RESISTANCE OF VARIETIES OF SORGHUMS TO THE CHINCH BUG (*BLISSUS LEUCOPTERUS* SAY, LYGAEIDAE, HEMIPTERA)

by

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INTRODUCTION

That phase of biological control of insects which has to do with host resistance has been studied only to a relatively small extent. The data presented here, gathered over a period of three years, deals with the possibility of preventing or reducing chinch bug injury to sorghums by host resistance.

Since efficient control of the chinch bug cannot always be effected economically by cultural practices or by destruction of the bugs in hibernation, it is necessary to seek other means for a satisfactory solution of the problem. One of the most feasible methods of control is the development of immune or resistant varieties of sorghums suitable to regions that are frequently and heavily infested with chinch bugs. Investigations with this purpose in view were originally pursued by the Kansas Agricultural Experiment Station, but due to the lack of infestation in successive years the work was transferred to the Dry Land Field Station, Lawton, Oklahoma, where the investigations reported

here have been carried on by the Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, through informal cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, and the Departments of Entomology and Agronomy of the Kansas Agricultural Experiment Station.

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REVIEW OF LITERATURE

A review of the literature on the general subject of host resistance has been prepared by McColloch (48) and by Wardle (71).

The literature relating to the resistance of wheat varieties to the Hessian fly has been reviewed by McColloch and Salmon (44) and by Painter, Salmon and Parker (57). Parker and Painter have presented a brief discussion of insect resistance in crop plants (59).

Marston of the Michigan station (39), (40),(41) has shown that in crosses between Maize Amargo, which is resistant to the European corn borer, and various susceptible local varieties, resistance to borer is inherited.

Gernert (26) has shown that teosinte is resistant to the corn root aphis (Aphis maidi-radicis) and the corn plant aphis (Aphis maidis) while corn is susceptible. In the cross teosinte x corn he found the F_1 plants to be as resistant to both the corn root aphis and the corn plant aphis as is the teosinte parent.

Spinks (65) has shown that Aberdeen Standard, Dumbarton Castle, Sturton Cross, and Tardive de Leopold varieties of strawberries are resistant to the strawberry aphis

(Capitophorus fragariae) and the varieties Royal Sovereign, and Sterling Castle are susceptible. The resistant varieties are of little value for fruit production while the susceptible varieties are of considerable importance. By crossing the resistant varieties with the better berry producing, but susceptible varieties several families of seedlings have been produced that are resistant to aphis injury and are good berry producers.

Literature relating to the resistance of plants to nematode attack has been reviewed by Collins and Hagen (13).

Flint and Hackleman (25) have shown that Democrat, a variety of white dent corn, also known as Champion White Pearl, is resistant to chinch bug injury, while many other varieties were proven to be highly susceptible.

MATERIAL AND METHODS

Measuring the resistance of a series of varieties in a given number of tests offers a number of problems which are not encountered in time of planting tests or others where a single variety is used. In a variety test for insect resistance variety heterogeneity for resistance or susceptibility is ever present in varying degrees. Measuring the degree of injury to varieties that are partially killed is rather

difficult. No two tests are ever quite equivalent in intensity and uniformity of infestation and very few field tests contain the same number of varieties or strains. The necessity of using small numbers of plants of a large number of varieties and strains of sorghums brings in other complications. These are only a few of the more or less specific problems encountered in a test of this kind. In addition such general problems as soil heterogeneity and climatic variations are to be considered.

The particular way in which data are secured and recorded is important. Counting the number of plants killed by the bugs has proved useful in measuring the resistance of the varieties. Grain yields are valuable in that they generally vary directly with the number of surviving plants. The percentage of plants killed can be determined most accurately by counting the live plants at full growth or maturity and subtracting the number from the original number of plants in the test. This eliminates error due to dead plants being dislocated or destroyed, if the count of dead plants is relied upon.

Eighty-five varieties and strains of sorghum were grown in field plots at Lawton, Oklahoma, in one or more of the three years from 1930 to 1932, inclusive. In most cases the plots consisted of a single row 100 feet long in which the

plants were spaced 6 inches apart in 1930 and 9 inches in 1931 and 1932. Thus 200 plants of each variety were available for study in each plot in 1930 and 133 in each of the other years. The rows were 44 inches apart. Ten of the varieties were planted in triplicate 60-foot rows in 1931 and 1932. All of the varieties and strains were planted on three dates each season. In 1931 and 1932 Atlas, Dwarf Yellow milo and Blackhull were grown in check plots, each variety being planted in three distributed plots on each date of planting. In 1930 Kansas Orange, Blackhull, Dwarf Yellow milo, and Feterita were planted in check plots.

EXPERIMENTAL RESULTS

Developing Adapted Varieties of Sorghum That Are Resistant to Chinch Bugs

There are four methods of obtaining adapted varieties of sorghum that are resistant or immune to chinch bugs: (1) Testing the chinch bug resistance of varieties suited to the region, (2) testing the regional adaptation of varieties known to be resistant to chinch bugs, (3) selecting resistant strains from adapted varieties, and (4) hybridization.

Testing the Chinch Bug Resistance of Varieties Suited to the Region. Varieties of sorghums commonly grown in the region of Lawton, Oklahoma, were included in the variety test for chinch bug resistance. Plots of these varieties, which are listed in Table I, were planted in the nursery where they would be subject to the same infestation as the other varieties in the test.

Table I.- Percentage of Chinch Bug Injury in Sorghum Varieties Commonly Grown in the Vicinity of Lawton, Oklahoma

Variety	No.	Plants killed by chinch bugs percentage		
		1930	1932	Average
Dawn kafir	C.I. 904	39.2	1.5	20.4
Sunrise	C.I. 472	39.5	2.2	20.9
Sumac	F.C. 1712	- -	21.6	- -
Blackhull kafir	C.I. 71	37.1	6.5	21.8
Reed kafir	C.I. 628	45.5	0.0	22.8
African millet	F.C. 9111	- -	28.7	- -
Darso	C.I. 615	56.2	2.2	29.2
Spur feterita	C.I. 623	91.5	42.2	66.9

All the local varieties except Spur feterita C.I.623, which is not so extensively grown, showed considerable resistance when compared with the other varieties grown in the nursery. The percentage of plants killed ranged from

11.2 per cent to 99.9 per cent for the different varieties grown in the nursery. The injury to the varieties commonly grown in this region ranged from 20.4 per cent to 29.2 per cent with the exception of Spur feterita which was injured 66.9 per cent.

The resistance found in locally grown varieties is probably largely responsible for their adaptation to the region of Lawton, Oklahoma. Blackhull kafir C.I. 71, Darso C.I. 615, Reed kafir C.I. 628, Sumac F.C. 1712, and African millet F.C. 9111 are grown more extensively than the other varieties.

Testing the Regional Adaptation of Varieties Known to be Chinch Bug Resistant. Two varieties, Atlas C.I. 899 and Kansas Orange F.C. 9108, and two hybrids, Kansas Orange x Dwarf Yellow milo Sel. 30-303 and Red Amber x Feterita A.B. 2513, were included in the tests because of their reputed resistance to chinch bug injury. Each of the varieties and the hybrids demonstrated their resistance and showed ability to produce satisfactory grain yields under the conditions at Lawton. These varieties and the hybrids may be compared for chinch bug resistance with the varieties commonly grown in this region by referring to Tables I and II. The varieties were all grown under conditions providing equal

infestation, and observations indicated that all of them were about equally infested.

Table II.- Percentage of Chinch Bug Injury to Varieties and Hybrids Known to be Resistant

Variety	No.	Plants killed by chinch bugs, Per cent: 1930	1932	Average
Kansas Orange x Dwarf Yellow milo	Sel.30-303	20.2	2.2	11.2
Atlas	C.I. 899	20.2	6.7	13.5
Red Amber x Feterita	K.B. 2513	28.5	1.3	14.9
Kansas Orange . . .	F.C. 9108	38.3	7.1	22.7

The regional adaptation of these varieties as indicated by grain yields is shown in Table III. The yields are shown for the years of 1931 and 1932 for both the commonly grown varieties and the varieties known to be resistant but of doubtful adaptation. In 1931 chinch bug injury was extremely light and was not an important factor influencing yield. In 1932 the varieties were grown under a rather heavy infestation of bugs, but otherwise the season compared rather closely with that of 1931.

Atlas, Kansas Orange, Kansas Orange x Dwarf Yellow milo and Red Amber x Feterita all seemed to be well adapted to

the production of grain in this region in addition to being chinch bug resistant. Other characters, however, must be considered in determining their regional adaptation (see variety descriptions). The demand in this region requires a chinch bug resistant variety of sorghum that has the ability to produce a high yield and a good quality of grain and forage. Atlas appears to meet all of these demands exceptionally well, and shows much promise in this section. Although Kansas Orange ranks next, it has grain of lower quality and is more likely to lodge than Atlas. Kansas Orange x Dwarf Yellow milo has the ability to resist chinch bug injury and produce a good yield of grain, but it has a dry pithy stalk and is deficient in leaves. This is decidedly objectionable because of the local demand for forage as well as grain. The Red Amber x Feterita hybrid produces grain about equal in quality to that of Feterita, but the quality of forage is deficient. This hybrid while of little value agronomically in this section does have some plant breeding importance due to its chinch bug resistance and because of claims that have been made for its resistance to three forms of kernel smut (Sphacelotheca sorghi (Link) Clinton) found in the United States (68).

Table III.- Grain Yields of Sorghum Varieties
Lawton, Oklahoma

Variety	No.	Yields of grain, bus. per acre		
		1931	1932	Average
African millet	F.C.9111	43.6	30.9	37.3
Atlas	C.I. 899	36.4	35.0	35.7
Kansas Orange x Dwarf Yellow milo	Sel.30-303	32.8	27.1	32.5
Sunrise	C.I. 472	33.2	31.3	32.3
Darso	C.I. 615	30.2	29.2	29.7
Reed kafir	C.I. 628	32.0	26.7	29.4
Red Amber x Feterita	K.B.2513	34.9	23.1	29.0
Kansas Orange	F.C.9108	31.8	24.6	28.2
Blackhull kafir	C.I. 71	29.8	24.8	27.3
Sumac	F.C.1712	24.9	29.5	27.2
Dawn kafir	C.I. 904	24.7	29.3	27.0
Sour feterita	C.I. 623	37.0	16.8	26.9

Selecting Resistant Strains From Adapted Varieties.

Some selections from adapted varieties have been made but none appear to be more resistant than the population from which they were selected. Natural selection probably offers the best explanation for such results, since the varieties have been growing under more or less constant chinch bug infestation for several years.

Developing Resistant Varieties by Hybridization.

