EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE

MANHATTAN, KANSAS

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SOME COMPARISONS OF VARIETIES OF SORGHUM.
PRELIMINARY REPORT ON SORGHUM BLIGHT

MANHATTAN, KANSAS
PRINTING DEPARTMENT, AGRICULTURAL COLLEGE
1888

A COMPARISON OF VARIETIES OF SORGHUM.

The Farm Department grew thirty-nine different kinds of sorghum. In two or three instances the seed was obtained under the same name from different sources, or had originally come from different sources. This will be seen by an inspection of the list below. The seed was planted on the nineteenth of May. The soil was a sandy loam, of average fertility for our second bottoms. Ordinary good tillage was given the crop. This sorghum was turned over to us for such investigations as we might find desirable. For our first season's work, it was planned to collect data upon the varieties at command, and to prepare for future efforts at improving sorghum as a sugar plant. The first of these objects included as its most important feature the determination of the sucrose, or cane sugar, and the so-called glucose, or reducing sugar of the chemist. But as a very important part of the work, full data upon the physical characters of the canes were obtained. The nature of this will be seen by reference to the accompanying table. One column is headed "Number of Dead Leaves." It was learned during a previous season's work on sorghum that stalks and portions of stalks having dead blades average poorer in quality than similar stalks that are not thus defective. Hence, the observation was made. But stalks that had many dead blades, or that were much bent, were entirely rejected in taking samples for analysis. The juice was extracted from the canes by a one-horse three-roll mill. The mill was kept at the same adjustment throughout the season. The proportion of the juice extracted probably varied with the size of the stalks. Large stalks would be pressed harder than smaller ones. The tables give our analyses of sorghum for the season.

In all cases where the cane ripened early enough and we had sufficient cane, three analyses were made; in a few cases a greater number of analyses were made for special reasons. Since it has been well established that the immature sorghum is not in proper

This Bulletin was included as part of the Annual Report for this year, so the Bulletin version is used here .

This version is longer than the bulletin that was issued separately.

condition for sugar making, and is in poor condition for making syrup, our work began upon the several plants when they were approaching maturity. As a suitable stage of development for the first analysis, that when the seed is dry, but yet easily split, was chosen. This condition was reached about a week after the seed passed out of the dough state. Other analyses were made to study the development of the plant and to learn how well the quality is maintained while standing in the field after ripening. A fair comparison of the order in which the varieties ripened may be had from the table, since it was the intention to make the several "first analyses" at the same degree of development. The height as given in the table includes the seed top. The weight is of the whole can. The per cent. of top includes the seed head proper with about six inches of stalk attached. The per cent. of juice extracted is calculated upon the weight of clean cane. "Reducing sugar" includes what is frequently reported as glucose.

VARIETIES OF SORGHUM COMPARED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
African	Sept. 22	10	9.00	2.12	13.1	2.1	11.37	25.21	63.42	47.69	1.0657	8.65	5.00	13.65
African	Oct. 13	10	7.68	1.73	12.7	6.9	11.72	22.37	65.91	44.95	1.0738	10.11	4.38	14.49
African	Oct. 18	1	9.25	1.97	11.0	3.0	....	....	....	49.19	1.0717	11.05	7.05	18.10
Gooseneck	Sept. 22	10	8.88	2.18	13.3	2.5	12.08	26.17	61.75	41.32	1.0658	9.14	4.71	13.85
Liberian, from Alabama	Sept. 26	6	8.10	2.79	13.6	4.0	13.28	28.01	58.71	49.44	1.0701	11.15	3.31	14.46
Liberian, from Missouri	Sept. 26	6	7.75	2.37	13.2	3.7	13.85	25.96	60.19	46.49	1.0742	11.98	3.13	15.11
Liberian, from Missouri	Oct. 16	5	7.74	1.53	11.8	5.8	19.58	16.71	63.71	46.72	1.0717	11.65	2.88	14.53
Chinese sugar cane, small variety	Aug. 29	8	8.12	1.10	6.6	0.8	34.05		65.95	47.85	1.0417	5.01	3.35	8.36
Chinese sugar cane, small variety	Sept. 24	10	7.93	.84	6.2	1.4	8.44	23.96	67.66	47.98	1.0563	9.90	2.01	11.91
Chinese sugar cane, variety	Sept. 24	2	8.21	.96	5.5	0.	12.50	22.40	65.10	45.60	1.0382	3.14	1.42	4.56
Chinese sugar cane, variety	Sept. 24	1	9.92	2.36	9.0	3.0	10.17	11.02	78.81	54.84	1.0523	6.71	4.22	10.93
Chinese sugar cane, variety	Sept. 24	2	10.08	1.24	9.5	1.0	10.86	17.91	71.23	46.55	1.0563	7.50	3.91	11.41
Chinese sugar cane, variety	Oct. 2	6	12.06	3.24	13.8	1.0	13.99	21.25	64.76	47.49	1.0729	10.90	4.38	15.18
Chinese sugar cane, large variety, seed removed	Oct. 13	3	13.94	3.71	16.0	6.7	29.83		70.17	30.60	1.0722	12.02	0.91	12.93
Chinese sugar cane, large variety, seed removed	Oct. 20	4	....	......	......	.....	24.34		75.66	34.14	1.0571	8.78	1.88	10.66

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VARIETIES OF SORGHUM COMPARED—CONTINUED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops.	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
Chinese sugar cane, large variety, seed not removed	Oct. 13	3	15.25	4.05	16.7	5.0	10.77	20.89	68.34	37.39	1.0665	10.86	1.48	12.34
Chinese sugar cane, large variety, seed not removed	Oct. 20	4	15.50	4.58	17.0	.....	24.80		75.20	32.88	1.0666	10.66	2.46	13.12
Cross between Amber and Orange	Sept. 4	8	7.75	1.93	9.3	1.5	35.94		64.06	49.84	1.0565	9.50	2.25	11.75
Cross between Amber and Orange	Sept. 22	10	8.69	1.57	9.8	1.6	12.17	24.16	63.67	45.90	1.0691	12.71	1.57	14.28
Cross between Amber and Orange	Oct. 15	10	8.39	1.45	9.0	3.8	14.02	23.42	62.56	43.63	1.0699	12.69	1.33	14.02
Cross between Amber and Orange	Sept. 12	1	8.42	1.99	10.0	2.0	37.24		62.76	53.60	1.0744	14.18	1.70	15.88
Cross between Amber and Orange	Sept. 12	1	7.92	1.64	9.0	1.0	35.97		64.03	50.00	1.0533	7.92	2.95	10.87
Dutcher's Hybrid	Aug. 29	7	7.90	1.49	7.7	.7	36.79		63.21	53.54	1.0497	6.32	4.44	10.76
Dutcher's Hybrid	Sept. 17	10	7.28	1.23	7.1	1.1	12.19	23.07	64.74	51.47	1.0613	9.36	2.89	12.25
Dutcher's Hybrid	Oct. 6	10	7.49	1.05	7.5	2.0	38.10		61.90	46.61	1.0621	9.59	2.43	12.02
Dutcher's Hybrid	Sept. 19	1	8.00	1.21	9.0	1.0	42.15		57.85	41.43	1.0702	12.19	....	....
Early Amber	Aug. 29	7	6.96	1.13	6.5	0.9	30.09		69.91	53.77	1.0537	7.97	2.65	10.62
Medium Orange	Aug. 28	9	7.52	1.11	7.7	1.0	36.79		63.21	49.52	1.0508	8.75	1.64	10.39
Medium Orange	Sept. 15	10	7.49	1.12	7.8	2.4	36.10		63.90	45.44	1.0667	12.32	1.07	13.39
Medium Orange	Sept. 18	1	7.00	1.24	8.0	2.0	35.49		64.51	37.50	1.0873	16.25	0.45	16.70

VARIETIES OF SORGHUM COMPARED—CONTINUED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
Medium Orange	Sept. 18	1	7.00	1.06	9.0	3.0	31.13		68.87	43.83	1.0409	6.00	1.72	7.72
Enyama	Sept. 22	8	9.53	1.98	13.9	5.4	11.23	14.88	73.89	48.48	1.0628	10.84	2.23	13.07
Enyama	Oct. 12	10	9.26	1.96	13.0	7.2	13.47	12.05	74.48	47.15	1.0670	11.59	1.85	13.44
Golden Rod, variety	Sept. 25	3	9.83	*.88	......	.....	....	....	....	40.75	1.0684	12.09	2.07	14.16
Golden Rod, variety	Sept. 25	6	8.00	*.61	......	.....	....	....	....	30.70	1.0634	10.56	1.81	12.37
Golden Rod, variety	Sept. 25	2	12.00	*1.46	12.5	.....	....	....	....	25.77	1.0791	14.69	.83	15.52
Golden Rod, tall variety	Oct. 12	6	10.56	1.74	13.5	4.7	42.94		57.06	35.80	1.0686	10.56	1.47	12.03
Honduras	Oct. 4	10	9.27	2.07	12.4	5.4	10.86	16.75	72.39	49.60	1.0624	9.36	3.29	12.65
Honey Cane	Oct. 20	3	8.92	1.10	10.0	.....	16.33		83.67	43.32	1.0661	10.92	......	....
Honey Cane	Oct. 20	1	9.25	2.00	12.0	.....	20.00		80.00	48.75	1.0520	6.48	6.46	12.94
Honey Dew	Sept. 4	10	8.35	1.38	8.0	1.0	34.83		65.17	48.11	1.0525	7.42	3.07	10.49
Honey Dew	Sept. 22	10	8.24	1.22	8.8	1.7	†4.35	26.41	69.24	43.84	1.0634	10.70	2.20	12.90
Honey Dew	Oct. 15	10	8.16	1.15	8.3	3.4	†5.76	24.15	70.09	42.84	1.0641	10.18	1.53	11.71

* Stripped. † Empty.

