drought. Drought injury and chinch bug injury are similar in that both operate as limiting factors, dwarfing plant growth and reducing yields of grain and forage. In the absence of chinch bugs, most sorghums are able to withstand relatively long periods of drought and then resume growth when the drought is broken. Chinch bug injury, on the other hand, usually continues unabated throughout the growing season, becoming more intense with each new generation of bugs. Information obtained under such conditions is useful in the breeding of a new variety. That is, if a variety grown under conditions of a combined heavy chinch bug infestation and drought produces a good crop, the variety is probably well adapted to these conditions that are of frequent occurrence in southwestern Oklahoma. If a variety survives by escaping chinch bug injury through earliness, the fact should be determined, because under some conditions the variety probably will be planted late with very disastrous results.

Most sorghums have certain characteristics typical of the variety when injured by chinch bugs. The most striking symptom is the discoloration of the foliage when wilting is produced by such injury. Feterita plants show a yellow discoloration of the lower leaves, while most varieties of milo usually show a red discoloration of the lower leaves. Other varieties may show one or the other of these colors. One of the early indications of

chinch bug injury is the wilted and stunted appearance of the plants and the discoloration of their lower leaves. Fig. 4 illustrates typical chinch bug injury to a susceptible plant that is growing beside an uninjured resistant plant. Sorghum plants, weakened by chinch bug injury, lodge more easily than those that are uninjured. but do not lodge so easily as corn that has been injured by these insects. The yields of grain and forage are greatly reduced by chinch bug injury, depending upon the date at which varieties are planted and upon the resistance of the individual variety.

The causes of resistance to chinch bug attack in sorghum varieties are complex and greatly influence the biology of the insect itself. This phase of the problem is being investigated in the laboratory, and a preliminary report has been published by Dahms et al.[4] [5] These studies have shown that more bugs are attracted to a susceptible variety than to one that is resistant, therefore, under field conditions, such a variety may receive a larger population of adults that are migrating by flight. Furthermore, the bugs live longer and lay more eggs; the nymphs develop faster

