OKLAHOMA
AGRICULTURAL AND MECHANICAL
COLLEGE

AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 102 OCTOBER, 1914

THE GRAIN SORGHUMS

BY O. O. CHURCHILL AND A. H. WRIGHT
DEPARTMENT OF AGRONOMY

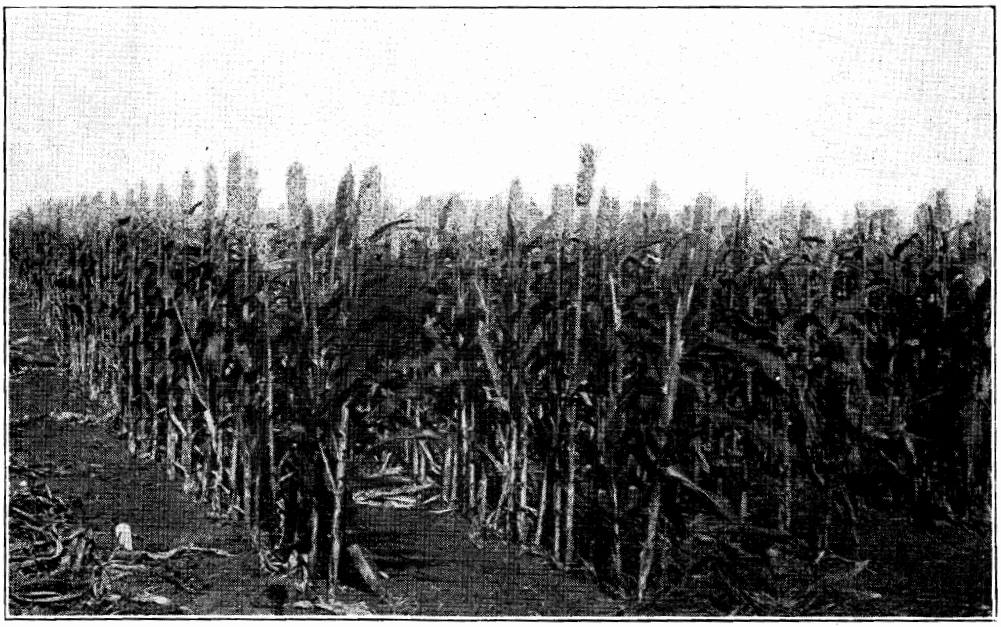

Figure 1.—A field of well bred, pure Black Hulled White Kafir on Station Farm, 1913

STILLWATER, OKLAHOMA

STATE BOARD OF AGRICULTURE
(Ex-Officio Board of Regents)

G. T. BRYAN, *President*	Oklahoma City
FRANK GAULT, *Treasurer*	Geary
J. F. DARBY	Muskogee
G. A. RAMSEY	Colbert
I. C. RENFRO	Sulphur

L. L. LEWIS, M. S., D. V. M., *Acting President of the College*

STATION STAFF

L. L. LEWIS, M. S., D. V. M.,	*Acting Director and Veterinarian*
ROY C. POTTS, B. S.,	*Dairyman*
C. E. SANBORN, M. A.,	*Entomologist*
CHAS. K. FRANCIS, A. M., Ph. D.,	*Chemist*
N. O. BOOTH, B. Agr.,	*Horticulturist*
O. O. CHURCHILL, B. S.,	*Agronomist*
W. L. FOWLER, B. S.,	*Animal Husbandman*
W. P. SHULER, M. S., D. V. M.,	*Assistant Bacteriologist*
A. F. ROLF, B. A.,	*Poultry Husbandry*
RAY PAINTER, B. S.,	*Assistant Entomologist*
LEONARD G. HERRON, B. S.,	*Assistant Horticulturist*
O. C. SMITH, A. M.,	*Assistant Chemist*
D. A. SPENCER, B. S.,	*Assistant Animal Husbandman*
B. A. AHRENS, B. S.,	*Poultryman*
R. E. KARPER, B. S.,	*Assistant Agronomist*
ADRIAN DAANE, M. S.,	*Assistant Agronomist*
M. J. OTEY, B. S.,	*Financial Secretary*
LULA TOURTELLOTTE	*Clerk*

VISITORS ARE CORDIALLY WELCOMED AT ALL TIMES

The publications of this Station are sent free to residents of Oklahoma on request. All communications should be addressed, not to individuals or departments, but to the EXPERIMENT STATION, Stillwater, Oklahoma.

THE GRAIN SORGHUMS

BY O. O. CHURCHILL AND A. H. WRIGHT

INTRODUCTORY

Comparatively, the grain sorghums constitute a new crop in the United States. Only during the last fifteen to twenty years have they been grown, and then in a haphazard way. Until very recently little has been known of the different types and varieties or of their suitability for different localities. At first mixed seed of poor varieties was planted in unfavorable regions. Poor results were consequently obtained. Then in many instances the sorghums were planted where other crops were more profitable.

It is still a common opinion that grain sorghums will grow with indifferent or no preparation of the soil and without cultivation. Some still think it a disgrace to themselves, and an insult to the soil and country, to plant these crops. These are some of the reasons why many people still view with suspicion this valuable group of plants.

But the grain sorghums have been tried and proven. At this time there can be no question as to their right to an important place in the cropping

Figure 2.—A field of good Black Hulled White Kafir on Station Farm, 1912

systems throughout the southern half of the Great Plains area. It appears wonderful that this stage of development has been passed through so rapidly when we consider the relatively small area in which the grain sorghums are eminently adapted.

All problems as to seed, variety, culture, climate, enemies and feeding still had to be solved. Besides this, there was practically no market for the crop. In a new country it is necessary to produce a crop which can be easily and profitably marketed.

We now know that in certain rather definite areas the better varieties of grain sorghums are destined to become the leading crops for both grain and forage production. This statement cannot be reasonably disputed. A large portion of Oklahoma lies within this area.

It is not to be expected that the best possible results will be obtained when a new crop is first introduced. A period of investigation, development and final information must be experienced. The grain sorghums have passed through these stages and now unquestionably are deserving of wider cultivation.

Markets have been developed as the quantity of grain produced has increased. There is now a wide demand both at home and abroad for the standard varieties. No doubt all the grain produced can be readily and profitably marketed at this time.

The sorghums are noted for their drouth resistance. The principal place for production will therefore be in "semi-humid" sections, or in those places where crop yields are frequently reduced owing to an insufficient supply of water. These conditions are affected by both soil and climate.

The grain sorghums in such localities should have the same place in the cropping systems as corn has where conditions are favorable for that crop. In the western part of Oklahoma the grain sorghums should replace corn entirely. In the central and eastern portions of the State they should replace corn on poor upland, and they might be grown to some extent in all parts of the State as an insurance against total failure in case of an unusually adverse season.

TABLE I

Comparison of yields of corn and kafir.

Place	Crop	1909	1910	1911	1912	1913	Average
Stillwater (1)	Kafir	34.0	19.0	00.0	1.5	1.0	1.0
Stillwater (1)	Corn	2.5	00.0	45.5	48.0	28.0	34.9
Goodwell (2)	Corn		Has never been a success				
Goodwell (2)	Dwarf Milo		Has always given fair yields				

(1) On poor, thin upland underlain with a hardpan.
(2) On average upland prairie soil.

Previous to this time several press bulletins have been published on the grain sorghums by this Station. The importance of these crops justifies the

widest distribution of the latest information concerning their adaptability, culture and uses. The data obtained during several years of experimentation warrants the publication of a rather complete bulletin on the subject of grain sorghums.

———o———

HISTORY

Hundreds of types or strains of the grain sorghums are grown in the old world. They are cultivated in all parts of Africa, in much of China and in immense tracts in India.

The sorghums, using the term in its broadest sense, and including all the types grown in this country and numerous others not grown here, constitute the chief crops both for human food and feed for livestock throughout large areas of Africa, Asia and many of the islands off the coasts of those countries. In those countries the sorghums not only sustain animal life, but are used for numerous other purposes such as making fermented drinks, houses, bridges and baskets. In fact, civilization in many of those sections is almost entirely dependent upon these crops.

Relatively speaking, the grain sorghums are of recent importation into the United States. They first attracted attention in this country between 1875 and 1885. It was not until 1895 that any of these could be considered as even approaching a staple crop in any section of the United States. The reason that they did not soon meet with favor is undoubtedly due to the very inferior types which were first introduced. Such strains as Jerusalem corn and white kafir were tried out for many years. All of these had so many undesirable characteristics that their growth was soon discontinued, and not until yellow milo and black hulled kafir became more generally known did grain sorghum production become important in the Southwest.

Another thing that has had much to do with the increased attention given to kafir and milo is the fact that it has been only since 1890 that the Southwest has to any appreciable extent been settled by farmers. The necessity for crops that could be depended upon to produce feed for livestock during the years of severe drouth—1910, 1911 and 1912—rapidly brought these sorghums into prominence.

C. R. Ball writes: "It was estimated a few years ago that the area annually devoted to sorghums in India was 25,000,000 acres. More than three hundred varieties have been imported from there and grown by the United States Department of Agriculture."

The sorghums have evidently been grown in those countries for centuries. De Condolle states that the sorghums are prehistoric. It is no wonder that about every imaginable type of plant and head has been found. Under primitive systems of culture they must have become badly mixed. It was to be expected that many poor varieties would at first be imported and distributed. The suitability of different varieties for different localities could be determined only by test.

Varieties varying in height from 3 to 4 feet up to 20 feet have been found.

Figure 3.—Plots of Kaoliangs on Station Farm, 1913. A, Brown Kaoliang; B, White Kaoliang

———o———

DISTRIBUTION

Grain sorghum production in the United States is confined almost entirely to a rather definite belt in the Southwest. This area is so definitely bounded that it may well be termed the "Grain Sorghum Belt". It embraces the southern part of the Great Plains east of the Rocky mountains. The belt extends on the north into southwestern Nebraska, or about latitude 41° north, and on the south into Texas to about 30° north. On the east the line runs irregularly. In Kansas and Oklahoma grain sorghums are grown to some extent as far east as the 95th meridian, but in Texas and Nebraska the eastern limit is near the 98th meridian. On the west the limit approaches the foothills of the Rocky mountains, but so little is grown west of the 104th meridian that it may be considered the western boundary.

The grain sorghums are grown in nearly all parts of Oklahoma, but their production is confined practically to the western half of the State. In the extreme western part of the State they constitute a leading crop.

Statistics on the grain sorghums are very unreliable and in many ways misleading. This is particularly true of the yields per acre. Much of the crop is cut for forage. A large acreage is planted after wheat and oats. These areas are counted in the acreage and the average yield is based on the total acreage.

For these reasons care should be exercised in using data on grain sorghums no matter where found. The following statistics are based on the census report as published by the United States Bureau of Census, 1910.

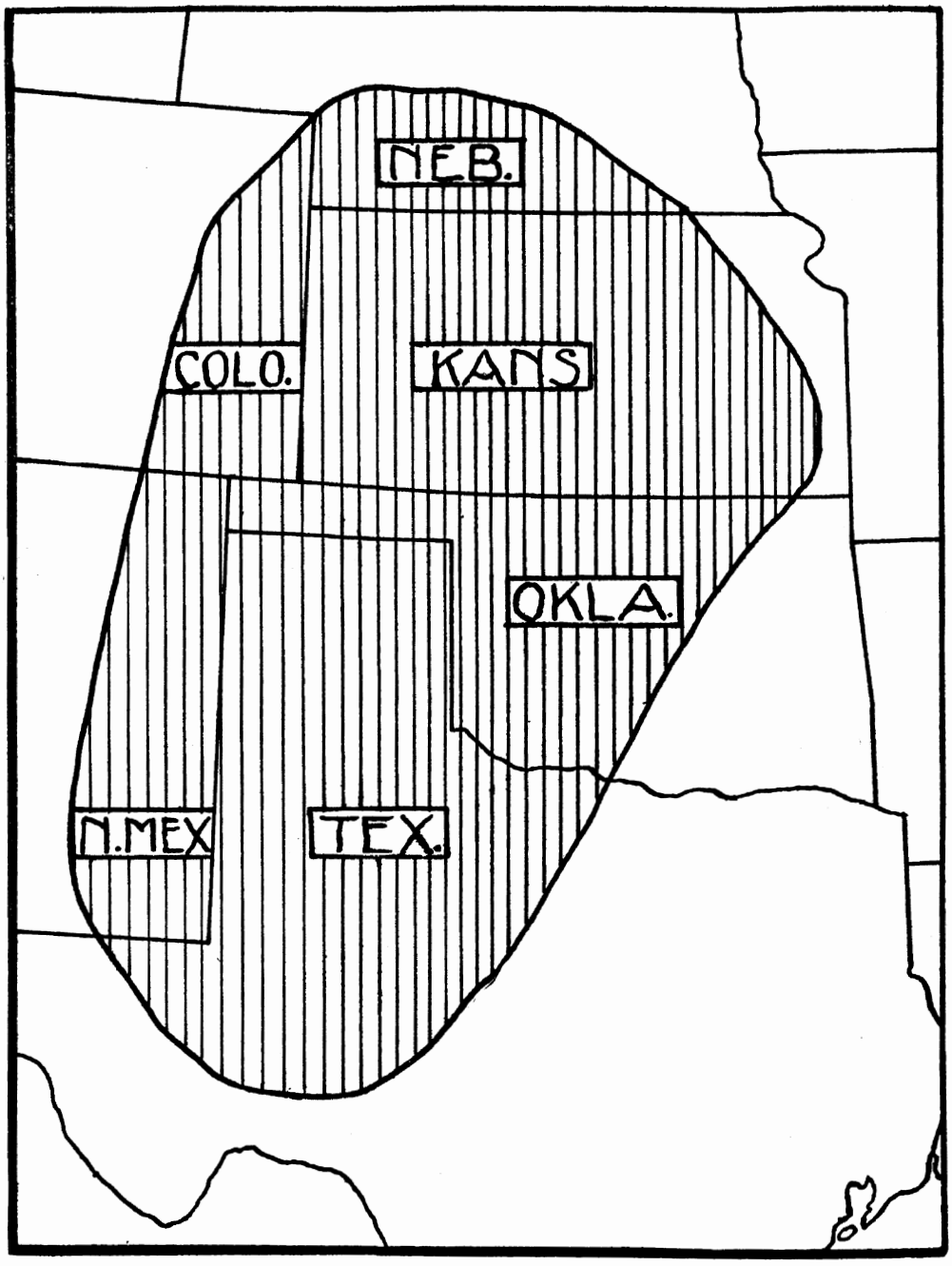

Figure 4.—Showing distribution of the grain sorghums, including practically all important sections in the United States. Note its relation to Oklahoma

According to this report Oklahoma in 1909 grew 532,515 acres of kafir and milo, producing 4,685,752 bushels of grain. The average yield per acre is unquestionably higher than this would indicate.

There were in 1909 nine counties in Oklahoma having more than 20,000 acres devoted to the grain sorghums. Nine counties grew between 10,000 and 20,000 acres, and ten counties grew between 5,000 and 10,000 acres. In 1913 the acreage devoted to these crops in Oklahoma was probably about three times greater than in 1909. No definite data can be given on yields or acreage.

TABLE II

Showing acreage devoted to kafir and milo in counties having more than 5,000 acres in 1909:

Texas	68,380	Jackson	19,354	Noble	8,974
Beaver	63,727	Roger Mills	13,888	Blaine	7,920
Ellis	42,814	Payne	13,578	Logan	7,370
Harper	27,967	Major	12,954	Grant	6,941
Custer	24,443	Washita	12,857	Oklahoma	6,625
Dewey	23,477	Harmon	12,269	Garfield	6,453
Woods	23,281	Kiowa	12,039	Alfalfa	6,142
Woodward	22,282	Beckham	11,626	Lincoln	5,730
Cimarron	20,744	Greer	11,342	Caddo	5,614
				Pawnee	5,288

The center of production of grain sorghums at this time is shown in Figure 4. While the boundaries may be somewhat extended, in the future this will undoubtedly remain the center of production. A limited area of sorghums may be grown in Arizona, Utah and California, but it is doubtful if the crop will ever become important in these sections.

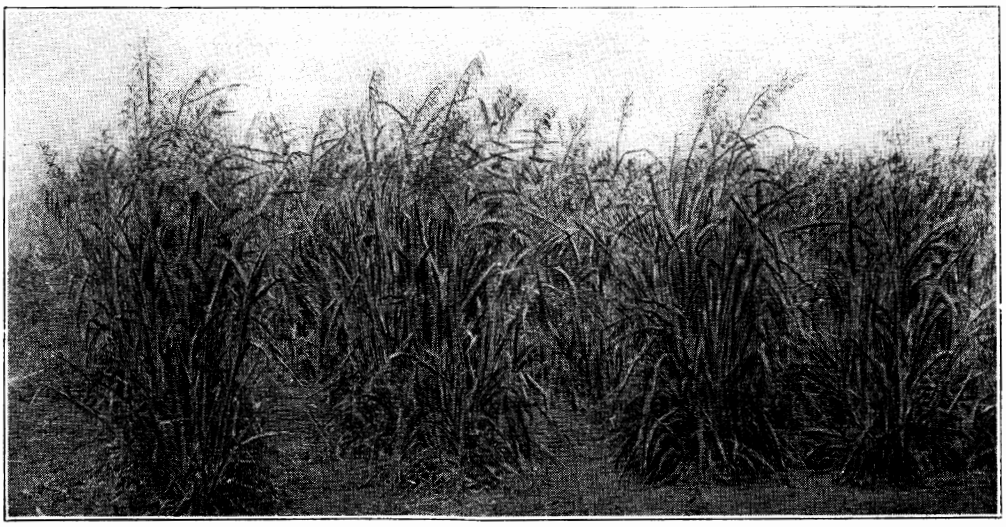

Figure 5.—Sudan Grass, showing wide variation in sorghums. This sorghum is grown for hay and promises to become an important crop in Oklahoma

EXPERIMENTAL WORK BEING CONDUCTED

Some of the data collected in the experimental work is presented under the proper headings throughout this bulletin. At this time the following lines of work relating to grain sorghums are in progress in the Agronomy Department:

1. Variety tests.
2. Breeding.
3. Drouth resistance studies.
4. Continuous culture.
5. Soil management after a sorghum crop.
6. Rotations.
7. Inter-rowed and mixtures with cowpeas.
8. Moisture requirements.
9. Proportion of grain to head.
10. Comparing grain sorghums and corn yields.

These experiments have been run for varying lengths of time. As each line of investigation is completed the results will be published in separate bulletins. Data is purposely omitted in this bulletin in order to keep it down to a reasonable size.

———o———

MOISTURE REQUIREMENTS

The climatic conditions and distribution of rainfall determine the area to which the grain sorghums are best adapted. At the center of this area they are preeminent. Their value decreases as the distance from this central point increases. (See Figure 4.)

This area is subject to great fluctuations in amount and distribution of rainfall. Hot winds are likely to occur at irregular intervals during the growing period. Hence plants which require a small amount of water per

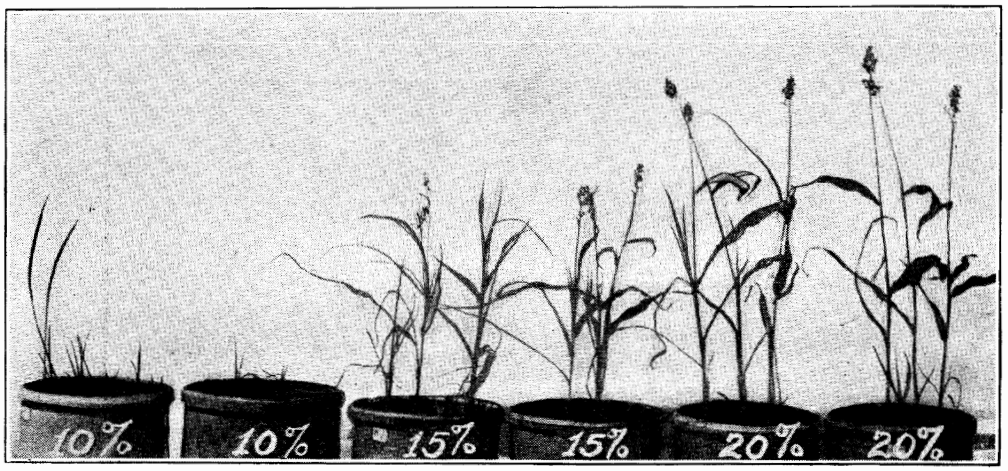

Figure 6a.—Illustrating experimental method of determining water requirement of plants. This series of pots show tests with Kafir, supplying varying amounts of water to the different pots

Figure 6b.—The remaining pots in experiment shown in 6a.

pound of dry matter, and those which dodge drouths, and those which can stand high temperatures, are especially well adapted.