VARIETIES OF SORGHUM COMPARED—CONTINUED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints.	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
Honey Drip	Sept. 13	10	7.92	1.76	12.1	2.3	38.68		61.32	50.92	1.0562	8.41	2.91	11.32
Honey Drip	Sept. 28	10	8.00	1.77	12.1	2.3	13.60	26.25	60.15	45.97	1.0709	12.10	1.98	14.08
Honey Drip	Oct. 16	10	8.00	1.85	12.6	8.2	13.86	18.14	68.00	47.61	1.0666	11.88	2.34	14.22
Honey Drip	Sept. 13	1	8.58	2.33	14.0	2.0	37.34		62.66	50.67	1.0638	10.41	2.70	13.11
Honey Drip	Sept. 13	1	8.42	2.09	13.0	2.0	37.09		62.91	51.71	1.0633	10.13	.....	.....
Honey Drip	Sept. 13	1	7.67	2.19	13.0	2.0	36.08		63.92	50.71	1.0395	2.92	4.41	7.33
Kansas Orange (I)	Sept. 10	7	7.33	1.89	9.8	1.7	36.78		63.22	50.47	1.0459	4.62	4.63	9.25
Kansas Orange (I)	Sept. 20	10	8.96	1.57	11.6	1.8	10.40	26.96	62.64	49.23	1.0623	9.65	3.74	13.39
Kansas Orange (I)	Oct. 3	10	9.04	1.74	11.7	1.7	10.07	28.42	61.51	46.11	1.0739	12.62	2.90	15.52
Kansas Orange (I)	Oct. 4	1	8.50	2.00	12.0	3.0	41.00		59.00	45.76	1.0815	15.51	1.69	17.20
Kansas Orange (I)	Oct. 4	1	9.33	1.92	13.0	2.0	33.68		66.32	44.09	1.0815	15.17	2.24	17.41
Kansas Orange (I)	Oct. 17	9	8.46	1.12	11.1	3.5	13.97	24.98	61.05	45.94	1.0773	13.79	3.78	17.57
Kansas Orange (I)	Oct. 18	9	8.77	2.01	12.9	5.7	11.88	19.05	70.07	49.01	1.0656	11.24	4.68	15.92
Kansas Orange (I)	Oct. 19	10	8.99	1.59	12.2	5.4	11.21	18.32	70.47	45.66	1.0734	12.95	4.38	17.33

VARIETIES OF SORGHUM COMPARED—CONTINUED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
Kansas Orange (I)	Oct. 27	10	....	*1.06	....	....	....	....	....	44.70	1.0645	9.47	5.68	15.15
Kansas Orange (II)	Oct. 2	10	8.02	2.01	13.2	4.8	14.93	18.17	66.90	48.14	1.0694	12.64	1.30	13.94
Kansas Orange (II)	Sept. 12	1	7.33	2.68	13.0	5.0	34.33		65.67	50.00	1.0518	8.42	2.12	10.54
Kansas Orange (II)	Sept. 12	1	7.75	2.53	13.0	4.0	32.01		67.99	51.10	1.0647	12.12	1.57	13.69
Kansas Orange (II)	Sept. 14	1	9.17	1.48	12.0	1.0	31.08		68.92	43.13	1.0764	14.44	1.32	15.76
Kansas Orange (II)	Sept. 14	1	8.83	1.30	11.0	5.0	27.00		73.00	46.31	1.0523	8.13	2.49	10.62
Kansas Orange (II)	Sept. 14	1	9.17	1.92	12.0	3.0	27.61		72.39	56.83	1.0754	14.54	1.32	15.86
Kansas Orange (II)	Sept. 14	1	8.17	1.28	10.0	3.0	33.60		66.40	42.35	1.0791	15.49	.96	16.45
Kansas Orange (II)	Sept. 14	1	8.17	1.73	12.0	3.0	33.00		67.00	41.38	1.0835	16.44	.95	17.39
Late Orange	Sept. 10	6	7.10	1.83	9.0	2.0	33.70		66.60	46.78	1.0567	8.70	3.38	12.08
Late Orange	Sept. 20	10	8.35	1.65	11.4	1.8	12.16	25.50	62.34	46.53	1.0752	13.87	3.28	17.15
Late Orange	Oct. 3	10	8.35	1.59	11.9	2.3	8.23	27.35	64.42	40.68	1.0814	15.04	1.69	16.73
Late Orange	Oct. 3	1	8.25	2.42	16.0	8.0	24.40		75.60	46.12	1.0795	13.47	1.74	15.21

*Stripped.

VARIETIES OF SORGHUM COMPARED—CONTINUED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
Late Orange	Oct. 3	1	9.58	2.07	15.0	2.0	35.75		64.25	48.49	1.0834	15.37	2.01	17.39
Late Orange	Oct. 3	1	8.25	1.04	11.0	3.0	29.81		70.19	43.15	1.0867	16.56	1.22	17.78
Early Gooseneck	Sept. 7	2	7.50	2.14	10.5	1.0	35.05		64.95	50.36	1.0442	4.84	4.85	9.69
Early Gooseneck	Sept. 20	10	8.94	1.78	12.0	1.2	8.95	29.22	61.83	47.23	1.0732	15.66	3.20	18.86
Early Gooseneck	Oct. 6	10	8.68	1.73	11.9	2.0	37.38		62.62	46.21	1.0765	13.44	2.32	15.76
Early Gooseneck	Oct. 22	12	....	......	......	.....	....		....	41.20	1.0753	12.84	4.14	16.98
Early Gooseneck	Oct. 27	10	....	......	......	.....	....		....	41.66	1.0657	10.22	5.27	15.49
New Orange	Sept. 7	10	6.58	1.52	8.7	1.1	41.81		58.19	48.41	1.0530	6.69	4.91	11.60
New Orange	Sept. 26	10	7.71	1.24	10.5	1.8	18.61	30.55	50.84	47.07	1.0804	14.07	2.80	16.87
New Orange	Oct. 15	10	7.21	1.24	10.0	4.8	18.33	19.61	62.06	41.58	1.0774	13.33	2.12	15.45
S. C. Early Orange	Sept. 10	9	9.33	1.73	9.6	2.0	35.80		64.20	50.00	1.0505	6.49	4.41	10.90
S. C. Early Orange	Sept. 28	11	8.18	1.48	11.2	2.6	35.62		64.38	44.28	1.0785	13.69	2.29	15.98
S. C. Early Orange	Oct. 16	10	8.29	1.23	10.9	6.5	9.47	20.89	69.64	41.27	1.0815	14.63	4.34	18.97
S. C. Early Orange	Oct. 17	1	8.50	1.53	13.0	.....	26.60		73.40	43.30	1.0831	15.34	1.64	16.98

VARIETIES OF SORGHUM COMPARED—CONTINUED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
Liberian, from Kansas	Oct. 2	6	10.54	2.64	13.5	4.20	14.21	21.48	64.31	42.70	1.0604	9.51	2.52	12.03
Little Sumach	Sept. 21	9	7.63	2.15	10.8	2.88	17.50	23.94	58.56	50.84	1.0456	8.38	3.51	11.89
Link's Hybrid	Sept. 27	10	9.69	1.81	12.0	3.90	13.83	18.34	67.83	46.37	1.0657	11.88	1.24	13.12
Link's Hybrid	Oct. 13	12	9.74	1.60	11.3	4.30	13.48	18.66	67.86	42.67	1.0737	14.01	.83	14.84
Link's Hybrid	Oct. 13	1	9.92	2.26	12.0	6.00	32.30		67.70	46.73	1.0750	14.27	.54	14.81
New Variety, from Missouri	Sept. 22	10	10.03	2.22	12.1	3.00	12.24	23.18	64.58	48.18	1.0655	12.05	1.41	13.46
New Variety, from Missouri	Oct. 27	8	....	......	......	......	....	....	....	42.34	1.0585	9.04	3.61	12.65
New Variety, from Missouri	Oct. 1	1	11.17	2.50	14.0	3.00	34.00		66.00	46.67	1.0727	13.62	1.30	14.92
Early Orange	Sept. 27	10	9.76	1.73	11.1	3.00	12.59	21.67	65.74	45.52	1.0684	12.68	1.03	13.71
Early Orange	Oct. 11	12	9.22	1.38	11.2	4.50	31.86		68.14	40.28	1.0696	12.64	.96	13.60
Early Orange	Oct. 11	1	10.08	1.52	13.0	3.00	36.12		63.88	34.02	1.0771	14.92	......	....
Russell's	Sept. 27	6	9.86	1.84	9.5	4.00	14.38	22.06	63.56	46.23	1.0660	11.94	1.05	12.99
Russell's	Oct. 22	10	....	......	......	......	....	....	....	42.63	1.0621	10.74	2.00	12:74
New sugar cane from Central America	Sept. 17	10	10.8	1.92	10.5	0.70	8.60	20.40	71.00	48.96	1.0606	9.49	2.90	12.39