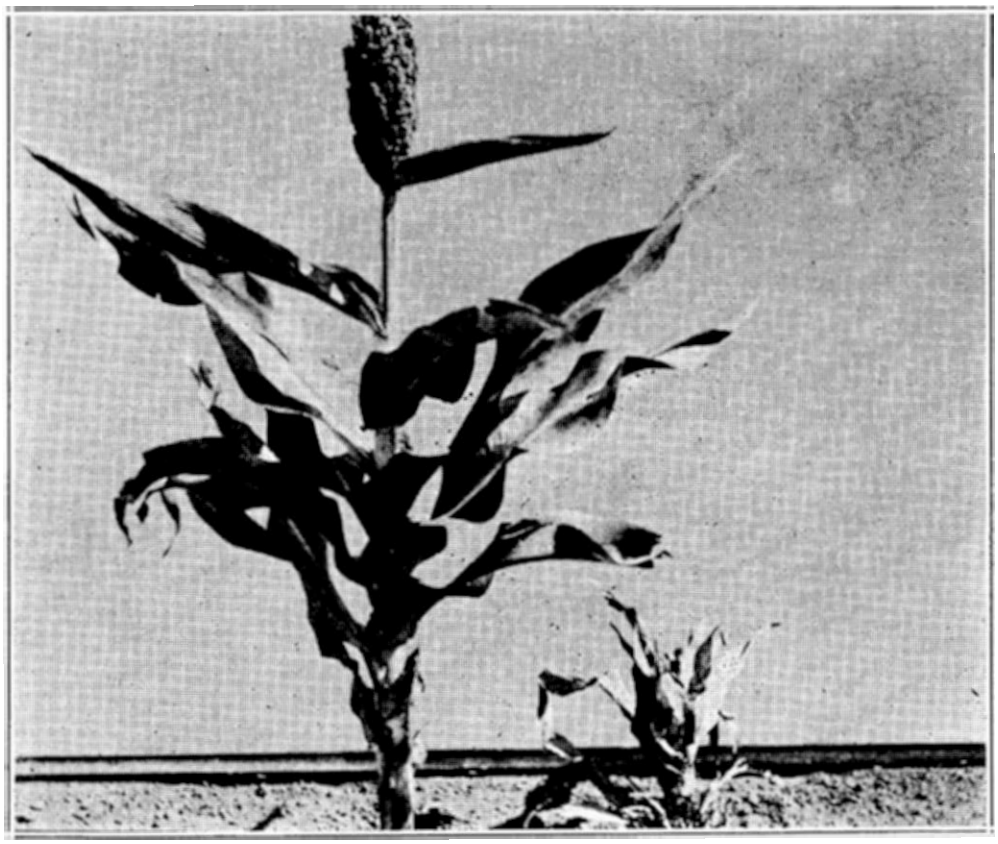


Fig. 4.—Second generation plants from the cross Club x Day milo showing typical chinch bug injury to a susceptible segregate growing beside a resistant, uninjured plant. Lawton, Oklahoma, 1934.

[4] Dahms, R. G., R. O. Snelling, and F. A. Fenton. Effect of Different Varieties of Sorghums on Biology of the Chinch Bug. *Jour. Amer. Soc. Agron. 28*:160-161. 1936.

[5] Dahms, R. G., R. O. Snelling, and F. A. Fenton. Effect of Several Varieties of Sorghums and Other Host Plants on the Biology of the Chinch Bug. *Jour. Econ. Ent.*: *29*:1147-1153. Dec. 1936.

and more of them reach maturity on a susceptible variety than on one that is resistant. These are factors that tend to increase still more the bug population on susceptible varieties. Tests have also shown that resistant varieties withstand the attack of a concentrated number of bugs better than do susceptible varieties.

TABLE 2.—Injury to forage sorghums and kafirs by chinch bugs at Lawton, Oklahoma, 1930, 1932, 1933, and 1934.

Variety	Record No.*	PERCENTAGE OF PLANTS KILLED				Four-yr. average 1930, 1932 1933, 1934
		1930	1932	1933	1934	
Sorgo (forage sorghums):						
Atlas	C. I. 899	20	7	20	5	13
Sunrise	C. I. 472	40	2	8	5	14
Red Amber	F. C. 7038	--	5	18	--	--
Leoti	F. C. 6610	67	20	29	52	42
Kansas Orange	F. C. 9108	38	7	21	2	17
Waconia Orange	----------	--	--	47	8	--
African Millet	F. C. 9111	--	12	24	1	--
Sourless	F. C. 9074	--	2	41	--	--
Standard Sumac	F. C. 1712	--	22	30	25	--
Early Sumac	F. C. 6611	42	50	21	5	30
Kafir:						
Blackhull	C. I. 71	37	7	37	9	23
Reed	C. I. 628	46	0	8	5	15
Hydro	C. I. 1023	--	1	46	12	--
Dawn	C. I. 340	33	--	39	13	--
Dawn Selection	C. I. 904	39	2	5	2	12
Western Blackhull	C. I. 906	23	1	47	10	20
Texas Blackhull	F. C. 8962	46	--	--	9	--
Sharon	C. I. 813	42	1	8	5	14
Weskan	F. C. 9171	37	3	8	1	12
Pink	C. I. 432	36	1	19	0	14
Juicy Pink	F. C. 9091	55	1	44	5	26
Red	----------	43	4	41	51	35

* C. I. designates the accession numbers of the Division of Cereal Crops and Diseases and F. C. designates the accession numbers of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

The percentage of sorghum plants killed during the years, 1930, 1932, 1933, and 1934 at Lawton, Oklahoma, is shown in tables 2 and 3. The strains are arranged in variety groups. Information is presented in the tables only for varieties of interest in Oklahoma, or for those likely to become of interest, although a much greater number have been tested. In this experiment the infestations of chinch bugs were of about equal intensity in 1930, 1933, and 1934, and were greater in these years than in 1932. In spite of these differences in the intensity of infestation, the relative degree of injury among the varieties was similar in the four seasons. Most

TABLE 3.—Injury to feterita, milo; to derivatives of kafir, feterita and milo; and to miscellaneous varieties by chinch bugs at Lawton, Oklahoma, 1930, 1932, 1933, and 1934.