In order to determine the water requirements of plants under Oklahoma conditions a series of pot tests were run in the greenhouse. The following table and notes briefly summarize the results of these tests:

TABLE III

Showing pounds of water required to produce one pound of dry matter of different crops when varying amounts of water were supplied:

Water Content of Soil Percent.	Pounds of Water to Produce One Pound Dry Matter.				
	Kafir	Milo	Corn	Broom-corn	Oats
5	1187*	1905*	1555*	2834*	1232*
10	581	673	590	3926*	1680*
15	409	627	411	658	661
20	402	495	347	554	620
30	439	479	433	465	773
40	561	626	488	513	870
Average	478	578	454	547	731

*Not included in average.

Practically no growth with broomcorn or oats occurred in the pots containing 5% or 10% of moisture. This accounts for the apparently large quantities of water required to produce a pound of dry matter, since much

of the water evaporated from the soil instead of passing through the plants. The plants grew only a short time after coming up, and then wilted and dried out to such an extent that practically no water could be transpired. In the series of corn, kafir and milo the plants in the pots containing 10% moisture kept green enough to transpire some water during most of the experiment.

In all series the amount of water required to produce a pound of dry matter decreased as the water content approached 25%. This is approximately 55% of the total water-holding capacity of the soil. The amount of water required to produce a pound of dry matter increased above this percent. This indicates that plants make the most economical use of water in this soil when the moisture content is about 20%.

Most of the milo and kafir plants matured sufficiently to produce some grain. The oats also produced some grain. The broomcorn failed to head. Nearly all of the stalks of corn tasseled and a few of them began to silk, but they did not sufficiently mature to produce grain.

Kafir produced the greatest weight of dry matter at low percents of moisture.

Five percent of moisture produced very little growth in any of the series.

Ten percent moisture produced very little growth in broomcorn or oats, but a fair growth in corn, kafir and milo.

From 15% to 30% moisture the growth increased nearly in proportion to the increase in moisture present. The plants grown in soil containing 40% moisture did not show any decided increase in dry matter over those grown in 30%.

Twenty percent moisture in this soil seems to be the most economical proportion for the use of crops.

The sorghums grew and produced well with 15% of water in the soil.

This test indicates that kafir and milo will grow and produce fair crops when the water content of the soil is too low for the production of corn.

Another series of pot tests was run to determine the wilting coefficient of corn, oats, kafir, milo and cowpeas. No water was added to any of these jars after the start of the tests except to the jars of soil which contained 15% moisture. It was necessary to add some water to those in order to cause the seeds to germinate. Accordingly 65 cc. of water, which is equal to an extra 5% of moisture, was added to the jar of the "straight series", which started with but 15% of moisture content. In studying Table IV it should be noted that the tabulated 15% was made 20% five days after the test started.

When the seeds were planted and mulch added the weight of the jar and contents was taken and recorded and the total weight was taken once each week thereafter. Observation and records were made each morning as soon as any of the plants showed the first signs of suffering from lack of moisture. The wilting coefficient was computed from the weight at the time of wilting by substracting from this weight, the weight of the empty jar plus the weight of the dry soil (1,300 grams) plus the weight of the gravel

TABLE IV—Weights and Records as Kept, and Wilting Coefficient as Computed for Plants of "Straight Series"

Jar No.	Crop	Pr Ct Water	Wt. of Empty Jar	Weight of Jar, Soil, Water, Mulch									Wilting Coefficient.	
				1-25	2-4	2-11	2-18	2-25	3-4	3-11	3-18			
A1	Corn	15	738	2363	2406	2385	2348	2306	Wilted 3-1 Wt. 2285					
A2	Corn	20	694	2384	2362	2321	Wilted 2-17 Wt. 2239						9.00	
A3	Corn	25	677	2432	2386	2344	2221	Wilted 2-18 Wt. 2221					8.84	
A4	Corn	30	639	2459	2404	2372	2283	2222	Wilted 3-4 Wt. 2179				8.77	Mean Corn
													8.46	8.77
B1	Oats	15	691	2316	2355	2328	2240	Wilted 2-23 Wt. 2226						
B2	Oats	20	675	2365	2335	2265	Wilted 2-16 Wt. 2210						8.00	
B3	Oats	25	652	2407	2367	2298	2186	Wilted 2-18 Wt. 2186					8.07	
B4	Oats	30	663	2483	2405	2308	Wilted 2-16 Wt. 2201						8.00	Mean Oats
													8.23	8.07
C1	Kafir	15	770	2395	2435	2406	2384	2372	2361	2344	2326	Wlt 3-24 2318	9.07	
C2	Kafir	20	672	2362	2341	2329	2305	2284	2257	2221	Wlt. 3-13 Wt. 2218		8.92	
C3	Kafir	25	764	2519	2477	2457	2428	2402	2369	2323	Wlt. 3-13 Wt. 2314		9.23	Mean Kafir
C4	Kafir	30	762	2582	2529	2509	2467	2435	2397	2347	Wlt. 3-16 Wt. 2308		8.92	9.03
D1	Milo	15	608	2233	2278	2258	2223	2193	2165	Wilted 3-6 Wt. 2160				
D2	Milo	20	649	2339	2333	2307	2275	2249	2220	Wilted 3-6 Wt. 2208			9.38	
D3	Milo	25	697	2452	2418	2395	2351	2313	2274	Wilted 3-6 Wt. 2253			9.92	
D4	Milo	30	747	2567	2529	2496	2436	2391	2333	Wilted 3-8 Wt. 2304			9.69	Mean Milo
													9.77	9.69
E1	Cowpeas	15	649	2274	2317	2297	2253	2223	2204	Wilted 3-11 Wt. 2190				
E2	Cowpeas	20	641	2331	2296	2276	2242	2216	2196	Wilted 3-8 Wt. 2186			8.54	
E3	Cowpeas	25	660	2415	2381	2332	2240	2214	2199	Wilted 3-6 Wt. 2195			8.84	
E4	Cowpeas	30	629	2449	2404	2363	2246	2195	2168	Wilted 3-5 Wt. 2163			8.07	Mean Cowpeas
													8.00	8.36

Note.—On February 1, added 65 cc. of water to the following jars: A 1, B 1, C 1, D 1, and E 1, as the seed had not germinated. (65 cc. was 5% extra.

TABLE V—Records as Kept for Plants in "Mixed Series"

Jar No.	Crops.	Percent Water.	Wt. Jar Empty.	Wt. of Jar, Soil, Water and Mulch									Date of Dying.
				Jan. 25	Feb. 4	Feb. 11	Feb. 18	Feb. 25	Mar. 4	Mar. 11	Mar. 17	Mar. 24	
F1	C. & O.	20	679	2369	2337	2256	2211	2199	2190	2186	2178	2180	C. & O. wilt simultaneously.	C. 3-17, O. 3-30
F2	C. & K.	20	653	2343	2310	2269	2201	2181	2171	2167	2156	2155	C. wilts first, 4 or 5 days.	C. 3-25, K. 4-3
F3	C. & M.	20	809	2499	2469	2436	2376	2355	2344	2336	2329	2330	C. wilts first, 3 or 4 days.	C. 3-27, M. 4-2
F4	C. & Cp.	20	742	2432	2401	2371	2317	2292	2275	2270	2260	2264	C. wilts first, 4 days.	C. 3-25, Cp. 3-30
G1	C. & O.	25	714	2469	2418	2367	2278	2248	2231	2222	2212	2212	Only Oats grew.	
G2	C. & K.	25	648	2403	2361	2335	2285	2237	2191	2163	2150	2143	C. wilts first.	C. 3-28, K. 4-4
G3	C. & M.	25	622	2377	2332	2306	2266	2232	2192	2159	2136	2128	Only milo grew.	
G4	C. & Cp.	25	683	2438	2388	2331	2242	2117	2204	2195	2185	2180	Corn wilts first.	C. 3-26, Cp. 3-22
H1	C. & O.	30	704	2524	2479	2399	2262	2234	2219	2206	2195	2196	Only oats grew.	
H2	C. & K.	30	650	2470	2434	2409	2376	2346	2304	2245	2188	2170	Only kafir grew.	
H3	C. & M.	30	631	2451	2411	2388	2349	2315	2266	2193	2158	2147	Only milo grew.	
H4	C. & Cp.	30	705	2526	2485	2458	2394	2332	2270	2240	2223	2222	Only corn grew.	
I1	K. & C.	20	755	2445	2414	2358	2309	2293	2283	2273	2268	2265	C. wilted first 3 or 4 days.	K. 4-5, C. 3-27
I2	K. & O.	20	721	2411	2396	2350	2291	2268	2254	2239	2238	2235	O. wilted first 2 or 3 days.	K. 4-2, O. 3-31
I3	K. & M.	20	655	2345	2310	2287	2253	2225	2202	2188	2178	2176	M. wilts first 1 or 2 days.	K. 4-5, M. 4-3
I4	K. & Cp.	20	780	2470	2441	2424	2388	2358	2333	2319	2307	2306	Kafir wilts first.	K. 4-6, Cp. 4-4
J1	K. & C.	25	633	2388	2358	2339	2315	2293	2264	2234	2196	2181	Only kafir grew.	
J2	K. & O.	25	769	2524	2477	2405	2329	2311	2299	2296	2286	2287	Only oats grew.	
J3	K. & M.	25	762	2517	2485	2457	2414	2376	2338	2308	2300	2293	Milo wilts first.	K. 4-5, M. 4-4
J4	K. & Cp.	25	648	2403	2369	2346	2316	2284	2245	2204	2185	2179	K. wilts first 1 or 2 days.	K. 4-4, Cp. 4-1
K1	K. & C.	30	710	2530	2492	2473	2447	2428	2402	2365	2337	2320	Check.	
K2	K. & O.	30	751	2571	2521	2449	2327	2301	2289	2278	2667	2265	Oats wilted first.	K. 3-17, O. 3-15
K3	K. & M.	30	750	2570	2531	2507	2471	2435	2390	2335	2300	2286	Milo wilted first.	K. 4-4, M. 4-3
K4	K. & Cp.	30	740	2560	2520	2484	2386	2334	2306	2283	2273	2266	Kafir wilted first.	K. 4-2, Cp. 3-30

Note.—On March 23 during a snow storm a glass of the greenhouse broke and allowed some snow to enter, which caused slight increase in weight.

mulch (1,300 grams). This remainder represents the amount of moisture in the 1,300 grams of dry soil. The wilting coefficient for that plant in that particular soil is determined by dividing the weight of the water by the weight of the soil.

From Table IV it is seen that it requires a longer period of time for the grain sorghums to reach the wilting point than it does oats and corn. Cowpeas are next to the grain sorghums in this respect. Because oats and corn wilted first it might appear that their wilting points are higher than that for the grain sorghums. The fact is that in this experiment the wilting coefficient for oats and corn proved to be lower than that for kafir and milo.

As shown by this test the oats removed more of the moisture from the soil before wilting than any of the other plants grown; cowpeas ranked next to oats, corn third, kafir fourth, while milo left more of the moisture in the soil at its wilting point than any of the other crops.

From the wilting coefficient for the plants, as determined from the preceding data, it is seen that the drouth resistant character of the grain sorghums is not directly due to their ability to use the soil moisture down to the lowest extent.

From Table V it is seen that when two kinds of plants are grown in the same soil mass, corn and oats wilt at the same time, corn wilts before kafir, milo and cowpeas, while oats and milo wilt before kafir, and kafir wilts before cowpeas. These were the results as the observation and records show.

As to the time of dying of the plants when in the various combinations in the same soil mass, corn died before oats, kafir and milo, and in one case it died before cowpeas, while in a second instance it survived longer than the cowpeas.

When the kafir was grown in combination with other crops, the kafir in every case was the last to die. That is, it survived the dry conditions longer and better than corn, oats, milo and cowpeas.

———o———

CLASSIFICATION

General Relationships.—There are two general divisions of sorghums; the saccharine and the non-saccharine. The saccharine sorghums are so termed because they contain in the cells of their tissues a large amount of sap or juice which is rich in sugar. They are sometimes called the sweet sorghums or canes. These plants are grown primarily for forage and for the manufacture of syrup and sugar.

The non-saccharine sorghums comprise a large variety of plants which in this country are grown almost entirely for feed, including both grain and forage for livestock. Broomcorn is seldom grown except for its brush, which is used in the manufacture of brooms, but also used to some extent as feed, and hence is grouped with the grain sorghums. The non-saccharine sorghums which are grown primarily for grain production are now known as "The Grain Sorghums". In this division are included kafir, milo, durras, kaoliang and shallu.

Sorghums belong to the grass family and are believed to have originated from the wild species of grass, Andropogon halepensis, which is found widely distributed over the tropical and semi-tropical regions of the Eastern Hemisphere. Johnson grass and some of the plants known as millets belong to the sorghum family. They do not, however, belong to the same species.

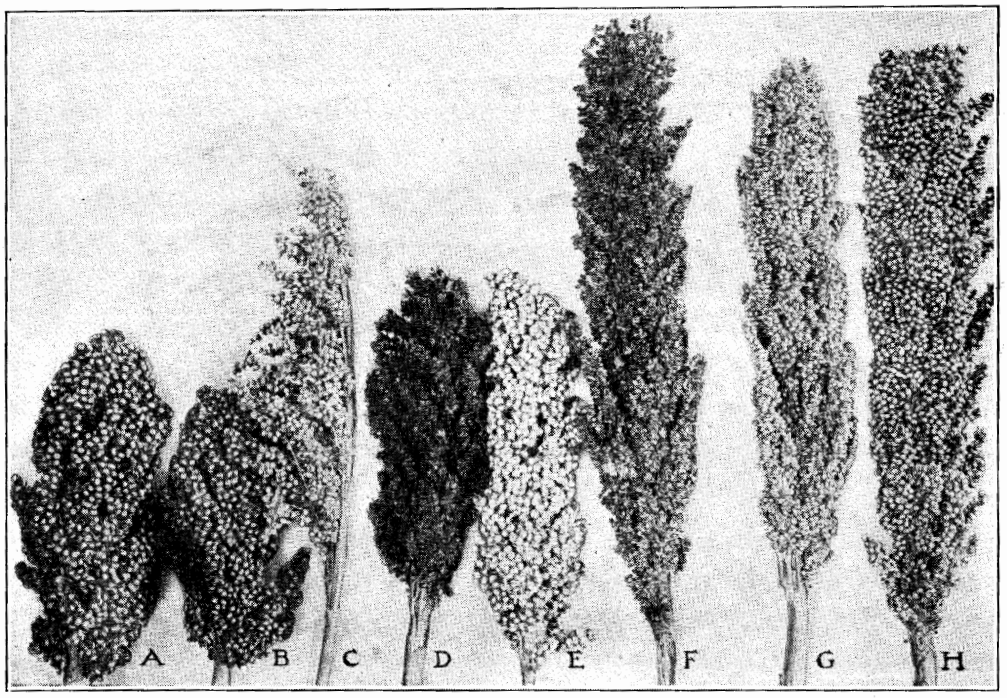

Figure 7.—Varieties of Grain Sorghums: (a) White Milo; (b) Yellow Milo; (c) White Kaoliang; (d) Brown Kaoliang; (e) Feterita; (f) Red Kafir; (g) Pink Kafir; (h) Black Hulled White Kafir

Structure.—The sorghums have erect stems and produce their seed at the top. The stems are relatively thick and coarse. The interior of the stems is filled with a pith which varies from dry to very juicy; the internodes (space between joints) are comparatively long. A leaf is produced at each joint and the leaves are arranged alternately. The sheaths are open, although in some cases strongly overlapping. The roots are fibrous and abundant. Leaves, long, slender to relatively broad. Heads vary greatly in shape and structure in the different types. Can be either self-fertilized or cross-fertilized. When cross-fertilization occurs it is usually due to the pollen grains being carried by the wind.

Groups, Types and Varieties.—Strictly speaking, there are no definitely established varieties of grain sorghums in the United States. While there are variety names used to distinguish different importations into this country, yet most of these names are either never known by the grower or are soon lost by him. As a result nearly all of the so-called varieties of grain sorghums in this country are in reality not varieties but groups. It is at least safe to state that definite varieties of the grain sorghums do not exist

in the same sense as do varieties of corn, cotton and most other important farm crops.

Since there is considerable variation in the plants of all groups (varieties) of the grain sorghums, and since any type selected is not very difficult to maintain, it is altogether probable that when the grain sorghums have become more definitely established and widely distributed, varieties will be developed as pure and distinct as Boone County White and Reid's Yellow Dent corn.

In order to procure a logical conception of the differences and relations of the different grain sorghums now grown in the United States, and particularly in the Southwest, it seems imperative to make some sort of grouping or classification. In making such classification we find ourselves confronted with serious difficulties. No complete botanical classification of these plants has yet been made, and the classifications which have been given are not satisfactory for a treatise of this kind. The classification which we offer is made from an agronomic rather than a botanical standpoint. We believe that such an arrangement will provide a working knowledge of the subject and at the same time be sufficiently accurate for purposes of a general classification.

Kafir Group	Durra Group	Kaoliang and Miscellaneous Groups
Black Hulled Kafir	Yellow Milo	Brown Kaoliang
Standard	Standard	White Kaoliang
Dwarf	Dwarf	Shallu
Very Dwarf	Very Dwarf	Darso
Red Kafir	White Milo	
Pink Kafir	Feterita	
White Kafir	Jerusalem Corn (white durra)	
	Brown Durra	

———o———

THE KAFIRS

This group includes the most important and best known grain sorghums grown in the United States. The kafirs are characterized by having little juice in the pith. The juice is sweet to sub-acid. The internodes are short; the stems are fairly thick; the sheaths are strongly overlapping; leaves wide and fairly long, from twelve to fifteen in number; heads erect, compact and cylindrical; seeds obovate and somewhat hard in texture.

Black Hulled Kafir.—This type is more commonly called "Black Hulled White" and is by far the most important, not only of the kafirs, but of all the grain sorghums grown in this country. Black Hulled Kafir is in all probability a native of Natal, South Africa, but was imported into this country from the Orange River Colony about 1876. Importations of White Kafir and Red Kafir were made from the same country and probably at about the same time. (Bulletin No. 175, Bureau of Plant Industry.)

