AGRICULTURAL EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE
MANHATTAN, KANSAS

RELATIVE WATER REQUIREMENT OF CORN AND SORGHUMS

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SUMMARY.

These experiments were conducted at Garden City in 1916 and 1917 and at Manhattan in 1918, 1919, and 1920, to ascertain the relative water requirement of some of the more common varieties of corn and sorghum when grown under similar environmental conditions and to find whether there is any definite relationship between the water requirement of these plants and their ability to withstand drought.

A summary of the water requirement for the five seasons is given in Table I.

TABLE I.—Summary of the water requirement of corn and sorghums for 1916, 1917, 1918, 1919, and 1920.

PLANTS.	WATER REQUIREMENT.				
	Garden City.		Manhattan.		
	1916.	1917.	1918.	1919.	1920.
Milo, Dwarf	330±3	290±2	368±2	252±3	228±5
Kafir, Dawn	346±6	279±2	343±6	261±2	231±2
Kafir, Blackhull	327±5	282±3	351±4	254±3	232±3
Feterita	401±6	322±5	389±14	289±3	247±5
Sudan grass	431±2	388±8	447±4	337±12	275±6
Sorgo, Freed			492±2	293±4	243±2
Milo, White			341±9	238±2	215±6
Sorgo, Red Amber			315±2	253±2	221±3
Broomcorn, Acme Dwarf			353±7	270±8	227±5
Sorgo, Kansas Orange			326±12	243±3	203±8
Corn, Pride of Saline	433±8	366±4	428±20	317±13	231±3
Corn, Sherrod W. D.	395±11	348±4	407±18	293±6	237±8
Corn, Freed W. D.			398±4	343±14	278±18
Corn, Kansas Sunflower			475±30	293±3	280±10
Corn, Reid Y. D.			499±19	326±6	259±2

Considering the average water requirement of Kansas Orange sorgo as 1, the average water requirement of the plants grown at Manhattan in 1918, 1919, and 1920 would be as follows: Red Amber sorgo, 1.02; White milo, 1.03; Dawn kafir, 1.08; Blackhull kafir, 1.08; Dwarf milo, 1.10; Acme Dwarf Broomcorn, 1.10; feterita, 1.19; Sherrod White Dent corn, 1.21; Pride of Saline corn, 1.26; Freed White Dent corn, 1.31; Freed sorgo, 1.33; Kansas Sunflower corn, 1.35; Sudan grass, 1.37; Reid Yellow Dent corn, 1.40.

The relative value of the water requirements of the plants grown at Garden City in 1916 and 1917 was as follows: Blackhull kafir, 1; Dwarf milo, 1.01; Dawn kafir 1.02; feterita, 1.18; Sherrod White Dent corn, 1.21; Pride of Saline corn, 1.31; and Sudan grass, 1.34.

The results of these experiments indicate that there is little or no relationship between the water requirement of plants and their ability to produce a yield of grain in agricultural practice under conditions of limited and uncertain rainfall.

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RELATIVE WATER REQUIREMENT OF CORN AND SORGHUMS.[1]

E. C. MILLER.

INTRODUCTION.

During the past seven years a physiological study has been made of the water relations of several varieties of corn and sorghum. In connection with other experiments, it was thought advisable to determine the water requirements of these plants. The term water requirement as used in this discussion means the ratio of the number of units of water absorbed by the plant during its growing season to the number of units of dry matter produced by the plant, exclusive of the roots, in that time. The preliminary work of the water-requirement determinations, made by the writer during the growing seasons of 1914 and 1915 at Garden City has been reported previously (Miller, 1916). The data herein reported were obtained at Garden City in 1916 and 1917, and at Manhattan in 1918, 1919, and 1920.

It is not the intention to discuss the various factors which influence the water requirement of plants, but to consider only the behavior of the different varieties in question when grown under similar conditions. The literature concerning the various factors that influence the water requirement of plants has been thoroughly discussed by Briggs and Shantz (1913 and 1914) and by Kiesselbach (1915).

EXPERIMENTAL METHODS.

THE METHOD OF GROWING THE PLANTS.

The plants were grown in large metal cans constructed from 22-gauge galvanized iron. These cans had a height of 26 inches and a diameter of 15 inches and contained under the conditions of the experiments from 280 to 290 pounds of soil. Sandy loam soil obtained from the surface foot of the soil of a cultivated field was shovelled from its position in the field upon a one-fourth inch mesh screen and at once worked through into the cans and thoroughly tamped. The soil in all the experiments was in good tilth but its moisture content necessarily varied from year to year. The per cent of

1. Contribution No. 190 from the Department of Botany.

moisture and the wilting coefficient of the soils used during each growing season were as follows:

Year.	Per cent of moisture in soil.	Wilting coefficient of soil.
1916	18.1	11.1
1917	22.1	11.1
1918	22.9	14.7
1919	23.0	13.8
1920	21.0	13.8

The cans were provided with metal lids which were sealed with ordinary binding tape made water proof by applying a heavy coat of shellac or varnish after it was in position. Circular openings, 3.5 inches in diameter, were made in the metal lids of the cans to accommodate the plants. The number and position of these openings varied acording to the number of plants grown in each can. (Figs. 1 and 2.) In the experiments with corn, only one plant was grown in each can, as the preliminary work of 1914 and 1915 had shown that such a limited amount of soil was insufficient to grow a greater number to maturity. The number of sorghum plants grown in each can in 1916 and 1917 varied from one to three as shown in Table II. In 1918, 1919, and 1920 two plants of the dwarf varieties of sorghums were grown in each can, while in the case of the standard sorghum varieties the number was limited to one plant per can. In all cases the volume of soil was large enough to furnish sufficient nutrients to grow the plants to normal maturity. This fact is well shown in the case of Blackhull kafir in 1916. Table II shows that the water requirement for this variety of sorghum was practically the same when two plants were grown in each can as when only one was grown.

The seeds were planted in the soil in the openings of the cans and after they had germinated the young plants were gradually thinned to the desired number. As soon as the plants had emerged sufficiently from the soil, the openings in the lids of the cans were made water tight by sealing them with a mixture of approximately 20 parts, by weight, of beeswax to 1 part of Venetian turpentine. This mixture makes a very efficient seal for this type of experimental work since it retains its solidity during hot weather, if properly protected, and is pliable enough to permit the extension of the growing plant stems. It was found necessary to protect the wax seals and the lids of the cans from the heat of the sun until the plants were sufficiently large to shade these parts. This protection was provided by two layers of burlap over the wax seals and by a single thickness of the same material over the lids.

METHOD OF WATERING THE PLANTS.

One of the greatest difficulties experienced in growing plants in soil in large containers is to replace evenly throughout the soil the water that has been removed by the plants. In these experiments

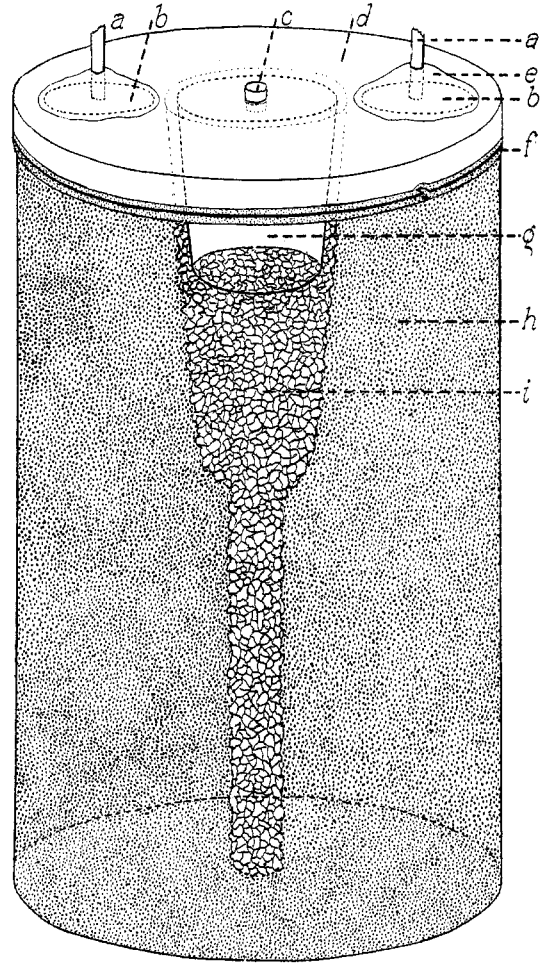

FIG. 1. Arrangement of plants and watering device when two plants were grown in each can. *a*, plant; *b*, hole in lid to accommodate plant; *c*, corked hole for the addition of water; *d*, can lid; *e*, wax seal around plant; *f*, seal of binding tape; *g*, flower pot; *h*, soil; *i*, coarse sand and gravel.