Variety	Record No.*	PERCENTAGE OF PLANTS KILLED				Four-yr. average 1930, 1932 1933, 1934
		1930	1932	1933	1934	
Feterita:						
Standard	C. I. 182	98	39	24	43	51
Spur	C. I. 623	92	42	18	65	54
Feterita-kafir derivatives:						
Ajax	F. C. 6620	99	30	58	33	55
Chiltex	C. I. 874	100	22	23	52	49
Premo	C. I. 873	86	8	25	--	--
Kafirita	C. I. 812	--	16	7	10	--
Wonder	C. I. 872	58	19	17	--	--
Club	C. I. 901	84	8	33	6	33
Milo:						
Dwarf Yellow	C. I. 332	100	100	100	100	100
Dwarf Yellow	G. C. 30-1	---	100	100	100	---
Day	----------	---	100	100	100	---
Sooner	C. I. 917	100	100	69	---	---
Milo derivatives:						
Bishop	C. I. 814	100	88	100	---	---
Desert Bishop	C. I. 870	--	100	100	---	---
Manko	F. C. 8991	29	5	87	---	---
Fargo	C. I. 809	--	70	96	100	---
Kalo	C. I. 902	77	81	28	60	62
Early Kalo	C. I. 1009	--	--	8	17	---
Custer	C. I. 919	78	29	100	---	---
Beaver	C. I. 871	96	100	100	100	99
Wheatland	C. I. 918	98	47	100	100	86
Misc. varieties:						
Hegari	C. I. 750	98	11	44	---	---
Grohoma	C. I. 920	37	22	38	---	---
Schrock	C. I. 616	52	---	19	14	---
Darso	C. I. 615	56	2	29	8	24
Dwarf Freed	C. I. 971	70	13	14	75	43
Greeley	----------	---	---	10	28	---
Cheyenne	----------	---	---	25	33	---

* C. I. designates the accession numbers of the Division of Cereal Crops and Diseases and F. C. designates the accession numbers of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

of the varieties that were severely injured in 1930 were also severely injured in 1932, 1933, and 1934. Several varieties and hybrids that showed a relatively high degree of resistance in 1930 were also resistant in 1932, 1933, and 1934. A few varieties and hybrids differed in their reaction during the four years, as is often true where a large number of varieties are involved. In some cases, the reason for such discrepancies is known to be due to natural selection, but in other instances the reason for smaller variations is not so evident. One of the most plausible explanations for an unusual reaction of a variety to chinch bug injury is the peculiar adaptation of the variety to seasonal conditions. The fact that some varieties are not purified for resistance factors is responsible for some discrepancies in the reaction of certain strains. This is especially true when seed is saved, year after year, from varieties that have been grown under severe infestations of chinch bugs.

Atlas sorgo, a cross between Blackhull kafir and Sourless sorgo, is highly resistant to chinch bugs and drought and is well adapted to Oklahoma conditions. It is a dual-purpose variety, has white, palatable grain, is leafy and has sweet, juicy stalks resistant to lodging. Atlas is more resistant to chinch bugs than are Sourless (African Millet) or Standard Sumac, two forage varieties widely grown in Oklahoma (table 2). This variety is similar to African Millet and Sumac in that all are late and for that reason are not dependable for grain production. A plot of this variety growing on the Lawton station, in 1931, is shown in fig. 5.

Fig. 5.—Plot of Atlas sorgo growing at the U. S. Dry Land Field Station, Lawton, Okla., 1931.

Among the kafirs, Reed, Dawn Selection, Sharon, and Weskan are the most resistant (table 2). Reed is more widely known in Oklahoma than the other three mentioned. This variety is about as dependable as any of the kafirs for the production of grain, but the forage value is somewhat lessened by the fact that the foliage is not retained well. Fig. 6 shows a plot of Reed kafir producing a fair crop of grain in contrast with a plot of Spur feterita that has been killed by chinch bugs. Texas Blackhull is slightly earlier than Reed kafir in most years and exsertion of the head is not delayed so often by dought. For these reasons, Texas Blackhull often produces higher yields of grain in drought seasons. Either of these varieties can be used on upland soils with fair success when

kafirs produce a crop. Hydro, while not so resistant to bugs as Reed or Texas Blackhull, has been producing satisfactory grain yields on bottom land.

