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Chemical Composition of Sorghum Plants at Various Stages of Growth, and Relation of Composition to Chinch Bug Injury

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More Knowledge About Sorghums.

Chinch bug damage is a major obstacle to full development of the sorghums as a basis for agriculture in areas where corn yields are uncertain. Breeding of varieties to withstand chinch bug attacks would be greatly speeded up if the resistance of parent stock and first-generation hybrids could be determined by a chemical test. Some years ago it seemed this might be possible, so Station chemists began a series of analyses of resistant and non-resistant varieties.

To date, no positive relationship between chemical composition and chinch bug injury has been found. But the analyses have eliminated some theories from consideration and thereby narrowed the search. The data obtained provide the basis for a more intensive search in the future. They also provide hitherto unavailable information on the nutritive value and other chemical characteristics of young sorghum plants. Most previous research dealt only with plants at the heading stage or later. This bulletin therefore was prepared to make the informaton obtained available to other research workers and to those interested in the use of sorghums for feeding and industrial processing.

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TABLES

Chemical Composition of Sorghum Plants at Various Stages of Growth, and Relation of Composition to Chinch Bug Injury

By JAMES E. WEBSTER, JOHN B. SIEGLINGER, and FRANK DAVIES*

The data reported in this bulletin were secured in the course of an effort to determine:

(a) If gross chemical differences between sorghum varieties could be correlated with resistance to chinch bug injury, and

(b) If there were differences that could explain why some varieties recover from such injuries more readily than do others.

At the time this work was begun or shortly thereafter, most of the commoner varieties of sorghum had been classified roughly as to chinch bug resistance. Great differences in resistance had been noted, and it was known that these differences are most pronounced when the plants are small.

A survey of existing literature indicated very little had been published regarding the composition of immature sorghum plants, and in that which had been published varietal comparisons had not been stressed. The data reported in this bulletin were secured to furnish research workers with information regarding the basic chemical changes that occur in young sorghum plants as they grow, and to find if these changes could be correlated with the known differences in chinch bug resistance. Little hope was held that a knowledge of these changes would finally solve the problem, but the data obtained should serve as a basis for future and more intensive researches on the subject.

In preliminary analytical work with Atlas and Milo plants (21), several differences were found which it seemed might be correlated with resistance. These varieties, however, are quite dissimilar in growth characteristics, and many of the observed differences were undoubtedly correlated with differences associated with large- and small-seeded plants (2) and dwarf- and tall-growing varieties, rather than with insect resistance.

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The present study included several varieties of grain sorghums of widely differing growth characteristics. Some varieties used are very resistant to chinch bug injury as determined at the earlier stages of growth. Others are moderately so, and some are quite susceptible.

Also included in this bulletin are some studies of root exudates and of sap viscosities.

REVIEW OF LITERATURE

Plant Protection by Martin (8) and the article on "Resistance of Plants to Insect Attack" by Snelling (17) are useful general references. A review article (18) which appeared while this bulletin was being written discusses in detail the chemical factors associated with insect resistance.

Nearly all of the published work relating to the composition of the sorghum plant, for example the paper by Willaman (22), deals with the plants after the panicles have appeared. Miller (10 and 11), however, made studies of sorghum leaves that covered their moisture content, and in one paper their carbohydrate content at various stages of growth commencing when the plants were about one foot in height. A more recent paper (6) reports results of sugar determinations run every 14 days during growth. In it total sugars are reported to increase up to seed formation, with glucose predominating in young plants and sucrose in the mature plants.

EXPERIMENTAL METHODS

Location of Plantings, Soil, and Cultural Methods

The field plantings were chiefly made on the Perkins Agronomy farm 9 miles south of Stillwater, Oklahoma, except the first year, when the crop was grown on the U. S. Field Station at Lawton, Oklahoma. Some limited plantings were made at Stillwater and results for these plantings are covered in Tables VI, VII and VIII. Some of the latter discussions are based upon samples grown at Stillwater. Greenhouse plantings also were made at Stillwater in a typical composited greenhouse soil.

The Agronomy farm soil is classified as Chickasha very fine sandy loam. The sorghums were grown in a crop rotation of corn, cotton, and grain sorghum. The rows were planted 3½ feet apart and seed was sown very thickly in the rows to provide a large number of plants for samples while the plants were small. Later the plants were thinned to a stand of 8 to 12 inches apart. The soil was cultivated as often as necessary to keep it free from weeds until the plants were too large to be cultivated. Usually the plants were grown in two-row plots, 100 to 200 feet long, and varieties were alternated, first a resistant and then a susceptible variety. No fertilizer or special soil treatments were used.

Growth conditions at Lawton were similar to those on the Agronomy farm.

Varieties of Sorghum

Many strains and selections of the various sorghums exist and for this reason a detailed description of the varieties used is necessary. The same strain has been used throughout for all of the varieties with one exception. Two strains of Dwarf Yellow Milo were in use at the time these tests were run, and as a result both the Finney and Texas Milo were used at one time or another. These are both true Dwarf Yellow Milos and their indiscriminate use should not significantly alter the results. For convenience in writing and tabulating only the commoner names are used in the tables and discussions that follow.

The sorghum varieties used in these tests, and their record numbers were:

Sorgo:	
Atlas	C. I. 899
Kansas Orange	F. C. 9108
Kafir:	
Blackhull	C. I. 71
Reed	C. I. 628
Sharon	C. I. 813
Club	C. I. 901
Kafir (Woodward)	60-50-49-21
Kafir (Woodward)	58-55-46-19
Feterita:	
Feterita	C. I. 182
Feterita and kafir derivatives:	
Chiltex	C. I. 874
Milo:	
Dwarf Yellow, Finney	C. I. 1089
Dwarf Yellow, Texas	T. S. 338
Day	C. I. 959
Milo derivatives:	
Wheatland	C. I. 918
Kansas Orange × Dwarf Yellow Milo (Kansas)	24-136
Club × Day, Lawton	38-65
Other varieties:	
Quadroon	F. C. 16181
Darso	C. I. 615
Pig-Nose Durra	C. I. 696
Corneous Durra	C. I. 695

Collection and Preparation of Samples

Samples for analyses were secured by cutting the stalks just above the surface of the soil. The plants were placed in paper bags and transported to the laboratory where they were measured (height and diameter) and then cut into ½ inch pieces in a hand ensilage chopper. The time required for this stage of the sampling occupied about one hour. Two procedures were followed after this stage: (1) from the beginning through 1938, the samples were stored in a refrigerator and as quickly as possible they were ground through a power meat grinder and samples taken at once for pressing to secure juice or for alcoholic storage; (2) from 1939 on, the chopped samples were mixed with dry ice in sacks and placed in a freezing chamber over night. The frozen samples were thawed the next day as needed and ground through the power grinder as before. This freezing step permitted the samples to be secured in the afternoon and then worked up conveniently the following day.

Some of the samples were cut in the morning at 7:00 a. m., others were cut at 12:30 p. m., and others were cut at 3:30 to 4:30 p. m. The later samplings were taken because sugars have been found to reach their maximum percentage at about this time (21) and sucrose was one of the constituents of particular interest. This time of cutting also permitted a whole day after freezing for working up the samples. The number of plants used varied from a hundred or more when the plants were small to as few as five or six at the last sampling period. These samples were selected from various places in the row to reduce as far as possible any error due to soil heterogeneity. Samples taken when the plants were quite small were often contaminated with sand which could not readily be removed from the stalks without loss of soluble material.

Leaves and stalks were not separated because during the earlier stages of growth the stalk is made up quite largely of the basal portions of the leaves, and even when the plants are quite large the insects apparently secure an appreciable part of their nutrients from the portion of the leaves surrounding the stalk.