the following watering device, which is a modification of that used by Briggs and Shantz (1913), proved to be a very efficient method for distributing the water evenly throughout the soil mass in the

cans. A more or less cone-shaped mass of soil 6 inches in diameter and 15 inches in depth was removed from the upper portion of the container. From the bottom of this cavity, a hole 1.5 inches in di-

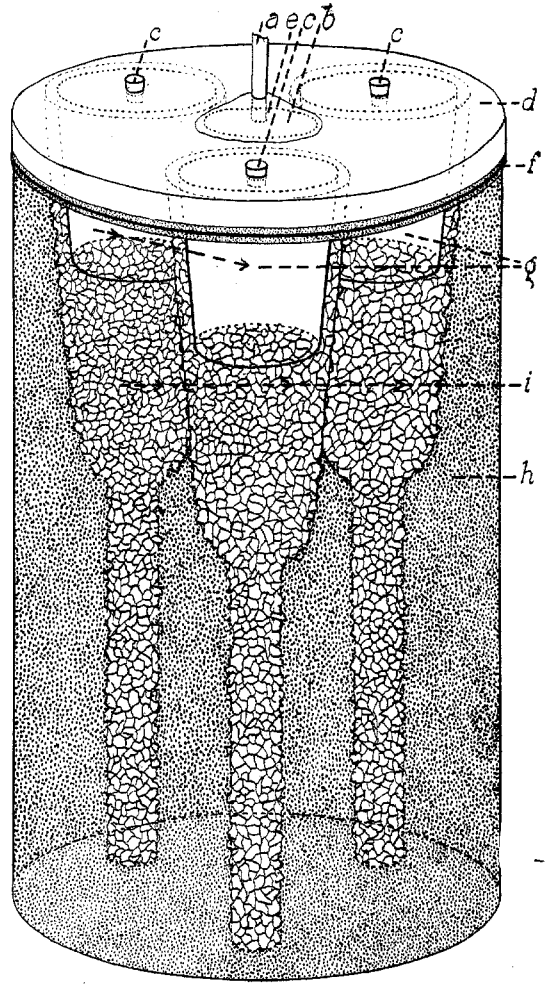

FIG. 2. Arrangement of plant and watering device when one plant was grown in each can. *a*, plant; *b*, hole in lid to accommodate plant; *c*, corked holes for the addition of water; *d*, can lid; *e*, wax seal around plant; *f*, seal of binding tape; *g*, flower pot; *h*, soil; *i*, coarse sand and gravel.

ameter was made to the bottom of the can by means of a soil tube. The entire cavity was then filled with coarse sand to within 5 or 6 inches of the top of the can. A 5-inch clay flower pot with the bottom removed was placed directly on top of this sand so that the

rim of the pot was flush with the metal lid of the can. An inch hole in the lid of the can was directly over each flower pot.

When two or three plants were grown in each can, as in the case of the dwarf sorghums, one watering device only was used and this was placed in the center of the can as shown in figure 1. When but one plant was grown to each can, as in the case of corn and the large sorghum varieties, three such devices were used and were distributed around the border of the cans as shown in figure 2.

The amount of water removed from the cans by the plants was determined every 48 hours by the weighing method described by the writer (1916). The water thus lost was replaced by an equal volume which was poured by means of a funnel into the watering device described above. The soil of the cans was thus kept approximately at a constant moisture content during the growing season. This method of watering seems also to be a very efficient means for the aeration of the roots since the root systems were evenly distributed throughout the soil and showed very little tendency to collect between the soil and the inner surfaces of the cans.

METHOD OF PROTECTING THE PLANTS.

The plants were grown within a screened shelter in order to protect them from hail and from birds during the period of grain formation. The enclosure was 12 feet high and of sufficient lateral dimensions to accommodate all of the plants grown. It consisted of a framework of 2 by 4 studding spaced 3 feet apart and covered on both top and sides with wire netting. The netting used at Garden City had a one-fourth inch mesh while that used for the enclosure at Manhattan was of one-half inch mesh. The enclosures at both stations were surrounded by crops of corn and sorghum growing under field conditions. At Garden City the cans were placed upon the surface of the soil within the enclosure so that the plants growing in these cans were elevated approximately 2 feet above those growing in the surrounding field. In order to break the force of the severe winds prevalent in that region, cheese cloth was placed around the sides of the enclosure to a height of 4.5 feet. At Manhattan the soil within the enclosure was excavated to a depth of 2 feet, so that the plants growing in the cans were on a level with those growing in the field and were thus protected from the force of the wind by the surrounding plants in the field. The evaporation inside of the enclosure at Garden City was one-third less than that in the open field as measured by Livingston porous-cup atmometers, while in the en-

closure at Manhattan the evaporation, measured in the same manner, was only one-fifth less than that in the open field.

The plants grown in these enclosures were placed, so far as light intensity was concerned, under somewhat abnormal conditions and the water requirement thus obtained might differ considerably from that of plants growing in the field. The purpose of these experiments, however, was to make a comparative study of the water requirement of the different varieties of plant's growing under the same conditions. The relative water requirement is probably affected little if at all by the shading due to an enclosure of this kind and the shelter seemed to offer the only reliable method for studying the relative water requirement of these plants under the condition.: experienced in this region.

CLIMATIC DATA.

Since the water requirement of plants is influenced primarily by the weather conditions prevailing during their growing season, the general climatic conditions under which the plants in these experiments were grown are important. The total evaporation from a free water surface and the total rainfall for each month during the growing seasons of 1916 and 1917 at Garden City and of 1918, 1919 and 1920 at Manhattan were as follows:

Date.	Evaporation. *Inches.*	Rainfall. *Inches.*
1916.		
June	10.326	4.21
July	13.218	.30
August	10.674	3.99
September	7.431	1.16
1917.		
June	12.670	1.19
July	12.480	2.96
August	8.909	2.99
September	7.053	1.13
1918.		
May	7.342	2.13
June	8.795	.76
July	9.328	2.17
August	10.117	3.60
1919.		
May	4.923	3.08
June	5.416	4.50
July	9.544	1.16
August	8.622	1.65
1920.		
May	4.286	1.58
June	8.912	1.96
July	8.439	4.83
August	6.775	6.07

DISCUSSION OF EXPERIMENTAL DATA.

DESCRIPTION OF PLANTS.

Two varieties of corn, Sherrod White Dent and Pride of Saline, and fine varieties of sorghum, Dwarf milo, Blackhull kafir, Dawn (Dwarf Blackhull) kafir, Feterita, and Sudan grass were grown during the seasons of 1916 and 1917 at Garden City. In the experiments at Manhattan in 1918, 1919, and 1920, five varieties of corn and ten varieties of sorghum were grown. The varieties of corn used were Pride of Saline, Sherrod White Dent, Freed White Dent, Kansas Sunflower, and Reid Yellow Dent. The sorghums grown were Blackhull kafir, Dawn kafir, Dwarf milo, White milo, Feterita, Acme Dwarf broomcorn, and Sudan grass of the non-saccharine varieties, and Red Amber, Kansas Orange, and Freed sorgo of the saccharine varieties.