Standard and Spur feterita differ but little in their response to chinch bugs (table 3). Both varieties tend to be injured rather severely in the presence of moderate to heavy infestation of bugs (fig. 6). Standard feterita is somewhat earlier than Spur and for that reason escapes considerable chinch bug damage when planted relatively early. However, it is often difficult to obtain stands of either variety when they are planted before the soil becomes warm in the spring. In years when chinch bugs are not so serious, Spur feterita usually produces higher yields of grain than the Standard variety.

Ajax and Chiltex are the most widely grown Oklahoma varieties developed from feterita-kafir hybrids. Both varieties are usually damaged rather severely by chinch bugs (table 3). Ajax is much later than Chiltex and this probably accounts for this variety showing a slightly higher percentage of plants killed. A later variety must necessarily withstand chinch bug feeding over a longer period of time before reaching maturity. Chiltex often produces a fair yield of grain when the chinch bug infestation is light, but it is not a dependable variety in years of heavy infestation. Kafirita has shown more chinch bug resistance than any other of the kafir-feterita hybrids that have been tested. This variety is still under experimental test and has not been released to farmers. Club, a variety originated at the Hays (Kansas) Branch Experiment Station, has shown promise in drought years under conditions of a heavy chinch bug infestation.

The milos and most milo derivatives are susceptible and are not recommended for sections of the State where chinch bugs commonly occur (table 3). Beaver and Wheatland, two varieties bred at the United States Field Station, Woodward, Oklahoma, are popular in northwestern Okla-

Fig. 6.—Plat of Reed kafir (right) producing a fair crop of grain in contrast to a plat of Spur feterita (left) that was killed by chinch bugs. Lawton, Oklahoma, 1932.

homa, as varieties suited to combine harvesting. In that section, where chinch bugs seldom cause serious damage, these varieties are successfully grown, but they are not adapted to chinch bug infested areas.

Of the group of miscellaneous varieties listed in table 3, Hegari and Darso are most widely grown. Hegari is more generally adapted to bottom land than it is to upland soils. This variety is erratic in its behavior and grain yields vary widely, apparently irrespective of the time of planting, method of tillage, or source of seed. Hegari apparently is more sensitive to certain environmental conditions than most other varieties. The erratic response of this variety to such environmental conditions is not well understood. If Hegari has been grown with success over a period of years, it is not our intention to discourage its use. If, however, the variety has not been previously grown it is recommended that its use be undertaken with precaution. Some farmers have been growing Hegari for several years, especially on bottom land, with good success, while others, especially on upland soil, have had many failures. This variety does not produce satisfactory yields on upland soil at the United States Field Station, Lawton, Oklahoma.

Darso is widely grown in the State and its ability to withstand drought and chinch bugs is fairly well known. This variety has brown, bitter seed which is not in its favor from the feed standpoint. This characteristic, however, discourages bird damage. Darso is being used as a parent in the breeding program at Lawton in an attempt to produce a new variety as well adapted to Oklahoma conditions, but having white palatable grain. Several promising new strains are now under test, but none will be ready for distribution until it has been subjected to further selection and testing. Dwarf Freed, Greeley, and Cheyenne are grown in the northern part of the sorghum belt and are not adapted to Oklahoma conditions. Grohoma is not well adapted to most Oklahoma conditions, but under rather favorable conditions it is fairly productive. On thin soil and under conditions of chinch bugs and drought many varieties are more dependable, and for this reason Grohoma has lost much of its popularity.

TIME OF PLANTING SORGHUMS IN RELATION TO CHINCH BUG INJURY

Chinch bugs attack sorghum during any part of the vegetative period, but older and less tender plants are better able to withstand their attacks. The plants in the earlier plantings at Lawton have been largest at the time the chinch bugs migrated to the sorghum fields and consequently showed the least injury and produced the highest yields. Late May and early June plantings usually are recommended in sections of the State where chinch bugs are not serious, but at Lawton, as well as in other parts of the State where chinch bugs cause serious damage, such plantings are frequently completely destroyed by the bugs.