After grinding through the power grinder, the samples were thoroughly mixed to secure an homogenous sample and portions immediately weighed out for moisture, nitrogen, and any other determination requiring the whole material, and for preservation in 80 percent alcohol. Where juice analyses were made, the large cage of a Carver hand press was filled with the ground tissue and the juice immediately expressed to the capacity of the press. This juice was then centrifuged in large cups for 10 minutes and determinations run using the supernatant liquid.

For preserving samples in alcohol, duplicate 50 g. aliquots were weighed out and placed in 500 ml. wide mouth Erlenmeyers, covered with 95 percent redistilled alcohol, and boiled for 10 minutes. After cooling, enough alcohol was added to give a final alcohol concentration of 80 to 85 percent by volume. Extraction of the preserved samples was completed in large soxhlets, running until the percolate was clear (16 to 30 hours). After a short extraction, the original alcohol in the soxhlets was replaced with fresh alcohol, thus preventing a prolonged heating of concentrated extracts.

Chemical Methods

Solids: Values for solids were secured by drying the samples over night in an oven held at 105° C. If this did not give a constant weight the samples were again dried for 4 to 6 hours and finally brought to constant weight. No appreciable caramelization occurred with this procedure, therefore drying in a vacuum oven was not deemed necessary.

Ash: Figures given for ash represent the residue left after the solids samples were incinerated at low red heat (600° C.) for at least one hour. All solids and ash determinations were run in platinum dishes.

Mineral Analyses (Cl, K, P, Ca): Determinations of Ca, P, and K were run according to the directions in the *Official and Tentative Methods of Analyses* (1), in the section on plant analyses. Chlorides were run according to the volumetric procedure in this same section, except that samples were not ashed separately; instead, the determinations were run on the ash determination residues.

Titratable Acidity: Titrations were run on 5 ml. samples of the centrifuged juice after diluting to 300 ml. with distilled water. One ml. of phenolphthalein solution was used as an indicator. In the tables, the results are expressed in the number of ml. of N/10 alkali required to titrate 100 ml. of the centrifuged juice.

Hydrogen-ion Concentration: The Youden quinhydrone set-up was used for the earlier pH determinations. Later determinations were run with a Coleman glass electrode set-up.

Astringency: Tannins and related substances were determined using the Loewenthal-Procter method as described in the text by Griffin (4). This is essentially a method for tannins and the results expressed as total astringency and non-tannins are of value only for comparison because they are calculated as tannins. They include any plant substance easily oxidized by $KMnO_4$ solution. The results for non-tannins were secured by subtracting the tannin figures from the total astringency values.

Sugars: Sugars were run by the Shaffer-Hartman procedure as outlined in the laboratory manual by Morrow (13). Samples of the juice were clarified with neutral lead acetate, and the excess lead was removed with solid neutral potassium oxalate. Aliquots of the clear filtrate were then used for the determination of *REDUCING SUGARS,* which were calculated as invert sugars. *TOTAL SUGARS* values were secured by inverting an aliquot of this cleared juice with HCl (1). This was accomplished by allowing the acidified sample to stand over night and then neutralizing it with solid Na_2CO_3. Reducing sugars were run on this neutral solution as before. The values recorded in the tables are the values secured in the actual determinations and were not secured by adding together the reducing and sucrose values, as is often done. *SURCROSE* values were secured by subtracting the reducing sugar percentage from the total sugar percentage and multiplying the result by the factor .95. Sugars were run on alcohol-preserved material as follows: (See sampling methods for preparation of the extract). 100 ml. aliquots of the extract were transferred to 250 ml. evaporating dishes and the alcohol was removed by repeated concentrations of the liquid, care being taken to keep the sample from going to dryness. The concentrated extract was then diluted with water and cleared with lead acetate as previously described. Sugars were then determined as described for the fresh juice.

Nitrogen: All nitrogen determinations were run by the official Kjeldahl method using the Gunning modification (1). All total nitrogen determinations were run on either the mixed ground samples or the centrifuged juice after it had been evaporated to dryness on a steam bath (1 ml. of concentrated H_2SO_4 was added before evaporation was begun). Soluble nitrogen values are given only for the samples preserved in alcohol and they represent that fraction of the nitrogen soluble in 80 percent alcohol. Aliquots of the alcoholic extract were acidified with H_2SO_4 and evaporated to near dryness before beginning the digestion. Where given, the insoluble nitrogen values were secured by subtracting the soluble percentages from the total nitrogen percentages.

Hydrocyanic Acid: The procedure used for determining hydrocyanic acid was essentially that described in the paper by Menaul and Dowell (9).

Enzymes: *CATALASE* was run on 10 ml. of neutralized juice following the procedure outlined by Davis (3). The iodimetric method of Guthrie (5) was used for *OXIDASE* determinations and *PEROXIDASE* determinations were run essentially as outlined in the paper by Miller (12).

EXPERIMENTAL RESULTS, AND DISCUSSION OF INDIVIDUAL CONSTITUENTS

The tables include much of the data secured over a period of years on the gross composition of various sorghum varieties. Attention is called particularly to the time of day at which samples were secured, since earlier publications have shown a marked diurnal fluctuation.

Tables are arranged so the most susceptible varieties come first and the most resistant last, using as a basis the classification given by Snelling *et al.* (15) and the observations of the authors at Stillwater. Many factors may alter this absolute listing, such as age of plants, climate, soil and degree of infestation. It should in no case be considered as a positive listing, but rather as a tool for discussing resistance.

Composition of Juice and Plants

Expressed Juice

Solids: There was a tendency in all varieties for the solids to decrease somewhat from an initial high point when plants are small and then increase as heading time is approached. The low point seems to correspond generally to the place where accelerated growth begins (2). Juice from late plantings runs somewhat higher in solids than does that from earlier plantings (Table I), which may be due to better all-round growth conditions. Juice from plants grown in the greenhouse is lower in solids than juice from outdoor plants of the same approximate height (Table II). There are a few differences that are consistent year after year. Sap from the dwarf varieties, Dwarf Yellow Milo and Wheatland for example, always runs higher than the average, while Atlas and Kansas Orange are consistently lower. Interestingly enough, the Kansas Orange × Dwarf Yellow Milo cross much more resembles the milo in composition than it does Kansas Orange. There is little apparent correlation between chinch bug injury and the solids content of the juices, for the juice from Feterita, a very susceptible variety when the plants are small, is just as low as are Atlas and Kansas Orange.

Ash: The ash percentages usually vary in much the same direction as the solids while the plants are small. Later, the ash percentages decrease or remain stationary while the solids percentages increase. As with the solids, the two sorgo varieties consistently remain low in ash. The comparative ash percentages vary with the type of growth in that there was a marked decrease when the tall varieties began to grow rapidly. This stage is beyond the usual point where chinch bug resistance differences are most pronounced and seems without any special significance. The dwarf varieties or dwarf growth of tall varieties were comparatively higher in ash percentages.

Titratable Acidity: There was little difference between varieties as regards initial and final values for titratable acidity, but there was considerable variation during intermediate stages. Some varieties decreased for a time and then increased; others increased for a time, then decreased, and finally increased again. There was no apparent correlation between this value and chinch bug resistance.

Hydrogen-ion Concentration: The different varieties are probably more nearly alike in pH than in any other respect. Nearly all of the values fall into the range pH 5.00 to 5.30, with most in the narrower range of pH 5.1 to 5.25. An exception was the crop grown in the greenhouse (Table II), where the acidity was considerably less. There was definitely no correlation between pH and chinch bug resistance as shown by the figures in these tables.

Astringency, Tannins and Related Substances: Determinations of tannins and related substances were made chiefly to find if there was any relation between the tannin content and insect resistance. In most varieties there was a steady decrease in amounts of tannins until heading began. This was most pronounced, perhaps, in the susceptible varieties; however, as with many other constituents, the changes occurred only after the period when varying susceptibility is greatest. Total astringency values were quite similar for all varieties and showed a gradual decline as the plants aged. Plants grown in the greenhouse are relatively low in total astringencies and tannins, a characteristic probably associated with a lack of greenness and lush growth. It does not seem that tannins are a major contributing factor in resistance, although at heading time the susceptible varieties are generally much lower in tannins but not in non-tannin astringencies. Whole plants when small contain tannins in about the same amounts, yet they show wide variations in resistance. This is in conformity with widely held views regarding the relation of tannins to disease resistance in plants (14).