FIG. 3. Blackhull kafir at the "booting" stage showing the normal vegetative growth of the plants grown in the water-requirement experiments. These plants were approximately 5 feet in height and were grown at Garden City in 1916.

The plants grown were normal in regard to vegetative growth and yield of grain since in these respects they were the equal of the plants growing under favorable conditions in the surrounding fields. The lower leaves of the plants remained green and intact until harvest

time and did not wither and drop off as in the case when plants are crowded in pot cultures.

Figure 3, which represents Blackhull kafir at the time of "booting," illustrates the healthy vegetative condition of the plants, while an idea of the grain yield of this variety of sorghum can be obtained from figure 4. The corn plants reached a height of 6 to 10 feet depending upon the season or the conditions under which they were grown, and produced a normal yield of grain. Figure 5 shows the average size of ears produced by Sherrod White Dent corn at Manhattan in 1919.

FIG. 4. Blackhull kafir heads at the time of harvest showing the normal grain yield of the sorghum plants grown in the water-requirement work. These heads were approximately 12 inches in length and were produced by the plants shown in figure 3.

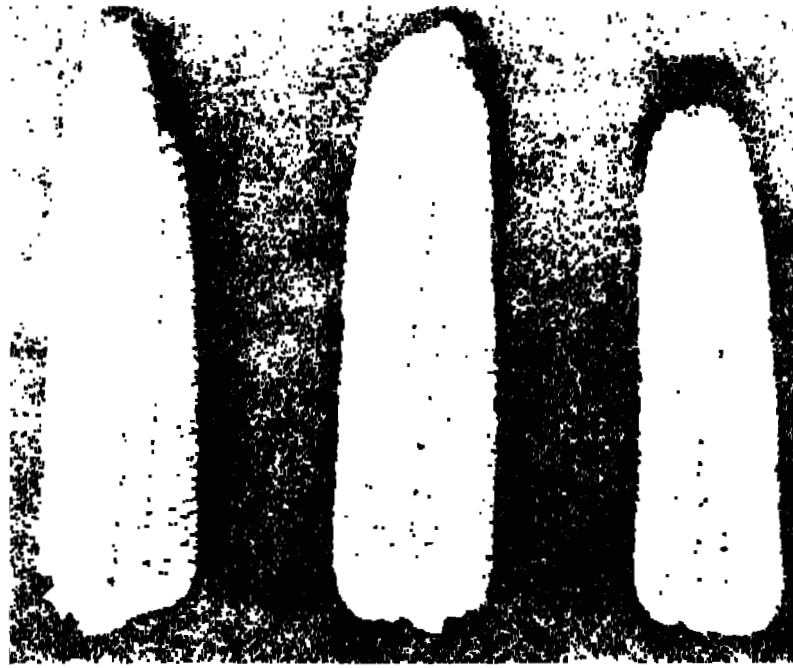

FIG. 5. Average ears of Sherrod White Dent corn grown in the water-requirement work at Manhattan in 1919. These ears were approximately 8 inches in length.

The detailed data concerning the various plants are tabulated in Table II which may be consulted for the individual record of the plants, for the production of dry matter, and the water requirement. The probable error of the mean was calculated by Peter's formula based upon the sum of the departures.[2] The water requirements of the various varieties are contrasted in Tables II to V.

2. The following formula was used: $Rm = 0.845 \frac{Sd}{n\sqrt{n-1}}$ where Rm = the probable error of the mean, Sd, the sum of the departures, and n, the number of determinations.

TABLE II.—Data on water requirements of corn and sorghums, 1916 to 1920.

VARIETY AND PERIOD OF GROWTH.	Pot No.	Number of plants.	Dry matter without roots.	Grain.	Stem and leaves.	Water transpired.	Water requirement based on—		
							Total dry weight excluding roots.	Grain.	Stem and leaves.
I. GARDEN CITY, 1916.									
			Gm.	*Gm.*	*Gm.*	*Kg.*			
Milo, Dwarf, May 24 to Aug. 10	2	3	249.4	153.1	96.3	83.2	334	544	864
	3	3	228.0	138.8	89.2	75.4	331	544	846
	4	3	239.9	135.5	104.4	75.2	314	555	721
	6	3	239.7	135.4	104.3	77.0	321	569	739
	7	3	237.8	130.5	107.3	79.7	335	611	743
	10	3	241.0	134.9	106.1	82.8	344	614	781
Mean							330±3	573±11	782±18
Kafir, Dawn, May 24 to Aug. 21	12	2	220.3	84.7	135.6	84.3	383	996	622
	14	3	279.7	108.6	171.0	94.7	339	873	554
	15	3	258.2	99.8	158.4	89.2	346	894	563
	16	2	271.0	116.6	154.4	98.7	364	847	640
	18	1	151.3	68.1	83.2	46.1	305	678	555
	19	2	268.3	102.1	166.2	91.2	340	894	549
Mean							346±6	864±25	580±13
Kafir, Blackhull, May 24 to Sept. 4	43	2	379.8	149.9	229.9	117.2	309	782	510
	44	1	256.1	113.8	142.3	78.9	308	694	555
	45	2	364.7	142.4	222.3	123.1	338	865	554
	46	1	255.9	114.2	141.7	83.3	326	730	588
	48	1	277.1	115.8	161.3	96.9	350	837	601
	50	2	385.2	145.1	240.1	127.9	332	882	533
Mean							327±5	798±24	557±9
Feterita, May 24 to Aug. 17	51	3	346.6	121.9	224.7	132.2	381	1085	589
	52	2	211.8	99.4	112.4	86.2	407	867	767
	53	1	180.3	85.8	94.5	78.0	432	909	825
	54	2	274.4	105.9	168.5	104.5	381	987	620
	55	1	186.1	75.5	110.6	74.8	402	991	676
Mean							401±6	968±27	695±34

Sudan grass, May 24 to Aug. 7	56	6	262.4	72.5	189.9	117.1	446	1616	617
	57	6	275.8	57.1	218.7	119.0	432	2085	544
	58	6	288.4	52.7	235.7	122.3	424	2322	519
	59	6	274.0	62.6	211.4	116.2	424	1856	550
	60	6	286.3	63.7	222.6	123.3	431	1935	554
Mean							431 ±2	1963 ±81	557 ±10
Corn, Pride of Saline, May 24 to Sept. 5	26	1	250.3	113.1	137.2	113.3	453	1002	826
	27	1	291.2	156.2	135.0	117.6	404	753	871
	29	1	251.1	98.9	152.2	114.6	456	1158	753
	31	1	266.8	111.7	155.1	116.7	438	1045	753
	32	1	285.9	71.0	214.9	114.7	401	1616	534
	34	1	247.5	73.5	174.0	110.3	446	1501	634
Mean							433 ±8	1179 ±96	728 ±36
Corn, Sherrod W. D., May 24 to Aug 25	21	1	174.9	106.0	68.9	68.2	390	644	991
	22	1	169.5	93.3	76.2	60.1	355	645	790
	23	1	188.3	84.5	103.8	81.0	430	959	780
	24	1	255.3	96.5	158.8	103.0	406	1073	652
Mean							395 ±11	830 ±90	803 ±47

II. GARDEN CITY, 1917.

Milo, Dwarf, May 24 to Aug. 10	6	3	329.8	156.3	164.9	93.4	283	598	566
	7	3	334.4	166.8	167.6	95.1	284	570	567
	8	3	313.3	163.5	149.8	91.1	291	557	608
	9	3	308.9	172.5	136.4	90.3	292	523	662
	10	3	322.8	181.6	141.2	94.1	292	518	666
	11	3	319.7	160.2	159.5	94.9	297	592	595
Mean							290 ±2	560 ±10	611 ±14
Kafir, Dawn, May 24 to Sept. 3	14	2	257.5	112.0	145.5	72.7	283	650	500
	15	2	269.3	112.8	156.5	75.2	279	667	481
	16	3	294.9	133.1	161.8	83.6	284	629	517
	20	3	292.1	117.7	174.4	81.0	277	688	465
	23	1	181.2	76.6	104.6	48.8	270	467	638
Mean							279 ±2	654 ±8	486 ±8
Kafir, Blackhull, May 24 to Sept. 19	41	1	266.9	114.5	152.4	78.8	295	689	517
	62	1	257.2	81.0	176.2	74.1	288	915	421
	64	1	254.8	105.7	149.1	72.0	283	682	483
	65	1	245.5	84.3	161.2	68.2	278	809	423
	66	1	238.5	66.8	171.7	63.5	266	951	370
Mean							282 ±3	809 ±42	443 ±19

TABLE II.—CONTINUED.