VARIETIES OF SORGHUM COMPARED—CONTINUED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
New sugar cane from Central America	Oct. 6	7	11.10	1.96	10.6	1.0	7.71	18.62	73.67	49.16	1.0701	11.98	1.96	13.94
Price's	Aug. 28	8	7.91	1.30	6.9	0.8	34.30		65.70	51.61	1.0392	4.47	3.73	8.20
Price's	Sept. 15	10	8.22	1.35	7.2	1.8	31.40		68.60	51.13	1.0467	4.98	3.70	8.68
Price's	Oct. 5	15	8.44	1.31	8.0	1.7	34.74		65.26	50.82	1.0623	9.25	2.73	11.98
Silver Top*	Oct. 19	*6	10.46	2.50	12.0	.....	38.95		61.05	48.36	1.0550	8.02	5.71	13.73
Swain's Early Golden	Aug. 28	8	7.93	1.13	6.3	0.9	31.35		68.65	50.48	1.0654	12.67	1.55	14.22
Swain's Early Golden	Oct. 6	10	7.49	.91	6.5	5.3	7.43	22.58	70.04	44.31	1.0515	8.14	1.26	9.40
Swain's Early Golden	Sept. 8	1	7.67	1.21	6.0	1.0	31.40		68.60	43.37	1.0640	12.60	1.18	13.78
Swain's Early Golden	Sept. 8	1	8.00	1.28	7.0	3.0	32.80		67.20	45.35	1.0680	13.42	1.13	14.55
Swain's Early Golden	Sept. 10	1	7.83	1.20	7.0	2.0	24.20		75.80	43.95	1.0739	14.65	1.02	15.67
Wabaunsee	Aug. 29	6	8.25	1.92	8.8	2.2	35.04		64.96	53.41	1.0486	6.97	2.08	9.05
White African†	Sept. 7	7	9.13	1.69	10.0	1.3	30.78		69.22	48.78	1.0590	9.28	2.46	11.74
White African†	Sept. 26	8	....	......	9.5	2.7	....	....	....	42.56	1.0653	10.67	1.31	11.98

*Inferior canes. †Seed largely taken by birds.

VARIETIES OF SORGHUM COMPARED—CONTINUED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
White African †	Sept. 8	1	8.25	1.34	9.0	1.0	....	....	82.10	54.50	1.0542	2.65	....	....
White African †	Sept. 7	1	8.67	1.31	10.0	1.0	23.70		76.30	45.00	1.0665	10.37	2.80	13.17
White African †	Sept. 7	1	8.92	1.28	9.0	.0	23.40		76.60	42.80	1.0748	9.77	6.46	16.23
White Amber	Aug. 28	8	8.12	1.20	6.6	1.8	29.87		70.13	50.37	1.0533	9.53	2.63	12.16
White Amber	Sept. 15	10	7.70	.96	6.4	1.5	30.53		69.47	48.58	1.0594	10.43	1.65	12.08
White Amber	Oct. 3	10	7.47	.88	6.5	3.7	30.98		69.02	41.58	1.0581	9.58	1.67	11.25
White Amber	Sept. 11	1	8.58	1.05	7.0	2.0	30.50		69.50	46.57	1.0621	11.68	1.85	13.53
White Amber	Sept. 11	1	7.83	1.22	7.0	3.0	27.05		72.95	48.30	1.0483	7.45	3.06	10.51
White Amber	Sept. 11	1	7.33	1.10	6.0	3.0	27.30		72.70	46.25	1.0663	12.51	1.22	13.73
White India	Sept. 21	10	9.08	1.95	11.8	2.6	8.21	21.18	70.61	48.59	1.0642	11.59	2.04	13.63
White India	Oct. 12	10	9.28	1.60	12.1	5.3	6.05	15.16	78.79	45.33	1.0721	12.73	1.49	14.22
White Mammoth	Sept. 21	10	7.80	1.67	11.2	3.5	17.97	19.30	62.73	45.46	1.0691	11.87	2.71	14.58
White Mammoth	Sept. 24	1	6.67	1.96	10.0	5.0	20.92	16.84	62.24	45 90	1.0633	10.07	....	....
Whiting's	Aug. 21	9	*5.33	*.34	5.2	1.6	....	*22.00	*78.00	41.28	1.0237	1.74	2.27	4.01

* Without seed top. † Seed largely taken by birds.

VARIETIES OF SORGHUM COMPARED—CONCLUDED.

VARIETIES.	Date of Analysis.	No. of stalks	Average height in feet	Average weight in pounds	Average No. of joints	Average No. of dead leaves	Per cent. of tops	Per cent. of leaves	Per cent. of clean cane	Per cent. of juice calculated on clean cane	Specific gravity of juice	Per cent. of cane sugar in juice	Per cent. of reducing sugar in juice	Per cent. of total sugars in juice
Whiting's	Sept. 24	10	5.79	.40	4.9	2.5	18.13	21.92	59.95	36.22	1.0449	6.37	1.79	8.16
Whiting's Earliest Cane	Aug. 21	1	5.67	*.46	5.0	2.0	*19.57		*80.43	40.50	1.0181	.96	1.37	2.33
Variety, with Early Amber	Sept. 21	9	7.69	1.65	11.4	3.4	14.74	20.84	64.42	48.54	1.0664	12.26	1.36	13.62
Unnamed new variety	Oct. 4	6	11.67	3.64	15.5	3.7	8.89	20.87	70.24	49.93	1.0646	9.69	3.36	13.05

*Without seed top.

It is fully realized that one season is too short a time to determine relative value with precision; for the conditions of growth may have favored some varieties. Nor is exact sampling possible by selecting stalks from plats. But in these analyses care was taken to get an average lot in size. All sizes — small, medium, and large — were taken.

There are five principal points to be looked after in selecting varieties of sorghum. These are, quality, size, feeding value of the by-products — blades and tops, whether the canes retain their good qualities well after they have ripened, and how to secure a long working season. The last two mentioned are intimately related. An early maturing variety, if a good keeper, might give a long campaign. But the early kinds are usually small, giving a light yield to the acre. The large varieties, conversely, are late. It will, therefore, generally be found advisable to obtain length of season by growing several kinds. Quality has primarily to do with the total quantity of sugar; but the solids not sugars, extracted in the juice, are worthy of attention. Where the quality of the cane is judged by the composition of the juice expressed, the per cent. of juice obtained is an essential factor. For sugar making, crystallizable sugar, or sucrose, as the chemists call it, is the one important substance; and for this purpose alone, all solids not sucrose, including uncrystallized sugars, so called, are not only useless, but positively objectionable. A kind of sorghum that is rich in sucrose and poor in uncrystallizable sugar should be selected for making sugar. If syrup is to be the product, it makes much less difference what kind of sugar is present. A large content of total sugars will give a large yield of syrup. And although the same quantity of sucrose would be somewhat sweeter than the mixture of the two, other good qualities may greatly overbalance this consideration, so that we would be justified in selecting for syrup a variety that contains a large amount of uncrystallizable sugar.

The ratio between the weight of the whole cane and the same when stripped and topped is an important consideration in choosing a variety of sorghum. If the cane is used for syrup or

sugar the seed is a valuable by-product, and a large yield, if not accompanied by a corresponding lack of sugar, would be a good characteristic in a variety. If the cane is to be used solely for forage, a small, leafy stalk with a large seed top should be chosen. In the manufacture of sugar from sorghum by the diffusion process, the tops and almost all of the leafy portion are separated from the cane, and are available as fodder. It seems desirable, therefore, that we should possess fuller data in regard to the ratio existing between these portions of the plant, and all our examinations of sorghum include a determination of the weight of the clean cane as well as the whole stalk. In most cases, the seed tops were weighed separately, also, and the weight of the leaves found by difference. In all analyses made by us this season, the leaf sheaths, as well as the blades, were removed in ascertaining the weight of the clean cane. The table includes our data respecting the physical characteristics of the varieties grown.

The following notes are designed to draw attention to the principal characteristics of some of the varieties, and to bring out some facts that cannot well be tabulated.

The varieties African and Liberian are apparently identical, and the same as that grown throughout the State for syrup. It is often called Imphee. It has a very compact head, with small, round dark-red seed, extending considerably beyond the glumes. Its large sugar content makes it very valuable for syrup, but the large proportion of uncrystallizable sugar detracts from its value for sugar making. The stalks stand up well.