Sugars: There was a gradual increase in percentages of sugars as the season progressed, with the increase being greater for surcrose than for reducing sugars. The sorgos are an exception in that up until heading time very little sucrose was ever present. It is interesting to note that the Kansas Orange × Dwarf Yellow Milo seems to have acquired the sugar characteristics of Milo since it always contained sucrose in appreciable amounts. In an earlier bulletin (21) it was noted that one of the greatest apparent differences between Milo and Atlas was in the amount of sucrose present, particularly in the late afternoon. The hope that this might prove of value in classifying plants in relation to resistance has not been fulfilled, as can be seen by reference to the tables. All of the varieties except the sorgos contained large amounts of sucrose at all stages of growth including, as noted, the highly resistant Kansas Orange cross. It is to be noted that statements regarding the differences in sweetness of mature varieties are not valid when applied to younger plants in that there is very little over-all difference in the percentages of sugar in the juices from the different varieties before heading.

While the plants are developing before heading there is a steady increase in the proportion of total solids that is sugars. When the plants are first analyzed, sugars make up about 35 percent of the solids, while at heading time often 60 to 65 percent of the solids are sugars.

Nitrogen: As with many other constitutents, the sorgo family is different from the other sorghums in nitrogen. There was usually a decrease in nitrogen percentages in sorgos as the plants neared the heading stage. A part of this was undoubtedly due to the rapid growth of these varieties, but a part was probably due to varietal differnces. It would seem that there is only a limited amount of nitrogen available to the plants, and if rapid growth takes place (sorgos) the percentages decrease, while if the increase in size is slow (dwarf varieties) the nitrogen percentages increase. On the basis of amounts present it would seem that the total nitrogen content of the juice is not a factor in chinch bug resistance. Perhaps, as indicated in a previous paper, the distribution between forms (19) may be a factor.

Chlorides: Analyses for chlorides were made in only one year, and they do not seem significant in relation to chinch bug resistance.

Enzymes: The analyses for enzymes as given in Tables I and II are not very extensive and they fail to show any significant difference unless it is the catalase values recorded in Table

II. These analyses are of greenhouse plants, and unpublished data on field samples as well as the data in Table I fail to show these differences.

WHOLE PLANTS

Solids: With the exception of the first sampling when the percentages of solids are uniformly high because of entrapped sand, the percentages remained generally the same or increased somewhat as growth continued. Most of the varieties contained about the same percentages while the plants were small. Tall-growing plants increased less in percentage of solids than did the dwarf forms.

Ash: Percentages of ash fluctuated more than the solids percentages, and the values for the first sampling are highly erroneous because of the sand present. Relatively, the ash percentages remained about the same as the plants grew, most tall-growing forms remaining somewhat lower in percentages. Previous work had shown some differences in the chloride content of varieties and the analysis was repeated on the larger number of varieties. As with most of the other analyses, no correlation could be found with chinch bug resistance. The chlorides percentages rise for a time and then decrease as heading time is approached.

Sugars: Reducing sugars percentages uniformly increase as the plants matured, with all varieties starting at about the same general level. Most of the varieties at the first sampling time contained about the same percentage of sucrose as of reducing sugars, but Atlas and Kansas Orange varieties are notable exceptions. Sucrose percentages generally increased faster than did the reducing sugars and rapidly exceeded the amounts of reducing sugars present in nearly all varieties except Atlas, which again is a notable exception. There is little evidence of any correlation between chinch bug resistance and either the total amounts of sugars present or classes or sugars.

Nitrogen: It is generally recognized that increased supplies of nitrogen to plants often increase their susceptibility to insect injury. For this reason the nitrogen content of the plants was examined at considerable length (19). However, the data in this publication fail to show any positive correlation of the nitrogen content, either total or soluble, with the known chinch bug resistance of the plants. The percentages decrease irregularly in most varieties; some few, however, show increases. All that can be said about the soluble nitrogen percentages is that they vary in no predictable manner.

Hydrocyanic Acid: Another factor that has been mentioned as having a possible relation to chinch bug resistance is the presence of cyanogenetic glucosides. The data in Tables I and II indicate about the same relative amounts of HCN in the plants irrespective of their chinch bug resistance. Certainly, no variety was lacking in HCN nor did any one variety show excessive amounts.

Mineral Analysis: The data in Table VIII show the more important mineral elements found in sorghums. None of the comparisons appears to have significant relation to chinch bug damage.

Composition of Genetically Related Species

An earlier, preliminary discussion of the results indicated that there was little hope of finding consistent variations in chemical composition when such widely dissimilar varieties were compared. Therefore, two varieties of sorghum each having two strains of differing chinch bug resistance were selected for further testing. These four strains were grown for two years at Stillwater and results secured one year are given in Tables VI and VII. Results for the other year are quite comparable and so are not included in the tables. Generally, the results failed to show any differences that could be correlated with varying resistances; in fact, they are characterized more by their close agreement than by disagreement. Tannin analyses were repeated on these strains, but the differences were negligible.

Other Chemical Tests in Relation to Resistance

Root Exudates

The fact that sorghums severely infested with chinch bugs bleed freely and are always gummy and sticky raised a question concerning the amount of sap supplied by the roots to these plants as compared to resistant plants. Further interest in this question was stimulated by the suggestion of Snelling *et al.* (16), that injury may be due to the "exudation of plant fluids from punctures left open after the feeding of the insects, with possible attendant interference with root pressure and translocation." Therefore, root exudates were collected over a period of two years from several varieties of sorghums, using the technique described in the bulletin by Lowry *et al.* (7). Detailed figures are not presented for these data because of the great individual variations and irregular time of sampling. The amounts of exudate increased with the age of the plants, but in no regular way. When the plants were 6 to 10 inches high, from 2 to 12 ml. were usually collected in a 24-hour period. As much as 200 ml. was collected from older plants. The data are very erratic. A certain variety might yield 40 ml. of juice one day and only a few milliliters a few days later. Certain varieties consistently yielded only small volumes, others yielded larger volumes, and nowhere can there be found any corelation with resistance. For example, both Atlas and Feterita regularly yielded small volumes of exudate although one is very susceptible, the other very resistant.

In addition to measuring the volume of exudate, some analyses were made for chlorides, phosphates and solids (by the refractometer). No qualitative differences were found. The amount of solids in the exudate gradually increased from around 1.2 percent when the plants were 6 to 8 inches tall to about 1.55 percent when heading had begun.

Viscosity of Expressed Juice

Some questions had been raised concerning the ease with which sap flowed from the various varieties when they were punctured by chinch bugs, and also as to whether or not some saps from some varieties might congeal more readily than saps from other varieties. To answer these questions, juice was expressed from six of the varieties and the viscosity determined with a Stormer viscosimeter. The data secured from these studies fail to show any correlations with resistance. The viscosity of all juice changed on standing, but the changes were similar for all varieties and no positive relationships to resistance could be obtained.

SUMMARY AND CONCLUSIONS

Many differences between individual varieties have been found and recorded, but none of these has proved to be correlated with chinch bug resistance when a large number of varieties is compared.

It has been demonstrated that some of the existing theories do not adequately explain the known differences in resistance. The amounts of tannins and hydrocyanic acid present apparently are not important factors in resistance, nor are the amounts of sugars or of total acidity. It also seems very doubtful if the relation between reducing sugars and sucrose has any significance. Bleeding does not seem to be an important factor in resistance, because several of the more susceptible varieties furnish much larger amounts of exudate than do the chinch bug resistant varieties.