VARIETY AND PERIOD OF GROWTH.	Pot No.	Number of plants.	Dry matter without roots.	Grain.	Stem and leaves.	Water transpired.	Water requirement based on—		
							Total dry weight excluding roots.	Grain.	Stem and leaves.
II. GARDEN CITY, 1917—CONCLUDED.									
			Gm.	*Gm.*	*Gm.*	*Kg.*			
Feterita, May 24 to Aug. 23	69	3	273.1	108.8	164.3	80.5	295	740	490
	70	3	222.9	104.4	118.5	74.4	334	713	628
	75	3	204.4	97.0	107.4	68.5	335	706	638
	76	3	223.2	90.4	132.8	70.9	318	784	534
	78	3	258.5	107.4	151.1	84.4	326	786	558
Mean							322±5	746±13	570±21
Sudan grass, May 24 to Sept. 3	1	6	285.7	59.5	226.2	113.6	398	1910	503
	2	6	298.1	46.5	251.6	109.9	369	2363	437
	3	6	284.5	65.4	219.1	120.8	424	1848	551
	25	6	280.3	62.9	217.4	104.1	371	1655	479
	26	6	311.7	50.6	261.1	118.3	380	2338	453
Mean							388±8	2023±110	485±14
Corn, Pride of Saline, May 24 to Sept. 17	31	1	200.3	80.2	120.1	71.3	356	889	594
	32	1	241.1	91.4	149.7	88.2	366	966	590
	34	1	258.8	118.0	140.8	90.2	349	765	641
	36	1	201.8	78.9	122.9	79.9	396	1013	651
	37	1	256.4	70.4	186.0	93.0	363	1322	500
	39	1	255.2	95.1	160.1	93.4	366	983	584
Mean							366±4	990±45	593±14
Corn, Sherrod W. D., May 24 to Sept. 3	47	1	180.3	80.4	99.9	65.6	364	817	657
	50	1	181.7	81.0	100.7	62.3	343	770	620
	51	1	177.1	98.0	79.1	59.6	337	609	754
	52	1	150.3	68.4	81.9	53.1	354	777	649
	53	1	157.5	61.6	95.9	53.9	342	875	562
Mean							348±4	770±27	648±11

III. MANHATTAN, 1918.

Milo, Dwarf, May 23 to Aug. 26	31	2	275.4	134.8	140.6	99.1	360	735	705
	32	2	278.1	140.8	137.3	100.1	368	711	732
	33	2	272.1	94.7	177.4	101.1	372	1068	570
	34	2	277.9	144.4	132.5	100.9	363	699	762
	35	2	263.5	58.6	204.9	99.2	376	1693	484
Mean							368 ±2	981 ±135	651 ±42
Kafir, Dawn, May 23 to Aug. 26	6	2	246.1	90.5	155.6	86.9	353	961	556
	7	2	203.1	68.2	134.9	74.9	367	1092	552
	8	2	271.5	112.8	158.7	88.1	325	782	556
	9	2	279.5	104.8	174.7	91.9	329	877	526
	10	2	271.9	107.0	164.9	92.4	340	864	560
Mean							343 ±6	915 ±38	550 ±4
Kafir, Blackhull, May 18 to Aug. 27	66	1	237.7	82.5	155.2	83.3	351	1010	537
	67	1	183.3	53.9	129.4	66.7	364	1238	516
	68	1	267.9	71.5	186.4	87.1	325	1219	467
	69	1	135.0	45.0	90.7	47.6	351	1058	525
	70	1	209.9	69.7	140.2	76.6	365	1099	547
Mean							351 ±4	1125 ±27	518 ±9
Feterita, May 18 to Aug. 26	21	2	240.8	55.5	185.3	92.2	383	1662	498
	22	1	105.9	31.4	74.5	50.3	475	1597	675
	23	2	255.9	100.5	155.4	93.3	365	929	601
	24	2	270.7	105.8	164.9	94.7	350	895	574
	25	2	241.5	84.8	156.7	90.3	374	1065	576
Mean							389 ±14	1230 ±107	585 ±18
Sudan grass, May 23 to Aug. 22	36	6	284.3	58.2	226.1	126.1	444	2167	558
	37	6	291.8	55.1	236.7	128.2	439	2327	542
	38	6	266.9	55.8	211.1	122.4	459	2195	580
	39	6	282.2	28.2	254.0	129.7	460	4599	511
	40	6	297.6	44.1	253.5	128.0	431	2903	505
Mean							447 ±4	2838 ±308	539 ±10
Sorgo, Freed, May 23 to Aug. 23	1	2	176.5	41.6	134.9	86.2	489	2074	640
	2	2	158.5	36.8	121.7	78.9	498	2145	648
	3	2	168.8	47.6	121.2	81.6	483	1714	673
	4	2	134.9	32.2	102.7	67.7	502	2105	660
	5	2	158.9	36.5	122.4	77.9	490	2134	636
Mean							492 ±2	2034 ±54	651 ±6

TABLE II.—CONTINUED.

VARIETY AND PERIOD OF GROWTH.	Pot No.	Number of plants.	Dry matter without roots.	Grain.	Stem and leaves.	Water transpired.	Water requirement based on—		
							Total dry weight excluding roots.	Grain.	Stem and leaves.
III. MANHATTAN, 1918—CONTINUED.									
			Gm.	*Gm.*	*Gm.*	*Kg.*			
Milo, White, May 23 to Aug. 26	11	2	308.2	105.0	203.3	97.6	317	930	480
	12	2	300.8	171.9	128.9	97.5	324	567	756
	13	2	285.2	104.7	180.5	97.9	344	936	543
	14	2	250.7	119.8	130.9	98.0	391	819	749
	15	2	292.7	146.0	146.7	96.5	330	661	658
Mean							341±9	783±48	637±42
Sorgo, Red Amber, May 18 to Aug. 26	26	2	292.6	64.4	228.2	93.1	318	1446	408
	27	2	303.8	84.4	219.4	95.3	314	1130	435
	28	2	300.2	47.4	253.8	96.2	320	2029	379
	29	2	295.6	87.1	208.5	90.5	306	1039	434
	30	2	294.5	75.5	219.0	93.7	318	1238	428
Mean							315±2	1376±105	417±8
Broomcorn, Acme Dwarf, May 23 to Aug. 23	17	2	247.1	65.3	181.8	92.1	373	1411	507
	18	2	241.0	80.5	160.5	86.8	361	1079	541
	19	2	265.3	74.3	191.0	85.9	324	1157	450
	20	2	254.8	77.5	177.3	89.6	352	1157	506
Mean							353±7	1201±51	501±12
Sorgo, Kansas Orange, May 18 to Aug. 27	71	1	269.8	55.7	214.1	94.3	350	1693	440
	72	1	271.7	26.3	245.4	93.5	344	3557	381
	73	1	272.1	38.6	234.5	90.2	332	2338	385
	74	1	269.0	45.6	223.4	74.6	277	1637	334
Mean							326±12	2306±261	385±13
Corn, Kansas Sunflower, May 8 to Aug. 22	41	1	185.8	.....	185.8	117.6	633	No grain	633
	42	1	303.9	72.7	231.2	127.2	419	1751	551
	43	1	198.5	.....	198.5	97.4	491	No grain	491
	44	1	293.5	132.1	161.4	109.1	372	826	676
	45	1	265.5	93.6	171.9	121.5	458	1299	707
Mean							475±30	1288±188	612±31