Just where Black Hulled Kafir was first grown in the United States is not known. Not until the ranchmen and farmers of the Southwest com-

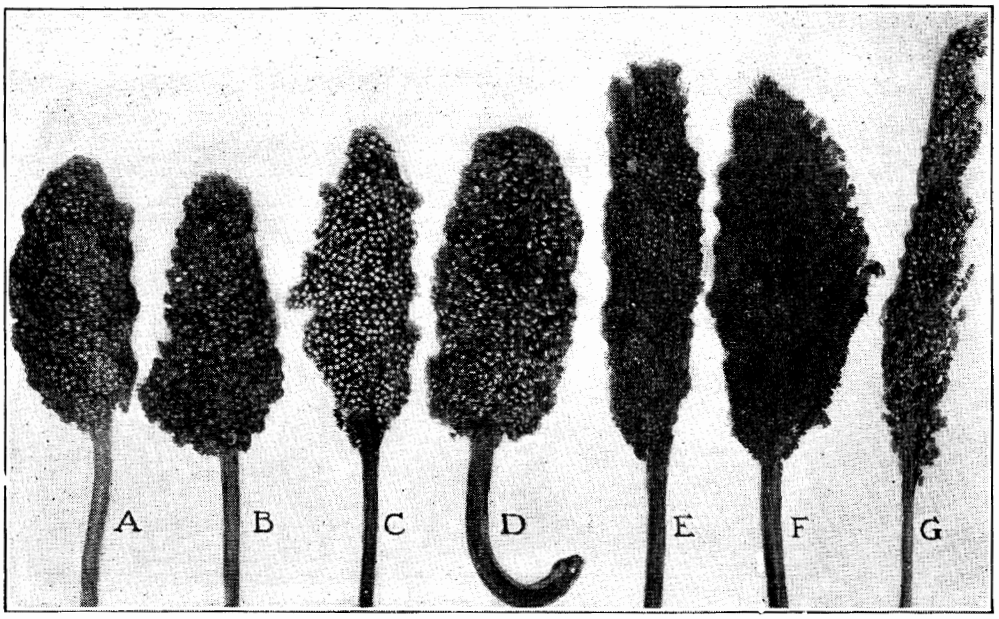

Figure 8.—Heads of (a) Yellow Milo; (b) White Milo; (c) Feterita; (d) Jerusalem Corn, (e) Pink Kafir; (f) Brown Kaoliang; (g) White Kaoliang

menced to grow it did it attract very much attention. During the last twenty years, it has gradually received increased recognition and is now considered one of the most important staple crops in western Nebraska, Kansas, Oklahoma and Texas. It is also grown considerably in eastern Colorado and New Mexico, although in the latter section it does not seem to be as well adapted as are some types of milos and durras.

All results seem to indicate that black hulled kafir is superior to any of the grain sorghums when grown in the eastern part of the grain sorghum belt. It usually yields better than either red or white kafir; does not lodge or "go down" as does Jerusalem corn, feterita and the kaoliangs; does not shatter as does white kafir and Jerusalem corn; has erect heads, a characteristic not possessed by milos and Jerusalem corn; and does not sucker as many of the grain sorghums do. In brief, black hulled kafir possesses the following very desirable characteristics—no other grain sorghum possesses all of these: Yields well both grain and forage; does not sucker or produce side branches; has erect, compact heads; does not "go down" or lodge if allowed to stand unharvested in the field for several weeks after maturity.

This is the only important type of the kafirs grown in the Southwest and hereafter in this bulletin, when the term kafir is used, the black hulled is meant.

Black hulled kafir has been selected into several sub-types or varieties. These sub-types are not well fixed and are not clearly differentiated.

Red Kafir.—This type is very similar to the black hulled. It was introduced at about the same time from the Orange River Colony, South Africa, and first attracted attention in Kansas and other sections of the Southwest. It seems to be adapted to the same conditions as the black hulled. The

stalks are a little more slender and, as a rule, the plants grow a little higher. The heads differ considerably from the black hulled in that they are long and slender; the glumes and kernels are red or reddish brown, the glumes are usually darker than the kernels. The kernels are smaller and harder than those of the black hulled. Red kafir matures a little earlier than most strains of the black hulled.

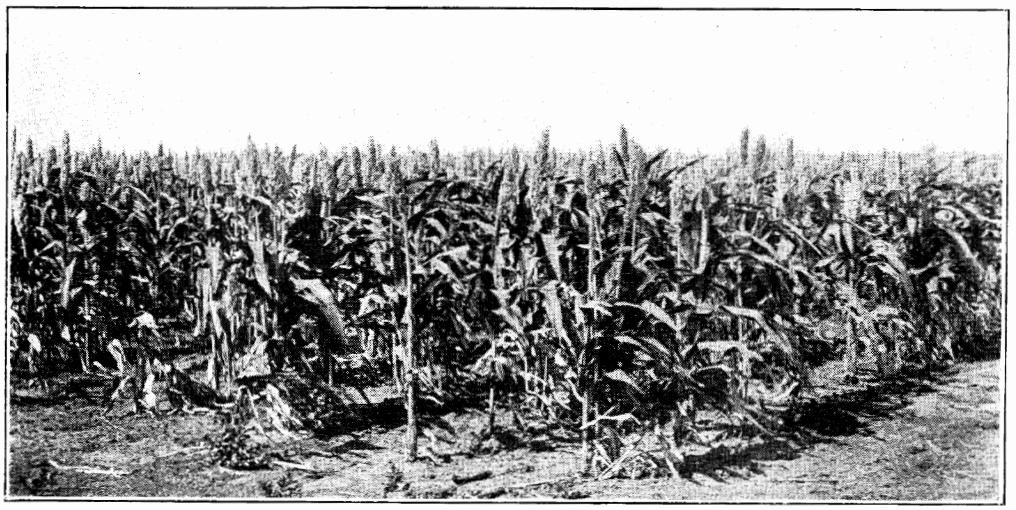

Figure 9.—Field of Black Hulled White Kafir. Showing uniformity—result of careful breeding

Red kafir, while grown to a considerable extent in the Southwest, is rapidly decreasing in importance, and since it possesses no particular characteristic that gives it a distinct advantage over the black hulled, it will probably never compare in importance with the black hulled type.

Pink Kafir.—Pink kafir is but a strain of the red, having lighter colored kernels and glumes. In other respects it is practically the same as the red kafir. Therefore it requires no further discussion.

White Kafir.—This type was the first grain sorghum to attract attention in the Southwest. It was grown more extensively than any other kafir about twenty years ago. Since it did not yield well, lodged to a considerable extent and shattered badly, it soon lost favor and is now practically unknown among farmers.

———o———

THE DURRAS

The durras are characterized by having scanty, sub-acid juice; internodes medium in length; stems coarse; plants vary in height from a few feet in the extreme dwarf strains to ten to twelve feet in some of the standard milos and Jerusalem corn; the sheaths scarcely overlapping; heads inclined or gooseneck in most varieties, compact and ovate in shape; seeds, large, slightly to strongly flattened and kernels soft in texture. These plants have relatively few leaves compared with the kafirs, and consequently are not as valuable for forage production.

Yellow Milo.—This type was probably introduced from Africa between 1880 and 1885. It was first grown in some of the Southeastern States, but failed to attract very much attention, and, like the kafirs, it did not reach any importance in this country until it found its way into the Panhandle of West Texas. Next to kafir, it is the most widely distributed and extensively grown of the grain sorghums. The present limit of its production is practically the same as that of kafir, but in comparison to the latter it is grown more in the extreme west and but very little in the extreme eastern part of the grain sorghum belt.

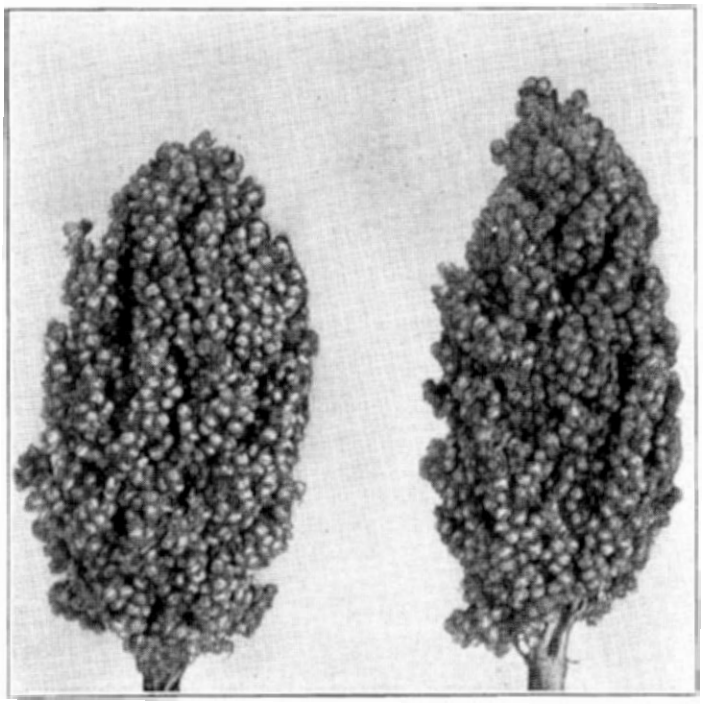

Figure 10.—Yellow Milo

Yellow milo has dark yellow or yellowish-brown glumes and seeds, varying in different strains from very dark to very light in color. Brown milo, red milo and orange milo are other names for yellow milo, and all are identical. Yellow milo is the name most commonly used. Milo varies in height from as low as four feet to as high as eleven feet. Dwarf milo is the name given the low-growing strains which have been developed in the regions of scant rainfall, and standard milo is the name given to high-growing strains. As a result of continual growth under dry conditions, combined with both natural and artificial selection, the dwarf characteristic has become fairly well established. But if grown in humid sections and on rich soil it will grow considerably higher than in the dry sections, yet it will not grow as high as the standard milo. On the other hand, if the standard is grown in the dry regions it will not attain as great a height as when grown in the sections of greater rainfall, but will grow higher than the dwarf in the dry sections. There is practically every gradation intermediate between

the two strains noted. Since grain production is the chief aim in growing this crop, the dwarf milo is preferred by farmers, and is now almost universally grown in preference to the standard.

The general claim is made by growers that yellow milo is more drouth resistant than kafir. While this may be true, yet it cannot be proved. But since it matures from one to two weeks earlier than most strains of kafir, it is better able to evade drouth and consequently is more profitably grown in the driest sections of the grain sorghum belt. Yellow milo has several objectionable features which render it a less desirable crop than kafir. Chief among these are: A small amount of forage; inclined or goose-necked heads; stooling or suckering; some side branching; and lodging. Yellow milo suffers much worse from the ravages of chinchbugs than does kafir. In all other respects it compares very favorably with kafir.

Yellow milo has been selected for erect heads. Some strains of this type have practically 100% of the heads erect. Some strains have only a small percent of erect heads. This characteristic varies under different conditions.

The types having erect heads seem to produce smaller heads on the average, and so far in our experimental work are less productive than those having goosenecks. The advantages of the erect heads are so great that

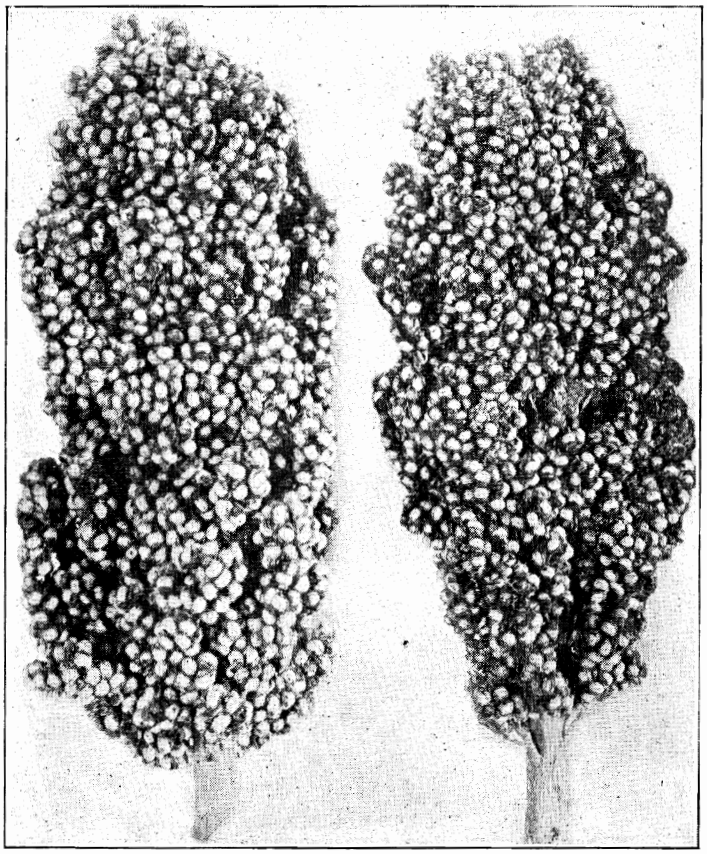

Figure 11.—White Milo

this particular feature is desirable even if the yield is slightly reduced. In any case further time and work in developing this character is worth while.

White Milo.—This type is closely related to yellow milo, being similar in nature of growth and general appearance. The chief difference in appearance is due to white glumes and seed. While it is not grown as extensively as the yellow milo, yet it has met with much favor and it undoubtedly will become nearly, if not quite, as important as the yellow milo.

Feterita (Sudan Durra).—This type was introduced from Alexandria, Egypt, November 6, 1906, through the United States Department of Agriculture, Division of Foreign Seed and Plant Introduction. It is now grown in a limited way in Northwestern Texas and Oklahoma. The acreage devoted to feterita was greatly increased in 1913 and 1914.

Feterita is characterized by rather slender, medium tall plants, having more leaves than milo, but less than kafir. The stalks are more slender than either kafir or milo. The heads are erect. The seeds are white or bluish-white and flattened. The glumes vary in color from white to shades of pink, red, brown and black. The height is irregular and varies in different seasons, different sections, and according to the fertility of the soil. From six to seven and one-half feet is a fair average.

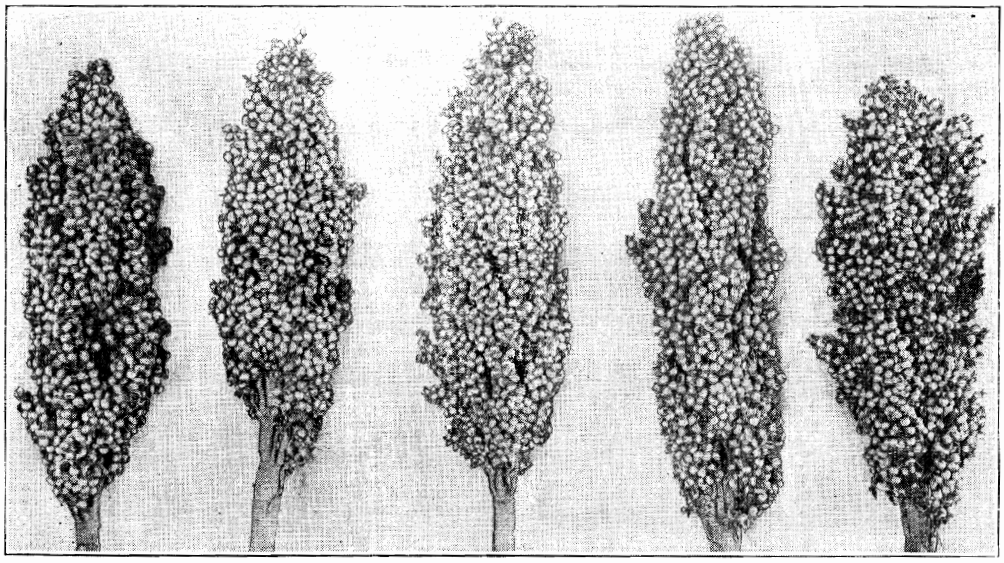

Figure 12.—Feterita heads, showing variation in color of glumes

Feterita produces suckers, but not as extensively as milo. It also produces side branches. It usually lodges badly if left in the field after maturity. Feterita matures from ten to twenty days earlier than black hulled kafir. It yields about the same amount of grain as kafir, but considerably less forage.

When feterita and milo are seeded early they mature in practically the same length of time. When late seeding is practiced, the feterita matures in a shorter period of time. The later the seeding the greater the advantage

is in favor of feterita. The later the planting of any of the grain sorghums the shorter the time it takes them to mature, if conditions are at all favorable, but this is especially true of feterita. For this reason feterita will generally be found to be the best variety for planting after wheat or oats.

The true value of feterita for Oklahoma has not yet been fully determined. In both 1913 and 1914 it gave yields far superior to either kafir or milo in many instances.

Figure 13.—Two plots of Feterita in the variety test, 1913

The fact that it stools badly and that it lodges very easily and quickly after maturity seriously affects its value as a grain crop. For hogging down or for silage it seems to rank very high and to be even as good if not better than either kafir or milo. We feel justified in strongly recommending feterita for those sections where kafir cannot be grown successfully. Even though feterita produces a higher yield of grain in many instances than kafir, still its tendency to sucker and lodge makes it a less desirable crop in the eastern part of the grain sorghum belt for the general farmer whose principal aim is grain production.

Brown Durra and White Durra.—These two durras constitute the first introduction of grain sorghums into the United States. They were first grown in California in 1874. The white durra became rather generally distributed over the southwestern plains. In that section it was commonly known as Jerusalem corn. White durra was never grown to any great extent and is now almost unknown. The brown durra has been grown in but a limited way and has attracted less attention than the white. Neither of these grain sorghums are of any agricultural importance in the grain sorghum belt.

These durras are high growing plants, varying from eight to twelve feet. They have coarse stems, relatively few leaves, and the heads are inclined to gooseneck. The plants lodge easily and sucker considerably. The heads are fairly compact; egg-shaped; the grain shatters very easily. The kernels are strongly flattened. The kernels are white in Jerusalem corn and reddish-brown in the brown durra.

———o———

MISCELLANEOUS

The Kaoliangs.—The Chinese word for sorghum is "kaoliang". Many importations of kaoliang seed have been made since about 1898 by the United States Department of Agriculture. Scattering importations were made previous to this time, but they seem to have been tested almost entirely for syrup production, and since they were found to have no value for this purpose, their growth was entirely discontinued. These plants have been grown experimentally by the United States Department of Agriculture at Amarillo and Chillicothe, Texas, and by the Oklahoma Experiment Stations at Goodwell and Stillwater. They have also been grown in a cooperative way by farmers in New Mexico, Colorado, Oklahoma and Texas.

Figure 14.—Brown Kaoliang, showing slender stalks

Figure 15.—Brown Kaoliang, showing habit of plant

The two types principally grown are the brown and the white kaoliangs. These types seem to be fairly well established in this country and are reasonably free from mixture. Both of these types mature in from 100 to 120 days. On the high plains they are relatively low-growing, varying in height from five to eight feet. The forage production is low and the stalks are slender. The heads are loose or open, erect, and practically no suckers or side branches are produced. They do not shatter easily. They compare favorably in yield of grain with milo, and in years of very severe drouth have given a proportionately better yield. In 1911 and 1912 at Goodwell, Oklahoma, the kaoliangs produced considerable grain while kafir produced practically nothing, and milo gave a very low yield. At the Oklahoma Experiment Station both the brown and the white kaoliangs gave a fair yield, but in no case compared in grain production with the other grain sorghums tested.

The brown kaoliang has medium compact heads, oval or ovate in shape. The kernels and glumes vary in color from reddish to dark reddish-brown. White kaoliang has open, somewhat flaring heads. The kernels are white and somewhat glossy, and the glumes are light gray to white.

It is impossible at this time to state definitely the value of the kaoliangs. Since they seem to be able to mature a fair yield of grain under the most severe conditions of drouth, they promise to be of considerable value in the extreme northwestern sections of the grain sorghum belt. Wherever kafir, milo or feterita can be successfully grown, the kaoliangs will probably never compare with them in value.

Shallu.—More commonly known as Egyptian wheat, is extensively grown in parts of Africa, India and the Island of Madagascar. It was imported directly from Africa by the Louisiana Experiment Station about 1890. This grain sorghum has been grown to some extent all over the Southwest, particularly in Texas and Oklahoma.

Shallu has been tested at the Louisiana Experiment Station, the Texas Station, the Oklahoma Station, the Kansas Branch Station at Hays, and by the Bureau of Plant Industry of the United States Department of Agriculture. Reports from these tests are unanimous in concluding that as a grain or forage plant, shallu is of very little value.