The results reported here thus have eliminated from consideration some factors that might have explained differential chinch bug resistance, but they give little indication of any factor with a positive correlation for resistance. It is possible that a variety of factors may be concerned. However, it is perhaps not too much to hope that further work may reveal some one factor that can be positively correlated with resistance.

The more important results secured from this study can be briefly summarized as follows:

1. Chemical analysis for solids, ash, certain mineral elements, sugars, nitrogen, tannins, hydrocyanic acid and certain enzymes were made of several sorghum varieties over a period of years.

2. These analyses give a continuous picture of the changes that occur in sorghum plants and expressed juice of the plants from the time they begin to grow until heading begins.

3. No over-all chemical differences were found that can be correlated with chinch bug resistance when a number of varieties is considered. Differences can be found between selected resistant and susceptible varieties, but these always disappear when a greater number of varieties is compared.

4. Tannins and hydrocyanic acid contents showed no correlation with chinch bug resistance.

5. The classification of sorghum plants as saccharine or non-saccharine at time of maturity fails to extend to the young plants; there was little over-all difference in the total sugar content of immature plants up until heading began. In fact, some of those classed as sweet sorghums were lowest in sugar when immature.

6. A chemical study of two varieties each having a resistant and a moderately susceptible strain failed to show any material differences.

7. A study of root exudates failed to show differences in flow that could account for serious injury to plants even when some losses occur from bleeding.

LITERATURE CITED

(1) Association of Official Agricultural Chemists. Official and Tentative 1935 Methods of Analyses. 4th Ed. 710 pp.

(2) Bartel, A. T. and J. H. Martin
1938 The Growth Curve of Sorghum. J. Agri. Res. 57:843-849.

(3) Davis, Wilmer E.
1926. The Use of Catalase as a Means of Determining the Viability of Seeds. Boyce Thompson Inst. for Plant Res. Prof. Paper No. 2:6-12.

(4) Griffin, Rodger Castle
1927 Technical Methods of Anaylsis. McGraw-Hill Co., N. Y. 2nd Ed. 936 pp.

(5) Guthrie, J. D.
1930 An Iodimetric Method of Determining Oxidase Activity. J. Am. Chem. Soc. 52:3614-3618.

(6) Herman, George
1942 Origin of Sugars in the Stalks of **Sorghum saccharatum.** Pers. Bull. sect. sci. acad. roumaine. 24:455-9 (from Chemical Abstracts.)

(7) Lowry, M. W., W. C. Huggins and L. A. Forrest
1936 The Effect of Soil Treatment on the Mineral Composition of Exuded Maize Sap at Different Stages of Development. Georgia Expt. Sta. Bull. 193. 28 pp.

(8) Martin, Hubert
1940 The Scientific Principles of Plant Protection. Edward Arnold and Co. London. 3rd Ed. 385 pp.

(9) Menual, Paul and C. T. Dowell
1920 Cyanogenesis in Sudan Grass: A Modification of the Francis-Connell Method of Determining Hydrocyanic Acid. J. Agri. Res. 18:447-450.

(10) Miller, E. C.
1917 Daily variation of Water and Dry Matter in the Leaves of Corn and the Sorghums. J. Agri. Res. 10:11-46.

(11) ______________________
1924 Daily Variation of the Carbohydrates in the Leaves of Corn and the Sorghums. J. Agri. Res. 27:785-808.

(12) Miller, Lawrence P.
1933 Effect of Sulfur Compounds in Breaking the Dormancy of Potato Tubers and in Inducing Changes in the Enzyme Activities of the Treated Tubers. Cont. Boyce Thompson Inst. 5:29-81.

(13) Morrow, Clarence Austin
1927 Biochemical Laboratory Methods for Students of the Biological Sciences. John Wiley and Sons. N. Y. 350 pp.

(14) Offord, H. R.
1940 The Function of Tannin in Host-parasite Relationships with Special Reference to Ripes and Cronartium Ribicola. U. S. D. A. Bureau of Entom. and Plant Quarantine. Bull. E-518. 27 pp.

(15) Snelling, R. O. and R. G. Dahms
1940 Resistant Varieties of Sorghums and Corn in Relation to Chinch Bug Control in Oklahoma. Okla. Agri. Exp. Sta. Bull. 232. 22 pp.

(16) ____________, Reginald H. Painter, John H. Parker and W. M. Osborn.
1937 Resistance of Sorghums to the Chinch Bug. U. S. D. A. Tech. Bull. 585. 56 pp.

(17) ____________________
1947 Resistance of Plants to Insect Attack. Bot. Rev. 7:543-586.

(18) Trager, William
1947 Insect Nutrition. Biol. Rev. 22:148-177.

(19) Webster, James E. and Howard Mitchell
1940 Determiation of the Nitrogen Fractions in Atlas and Milo Sorghum Plants. Plant Physiol. 15:749-753.

(20) ____________________ and Robert Wall
1942 Electrical Conductivities of Sorghum Juices in Relation to Chinch Bug Injury. Proc. Okla. Acad. Sci. 22:35-37.

(21) ____________________ and V. G. Heller
1942 The Chemical Composition of Atlas and Dwarf Yellow Milo Plants in Relation to Chinch Bug Injury. Okla. Agri. Exp. Sta. Tech. Bull. No. T-12. 29 pp.

(22) Willaman, J. J., R. M. West, D. O. Spriestersbach and G. E. Holm
1919 Notes on the Composition of the Sorghum Plant. J. Agri. Res. 18:1-31.

*TABLE I.—Composition of Expressed Juice From Whole Sorghum Plants at Different Stages of Growth; Lawton, 1936.**

Date	Av. Ht.	Solids	Ash	Astringency: Total	Astringency: Non-Tannin	Astringency: Tannin	Sugars: Red.	Sugars: Total	Sugars: Sucrose	Enzymes: Catalase	Enzymes: Peroxidase	Enzymes: Oxidase	HCN**	N**
	in.	%	%	g/l	g/l	g/l	%	%	%				%	%
Dwarf Yellow Milo														
June 1†	4-6	4.53	1.33	4.999	2.409	2.590	0.85	0.87	.02	1.2	22.0	21.4		.208
July 15	6	5.63	1.41	2.910	2.126	.784	1.26	1.43	.16	1.2	19.7		.0084	.219
Honey														
June 1	7	4.33	1.10	5.161	2.825	2.336	1.02	1.02	.00	2.1	17.9	17.0	.0091	.205
July 15	8	5.91	1.50	3.388	2.723	.565	1.62	1.80	.17	1.2	22.0		.0087	.203
Feterita														
June 3	9	4.49	1.24	4.136	2.735	1.401	.97	.97	.00	2.0	30.9	18.1	.0074	.183
July 15	5	6.28	1.49	3.554	3.030	.524	1.51	1.86	.33	1.1			.0070	.230
Sharon Kafir														
June 1	8	4.16	1.40	3.831	2.789	1.042	.73	.83	.00		37.6	21.6	.0013	.201
July 15	8	5.93	1.46	3.845	2.598	.247	1.53	1.53	.00	1.5			.0108	.235
Blackhull Kafir														
June 1	8	4.38	1.11	4.926	2.700	2.229	.73	.73	.00	2.4	31.3	21.3	.0074	.209
July 15	4	8.25	1.74	5.583	4.213	1.370	2.69	2.69	.00				.0099	.274
Kansas Orange														
June 2	11	3.83	1.04	3.849	2.735	1.114	.94	.94	.00	1.2	22.3	29.3	.0010	.192
July 15	8	5.05	1.67	3.596	3.060	.536	1.70	1.70	.00	1.0				.230
Atlas														
June 2	5	4.38	1.29	4.818	2.609	2.209	.96	.96	.00	1.2	21.1	22.5	.0055	.208
July 15	4	7.53	1.53	5.009	3.824	1.185	2.22	2.43	.20				.0092	.275
Kansas Orange × Dwarf Yellow Milo														
June 2	7	4.48	1.11	4.296	2.663	1.633	.97	.97	.00	1.0	19.7	18.8	.0021	.197
July 15	5	5.65	1.46	3.868	2.841	1.027	1.60	1.60	.00	1.5			.0096	.225

* Sampled at 6:00 a. m.
** Percentage of whole plants.
† Early and late plantings of the same variety.