Corn, Sherrod W. D., May 8 to Aug. 12	46	1	187.9	87.5	100.4	73.4	391	840	732
	47	1	223.4	116.3	107.1	81.8	366	704	764
	48	1	160.1	.....	160.1	78.3	489	No grain	489
	49	1	201.2	105.9	95.3	86.9	432	821	913
	50	1	278.9	148.8	130.1	99.4	351	669	765
Mean							407±18	757±35	733±41
Corn, Pride of Saline, May 8 to Aug. 22	51	1	233.5	.....	233.5	120.3	515	.....	515
	52	1	301.9	104.4	197.5	129.1	428	1237	654
	53	1	255.9	58.6	197.3	117.2	458	2000	594
	54	1	332.3	122.6	209.7	124.0	373	1012	592
	55	1	337.0	150.2	186.8	123.9	368	825	664
Mean							428±20	1268±176	604±18
Corn, Freed W. D., May 8 to Aug. 22	56	1	232.6	113.6	119.0	90.1	388	794	758
	57	1	313.4	167.8	145.6	121.3	387	723	834
	58	1	275.7	128.6	147.1	109.3	397	850	743
	59	1	264.2	126.0	138.2	109.1	413	867	790
	60	1	291.5	152.2	139.3	118.1	405	878	848
Mean							398±4	822±17	795±16
Corn, Reid Y. D., May 8 to Aug. 22	61	1	237.9	93.0	144.9	109.7	461	1180	757
	62	Lost	.....	.....	.....	.....	.....	.....	.....
	63	1	253.5	.....	253.5	132.7	524	No grain	524
	64	1	268.6	124.7	143.9	123.2	459	988	856
	65	1	236.4	.....	236.4	130.8	553	No grain	553
Mean							499±19	1084±81	672±63

IV. MANHATTAN, 1919.

Milo, Dwarf, May 24 to Sept. 1	61	2	516.0	232.0	284.0	133.4	264	575	470
	62	2	483.7	233.2	250.5	123.5	255	530	493
	63	2	519.8	221.1	298.7	128.7	248	582	431
	64	2	442.8	185.6	257.2	106.9	242	576	416
Mean							252±3	565±9	452±14
Kafir, Dawn, May 24 to Aug. 21	11	2	233.7	104.3	129.4	62.7	269	602	485
	12	2	214.4	92.9	121.5	56.3	263	607	464
	13	2	221.1	84.2	136.9	56.1	254	667	410
	14	2	228.6	98.2	130.4	60.0	263	611	460
	15	2	219.0	103.6	115.4	56.6	259	547	491
Mean							261±2	606±10	462±9

TABLE II.—CONTINUED.

VARIETY AND PERIOD OF GROWTH.	Pot No.	Number of plants.	Dry matter without roots.	Grain.	Stem and leaves.	Water transpired.	Water requirement based on—		
							Total dry weight excluding roots.	Grain.	Stem and leaves.
IV. MANHATTAN, 1919—CONTINUED.									
			Gm.	*Gm.*	*Gm.*	*Kg.*			
Kafir, Blackhull, May 24 to Sept. 1	51	1	204.0	101.1	102.9	51.5	253	510	501
	52	1	155.7	75.1	80.6	41.5	267	554	516
	53	1	196.1	86.2	109.9	48.8	249	566	438
	54	1	197.3	99.2	98.1	46.5	236	469	474
	55	1	186.8	91.0	95.8	47.6	255	524	498
Mean							254±3	524±12	485±10
Feterita, May 24 to Aug. 15	76	2	279.6	103.4	176.2	78.7	282	760	447
	77	2	349.7	104.4	245.3	100.0	287	963	410
	78	2	310.6	130.7	179.9	86.6	279	663	481
	79	2	275.9	100.8	175.1	79.8	289	792	456
	80	2	265.4	111.0	154.4	81.7	309	737	530
Mean							289±3	783±32	464±14
Sudan grass, May 24 to Aug. 19	66	4	588.5	103.9	484.6	190.1	323	1830	392
	67	4	603.1	103.7	499.4	187.2	310	1815	375
	68	4	424.6	70.4	354.2	169.9	400	2413	480
	69	4	604.3	123.5	480.8	183.6	304	1486	382
	70	4	551.1	113.6	437.5	192.3	349	1693	440
Mean							337±12	1847±95	413±16
Sorgo, Freed, May 24 to Aug. 15	1	2	216.2	118.3	97.9	64.0	296	541	654
	2	2	206.8	91.8	115.0	64.5	312	703	561
	3	2	255.8	109.8	146.0	71.4	279	650	489
	4	2	181.2	91.5	89.7	52.6	290	575	587
	5	2	215.3	96.5	118.8	62.4	290	648	526
Mean							293±4	623±22	563±19

Milo, White, May 24 to Sept 1.	6	2	502.7	167.1	335.6	120.2	239	719	351
	7	2	520.1	183.9	336.2	124.4	239	677	370
	8	2	504.1	172.1	332.0	126.8	252	737	382
	9	2	488.2	138.9	349.3	114.2	234	823	327
	10	2	543.1	154.4	388.7	124.7	230	808	321
Mean							238±2	752±21	350±12
Sorgo, Red Amber, May 24 to Aug. 15.	71	2	346.3	123.4	222.9	90.5	261	733	406
	72	2	282.7	123.5	159.2	71.8	254	581	451
	73	2	326.5	114.7	211.8	80.0	245	698	378
	74	2	277.8	116.9	160.9	72.5	261	621	451
	75	2	313.0	100.9	212.1	77.7	248	770	366
Mean							253±2	680±27	410±14
Broom corn, Acme Dwarf, May 24 to Aug. 21.	16	2	248.6	64.2	184.4	70.7	285	1102	384
	17	2	260.8	71.7	189.1	73.4	282	1024	388
	18	2	227.9	57.6	170.3	64.0	227	1111	376
	19	2	265.5	67.0	198.5	71.9	271	1074	363
	20	2	288.5	82.9	205.6	83.4	289	1006	406
Mean							270±8	1063±16	383±5
Sorgo, Kansas Orange, May 24 to Sept. 1.	56	1	295.7	94.1	201.6	73.9	250	786	367
	57	1	267.9	83.5	184.4	64.4	241	772	350
	58	1	213.7	62.8	150.9	54.9	257	875	364
	59	1	306.2	111.5	194.7	70.5	230	632	362
	60	1	317.1	107.3	209.8	75.4	238	704	360
Mean							243±3	753±29	360±2
Corn, Kansas Sunflower, May 10 to Aug. 28.	31	1	529.5	171.7	357.8	153.9	291	897	430
	32	1	456.7	170.1	286.6	130.4	286	767	455
	33	1	424.0	183.6	240.4	133.5	315	727	555
	34	1	478.5	204.9	273.6	135.8	283	663	497
	35	1	478.7	224.4	254.3	140.3	293	626	552
Mean							293±3	736±32	497±19
Corn, Sherrod W. D., May 10 to Aug. 19.	46	1	343.7	198.0	145.7	93.4	272	472	642
	47	1	337.9	195.2	142.7	102.9	305	527	721
	48	1	319.2	147.9	171.3	93.8	294	634	548
	49	1	282.1	139.9	142.2	79.6	282	569	560
	50	1	323.2	156.1	167.1	101.0	315	647	605
Mean							293±6	569±24	615±22
Corn, Pride of Saline, May 10 to Aug. 28.	21	1	367.7	17.6	350.1	105.0	286	No grain	286
	22	1	413.4	146.3	267.1	128.0	310	875	480
	23	1	392.4	106.0	296.4	133.1	339	1255	449
	24	1	355.9	142.8	213.1	122.0	343	855	573
	25	1	400.3	120.3	280.0	124.3	311	1033	444
Mean							317±13	1004±70	446±27

TABLE II.—CONTINUED.