Unscrupulous seedmen have greatly misrepresented this sorghum. They have often represented it as producing fabulous yields and have sold the seed at exorbitant prices. It has undoubtedly been used as a seedman's "fake" more than any other plant in the Southwest. Shallu has been known by many names, the most common of these are: "Desert Wheat Corn", "Egyptian Wheat", "California Wheat", "Desert Wheat" and "Mexican Wheat".

In this country shallu grows from five to eight feet in height. The stems are somewhat slender and less coarse in texture than kafir. It suckers considerably and lodges readily. The head does not come completely out of the leaf sheath or boot (is not fully exserted). The heads are low and spreading and usually somewhat inclined or drooping at maturity.

Figure 16.—A field of Shallu

There is considerable shattering of the seed. The spikelets are long and flexible and hang downward forming a one-sided head. The kernels are small, almost round, and hard in texture. The glumes and kernels are light or white in color.

Darso.—We have had in our variety tests during the last two years a

Figure 17.—Darso plot on Station Farm, 1913

dwarf red sorghum of unknown history and breeding. It is very dwarf and very early. It is remarkable for its uniformity. We received our first supply of seed from a farmer in southwest Logan county, who sent us a head for identification. Later we learned that it had been grown in a small way in Kingfisher and adjoining counties. In order to give this strain a distinctive name we have named it darso.

The habit of darso is very similar to kafir. The juice is slightly sweet. The seeds are medium small and medium soft, somewhat resembling cane seed. The color is about the same as red kafir. The heads are erect and slightly more open than red kafir.

The agricultural value of this strain cannot, of course, be stated at this time, but on account of its earliness and very dwarf stature it promises to be a valuable addition to the grain sorghums.

Kafir, milo and feterita are the important varieties of the grain sorghums. Data collected at this Station will not accurately represent the comparative value of the different varieties in different localities. Kafir is best for this part of the State. Milo and feterita are best for the western part of Oklahoma.

It is entirely possible, and even probable, that darso and other types of value will be introduced later.

TABLE VI

Variety Test With Grain Sorghums

	Yields				Days to Mature	
	1912		1913		1912	1913
	Tons	Bu.	Tons	Bu.		
Kafir	2.87	45.27	2.55	34.4	113	110
Feterita	3.15	46.43	1.66	28.0	94	93
Milo	2.7	31.31	.....	.....	105	101
Darso	.....	.....	1.47	21.2	.....	98
Shallu	2.43	47.33	1.71	35.2	124	127
White Kaoliang	1.39	18.36	1.23	8.8	98	96
Brown Kaoliang	.....	.....	.....	.....	95	92

———o———

SEED AND SEED SELECTION

All the grain sorghums are easily cross-pollinated, not only with each other, but also with the saccharine sorghums and broomcorn. This, together with the fact that the sorghums are grown in a section where high winds prevail, makes it difficult to keep them pure.

The kaoliangs cross very freely. Kafir does not seem to cross much even when planted close to other varieties. Darso seems to remain entirely pure.

The dates of planting will have a marked effect on the amount of crossing. From the standpoint of crossing it is best to plant not more than one or two varieties in a locality. A great advancement would be made if large areas, such as a county, would produce but one or two varieties of the sorghums.

But little or no attention has been given to growing the grain sorghums in separate fields, and in many cases the grain of different types has been mixed together either in threshing or intentionally after threshing. While most of such mixtures are used for feed, yet they are often sold as seed, and consequently it is very seldom that one will see a field of kafir or milo that is even relatively pure.

Most fields are usually very irregular in height and are badly mixed with cane or broomcorn. It is not uncommon to find a field which contains a mixture of practically every sorghum common to this region. While it is evident that such conditions are very undesirable, yet it might be well to mention a few specific reasons why such mixture is undesirable. Aside from the pure seed question, the unevenness of maturity, which results from planting mixed seed, and the unevenness of the height of plants constitute

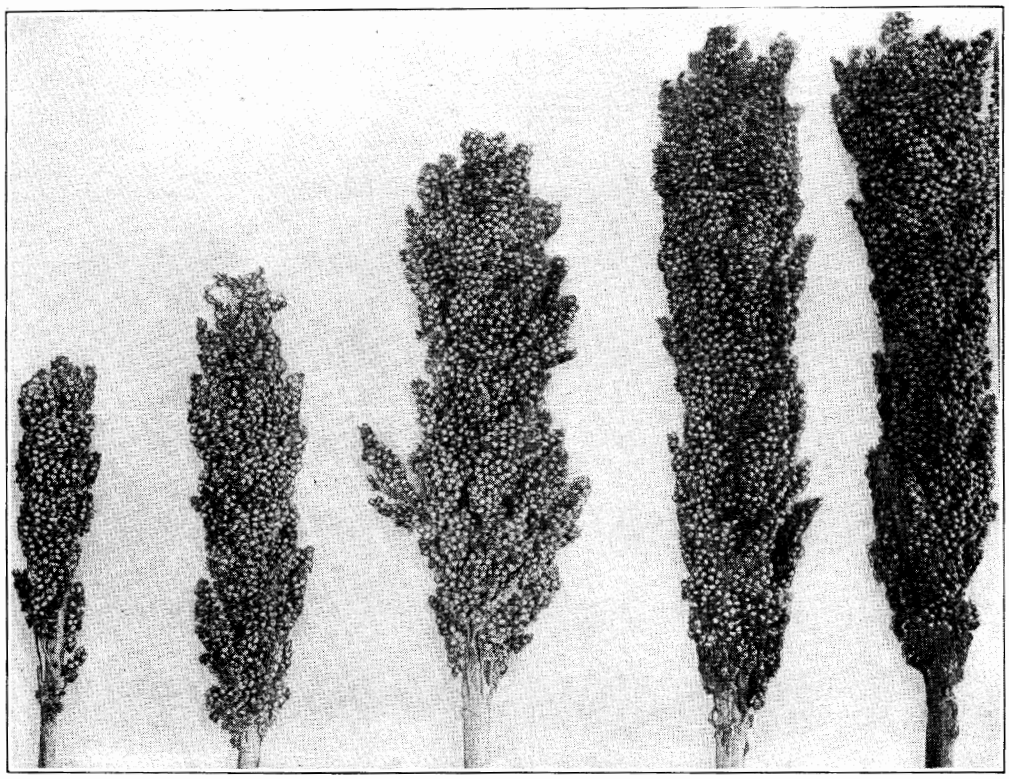

Figure 18.—Heads of Black Hulled Kafir, showing why seed should be bought in the head

the most serious objections. Grain of the sorghums when put on the market should be evenly matured and relatively pure in order to command the highest price. If the seed sown is badly mixed, the crop will not mature evenly, and consequently will have a lower market value.

Harvesting is an item of great importance in growing sorghums for grain production, and whatever means of harvesting is used, the more even the plants are in height the less will be the trouble and expense of the work. Several makes of harvesters have been put on the market for heading the crop in the field. The chief objections to the use of these machines are that they either cut off too much of the stalks or leave whole heads or parts of heads. If the plants were regular in height this objection would be overcome and the cost of harvesting materially reduced.

Procuring a Start of Good Seed

Before beginning the improvement of seed on the farm it is important that one should first **procure the best foundation stock possible.** There is no use in conducting several years of needless work if some one else has already made the desired improvement. The grower will be able to save much time if he starts with good, pure seed. It will pay to start with the best seed obtainable, regardless of the price. In procuring a start of good seed the reputation of the grower should be learned if possible, and one should know the methods he has used and the type or ideal of both head and plant that he had in mind for improving the crop.

Good seed can be obtained either threshed or in the head. Where the grower is known to be responsible, but little risk will be incurred in procuring threshed seed if the seed germinates well. Everything considered, it is

Figure 19.—Selecting seed in the breeding plot. Yield 56 bushels per acre, 1912

advisable to procure the seed in the head. If such seed is procured, a knowledge of the type and purity of heads can be obtained and individual judgment can be used in selecting from the lot received only those heads desired. Such seed is also more likely to be of good vitality since threshed seed heats very readily and requires a great deal of care in storing and drying to keep the germinating power from being seriously affected. The fact that poor stands of kafir and milo have been almost universal throughout the grain sorghum belt is undoubtedly due to a great extent to the use of seed which has been allowed to heat.

Improving the Crop

After a start of good seed has been procured, the grower is in a position to undertake not only to keep his seed pure, but also to improve the crop by selection for his own local conditions. Good seed, like good animals, will rapidly deteriorate unless given proper attention. The prevalent notion that after a start of good seed is obtained it needs no further attention, but will remain pure and continue to produce high yields indefinitely, is altogether wrong. The notion also that seed "runs out" and a change is necessary is as equally untrue. Deterioration of seed is not caused by the seed running out, but rather by the fact that impurities and immature seeds "run in" unless they are kept out by careful methods of seed selection. It is universally true that the best seed is produced under conditions where the

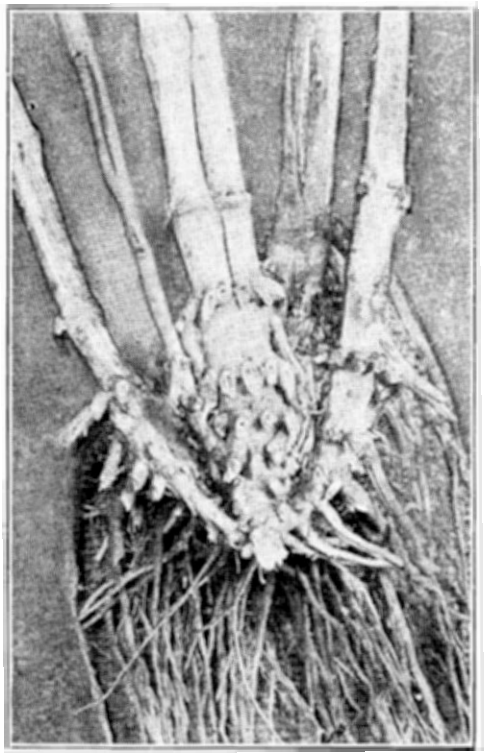

Figure 20.—Showing undesirable stooling

Figure 21.—Showing undesirable side branching

plants of that variety find the most favorable home for normal development.

In improving the crop, the question of what to select for and what method to use in selecting require consideration. This does not mean that the seed plots should be highly fertilized or given special preparation.

Valuable Characteristics.—There are certain definite characteristics that are desired in the grain sorghums. Chief among these are even height, early maturity, dwarf stature, well shaped, fairly compact heads, erect heads, freedom from stooling and side branching. While an enumeration of these characteristics is an easy matter, yet to make actual field selection which will result in establishing a strain possessing all these characters, is a problem far beyond the average grower and has not as yet been worked out by plant breeders. Many of these desirable characteristics seem to oppose one another. For example, early maturity is often accompanied by an unusual tendency toward suckering, and in the durras erect heads are usually smaller than those which are inclined or goosenecked. In spite of this there are certain fundamental things which the farmer can accomplish by exercising good judgment in making selections. He can keep his seed pure, maintain an even height of plants, avoid heads that are open and loose, and do something toward eliminating suckers and side branches. If the other characteristics mentioned are ever permanently established it will be through years of careful plant breeding. Considerable work has already been done by systematic plant breeding and local strains of dwarf kafirs and erect-headed

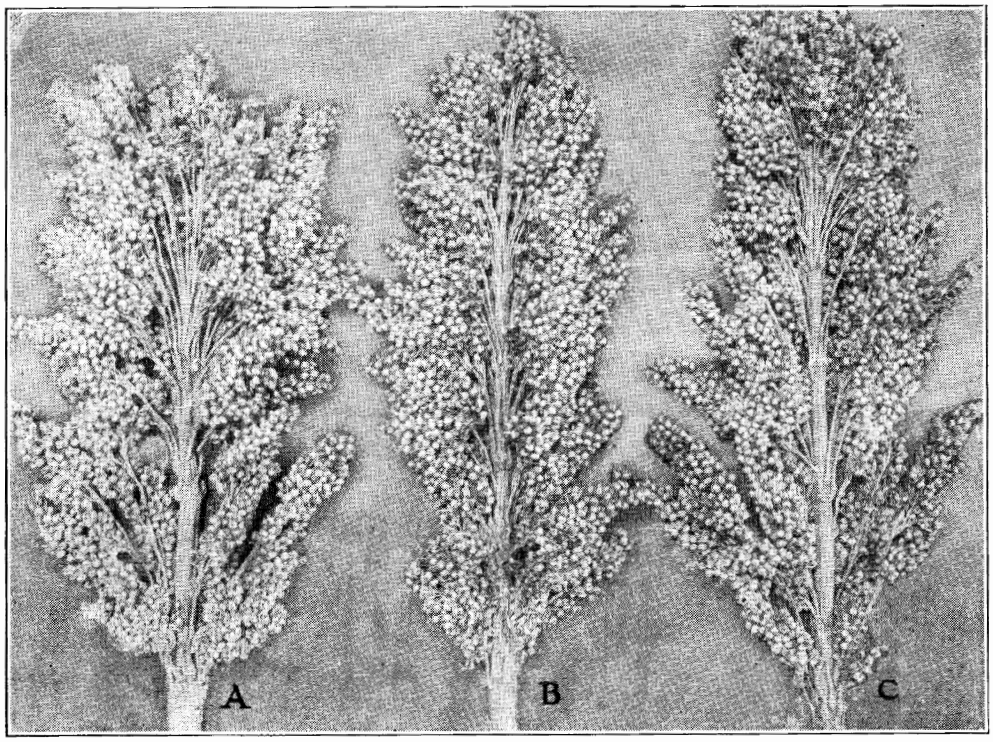

Figure 22.—Structure of Kafir heads: (a) Poor type of head; (b) good head; (c) Poor head

milos have been established. Whether or not these characteristics are permanently fixed has not yet been determined.

Drouth Resistance.—It has been almost universally contended that drouth resistance is a most important characteristic of the grain sorghums, and yet no one knows what constitutes drouth resistance. A great deal of investigational work has been done on this subject by the Oklahoma Experiment Station, United States Department of Agriculture and by the Western Experiment Stations. These investigations have involved the grain sorghums as well as many other so-called drouth resistant crops. No results either positive or negative have yet been obtained.

From a review of the work that has been done it would seem that drouth resistance is a condition rather than a definite characteristic, and that drouth resistance is affected by many specific characteristics which are not clearly understood. Drouth evasion, though often confused with drouth resistance, is a different matter entirely. Plants which grow rapidly and mature before drouth occurs are called "drouth evaders". This accounts for the fact that early maturity is such an important characteristic in the plants of the grain sorghum group. Plants which are dwarf in stature, or low-growing, usually mature earlier than the standard or high-growing plants, and consequently the development of dwarf strains is very important.

When and How to Select Seed.—To get the best results, kafir and other grain sorghums should be selected in the field before the grain is harvested. The best way to select seed is to go into the field after the heads are reasonably mature and with a sack suspended from the shoulder (a common cotton sack can be used to good advantage) pass between two rows and gather only those heads which conform to the type desired. In this way attention

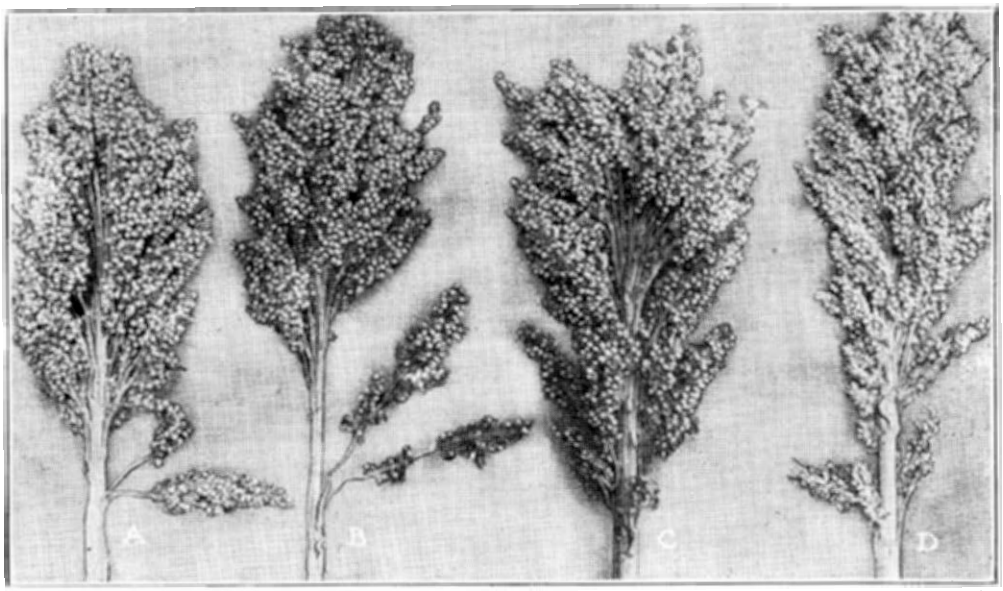

Figure 23.—Structure of Kafir heads: (a) Good seed branches; (b) poor seed branches; (c) poor top branching; (d) poor butt branching

can be given not only to the heads themselves, but to the height and general characters of the plants which produce them. The sack can be emptied at the ends of the rows and the next two rows can be gone over in the same manner. In this way not only can great discrimination be used in making the selections, but also a great number of desirable heads can be procured. The heads thus selected can then be again gone over, can be compared with each other, and only those possessing the desired characteristic and uniformity need be reserved.

Storing the Seed.—After the heads which are to be used for seed are selected they should be stored in such a way that they will not be injured by heating or molding, but will be thoroughly and rapidly dried out. Care should be used to prevent their being destroyed by mice and rats. The seed should be stored in the head. Tying the butts together in groups of two each and hanging them over a wire is a good practice. After the heads are thoroughly dry they can be placed in common burlap or grain sacks and suspended from the rafters, or by means of hooks in the ceiling. The important thing is to keep the heads thoroughly dry.

Testing for Germination.—If mature heads have been selected and they have been properly stored, there is little likelihood of the seed being low in germination. If such attention is not given the seed, or if there is any doubt about its condition, tests should be made. If seed is obtained from outside sources, it should invariably be tested for germination.

There are several cheap and effective methods for testing the vitality of the seed of the grain sorghums. The most important of these are: The common dinner plate method, the box method, and the "rag doll" method.

A common dinner plate is filled with clean, white sand. Dirty sand or soil should not be used as such material contains organic matter and the seed are more liable to mold. The sand is moistened by means of a common sprinkler or sprinkled with the hands. Air must enter the sand freely. Too much moisture should therefore be avoided. One hundred of the kernels taken from the seed to be tested are pressed slightly into the sand. To prevent excessive evaporation a second plate is placed in an in-

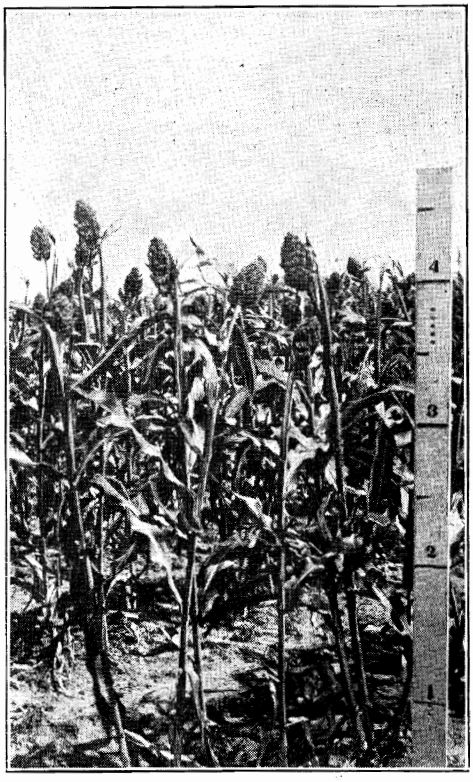

Figure 24.—Dwarf Yellow Milo. All heads erect. (Courtesy of C. R. Ball.)

verted position on the one containing the sand and seed. The tester should be kept in a room where the temperature is fairly constant. The temperature should be about 75° Fahrenheit. The seed should be observed every day and the moisture renewed whenever there is evidence that the sand is too dry. It will require about a week to complete the germination. The number of kernels which sprout will represent the percent of germination. A successful modification of the above method can be made by substituting blotters for the sand. If this is done, blotters should be placed both under and over the seed. More attention is necessary in this case in maintaining the proper supply of moisture.