*TABLE II.—Composition of Expressed Juice From Plants Grown in The Greenhouse.**

Name			Acidity		Astringency			Sugars			Enzymes				
	Solids	Ash	Tit.**	pH	Total	Non-Tannin	Tannin	Red.	Total	Sucrose	Catalase	Peroxidase	Oxidase	HCN†	N†
	%	%			g/l	g/l	g/l	%	%	%				%	%
A. Grown 9/20 to 12/15, 1935															
Dwarf Yellow Milo	7.97	.88	58.4	5.61	1.359	.761	.598	1.93	5.54	3.43	1.2		4.0	.0028	.272
Honey	5.65	.84	31.4	5.56	1.083	.599	.484	3.15	3.62	.45	1.6		4.75	.0043	.152
Kansas Orange	8.77	.85	50.4	5.38	1.544	.923	.621	2.48	6.47	3.79	.9		4.45	.0032	.223
Atlas	5.93	1.09	43.6	5.65	1.476	.900	.576	2.85	3.22	.35	.9		6.25	.0025	.185
B. Harvested 5/8/36 Plants around 2 feet tall															
Dwarf Yellow Milo	3.18	1.09	26.6	5.31	1.303	.819	.484	.44	.44	.00	3.93	20.4	3.1	.0012	.102
Honey	3.10	1.04	28.7	5.31	1.420	1.160	.260	.58	.58	.00	14.90	15.6	3.0	.0000	.107
Atlas	2.37	.98	23.6	5.33	.878	.657	.216	.22	.22	.00	33.60	20.4	3.6	.0000	.094
Kansas Orange	2.44	.96	22.5	5.36	.900	.711	.189	.38	.38	.00	32.25			.0000	.116
Kansas Orange × Dwarf Yellow Milo	2.72	.98	25.6	5.26	1.070	.890	.180	.34	.34	.00	15.35	19.2		.0006	.097

* Sampled at 1:00 p. m.
** Ml. N/10 alkali per 100 ml. juice.
† Percentage of whole plants.

*TABLE III.—Composition of Expressed Juice and Whole Plants at Different Stages of Growth; Perkins, 1938.**

Age	Juice												Whole Plants			
				Acidity		Astringency			Sugars							
	Av. Ht.	Solids	Ash	Tit **	pH	Total	Non-Tannin	Tan-nin	Red.	Total	Sucrose	N	Chlor-ides	Solids	Ash	Nitro-gen
days	in.	%	%			g/l	g/l	g/l	%	%	%	%	%	%	%	%
Dwarf Yellow Milo																
41	8	5.76	1.35	62.4	5.10	3.183	2.423	.760	1.64	1.97	.31	.174	.013	17.14	2.56†	.441
55	18	4.87	1.03	50.4	5.18	1.704	1.211	.493	1.37	1.78	.39	.186	.014	14.98	2.37	.419
67	23	6.36	1.35	51.4	5.22	1.507	1.115	.392	1.60	3.08	1.41	.202	.022	16.27	1.49	.503
76	39††	8.78	1.41	59.8	5.20	1.465	1.382	.080	2.14	5.32	3.03	.181	.016	20.54	1.56	.610
Feterita																
45	9	6.00	1.25	70.0	5.10	3.429	2.751	.678	2.04	2.13	.07	.160	.004	17.40	1.74	.573
56	12	4.92	1.08	48.2	5.14	2.014	1.350	.664	1.30	1.81	.48	.191	.018	15.53	2.35†	.435
68	24	5.45	.94	46.0	5.14	1.465	1.115	.354	1.98	2.75	.73	.178	.027	15.04	1.30	.492
87	40††	7.16	.86	52.2	5.25	1.450	1.321	.029	2.22	4.44	2.11	.154	.037	18.09	1.31	.440
Honey																
45	10	5.03	1.38	62.4	5.10	2.957	2.320	.637	1.63	1.63	.00	.139	.014	15.30	1.83	.462
56	22	5.03	1.26	47.0	5.22	1.661	1.059	.602	1.63	1.83	.19	.192	.016	14.51	2.06†	.401
68	35	5.35	1.19	43.8	5.19	1.238	1.032	.206	2.05	2.50	.43	.141	.018	12.96	1.35	.412
77	55††	7.36	1.27	48.0	5.28	1.424	1.362	.062	3.35	4.57	.16	.120	.023	16.70	1.22	.280
Wheatland																
42	9	5.22	1.42	62.4	5.22	3.019	2.423	.596	1.34	1.42	.08	.178	.017	15.70	2.20†	.490
55	17	4.84	1.20	48.2	5.14	1.807	1.294	.513	1.17	1.46	.27	.185	.014	15.66	3.12†	.454
67	22	6.20	1.42	53.6	5.26	1.527	1.053	.474	1.30	2.50	1.14	.260	.026	16.23	1.73	.609
76	23††	8.29	1.53	73.0	5.15	1.465	1.465	.475	2.12	4.39	2.16	.260	.026	20.09	1.73	.610

TABLE III, Continued.

Age				Juice									Whole Plants			
				Acidity		Astringency			Sugars							
	Av. Ht.	Solids	Ash	Tit.**	pH	Total	Non-Tannin	Tannin	Red.	Total	Sucrose	N	Chlorides	Solids	Ash	Nitrogen
days	in.	%	%			g/l	g/l	g/l	%	%	%	%	%	%	%	%
						Blackhull Kafir										
45	12	5.02	1.44	60.2	5.20	2.752	1.951	.801	1.45	1.45	.00	.170	.012	15.95	1.80	.518
56	21	4.58	1.23	44.8	5.21	1.557	1.225	.332	1.14	1.38	.23	.196	.019	14.67	2.35†	.425
68	32	5.26	1.22	48.7	5.20	1.321	1.032	.289	1.34	2.07	.69	.181	.021	14.89	1.47	.492
77	38	6.65	1.46	60.0	5.28	1.631	1.403	.228	2.27	4.13	1.77	.179	.085	17.63	1.74	.407
						Atlas										
55	20	4.15	.94	44.8	5.13	1.519	1.088	.431	1.61	1.62	.01	.141	.007	13.04	1.78	.344
67	33	5.08	1.13	42.6	5.20	1.754	.949	.805	2.52	2.61	.09	.145	.013	13.34	1.21	.432
76	50	7.19	1.04	48.0	5.15	1.445	1.176	.269	4.28	4.38	.10	.120	.012	16.23	1.14	.398
						Kansas Orange										
42	8	5.21	1.25	58.0	5.14	3.655	2.711	.944	1.77	1.77	.00	.168	.017	17.20	2.21†	.470
56	20	4.76	1.08	46.0	5.20	1.495	1.184	.311	2.07	2.07	.00	.185	.018	12.68	1.77	.330
68	37	5.08	.94	38.2	5.15	1.094	.888	.206	2.78	2.78	.00	.111	.020	12.13	1.10	.369
78	61††	7.16	.86	57.0	5.25	1.094	.826	.268	4.88	5.50	.59	.088	.020	15.27	.96	.289
						Kansas Orange × Dwarf Yellow Milo										
41	8	5.54	1.38	61.2	5.10	3.697	2.834	.863	1.52	1.85	.31	.156	.018	16.66	2.34†	.452
55	21	4.69	1.16	49.2	5.10	1.643	1.273	.370	1.43	1.73	.28	.155	.021	14.18	2.33	.386
67	40	5.45	1.16	48.2	5.12	1.073	.949	.124	1.88	2.79	.86	.118	.017	14.50	1.31	.399
76	60††	8.59	1.40	60.0	5.10	1.548	1.321	.227	2.27	5.24	2.82	.142	.025	20.19	1.46	.407

* Sampled at 12:30 p. m.