The Chinese sugar cane seed planted was said to produce a large number of varieties from the same seed. Six or eight more or less distinct varieties were noticed in the plat, and were analyzed. Some of these kinds were of only medium height, while some were fully seventeen feet high. Some had black seed and some had red seed. The seed of these varieties will be planted separately. None of the varieties seems to have a special value. The very large sort has juice of good composition, but in small quantity only. It ripens so late that un-

less planted very early it will not mature. The frost caught ours before maturity. Another year will show more in regard to these interesting plants.

Early Gooseneck is not early and is not goosenecked. It seems to be identical with Late Orange.

Dutcher's Hybrid is one of the earliest sorts. It is of only medium size, and so far as one season can show seems to have no peculiar advantages to counterbalance its rather inferior sugar content.

Enyama is a cane above the medium size, having nearly white seed inclosed in black glumes.

The Golden Rod, so called, was a mixture of even more varieties than the Chinese, and these varied, in time of ripening, from moderately early to very late. There was considerable difference in their habits of growth also, but they shaded into each other, so that it was difficult to decide where to draw lines of distinction. It is scarcely an exaggeration to say, that no two hills were alike. Quite a number of the more pronounced types were analyzed. They were about like the Chinese, but had in general a less amount of reducing sugar. The per cent. of juice was usually low.

Honey Dew has white seed, which was badly attacked by sparrows. The cane is of medium size and the juice of fair quality.

Honey Drip has a peculiar top. The upper portion of the panicle droops over on all sides, giving it a mushroom-like shape. It seems to be among our best varieties, having a heavy stalk and juice of large sugar content. It ripens in good season.

Liberian from Kansas does not at all resemble the other Liberian canes, and is probably not truly named. The type varied greatly and it is too late to be of much value here.

Link's Hybrid is a good sort. The stalks are of fair size and of more than medium height. They are a little inclined to be slender above, and generally have the appearance of being top-heavy. The head is lengthy and loose, the seed pendulous, and, with the head as a whole, hangs to one side. The glumes are

black, and the exposed part of the seed is light reddish yellow with black specks.

This cane is doubtless the true Link's. In our work in 1883, upon the quality of sorghum at different stages of ripeness, we found that the sort sold us a Link's was worthless. It was a different cane from that of the same name this year. The canes were short and stocky, and the seed tops close and bunchy. But it is no great rarity to find confusion in the names of varieties of sorghum. Four sorts on the present list are really Link's. These are the ones marked Link's, Early Orange, Russell's, and New Variety from Missouri. There is no apparent difference between them except in name.

New sugar cane from Central America is above the medium height, and although a little late seems to be a promising variety. It very much resembles the old Chinese sorghum.

Another unnamed new variety, said to have been originated in Missouri, is a tall, large cane, but quite late. The percentage of total sugars is large, but reducing sugar forms a considerable portion.

The Orange cane is well known in a considerable portion of our State. There are several varieties, more or less distinctly marked, either by appearance or time of ripening. Seed from different sources, purporting to be the same variety, we have found to produce canes having notable differences. Kansas Orange (I), as given in the table, was from seed purchased the present season from a well-known dealer. The seed from which Kansas Orange (II) was grown was obtained in this State. It was derived from seed originally obtained by us several years ago from another well-known dealer in sorghum seed. The seed top from (II) differs from (I) in being longer and having no tendency to spread. Both were planted in considerable quantity and in adjoining plats. (II) was almost totally destroyed, except at one end of the plat, by the disease described by Professor Kellerman in this volume, while (I) was but little affected.

Late Orange, New Orange, and South Carolina Early Orange

furnish noticeably large percentages of sugars. Late Orange is no later in ripening than Kansas Orange. There are some indications that it preserves its good qualities later in the season, but further observations are needed on this point.

Medium Orange is not an Orange cane. It resembles Early Amber closely, and may be the same cane. Of the seed marked Early Amber, only a few germinated; hence this kind is given less prominence in our work than would otherwise have been the case.

Amber and Orange Crossed has shown itself in the past season to be an excellent cane. It is early, and the juice is of good quality. It is not intended in anything presented in this article to in any way express an opinion on the disputed point of crossing of sorghum.

Price's has shown no advantageous qualities the past season.

Swain's Early Golden appears to be one of the best early varieties we have examined. No other variety this season has made as good a showing at an early stage of ripeness. For early working, this variety merits a trial.

White African is chiefly noticeable for its large white seed. The head is not large, however. The sparrows took the seed very badly, also.

White Amber differs little, if any, from the Early Amber.

White India is a beautiful cane, tall, and stands up remarkably well. The seed is similiar to that of Enyama, and was taken somewhat by sparrows.

Whiting's has been recommended as useful for early working. The figures obtained on the small amount at our disposal are not favorable to this view. The stalks are extremely small, and the juice poor.

From lack of sufficient cane upon which to work, we are unable to form any serviceable judgment respecting the following sorts: White Mammoth, Silver Top, Little Sumach, India, Red Top, Wabaunsee, Honduras, and Honey Cane. Several of these ripen so late, that the analyses given do not show the cane at its best stage.

THE KEEPING QUALITIES OF SORGHUM.

It has long been known that the uncrystallizable sugar decreases, and the crystallizable sugar increases, as the cane develops. Our work did not begin on the sorghum until it had reached a workable condition. The figures in the table show, that the juices of those varieties which became fully ripe before frost continued to improve until the cane was dead ripe, and then continued sensibly constant until the cane was injured by freezing; then rapid deterioration set in. The diagram below shows the eye these facts. It is made up from the table. Enough of the varieties have been included in the diagram to show that this kind of development is a general rule. The principal point to which attention is called, is the fact that these varieties at least retain their good qualities after ripening as long as the canes are left standing in the field without being injured by some external agent. Some writers voice a generally received notion, that the sugar in the sorghum is so far an accident to the plant that it is extremely liable to transformation; so much so, in fact, that unless worked promptly on ripening the sap rapidly deteriorates. It has been thought that, because of this habit of the plant, little should be expected from it. Our results the past year have not sustained this view. Other kinds of sorghum or a different season may give different results and lead to opposite conclusions.

In calling attention to the diagram, it is necessary to mention that a frost on the morning of October 3 killed some sorts and injured others, so that they gradually gave outward evidence of the freeze, although at first it was not prominently noticeable. On October 20, the whole of the sorghum was killed by the frost, and rapid deterioration set in. The chemical characters of the juice, even before the frost of October 20, had become so modified by the frost of October 3 that much reliance cannot be placed on any analyses made later than October 15, and some of earlier date seemed anomolous.

DIAGRAM showing percentage of sugars contained in certain varieties of sorghum at the dates named. The length of the open portion shows the per cent. of cane sugar; that of the shaded portion, the reducing sugar.