The data presented here on time of planting agree closely with observations and experimental records on a few varieties that have been studied for several years at the Lawton station, regarding the effect of time of planting as related to chinch bug injury and yield (table 4; fig. 7). The grain yields obtained from 20 varieties and strains of sorghum planted April 13, and May 7, and June 1, 1931, are presented in table 5. In this ex-

TABLE 4.—Effect of date of planting kafir, feterita and milo on yields at Lawton, Oklahoma[1]

Planting Date	VARIETY AND AVERAGE NUMBER OF BUSHELS OF GRAIN TO THE ACRE			
	Reed kafir[2]	Dwarf feterita[3]	Dwarf milo[3]	Average of three varieties
April 15	20.6	11.2	20.3	17.4
May 1	21.3	18.5	22.6	20.8
May 15	16.9	18.2	23.7	19.6
June 1	10.8	16.9	19.1	15.6
June 15	10.5	16.3	14.1	13.6
July 1	8.8	10.0	10.7	9.8

[1] Data taken from Oklahoma Agri. Expt. Sta. Bull. 210.

[2] Average of five years results.

[3] Average of three years results.

TABLE 5.—Grain yields of sorghum varieties planted on three dates at Lawton, Oklahoma, 1931.

Variety	Record number*	GRAIN YIELDS (BU. PER ACRE)			
		DATES OF PLANTING			
		April 13	May 7	June 1	Average
Club	C. I. 901	38.7	41.3	47.2	42.4
Ajax	F. C. 6620	38.7	38.6	40.8	39.3
Spur feterita	C. I. 623	46.9	35.0	29.2	37.0
Atlas sorgo	C. I. 899	35.2	38.5	35.7	36.4
Grohoma	C. I. 920	29.2	41.3	38.7	36.4
Sunrise	C. I. 472	29.7	35.5	34.4	33.2
Reed kafir	C. I. 628	33.8	35.0	27.2	32.0
Kansas Orange sorgo	F. C. 9108	42.8	35.0	17.5	31.8
Darso	C. I. 615	34.5	23.3	32.8	30.2
Pink kafir	C. I. 432	35.0	26.5	28.1	29.9
Blackhull kafir	C. I. 71	27.6	30.7	31.2	29.8
Sharon kafir	C. I. 813	22.8	26.5	27.5	25.6
Kalo	C. I. 902	26.0	21.2	29.1	25.4
Dawn kafir	C. I. 904	27.6	22.2	24.4	24.7
Standard feterita	C. I. 182	20.9	22.3	22.3	21.8
Chiltex	C. I. 874	23.9	16.9	18.0	19.6
Dwarf Yellow milo	C. I. 332	15.9	8.8	28.6	17.8
Wheatland	C. I. 918	10.2	11.6	14.6	12.1
Sooner milo	C. I. 917	15.4	10.6	5.8	10.6
Beaver	C. I. 871	2.9	4.9	14.6	7.5
Average yields (20 varieties)		27.9	26.3	27.4	

* C. I. designates the accession numbers of the Division of Cereal Crops and Diseases and F. C. designates the accession numbers of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

TABLE 6.—Grain yields of sorghum varieties planted on three dates at Lawton, Oklahoma, 1932.