VARIETY AND PERIOD OF GROWTH.	Pot No.	Number of plants.	Dry matter without roots.	Grain.	Stem and leaves.	Water transpired.	Water requirement based on—		
							Total dry weight excluding roots.	Grain.	Stem and leaves.
IV. MANHATTAN, 1919—CONCLUDED.									
			Gm.	*Gm.*	*Gm.*	*Kg.*			
Corn, Freed W. D., May 10 to Aug. 25	26	1	257.3	123.9	133.4	80.2	312	647	601
	27	1	187.9	36.2	151.7	79.5	423	No grain	423
	28	1	296.0	13.0	283.0	101.0	341	No grain	341
	29	1	365.4	199.5	165.9	107.4	294	538	647
	30	1	390.8	146.7	244.1	134.7	345	919	557
Mean							343±14	701±86	512±45
Corn, Reid Y. D., May 10 to Aug. 28	36	1	321.7	165.8	155.9	108.3	337	653	695
	37	1	321.7	165.8	155.9	109.3	340	659	701
	38	1	354.0	195.7	158.3	118.9	336	608	752
	39	1	468.4	178.1	290.3	141.0	301	792	486
	40	1	420.5	227.2	193.3	132.8	316	585	687
Mean							326±6	659±22	664±30
Sorgo, Sumac, May 24 to Sept. 1	41	1	217.4	98.7	118.7	52.5	241	532	442
	42	1	220.2	94.8	125.4	51.9	236	548	414
	43	1	301.6	78.4	223.2	65.3	217	834	293
	44	1	206.9	67.9	139.0	52.7	255	777	380
	45	1	228.6	86.6	142.0	56.3	247	651	397
Mean							239±4	668±46	385±16
V. MANHATTAN, 1920.									
Milo, Dwarf, May 21 to Sept. 1	61	2	271.8	108.0	163.8	66.0	243	611	403
	62	2	255.8	127.7	128.1	61.6	241	482	481
	63	2	257.8	135.2	122.6	60.6	233	448	494
	64	2	209.2	111.6	97.6	47.6	227	426	487
	65	2	294.5	143.0	151.5	58.3	198	407	385
Mean							228±5	475±24	450±19

Kafir, Dawn, May 21 to Aug. 25	1	2	194.6	100.0	94.6	46.2	238	463	489
	2	2	216.6	118.2	98.4	47.8	221	404	485
	3	2	232.7	94.2	138.5	55.0	236	584	397
	4	2	180.2	94.9	85.3	41.4	230	436	485
	5	2	261.8	137.4	124.4	60.1	230	438	483
Mean							231±2	465±12	468±12
Kafir, Blackhull, May 21 to Sept. 1	46	1	128.2	23.5	104.7	31.1	243	1324	297
	47	1	163.0	83.5	79.5	37.2	228	446	468
	48	1	158.7	84.1	74.6	35.3	223	420	474
	49	1	131.9	58.6	73.3	31.3	237	534	427
	50	1	202.1	100.2	101.9	45.9	227	458	451
Mean							232±3	636±12	423±21
Feterita, May 21 to Aug. 19	76	2	189.2	72.6	116.6	46.7	247	643	400
	77	2	227.1	102.9	124.2	56.6	249	550	456
	78	2	249.2	120.4	128.8	57.1	229	475	444
	79	2	200.3	99.9	100.4	51.5	257	516	513
	80	2	235.6	111.6	124.0	59.7	253	535	481
Mean							247±5	544±18	459±13
Sudan grass, May 21 to Aug. 18	66	2	351.8	93.8	258.0	90.0	256	959	349
	67	2	324.9	92.7	232.2	96.4	297	1040	415
	68	2	321.8	114.7	207.1	91.3	284	796	441
	69	2	291.8	85.1	206.7	80.9	277	951	391
	70	2	367.0	87.3	279.7	95.9	261	1099	343
Mean							275±6	969±34	388±14
Sorgo, Freed, May 21 to Aug. 18	11	2	193.7	95.6	98.1	45.3	234	474	462
	12	2	166.8	81.8	85.0	41.3	248	505	486
	13	2	168.2	75.8	92.4	41.5	246	547	449
	14	2	168.6	83.0	85.6	41.1	244	495	480
	15	2	199.5	96.3	103.2	48.8	245	507	473
Mean							243±2	506±7	470±5
Milo, White, May 21 to Aug. 25	6	2	306.5	No grain	306.5	72.0	235	No grain	235
	7	2	332.6	No grain	332.6	71.6	215	No grain	215
	8	2	339.4	126.7	212.7	67.1	198	530	316
	9	2	323.4	No grain	323.4	74.5	230	No grain	230
	10	2	351.2	129.5	221.7	70.0	199	541	316
Mean							215±6	535±5	262±18

TABLE II.—CONCLUDED.

VARIETY AND PERIOD OF GROWTH.	Pot No.	Number of plants.	Dry matter without roots.	Grain.	Stem and leaves.	Water transpired.	Water requirement based on—		
							Total dry weight excluding roots.	Grain.	Stem and leaves.
V. MANHATTAN, 1920—CONCLUDED.									
			Gm.	*Gm.*	*Gm.*	*Kg.*			
Sorgo, Red Amber, May 21 to Aug. 19	71	2	232.6	103.0	129.6	52.4	225	509	405
	72	2	254.6	115.4	139.2	56.1	220	486	403
	73	2	202.0	87.2	114.8	44.2	219	507	385
	74	2	204.2	87.0	117.2	48.2	236	554	412
	75	2	221.2	83.0	138.2	45.3	205	545	328
Mean							221±3	520±10	386±10
Broomcorn, Acme Dwarf, May 21 to Aug. 19	16	2	238.5	50.5	188.0	48.9	205	968	260
	17	2	254.5	73.1	181.4	56.7	223	776	313
	18	2	254.1	68.9	185.2	59.4	234	862	321
	19	2	258.3	70.7	187.6	64.6	250	914	344
	20	2	271.7	70.2	201.5	60.6	223	863	301
Mean							227±5	878±22	308±9
Sorgo, Kansas Orange, May 21 to Sept. 1	56	1	308.8	119.1	189.7	48.9	158	411	258
	57	1	204.3	88.7	115.6	42.4	207	477	366
	58	1	253.6	111.7	141.9	52.4	206	469	369
	59	1	220.4	84.4	136.0	48.2	218	570	354
	60	1	196.9	101.8	95.1	44.6	226	438	469
Mean							203±8	473±17	363±19
Corn, Kansas Sunflower, May 17 to Sept. 1	31	1	382.1	135.5	246.6	95.2	249	703	386
	32	1	319.6	172.6	147.0	84.0	263	487	572
	33	1	264.8	No grain	264.8	78.3	296	No grain	296
	34	1	230.6	No grain	230.6	74.1	321	No grain	321
	35	1	328.3	151.0	177.3	88.5	270	586	499
Mean							280±10	592±24	415±41