** Ml. N/10 NaOH per 100 ml. juice

† Ash percentage is high because of sand contamination.

†† Plants heading; heads not included in sample.

*TABLE IV.—Composition of Whole Sorghum Plants at Different Stages of Growth; Perkins, 1940**

					Sugars			Nitrogen		
Age	Av. Ht.	Diam.	Solids†	Ash†	Red.	Total	Sucrose	Total	Sol.	Chlorides
days	in.	in.	%	%	%	%	%	%	%	%
Finney Milo (Dwarf)										
34	6	⅜	19.21	7.68	.55	1.09	.51	.468	.109	.016
43	11	½	18.10	2.08	.94	2.43	1.42	.521	.085	.021
50	14	¾	24.23	6.70	.91	3.06	2.15	.748	.243	.023
62	16	1	19.53	3.08	1.10	2.75	1.52	.557	.168	.017
70	20		18.87	1.76	1.23	3.16	1.83	.503	.147	.021
Day Milo										
34	5½	5/16	20.97	9.24	.47	1.04	.54	.481	.110	.015
43	10	½	16.38	2.16	.72	2.07	1.28	.495	.082	.025
50	15	⅝	18.81	3.64	.89	2.53	1.56	.577	.145	.033
62	18	¾	18.83	2.22	.74	1.99	1.19	.513	.137	.011
Feterita										
34	5	5/16	22.16	9.27	.69	1.42	.69	.501	.104	.008
43	8	½	18.08	1.83	.94	2.90	1.86	.471	.084	.018
50	18	¾	18.01	2.07	.91	2.87	1.86	.496	.119	.028
62	25	1	17.20	1.30	1.18	2.56	1.31	.346	.077	.007
70	30	1	19.93	1.15	1.55	4.03	2.36	.316	.067	.015
Chiltex										
34	6	5/16	23.67	11.61	.61	1.33	.68	.520	.102	.018
43	13	½	15.90	1.93	.70	2.02	1.25	.529	.088	.026
50	20	¾	16.85	2.86	.73	2.27	1.46	.557	.142	.036
62	30	1⅛	15.57	1.72	.93	2.36	1.36	.429	.097	.011
70	34	1⅛	20.16	1.59	1.36	3.60	2.13	.468	.131	.021

TABLE IV, Continued.

Age	Av. Ht.	Diam.	Solids†	Ash†	Sugars Red.	Sugars Total	Sugars Sucrose	Nitrogen Total	Nitrogen Sol.	Chlorides
days	in.	in.	%	%	%	%	%	%	%	%
					Quadroon					
34	6	⅜	19.96	8.61	.63	1.36	.69	.484	.145	.013
43	13	9/16	15.33	1.80	.77	2.09	1.39	.448	.079	.022
50	18	¾	17.36	2.35	.93	2.60	1.59	.506	.131	.034
62	27	⅞+	19.12	1.85	1.12	3.00	1.78	.410	.099	.024
70	32	⅞+	20.68	1.78	1.29	3.06	1.68	.421	.124	.030
					Wheatland					
34	6	⅜	19.38	8.25	.39	1.07	.65	.461	.108	.017
43	13	7/16	16.69	2.08	.68	2.17	1.42	.477	.073	.021
50	19	¾	18.65	2.37	.83	2.90	1.97	.575	.129	.024
62	25	1	17.76	1.90	.93	2.80	1.02	.426	.100	.009
70	25	1	22.12	2.06	1.05	3.34	2.18	.393	.097	.016
					Reed Kafir					
34	6	¼	24.10	12.69	.52	1.24	.68	.476	.114	.016
43	17	½—	14.63	1.65	.59	2.01	1.42	.411	.062	.021
50	21	¾	15.17	2.19	.69	2.17	1.41	.443	.083	.026
62	32	1	17.64	1.53	1.06	2.33	1.21	.340	.062	.016
70	43	1	18.25	1.48	1.45	3.34	1.79	.304	.065	.014
					Blackhull Kafir					
34	6	⅜	23.20	11.34	.46	1.25	.75	.521	.076	.014
43	13	½	18.34	1.86	.59	1.72	1.07	.447	.088	.021
50	23	⅞	14.83	2.01	.69	1.97	1.22	.477	.094	.028
62	32	1+	15.88	1.76	----	----	---	.376	.079	.017
70	38	1¼	20.53	1.66	1.28	3.06	1.69	.378	.077	.028
					Darso					
34	5	⅜	22.18	9.11	.75	1.32	.55	.567	.114	.014
43	12	⅝	17.42	1.68	.78	2.04	1.20	.437	.091	.020
50	17	⅝	17.53	2.09	.87	2.30	1.36	.466	.103	.021
62	28	1⅛	17.31	1.84	.90	2.77	1.78	.454	.090	.016
70	33	1¼	20.36	1.64	1.15	4.14	2.84	.382	.070	.025

TABLE IV, Continued.

Age	Av. Ht.	Diam.	Solids†	Ash†	Sugars Red.	Sugars Total	Sugars Sucrose	Nitrogen Total	Nitrogen Sol.	Chlorides
days	in.	in.	%	%	%	%	%	%	%	%
Club × Day Milo										
34	5	5/16	20.31	8.44	.56	1.29	.69	.517	.127	.010
43	10	½—	15.64	1.96	.70	2.02	1.25	.494	.090	.017
50	15	⅝	17.83	3.67	1.00	2.47	1.40	.584	.148	.036
62	26	⅞	14.70	1.66	.90	2.08	1.12	.414	.098	.038
70	33	1—	26.04	1.73	1.11	2.60	1.42	.409	.124	.020
Club Kafir										
34	5	⅜	19.33	7.82	.49	1.09	.57	.490	.100	.006
43	13	⅝	14.21	1.75	.71	1.87	1.10	.455	.094	.021
50	17	⅞	14.95	2.33	.75	2.07	1.25	.456	.097	.035
62	30	1⅛	17.28	1.63	.95	2.10	1.15	.346	.074	.022
70	39	1⅛	18.79	1.20	1.31	2.83	1.52	.367	.065	.019
Kansas Orange										
34	5	⅜	18.25	6.64	.90	1.29	.37	.467	.104	.007
43	14	½	13.44	1.80	1.53	2.17	.61	.363	.062	.018
50	21*	¾	16.28	2.15	1.90	2.83	.88	.417	.082	.024
62	39	⅞	13.55	1.30	1.98	2.60	.60	.288	.055	.014
70	59	1	16.22	1.20	1.54	3.78	2.12	.255	.042	.016
Atlas										
34	5	5/16	20.66	9.27	.87	1.09	.21	.478	.092	.014
43	11	½	14.76	1.69	1.51	1.84	.31	.429	.063	.020
50	19	1 1/16	15.20	2.31	1.41	2.23	.78	.428	.077	.026
62	29	¾	13.37	1.56	1.48	1.90	.40	.312	.058	.012
70	49	1 1/8	15.60	2.35	2.35	2.90	.52	.298	.055	.014
Kansas Orange × Dwarf Yellow Milo										
34	5	¼	22.24	10.10	.63	1.34	.67	.483	.101	.017
43	13	½	14.57	1.85	.89	2.24	1.28	.393	.059	.019
50	19	¾	14.90	2.11	1.09	2.56	1.40	.412	.092	.020
62	35	⅞	13.72	1.54	1.30	2.36	1.01	.291	.058	.014
70	52	1+	18.06	1.46	1.78	3.67	1.79	.402	.071	.016

* Sampled at 3:30 p. m.

† Samples taken at age 34 days are high in solids and ash because of sand contamination.