The box method is used in testing individual heads. This is a commendable practice as it enables the grower to discard any head which is low in vitality. One head furnishes a considerable quantity of seed, and by discarding the heads which are poor in germination a high quality of seed is provided. For this method a box about 18 inches long, 12 inches wide and 1½ inches deep is used. This box is filled with clean sand. By stretching strings in both directions across the box it is laid off into squares of about one inch. These squares are numbered consecutively. The heads to be tested are also numbered. Five to ten kernels are taken from each head

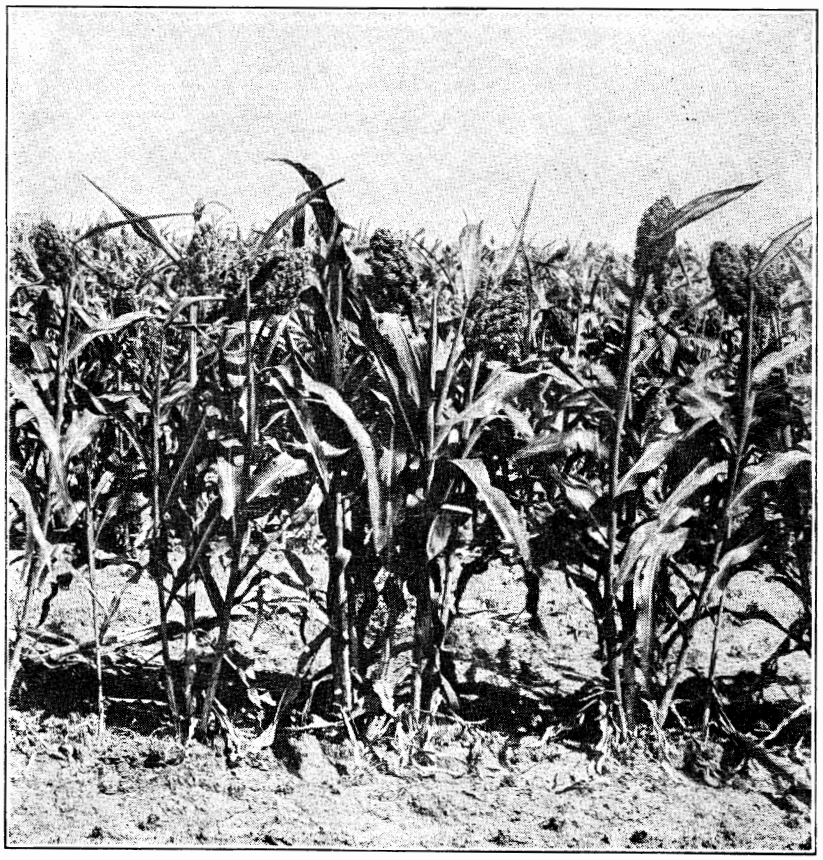

Figure 25.—Yellow Milo, showing results of selecting for erect heads. Part erect and part inclining.

and placed in the square corresponding to the number of the head. The sand is moistened and a cloth is placed over the box. After this the procedure is the same as in the preceding method.

The "rag doll" method was devised particularly for ear tests of corn, yet we have tried this method for kafir and have found that it can be used equally as well for kafir as for corn. Briefly described, this method is as follows: Strips of sheeting from 8 to 10 inches wide and from 3 to 5 feet long are procured. Each strip is marked into squares by means of a heavy pencil, making the squares about 3 inches wide. The squares are numbered consecutively beginning with one. After the strip is marked off it is moistened and spread out on a table or other smooth surface. The heads to be tested are numbered the same as the squares, and from five to ten kernels are taken from each head and placed on the squares which bear the number corresponding to that of the head. After all the squares have been filled the sheet should be rolled up. A broomhandle or similar piece of wood can be used as a core around which to roll the cloth. After the cloth containing the seed has been rolled, a strong cord should be tied loosely around the middle of the roll. As many rolls as are necessary can be made. The rolls are then placed in a bucket of water and allowed to soak for several hours. The water is then poured off and the rolls are covered with the bucket by turning it upside down. Provision must be made for the entrance of air. The test should be ready to count out in about a week.

———o———

STANDARD OF PERFECTION

In judging any sample, the score card is useful for the beginner. It calls to attention the important points to consider in selecting seed and also the comparative values of these different points.

It is necessary to have a "standard of perfection" or an ideal type in mind when either selecting seed or judging. There should be a standard of perfection for every type and for every variety. These standards are discussed following the score card, but it is thought best to give a brief summary here. It is not possible to work this data out in tabular form in detail owing to the great variations which occur within all types. There are no "fancy points" in this score card. Every character mentioned has a positive value and should be considered when selecting seed.

STANDARD OF PERFECTION

	HEAD			SEED				GLUMES		
	Inches Length	Circumference	Shape	Size	Shape	Color	Hardness	Hairy Smooth	Color	Length
Black Hulled Kafir	11	8	Cylindrical	Medium	Ovate	Gray White	Medium	Smooth	Black	Medium
Red Kafir	13	7	Cylindrical	Medium	Ovate	Reddish	Medium	Smooth	Red Brown	Medium
Pink Kafir	12	7	Cylindrical	Medium	Ovate	Pink	Medium	Smooth	Pink	Medium
Yellow Milo	6½	7½	Ovate	Large	Flat	Yellow	Medium Soft	Awned Smooth	Light Brown	Short
White Milo	6½	7½	Ovate	Large	Flat	Light	Medium	Awned	Light	Short
Feterita	9	7	Cylindrical	Large	Flat	Bluish White	Soft	Smooth	Varying	Short
Jerusalem Corn	6	7	Flattened Ovate	Large	Very Flat	Gray White	Hard	Awned Hairy	Gray White	Very Short
Brown Kaoliang	8	7	Ovate	Medium Large	Slightly Flat	Dark Red	Hard	Smooth	Reddish Brown	Medium
White Kaoliang	9	....	Open	Small	Ovate	White Glossy	Hard	Awned Hairy	White	Medium
Shallu	12	....	Open	Medium Small	Ovate	White	Very Hard	Awned Hairy	White	Long
Darso	11	7	Cylindrical	Medium Small	Ovate	Light Red	Soft	Smooth Awned	Red Black	Medium

SCORE CARD FOR GRAIN SORGHUMS

Head Samples

Points	Value	Score
Uniformity of heads and kernels	20	
Shape of heads	10	
Size of heads	5	
Arrangement of spikelets	20	
Shape of kernels	5	
Size of kernels	5	
Color of kernels and glumes	5	
Freedom from shattering	5	
Exsertion	10	
Market conditions	15	
Total	100	

Grain Samples

Points	Value	Score
Uniformity in size and color	20	
Shape and size of kernels	20	
Market condition	35	
Weight per bushel	25	
Total	100	

——o——

EXPLANATION OF POINTS

Head Exhibits

Uniformity.—The ten or more heads in the sample should be similar in size, shape and color. In considering this point the exhibitor should not consider any specific size, shape or color, but rather that all heads should be similar in each of these respects. Uniformity is important because it indicates carefulness and clear thinking on the part of the exhibitor, and it also conveys to the judge an idea of the methods practiced in producing the heads.

Shape and Size.—Each grain sorghum has desirable standards of size and shape. The heads of kafir should be cylindrical in shape and taper very slightly at base and tip. They should be about 11 inches in length and nearly 8 inches in circumference at the center.

The heads of milo should be ovate, tapering but slightly at base and tip. The length should be about 6½ inches and the circumference at center about 7½ inches.

The heads of feterita should be cylindrical, tapering strongly at base and tip. The length should be about 9 inches and the circumference at center about 7 inches.

The heads of brown kaoliang should be slightly ovate, tapering at base and tip. Length should be about 8 inches and circumference at center about 7 inches.

The heads of white kaoliang are irregular in shape, flaring and open; should taper strongly at base and tip. The length should be about 9 inches.

Arrangement of Spikelets.—The spikelets or seed stems should be close together in the common types of the grain sorghums, except shallu and white kaoliang. A compact head indicates a high percent of grain. The spikelets should lie close together, should be short and thickly covered with seed, both on the inside and outside. Low-yielding or light heads have few or no grains on the inside of the spikelets and on the lower half of the spikelets. The joints of the main spikes or seed stems should be short. Short jointed main stems, five or more joints in number, indicate a large number of rows of spikelets. This gives a high yielding head. The spikelets should not grow too nearly erect or close to the main stem, but should extend outward, but not to such a degree as to make the head flaring or loose. While a reasonable degree of compactness is desired, yet the head should not be overly compact, for in such heads injury from moisture is likely to occur. This is especially true when the crop is grown in the more humid sections.

Shape and Size of Kernels.—The kernels of the different grain sorghums vary materially in shape and size. The kernels of the kafirs are medium in size, and ovate or egg-shaped and slightly flattened. In feterita and Jerusalem corn, the kernels are large and strongly flattened. Brown kaoliang has fairly large, slightly flattened kernels, and white kaoliang has rather small, ovate kernels.

Color of Kernels.—The color of the kernels should conform to the type represented. The kernels of yellow milo should be reddish-yellow or brown with slightly darker colored glumes. Feterita kernels are white or bluish-white with glumes varying from almost black to almost white. White milo has light-colored kernels and glumes. In Jerusalem corn the kernels and glumes are almost white. Black-hulled kafir has black glumes and grayish-white kernels. Each kernel is characterized by a small pink dot at the tip. This dot becomes darker in color after the heads are dried. The kernels of red kafir are red or reddish-brown; the glumes are usually a little darker in color than the kernels. Pink kafir, as the name indicates, has pink glumes and seeds. The glumes are usually a little darker in color than the kernels. White kafir differs from the black-hulled kafir in that the glumes are white. The kernels of the white kaoliang are light and glossy, while the glumes are

white or nearly white. In brown kaoliang the glumes are dark reddish or reddish-brown and the kernels slightly lighter in color. Shallu has glossy, light-colored seed with light-colored glumes.

Freedom From Shattering.—Shattering is an objectionable feature in any of the grain sorghums. Shallu, feterita and Jerusalem corn are especially bad in this respect. In examining the heads of the exhibit one should shake them, and if many of the kernels shatter out the head should be discriminated against.

Exsertion.—The heads should be fully exserted from the boot or upper leaf sheaths. If the lower spikelets are not filled out, or are moldy, poor exsertion is indicated. Such heads are inferior for seed purposes.

Market Condition.—The heads and the kernels should be in good market condition. In other words, there should be no evidence of decay, smut, mold, immaturity, or anything else that would affect the selling price.

Grain Exhibits

Uniformity in Size and Color.—The kernels should be uniform in size and color, for such a condition indicates good breeding, careful selection, evenness of maturity and to a considerable extent suitable conditions for storage.

Shape and Size of Kernels.—The kernels should be full-sized for the type represented, neither shriveled nor otherwise misshaped. The shape of kernels in the different types of grain sorghums should comply with description given under explanation of this point under "Head Samples".

Market Condition.—The grain should be sound and free from dirt, must and foreign material.

Weight Per Bushel.—The weight per bushel varies slightly with the different types—no standard weights have been adopted for any of the grain sorghums. Kafir weighs approximately fifty-six pounds per measured bushel, and this weight is almost universally established. The weight used for kafir is adopted in practically all the local markets for all other grain sorghums.

When the sample is being scored for seed purposes, as is usually the case at fairs, it should be carefully examined for mixtures, molds, immaturity, heating, smut and decay. If any one of these conditions are found the sample should be discarded, for such samples are absolutely unfit for seed. Such affected samples ought never be given a premium at a fair.

It is not to be expected that samples will receive a perfect score in other respects, but these points should be perfect. For these reasons these points are not listed on the score card.

SHELLING PERCENT

There is no legal or standard weight for the grain of the sorghums in Oklahoma. The customary basis for selling these seeds is fifty-six pounds per bushel. Actual tests usually show fifty-four pounds per bushel. This weight, of course, varies.

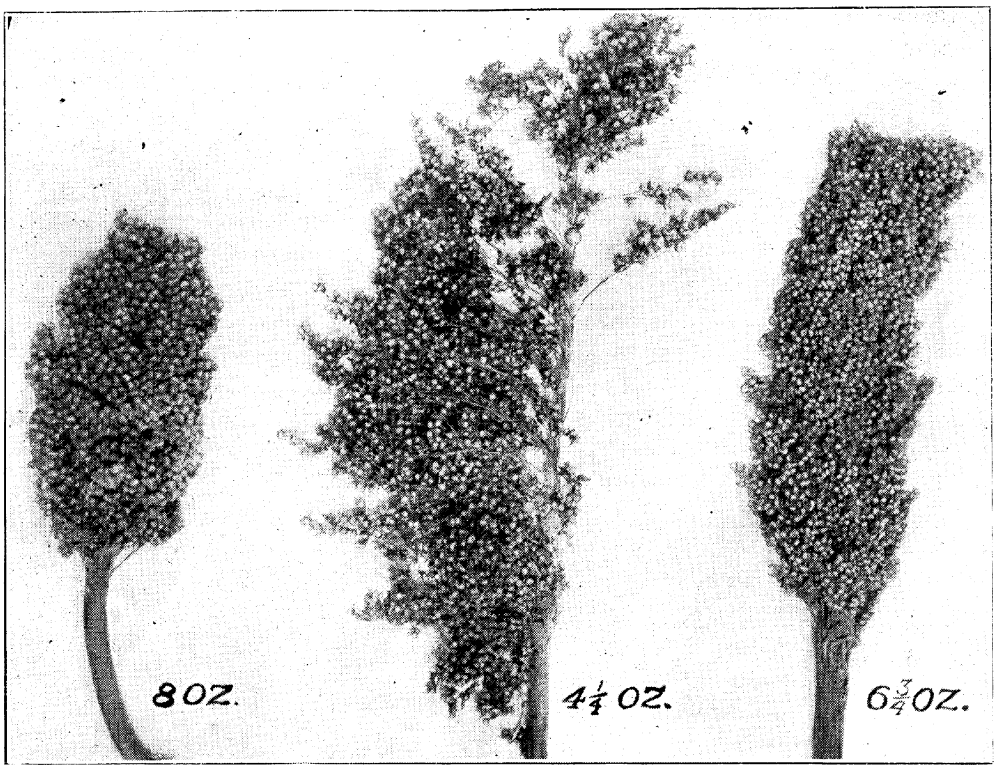

Figure 26.—Showing comparative sizes and weights of three Grain Sorghum heads. This indicates one reason why the yield of Shallu is so often overestimated

We have in this connection run a large number of tests to determine the threshing percent of kafir and milo heads. The results of these tests show an average of 77% for kafir and 84% for milo. These percentages will vary, depending upon filling of heads and amount of stems left when heading.

These tests show that it requires approximately sixty-six pounds of milo or seventy-three pounds of kafir in the head to thresh out fifty-six pounds of grain.

In uneven fields of mixed varieties where heading must be done low, the shelling percentages given would probably prove a little high. They will, however, prove to be accurate enough for ordinary estimates when the height is fairly uniform and the heading is done with reasonable care.

CLIMATE

Grain sorghums seem to do best in a rather dry, hot climate. They will not grow well in high altitudes owing to the cool nights. Great difficulty is met in curing these crops where the fall rains are abundant.

The climatic conditions where grain sorghums do best demand that the soil be properly tilled. They will respond to good treatment and good culture. Good cultivation of the soil in the grain sorghum belt is of far greater importance than where the rainfall is relatively abundant.

———o———

SOILS

There is great variation in the soil types found in the grain sorghum belt. It varies from light "blow" sand to heavy waxy clay. These variations often occur within small areas.

Different types of soil must be handled differently. Heavy clay soils must be given better care than sandy or loamy soils. It is almost impossible to harm sandy soil, while the proper physical condition of clay soil is easily destroyed.

The following discussions do not refer to soils which blow. Such soils are treated under a separate heading, "Blow Soils".

In the discussion on soil the terms "heavy soils" and "light soils" are used in accordance with their common usage. By heavy soil is meant one which has fine grains, is easily puddled and is hard to plow if too wet or too dry. Light soils are those which till easily. The facts are that sandy soil weighs more than an equal volume of clay soil.

Fertility

The soils of the semi-arid section are almost invariably rich in mineral plant food elements. The fertility can be easily maintained if the crops are rotated and a good content of organic matter is maintained. Low yields will seldom be due to an insufficient supply of the mineral element of fertility.

It is well to call to attention the notion prevalent in the grain sorghum belt that kafir and other sorghums are hard on land. While there is good reason for this general opinion among growers, yet the cause is due to the methods used in handling the soils rather than to the crops themselves. Since these crops require about the same amount of the different elements in proportion to the dry matter produced as do other staple farm crops, it is evident that the basis for this notion is due to causes other than the exhaustion of plant food. The fact that kafir has been grown continuously for a number of years in many sections of the Southwest, without producing more injurious effects than the continuous culture of wheat, is sufficient evidence to prove that, if proper attention is given to handling the soil the sorghums can be produced without any more rapid deterioration of the soil than is brought about by the production of other crops.

The grain sorghums, because of their nature and the conditions surrounding their successful production, require that more than ordinary attention be given to the management of the soils upon which they are grown.

Importance of Soil Moisture

Throughout most of the grain sorghum belt production is limited by an insufficient supply of moisture and not by deficient soil fertility. Moisture is the limiting factor. The natural fertility of the soil is above the average, because the loss of plant food by leaching and erosion is small, and the crop yields are often low.

The most important thing is to maintain a good physical condition of the soil. While the grain sorghums are drouth resistant, yet it must be borne in mind that while this characteristic adapts them for regions of little rainfall, long periods of drouth and hot winds, yet it does not imply that they will not respond to greater supplies of moisture if it is properly distributed throughout the season. It must also be remembered that drouth resistance does not necessarily imply that these plants use materially less moisture in their growth, but has reference only to their power of enduring severe periods of drouth without being destroyed.

It is a matter of common experience in the regions where the grain sorghums are principally grown that these crops increase in production as the moisture is increased until the limit for the normal production of most crops is reached. It is not necessary to go into detail in discussing the uses of water in plant production, but it might be well to summarize these uses. Plants obtain all their moisture from the water in the soil. Water is a universal solvent and the mineral elements of plant food must be dissolved before the plant can use them. Water contains two essential elements of plant food. Water furnishes a circulatory medium by which the plant food is carried throughout the plant tissues. Moisture is necessary for the growth and multiplication of the soil bacteria.

Most of the soil types represented in the grain sorghum belt are deficient in organic matter and consequently are low in total water-absorbing capacity. To increase the organic matter is, therefore, deserving of careful consideration.

To store moisture in the soil it is necessary to handle the soil in such a way that it will readily absorb as large a percent as possible of the precipitation. While the general principles involved in storing moisture are more or less universal, yet they will vary in many important respects according to the types of soil involved.

Evaporation

All the water absorbed by soils is lost by either percolation or evaporation. Evaporation occurs from the surface of the soil or is given off through the leaves of plants. The latter in the grain sorghum belt is of little importance, yet it has an important bearing on the rate of planting. It is an important reason why no weeds should be allowed to grow.

Evaporation in the territory being considered is much larger than the annual rainfall. In fact, an arid region may be considered one in which, under natural conditions, much more water evaporates annually from a free water surface than falls as rain or snow.