Progress along this line has been made by testing hybrids from other stations in comparison with their parents. The

brief data that have been obtained are highly indicative that resistance in sorghums to chinch bug injury is inherited. The percentage of injury (plants killed) in some of the more outstanding hybrids and their parents is shown in Table IV.

Table IV.- Percentage of Chinch Bug Injury to Hybrids and Their Parents

Variety	No.	Plants killed by chinch bugs, Per cent: 1930	1932	Average
Dwarf Yellow milo	C.I. 332	99.8	100.0	99.9
Kansas Orange x Dwarf Yellow milo	Sel.30-303	20.2	2.2	11.2
Kansas Orange x Dwarf Yellow milo	Sel.30-33	68.0	7.5	37.8
Kansas Orange	F.C. 9108	38.3	7.1	22.7
Feterita	C.I. 182	98.6	38.8	68.7
Red Amber x Feterita	K.B. 2513	28.5	1.3	14.9
Red Amber	F.C. 7038	- -	5.0	- -
Dwarf White milo	- -	99.8	100.0	99.9
Dwarf White milo x Hegari	H.C. 282	39.4	1.3	20.4
Hegari	C.I. 750	98.0	11.3	54.7
Dwarf Yellow milo	C.I. 332	99.8	100.0	99.9
Dwarf Yellow milo x Dwarf Freed	H.C. 303	59.5	5.2	32.4
Dwarf Freed	C.I. 971	69.5	12.7	41.1
Dwarf Yellow milo	C.I. 332	99.8	100.0	99.9
Pink kafir x Dwarf Yellow milo	C.I. 903	85.7	6.7	46.2
Pink kafir	C.I. 432	35.8	0.7	18.3

These hybrids are fixed for agronomic characters. Of the two selections from the cross, Kansas Orange x Dwarf Yellow milo, Selection 30-33 showed more resistance than the susceptible milo parent but less resistance than the resistant Kansas Orange parent. Selection 30-303 showed transgressive segregation and is more resistant than the resistant parent. This cross was made for the purpose of producing a chinch bug resistant variety while the other four were made primarily for agronomic reasons. The Dwarf White milo x Hegari H.C. 282 hybrid, the progeny of susceptible parents showed only 20.4 per cent injury as compared to 99.9 per cent injury to the milo parent and 54.7 per cent to the Hegari parent. Although hybrid vigor was not manifested for size characters, it is possible that hybrid vigor was in some way responsible for the resistance of this strain. In a Dwarf Yellow milo x Dwarf Freed cross in which a susceptible parent (milo) and an intermediate parent (Dwarf Freed) were used the hybrid showed more resistance than the Dwarf Freed parent. In this case the injury to the milo parent was 99.9 per cent and to the Dwarf Freed parent 41.1 per cent, while the hybrid showed only 32.4 per cent injury. The other hybrids,Red Amber x Feterita K.B. 2513 and Pink kafir x Dwarf Yellow milo C.I.903,were both somewhat intermediate between their parents in percentage of

injury. The former hybrid showed 14.9 per cent injury as compared with 5.0 per cent to the Red Amber parent and 68.7 per cent injury to the susceptible Feterita parent. The Pink kafir x Dwarf Yellow milo hybrid more nearly approached an intermediate reaction than did the Red Amber x Feterita hybrid. This hybrid was injured 46.2 per cent as compared with 18.3 per cent to the resistant Pink kafir parent and 99.9 per cent to the susceptible Dwarf Yellow milo parent.

Differential Resistance of Some of the More Important Varieties and Strains of Sorghum Tested

During the seasons of 1930 and 1932 when differential resistance data were obtained about 85 varieties and strains were tested. Of this number 40 varieties and strains were included in the test in both seasons. The percentage of injury (plants killed) to the varieties for which two years data were obtained are shown in Table V. Two varieties, Blackhull kafir C.I. 71 and Dwarf Yellow milo C.I. 332 were used as checks both seasons and their reactions are shown at the beginning of the table. They are also inserted in the table for easy comparison with the other varieties, using the average percentage for the checks. The varieties are arranged in the table from most resistant to most susceptible.

In 1930 the infestation of chinch bugs was greater than in 1932. However, in spite of this difference in the intensity of the infestation, the relative injury among many of the varieties was similar in the two seasons. This is shown by the fact that the correlation between the injury in 1930 and 1932 was 0.66 as determined by Spearman's rank method for measuring correlation. Most of the varieties that were severely injured in 1930 were also severely injured in 1932. Several varieties and hybrids that showed a relatively high degree of resistance in 1930 were also relatively resistant in 1932. A few varieties and hybrids differed in their reaction in the two years. Club C.I.901 was injured 81 per cent in 1930 and only 8.2 per cent in 1932. Pink kafir x Dwarf Yellow milo H.C.903 was injured 85.7 per cent in 1930 and 6.7 per cent in 1932. Premo C.I. 873 showed 86 per cent injury in 1930 as compared to 7.5 per cent injury in 1932. Fargo C.I. 809 was injured 46 per cent in 1930 while in 1932 this variety was injured 70.2 per cent. No explanation is offered for the unusual reaction of Fargo since, in general, the infestation was greater in 1930 when this variety was injured 46 per cent than it was in 1932 when it was injured 70.2 per cent. Chiltex was injured 100 per cent in 1930 and only 22.4 per cent in 1932. Ajax was injured 99 per cent in 1930 as compared to 29.9

per cent in 1932.

Severe injury to a few varieties and hybrids in 1930 and a relatively low percentage of injury in 1932 could probably be explained on the basis of natural selection by the bugs had the seed been selected under chinch bug conditions. But a new supply of seed was obtained from non-infested areas for the 1932 planting. The inconsistant reaction of a few varieties and hybrids is difficult to explain. But all of those that were inconsistant in their reaction to bug injury are recently developed varieties (see variety histories) which might in some way be responsible for their reactions.

Table V.- Differential Resistance of Sorghum Varieties to Chinch Bug Injury at Lawton, Oklahoma

Rank	Variety	No.	Plants killed by chinch bugs, Per cent: 1930	1932	Average
	Blackhull kafir (check)	C.I. 71	23.3	5.2	14.3
	Blackhull kafir (check)	C.I. 71	39.0	6.7	22.6
	Blackhull kafir (check)	C.I. 71	49.0	7.5	28.3
	Average Blackhull checks		37.1	6.5	21.8
	Dwarf Yellow milo (check)	C.I. 332	99.5	100.0	99.8
	Dwarf Yellow milo (check)	C.I. 332	99.9	100.0	100.0
	Dwarf Yellow milo (check)	C.I. 332	100.0	100.0	100.0
	Average Dwarf Yellow milo checks		99.8	100.0	99.9
1.	Kansas Orangex Dwarf Yellow milo	Sel.30-303	20.2	2.2	11.2
2.	Atlas	C.I. 899	20.2	6.7	13.5
3.	Red Amber x Feterita	K.B. 2513	28.5	1.3	14.9
4.	Pink kafir	C.I. 432	35.8	0.7	18.3
5.	Milo x Hegari	H.C. 282	39.4	1.3	20.4
6.	Dawn kafir	C.I. 904	39.2	1.5	20.4
7.	Sunrise	C.I. 472	39.5	2.2	20.9
8.	Sharon kafir	C.I. 813	41.5	0.8	21.2
9.	Blackhull kafir	C.I. 71	37.1	6.5	21.8
10.	Kansas Orange	F.C. 9108	38.3	7.1	22.7
11.	Reed kafir	C.I. 628	45.5	0.0	22.8

Table V.- Continued

12.	White Darso	K.B. 3002	42.0	6.2	24.1
13.	Juicy Pink kafir	F.C. 9091	55.0	0.7	27.9
14.	Grohoma	C.I. 920	36.5	21.6	29.1
15.	Darso	C.I. 615	56.2	2.2	29.2
16.	Dwarf feterita x Smith(m x k)	H.C. 302	43.5	18.7	31.1
17.	Dwarf Yellow milo x Dwarf Freed	H.C. 303	59.5	5.2	32.4
18.	Kansas Orange x Dwarf Yellow milo .b.	Sel.30-33	68.0	7.5	37.8
19.	Wonder	C.I. 872	58.0	18.7	38.4
20.	Dwarf Freed	C.I. 971	69.5	12.7	41.1
21.	Leoti Red	F.C. 6610	67.4	20.2	43.8
22.	Club	C.I. 901	81.0	8.2	44.6
23.	Modoc	C.I. 905	79.0	11.9	45.5
24.	Pink kafir x Dwarf Yellow milo	C.I. 903	85.7	6.7	46.2
25.	Early Sumac	F.C. 6611	42.5	50.0	46.3
26.	Premo	C.I. 873	86.0	7.5	46.8
27.	Dwarf feterita x Smith(m x k)	H.C. 301	63.2	32.1	47.7
28.	Custer	C.I. 919	77.5	29.1	53.3
29.	Pierce	Sel.30-206	99.5	12.7	56.1
30.	Fargo	C.I. 809	46.0	70.2	58.1
31.	Chiltex	C.I. 874	100.0	22.4	61.2
32.	Ajax	F.C. 6620	99.0	29.9	64.5
33.	Spur feterita	C.I. 623	91.5	42.2	66.9
34.	Feterita	C.I. 182	98.6	38.8	68.7
35.	Wheatland	C.I. 918	97.5	46.8	72.2
36.	Kalo	C.I. 902	77.4	81.4	79.4
37.	Bishop	C.I. 814	99.5	88.1	93.8
38.	Beaver	C.I. 871	96.0	100.0	98.0
39.	Sooner	C.I. 917	99.6	100.0	99.8
40.	Dwarf Yellow milo	C.I. 332	99.8	100.0	99.9

Effect of Time of Planting Sorghums on the Degree of Chinch Bug Injury

Profitable yields of sorghums depend to a large extent upon good cultural methods. One of the most important cultural practices is seeding at the proper date. This is often difficult to determine locally because of the extreme irregularity of temperature and moisture conditions in the southern portion of the Great Plains area, where most grain and forage sorghums are grown. In the Southern Great Plains there is a considerable period during which sorghums may be planted without danger of killing frosts before the crop matures. But, in certain sections of this area insects cause greater damage to some seedings than to others. The sorghum midge (Contarinia sorghicola) is one of the chief factors to be considered in time of planting throughout the Gulf coast district (42). In that district the grain sorghums should be seeded as early as possible, in order to be past the blooming period before the midges have emerged (37). The early seedings usually show the highest yields under conditions of heavy midge infestation, although the crop would be much better from later seedings if the midges were not present. Late maturing varieties of grain sorghums sometimes can be planted in July, so that the blooming occurs

after most of the midges have ceased oviposition (42).