Corn, Sherrod W. D., May 17 to Aug. 25	41	1	309.1	165.5	143.6	71.9	233	435	501
	42	1	296.1	166.0	130.1	67.5	228	406	519
	43	1	228.2	86.4	141.8	59.7	262	691	421
	44	1	279.7	123.8	155.9	71.8	257	580	461
	45	1	335.6	209.0	126.6	68.7	205	329	543
Mean							237 ±8	488 ±49	489 ±16
Corn, Pride of Saline, May 17 to Sept. 1	21	1	420.5	188.0	232.5	96.4	229	513	414
	22	1	416.9	167.6	249.3	96.5	231	576	387
	23	1	436.1	188.0	248.1	102.5	235	545	413
	24	1	420.1	158.9	261.2	90.7	216	571	347
	25	1	459.5	156.1	303.4	112.4	245	720	370
Mean							231 ±3	585 ±23	386 ±9
Corn, Freed W. D., May 17 to Sept. 1	36	1	251.3	72.6	178.7	84.5	336	1164	473
	37	1	442.1	211.7	230.4	90.1	204	426	391
	38	1	300.1	No grain	300.1	85.8	286	No grain	286
	39	1	384.7	138.9	245.8	93.6	243	674	381
	40	1	263.0	115.4	147.6	84.0	320	728	570
Mean							278 ±18	748 ±102	420 ±35
Corn, Reid Y. D., May 17 to Sept. 1	26	1	320.0	77.7	242.3	85.1	266	1095	351
	27	1	390.4	146.6	243.8	102.0	261	696	418
	28	1	351.2	195.4	155.8	89.3	254	457	573
	29	1	417.6	204.1	213.5	104.9	251	514	492
	30	1	376.1	182.5	193.6	98.5	262	540	509
Mean							259 ±2	660 ±79	468 ±28
Sorgo, Sumac, May 21 to Sept. 1	51	1	160.3	92.0	68.3	36.0	225	391	527
	52	1	142.6	Smutted	142.6	40.7	285	Smutted	285
	53	1	231.0	83.8	147.2	48.4	210	578	329
	54	1	192.3	105.7	86.6	39.4	205	373	455
	55	1	233.1	76.8	156.3	44.7	192	582	286
Mean							223 ±10	481 ±48	376 ±39

TABLE III.—Comparison of the water requirement of corn and sorghums for the years 1916 and 1917 at Garden City and for the years 1918, 1919, and 1920 at Manhattan.

PLANTS.	Average water requirement.	Relative value considering the lowest water requirement in each period equal to 1.	Acre-inches of rain fall used in the production of a ton of dry matter.
I. PLANTS GROWN DURING THE TWO YEARS 1916 AND 1917 AT GARDEN CITY.			
Kafir, Blackhull	305	1.00	2.69
Milo, Dwarf	310	1.01	2.73
Kafir, Dawn	313	1.02	2.76
Feterita	361	1.18	3.18
Corn, Sherrod W. D.	372	1.21	3.28
Corn, Pride of Saline	400	1.31	3.53
Sudan grass	410	1.34	3.62
II. PLANTS GROWN DURING THE THREE YEARS 1918, 1919, AND 1920 AT MANHATTAN.			
Sorgo, Kansas Orange	257	1.00	2.26
Sorgo, Red Amber	263	1.02	2.32
Milo, White	265	1.03	2.33
Kafir, Dawn	278	1.08	2.45
Kafir, Blackhull	279	1.08	2.45
Milo, Dwarf	283	1.10	2.49
Broomcorn, Acme Dwarf	283	1.10	2.49
Feterita	308	1.19	2.71
Corn, Sherrod W. D.	312	1.21	2.75
Corn, Pride of Saline	325	1.26	2.86
Corn, Freed W. D.	339	1.31	2.99
Sorgo, Freed	343	1.33	3.02
Corn, Kansas Sunflower	349	1.35	3.08
Sudan grass	353	1.37	3.11
Corn, Reid Y. D.	361	1.40	3.18
III. PLANTS GROWN DURING 1916 AND 1917 AT GARDEN CITY AND DURING 1918, 1919, AND 1920 AT MANHATTAN.			
Kafir, blackhull	289	1.00	2.55
Kafir, Dawn	292	1.01	2.57
Milo, Dwarf	294	1.01	2.59
Feterita	329	1.13	2.90
Corn, Sherrod W. D.	336	1.16	2.96
Corn, Pride of Saline	355	1.22	3.13
Sudan grass	376	1.30	3.31

TABLE IV.—Comparative differences in the water requirements of the varieties of corn and sorghum grown at Garden City in 1916 and 1917, and at Manhattan in 1918, 1919, and 1920.

PLANTS.	Average water requirement.	Kafir, Dawn.	Milo, Dwarf.	Feterita.	Corn, Sherrod W. D.	Corn, Pride of Saline.	Sudan grass.
Kafir, Blackhull	289.2±1.6	2.8±2.4	4.4±2.1	40.4±2.6	46.8±5.3	65.8±5.3	86.4±3.6
Kafir, Dawn	292.0±1.8		1.6±2.3	37.6±2.7	44.0±5.4	63.0±5.4	83.6±3.6
Milo, Dwarf	293.6±1.4			36.0±2.5	32.4±5.3	61.4±5.5	82.0±3.5
Feterita	329.6±2.1				6.4±5.5	25.4±5.5	46.0±3.8
Corn, Sherrod W. D	336.0±5.1					19.0±7.2	39.6±6.0
Corn, Pride of Saline	355.0±5.1						20.6±6.0
Sudan grass	375.6±3.2						

TABLE V.—Comparative differences in the water requirements of the varieties of corn and sorghum grown at Manhattan in 1918, 1919, and 1920.

PLANTS.	Average water requirement.	Sorgo, Red Amber.	Milo, White.	Kafir, Dawn.	Kafir, Blackhull.	Milo, Dwarf.	Broomcorn, Acme Dwarf.	Feterita.
Sorgo, Kansas Orange	257.3±4.9	5.7±5.1	7.3±6.1	21.0±5.3	21.7±5.2	25.3±5.3	26.0±6.2	51.0±7.0
Sorgo, Red Amber	263.0±1.4		1.6±3.9	15.3±2.5	16.0±2.3	19.6±2.5	20.3±4.1	45.3±5.3
Milo, White	264.6±3.7			13.7±4.3	14.4±4.1	18.0±4.3	18.7±5.3	43.7±6.3
Kafir, Dawn	278.3±2.2				.7±2.9	4.3±3.0	5.0±4.4	30.0±5.5
Kafir, Blackhull	279.0±1.9					3.6±2.8	4.3±5.3	29.3±5.4
Milo, Dwarf	282.6±2.1						.7±4.4	25.7±5.5
Broomcorn, Acme Dwarf	283.3±3.9							25.0±6.4
Feterita	308.3±5.1							
Corn, Sherrod W. D	312.3±6.9							
Corn, Pride of Saline	325.3±8.0							
Corn, Freed W. D	339.6±7.7							
Sorgo, Freed	342.6±1.6							
Corn, Kansas Sunflower	349.3±10.6							
Sudan grass	353.0±4.7							
Corn, Reid Y. D	361.3±6.7							

The difference between the mean water requirements of two varieties was obtained by the formula $M-M^1 \pm \sqrt{(a_1)^2+(a_2)^2}$ where M and M^1 represent the two means in question and a_1 a_2 represent the probable error, respectively, of each mean.

TABLE V.—CONCLUDED.

PLANTS.	Corn, Sherrod W. D.	Corn, Pride of Saline.	Corn, Freed W. D.	Sorgo, Freed.	Corn, Kansas Sunflower.	Sudan grass.	Corn, Reid Y. D.
Sorgo, Kansas Orange	55.0±8.4	68.0±9.3	82.3±9.1	85.3±5.1	92.0±11.6	95.7±6.8	104.0±8.3
Sorgo, Red Amber	49.3±7.0	62.3±8.1	76.6±7.8	79.6±2.1	86.3±10.7	90.0±4.9	98.3±6.8
Milo, White	47.7±7.8	60.7±8.8	75.0±8.5	78.0±4.0	84.7±11.2	88.4±6.0	96.7±7.0
Kafir, Dawn	34.0±6.5	47.0±8.3	61.3±8.0	64.3±2.7	71.0±10.8	74.7±5.0	83.0±7.0
Kafir, Blackhull	33.3±7.1	46.3±8.2	60.6±7.8	63.6±2.4	70.3±10.7	74.0±5.0	82.3±7.0
Milo, Dwarf	29.7±7.2	43.7±8.2	57.0±8.0	60.0±2.6	66.7±10.8	70.4±5.1	78.7±7.0
Broomcorn, Acme Dwarf	29.0±7.8	42.0±8.4	56.3±8.6	59.3±4.2	66.0±11.2	70.0±6.1	78.3±7.7
Feterita	4.0±8.6	15.0±9.4	31.3±9.2	34.3±5.3	41.0±11.7	44.7±6.9	53.0±8.4
Corn, Sherrod W. D		13.0±10.5	27.3±10.3	30.3±7.1	37.0±12.7	40.7±8.3	49.0±9.5
Corn, Pride of Saline			14.3±11.1	17.3±8.1	24.0±13.2	27.7±9.2	36.0±10.4
Corn, Freed W. D				3.0±7.8	9.7±13.1	13.4±9.0	21.7±10.2
Sorgo, Freed					6.7±10.7	10.4±5.0	18.7±6.8
Corn, Kansas Sunflower						3.7±11.6	12.0±12.5
Sudan grass							8.3±8.1
Corn, Reid Y. D							

THE WATER REQUIREMENT OF SORGHUMS.