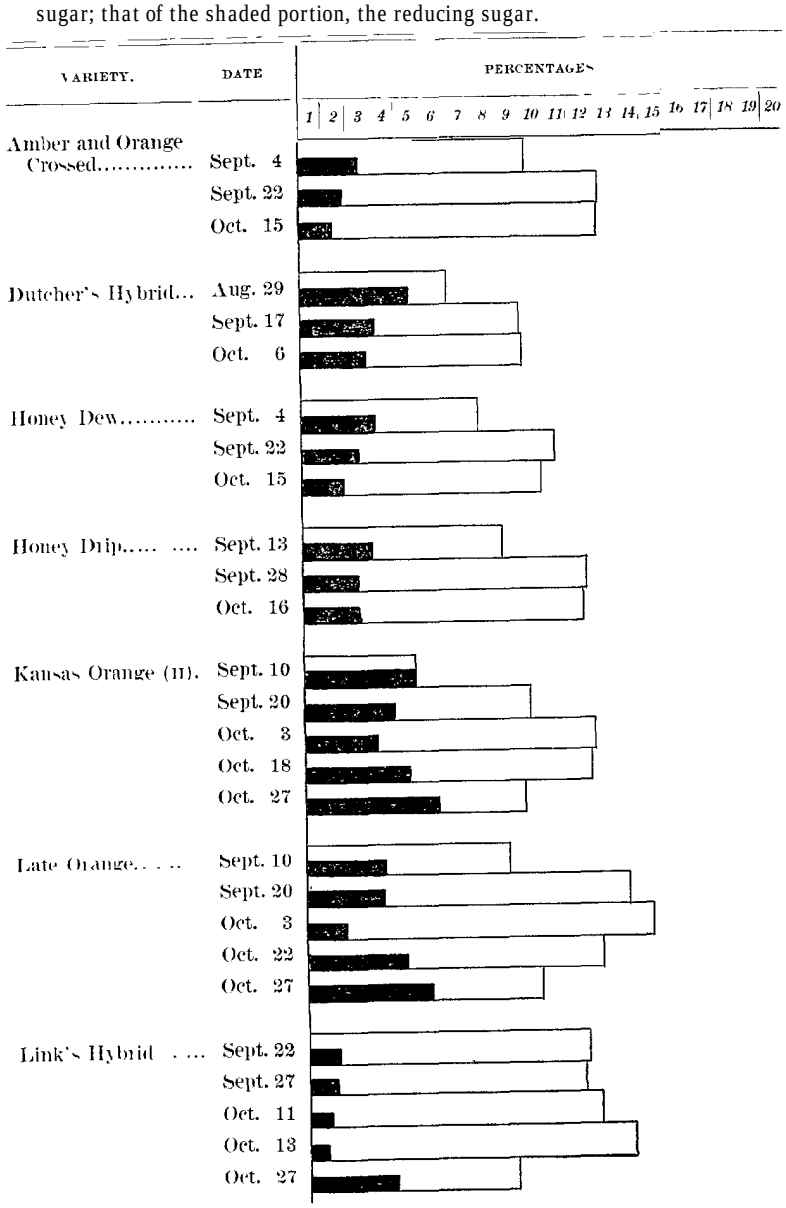
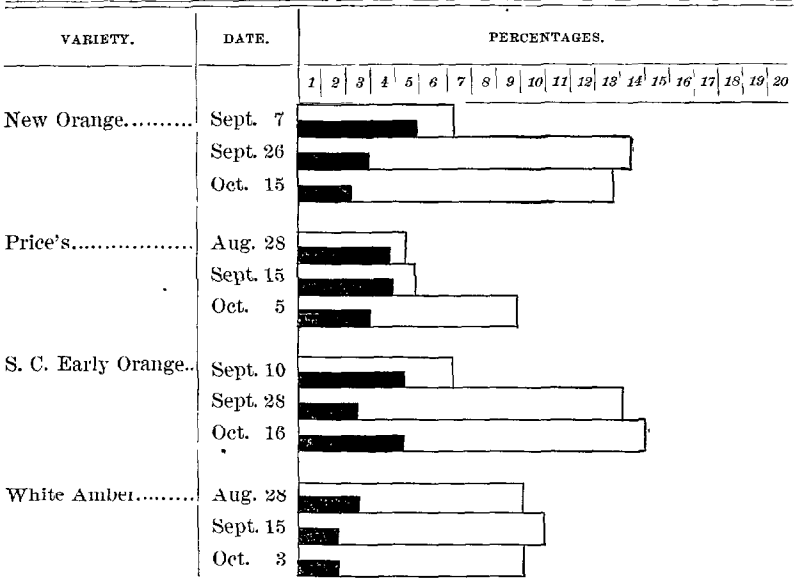


DIAGRAM SHOWING PERCENTAGES OF SUGARS, ETC.— CONCLUDED.



ATTEMPTS TO IMPROVE SORGHUM BY SEED SELECTION.

The great success attending the efforts to improve the quality of beets for sugar making — an improvement which consisted in greatly increasing the content of the true crystallizable sugar, and at the same time decreasing the substances that would interfere with the separation of the sugar — led to hopes that an analogous change might be effected in the sorghum plant. It is fully recognized by those who have worked with both, that the juice of the sorghum plant is not so well suited for sugar making by old methods as that of the southern cane. But sorghum is much better suited for working by the present methods than were beets by the methods in vogue when their improvement was undertaken. While all have felt the importance of improving sorghum, and many have believed in its possibility, but little has been done towards accomplishing it. All have

realized the magnitude of the work. A long series of years will without doubt be required to change and fix a quality. Then how shall the end be reached? Shall it be by seed selection? Shall it be by crossing? or is the improvement to be sought in better tillage and by the use of fertilizers? or is it to be attained in some other way? No one pretends to be able to answer these questions, and any attempts at improvement must be attended with uncertainty as to results. In the years 1885 and 1886, some work was done in our laboratory in an attempt to improve the quality of sorghum by seed selection.* But the work was temporarily discontinued. It was taken up again the past season. It has been accepted by common consent that the seed from stalks rich in sugar and poor in objectionable substances would produce canes of similar character, but with these features intensified, while seed from a poor stalk would bring poor canes. Were this true, simple seed selection would effect an improvement in the average quality of the cane, if there is any considerable difference in the quality of individual stalks of the same variety grown under the same conditions. For, where seed is taken promiscuously, the mixture will be an average of the better and the poorer. To determine to what extent individual stalks vary when grown under the same circumstances, as well as to form a basis for present selection of seed and for future comparison, analyses were made of the juice pressed separately from a number of stalks. The varieties from which individual stalk selections were made were those which the general comparison of varieties showed to be promising sorts. This judgment was based upon the sugar content. Only perfect stalks of fair size were used. A number of stalks of each variety were taken for comparison with each other. The analyses were completed on those stalks only which the initial work showed to be extremes. In this way many more stalks could be subjected to the comparison. About one hundred and sixty-five stalks were separately thus either partially

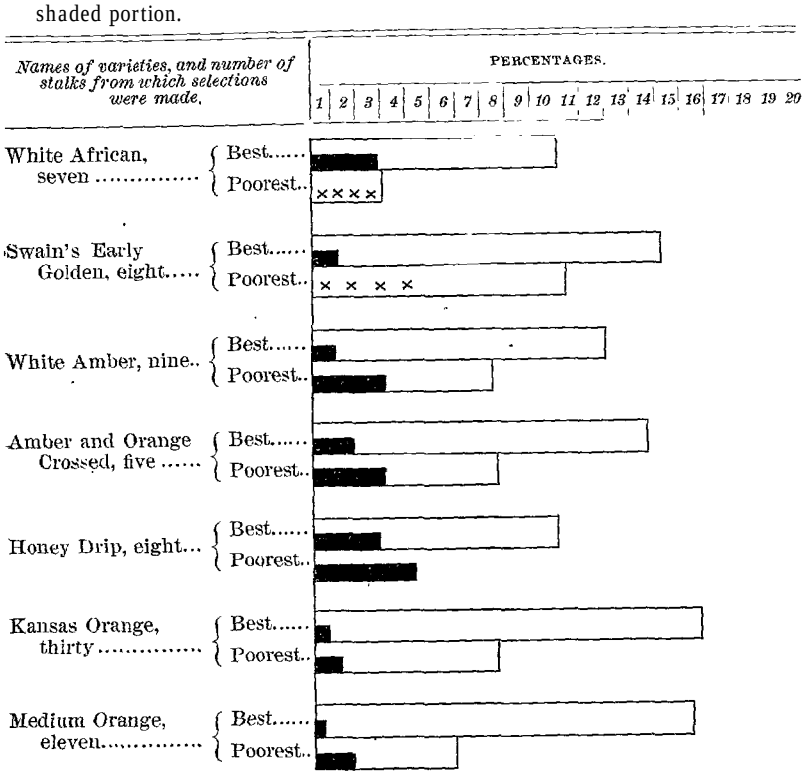
*See Transactions Kansas Academy of Science for 1885-86, p 70.

or wholly analyzed. It is obvious that the figures obtained in these analyses are of use in our work here, but are not of great interest to others. The partial analyses are entirely omitted, but the complete ones are inserted in the table on pages 124 to 133. In most cases, only the best stalks were completely analyzed. These single stalk analyses may be selected from the table by observing in the column headed "No. of Stalks" the figure 1. It is not known with any degree of certainty whether each stalk of sorghum closely resembles in sugar content the stalk from which the seed producing it was obtained. Knowing the history of the seed, we shall probably be able in a few seasons, possibly the next, to speak authoritatively on this matter. We have preserved seed from some very poor stalks as well as from the richest, believing that by this means an answer will best be obtained to the question whether richness in sugar is hereditary. It was deemed that a selection of seed from poor stalks of some half dozen varieties was sufficient, in connection with the seed of good stalks, to settle the matter in question. But the seed of stalks of all varieties on our list, which by their content of sugar or by their time of ripening give promise of good results from efforts to improve them, have been carefully labeled and preserved, and next year will be grown under similar conditions as to soil and tillage; and the crop as a whole and in individual stalks will be compared with that producing the seed. In order to show to what extent the juice of similar stalks of the same variety grown in the same plat will vary, some of the single stalk analyses given in the preceding table are brought together below. In selecting these figures, all cases have been included where both a "poorest" and a "best" stalk of the same variety were analyzed. These were consecutive analyses, and hence represent what would probably be found in almost every variety of sorghum. The intermediate stalks not given ranged promiscuously between these extremes. The figures of the table may perhaps be better appreciated by an observation of the diagram following the table.

TABLE showing extreme variations of sugar content observed in certain varieties of sorghum.