Chinch bugs usually cause severe injury to grain and forage sorghums at Lawton, Oklahoma. They will attack sorghums during any part of the vegetative period of the plant but older and less tender plants are better able to withstand the attacks. The plants in the earlier seedings at Lawton have been largest at the time the chinch bugs migrate to the sorghum fields and, consequently, show the least injury and produce the highest yields. The late seedings, at Lawton, frequently have been entirely destroyed by the bugs.

The data presented here are for only a two-year period, but agree quite closely with observations and experimental records on the varieties that have been studied for several years at the Lawton station, regarding the effect of time of planting on the degree of chinch bug injury. The grain yields obtained from 40 varieties and strains of sorghums planted on three dates in 1931 (April 13, May 7, and June 1) are presented in Table VI.

Table VI.- Grain Yield for Different Dates of Planting at Lawton, Oklahoma, in 1931

Rank	Variety	No.	Grain yields, bus. per acre			
			Planted April 13	Planted May 7	Planted June 1	Average
1.	Club	C.I. 901	38.7	41.3	47.2	42.4
2.	Ajax	F.C. 6620	38.7	38.6	40.8	39.3
3.	Spur feterita	C.I. 623	46.9	35.0	29.2	37.0
4.	Atlas	C.I. 899	35.2	38.5	35.7	36.4
5.	Grohoma	C.I. 920	29.2	41.3	38.7	36.4
6.	Premo	C.I. 873	33.4	38.1	33.4	35.0
7.	Red Amber x Feterita	K.B. 2513	32.7	36.9	35.0	34.9
8.	Pierce	Sel.30-206	41.4	33.3	27.0	33.9
9.	Sunrise	C.I. 472	29.7	35.5	34.4	33.2
10.	Milo x Hegari	H.C. 282	31.1	28.1	39.9	33.0
11.	Kansas Orange x Dwarf Yellow milo	Sel.30-303	34.5	25.9	37.1	32.8
12.	Reed kafir	C.I. 628	33.8	35.0	27.2	32.0
13.	Kansas Orange	F.C. 9108	42.8	35.0	17.5	31.8
14.	Darso	C.I. 615	34.5	23.3	32.8	30.2
15.	Juicy Pink kafir	F.C. 9091	34.0	25.4	30.7	30.0
16.	Pink kafir	C.I. 432	35.0	26.5	28.1	29.9
17.	Blackhull kafir	C.I. 71	27.6	30.7	31.2	29.8
18.	Bishop	C.I. 814	41.4	16.4	30.2	29.3
19.	White Darso	K.B. 3002	36.9	18.4	31.1	28.8
20.	Fargo	C.I. 809	30.2	24.7	31.2	28.6
21.	Dwarf feterita x Smith(m x K)	H.C. 302	27.0	30.7	26.5	28.1
22.	Wonder	C.I. 872	28.6	20.1	32.8	27.3
23.	Sharon kafir	C.I. 813	22.8	26.5	27.5	25.6

Table VI.- Continued

24.	Kalo	C.I. 902	26.0	21.2	29.1	25.4
25.	Dawn kafir	C.I. 904	27.6	22.2	24.4	24.7
26.	Early Sumac	F.C. 6611	24.9	26.5	22.2	24.5
27.	Modoc	C.I. 905	29.2	15.9	25.9	23.7
28.	Custer	C.I. 919	19.1	21.2	26.5	22.3
29.	Feterita	C.I. 182	20.9	22.3	22.3	21.8
30.	Pink kafir x Dwarf Yellow milo	C.I. 903	20.7	23.3	19.6	21.2
31.	Dwarf feterita x Smith(m x k)	H.C. 301	25.9	14.3	22.8	21.0
31.	Dwarf Yellow milo x Dwarf Freed	H.C. 303	15.9	17.4	29.7	21.0
33.	Chiltex	C.I. 874	23.9	16.9	18.0	19.6
34.	Leoti Red	F.C. 6610	21.2	19.6	17.5	19.4
35.	Dwarf Freed	C.I. 971	19.6	14.8	19.6	18.0
36.	Dwarf Yellow milo	C.I. 332	15.9	8.8	28.6	17.8
37.	Kansas Orange x Dwarf Yellow milo	Sel.30-33	14.3	14.8	22.2	17.1
38.	Wheatland	C.I. 918	10.2	11.6	14.6	12.1
39.	Sooner	C.I. 917	15.4	10.6	5.8	10.6
40.	Beaver	C.I. 871	2.9	4.9	14.6	7.5
	Average yields (40 varieties)		28.0	24.8	27.7	26.8

In 1931 chinch bug injury was very light and did not affect the grain yields to any appreciable extent. These data show an average grain yield for the 40 varieties of 28 bushels to the acre from the April 13 planting, 24.8 bushels to the acre from the May 7 planting,and 27.2 bushels to the acre from the June 1 planting. Yields from the May 7 planting were lowered somewhat by the occurrence of a few hot dry days during the heading and blooming period. Yields from the three dates of seeding would probably be about equal over a longer period of years and in the absence of chinch bugs the difference would probably not be great enough to recommend that a farmer reorganize his program of work in order to plant at one date instead of the other.

The season of 1931 was exceptional, however, from the standpoint of chinch bug injury. Very few seasons of light infestations occur and recommendations as to time of planting should be based on seasons of heavy infestation. Results shown in Table VII are more nearly comparable with those frequently obtained in a time of planting test with sorghums at Lawton, Oklahoma. Grain yields are shown for 40 varieties grown in 1932 on three dates of planting (April 15, May 4, and June 8). Migration of the bugs from the small grains took place about the time the plants in the April 15

seeding were heading and consequently this date of planting failed to show any appreciable chinch bug injury. The May 4 planting was injured to some extent throughout and some of the more susceptible varieties were completely destroyed. The plants on the June 8 seeding were about 6 or 8 inches high when the bugs migrated and were severely injured within a few days. The average yield for the 40 varieties on the April 15 planting was 46.5 bushels to the acre, the average for the May 4 planting was 18.1 bushels to the acre, and the June 8 planting was a complete failure. The grain yields for the three dates of planting in 1931 and 1932 are shown graphically in figure 1.

Table VII.- Grain Yields for Different Dates of Planting at Lawton, Oklahoma, in 1932

Rank	Variety	No.	Grain yields, bus. per acre			
			Planted April 15	Planted May 4	Planted June 8	Average
1.	Atlas	C.I. 899	70.3	34.8	0.0	35.0
2.	Club	C.I. 901	63.0	39.3	0.0	34.1
3.	Sunrise	C.I. 472	63.2	30.8	0.0	31.3
4.	Premo	C.I. 873	61.5	28.7	0.0	30.1
5.	Dawn kafir	C.I. 904	51.8	36.1	0.0	29.3
6.	Darso	C.I. 615	53.7	34.0	0.0	29.2
7.	Sharon kafir	C.I. 813	55.8	27.6	0.0	27.8
8.	Juicy Pink kafir	F.C. 9091	56.2	25.5	0.0	27.2
9.	Kansas Orange x Dwarf Yellow milo	Sel.30-303	56.9	24.4	0.0	27.1
10.	Reed kafir	C.I. 628	49.8	30.3	0.0	26.7
11.	Pierce	Sel.30-206	55.2	23.9	0.0	26.4
12.	Grohoma	C.I. 920	51.8	26.5	0.0	26.1
13.	Pink kafir	C.I. 432	53.5	24.4	0.0	26.0
14.	Modoc	C.I. 905	54.1	22.8	0.0	25.6
15.	Dwarf Yellow milo x Dwarf Freed	H.C. 303	52.0	24.4	0.0	25.5
16.	Wonder	C.I. 872	56.9	19.1	0.0	25.3
16.	Fargo	C.I. 809	73.8	2.1	0.0	25.3
18.	White Darso	K.B. 3002	58.3	16.7	0.0	25.0
19.	Blackhull kafir	C.I. 71	44.3	30.2	0.0	24.8
20.	Kansas Orange	F.C. 9108	44.7	29.2	0.0	24.6
21.	Milo x Hegari	H.C. 282	48.6	24.5	0.0	24.4
21.	Chiltex	C.I. 874	55.6	17.5	0.0	24.4

23.	Red Amber x Feterita	K.B. 2513	40.8	28.4	0.0	23.1
24.	Dwarf feterita x Smith(m x k)	H.C. 302	45.0	21.2	0.0	22.1
25.	Leoti Red	F.C. 6610	48.6	17.0	0.0	21.9
26.	Ajax	F.C. 6620	45.4	12.7	0.0	19.4
27.	Dwarf Freed	C.I. 971	43.1	11.7	0.0	18.3
27.	Early Sumac	F.C. 6611	49.2	5.8	0.0	18.3
29.	Kansas Orange x Dwarf Yellow milo	Sel.30-33	42.0	11.1	0.0	17.7
30.	Spur feterita	C.I. 623	40.8	9.7	0.0	16.8
31.	Pink kafir x Dwarf Yellow milo	C.I. 903	33.1	14.3	0.0	15.8
32.	Dwarf feterita x Smith(m x k)	H.C. 301	41.6	4.2	0.0	15.3
33.	Dwarf Yellow milo	C.I. 332	43.0	0.0	0.0	14.3
34.	Bishop	C.I. 814	41.2	0.0	0.0	13.7
35.	Kalo	C.I. 902	40.7	0.0	0.0	13.6
36.	Feterita	C.I. 182	15.6	10.9	0.0	8.8
37.	Wheatland	C.I. 918	21.4	1.9	0.0	7.8
38.	Sooner	C.I. 917	22.7	0.0	0.0	7.6
39.	Custer	C.I. 919	15.3	2.7	0.0	6.0
40.	Beaver	C.I. 871	0.0	0.0	0.0	0.0
	Average Yields (40 varieties)	- -	46.5	18.1	0.0	21.5