In considering sorghums the most striking fact is the wide difference between the lowest and highest water requirement of the varieties studied. Sudan grass had the highest water requirement of any of the sorghums grown in these experiments For the three seasons at Manhattan the water requirement of this crop averaged 353, while for the two years at Garden City its average was 375. Kansas Orange sorgo with an average water requirement of 257 was the lowest in the list of the 10 varieties grown during the three seasons at Manhattan. Daring the two seasons at Garden City, Blackhull kafir with a water requirement of 289 stood the lowest in the list of the five varieties grown in that location. The difference between the highest and the lowest average water requirement of the sorghum varieties was 96 for the plants grown at Manhattan and 87 for those grown at Garden City. From Table III it is seen that the average water requirement of Sudan grass was 1.37 times that of Kansas Orange sorgo at Manhattan and 1.34 times that of Blackhull kafir, the plant with the lowest water requirement at Garden City. These differences between the maximum and minimum average water requirements are equivalent to 0.85 and 0.93 of an acre-inch of rainfall in the production of a ton of dry matter for the two plants in question at Manhattan and at Garden City, respectively.

It has been observed that the sorghums grown in these experiments may be placed in fairly definite groups based on the value of their water requirements. In Tables IV and V little difference is seen between the water requirement of Kansas Orange sorgo, Red Amber sorgo, and White milo and if the probable error is taken into consideration the differences are of no significance since their values are approximately equal to the probable errors. Blackhull kafir, Dawn kafir, Dwarf milo, and Acme Dwarf broomcorn fall into another group that is distinct in regard to the water requirement. The differences between the water requirements of these four varieties are of no significance when we consider the probable errors in the case. The water requirement of this group, however, is distinctly and significantly higher than that of the preceding group and strikingly lower than that of feterita, Freed sorgo, and Sudan grass. The last two plants have the highest water requirement of the sorghum varieties considered in the experiment, while feterita occupies an intermediate position between the sorghums with a relatively low water requirement and those with a relatively high water requirement.

THE WATER REQUIREMENT OF CORN.

At Manhattan the lowest average water requirement was 312 (Sherrod White Dent.) and the highest was 361 (Reid Yellow Dent). This makes a difference of 49 between the highest and the lowest mater requirement for corn, a difference approximately half of that between the two extremes for the sorghums. At Garden City only Pride of Saline and Sherrod White Dent were grown and in both years Sherrod White Dent had a water requirement significantly lower than that of Pride of Saline, but at Manhattan there was no significant, difference in the average water requirement of the two varieties. At Manhattan the average water requirement of Sherrod White Dent for three seasons was significantly lower than that of Freed White Dent, Kansas Sunflower, or Reid Yellow Dent. The differences in average water requirement of Freed White Dent, Kansas Sunflower, and Reid Yellow Dent were of no significance when the probable error of these differences was taken into consideration.

RELATIONS OF THE WATER REQUIREMENT TO CROP PRODUCTION IN SEMIARID REGIONS.

It is interesting to note the relationship between the water requirement of plants and their ability to produce a crop of grain in regions subject to drouth conditions during the growing season. In actual agricultural experience Freed sorgo, Dwarf milo, White milo, and feterita have been found to be the most reliable sorghums for grain production under the climatic conditions in western Kansas and the southern portion of the Great Plains area. These plants produce a grain crop under conditions in which corn and other sorghums fail entirely in grain production.

From Table III it is seen that the water requirements of these four plants differ widely. Freed sorgo has an average water requirement 30, 23, and 12 per cent higher, respectively, than that of White milo, Dwarf milo, and feterita, while feterita has an average water requirement for five seasons 12 per cent higher than that of Dwarf milo.

Dawn kafir, Red Amber sorgo, and Sudan grass are next to the above-named group in the certainty of grain production under conditions of drouth. Red Amber sorgo is one of the lowest sorghums in the list in regard to its water requirement while for five years Sudan grass has had the highest water requirement of any of the corn or sorghum varieties studied with but one exception, and in that case the difference is of no significance when the experimental error is taken into consideration. The average water requirement of Sudan grass was 29 per cent higher than that of Dawn kafir and 35 per

cent higher than that of Red Amber sorgo. Kansas Orange sorgo in the three years at Manhattan had the lowest water requirement of any of the plants studied but in actual farming practice it is one of the least reliable of the sorghums for the production of a crop of grain under conditions that prevail in western Kansas and in the southern portions of the Great Plains.

Sherrod White Dent corn had a water requirement significantly lower than that of all of the varieties of corn with the exception of Pride of Saline at Manhattan. It is an early-maturing corn and is one of the most reliable varieties under conditions of drouth. It is worthy of note that its water requirement is approximately the same as that of feterita and much lower than that of Freed sorgo and Sudan grass.

The results of these experiments show that there is little or no relationship between the water requirement of a plant and its ability to produce a crop of grain under severe climatic conditions during its growing season. It must be considered, however, that the plants in question were grown during the entire season in a soil that was supplied with an amount of moisture sufficient for optimum growth. What the water requirement of these plants mould be if their water supply were limited during all or part of the growing season has not been determined.

It would appear, however, that a short growing season, a small leaf surface, and an efficient absorbing system are more important factors in determining the maturity of a crop in regions of limited or uncertain rainfall than the relationship between the amount of water evaporated and the amount of dry matter produced during the growing season. The dwarf varieties of sorghums possess these characteristics in a marked degree. On account of their quick growth and maturity, they can escape a portion of severe weather. During severe climatic conditions, their small leaf surface prevents a large loss of water by evaporation while their extensive root systems (Miller, 1916) keep the aerial parts supplied with the water necessary for growth or at least with an amount sufficient to prevent the death of the parts until more favorable conditions arrive. These facts are well illustrated in the case of feterita and Freed sorgo which have a relatively high water requirement. These plants have long internodes and develop comparatively few leaves and although the amount of water lost during the growing season is relatively high compared to the amount of dry matter produced, the amount of water evaporated by each plant during any given period of time is small and is quickly replaced by an elaborate root system.

CONCLUSIONS.

The purpose of these investigations was to study relative water requirement of corn and sorghums when grown under the same environmental conditions and to determine whether there was any relationship between the water requirement of these plants and their ability to produce a crop under conditions of limited and uncertain rainfall during their growing season. The experiments during five years show the following facts:

1. Water requirements of the different varieties of sorghums vary greatly. The difference between the lowest and highest water requirement amounted to 37 per cent or the equivalent of 0.85 of an acre-inch of rainfall per ton of dry matter produced.

2. Water requirements of the varieties of corn studied showed less variation than did the sorghums. The difference between the lowest and highest water requirement amounted to only 19 per cent, or the equivalent of 0.43 of an acre-inch of rainfall in the production of a ton of dry matter. The water requirement of two of the sorghum varieties was as high or higher than that of any of the five varieties of corn.

3. There is no relationship between the water requirement of a plant and its ability to withstand drouth conditions. Some of the plants that agricultural practice has shown to be the most reliable in the production of a grain crop under conditions of drouth have a water requirement much higher than those which are known to fail frequently under the same conditions, while some of the plants that are the most unreliable in the production of a crop under severe weather conditions have the lowest water requirement of any of the plants studied.

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