NAMES OF VARIETIES, AND NUMBER OF STALKS FROM WHICH SELECTIONS WERE MADE.		*Weight in pounds.*	*Per cent. of juice.*	*Per cent. of cane sugar.*	*Per cent. of reducing sugar.*
White African, seven,	Best	1.31	45.0	10.37	2.80
	Poorest	1.34	54.5	2.98	.....
Swain's Early Golden, eight,	Best	1.20	43.9	14.65	1.02
	Poorest	1.29	47.8	10.75	.....
White Amber, nine,	Best	1.22	46.3	12.51	1.22
	Poorest	1.10	48.3	7.45	3.06
Amber and Orange Crossed, five,	Best	1.99	53.6	14.18	1.70
	Poorest	1.64	50.0	7.92	2.95
Honey Drip, eight,	Best	2.33	50.7	10.41	2.70
	Poorest	2.19	50.7	2.92	4.41
Kansas Orange, thirty,	Best	1.73	41.4	16.44	.95
	Poorest	1.30	46.3	8.13	1.32
Medium Orange, eleven,	Best	1.24	37.5	16.25	.45
	Poorest	1.06	43.8	6.00	1.72

DIAGRAM showing the extreme variations of sugar content observed in single stalks of the varieties named. The per cent. of cane sugar is shown by the length of the open portions, the reducing sugar in the same stalk is shown by the shaded portion.



From this table and diagram, it will be seen that there are extreme variations in the quality of the juice expressed from stalks. The following considerations, while presenting the matter correctly, will probably show it in stronger colors than the mere figures of the table do:

First, let it be remembered that for sugar making all soluble substances not true cane sugar, in the juice, will interfere with the separation of the cane sugar as crystals. Refiners usually expect a quantity of cane sugar equal in weight to the foreign substances to be held in solution by them, so that for every pound of solids not cane sugar in the juice a pound of

the cane sugar will be unavailable for making sugar. Applying this principle to the case of Honey Drip in the previous table: if one hundred pounds of the juice of the best cane be taken, there would be 10.41 pounds of cane sugar; this, diminished by 2.70 pounds, representing the uncrystallizable sugar would leave 7.71 pounds for sugar making neglecting other solids. One hundred pounds of juice from the poorest of Honey Drip would contain 2.92 of cane sugar, which in the presence of 4.41 pounds of glucose would not be able to crystallize at all. Only syrup could be made from such a juice. Even in Medium Orange the comparison is striking. One hundred pounds of the best juice would contain 16.25 pounds of cane sugar. This diminished by .45 gives 15.8 pounds of available sugar. One hundred pounds of the poorest would contain 6 pounds of cane sugar. This diminished by 1.72 pounds leaves 4.28 pounds of available sugar. The one is worth nearly four times as much as the other for sugar. Is anything more required to make the variations of individual canes apparent? And these canes are sensibly alike in size, weight, and in general appearance.

The foregoing only shows what we are trying to do, and how, with perhaps why, we are trying to do it. But obviously we have only made a beginning. It is hoped that another season will settle some of the points, and that progress will be made in others. But from the nature of the case we cannot expect great returns for some time yet. And they may not be secured at all. It may be that ultimate success is to be had by some other line of work entirely. We can learn only by experience.

It is suggested that cane growers, next season, select seed from stalks of a good quantity, and assist in the test as to heredity of qualities, as well as in efforts to improve the sorghum. It was observed that the quality of cane sugar, in fully ripe canes, followed very nearly the specific gravity of the juice. But since all other soluble substances, as well as the cane sugar, increase the specific gravity, it is obvious that this test is only approximate. But as cane growers may not be able to select

by means of a chemical analysis, the gravity test might be made to serve a useful purpose. A delicate hydrometer should be used, so that small differences will be apparent.

FERTILIZERS ON SORGHUM.

The effect of fertilizers on sorghum was tried on plats of three rows in width and some ten rods long. The fertilizers used were superphosphate, sodium nitrate, lime and plaster. Each of these was applied to one plat, but no record seems to have been kept of the amount used. "Nothing" plats alternated with these. These experimental plats were adjacent to the sorghum so badly injured by the blight described by Professor Kellerman in his report, plat 1 being on the side next the diseased sorghum. The disease attacked the plants when they were quite young, and killed many in the first and second plats. It was less severe further from the source of contagion.

All of this sorghum, except 33 feet off the south end of the plats, was used for feed, and these short plats were placed at our disposal. As the plats were separated by no more than the usual space between rows, it was thought best to take the middle row of the plat for analysis. This would avoid any effect. from such of the fertilizers as might have been washed from one plat to another. The entire row, 33 feet in length, was taken for the sample. The average height was determined by measuring all of the stalks in one row of the plat.

From the following table it appears that there was very little effect from the fertilizers. The lime seems to have been an injury, and the plaster may have been of benefit.

TABLE SHOWING RESULTS OBTAINED IN PLATS OF SORGHUM TO WHICH CERTAIN FERTILIZERS WERE APPLIED.

ITEMS.	*Plat I—Superphosphate.*	*Plat II—Nothing.*	*Plat III—Sodium nitrate.*	*Plat IV—Nothing.*	*Plat V—Lime.*	*Plat VI—Nothing.*	*Plat VII—Plaster.*
Number of stalks	37	43	60	57	59	51	66
Average height	8.34	8.43	8.51	8.71	8.59	8.90	8.89
Average weight	1.51	1.76	1.48	1.63	1.51	1.54	1.47
Per cent. of clean cane	62.23	61.42	58 76	60.22	62.36	59.87	61 85
Per cent. of tops	11.93	10.03	11.51	10.28	11.55	10.83	11.14
Per cent of leaves	25.84	28.55	29.73	29.50	26.09	29.30	27.01
Per cent. of juice calculated on whole cane	30.10	29.20	29.28	30.08	29.67	28.21	29.79
Per cent. of juice calculated on clean cane	45.49	47.54	49.83	49.94	47.59	47.13	48.16
Specific gravity of juice	1.0684	1.0726	1.0710	1.0704	1.0680	1.0699	1.0750
Per cent. of cane sugar	11.99	13.02	12.24	12.25	11.30	12.04	13.01
Per cent. of reducing sugar	2.24	2.35	2.26	2.45	2.69	2.55	2.65
Per cent. of total sugars	14.23	15.37	14.50	14.70	13.99	14.59	15.66
Per cent. of solids not sugars	1.52	1.30	1.58	1.32	1.31	1.32	1.55
Per cent. of total solids	15.75	16.67	16.08	16.02	15.30	15.91	17.21

REPORT OF THE BOTANICAL DEPARTMENT.

W. A. KELLERMAN, PH. D. *Botanist.*
W. T. SWINGLE, *Assistant Botanist.*

SORGHUM BLIGHT.

During the season, several varieties of sorghum grown on the College farm and elsewhere suffered from a disease whose presence was indicated by red or reddish blotches on leaves, leaf sheaths and roots. When severe, it resulted in the complete destruction of the sorghum plants, but when the disease was mild, the growth of the sorghum was only slightly checked. This disease was not noticed until early in July, at which time careful observations and investigations were begun. These were continued through the season, and the results are given in detail below.

The recorded history of this disease, so far as accessible literature indicates, is as follows: In 1883, Prof. S. A. Forbes,* while studying the diseases of sorghum and broom corn and the insects infesting these plants, in Illinois, concluded that fungi might be wholly or in part the cause of the damage done. He accordingly sent specimens for examination to Prof. T. J. Burrill, of the Illinois University. Although the latter failed at this time to discover the cause of the disease, yet in July, 1886, he detected in the diseased plants numerous bacteria within the affected tissues, which proved to be the specific micro-organism of the disease. Prof. Burrill named this parasitic organism *Bacillus Sorghi.* An account of the disease and the

*In Thirteenth Report of the State Entomologist of Illinois.

investigations made were given by him in the Proceedings of the Eighth Annual Meeting of the Society for the Promotion of Agricultural Science (1887), and in *The Microscope,* Nov., 1887 (Vol. VII, No. 11).

PREVALENCE OF THE DISEASE.

The sorghum on the College farm was planted in plats, in two fields nearly a half mile apart. One series (D) was on ground occupied by sorghum last year, while the others (A, B and C) were on land which had never been occupied by sorghum.

Series A consisted of single rows, several rods long, of 39 varieties of saccharine sorghums.

Series B was immediately north of the preceding, consisting of the same number of somewhat longer rows of Kansas Orange. About half the rows were from seed obtained from a Kansas City firm, and the other from seed grown in Wabaunsee county, Kansas.

Series C was a duplication of some of the varieties in series A.

The soil in which series A, B and C were planted was of a uniform character, and the treatment was the same, except that some rows of series B were manured with several different fertilizers.

In series D, the plats were of considerable size, and consisted of eight fodder plants. The sorghum raised on this ground the previous year was in all probability affected with a mild form of the disease. Old stalks which had remained in the field over winter showed plainly that the sheaths had been stained red in a manner similar to that caused by the disease. When ensilage was being made (in 1887) from this sorghum, some of the finely chopped material accumulated on the floor under the machine. In the course of a few days these pieces of sorghum, and especially bits of the stalk, were stained red, presumably by the disease, though since cultures were not made this cannot be positively asserted. These facts were noted in 1887, though no serious disease of the sorghum was suspected.