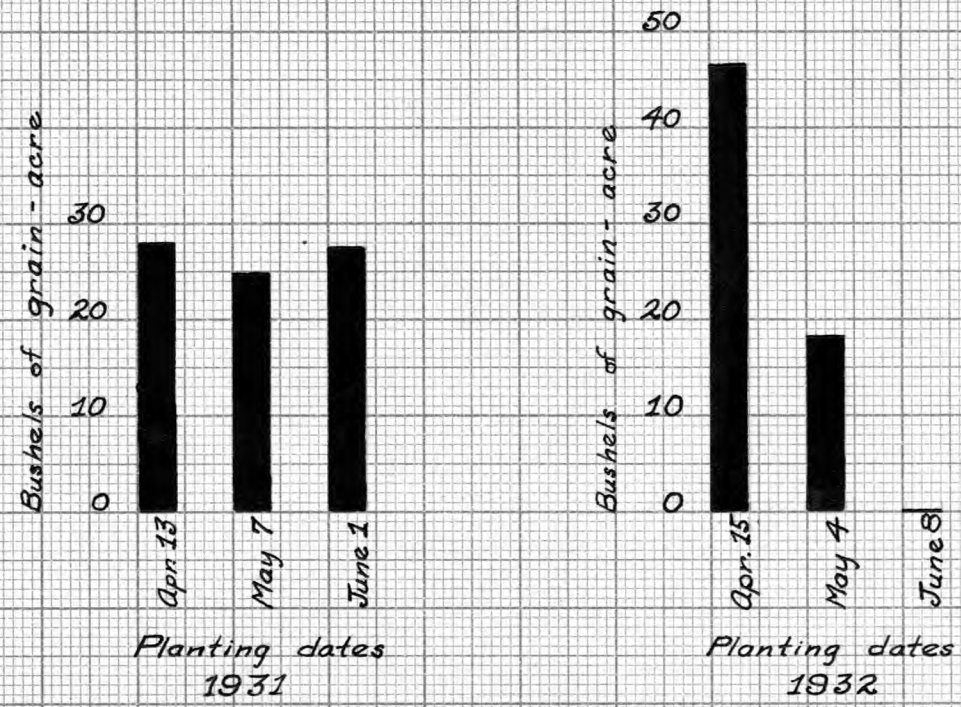

Fig. 1. Grain yields of sorghums on different planting dates (40 variety average)

The percentage of plants killed for the three dates of seeding in 1932 are shown in Table VIII. The April 15 planting was only slightly injured, with an average loss of plants of 6.9 per cent. In the May 4 planting 25.6 per cent of the plants were killed while 96.7 per cent of the plants in the June 8 planting were killed. The plants that survived in the June 8 planting failed to mature any grain. Many of the surviving plants were field hybrids, and appeared to survive the chinch bug attack because of their hybrid vigor, which tends to induce resistance to chinch bug injury (see reaction of F_1 hybrids to chinch bug injury.)

Table VIII.- Percentage of Plants Killed by Chinch Bugs for Different Dates of Planting at Lawton, Oklahoma, in 1932

Rank	Variety	No.	Percentage of Plants Killed			
			Planted April 15	Planted May 4	Planted June 8	Average
1.	Kansas Orange	F.C. 9108	0.0	7.1	70.0	25.7
2.	Blackhull kafir	C.I. 71	4.2	6.5	71.0	27.2
3.	Atlas	C.I. 899	0.2	6.7	78.9	28.6
4.	Kansas Orange x Dwarf Yellow milo	Sel.30-33	0.7	7.5	82.6	30.3
5.	Darso	C.I. 615	0.0	2.2	91.1	31.1
6.	Sharon kafir	C.I. 813	1.4	0.8	96.3	32.8
7.	Pink kafir	C.I. 432	0.0	0.7	98.5	33.1
8.	Dawn kafir	C.I. 904	3.0	1.5	95.5	33.3
8.	Juicy Pink kafir	F.C. 9091	0.0	0.7	99.3	33.3
10.	Sunrise	C.I. 472	3.0	2.2	95.6	33.6
11.	Reed kafir	C.I. 628	1.2	0.0	100.0	33.7
12.	Kansas Orange x Dwarf Yellow milo	Sel.30-303	0.0	2.2	100.0	34.1
13.	Milo x Hegari	H.C. 282	5.0	1.3	98.8	35.0
14.	Dwarf Yellow milo x Dwarf Freed	H.C. 303	0.7	5.2	99.3	35.1
15.	Modoc	C.I. 905	1.4	11.9	92.6	35.3
16.	White Darso	K.B. 3002	0.0	6.2	100.0	35.4
16.	Red Amber x Feterita	K.B. 2513	5.0	1.3	100.0	35.4
18.	Pink kafir x Dwarf Yellow milo	C.I. 903	0.7	6.7	99.3	35.6

19.	Premo	C.I. 873	0.7	7.5	100.0	36.1
20.	Club	C.I. 901	1.4	8.2	99.3	36.3
21.	Dwarf Freed	C.I. 971	0.0	12.7	100.0	37.6
22.	Pierce	Sel.30-206	5.2	12.7	100.0	39.3
23.	Leoti Red	F.C. 6610	0.0	20.2	100.0	40.1
24.	Wonder	C.I. 872	2.2	18.7	100.0	40.3
25.	Grohoma	C.I. 920	0.0	21.6	100.0	40.5
26.	Chiltex	C.I. 874	0.0	22.4	100.0	40.8
26.	Dwarf feterita x Smith(m x k)	H.C. 302	3.7	18.7	100.0	40.8
28.	Ajax	F.C. 6620	0.0	29.9	100.0	43.3
29.	Dwarf feterita x Smith(m x k)	H.C. 301	2.2	32.1	100.0	44.8
30.	Spur feterita	C.I. 623	0.0	42.2	100.0	47.4
31.	Custer	C.I. 919	17.1	29.1	99.3	48.5
32.	Early Sumac	F.C. 6611	0.0	50.0	100.0	50.0
33.	Wheatland	C.I. 918	7.4	46.8	100.0	51.4
34.	Fargo	C.I. 809	3.0	70.2	100.0	57.7
35.	Kalo	C.I. 902	1.4	81.4	100.0	60.9
36.	Bishop	C.I. 814	4.6	88.1	100.0	64.2
37.	Sooner	C.I. 917	2.2	100.0	100.0	67.4
38.	Dwarf Yellow milo	C.I. 332	3.9	100.0	100.0	68.0
39.	Feterita	C.I. 182	93.5	38.8	100.0	77.4
40.	Beaver	C.I. 871	100.0	100.0	100.0	100.0
	Average percentage plants killed	- -	6.9	25.6	96.7	43.0

Reaction of F_1 Sorghum Hybrids to Chinch Bug Injury

Studies are in progress regarding the inheritance of chinch bug resistance in sorghums, and the brief data that have been obtained are highly indicative that resistance is inherited. The limited data on F_1 plants that have been obtained are of considerable interest in this connection. Data presented in Table IX for five hybrids, namely; Dwarf Freed x Dwarf Yellow milo, Feterita x Dwarf Yellow milo, Feterita x Dawn kafir C.I. 904, Feterita x Dawn kafir C.I. 340, and Feterita x Western Blackhull kafir. The three kafir parents, Dawn C.I. 904, Dawn C.I. 340, and Western Blackhull C.I.906 are regarded as resistant, Feterita C.I. 182 is susceptible and Dwarf Yellow milo C.I. 332 very susceptible to chinch bug injury. Dwarf Freed C.I. 971 is intermediate as to resistance. The differential resistance of the parent varieties is given in Table V.

Dwarf Freed x Dwarf Yellow milo did not exhibit hybrid vigor for size characters and apparently none for chinch bug resistance since its resistance was intermediate between the parent varieties. The Dwarf Yellow milo plants were injured 100 per cent when about 10 inches high (July 18). The hybrid plants continued to survive until August 1, at which

time 100 per cent injury was recorded. The loss of plants in the Dwarf Freed parent was 64.3 per cent, and the surviving plants that reached maturity appeared stunted and produced very poorly developed heads.

The Feterita x Dwarf Yellow milo hybrid was of particular interest since both parents are susceptible to chinch bug injury, and one of them, milo, highly susceptible. The plants of Feterita were killed by July 7, and did not attain a height of more than 5 inches. The plants of the milo parent survived until July 18 before they were injured 100 per cent. At that time the plants were about 10 inches high. The hybrid plants were very late in reaching maturity (about October 10) and showed much hybrid vigor for size characters and probably for chinch bug resistance. The heads were poorly developed and only a small amount of seed was produced. Probably the poor development of the hybrid heads may be attributed to both chinch bug injury and late maturity. Certainly, late maturity was indirectly, if not directly, responsible for a part of the poor head development, since all other varieties in the nursery had matured when this hybrid was heading and, therefore, the bugs concentrated on these plants.

The other three hybrids involved Feterita and kafir parents, Feterita x Dawn kafir C.I. 904, Feterita x Dawn kafir C.I. 340 and Feterita x Western Blackhull kafir. The Feterita parent plants were all killed by chinch bugs when about 5 inches high or about July 7. All the kafir parents reached maturity without any apparent chinch bug injury. The kafir plants grew to normal height and produced well developed heads. Phenotypically the three F_1 hybrids were alike. They exhibited considerable hybrid vigor but failed to show the extreme lateness found in the Feterita x Dwarf Yellow milo hybrid. All the plants matured at approximately the same time as the kafir parents. In addition the resistance to chinch bugs was indicated by the production of well filled heads.

These data indicate a relationship between hybrid vigor for size characters and chinch bug resistance. This relationship is further supported by observations of the resistance to chinch bug injury in field hybrids that exhibit hybrid vigor. In the susceptible (milo) x intermediate (Dwarf Freed) cross hybrid vigor was not evident and the F_1 plants reacted as intermediate between the parents for chinch bug resistance. In the susceptible (Feterita) x susceptible (milo) cross the F_1 plants showed much hybrid vigor and chinch bug resistance. The susceptible (Feterita)

x resistant (kafir) crosses exhibited much hybrid vigor as well as chinch bug resistance. These data are limited to only a small number of hybrids and parent varieties, but tend to support a hybrid vigor - chinch bug resistance relationship theory.

Table IX.- Reaction of F_1 Sorghum Hybrids to Chinch Bug Injury, 1932

Parents and hybrids	No.	Plants killed per cent	Date all plants dead	Remarks
Dwarf Freed	C.I. 971	64.3	- - -	Surviving plants produced very poorly developed heads
Dwarf Freed x Dwarf Yellow milo F_1	- - - - -	100.0	August 1	No hybrid vigor, plants intermediate for resistance
Dwarf Yellow milo	C.I. 332	100.0	July 18	Plants killed when about 10 inches high
Feterita	C.I. 182	100.0	July 7	Plants killed when about 5 inches high
Feterita x Dwarf Yellow milo F_1	- - - - -	0.0	- - -	Very late, hybrid vigor, poor heads
Dwarf Yellow milo	C.I. 332	100.0	July 18	Plants killed when about 10 inches high
Feterita	C.I. 182	100.0	July 7	Plants killed when about 5 inches high
Feterita x Dawn kafir F_1	- - - - -	0.0	- - -	Plants well developed, hybrid vigor, medium maturity
Dawn kafir	C.I. 904	0.0	- - -	Plants developed normally
Feterita	C.I. 182	100.0	July 7	Plants killed when about 5 inches high
Feterita x Dawn kafir F_1	- - - - -	0.0	- - -	Plants well developed, hybrid vigor, medium maturity
Dawn kafir	C.I. 340	0.0	- - -	Plants developed normally
Feterita	C.I. 182	100.0	July 7	Plants killed when about 5 inches high
Feterita x Western Blackhull F_1	- - - - -	0.0	- - -	Plants well developed, hybrid vigor, medium maturity
Western Blackhull kafir	C.I. 906	0.0	- - -	Plants developed normally

Plate I.- Dwarf Yellow milo x Dwarf Freed F_1 hybrid with parents. (Left) Dwarf Yellow milo C.I. 332, (Center) Dwarf Yellow milo x Dwarf Freed F_1 , and (Right) Dwarf Freed C.I. 971.