TABLE V.—*Composition of Expressed Juice and Whole Plants at Different Stages of Growth; Perkins, 1941.**

		Juice							Whole Plants		
Age	Av. Ht.	Solids	Ash	Acidity	Sugars			T. N.	Solids	Ash	Nitrogen
					Red.	Total	Sucrose				
days	in.	%	%	ml.**	%	%	%	%	%	%	%
					Finney Milo						
31	6	6.09	2.00	44.85	1.25	2.08	.79	.223	16.18	2.14	.449
42	13	6.68	1.54	52.83	1.16	2.78	1.54	.215	16.42	1.68	.484
48	14	5.77	1.24	49.15	1.38	2.44	1.01	.211	15.54	2.17	.472
55	23	6.08	1.37	24.17	1.24	2.58	1.27	.206	15.94	1.79	.423
63	23	7.58	1.37	57.34	1.39	3.90	2.38	.177	17.77	2.16	.455
					Day Milo						
31	7	5.87	1.48	51.81	1.16	1.82	.63	.212	17.03	2.47	.473
41	11	5.80	1.44	48.13	1.16	2.03	.87	.217	15.36	1.63	.460
48	11	5.86	1.52	49.15	1.32	2.42	1.04	.191	15.78	2.57	.467
55	21	6.26	1.44	47.10	1.18	2.78	1.52	.245	16.80	1.83	.491
63	22	7.40	1.42	53.25	1.48	3.80	2.20	.163	18.00	2.19	.480
					Feterita						
31	5	5.89	1.21	54.27	.84	2.11	1.21	.179	18.50	2.16	.523
41	8	5.76	1.08	43.00	1.36	2.44	1.03	.175	17.46	1.40	.476
48	12	5.71	1.09	49.15	1.48	2.72	1.18	.156	19.66	2.43	.421
55	15	7.00	1.22	51.20	1.59	3.58	1.89	.199	18.87	1.75	.448
					Chiltex						
31	7	6.02	1.44	50.18	1.03	2.00	.92	.226	18.07	2.73	.525
41	10	5.78	1.29	54.27	1.14	2.11	.92	.222	15.48	1.66	.510
48	17	5.86	1.52	57.34	1.61	2.86	1.19	.221	15.35	1.90	.454
55	24	6.21	1.31	49.15	1.20	2.78	1.50	.219	15.50	1.61	.455
63	27	6.71	1.26	47.10	1.57	3.48	1.81	.187	17.62	1.52	.455

TABLE V, Continued.

Age	Av. Ht.	Juice						T. N.	Whole Plants		
		Solids	Ash	Acidity	Sugars				Solids	Ash	Nitrogen
					Red.	Total	Sucrose				
days	in.	%	%	ml.**	%	%	%	%	%	%	%
					Quadroon						
31	7	5.77	1.57	51.20	1.14	1.70	.53	.207	16.32	2.10	.439
41	12	5.69	1.38	54.27	1.12	2.04	.87	.184	15.84	1.59	.442
48	13	6.58	1.67	61.44	1.29	2.60	1.24	.162	16.14	2.33	.552
55	21	6.38	1.48	53.25	1.18	2.70	1.44	.207	16.35	1.80	.420
63	30	7.36	1.54	59.39	1.70	3.91	2.10	.178	19.76	2.02	.413
					Wheatland						
31	7	7.10	1.80	50.18	.88	2.12	1.18	.203	16.51	2.13	.503
41	12	6.39	1.48	57.96	1.05	2.03	.93	.227	15.94	1.79	.502
48	14	5.72	1.40	49.15	.94	2.26	1.25	.167	15.60	2.21	.443
55	20	6.74	1.49	53.25	1.12	2.80	1.60	.270	15.48	2.02	.477
63	22	7.39	1.48	57.34	1.42	3.64	2.11	.180	18.77	2.16	.490
					Reed Kafir						
31	9	5.62	1.51	41.57	1.05	1.75	.66	.224	17.33	2.39	.497
41	15	5.35	1.27	45.06	1.05	1.92	.82	.202	14.80	1.50	.467
48	22	5.28	1.27	41.98	1.02	2.11	1.04	.183	13.83	1.69	.412
55	28	5.73	1.37	38.91	1.01	2.15	1.08	.181	14.03	1.64	.400
63	31	6.42	1.31	47.10	1.57	3.48	1.81	.163	16.61	1.57	.368
					Blackhull						
31	8	5.96	1.44	50.18	1.18	1.74	.53	.232	16.40	2.13	.503
41	12	5.74	1.57	50.79	.82	1.79	.92	.201	15.44	1.62	.515
55	27	5.63	1.39	43.00	1.05	2.22	1.11	.222	13.86	1.65	.398
63	30	6.81	1.39	53.25	1.73	3.90	2.06	.163	16.76	2.24	.332
					Darso						
31	7	6.72	1.45	52.84	1.26	2.16	.85	.248	17.98	2.34	.528
41	12	5.55	1.30	45.06	1.30	2.15	.81	.190	16.33	1.60	.500
48	15	5.38	1.17	49.15	1.28	2.29	.96	.168	15.54	2.17	.457
55	23	5.93	1.31	44.03	1.17	2.60	1.36	.203	15.45	1.77	.427
63	29	7.37	1.23	51.20	1.71	4.35	2.51	.154	17.20	1.48	.368

TABLE V, Continued.

Age	Av. Ht.	Juice Ash	Juice Solids	Juice Acidity	Juice Sugars Red.	Juice Sugars Total	Juice Sugars Sucrose	T. N.	Whole Plants Solids	Whole Plants Ash	Whole Plants Nitrogen
days	in.	%	%	ml.**	%	%	%	%	%	%	%
				Club × Day							
31	8	9.32	1.23	46.28	.96	1.65	.66	.203	15.32	2.02	.453
41	14	5.57	1.38	50.80	1.01	2.01	.95	.207	14.99	1.55	.451
48	19	6.70	1.51	57.34	1.79	3.23	1.38	.151	15.76	1.73	.354
55	27	6.18	1.39	47.10	1.26	2.89	1.55	.240	23.80	1.60	.409
63	29	6.70	1.31	51.20	1.69	3.58	1.79	.155	17.18	1.60	.375
				Club							
31	9	5.81	1.42	45.88	.90	1.75	.80	.216	16.80	2.31	.482
41	12	5.85	1.51	51.81	1.08	2.02	.89	.217	15.29	1.58	.482
48	14	5.28	1.35	47.10	1.18	2.13	.90	.181	13.94	1.94	.411
55	23	5.72	1.32	45.06	1.28	2.48	1.14	.184	14.25	1.72	.379
63	32	6.14	1.10	45.06	1.83	3.58	1.61	.144	15.26	1.43	.302
				Kansas Orange							
31	7	8.19	1.96	70.86	2.85	2.95	.10	.278	16.33	2.01	.446
41	9	5.67	1.17	51.20	2.25	2.25	.00	.201	15.68	1.49	.482
48	13	5.14	1.17	44.03	2.29	2.32	.03	.168	15.18	2.09	.450
55	23	5.58	1.19	51.20	3.04	3.58	.51	.238	13.82	1.51	.394
63	27	6.11	1.15	43.00	2.93	3.48	.52	.164	13.77	1.39	.324
				Atlas							
31	7	5.32	1.37	51.20	1.54	1.62	.08	.196	16.45	2.11	.485
41	11	5.44	1.26	51.20	1.97	2.04	.07	.206	15.14	1.47	.470
48	14	5.04	1.08	43.00	2.07	2.26	.09	.161	13.98	1.79	.374
55	29	7.19	1.48	43.10	2.38	2.80	.40	.155	13.54	1.39	.325
63	42	6.00	1.10	43.00	3.26	3.74	.48	.145	13.89	1.27	.280
				Kansas Orange × D. Yellow Milo (K. S. 24-136)							
31	9	5.74	1.40	50.18	1.19	2.23	.99	.157	16.27	2.00	.414
41	16	5.63	1.27	51.20	1.38	2.49	1.05	.149	15.40	1.54	.390
48	18	5.56	1.27	45.06	1.23	2.13	.85	.180	14.78	1.98	.393
55	36	7.06	1.46	55.30	2.04	3.90	1.76	.169	14.68	1.44	.301
63	47	7.52	1.15	53.25	2.42	4.89	2.35	.115	16.21	1.32	.256

* Sampled at 4:00 p. m.