Variety	Record number*	GRAIN YIELDS (BU. PER ACRE)			
		DATES OF PLANTING			
		April 15	May 4	June 8	Average
Atlas sorgo	C. I. 899	70.3	34.8	0	35.0
Club	C. I. 901	63.0	39.3	0	34.1
Sunrise	C. I. 472	63.2	30.8	0	31.3
Dawn kafir	C. I. 904	51.8	36.1	0	29.3
Darso	C. I. 615	53.7	34.0	0	29.2
Sharon kafir	C. I. 813	55.8	27.6	0	27.8
Reed kafir	C. I. 628	49.8	30.3	0	26.7
Grohoma	C. I. 920	51.8	26.5	0	26.1
Pink kafir	C. I. 432	53.5	24.4	0	26.0
Blackhull kafir	C. I. 71	44.3	30.2	0	24.8
Kansas Orange sorgo	F. C. 9108	44.7	29.2	0	24.6
Chiltex	C. I. 874	55.6	17.5	0	24.4
Ajax	F. C. 6620	45.4	12.7	0	19.4
Spur feterita	C. I. 623	40.8	9.7	0	16.8
Dwarf Yellow milo	C. I. 332	43.0	0	0	14.3
Kalo	C. I. 902	40.7	0	0	13.6
Standard feterita	C. I. 182	15.6	10.9	0	8.8
Wheatland	C. I. 918	21.4	1.9	0	7.8
Sooner milo	C. I. 917	22.7	0	0	7.6
Beaver	C. I. 871	0	0	0	0
Average yields (20 varieties)		44.4	19.8	0	

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ceptional season, chinch bug injury was very light and did not affect the grain yields to any appreciable extent. The April 13 and June 1 plantings produced nearly the same yield. Yields from the May 7 planting were lowered somewhat by hot, dry weather during the heading and blooming period.

The season of 1932 was more nearly typical of the Lawton section. Migration of bugs from small grain crops to the sorghums took place about the time the plants in the April 15 planting were heading and consequently this planting failed to show any appreciable chinch bug injury. All of the varieties in the May 4 planting were injured to some extent and some of the more susceptible varieties were destroyed by chinch bugs, as indicated by the grain yields shown in table 6. The plants in the June 8 planting were only about 6 to 8 inches tall when the bugs migrated and were severely injured within a few days. The average yield for the 20 varieties in the April 15 planting was 44.4 bushels to the acre. In the May 4 planting, the average yield was 19.8 bushels to the acre. The June 8 planting was a complete failure. The average grain yields for the three dates of planting, in 1931 and 1932, are shown in fig. 8. The percentage of

plants killed in the three dates of planting in 1932, shown in table 7, was 11.1 percent in the April 15 planting, 31.0 percent in the May 4 planting and 94.8 percent in the June 8 planting. Most of the surviving plants among the susceptible varieties were natural hybrids and probably survived the chinch bug attack because of their hybrid vigor. The relationship of grain yield and percentage of injury is illustrated in fig. 9.

SUMMARY

The chinch bug is an important limiting factor in the production of corn and sorghums in Oklahoma throughout a wide belt of territory extending diagonally across the State from the northeastern part to the southwestern counties.

Control of the pest by methods advocated in other States is not always successful in Oklahoma owing to different climatic conditions which favor migration of the insect from small grains to corn and sorghums by flight rather than by crawling.

The use of barriers for preventing damage by this insect to corn and sorghums is not recommended in the southwestern part of the State because or migration by flight. High temperatures and wind render the creosote line ineffective, decreasing its repellent action and bridging the line with litter and soil. The creosote barrier, however, has been used successfully elsewhere in the State.

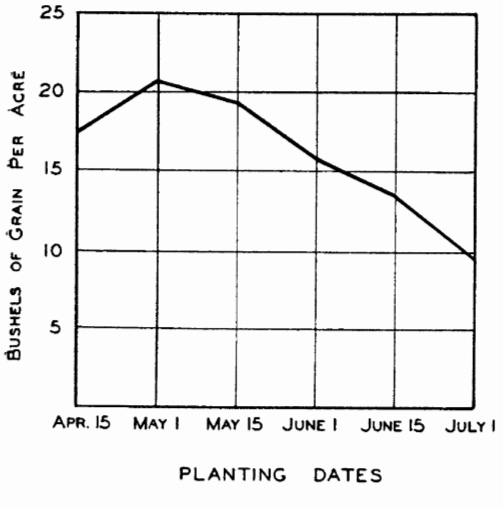

Fig. 7.—Average yields of three varieties of sorghums planted on six different dates as shown in Table 4.