Plate II.- Feterita x Dwarf Yellow milo F_1 hybrid with parents. (Left) Dwarf Yellow milo C.I. 332, (Center) Feterita x Dwarf Yellow milo F_1 and (Right) Feterita C.I. 182.

Plate III.- Feterita x Dawn kafir F_1 hybrid with parents. (Left) Dawn kafir C.I. 904, (Center) Feterita x Dawn kafir F_1 and (Right) Feterita C.I. 182.

Sorghum Varietal Resistance Versus Chinch Bug Preference

The cause of the resistance or susceptibility is one of the fundamental problems of insect resistance and is one of the most difficult to solve. Investigations to determine the reason why certain varieties survive a heavy infestation of chinch bugs when other varieties under similar conditions are greatly injured are still in the initiatory stages. Data obtained from such investigations as have been made indicate that resistance is due to a natural condition within the plant or variety rather than to a varietal preference of the bugs.

In studies dealing with the basic principles of resistance the number of bug punctures in the plants and the number of bugs feeding on the plants of a resistant variety as compared to a susceptible variety were obtained. Kansas Orange F.C.9108 (resistant) and Dwarf Yellow milo C.I. 332 (susceptible) were used in this study. The varieties were grown side by side in paired rows spaced six inches apart. No attempt was made to control infestation artificially, and equal chances for infestation on both varieties were

obtained by growing them close together.

When the plants were about 6 inches high and well infested they were preserved in 4 per cent formalin. The number of punctures and the number of bugs were determined later in the laboratory. The plants were cut below the crown and preserved for the bug counts when the bugs were feeding intensely, either in the early morning or late afternoon. Under these conditions the plants could be removed from the soil and placed in a cloth bag and submerged in the formaldehyde solution without disturbing the bugs to any extent. Plants for the puncture counts were preserved without attempt to save the bugs that were feeding on them.

Twenty plants of each variety were used for the bug counts which are recorded in Table X. On the twenty Kansas Orange plants, 2,776 bugs, or an average of 139±9 to the plant were found as compared to 1,918 bugs, or an average of 96±9 to the plant, on the twenty milo plants. Thus an average of 43±13 more bugs per plant were found on the resistant Kansas Orange plants than were found on the susceptible milo plants. These figures indicate a slight preference of the bugs for the Kansas Orange plants, the resistant variety. However, a slightly injured condition of the milo plants may have encouraged a few of the bugs to transfer

from the milo to the Kansas Orange plants. The data are highly indicative of a natural resistance within the Kansas Orange plants that was not found in the susceptible milo plants.

Certain phases of laboratory technic had to be worked out before making the puncture counts. Several methods were tested but the one briefly described below was most satisfactory. This method was worked out by Painter (10). As previously mentioned the plants were preserved in a 4 per cent solution of formalin. The formalin was washed from the plants in running water, and the plants were placed in a chlorine gas chamber for bleaching where chlorine gas was produced by the reaction of hydrochloric acid and potassium chlorate. After bleaching, the plants were stained in a dilute analin blue solution. Then they were washed in running water until the punctures could be differentiated. Leaf and sheath puncture counts were made under a binocular microscope. These counts are recorded in Table XI.

Table X.- Number of Chinch Bugs on Kansas Orange and Dwarf Yellow Milo Plants

Plant No.	Number of bugs on Kansas Orange	Number of bugs on Dwarf Yellow Milo	Plant No.	Number of bugs on Kansas Orange	Number of bugs on Dwarf Yellow Milo
1.	204	207	11.	84	19
2.	231	132	12.	64	52
3.	173	177	13.	69	18
4.	103	178	14.	97	26
5.	93	185	15.	56	28
6.	207	120	16.	131	45
7.	178	104	17.	88	60
8.	174	164	18.	81	68
9.	160	106	19.	180	78
10.	192	105	20.	211	46

Total number bugs (Kansas Orange) 2,776
(Dwarf Yellow Milo) 1,918

Average number of bugs per plant (Kansas Orange) 139±9
(Dwarf Yellow Milo) 96±9

Table XI.- Number of Chinch Bug Punctures in Kansas Orange and Dwarf Yellow Milo Plants

Leaf No.	Kansas Orange Plants *			Dwarf Yellow Milo Plants **		
	Leaf-blade punctures	Leaf-sheath punctures	Total	Leaf-blade punctures	Leaf-sheath punctures	Total
1.	109	505	614	135	532	667
2.	195	446	641	132	514	646
3.	235	311	546	105	655	760
4.	481	440	921	114	942	1,056
5.	508	219	727	238	409	647
6.	256	33	289	213	8	221
7.	128	0	128	3	0	3
Total punctures	1,912	1,954	3,866	940	3,060	4,004
Ave. per plant	191±25	195±29	387±35	104±12	340±42	444±39

* Average of 10 plants. ** Average of 9 plants.

An average of 444±39 punctures to the plant was recorded for the Dwarf Yellow milo as compared to an average of 387±35 punctures to the plant for the Kansas Orange. This average increase of 57±52 punctures to the plant on the milo is probably not great enough to be of much significance. Certainly this small difference alone could not account for the difference in the reaction of the two varieties to chinch bug injury. (See Table V.) These data, while not conclusive, offer considerable support to the theory that varieties and plants differ in resistance to chinch bugs rather than that the bugs show a preference for certain varieties or plants over others.

This varietal difference in the location of the chinch bug punctures may be explained on the basis of the mechanical structure of the plants. The leaf sheaths on the Kansas Orange plants grow rather closely to the stalk while on the Dwarf Yellow milo plants they are more open. Chinch bugs are gregarious and they feed in protected locations when possible. This gregarious habit and feeding in protected places results in concentrated injury on the plants. These feeding habits are borne out by field observations and the finding of a greater number of punctures on the side of the sheath next to the stalks. The leaf sheath of the Dwarf

Yellow milo plants fits the stalk loosely and affords a better opportunity for the bugs to feed under protection behind the leaf sheath than does the close fitting leaf sheath of the Kansas Orange plants. This fact probably accounts for approximately equal numbers of chinch bug punctures in the leaf sheath and the leaf blade of the Kansas Orange plants, while the Dwarf Yellow milo plants had many more punctures in the leaf sheath than in the leaf blade.

In the data presented in Table XI. the leaves were numbered upward from the base of the plants. In the leaf blades of the Kansas Orange plants the number of punctures increased from the first to the fifth leaf, after which a decrease was noted. A similar condition was found in the Dwarf Yellow milo leaf blades but the increase was not so great. A general decrease in the number of punctures was found in the Kansas Orange leaf sheaths while the Dwarf Yellow milo plants had an increase in the number of punctures in the leaf sheaths up to the fourth leaf, after which a decrease was found. This can also be explained by the mechanical structure of the plant and the feeding habit of the bugs.

The Kansas Orange plants offer more protection to the bugs feeding in the curl than they do behind the leaf

sheaths. The sixth and seventh leaves were rolled tightly in the curl which explains the decrease in the number of punctures in these leaves. The Dwarf Yellow milo plants probably offer about the same protection to the bugs in the curl as the Kansas Orange plants. But the Dwarf Yellow milo plants offer more protection behind the leaf sheath than they do in the curl which seems to explain the reason for a greater number of punctures in the leaf sheaths.

History of Sorghum Varieties

The histories of the more recently produced varieties of sorghum have been reported only to a very limited extent. The histories for most of the older varieties have been published but the literature is scattered and no one paper or bulletin deals with more than one or a few varieties. Literature was used when possible to obtain historical records of the older varieties but in most cases these records were obtained from investigators familiar with the varieties. A brief history of the varieties discussed in this thesis is presented in Table XII.

Table XII.- History of Sorghum Varieties

Variety	No.	Parentage	Place of Origin
Ajax	F.C.6620	(Feterita x kafir) x kafir	U.S.D.A. and Texas Agr.Expt.Sta. Chillicothe, Texas.
Atlas	C.I. 899	Sourless x Blackhull kafir	Cross by I.N.Farr,Stockton,Kan. Selection by Kan. Agr. Expt.Sta.
Beaver	C.I. 871	(kafir x milo) x Dwarf Yellow milo	U.S.D.A., Woodward, Oklahoma
Bishop	C.I. 814	Probably kafir x milo	George Bishop, Cordell, Oklahoma
Blackhull kafir	C.I. 71	Introduction	Melbourne, Australia
Chiltex	C.I. 874	Feterita x Blackhull kafir	U.S.D.A. and Texas Agr.Expt.Sta. Amarillo, Texas
Club	C.I. 901	Sel.from Dawn kafir C.I. 340	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Custer	C.I. 919	(Dwarf Yellow milo x Pink kafir) x Dwarf Yellow milo	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Darso	C.I. 615	Probably a milo x sorgo hybrid	Logan County, Oklahoma
Dawn kafir	C.I. 904	Sel.from Dawn kafir C.I. 340	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Dwarf feterita x Smith (m x k)	H.C. 302	Dwarf feterita x Smith (milo x kafir)	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Dwarf feterita x Smith (m x k)	H.C. 301	Dwarf feterita x Smith (milo x kafir)	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas

Dwarf Freed	C.I. 971	Sel. from Freed	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Dwarf Yellow milo	C.I. 332	Unknown	Unknown
Dwarf Yellow milo x Dwarf Freed	H.C. 303	Dwarf Yellow milo x Dwarf Freed	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Early Sumac	F.C.6611	Sel.from Standard Sumac F.C. 1712	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Fargo	C.I. 809	Probably a milo x kafir hybrid	H.Willis Smith,Garden City,Kansas
Feterita	C.I. 182	Introduction	Khartum, Sudan, Africa
Grohoma	C.I. 920	Probably a Feterita x sorgo hybrid	Fred Groff, Britton,Oklahoma
Juicy Pink kafir	F.C.9091	Sel.from Pink kafir C.I. 432	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Kalo	C.I. 902	Pink kafir x Dwarf Yellow milo	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Kansas Orange . . .	F.C.9108	Unknown	Unknown
Kansas Orange x Dwarf Yellow milo .	Sel.30-33	Kansas Orange x Dwarf Yellow milo	Kan.Agr. Expt. Sta., Manhattan, Kansas
Kansas Orange x Dwarf Yellow milo	Sel.30-303	Kansas Orange x Dwarf Yellow milo	Kan.Agr. Expt. Sta., Manhattan, Kansas
Leoti Red	F.C.6610	Probably Red Amber x Orange	Muncie, Indiana
Milo x Hegari . . .	H.C. 282	Dwarf White milo x Dwarf Hegari	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Modoc	C.I. 905	Pink kafir x Freed	U.S.D.A. and Kan.Agr.Expt.Sta. Modoc and Hays, Kansas

Pierce	Sel.30-206	Kafir x Feterita	Walter, Pierce, Darlow, Kansas
Pink kafir	C.I. 432	Introduction	Africa
Pink kafir x Dwarf Yellow milo . .	C.I. 903	Pink kafir x Dwarf Yellow milo	U.S.D.A. and Kan.Agr.Expt.Sta. Hays, Kansas
Premo	C.I. 873	Feterita x Blackhull kafir	U.S.D.A. and Texas Agr.Expt.Sta. Amarillo, Texas
Reed kafir	C.I. 628	Sel.from Blackhull kafir	W. N. Reed, Elk City, Oklahoma
Red Amber x Feterita	K.B.2513	Red Amber x Feterita	Kan. Agr. Expt.Sta., Manhattan, Kansas
Sharon kafir . . .	C.I. 813	Sel.from Blackhull kafir	U.S.D.A., Woodward, Oklahoma
Sooner milo . . .	C.I. 917	Early White milo x Dwarf Yellow milo	U.S.D.A., Woodward, Oklahoma
Spur feterita . .	C.I. 623	Sel.from Feterita C.I. 182	Texas Agr.Expt.Sta., Spur, Texas
Sunrise . . .	C.I. 472	Sel.from Blackhull kafir	Texas Agr.Expt.Sta., Amarillo, Texas
Wheatland . . .	C.I. 918	Kafir x milo	U.S.D.A., Woodward, Oklahoma
White Darso . . .	K.B.3002	Natural hybrid from Darso	U.S.D.A. and Kan.Agr.Expt.Sta. Manhattan, Kansas
Wonder	C.I. 972	Kafir x Feterita	C. A. Bowers, Sharon Springs, Kansas

Description of Sorghum Varieties

The tabulated description of the more recently produced sorghum varieties have been published only to a very limited extent. The descriptions presented in Table XIII are the result of a detailed sorghum variety character study made in connection with the chinch bug resistance project. In 1931 the chinch bug infestation was extremely light, and even the most susceptible varieties grew to maturity without suffering any appreciable injury. The season was favorable for the normal development of sorghums and this afforded a good opportunity for the sorghum variety character study reported herein.

Explanation of Descriptive Terms

Height of Plant. Since environment affects this character quite noticeably only a relative comparison of height was made among the varieties instead of measuring the plants in inches. The terms tall, medium, and dwarf were used to classify the varieties.

Leafiness of Stalk. Sorghum varieties do not vary much in regard to the number of leaves to the stalk, but a difference in leafiness is due largely to the height of plant.

The taller plants, while having about the same number of leaves as the shorter plants, are less leafy when the distance between the leaves is considered. Some of the varieties vary in regard to length and width of the leaves, a character which was considered in determining the relative leafiness of the varieties. The terms not leafy, medium leafy and leafy were used in classifying the varieties.

Coarseness of Stalk. This term refers primarily to the diameter of the stalk. As a general rule the shorter stalked varieties have a relatively larger diameter than the taller varieties. The varieties were grouped as slender, medium and coarse.

Retention of Foliage. Retention of foliage refers to the ease with which the leaves may be broken from the stalk by a downward stroke of the hand. The varieties were grouped as poor, referring to those which do not hold their leaves well, medium and good with regard to this character.

Lodging. This term as used in this thesis refers to lodging caused by the stalks breaking above the ground. In practically every variety where lodging was observed the breaking over took place at the top of the node. The growing season was not favorable to lodging, consequently only a few varieties showed this weakness. The terms much, some, and none were used to group the varieties for this character.

TABLE XIII SUMMARY OF SORGHUM VARIETY CHARACTERS

VARIETIES ARRANGED ACCORDING TO CHINCH BUG RESISTANCE

1930

Variety Name	C.I. No.	Other No.	Percent of Injury	Height of Plant	Leafiness of Stalk	Coarseness of Stalk	Retention of Foliage	Lodging Habit	Juiciness of Stalk	Color of Mid-rib	Sweetness of Stalk	Color of Plant	Color of Seed	Size of Seed	Subcoat of Seed	Shattering	Color of Stigma	Color of Glume	Shape of Glume	Length of Glume	Pubescence of Glume	Type of Awn	Shape of Head	Density of Head	Insertion of Head	Type of Peduncle	Maturity	Percent of Tannin
Kansas Orange x Dwf Yellow Milo		Sel. 30-303	20.2	Medium	Medium	Slender	Good	None	Pithy	White	Not Sweet	Dark Green	Buff	Medium	Present	Some	Creamy	Black	Slender Pointed	Medium	Pubescent	Awnless	Ovate	Medium	Good	Straight	Medium	20.2
Atlas Sorgo	899		20.2	Tall	Leafy	Slender	Good	None	Juicy	Gray	Sweet	Light Green	White	Medium	Absent	Some	White	Reddish-Black	Pointed	Short	Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Late	20.2
Red Amber x Feterita		KB 2513	28.5	Tall	Leafy	Slender	Good	None	Medium	Gray	Slightly Sweet	Light Green	White	Very Large	Present	None	Creamy	Black	Pointed	Medium	Pubescent	Awnless	Ovate	Medium	Good	Straight	Medium	28.5
Pink Kafir	432		35.8	Medium	Medium	Medium	Good	None	Pithy	White	Not Sweet	Green	Pink	Medium	Absent	Much	White	Gray	Slender Pointed	Short	Finely Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Medium	35.8
Grohoma	920		36.5	Medium	Leafy	Coarse	Good	None	Medium	White	Slightly Sweet	Dark Green	Buff	Medium	Present	Some	Creamy	Reddish-Black	Broad Pointed	Medium	Pubescent	Awnless	Conical	Lax	Poor	Straight	Medium	36.5
Std Blackhull Kafir	71		37.4	Medium	Leafy	Medium	Good	None	Medium	Gray	Not Sweet	Green	White	Medium	Absent	Some	White	Black	Pointed	Medium	Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Medium	37.4
Kansas Orange		FCI 9108	38.3	Tall	Leafy	Slender	Good	Some	Juicy	Gray	Sweet	Light Green	Reddish-Brown	Small	Present	Some	Yellow	Black	Slender Pointed	Medium	Finely Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Late	38.3
Dawn Kafir	904		39.2	Medium	Medium	Medium	Good	None	Medium	Gray	Slightly Sweet	Green	White	Medium	Absent	Some	White	Black	Broad Pointed	Medium	Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Medium	39.2
Milo x Hegari		HC 282	39.4	Medium	Not Leafy	Slender	Medium	None	Medium	Gray	Not Sweet	Light Green	White	Medium	Absent	Much	Creamy	Black	Pointed	Short	Pubescent	Awnless	Cylindrical	Dense	Medium	Straight	Medium	39.4
Sunrise Kafir	472		39.5	Tall	Medium	Slender	Good	None	Juicy	Gray	Sweet	Light Green	White	Medium	Absent	Some	White	Black	Pointed	Short	Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Medium	39.5
Sharon Kafir	813		41.5	Medium	Leafy	Medium	Medium	None	Medium	Gray	Not Sweet	Green	White	Medium	Absent	Some	White	Black	Pointed	Medium	Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Medium	41.5
White Darso		KB 3002	42.0	Medium	Medium	Slender	Good	None	Juicy	Gray	Not Sweet	Green	White	Medium	Absent	Some	Creamy	Black	Pointed	Medium	Finely Pubescent	Awned	Ovate	Medium	Good	Straight	Medium	42.0
Early Sumac		FCI 6611	42.5	Tall	Leafy	Slender	Good	None	Juicy	Gray	Sweet	Light Green	Red	Small	Absent	Some	Yellow	Reddish-Black	Rounded	Short	Pubescent	Awnless	Cylindrical	Dense	Good	Straight	Medium	42.5
Dwf Feterita x Smith (MsK)		HC 302	43.5	Dwarf	Leafy	Coarse	Medium	None	Medium	Gray	Not Sweet	Dark Green	White	Medium	Absent	Much	Creamy	Reddish-Black	Pointed	Short	Pubescent	Awnless	Conical	Medium	Medium	Straight	Medium	43.5
Reed Kafir	628		45.5	Medium	Medium	Medium	Good	None	Medium	Gray	Not Sweet	Green	White	Medium	Absent	None	White	Black	Pointed	Long	Finely Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Medium	45.5
Fargo Milo	809		46.0	Medium	Leafy	Coarse	Medium	None	Pithy	Yellow	Not Sweet	Dark Green	Yellow	Large	Absent	Some	Yellow	Dark Brown	Pointed	Medium	Pubescent	Awned	Ovate	Medium	Medium	Straight	Late	46.0
Juicy Pink Kafir		FCI 9091	55.0	Medium	Medium	Medium	Medium	None	Medium	Gray	Not Sweet	Green	Pink	Medium	Present	Much	Creamy	Gray	Slender Pointed	Short	Finely Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Medium	55.0
Darso	615		56.2	Medium	Medium	Medium	Good	None	Juicy	Yellow	Sweet	Dark Green	Reddish-Brown	Medium	Absent	None	Yellow	Reddish-Black	Pointed	Medium	Pubescent	Awned	Ovate	Medium	Good	Straight	Medium	56.2
Wonder Kafir	872		58.0	Medium	Medium	Medium	Good	None	Pithy	White	Not Sweet	Dark Green	White	Medium	Present	Some	White	Black	Pointed	Medium	Heavily Pubescent	Awnless	Oval	Medium	Good	Straight	Medium	58.0
Dwf Yellow Milo x Dwf Freed		HC 303	59.5	Dwarf	Leafy	Medium	Good	None	Medium	Gray	Not Sweet	Dark Green	Yellow	Medium	Absent	Some	Creamy	Black	Pointed	Short	Pubescent	Awned	Ovate	Medium	Good	Straight	Medium	59.5
Dwf Feterita x Smith (MsK)		HC 301	63.2	Dwarf	Medium	Coarse	Good	None	Medium	Gray	Not Sweet	Dark Green	White	Medium	Absent	Some	Creamy	Dark Brown	Pointed	Medium	Finely Pubescent	Awnless	Oval	Medium	Medium	Straight	Medium	63.2
Leoti Red		FCI 6610	67.4	Tall	Medium	Slender	Good	Some	Juicy	Gray	Sweet	Light Green	Reddish-Brown	Small	Present	None	Yellow	Red	Broad Rounded	Long	Pubescent on Tip	Awned	Obovate	Lax	Good	Straight	Medium	67.4
Kansas Orange x Dwf Yellow Milo		Sel. 30-33	68.0	Dwarf	Medium	Slender	Medium	Some	Medium	White	Not Sweet	Green	Yellow	Large	Absent	None	Yellow	Black	Pointed	Medium	Pubescent	Awned	Cylindrical	Medium	Medium	Straight	Medium	68.0
Dwarf Freed	971		69.5	Dwarf	Not Leafy	Slender	Good	None	Juicy	Gray	Sweet	Green	White	Medium	Absent	Some	Creamy	Gray	Pointed	Medium	Pubescent	Heavily Awned	Cylindrical	Lax	Good	Straight	Early	69.5
Yellow Kafir	902		77.4	Dwarf	Medium	Slender	Medium	None	Medium	Gray	Not Sweet	Green	Yellow	Medium	Absent	Some	Yellow	Black	Rounded	Medium	Finely Pubescent	Awned	Cylindrical	Medium	Good	Straight	Medium	77.4
Custer Milo	919		77.5	Dwarf	Leafy	Medium	Medium	None	Medium	Gray	Not Sweet	Green	Reddish-Yellow	Medium	Absent	Some	Yellow	Black	Rounded	Short	Pubescent	Awned	Ovate	Medium	Medium	Straight	Medium	77.5
Modoc Pink	905		79.0	Medium	Medium	Slender	Good	None	Medium	Gray	Not Sweet	Green	White	Medium	Absent	Some	Creamy	Black	Pointed	Medium	Heavily Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Early	79.0
Club Kafir	901		81.0	Medium	Leafy	Medium	Good	None	Medium	Gray	Not Sweet	Dark Green	White	Medium	Absent	None	Creamy	Black	Pointed	Long	Heavily Pubescent	Awnless	Ovate	Medium	Good	Straight	Medium	81.0
Pink Kafir x Dwf Yellow Milo	903	HC 2510	85.7	Medium	Leafy	Coarse	Good	None	Medium	Yellow	Not Sweet	Dark Green	White	Medium	Absent	Some	Creamy	Dark Brown	Broad Pointed	Short	Pubescent	Awned	Conical	Medium	Good	Straight	Late	85.7
Premo	873		86.0	Medium	Leafy	Coarse	Good	None	Medium	Gray	Not Sweet	Dark Green	White	Very Large	Present	Some	White	Black	Pointed	Medium	Pubescent	Awnless	Ovate	Medium	Medium	Straight	Medium	86.0
Spur Feterita	623		91.5	Medium	Leafy	Medium	Good	None	Pithy	White	Not Sweet	Light Green	White	Very Large	Present	Some	Creamy	Black	Broad Pointed	Short	Pubescent	Awnless	Ovate	Medium	Good	Straight	Medium	91.5
Beaver Milo	871		96.0	Dwarf	Leafy	Coarse	Good	None	Medium	Yellow	Not Sweet	Green	Yellow	Large	Absent	None	Yellow	Dark Brown	Broad Pointed	Medium	Pubescent	Awned	Oval	Medium	Medium	Straight	Medium	96.0
Wheatland	918		97.5	Dwarf	Medium	Medium	Medium	None	Medium	Yellow	Not Sweet	Green	Yellow	Medium	Absent	Some	Yellow	Dark Brown	Pointed	Medium	Pubescent	Awnless	Ovate	Medium	Medium	Straight	Medium	97.5
Common Feterita	182		98.6	Medium	Not Leafy	Slender	Good	Some	Pithy	White	Not Sweet	Light Green	White	Very Large	Present	Some	Creamy	Black	Pointed	Medium	Pubescent	Awnless	Ovate	Medium	Good	Straight	Medium	98.6
Ajax		FCI 6620	99.0	Medium	Leafy	Coarse	Good	None	Pithy	White	Not Sweet	Dark Green	White	Medium	Present	Some	Creamy	Black	Pointed	Medium	Pubescent	Awnless	Ovate	Medium	Good	Straight	Medium	99.0
Pierce Kafir		Sel. 30-206	99.5	Medium	Leafy	Coarse	Medium	None	Pithy	White	Not Sweet	Dark Green	White	Medium	Absent	Some	Creamy	Black	Broad Pointed	Short	Pubescent	Awnless	Conical	Medium	Good	Straight	Late	99.5
Dwarf Yellow Milo	332		99.5	Medium	Medium	Medium	Good	None	Medium	Yellow	Not Sweet	Green	Yellow	Large	Absent	None	Yellow	Black	Broad Pointed	Medium	Pubescent	Awned	Ovate	Dense	Good	Tendency to Goosenecking	Medium	99.5
Bishop Kafir	814		99.5	Medium	Leafy	Medium	Medium	None	Medium	Gray	Not Sweet	Green	White	Medium	Absent	None	Creamy	Black	Broad Rounded	Medium	Pubescent	Awned	Conical	Medium	Good	Straight	Late	99.5
Sooner Milo	917		99.6	Dwarf	Not Leafy	Slender	Good	Some	Medium	Yellow	Not Sweet	Light Green	Yellow	Large	Absent	None	Yellow	Dark Brown	Broad Rounded	Short	Pubescent	Awned	Oval	Dense	Good	Straight	Early	99.6
Chiltex	874		100.0	Medium	Medium	Medium	Good	None	Pithy	White	Not Sweet	Green	White	Medium	Present	Some	Creamy	Black	Pointed	Medium	Pubescent	Awnless	Cylindrical	Medium	Good	Straight	Medium	100.0