In the present year (1888), the disease appeared among the

College varieties, causing much damage. For a time it was supposed that the injuries were due to the attacks of insects, but the rapid spread and increasing damage induced a careful examination and study of the disease, beginning July 11. At this time, the Kansas Orange from seed from Wabaunsee county was very badly attacked, at least three-fourths of the crop being destroyed. The Kansas Orange from seed from a Kansas City firm was suffering but little from the disease. Some of the rows of the latter had been treated with fertilizers, namely, superphosphate, nitrate of soda, lime, and plaster. In no case could any difference be observed between these rows and the others which were not so treated. Later in the season, the difference between the two Kansas Orange plats became more marked. When ready to harvest, that grown from seed from Kansas City yielded a fair crop, while at least ninety per cent. of that grown from the Wabaunsee county seed had been destroyed. The north ends of the rows of both varieties were shaded by a row of trees, and these were much more diseased; but on the west side of the plat of Kansas Orange from Wabaunsee county seed, a half dozen rows, which were adjoining a millet field, were much less severely attacked by the blight. The difference between these and the other rows was not temporary, but continued throughout the season.

It should be mentioned that differences were observed in the panicle, internodes and character of the stalk of the Kansas Orange grown from the seed from the two sources mentioned above, and it is perhaps probable that they were two distinct varieties.

Of the varieties in series A, the following were but slightly attacked, the injury to the plants being inappreciable:

No. 1, Dutchess' Hybrid.

No. 2, Amber and Orange crossed.

No. 3, A new variety.

No. 4, Late Orange.

No. 5, Early Gooseneck.

No. 6, Whiting's.

No. 7, A new variety.

No. 8, Price's.

No. 9, Kansas Orange.

No. 10, Africa.

No. 11, Chinese sugar cane.

No. 12, Central American.

No. 13, White India, was at first seriously attacked, but later the disease made no further progress.

The following were somewhat diseased:

No. 14, Honey Drip.

No. 15, Medium Orange.

No. 16, White African.

No. 17, Honey Dew.

No. 18, White Amber.

No. 19, Golden Rod.

No. 20, South Carolina Early Orange.

No. 21, Gooseneck.

No. 22, Enyama.

No. 23, New Orange.

Of the following four varieties, very many (more than three-fourths) of the plants were destroyed by the disease:

No. 24, Russel's.

No. 25, Early Amber.

No. 26, Early Orange.

No. 27, Link's Hybrid.

The following two were badly attacked, though not to the same extent as Nos. 24–27:

No. 28, Swain's Early Golden.

No. 29, White Mammoth.

No. 30, Silver Top, was very badly blighted; at least three-fourths of the plants had been destroyed previous to July 23d.

No. 31, Little Sumac, was scarcely diseased.

Nine-tenths of the following two were destroyed:

No. 32, India.

No. 33, Red Top.

No. 34, Wabaunsee, was considerably diseased.

The following two were badly diseased; at least three-fourths destroyed:

No. 35, Honduras.

No. 36, Honey Cane.

No. 37, Liberian from Alabama seed, No. 38, Liberian from Missouri seed, and No. 39, Liberian from Kansas seed, were much injured.

The non-saccharine varieties of fodder plants (series D) were as follows:

No. 4, Rural Branching Sorghum, was not damaged by the blight.

No. 5, Kaffir Corn, was slightly diseased.

No. 6, Yellow Milo Maize: Early in the season this was but slightly diseased, but at the end of the season at least ninety-five per cent. of the plants were destroyed. They did not die rapidly, but became peculiarly stunted and branched.

No. 7, Pearl Millet: This was badly killed early in the season, especially where the plants were thin. The characteristic stains were not observed, and no cultures were made to determine the cause of the disease; therefore, the blight heretofore referred to may not in this case have been present.

No. 8, Doura: About one-half of the plants of this variety was killed, the principal damage occurring early in the season.

No. 9, African Millet, was damaged mostly in July. About two-thirds of the plants were destroyed.

No. 10, Japan Maize (a variety of Indian Corn), was not attacked by the disease.

No. 11, Teosinte, was also entirely free from the disease.

A plat of sorghum, in the same field with the above, but several rods distant, was sown thickly in summer, on land previously occupied by wheat. This was but slightly attacked by the disease.

A field of sorghum, (probably Red Top,) about a mile west of the College, belonging to Mr. Pierce, was examined August 8, 1888. The seed had been sown thickly, and during a violent

wind a few weeks previous had been blown almost flat. In the meantime it had become mostly upright, until a day or two before the observation, when a strong southwest wind again blew much of it down. The plants near the margin and in a strip in the middle of the field were upright, but the others were lying prostrate, with the heads bent upwards. The leaves and stalks showed little signs of the disease, but the roots were badly attacked, and the plants yielded easily to a slight pull. On August 15, it was observed that many of the stalks had broken, and in such case a red stain extended upward in the pith. A very bright yellowish-red stain was often seen on the sheath surrounding the head. In such cases, aphidæ (plant lice) were universally present. Cultures were made, but in no case were the micro-organisms causing the blight obtained.

In the latter part of August (1888), a field of sorghum (variety unknown) eight miles east of Manhattan was seen to be badly attacked by the blight. About one-third of the plants were destroyed—some parts of the field attacked much more than others. No cultures were attempted, but the characteristic stains were observed.

Leaves from affected sorghum plants, grown at Sterling, Rice county, Kansas, were sent for examination July 20 and August 1 (1888), by Mr. W. P. Clement, of the Sterling Sirup works. The characteristic stains were found on nearly all these specimens, and cultures were made, as will be mentioned later. There is no doubt but that the blight heretofore referred to was there prevalent, at least in a mild form. Damage might also have been caused by chinch bugs, or otherwise, as mentioned in the notes accompanying the specimens. Some of the varieties suffered more from the attack than others.

THE CHARACTER OF THE INJURIES TO THE PLANTS.

The diseased plants invariably presented blotches of red discoloration on the leaves or leaf sheaths. These stains were more numerous and brighter on the inner surface of the sheaths. In fact, the first discoloration to be noticed was invariably on

this surface. It often began on the extreme upper portion, at or on the ligule, and extended downwards. The blotches were very irregular in shape, but mostly more or less elongated. They were sometimes limited laterally by the large longitudinal veins, or the fibro-vascular bundles, that extend parallel through the sheath and blade. The blotches would widen out in many cases, so as to involve the whole surface. Very small dots and irregular patches, near the large blotches, were usually present. These would increase in size, and blend with adjacent ones. In most cases a very decided tendency to downward extension in lines or bands could be seen, limited below by the node, or joint, of the stem, which is the place of attachment of the leaf sheath. A very faint orange discoloration was usually the first indication of the diseased spots or portions. The coloration would become deeper, various shades of red would follow, and finally the diseased portions became very dark—almost black.

The colored figures on Plates I and II show some of the stages in the progress of the disease. The sheaths seen on Plate I show the earliest discoloration, on the inner surfaces, and those on Plate II show very advanced stages, involving both the inner and outer surfaces, as well as the entire intervening tissue.

The vitality of the affected parts finally became completely exhausted. The tissue could be easily crushed, and the interior showed the same deep coloration. The exterior of the leaf sheath in the earliest stages of the disease presented no blotches nor signs of discoloration, but very soon evidences of disease could be seen here also. The blotches always corresponded to similar patches within, yet in no case became bright colored. None of the small dots or patches near the large blothes, as on the interior surface, were here noticed.

Very frequently, but not invariably, the blade also presented blotches or patches of discoloration. In some cases these were very regular both in shape and distribution, and all the leaves of the plant were similarly and abundantly marked. In other

cases only scattering and irregular blotches could be seen. Elongated bands of discoloration, irregularly limited by the veins of the leaf, were in some cases noticed. The coloration was sometimes bright, but usually dull and dark. It is not likely that all these are directly associated with the disease in question; though some of them were proven to be so, others are doubtless referable to other causes.

The leaf sheath remained, until a late stage of the disease, closely adherent to the stem in the normal manner. Not even small insects could effect an entrance so as, perhaps, to cause by their presence the irritation that might result in discolored blotches. But later, especially in stalks that were not upright, the sheath often became partially separated from the stem, and in this recess chinch brigs occasionally congregated. Flies were noticed about the plants, and aphidæ in a few cases were also abundant, but these could not be associated directly with the disease, or regarded as its cause.

The roots of the diseased plants were examined, and found to be affected also. The characteristic coloration, though obscured by adhering soil, was present. Figures 1 and 3, in Plate III, show the stains on the underground portions of young plants. The outer (or cortical) portion of each affected rootlet presently lost its vitality, and would peel or slip off upon the slightest pressure. The plant, when diseased to this extent, could be very easily pulled out of the soil. The lowest roots were usually first attacked, and often entirely destroyed, so that a few of the uppermost only supported the plant. In severe cases the stem at the junction of the roots was also affected, and for some distance upward the central portion of it was discolored, and the tissue more or less disorganized. The stem, in all other cases, seemed to be free from the disease, except where it had in some way been wounded. In fractures or other wounds, the characteristic coloration could be seen, indicating the entrance of the disease.

The general effect on the plant was to reduce its vitality. When diseased but slightly, it attained its normal size, and,

aside from slight local discolorations, presented its usual appearance. But if the roots became diseased, the plant manifested signs of imperfect nutrition, a sickly yellow discoloration being very noticeable. A low and stunted growth was the result. In case of some varieties there was abundant branching from near the ground, but generally the plants perished soon after being attacked.