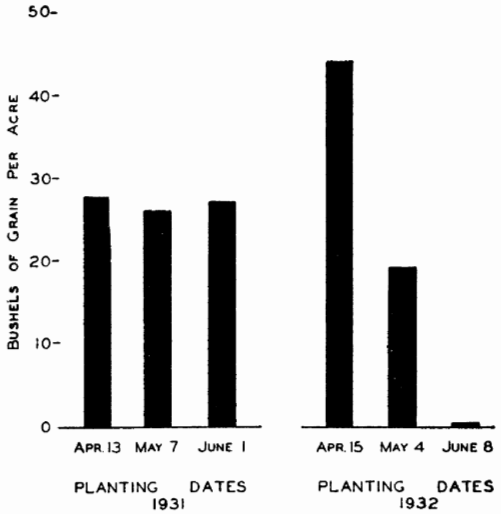

Fig. 8.—Grain yields for three dates of planting in 1931 and 1932, of very light and heavy infestations respectively. (Average yields of 20 varieties for each date, and year.)

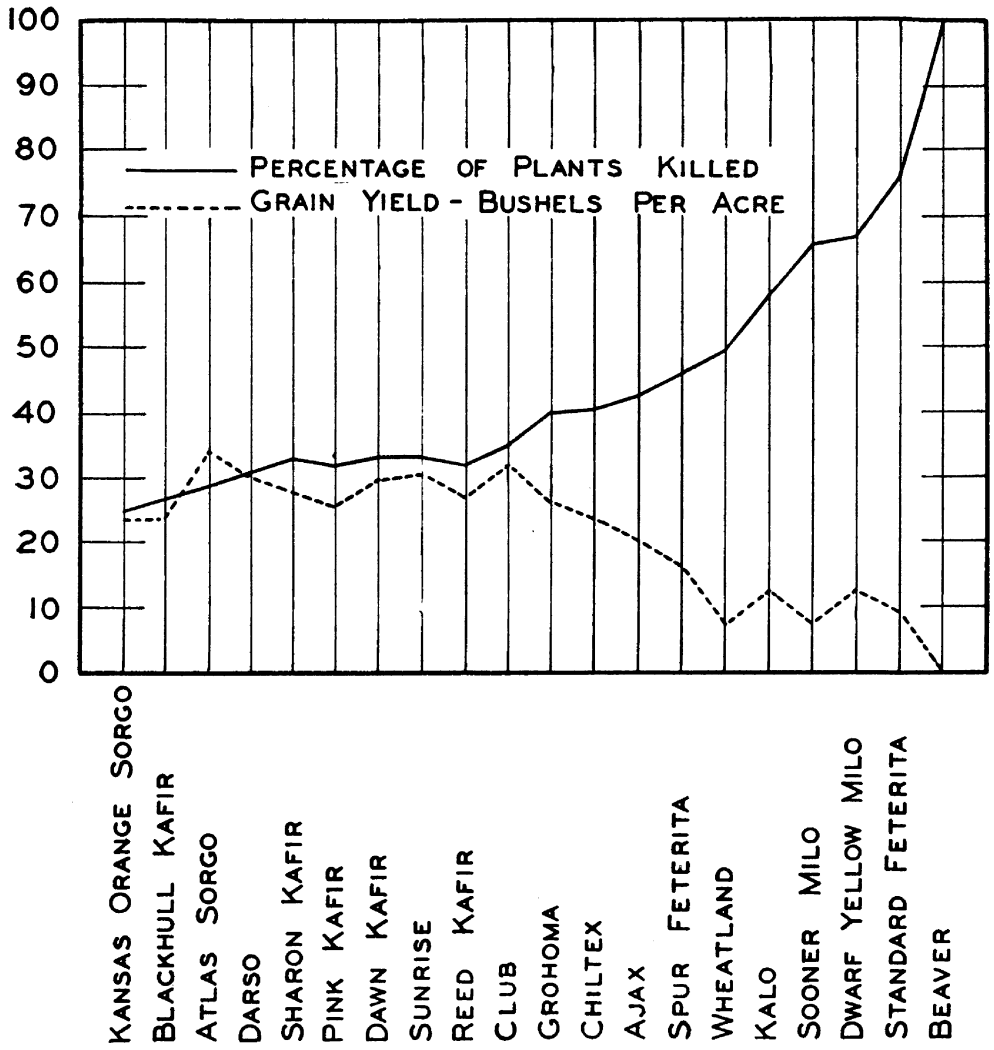

Fig. 9.—Percentage of plants killed in relation to number of bushels of grain produced per acre, average of three dates of planting in 1932.