The western half of the grain sorghum belt has an average annual rainfall of from ten to twenty inches; the eastern half from twenty to thirty inches. Wisconsin, Northwestern Iowa, Eastern South Dakota and Nebraska have the same rainfall as the eastern half of the sorghum belt. Practically all of the Dakotas have the same rainfall as the western half of this belt. The States just mentioned do not normally suffer severely from drouth, while there is seldom a year during which the grain sorghum belt is not seriously affected. While hot winds have something to do with this condition, yet the chief cause is evidently due to the excessive evaporation from the surface of the soil.

The great injury done by drouth in the grain sorghum belt cannot be attributed to the lack of a sufficient amount of annual rainfall for, as just mentioned, sections receiving no greater moisture produce crops without suffering from drouth. The fact that the grain sorghum belt suffers from drouth cannot always be attributed to an improper distribution of the rainfall, for the average records show that over 75% of the rainfall occurs during the growing months.

In reviewing the causes of evaporation previously mentioned, it is noted that dry atmosphere, high temperature, sunshine and wind velocity are agencies that cannot be controlled. While on the other hand, the structure can be materially affected and the organic matter controlled. Upon the handling of these factors depends the "Conservation of Soil Moisture".

Capillarity

Practically all water lost by evaporation from the soil occurs at the surface. In order to be evaporated, therefore, water must be brought to the surface.

Each soil particle is surrounded by a film of moisture that depends in thickness upon the amount of water in the soil. The movement of this moisture in the soil is a result of capillarity.

Capillary action varies in soils according to the structure and the texture. The texture or size of the soil particles does not alone determine capillarity, but it is also greatly affected by the structure or arrangement of the soil particles into crumbs. If the soil particles are in lumps or granules, more open spaces will be present and consequently the capillary action will be lessened. The compacting of the soil or bringing together of the soil particles increases capillarity; while cultivating, by decreasing the number of points of contact of the soil particles, decreases capillarity. A compact soil will, therefore, much more readily evaporate water from its surface than will a loose one. It must be remembered in this connection that if the entire surface soil is loose and open, very little of the moisture from the subsoil will be brought to the surface soil for the use of the plants. In prevent-

ing evaporation the important thing is not to keep the soil loose to a great depth, but to keep the surface soil only in such a condition. The problem of preventing evaporation involves the different methods used in maintaining this surface condition of the soil.

Mulches

Any coarse material, such as barnyard manure, straw and gravel decreases evaporation. While these mulches are of importance in intensive forms of agriculture, yet they are of no practical value in maintaining moisture for the production of the grain sorghums.

Dirt Mulches.—A layer of dry soil acts in the same manner as a layer of any of the artificial mulches mentioned, but to a less degree. Their use is of great practical value. Several factors are involved in maintaining a dirt mulch, chief among which are the depth, frequency of renewal, and the structure and texture of the soil of which the mulch is made.

The deeper the mulch the more effective it is. This is brought out in the following table:

TABLE VII

Showing the Effectiveness of Soil Mulches of Different Thicknesses.

	WATER LOST PER 100 DAYS				
	No Mulch	Mulch 1 In. Deep	Mulch 2 In. Deep	Mulch 3 In. Deep	Mulch 4 In. Deep
Inches of water	817.6	407.2	366.4	307.6	292.1
Tons of water per acre	7.20	3.59	3.23	2.72	2.58
Percent saved by mulches over no mulch	.....	50.2	55.6	62.2	64.2

The results in the preceding table show but a relatively slight increase in the amount of moisture retained as the mulch was increased from two to four inches. Yet it should be mentioned that this experiment would not give accurate results for drier conditions where the surface soil is deeper. Under the latter conditions such an increase in the depth of mulch would certainly show a greater difference in the reduction of evaporation.

In the humid regions where rains occur at intervals of from one to three weeks the feeding roots may usually be found within a few inches of the surface, while in the semi-arid region where no water enters the soil oftener than from one to three months the roots necessarily vegetate at lower depths and hence the protective surface mulch can and should be of greater thickness to prevent the penetration of excessive heat and dryness during the long intervals. A shallow mulch is less desirable as it is more readily destroyed by light showers. A mulch of three or four inches is more efficient and can be maintained with fewer cultivations.

In semi-arid and arid sections the available plant food material is more

evenly distributed among the upper and lower soil layers, and consequently a deep mulch can be maintained without reducing the feeding area of plants.

The soil type will largely determine the most effective depth under specific conditions. A fine clay or clay loam soil requires a deeper mulch than a coarse or loose sandy or sandy loam soil; loams are intermediate between the two. The first type has greater capillary power and it is accordingly more difficult to maintain a good mulch. The second type has much less capillary power and is normally loose.

It will be seen that the depth of the mulch in the grain sorghum belt should vary from two to three inches in depth in the eastern part to three or four inches in the extreme western.

Considering all factors affecting the depth of mulches it is seen that, after seeding, as deep a mulch as possible should be maintained without interfering with the root development. Mulches made before planting or after the crop is harvested should be from two to four inches in depth, depending upon local soil and climatic conditions.

Frequency of Renewing the Mulch.—The value of a mulch depends not only upon its depth, but also on how often it is renewed. Just how often a mulch should be renewed depends upon the type of soil and the frequency of rain.

The mulch should be renewed oftener on clay soils than on loam or sandy soils. Rainfall, even though light, destroys a mulch, and it is necessary to renew the mulch after every rain, just as soon as the surface becomes dry and a crust begins to form. On sandy or other loose soils the mulch can be renewed much sooner after a rain without injury than on clay or other compact soils. The latter types must be fairly dry before any cultivation is done in order to avoid injury from puddling.

Whether rains occur or not, the mulch should be renewed as often as necessary to maintain a loose, well pulverized, dry layer. Once every two weeks is considered a good average for nearly all soils in this belt.

In making a dirt mulch it is desirable to develop a fine, granular structure. A fine "dust" mulch is not the object sought and should be avoided if possible.

Methods Used for Maintaining Soil Mulches.—Any implement or device which will serve to pulverize the soil to the depth desired may be used for establishing a mulch. Many specially constructed tools have been placed upon the market for this purpose.

Devices which will cover a large surface quickly and cheaply, such as smoothing harrows, disk harrows and drags should be used previously to planting, and the smoothing harrow can often be used to good advantage for some time after planting or until the plants are of such a height that such treatment would injure them. If the crop is planted in the bottom of the lister furrow, the drag can be used to a much later date than when flat planted. The cropping should be planned so that these tools can be used as much as possible. After the plants have made considerable growth a two to four-shoveled cultivator, disk cultivator or a single-horse five or nine-

tooth cultivator is used. Usually the disk cultivator or the straddle-row cultivator is used early in the season as less evaporation occurs at this time and these implements will pulverize the ground deeper and more readily destroy weeds. Later in the season when the main object of cultivation is to maintain a surface mulch, the five or nine-tooth cultivator or single drag will better serve the purpose. Mower wheels and plank harrows are commonly used. Where blowing does not occur the soil should be left as smooth as possible.

———o———

FALL AND WINTER PLOWING

The grain sorghums leave the soil not only practically devoid of water, but also in a poor condition to absorb and retain succeeding rains and snows. As previously noted, this accounts for the prevalent belief that these crops are "hard on the land". The important problem in handling grain sorghum soils is, therefore, to give them every opportunity to readjust themselves.

Contrary to the usual practice of allowing these crops to remain in the field until late in the fall, they should be harvested early and the plowing should follow as soon as possible.

When late harvesting is practiced, plowing cannot be done earlier than the first of November. Most of the moisture which falls between the time of maturity and this date is lost by runoff and evaporation. It would seem advisable from a moisture standpoint to harvest the crop as soon as it is thoroughly mature, making it possible to plow many weeks earlier. It is better, however, to allow the crop to remain in the field until late in the fall rather than harvest the entire crop early in the season and permit a second growth to come on, for this second growth draws very heavily on the already deficient moisture supply.

If harvesting is done early and circumstances are such that plowing is impossible, it is advisable that at least the stubble be thrown out by means of a lister or some other device. This will prevent a second growth.

After a grain sorghum crop the soil is dry and hard, and when plowed will often turn up cloddy. It has been claimed by some that the turning up of clods is injurious. Experience fails to bear out this assertion, for the action of weathering during the fall and early winter will, in practically all cases, break down the clods and leave the soil in a good physical condition. It is usually very difficult to plow such soils in the fall on account of their being so dry and hard. In fact, it is often impossible to use a moldboard plow. In such cases the disk plow, because of its ability to work under such conditions, serves a good purpose. Regardless of the difficulty involved in plowing in the fall, there is every reason to believe that the farmers will be well paid for the extra effort and expense incurred.

Fall plowing is also important on account of the relatively low annual precipitation and its uneven distribution in portions of this belt. The grain sorghum grower should use every means for storing as much as possible of this moisture.

While the soils are usually dry in the fall, yet there are occasional years when considerable rainfall occurs, and in such years the farmer can take advantage of the situation and plow as much as possible with a moldboard plow. In the sandy or clay loam soils there is hardly a year when the moldboard plow cannot be used.

Aside from the effect upon the moisture-absorbing and retaining power, fall plowing will be of great advantage in increasing the amount of available plant food materials, combating insects, and will more evenly distribute farm labor.

Many injurious insects, such as cutworms, corn ear worms or cotton bollworms, enter the soil early in the fall and pass the winter in the pupa or first stage of development a few inches below the surface. By plowing in the fall or early winter the winter quarters of these insects are destroyed and they are exposed to the destructive effects of freezing and thawing, and as a result great numbers of them are destroyed.

One of the chief factors in successful farm management is to divide the farm labor as evenly as possible throughout the year. As a usual thing the fall and winter is a period of few farm activities compared to the spring and autumn. All labor, therefore, that can be performed in the fall and winter will greatly assist in lessening the amount of labor in the early spring. Under normal conditions, when a soil is plowed in the fall or winter, disking and harrowing will be all that is necessary to prepare the seedbed for the spring seeding.

The soil that is plowed in the fall and winter should not as a usual thing be harrowed, but should be left rough. The objects of harrowing are to pulverize the surface soil, to compact it and to prevent evaporation. Normally when soils are plowed in the fall and early winter they contain relatively little moisture. To harrow at this time would result only in pulverizing the surface soil, causing it to bake or crust, and as a result not only greater evaporation would occur, but it would also prevent the absorption of a great deal of the moisture which might fall either as rain or snow. The evaporation might be excessive in the case of early plowing, but it is of little consequence in late fall or early winter plowing as the evaporation at this period amounts to but little.

Harrowing also reduces the surface exposed and as a result lessens the amount of weathering; it also compacts the soil and prevents to some degree the good effects of freezing and thawing. This is particularly true in the case of the "hard" lands and so-called "runny" soils which are so prevalent in this belt. While the types of soil which are here considered are not "blow" soils, yet there are no soils in this belt but what suffer to a more or less extent from blowing. Harrowing in the fall and winter certainly would increase the tendency to blow.

If spring plowing is practiced, it should be done as early as possible in order that the seedbed may have sufficient time to become firm before the seeding is done. In plowing in the spring the problem is not so much one of conserving soil moisture as that of preparing as good a seedbed as possible. In fact, such plowing invites rather than prevents the effects of drouth.

It is important in spring plowing to avoid working the soil when it is wet, for if it be plowed under such conditions it will run together or "puddle", and as a result only be more difficult to handle and will also readily lose moisture by evaporation.

Spring plowed land should be harrowed immediately after plowing in order to compact and pulverize the soil and form a "dirt mulch", thereby preventing evaporation.

Depth of Plowing

Many surface soils become deficient in such essential plant food elements as calcium and potassium, especially by leaching, while their sub-surface soils may be well supplied with these elements. By deep plowing these lower layers of soil are incorporated with the upper layers and as a result more food elements are brought within the reach of the plants.

The water-holding capacity of a soil depends materially upon the looseness or compactness of the granules. The looser the soil the greater the amount of pore space and consequently the greater capacity for taking up water. The deeper the plowing, therefore, the greater the depth of the pulverized layer of soil and the greater the total water-holding capacity. Table VIII indicates the comparative amounts of water that loose and compact soils will hold.

TABLE VIII

Absorbing Capacity of Loose and Compact Soils

Soil	Condition	Percent of Water Taken Up
Clay Loam	Loose	40
	Compact	20
Silt Loam	Loose	41
	Compact	14
Medium Sand	Loose	23
	Compact	20

These results show that a loose, clay loam took up twice as much water as the compact clay loam, and that the loose silt loam took up about three times as much as the compact silt loam. While in the case of the medium sand there was comparatively little difference between the loose and compact conditions.

The only important experiment to determine the proper depth of plowing on soils characteristic of those of the grain sorghum belt was conducted at Oklahoma Agricultural Experiment Station. This experiment was begun in 1907 and continued for four years. While the experiment was made with wheat, yet the results are undoubtedly applicable to other crops as well. In this test, one series of plots was prepared with a disk harrow and seven other series were plowed to depths of three, four, five, six, seven, eight and nine inches, respectively. It was found that the lowest average yields—ten

bushels per acre—were obtained from the disked plots, and the heaviest average yields—about sixteen bushels per acre—were obtained from seven, eight and nine-inch plowing. This experiment was conducted on fine silt soil, very low in organic matter, which readily runs together, and as a result the effects of deep plowing was soon lost.

In discussing deep plowing, we have reference to semi-arid and arid soils. Most of the soils in the grain sorghum belt, like nearly all of the semi-arid and arid soils, have no great differentiation between the surface and subsoil. This is due to the low annual rainfall and consequent little leaching of the plant food. As a result, when the subsoil is brought to the surface and incorporated with the surface soil, it does not materially change the proportion between the amount of available and unavailable plant food elements.

The most profitable depth of plowing depends primarily upon the type of soil. Sandy soils and loose, sandy loam soils are normally loose enough as indicated in Table VIII. Tight clay and silt loams, because of their strong tendency to run together, do not respond to deep plowing unless large quantities of organic matter are incorporated. The organic matter is necessary to maintain a loose structure.

At the Oklahoma Experiment Station soils of a silty character were plowed to a depth of five, ten and fifteen inches. Just previous to the plowing each year samples were taken to a depth of fifteen inches in each series. In each case for three successive years it was found that the soils which were plowed to a depth of fifteen inches were just as hard and compact in structure as those which were plowed to a depth of five inches. There was no residual effect upon the soil from deep plowing. The effect entirely disappeared at the end of the first season. It may be further stated that in plowing the second and third years that the five-inch plowed plots were just as easily turned as were the ten and fifteen-inch plowed plots. This leads us to believe that extra deep plowing, that is, over seven inches, is not profitable on this type of soil.

There are considerable areas of "tight" land and soils underlaid with loose, sandy subsoils. In neither of these is it practicable to plow deeper than seven inches.

The soils which are underlaid with a deep, sandy subsoil should not be plowed deeply because such plowing only tends to increase the porosity or openness of the subsoil, which already is so loose and open that it permits a large amount of the water to be lost by percolation. On practically all other soils found in these groups deep plowing should be practiced. The depth of plowing depends upon the profits. The proposition is, how deep can you plow and make it pay.

When improved methods of farming are advocated there are always plenty of men to take the matter up and deal with it on the principle that "if a little is good, a whole lot more is better". Deep plowing has had its full share of these advocates, and we often hear it stated, both in the press and on the lecture platform, that any kind of soil should be plowed deep—the deeper the better. While no particular limit is usually set, yet twenty

inches or more is not uncommonly recommended. While such enthusiasts mean well, yet they are like all others belonging to that class—they usually do the cause more harm than good. More complete trials and experimentation are required on this subject before any definite depth of plowing can be positively advocated.

The depth to which plowing can be profitably done depends a great deal upon the type of soil involved. The heavier the soil the more expensive the operation. Plowing can be done to a depth of nine inches with a common moldboard plow. To plow deeper than this on average soils requires specially constructed implements, several makes of which are now on the market. In plowing with a common moldboard plow the sub-surface soil is brought to the surface and the surface soil is thrown over on the bottom of the furrow slice; in this method the sub-surface and surface soil are not well mixed. In the so-called deep tilling machines or deep furrow plows, disks are used instead of moldboards, one disk following directly behind the other. This results in more thoroughly mixing the lower and upper layers of soil than in case of the moldboard plow. The average depth at which plowing is done is approximately five and one-half inches.

The cost of plowing increases practically in proportion to the depth until the impervious sub-surface layers are reached. When these are penetrated the cost increases in a much greater proportion. From the results of depth of plowing tests it was found that it cost from three to four times as much to plow fifteen inches deep as it did to plow seven and one-half inches deep. This means that it costs from $3.75 to $5.00 per acre. The soil on which these tests were conducted is underlaid with a tenacious, impervious subsoil. Where the subsoils are more open and friable the cost would be materially reduced.

It is not our object to discourage the practice of deep plowing, for we are convinced that it will pay when used within reason, but we wish to emphasize the necessity for each farmer to practice deep plowing according to his own specific soil conditions.

Subsoiling

A great deal has been said both for and against subsoiling. By subsoiling is meant the loosening of the soil to a greater depth than can be done by the use of the common plow and without bringing the sub-surface and subsoil to the surface as in the case of the deep plowing machine.

The work is performed by a subsoil plow which follows behind and in the bottom of the furrow opened by an ordinary plow. By the use of this tool the soil can be loosened to an additional depth of six to twelve inches. The theory upon which subsoiling is based is that by this practice the subsurface and upper subsoil will be loosened, and as a result will not only increase the feeding surface and the ease of penetration of the plant roots, but will also make the percolation of the water easier, and in the case of clay soils increase the total water-holding capacity.

Not only the work of this Station, but all tests in the Southwest, so far

as reported, agree in indicating that subsoiling is not a profitable farm practice.

Subsoiling is such an expensive practice that it cannot be profitably adopted as a regular farm practice unless materially increased yields result.

In the soil moisture studies so far made it has been found that subsoiling has not increased the moisture content of the soil. Subsoiling does not pay on the soils of the Station farm.

Listing

As a general farm practice, listing is only a substitute for plowing. Since moisture is the limiting factor in plowing as well as in crop production in the grain sorghum belt, early listing is often profitably used. Listing should be done as soon after the crop is removed as possible for the same reasons that early plowing should be practiced. Where large areas are handled and it is desirable to stir the largest possible area, listing will be found advisable.

Listing leaves a great deal of the surface of the soil undisturbed, consequently the beneficial results obtained by the absorption and storing of water and the liberation of plant food elements is much less from listing than from plowing.

The practice of "busting" the middles or double listing more nearly approaches the results obtained by plowing and is, therefore, decidedly better than single listing.

Listing on unplowed land in the spring is a half way method of preparing a seedbed and is never advisable except on soils of an exceptionally open, sandy nature which have been well tilled during the previous year. Listing with a seeder attachment is often a good practice, provided deep plowing has been practiced in the fall or winter and the bottom of the listed furrow does not reach or penetrate into the unpulverized sub-surface soil. Spring listing as a method of seeding will be discussed under the subject of "Planting".

Disking

In the grain sorghum belt the land is often so dry in the fall that plowing is almost an impossibility. In such cases disking can be profitably practiced as a preliminary operation to plowing. If disking is done early the soil will be left in such a condition as to absorb more of the precipitated moisture than it would otherwise do. It will often be possible to plow the disked areas to much better advantage than if they were not disked.

The disk harrow is essentially a surface tool, intended to pulverize the surface soil and to make a soil mulch rather than a water reservoir. Disking cannot make a proper water reservoir in the soil and cannot give the plant roots a satisfactory feeding area.

HANDLING "BLOW" SOILS

The preceding discussion concerning storing and conserving soil moisture does not apply to certain types of soils commonly known as "blow" soils. In tilling blow soils the governing factor is to prevent erosion by winds, although moisture conservation is important. In treating this subject, therefore, this point alone must be considered.