Juiciness of Stalk. This character was recorded by observing the color of midvein of the leaf. The cloudy gray midvein indicating juiciness, a midvein that is gray on each side and yellow or white in the middle indicating a semi-juicy condition, and a clear white midvein indicating a dry pithy stalk. In varieties having a yellow midvein the gray shows the same as in varieties with a white midvein if the stalks are of a juicy type. The terms juicy, medium and pithy were used to group the varieties for this character.

Color of Midvein. Three colors are found in the midvein of the leaf of different sorghum varieties, namely, yellow, cloudy gray, and clear white. The gray color seems to vary in intensity with the juice content of the stalk. The terms yellow, gray, and white have been used to describe this character.

Sweetness of Stalk. Sorghum varieties vary in the amount of sugar that the stalks contain. The study of this character was made by chewing the stalks of the different varieties. The varieties were grouped as sweet or not sweet and without a chemical analysis a more elaborate grouping would not be desirable.

Color of Plant. This character is rather difficult to study, since the varieties do not exhibit much variation in the color of plant. However, it is possible to group the varieties as light green, green, and dark green with a reasonable degree of accuracy.

Color of Seed. In general the varieties can be grouped as white, yellow, and red in regard to this character. In a few cases the seed color is more or less intermediate between these colors making it desirable to use a more elaborate classification. The varieties were grouped as buff, reddish brown, pink, reddish yellow, yellow, and white.

Size of Seed. Size of seed is a character that is influenced by environmental conditions, making it advisable to group the varieties by comparing the seed with that of some of the better known varieties. They are reported as very large, large, medium, and small. The very large class refers to those varieties having seed as large as Feterita C.I. 182. The large group is much the same as Dwarf Yellow milo C.I. 332. Medium designates those varieties that have seed about the size of Blackhull kafir C.I. 71. The small class refers to seed that compares in size with Sumac F.C. 1712.

Subcoat of Seed. This term refers to the brown layer just beneath the outer seed-coat. Some varieties exhibit this subcoat while others do not. No attempt was made to distinguish between the colors of the subcoat for the different varieties, but it is always a shade of brown. The varieties were grouped according to the subcoat character either as present or absent.

Shattering. This character refers to the ease with which the grains separate from the glume. It was studied by shaking the heads quite vigorously, and observing the seed that fell to the ground. The study was made after the varieties had reached maturity. The varieties were grouped as much, some, and none for this character.

Color of Stigma. This perhaps is a character of little importance, but varies quite noticeably in the different varieties. This character was studied while the stigma was fresh and before it had become discolored. A variation in color from pure white to a bright yellow was observed, and the varieties were grouped as yellow, creamy and white for this character. The term creamy designating those varieties which showed an intermediate color between white and yellow.

Color of Glume. This character is rather difficult to study on some varieties since an individual head may exhibit

a variation in color making it advisable to use a larger classification than black, gray, and red. Two additional groups were used, reddish black and dark brown, to distinguish those varieties which showed a combination of red and black.

Shape of Glume. This is a character that varies from one extreme to another in the different varieties with all gradations between these extremes. The varieties were grouped as slender-pointed, pointed, broad-pointed, rounded, and broad-rounded. Pointed refers to those varieties that have a glume that is of medium width and pointed at the tip. Rounded designates those varieties that have a medium width glume that is rounded at the tip. The slender-pointed group is made up of those varieties with a slender narrow glume that is pointed at the tip. The broad-pointed group includes those varieties with a broad glume that is pointed at the tip, and likewise the broad and rounded group consists of varieties that have a broad glume with a rounded tip.

Length of Glume. This character is largely responsible for the degree of shattering that the variety exhibits. A long glume tends to hold the seed while a short glume is favorable to shattering of the seed. The varieties were grouped as long, medium, and short for this character.

Pubescence of Glume. All the varieties discussed in this thesis exhibited more or less pubescence of glume. A few varieties varied in the amount of pubescence present, and the grouping finely pubescent, pubescent, and heavily pubescent was used to distinguish the degree of pubescence. An additional group, pubescent on tip, was added for Leoti Red F.C. 6610 which showed pubescence only on the tip of the glume.

Type of Awn. In general the varieties were grouped as awned and awnless with the exception of Dwarf Freed C.I.971 which was distinguished from the other varieties as heavily awned. When the awn extended beyond the end of the glume the variety was considered awned, and if the awn did not extend beyond the glume the variety was considered awnless.