Burning grasses during the winter is not recommended because it does not destroy bugs hibernating in sorghum stubble, increases soil erosion, is unfavorable to wild life, and destroys winter pasture.

The use of immune crops such as legumes is limited in Oklahoma because of unfavorable soil and climatic conditions in many parts of the State where chinch bugs are a problem.

The most promising method for reducing chinch bug damage in Oklahoma is by the use of resistant varieties of plants adapted to those parts of the State that are frequently and heavily infested with chinch bugs. The adaptation of a corn variety to Oklahoma conditions is an important factor in the chinch bug resistance of the variety. Hays Golden is well adapted to Oklahoma and was the most dependable of all corn varieties tested. This variety is especially recommended for the western part of the State. Hybrid strains of corn have suffered less chinch bug damage than their inbred parents.

TABLE 7.—Percentages of sorghum plants killed by chinch bugs on three dates of planting at Lawton, Oklahoma, 1932.

Variety	Record number*	PERCENTAGE OF PLANTS KILLED			
		Dates of Planting			
		April 15	May 4	June 8	Average
Kansas Orange sorgo	F. C. 9108	0.0	7.1	70.0	25.7
Blackhull kafir	C. I. 71	4.2	6.5	71.0	27.2
Atlas sorgo	C. I. 899	0.2	6.7	78.9	28.6
Darso	C. I. 615	0.0	2.2	91.1	31.1
Sharon kafir	C. I. 813	1.4	0.8	96.3	32.8
Pink kafir	C. I. 432	0.0	0.7	98.5	33.1
Dawn kafir	C. I. 904	3.0	1.5	95.5	33.3
Sunrise	C. I. 472	3.0	2.2	95.6	33.6
Reed kafir	C. I. 628	1.2	0.0	100.0	33.7
Club	C. I. 901	1.4	8.2	99.3	36.3
Grohoma	C. I. 920	0.0	21.6	100.0	40.5
Chiltex	C. I. 874	0.0	22.4	100.0	40.8
Ajax	F. C. 6620	0.0	29.9	100.0	43.3
Spur feterita	C. I. 623	0.0	42.4	100.0	47.4
Wheatland	C. I. 918	7.4	46.8	100.0	51.4
Kalo	C. I. 902	1.4	81.4	100.0	60.9
Sooner milo	C. I. 917	2.2	100.0	100.0	67.4
Dwarf Yellow milo	C. I. 332	3.9	100.0	100.0	68.0
Standard feterita	C. I. 182	93.5	38.8	100.0	77.4
Beaver	C. I. 871	100.0	100.0	100.0	100.0
Average percentage of plants killed		11.1	31.0	94.8	

* C. I. designates the accession numbers of the Division of Cereal Crops and Diseases and F. C. designates the accession numbers of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

Sorghum varieties differ greatly in their ability to withstand drought and chinch bug attack. The degree of resistance among the varieties tested has ranged from very resistant to highly susceptible. Atlas sorgo, a cross between Blackhull kafir and Sourless sorgo, is highly resistant to chinch bug and drought injury and is well adapted to Oklahoma conditions. Several varieties of kafir, such as Dawn Selection, Weskan, Pink, Sharon, and Reed, have shown considerable resistance. Varieties of feterita, milo and milo derivatives tend to be susceptible.

Chinch bugs attack sorghums during any part of the vegetative period, but older and less tender plants are better able to withstand the attack. Plants in the earlier plantings have been largest at the time the chinch bugs migrated to the field, and consequently showed less injury and produced highest yields. Late sorghum plantings are frequently destroyed by chinch bugs. In sections of the State where chinch bugs do not damage sorghum, the highest yields are often obtained from plantings that are made relatively late.