Injury to soils from blowing is experienced to some extent in practically all sections of the Southwest. In many localities west of the 97th meridian the prevention of blowing constitutes one of the chief problems in soil management. This is especially true in the loose, sandy soils.

In handling "blow" soils there are three important things to be considered. The surface must be kept rough. It should be protected by a growing crop, a crop residue or artificial mulches such as straw and barnyard manure. The texture of the soil should be modified by the addition of organic matter in the form of barnyard manure or green plant growth.

The methods to be used in keeping the surface rough will depend upon the crop grown previously and upon the rotation practiced. Where wheat is to follow kafir or other grain sorghum (if kafir has been well cultivated) it will be well to leave the stalks on the field and to drill the wheat between the rows. Late in the fall or early winter the field may be gone over with a stalk cutter, and in this way the dead kafir plants will protect the soil until the wheat has formed a good covering. Where kafir follows wheat or other small grain the soil should be stirred as soon as possible after the crop is harvested in order to conserve the moisture. When stirred at this time, single listing should be done and the listed furrows should run east and west, as the prevailing winds are from the south and southwest. On these soils it is usually not necessary to "bust the middles" until the following spring.

After the land is listed it should receive no further treatment so far as cultivation is concerned until spring. In the spring the middles should be "busted" and the land disked. So far as preventing blowing is concerned, it is better to plant in listed furrows. When this method is used, if the soil is hard or weeds have started, it may be advisable to disk, but in the loose, sandy soils, which are the ones usually affected by blowing, disking is not necessary. If disking is done, the listed furrows should again be run east and west as in the fall. In cultivating, the ridges should not be leveled too rapidly, but should be left as prominent as possible until the plants have made sufficient growth to retard blowing. After this time less attention is necessary to prevent blowing.

The land should never be plowed and left flat, either in the spring or in the fall, and when any flat area is not protected by a growing crop, or crop residue, it should be listed at once. When wheat is grown and patches in the fields begin to blow, as is quite likely on the higher elevations or knolls, they should be covered as much as possible with straw, barnyard manure or other kinds of organic matter. Blowing usually begins in small patches and preventative measures should be used immediately.

Organic matter in any form when incorporated with loose soil tends to cement or bind its particles together and will greatly reduce the tendency to blow. This does not imply that heavy coats of manure, straw or grain crops should be plowed under, as in many sections there is not enough moisture in the soil to decompose this material and as a result the tendency to blow is increased rather than decreased. Where this is true, great care must be exercised in increasing the organic matter not to add very large amounts at one time, but rather to increase the organic matter in the soil gradually.

In some seasons rains occur during the late summer or early fall. These rains cause great numbers of weeds to spring up, and sometimes the weeds make considerable growth before frost, if not previously destroyed by cultivation. While such a growth will draw quite heavily on the soil moisture, yet it is often advisable to let them grow in order to prevent blowing.

Soils which have been allowed to blow for several years are much more difficult to handle than those which have been carefully managed. It is a common saying that when a soil once starts to blow, it is almost impossible to stop it. Greater care must be exercised in tilling such fields.

———o———

ROTATIONS

Crops may be grouped into different classes according to their habits and characteristics. The culture is practically the same for all crops belonging to a particular class. The habit of growth, the rooting system, the feeding of the plant, and seed production does not vary to any extent in any of the different classes of crops. The different crops grown in Oklahoma may be classified as:

1. Cereal Crops.
2. Cultivated Crops.
3. Grasses and Legumes.

In working out a rotation these classes of crops should be given consideration.

A rotation should be so arranged that one class of crops follows another class, and where the grasses and legumes are not commonly grown, some crop such as cowpeas should be used as a catch crop for green manuring purposes.

Briefly stated, the fundamental principle of crop rotation is to change from one class of crops to another, and not from one crop to another of the same class. A change from wheat to oats, or from corn to cotton is of little or no value.

It may be said that grain crops are all soil robbers, cultivated crops are soil cleaners, and grasses and legumes are soil builders. When these facts are taken into consideration the value of a rotation is easily understood. It is also easy for each farmer to work out a rotation suitable to his style of farming. The following suggestive rotations may be used, with proper modifications in different parts of the State:

North Central
1. Kafir
2. Cowpeas
3. Wheat
4. Wheat

Northwest Corner
1. Kafir
2. Cowpeas
3. Wheat

South Central
1. Cotton
2. Corn or Kafir
3. Oats

Southwest Corner
1. Kafir
2. Cowpeas
3. Wheat (Cotton)

Any grain sorghum may be substituted for corn or kafir. Wheat may be grown instead of oats, and cowpeas may be grown as a primary crop, or in favorable portions of the State often as a catch crop. In all cases it should be kept in mind to alternate from one class of crops to another.

In the rotations suggested, cowpeas occupy an important position. Yet it is doubtful if it would be a successful practice for any farmer to plant one-third of his cultivated land to cowpeas every year. It probably would pay well on a farm devoted largely to livestock, but it would not pay on a strictly grain farm.

If we assume that there will be but three fields where a three-year rotation is followed, it is not necessary to devote each field to one crop only. In the field devoted to corn, a part might be planted to kafir, cane or cotton. In the same way peanuts, millet or some other forage crop might be planted in a part of the cowpea field. Even a three-year rotation admits of almost endless modifications.

A rotation may be worked out to cover any number of years. In dry countries, and where crops are uncertain, the short rotations are best. Five, six or seven-year rotations are not necessary in this State. The most difficult proposition one has to face in working out a rotation for Oklahoma is the lack of grasses and legumes suitable for such practice. Alfalfa cannot be considered a rotation crop. It does best when left at least six or eight years. Yet at the same time alfalfa should be included on all suitable soils. If land is left in alfalfa for several years and is then broken it should be cropped for a few years before seeding down again. Bermuda does not work well in a rotation as it is too costly to start very frequently.

The rotation should be planned also to conserve moisture, to prevent soil erosion, and to keep the land covered. Moisture conservation should be given the most careful consideration.

SEED

The grain sorghums are usually grown where conditions are uncertain. This has a marked effect on the size of the seed from year to year. When any crop is grown under very unfavorable conditions the seed will be small. At the same time it will have the same breeding and will be entirely suitable for seed purposes if properly handled.

The variation in the size of the seed from year to year suggests the necessity of carefully calibrating the planting machine each season. In this way only can the desired rate of planting be assured.

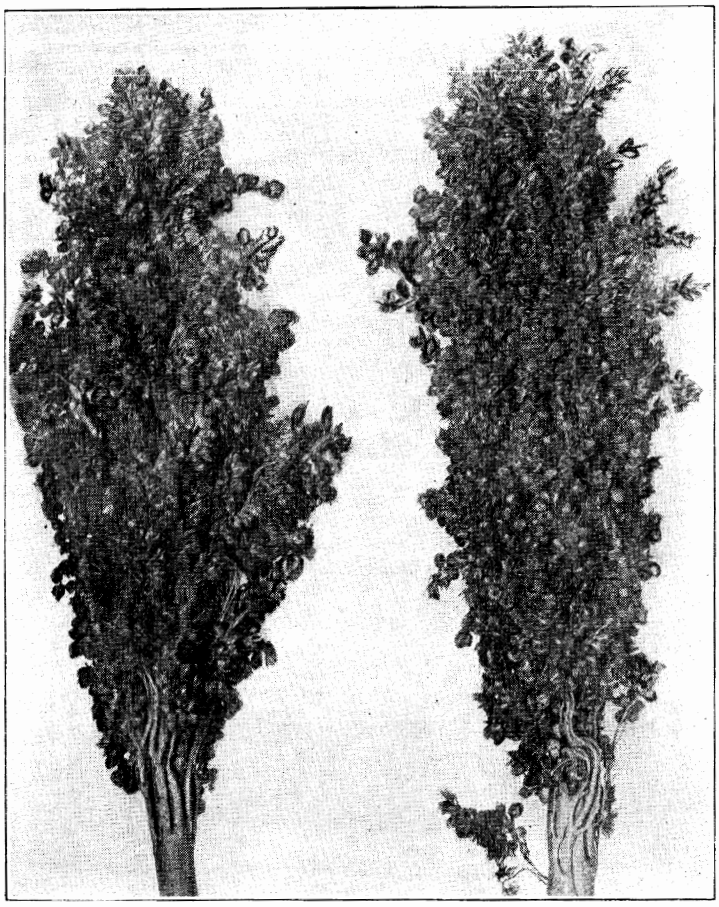

Figure 27.—Brown Kaoliang

PLANTING THE CROP

Date of Planting

The grain sorghums make a very slow growth in the early stages, especially if the weather is cold. As a result they should be seeded some time later than corn. If planting is done too early in the spring, not only will the seeds be liable to decay, but also those which germinate will make a very unsatisfactory growth.

The best time to seed in any season depends almost entirely upon the temperature and the distribution of rainfall, although the presence of injurious insects may be an important factor. Such things as soil fertility, condition of the soil, use of the crop and type or strain grown are specific factors and should be given consideration by the grower.

A review of the average rainfall year after year throughout the grain sorghum belt shows that there is a considerable variation in the monthly distribution. The distribution varies so much in different seasons that little dependence can be put on averages so far as time of planting is concerned.

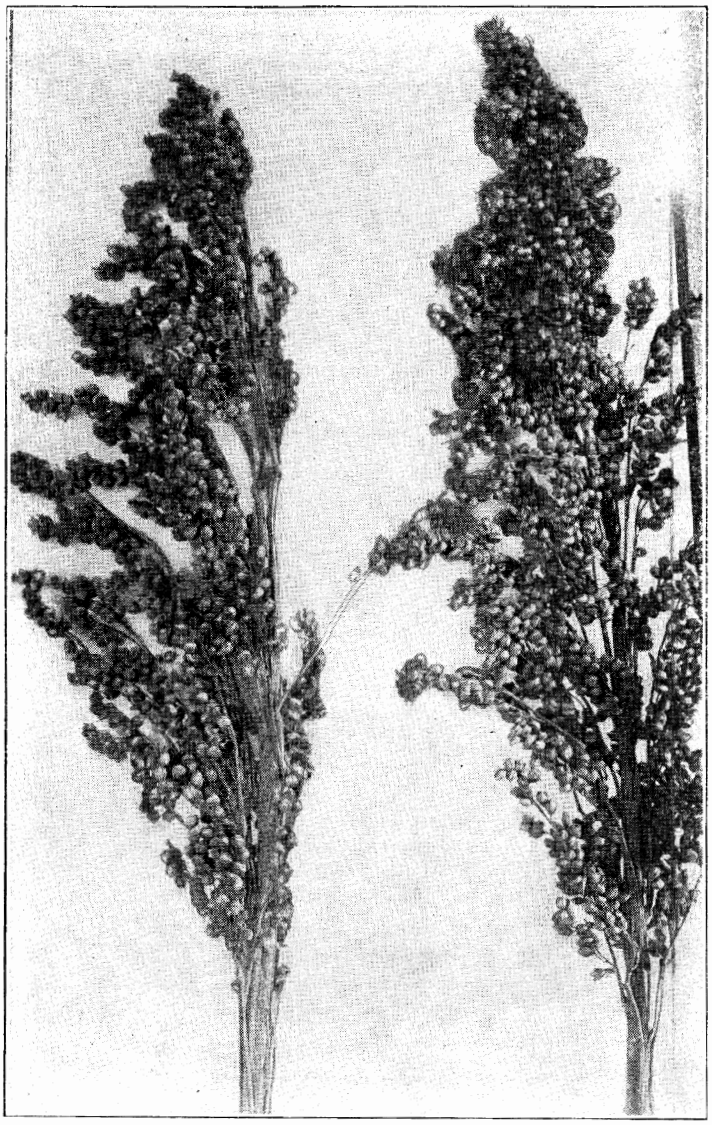

Figure 28.—White Kaoliang

In some seasons the spring is cold and backward and seeding is necessarily done later as there is no advantage from planting in a cold seedbed. The best general practice to follow is to plant as soon as the soil is sufficiently warm to insure germination of the seeds. In unusual seasons where high March and early April temperatures are experienced this practice cannot be followed. Everything considered, planting should be done relatively early.

This is especially true in sections where the chinchbug is prevalent. Chinchbugs have been known to destroy entire fields of kafir, milo and feterita. If the plants have made a good growth they are not so readily affected by the chinchbug, which come from wheat and oat fields.

At the Oklahoma Experiment Station in 1912 the kafir which was planted early, about April 20, produced a good average crop, while that

which was planted late, about June 1, was almost entirely destroyed by chinchbugs.

The date of planting will vary from about April 10 in the southern part of Oklahoma to about May 20 in the northern part. Feterita and milo may be planted about ten days later than kafir, but are usually planted at approximately the same date.

The above suggested dates have reference to the time of planting these crops in order to obtain a maximum production. In some seasons, corn, cotton or oats may be seriously injured by floods or early drouths and it is desirable to have some crop that will replace the ones destroyed and that will mature before frost. Under such conditions the question arises as to how late can one of the sorghums be planted and mature a crop. Just how late the grain sorghums can be planted and still mature before frost depends upon the moisture conditions in the early summer and how early the frost occurs in the fall. Kafir, milo and the other grain sorghums, on an average, will mature in from eighty to 110 days.

With a knowledge of the average date of the first fall killing frost, the grower can determine approximately the latest date at which seeding can be done. At the Oklahoma Experiment Station, which is centrally located in this belt, kafir has matured some seed when planted at late of July 20.

The average dates of the first killing frosts in the fall are about as follows: South of the line running irregularly from the southwest corner of the State through Caddo, Garvin, Seminole and Sequoyah counties, the first fall frosts have occurred from November 1 to November 11. North of this line the average date has been October 20 to October 30. In Harper, Ellis and the Panhandle counties the average date has been October 10 to October 20.

Seeding After a Grain Crop

It is a common practice to plant a few acres to grain sorghums after a wheat or oat crop has been removed. This is a good practice for a few acres if conditions are favorable and the work is not delayed. When conditions are such that the seed will germinate quickly, good yields of both grain and forage may reasonably be expected.

The following table shows what may be expected in the way of rainfall:

TABLE IX

Mean Average Rainfall for Eleven Years By Months

Place	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Kenton	0.25	0.61	0.57	1.65	2.61	1.75	2.24	2.05	1.73	0.95	0.63	0.35	15.16
Mangum	0.86	1.25	0.87	2.33	4.76	4.24	2.65	2.40	2.71	2.12	1.65	0.26	26.86
Stillwater	1.15	1.41	2.25	3.40	5.85	3.72	3.37	3.65	3.32	2.75	2.06	1.18	34.00
McAlester	2.03	1.86	3.44	6.06	6.62	4.90	3.62	3.19	3.29	3.79	2.68	2.45	42.42

When chinchbugs are bad in the wheat or oats there will be no use in planting one of the sorghums. In this case cowpeas should be grown.

Feterita or milo should be grown for this purpose on account of their early maturnty. Sudan grass will probably prove to be a good crop for forage. It is still earlier in maturity than feterita or milo.

In preparing the soil after a grain crop it will generally be best to list. If any of the grain sorghums are planted they should be planted in the listed furrow on account of the moisture necessary to germinate the seed.

Planting a grain sorghum after a grain crop as a general farm practice is not recommended, but a few acres might well be grown for feed or even for grain production. Usually the growing of two crops in one season on the same land makes too heavy a drain on the soil water.

Depth of Planting

The depth to plant depends upon the moisture condition of the soil, type of soil, whether loose or compact, firmness of seedbed and time of seeding.

On soil that is firm and smooth the seed can be planted shallower, as a usual thing, than if the soil is loose and cloddy. When the seed is planted late in the season it can be put deeper in the soil than when planted early. On sandy soils, planting can be done deeper than on clay types. The amount of moisture in the soil determines more than any other factor the depth to which the grain should be seeded. In planting seed of any crop, especially where the seeds are small, they should be planted in moist earth. Where the season is reasonably far advanced, it is advisable to plant the seed down in the moist soil even though a greater depth than in ordinary practice, is reached.

If the conditions are favorable, the seeds should be covered with about one to two inches of soil.

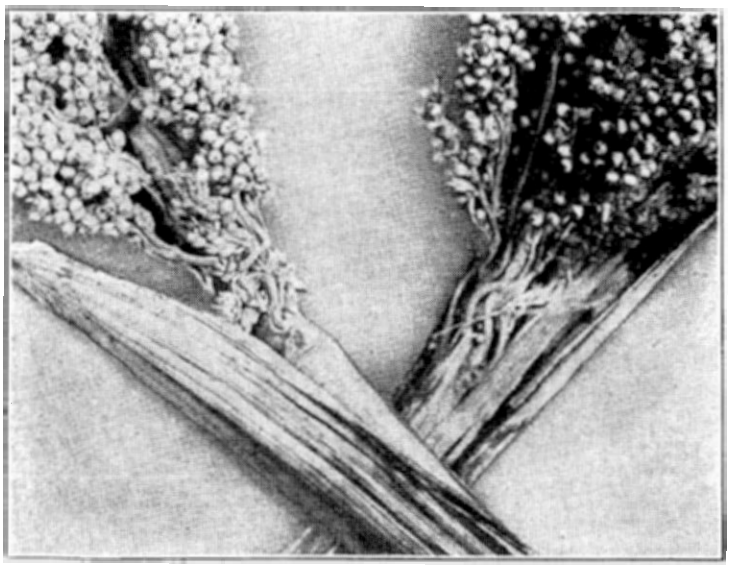

Figure 29.—Showing poor exsertion

Methods of Seeding

Both listing and surface planting are extensively used in seeding the grain sorghums. There has been considerable controversy over the comparative merits of these methods. The advantage of one method over the other under most conditions is mostly a matter of personal opinion. In soils that are relatively deep and loose, or in good physical condition, either method can be used successfully. On shallow soils, or soils which are hard and impervious, the seed should not be planted in the bottom of the listed furrow. If listing is done on such soils the ridge should be floated or otherwise dragged down before the planting is done. Where the soil is prepared by deep fall or winter plowing and is not too compact, spring listing can be done to good advantage. The chief objection to listing, as it is often practiced, is that it results in poor seedbed preparation. This is particularly true where shallow single listing only is practiced on soil which has not been prepared during the fall and winter.

Furrow openers are frequently used, but this practice does not seem to be increasing very rapidly. Where the surface soil is dry and cloddy this method can be used to advantage.

Planting Machinery

There are many reliable makes of both one and two-row planters on the market. Most of these machines are so arranged that they will plant corn, sorghums and seeds of practically all other rowed crops. The personal preferences and tastes of the grower will largely determine the particular make to be used.

Calibration of Planter.—It is wise to test the planter each year before the time for planting comes, using in the test the seed to be planted. The size of seed will vary from year to year. In order to plant at desired distances it will be necessary to procure plates having the proper sized openings.

It is well to have several plates with openings of different sizes. This is especially desirable if, at times, the seed is somewhat low in germination or if two or more varieties are to be planted.

Rate of Planting

The rate of planting should depend upon the productiveness of the soil, the purpose for which the crop is grown, the vitality of the seed and the climatic conditions.

The higher production comes from soils which have plenty of moisture and fertility. When the crop is grown for grain or silage it should be planted thinner than when grown for hay. As the average annual rainfall decreases the rate of seeding should also decrease.

The grain sorghums are planted in rows from thirty-six to forty-two inches apart. In general practice from forty to forty-two inches is found advisable. For grain and forage production the distance between plants in the rows should vary from about twenty inches in the more arid sections to

about eight inches in the more humid sections. If the rows are nearer together the distance apart in the row should be greater.