Shape of Head. This character depends largely upon the individual taking the records, since the varieties vary considerably in the shape of head, and also environmental conditions influence this character to some extent. The varieties were grouped as cylindrical, ovate, obovate,oval, and conical. The varieties in the cylindrical group could be distinguished fairly easily by their cylinder shaped heads. The other groups were more difficult to distinguish. An ovate head refers to those varieties having a head that

is large at the base and tapering toward the tip but not pointed at the tip. If the tip was pointed the variety was placed in the conical group. An obovate head is the reverse of the ovate head, having a large rounded tip and tapering toward the base of the head. The oval group distinguishes those varieties where the head bulges in the middle and tapers toward the base and the tip.

Density of Head. This is another character that is affected quite noticeably by environment, and is dependent upon the length of the seed branches and the distance that they are apart on the main branch. The varieties were grouped as lax, medium, and dense for this character.

Exsertion of Head. This term refers to the degree at which the heads exsert from the boot. This is a character that is largely dependent upon the growing conditions and the data presented here show a comparison of the varieties growing under only one set of conditions. The growing season was favorable for sorghums and some comparative variation between the varieties was observed. The varieties were grouped as poor, medium, and good for this character.

Type of Peduncle. This term refers to the erectness of the head which is dependent upon the straightness of the peduncle. The method by which the head exserts from the

boot influences the amount of recurving. If the head comes out through the side of the boot, more or less recurving is to be found, but if the head comes out through the top of the boot the peduncle tends to be straight. Dwarf Yellow milo C.I. 332 was the only variety of those reported here that showed a tendency to gooseneck or recurve. All other varieties were designated as straight.

Maturity. This term refers to the time it takes the varieties to reach maturity from planting. This is influenced by growing conditions and the time at which the varieties are seeded and must be a comparison between the varieties growing under nearly the same conditions. This comparison was made by designating the varieties as early, medium, and late.

Relationship Between Chinch Bug Reaction and Gross Morphological Characters of Sorghum Varieties

During the course of the experiments on chinch bug resistance in sorghums, observations indicated that in general the milo and the feterita groups were susceptible while the kafir and the sorgo groups were resistant. Recently developed varieties and hybrids have reacted with varying degrees of resistance or susceptibility. These observations led to a study of the relationship between gross morphological characters and chinch bug resistance. The sorghum variety characters listed in Table XII were correlated with chinch bug reaction of the varieties. Apparently chinch bug resistance or susceptibility is not closely correlated with any of the gross morphological characters of sorghums. However, slight correlations were found in a few characters and these are shown graphically in figures 2, 3, and 4.

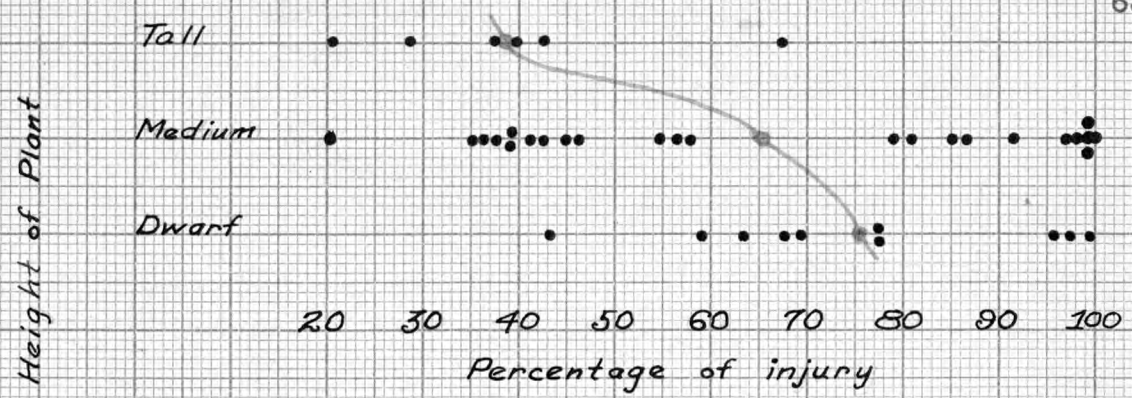

Fig. 2. Relationship of height of plant and chinch bug injury

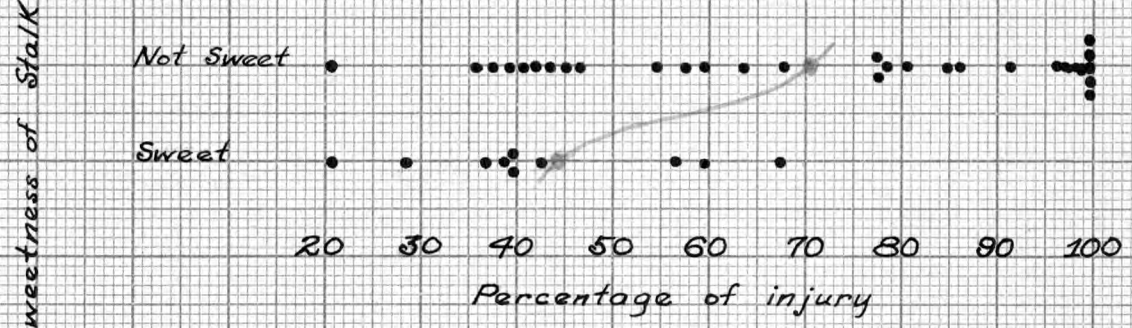

Fig. 3. Relationship of sweetness of stalk and chinch bug injury

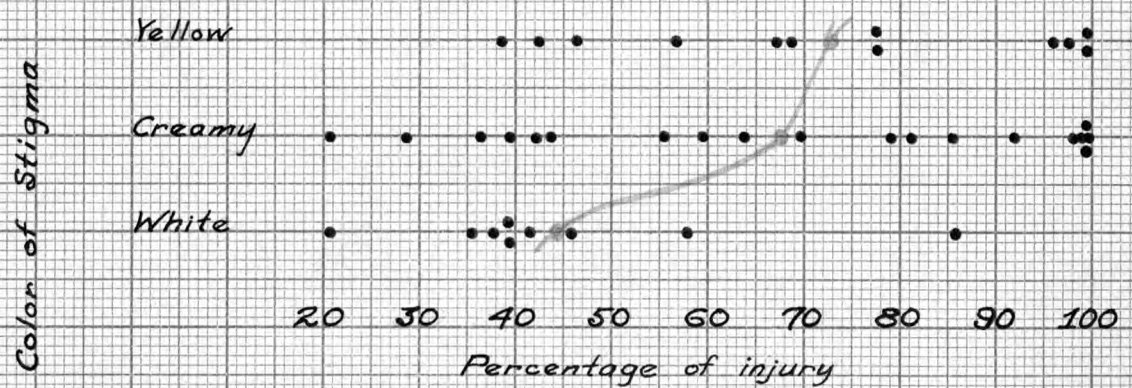

Fig. 4. Relationship of color of stigma and chinch bug injury

Height of plant indicated some relationship with the degree of chinch bug injury. A tall plant seemed to be correlated somewhat with chinch bug resistance while a dwarf plant appeared to be correlated with susceptibility. The taller varieties had a tendency to be distributed on the more resistant side of the graph, while the medium height varieties were distributed rather uniformly across the graph from a low to a high percentage of chinch bug injury. The dwarf varieties were generally distributed on the susceptible side of the graph, indicating that dwarfness might be correlated with chinch bug susceptibility. However, this could probably be explained as an indirect correlation since the dwarf class consists largely of milo and milo hybrids which are recognized as being susceptible to chinch bug injury for other unknown reasons. The tall varieties showed much the same distribution on the graph as the sweet-stalked varieties, and thus they might be indirectly correlated with chinch bug resistance, since a sweet stalk seems to be correlated with chinch bug resistance.

For the sweetness of stalk the varieties were classed as sweet and not sweet. The majority of the varieties studied were of the type classed as not-sweet and they were distributed on the graph from the most resistant to the most

susceptible, several of them falling between 99 per cent and 100 per cent injury (plants killed). The sweet types, ten in number, tended to distribution on the resistant side of the graph, which indicates some correlation between chinch bug resistance and sweetness of stalk. However, more sweet types should be tested before any definite conclusions are made regarding the relationship. A slight relationship was indicated between chinch bug reaction and color of stigma. The varieties were classed as yellow, creamy, and white for the color of stigma character. The yellow class included varieties that were generally more susceptible than the white stigma varieties, which appeared to be rather resistant with two exceptions. One white stigma variety was injured 58 per cent and the other was injured 86 per cent. The creamy class which was intermediate in color between the yellow and the white stigma groups included varieties that ranged from the most resistant to the most susceptible. There were indications that color of stigma might be correlated with chinch bug injury, however, more varieties of the yellow and the white stigma types should be tested in order to determine definitely the correlation.

Height of plant, sweetness of stalk, and color of stigma were the only sorghum characters that indicated any degree of correlation with chinch bug resistance or

susceptibility. All other gross morphological characters that were studied failed to indicate a relationship with chinch bug reaction.

SUMMARY

That phase of biological control of insects which has to do with host resistance has been studied only to a relatively small extent.

Measuring the resistance of a series of varieties in a given number of tests offers a number of problems which are not encountered in time of planting tests or others where a single variety is used. In addition such general problems as soil heterogeneity and climatic variations are to be considered.

There are four methods of obtaining adapted varieties that are resistant or immune to chinch bugs: (1) Testing the chinch bug resistance of varieties suited to the region, (2) testing the regional adaptation of varieties known to be resistant to chinch bugs, (3) selecting resistant strains from adapted varieties, and (4) hybridization.

A summary of the differential resistance to chinch bug injury of 40 varieties and strains of sorghums has been

presented in Table V, and showed that a varietal difference for chinch bug resistance or susceptibility exists.

Profitable yields of sorghums depend to a large extent upon seeding at the proper date. In regions where chinch bugs frequently occur early seeding may escape chinch bug injury and, therefore, produce the largest yield of grain. In regions not frequented by chinch bugs later seedings often produce higher yields.

Studies are in progress regarding the inheritance of chinch bug resistance in sorghums, and the brief data that have been obtained are highly indicative that resistance is inherited. In the crosses studied chinch bug resistance paralleled hybrid vigor in the F_1 plants. A cross failing to show hybrid vigor in the F_1 plants was susceptible. Thus a relationship was evidenced between hybrid vigor and chinch bug resistance.

The cause of resistance or susceptibility is one of the fundamental problems of insect resistance and is one of the most difficult to solve. Bug and puncture counts on Kansas Orange (resistant) and Dwarf Yellow milo (susceptible) plants indicated that chinch bug resistance is due to a natural condition within the plant rather than to a varietal preference of the chinch bugs.

Data have been presented to indicate that resistance or susceptibility to chinch bug injury is not closely related with any of the gross morphological characters of the sorghum plant.

A brief history and a detailed description has been presented for all of the sorghum varieties discussed in this thesis.

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