** Ml. N/10 NaOH per 100 ml. juice.

TABLE VI.—Composition of Two Sorghum Varieties Each Having a Susceptible and a Resistant Strain; Whole Plants—West Farm, Stillwater, 1942.

Age	Av. Ht.	Solids	Ash	Sugars			Nitrogen		
				Red.	Total	Sucrose	Sol.	Insol.	Total
days	in.	%	%	%	%	%	%	%	%
Pig-Nose Durra 696 (Suscept.)									
18	3	19.07	2.40	1.00	2.19	1.13	.14	.53	.67
21	5	20.43	2.22	1.37	2.73	1.29	.16	.58	.74
29	11	11.86	2.19	.95	1.63	.65	.07	.33	.40
36	19	14.25	2.48	.70	1.45	.71	.08	.36	.44
43	27	13.61	2.01	.63	1.57	.89	.11	.33	.44
50	46	13.75	1.50	.97	2.07	1.04	.12	.29	.41
57	74	15.68	1.40	1.30	2.55	1.19	.14	.22	.36
Corneous Durra 695 (Res.)									
18	4	20.51	1.87	1.15	2.80	1.59	.12	.61	.73
21	6	20.05	2.04	1.31	3.29	1.88	.12	.62	.74
29	12	14.54	2.42	1.05	1.84	.75	.07	.34	.41
36	18	16.20	2.84	.79	1.76	.92	.08	.33	.42
43	29	14.06	1.77	.66	1.73	1.02	.08	.33	.42
50	47	14.00	1.50	1.15	2.35	1.14	.08	.25	.33
57	63	15.92	1.41	1.55	2.80	1.19	.09	.23	.32
Kafir 58-55-46-19 (Suscept.)									
32	7	17.24	4.08	.81	1.60	.75	.12	.41	.53
36	11	17.19	3.69	.71	1.66	.90	.10	.41	.51
43	17	16.70	2.38	.91	2.16	1.19	.11	.40	.51
50	18	17.92	2.14	1.03	2.73	1.62	.12	.40	.53
57	22	17.69	2.62	1.18	2.23	1.00	.14	.34	.48
Kafir 60-58-49-21 (Res.)									
32	7	20.55	6.79	.86	1.28	.40	.13	.39	.52
36	13	17.01	3.20	.63	1.49	.82	.11	.40	.51
43	19	15.43	2.08	.74	1.63	.85	.10	.42	.52
50	18	16.14	2.10	.97	2.06	1.03	.12	.34	.46
57	22	21.90	2.47	1.36	3.26	1.81	.13	.41	.54

TABLE VII.—Composition of Two Sorghum Varieties Each Having a Susceptible and a Resistant Strain; West Farm, Stillwater, 1943.

Age		Juice**										Whole Plants		
					Astringency			Sugars						
	Av. Ht.	Solids	Ash	Tit.* Acidity	Total	Non-Tannin	Tannin	Red.	Total	Sucrose	Nitrogen	Solids	Ash	Nitrogen
days	in.	%	%		gms./100 ml.			%	%	%	%	%	%	%
					Pig-Nose Durra 696 (Suscept.)									
32	16	5.59	1.42	33.39	.163	.074	.089	1.25	1.90	.62	.219	14.47	3.27	.42
39	18	4.96	1.50	38.00	.149	0.71	.078	1.38	1.58	.19	.194	15.66	4.74	.43
46	35	5.50	1.40	39.00	.139	.057	.082	1.50	2.06	.53	.199	12.49	1.47	.37
54	48	4.71	.98	35.58	.071	.020	.051	1.86	2.24	.36	.229	13.66	1.35	.41
	70	6.55	1.26					1.86	3.39	1.44	.236	16.07	1.44	.37
					Corneous Durra 695 (Res.)									
32	15	4.80	1.23	32.60	.133	.044	.089	1.09	1.56	.39	.173	15.75	3.49	.42
39	19	5.25	1.53	34.80	.153	.073	.080	1.22	1.85	.60	.176	15.52	3.50	.41
46	35	5.63	1.45	39.00	.139	.057	.082	1.28	2.14	.81	.169	13.19	1.51	.35
54	23	4.72	1.12	47.81	.129	.052	.057	1.92	2.26	.41	.143	13.62	1.30	.31
	64	6.36	1.18					2.13	3.70	1.49	.153	17.08	1.45	.32
					Kafir 58-55-46-19 (Suscept.)									
39	14	4.55	1.24	36.60	.127	.051	.076	.91	1.62	.67	.179	18.12	6.18	.46
46	16	5.07	1.17	42.20	.135	.057	.078	1.16	2.04	.83	.191	15.63	1.69	.48
54	23	4.72	1.13	47.81	.129	.052	.077	1.70	1.93	.22	.188	15.54	1.66	.47
	24	8.96	1.86					2.05	4.64	2.46	.267	26.19	2.14	.53
					Kafir 60-58-49-21 (Res.)									
39	13	4.45	1.30	38.00	.135	.040	.095	.93	1.36	.41	.184	17.53	5.25	.48
46	18	5.31	1.28	43.00	.175	.093	.082	1.06	1.80	.70	.225	14.26	1.69	.46
54	20	4.58	1.22	46.79	.128	.053	.075	1.42	1.56	.13	.220	14.03	1.78	.47
	23	6.70	1.47					1.89	2.99	1.04	.265	27.23	3.34	.48

* Ml. N/10 NaOH per 100 ml. juice.

** Unless otherwise stated % are volume percentages.

*TABLE VIII.—Mineral Composition of Whole Sorghum Plants; Perkins, 1938.**

Age	Av Ht.	Solids	Ash	Chlorides	Potassium	Phos-phorus	Calcium
days	in.	%	%	%	%	%	%
			Dwarf Yellow Milo				
55	18	14.98	2.37	.029	.482	.033	.059
67	23	16.27	1.49	.027	.469	.040	.073
76	39**	20.54	1.56	.022	.527	.043	.087
			Honey				
56	22	14.51	2.06	.025	.348	.030	.049
68	35	12.96	1.35	.024	.522	.028	.058
77	55**	16.70	1.22	.023	.400	.030	.071
			Feterita				
56	12	15.53	2.35	.028	.298	.029	.052
68	24	15.04	1.30	.030	.592	.025	.056
77	40**	18.09	1.31	.036	.372	.028	.056
			Wheatland				
55	17	15.66	3.12	.031	.576	.037	.066
67	22	16.23	1.73	.030	.363	.043	.068
76	23**	20.09	1.73	.033	.508	.065	.099
			Blackhull Kafir				
56	21	14.67	2.35	.029	.349	.034	.052
68	32	14.89	1.47	.025	.427	.042	.056
77	38	17.63	1.74	.028	.560	.049	.056
			Kansas Orange				
56	20	12.68	1.77	.024	.512	.028	.048
68	37	12.13	1.10	.019	.412	.025	.045
77	61**	15.27	.96	.020	.268	.031	.067
			Atlas				
55	20	13.04	1.78	.024	.487	.030	.053
67	33	13.34	1.21	.018	.457	.028	.049
76	50	16.23	1.14	.023	.422	.033	.068
			Kansas Orange × Dwarf Yellow Milo				
55	21	14.18	2.33	.027	.627	.033	.061
67	40	14.50	1.31	.024	.597	.036	.060
76	60	20.19	1.46	.023	.516	.040	.085

* Sampled at 12:30 p. m.

** Plants had begun to head.

2/48—2½M