The amount of seed required per acre varies from one and one-half to three pounds when the crop is planted in rows for grain. The seeds of the durras are somewhat larger than those of other types and more is required

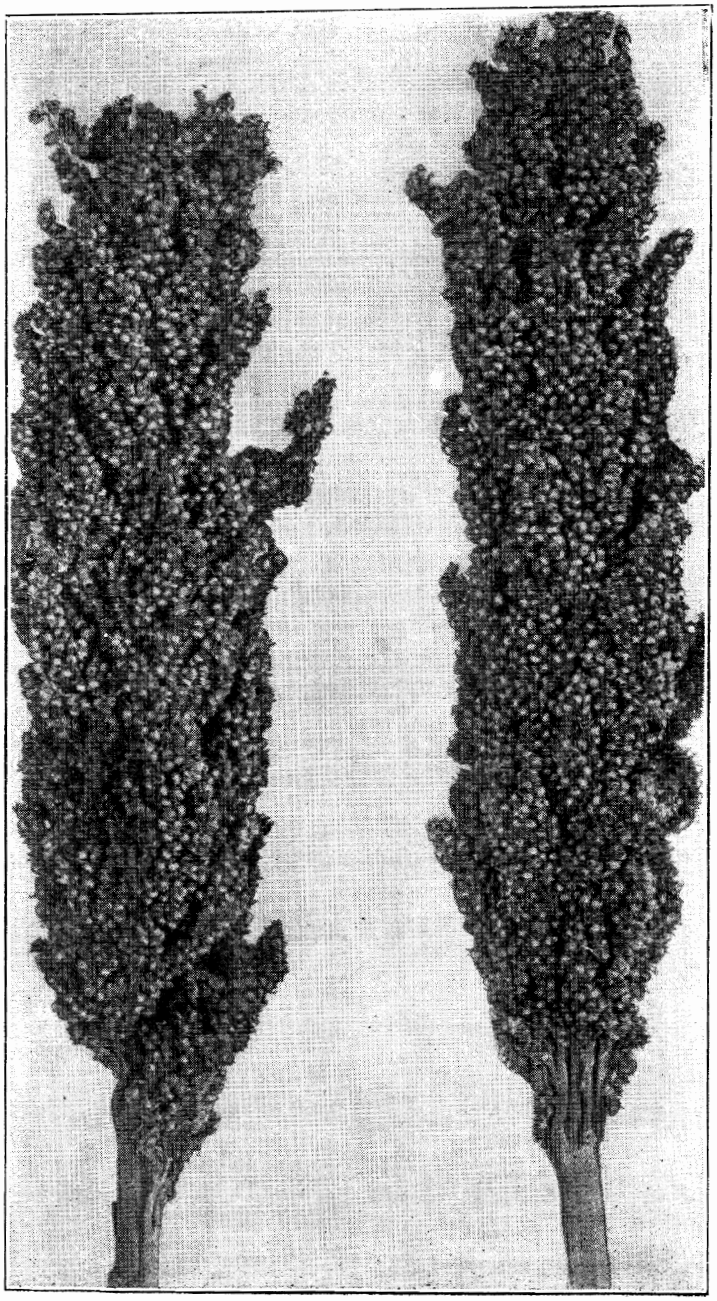

Figure 30.—Red Kafir

per acre. In broadcasting or planting with a grain drill from one to two bushels should be used.

CULTIVATING THE CROP

The number of cultivations that should be given the crop cannot be definitely stated. Cultivation should be given as often and continued as long as it is of service to the crop.

From the time the crop is planted until it is well above the ground it can be cultivated more cheaply and effectively with a harrow than with any other tool. It is a good practice to harrow as soon as possible after planting. A second harrowing can be profitably given just as the plants are coming up. The crop can be harrowed again when the plants are up, but in the case of level planting the crop should not be harrowed after the plants are more than two inches in height. If the crop has been planted with a lister it can be harrowed considerably later than when planted on the level.

Cultivating.—After the crop has reached such a height that it can no longer be harrowed without injury to the plants it is necessary to use a cultivator. The first cultivation will necessarily be shallow in order to avoid covering the plants. The second cultivation should be as deep as it can be made without throwing too much soil upon the plants. All later cultivations should be at the depth desired to maintain the soil mulch, although it is sometimes found necessary to cultivate deep in order to kill large weeds.

The frequency of cultivation should depend a great deal on seasonal conditions. There is little danger of cultivating too often, although so far as returns are concerned such could be the case. The early cultivations should be made frequently enough to keep the weeds in check. The later cultivations should, as far as possible, be made after rains in order to prevent the formation of a surface crust. Four or five cultivations are usually considered sufficient.

There is little choice between the different cultivating implements on the market. The six-shovel cultivator gives better results than the four-shovel cultivator. In cultivating the important thing is to keep the land in the right condition and it matters little what kind of an implement is used so long as the proper results are obtained.

HARVESTING THE CROP

Time of Harvesting

When grown for grain, the grain sorghums should not be harvested until they are well matured. In the case of such crops as kafir and milo, the grain may be allowed to remain in the field until late in the fall, or until a short time before frost. Where fall plowing is practiced, harvesting must be done at an earlier date. The grain sorghums which lodge or shatter badly must be harvested as soon as mature. If harvested with a binder and

cured in the shock, harvesting can ordinarily be done somewhat earlier than if the grain is headed. When the crop is grown for silage it should be harvested while the kernels are yet in the dough stage. At this stage the plant has not only stored up in its tissues a maximum amount of food material, but also contains a large percent of water.

When grown for hay the crop can be cut whenever needed. Generally speaking, it should be harvested while the stems are relatively soft and tender.

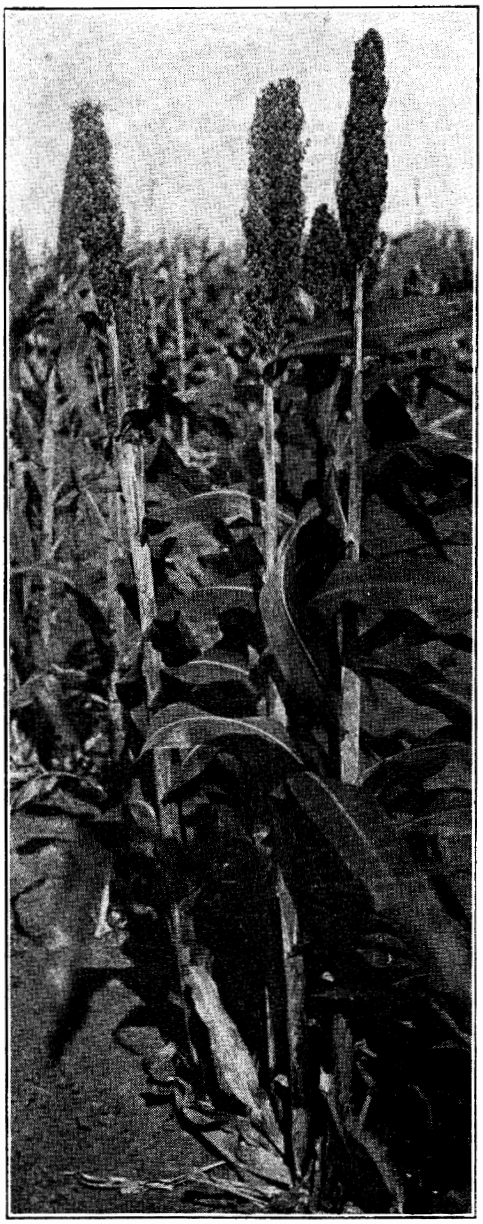

Figure 31.—Red Kafir

Method of Harvesting

When grown for hay the grain sorghums can be harvested either with a common mowing machine or with a common corn binder. If drilled in rows the latter method is more satisfactory.

When grown for silage the crop should be harvested with a corn binder. It is necessary to use this machine in order to handle the crop easily.

When grown for grain and stover the crop may be cut by hand or with a corn sled or corn header and shocked in the field, or the grain may be headed and the stover harvested afterward.

The common wheat header is sometimes used for heading. This method cannot be used to advantage unless the crop is relatively low-growing and the stalks are slender as a result of thick planting. If the crop is reasonably even in height a kafir header can be advantageously used. This machine, which may be attached to any wagon, is simple and inexpensive. It harvests one row at a time and elevates the heads into the wagon box. It is raised and lowered by means of a lever attachment.

It gets its power from the revolving of the hindwheel of the wagon to which it is attached. Several new types of heading machines have recently been placed on the market.

In harvesting by hand the method is similar to that of picking or shucking corn. In cutting off the heads a common jackknife or pruning knife is used. Hand harvesting has an advantage over using the header in that no grain need be left in the field and more even length of heads is obtained.

———o———

STORING THE UNTHRESHED GRAIN

If the grain is cut by hand or by a corn binder and shocked, it should be left in the field until it is well cured. It may then be easily headed or the entire plants may be run through a common threshing machine. The bound grain can be headed by hand with a sharp knife or by placing the stalks on a block and cutting off the heads with a broadaxe or heavy corn knife, or with a box header. A box header is a convenient device which can be easily constructed on the farm. It consists of a long box or trough with the ends open. At one end a heavy knife is attached on a pivot. A bundle is placed in the trough with the heads projecting beyond the end. The knife is brought down with a quick, strong stroke. The box should be placed upon legs about three feet high.

After the heads have been removed from the stalks they should be stored in well ventilated cribs or in long, narrow ricks. The care necessary in stacking the heads will depend largely on the degree of maturity reached before the heading is done. If the heads have been thoroughly field cured, less care is necessary in storing them, but if the heading has been done relatively early and the heads are not thoroughly cured, great care must be exercised in order to prevent heating. One of the most convenient and most

satisfactory methods for stacking heads is to make a long, low "A" shaped rack. This rack can be made out of either planks or poles. In either case plenty of cracks should be left to permit free circulation of air, but not wide enough to allow the heads to drop through. The rack should be from about a foot and a falf to two feet from the apex to the base, that is, in height. The heads should be stacked on and around this rack. After the rick of heads is completed it should be covered by leaning the headed stalks firmly against the heads on both sides and at the ends. The entire rick should be carefully protected from rains.

If the heads have been thoroughly cured before they are removed from the stalks they can be stacked in fairly large ricks without using the rack or a ventilating device. Some material such as poles or straw should be placed at the bottom of the rick to prevent the bottom layers from absorbing moisture.

If the headed grain is thoroughly cured in the rick, allowing it to remain unthreshed for a month or more, much less trouble will be experienced from heating after the grain is threshed than if threshing is done soon after harvesting. Threshed kafir heats very readily and great loss occurs annually from this cause. It is important, therefore, to give careful consideration to thoroughly curing the grain before threshing.

———o———

STORING FODDER

Little difficulty is experienced in storing the fodder to keep it from heating or spoiling. The fodder can be fed either directly from the shock or it can be stacked by standing it on end in long ricks, or it can be placed in stacks as in the case of cane or other sorghums.

If mown for hay it should be well field-cured before stacking.

———o———

THRESHING THE GRAIN

If the crop has been bound and shocked it can be threshed directly from the field with a common grain thresher. When this method is followed it is necessary to remove the concaves.

If the grain is headed it should be given ample time to cure before threshing, not only that it may thresh cleaner, but also in order that the grain may be in better condition for storing. Unless the grain has been allowed to thoroughly mature in the field before it is headed it should not be threshed until it has ample time to dry out in the ricks. A common grain separator is used in threshing the heads. In order to prevent the cracking of the kernels where seed is desired, the speed of the cylinder should be reduced to about six hundred revolutions per minute and a part or all of the concaves removed. Boards are sometimes substituted for the concave. Where the grain is to be used for feed only, the cracking of the grain does no damage and the precaution mentioned need not be taken.

Storing the Threshed Grain

As has been previously noted, much trouble is experienced from the heating of threshed kafir and milo. Perhaps no other grain on the farm heats as readily as do the grain sorghums. To prevent this the bins should be thoroughly ventilated. The following method of ventilation is very satisfactory:

A ventlator may be made of 1x4 pieces running crosswise of the bin, held together with narrow strips 6 inches long and covered on top and at the ends with heavy flyscreen. These ventilators should connect with the outside at each end. The ventilator is then placed on the floor of the bin, leaving the ends flush with the outside. The bottom can be left open or placed on top of the floor. The ventilators should be placed from two to three and one-half feet apart, depending upon the width and depth of the bin. They should be fastened securely in order that they may not be shoved out of place by the grain. This method is only suggestive, and any modification that will serve the same purpose can be made. The principle, however, is an important one, and if properly used will materially reduce loss from heating.

USES

The grain sorghums have already been put to a wide range of uses. The grain is used to a limited extent for human food and as a feed for all classes of animals. The fodder is widely used as a forage and for silage purposes.

COMPOSITION

The following table, adapted from Bulletin No. 203, Bureau of Plant Industry, gives the composition of the grain of different varieties:

TABLE X

Composition of Grain Sorghums and of Corn, Showing Percents

CROP	Water	Water-Free Substance.				
		Ash	Crude Protein	Fiber	Nitrogen Free Ext.	Fat
Black Hulled Kafir	10.05	1.90	13.69	2.08	78.87	3.46
Red Kafir	10.31	1.78	13.01	2.14	79.95	3.12
Milo	10.61	1.77	12.41	1.86	80.87	3.09
Dwarf Milo	10.34	1.93	12.08	2.02	80.73	3.24
White Durra	9.87	2.17	11.22	1.85	80.81	3.95
Feterita	10.82	1.66	12.89	1.29	80.41	3.75
Brown Kaoliang	10.26	2.12	10.51	1.75	80.98	4.64
White Kaoliang	10.05	2.40	11.53	1.39	79.53	5.15
Shallu	9.70	1.76	13.88	1.85	78.78	3.72
Corn	10.89	1.70	11.70	2.40	78.10	6.10

The Oklahoma Agricultural Experiment Station has made extensive analyses of the composition of both the grain and stover of kafir. The following comments and Tables XI and XII are adapted from Bulletin 89 of this Station:

TABLE XI

Showing Comparative Composition of Kafir Meal, Corn Meal, Kafir Grain and Shelled Corn

CROP	Water	Water-Free Substance. Ash	Crude Protein	Fiber	Nitrogen Free Ext.	Fat
Kafir Meal	12.78	1.41	12.41	1.41	82.02	2.75
Corn Meal	12.81	1.55	10.83	1.62	83.11	2.89
Kafir Grain	10.08	1.56	10.19	2.39	82.66	3.20
Shelled Corn	12.56	1.41	11.01	.....	83.44	4.14

TABLE XII

Showing Comparative Composition of Kafir Stover and Corn Stover, Calculated to Water-Free Substance

MATERIAL	Moisture	Water-Free Substance. Ash	Crude Protein	Fiber	Nitrogen Free Ext.	Fat
Kafir stover*	18.79	10.61	6.28	31.91	49.27	1.93
Corn stover**	19.18	5.79	6.33	32.89	53.28	1.83

*Data tabulated from Bulletin No. 37, Oklahoma Experiment Station.
**The analyses of corn stover is taken from "Computations of Rations for Farm Animals" by Armsby and calculated to Oklahoma moisture content as given in Press Bulletin No. 182, Oklahoma Experiment Station.

Tables XI and XII show that from the standpoint of composition there is little difference between kafir and corn. Kafir meal contains a little more protein than corn meal, but in other constituents they are about equal. Analyses of the grain shows that kafir is a little lower in nitrogen-free extract than shelled corn and about the same in protein, and a little lower in fat. The ash, which constitutes the mineral plant food removed from the soil, is practically the same in the meal and the grain of both corn and kafir.

When the stover, which is the plant without the grain, is considered, the only material difference between the composition is in the ash. The kafir stover contains 4.3% more ash than does the corn stover.

METHODS OF PREPARING KAFIR FOR FEED

Kafir is fed unthreshed in the head, as whole threshed grain, whole soaked grain and ground or crushed grain. When ground or crushed it is called kafir chop. When very finely ground it is known as kafir meal. The method of chopping or grinding the unthreshed heads is being practiced to a considerable extent and promises to be a very profitable and practical method of preparing it for feed. Several makes of machines for this purpose have been recently put on the market.

The fodder and stover are fed either from the field or run through a shredder. As yet the use of the shredder has not become a common practice in preparing kafir for feed, but there is no reason why it cannot be used as profitably for this purpose.

Kafir and milo have proved to have a feeding value of at least 90% of that of corn. Many feeding tests have been run with different classes of animals. These grains have proved to be entirely suitable for hogs, cattle, horses, chickens and sheep.

Best results will be secured when the grain is ground. Soaking improves the grain for hogs. The quality of meat produced from animals fed on the grain sorghums is good. Care, of course, should be taken to balance the rations. Some nitrogenous feed should be included in the rations, since the sorghums are too high in carbohydrates to give the best results when fed alone.

While kafir has a lower feeding value than corn, still its greater yield per acre makes it a more profitable crop. This is unquestionably true in the western part of the grain sorghum belt. For comparison of yields on poor upland in the central part of Oklahoma, see Table I.

———o———

SILAGE

Silage is a feed of established merit for livestock. This form of feed is attracting much attention in the grain sorghum belt. Silage is relished by stock, especially by cattle and sheep. It is palatable, cheap and succulent, and is particularly valuable for feeding breeding stock.

Kafir, milo and the other grain sorghums make excellent silage, ranking in this respect close to corn. A mixture of such legumes as alfalfa and cowpeas with the grain sorghums makes a first class, well balanced silage.

———o———

INSECT ENEMIES

At the present time the only very destructive insect peculiar to the sorghums is the "sorghum midge". This insect is not at all common in Oklahoma. It causes "blast" of the head. The description and methods of control for this insect are found in Bulletin No. 237, Bureau of Plant Industry.

The army worm, grasshopper and cutworms are of minor importance. Methods for their control may be found in other bulletins of this Station.

The chinchbug is the most destructive insect. In some seasons this insect destroys thousands of acres of corn and the sorghums. Several methods of control are advised. These methods may be found in other bulletins of this Station.

As a matter of crop management, early planting and isolation from wheat and oat fields is advised. Anything which will help the plants make a strong, rapid growth will reduce injury by chinchbugs.

———o———

DISEASES

The only diseases prevalent at this time are the smuts. There are two kinds of smut found in the sorghums, head smut and kernel smut.

There is no preventive treatment for head smut. In this respect it is like corn smut and should be treated in the same manner. Rotation of crops, planting clean seed on new ground and burning smutted heads will assist in its control.

The kernel smut may be prevented by the same methods as are used to kill smuts in wheat and oats. The hot water and formalin treatments are both good if properly handled. On account of ease of handling and general satisfactory results, we recommend the formalin treatment.

This treatment is briefly described as follows: Buy 1 pound of formalin of 40% strength from your druggist. Mix this with water at the rate of 1 pound (or pint) of formalin to 40 gallons of water. Place the sorghum seed to be treated in a burlap sack and soak in this solution for about two hours. Remove, drain, spread out and allow to dry enough to run through the planter nicely. If desired, the seed may be thoroughly dried and kept several weeks before planting. See that the bins, sacks and planters are also disinfected. Do not reinfect the seed after it has been treated.

———o———

ACKNOWLEDGEMENTS

The writers wish to acknowledge the help of E. E. Hall and H. L. Thomson in preparing this bulletin. Some data collected before our connection with this Station has been included. Mr. C. R. Ball furnished three figures for which credit has been given in the text.

———o———

SUMMARY

There can be no question as to the great value of the grain sorghums in the west half of Oklahoma.

Milo and feterita should be grown in the western part of the "grain sorghum belt", and black hulled kafir in the extreme eastern part. The kaoliangs are worthy of further test in the extreme western part.

Good culture will pay and is of great importance.

Early planting should be practiced.

Good, pure seed should be produced and used. The present seed condition is deplorable.

Grow but one variety in a locality.

The feeding value of the grain sorghums, both grain and forage, is high. The feeding value of the grain compares favorably with corn and the stover is superior to corn stover.

The grain sorghums are "sure crops" in comparison with corn in the section under consideration.

Grain sorghums are not substitutes for corn in the western part of Oklahoma, they are the "real thing".

TABLE OF CONTENTS