Since few observations were made regarding the microscopical injuries sustained by the host plant, the following account is taken from Prof. Burrill's article in the Proceedings of the Eighth Annual Meeting of the Society for the Promotion of Agricultural Science (1887), pp. 34 and 35:

"The cell walls are in nowise injured, so far as can be made out by the microscope, except that they are stained throughout with red. The first change observed in the cell contents is a shrinking of the protoplasm, as when treated with alcohol. It separates from the cell wall and appears rigid, instead of hav- its normal plastic consistence. The chlorophyll granules, if present, lose their green color and break up into smaller granules. Shrinking still continues, and the mass becomes tinted with red. From this time on the change does not appear to be always the same. Sometimes the shrunken mass seems tough, and remains like a lump in the middle of the cell. In other cases it breaks up into granular debris immersed in water. If starch grains existed at first, they are decomposed. At length the whole substance passes into what seems to be an emulsion of oily matter in water. The spherical particles are dark red, and usually exhibit Brownian or molecular motion. In certain cells minute starch grains, of uniform size and shape, like little double convex lenses, occur in great numbers, and oscillate rapidly in the cell fluids. They may be easily mistaken for microbes; but iodine stains them blue, revealing their nature. They have been observed only near the borders of the diseased areas, within red-stained cells. The surfaces of the walls of the cells, from which the contents have disappeared, seem to have a granular deposit upon them. Here, again, one needs caution

in looking for bacteria, as the deposited granules often appear somewhat like them. The liquid itself in the diseased cells is reddish in color, and certainly stains the cellulose of the walls beyond the area actually penetrated by the microbes."

No chemical analysis of the cane juices was made to determine, if possible, the effect of the blight on its composition. But in the Fourth Biennial Report of the State Board of Agriculture of Kansas, Prof. E. B. Cowgill gives, in his "Report on the Sorghum Industry in 1884," a statement of the "analysis of juices of canes injured by parasitic fungi," as follows:

September 30, Orange — most affected canes selected: Sp. gr., 1.0617; per cent. glucose, 7.85; per cent. sucrose, 3.49; and per cent. of other solids, 3.76.

The average of two analyses, September 29 and October 15, of Orange, (not diseased,) as reported by him, are as follows: Sp. gr., 1.0818; per cent. glucose, 1.3; per cent. sucrose, 13.32; and per cent. other solids, 5.03.

That the "parasitic fungi" referred to was the sorghum blight *(Bacillus Sorghi* BURRILL), can perhaps be reasonably assumed, as affected leaves, sent to the Botanical Department of the College at the time and yet preserved, show characteristic stains of the disease. He also observed that "after a time the canes in the worst patches broke and fell. Whenever the conditions were favorable to the healthy development of the plant, its vigor overcame the deleterious influence of the parasite, and no injury was observable."

GENERAL ACCOUNT OF BACTERIA.

The *Bacillus Sorghi,* causing the sorghum blight, belongs to a large group of very minute organisms called *Bacteria*. These consist of a single cell, or several loosely united cells, which are often of exceeding small size, in some cases not larger than 1/50000 inch in diameter. In shape, the micro-organisms may be spherical *(Micrococcus),* rod shaped *(Bacterium* and *Bacillus),* or spirally curved *(Spirillum).*

Nearly all bacteria can be grown on nutrient media, such as

boiled potatoes and other vegetables, vegetable infusions, and beef broth. Most of them grow best at a temperature of from 98° to 100° F. When grown on a firm medium, such as boiled potato, a compact mass of cells immersed in a colorless substance is formed. This mass, called a *zooglœa*, differs in shape, color, consistency, size, etc., in different species, so that very many of them may be identified by these characteristics alone. When grown in liquids, the cells usually have the power of motion, and are diffused throughout the medium, causing a cloudy or opalescent appearance of the previously clear fluid. At length, in most forms, a membrane develops on the surface, which, like the zoogloœa formed on solid media, differs in different species.

Micro-organisms grow so rapidly under favorable conditions, that in twenty-four hours the progeny of a single individual may number millions. They propagate by cell division, and in some genera, especially when nourishment becomes scanty, by the formation of spores. Owing to their extremely small size, these spores, and also, to a certain extent, the vegetative cells, may float in the air. In fact, they are so abundant that a momentary exposure to the air is usually sufficient to render a culture impure. Bacteria are also widely distributed in water. Very many of the diseases of animals, and a few diseases of plants, are caused by them.

CHARACTERS OF THE *BACILLUS SORGHI.*

The cells of this species vary much in size and shape, being from 1⅓–4 by ½–1¼ μ, but mostly 1½–3 by ¾–1 μ. The cells containing spores are the widest. The young cells are rod shaped, with usually abruptly rounded ends, while the fully mature spore-bearing cells are often nearly elliptical in outline. Every gradation between these may be seen in Plate IV, Figs. 1 and 3.

The cells are usually single, or, at most, only in pairs, though sometimes, especially in old fluid cultures, they are arranged in long chains, as seen in Plate IV, Fig. 2. Often these chains are very long, and approximately parallel. These are very rarely composed of spore-bearing cells.

The spore formation is first recognized by a minute spot or zone in the center of the cell remaining unstained, while the rest of the cell stains as usual. As spore formation progresses, the stain-resisting space becomes larger and slightly oval, until, when the spores are fully mature they occupy a considerable portion of the cell. The substance outside of the spore becomes smaller, and, when the spores are ripe, is seen as a dot at either end of the cell; in shape, it is usually concave on the side facing the spore, but is sometimes sharply rounded. The spores meanwhile, have acquired a cell wall of their own, and at length, when the wall of the parent cell breaks, or is dissolved, the spores are set free. All stages of spore formation are shown in Plate IV, Fig. 3.

The spores are oval or oblong in shape, and are about .6-.9 by 1-1.2 μ. They are not colored by any common stain, though, according to Prof. Burrill, "aniline red, with carbolic acid, does stain them." The development of spores into cells has not been watched, owing to lack of opportunity to make hanging-drop cultures, but in many cases all intermediate forms between spores and mature cells were seen in the same culture. In these cases, the staining capacity became greater as the cells became larger. It seems probable that in this species the spores do not germinate, but develop into vegetative cells by a simple increase in size.

In staining capacity, *Bacillus Sorghi* is only medium when compared with other species. Methyl violet, aniline violet and methyl green all stain the cell contents strongly; aniline green, Bismark brown and aniline red nearly as well but with the methyl blue and aniline blue at command, no stain could be obtained. Hæmatoxylon and aniline black stain the cell wall slightly, while fuchsine seems to stain both the cell wall and cell contents. Of these dyes, methyl violet acted most powerfully, though aniline violet or methyl green usually showed the details of structure better.

The zoogloœa vary with the culture medium used and with the age of the culture. On potato, the typical color is pearly

white, though there is sometimes a slight tinge of yellow or pink. The surface is free from minute roughness, which gives a pulverulent appearance to the zoogloœæ of several similar species, though it is wrinkled, except when the culture is very young. The zoogloœa is usually thin, but becomes somewhat thicker with age, though it never is sticky. When very old, it is of a dirty white color and very much wrinkled. On agar agar, the general characters are much the same as on potato, but the growth is slower and the resulting zoogloœæ thinner. The margin is usually crenate. In fluid cultures, the membrane was often smooth and pitted, but sometimes irregularly wrinkled.

GENERAL ACCOUNT OF CULTURES MADE.

In making potato cultures, sound tubers were selected, carefully cleansed, and then placed on a rack just over boiling water for about half an hour. The tubers were allowed to cool somewhat, and then were removed with a pair of forceps sterilized by heating. They were cut in two halves by a knife which was from time to time sterilized. As soon as cut, the halves were each placed under tumblers on glass plates, both having been previously sterilized by heating several hours in a dry chamber at 150-160° C. (200-220° F.)

In case the culture was from a diseased leaf or sheath, the method of starting the cultures was as follows: The diseased portion was flamed for an instant to destroy any foreign germs on the surface; it was then scratched with a sterilized knife and broken in two; a recently-heated platinum needle was then plunged into the diseased tissue and instantly placed on the surface of the tuber. The tumbler was now labeled and placed in an incubator, where a constant temperature of about 99º F. (37° C.) was maintained. These cultures were liable to be contaminated from the air, since the tumblers did not fit the plates closely. But even when contaminated thus, the growth of the foreign organism always began where the tuber touched the plates, and very seldom reached the cut surface.

The character of the growth of the *Bacillus Sorghi* on potato has been given elsewhere.

In all, fifteen potato cultures were started directly from diseased sorghum plants, mostly grown at Manhattan. Of these, eight gave pure cultures of *Bacillus Sorghi,* two remained sterile, and five were impure. The cultures made when the disease was first noticed were much more successful than those made late in the season. Whenever the part used to start the culture was dried up or hard, it was very difficult to obtain a pure culture. Very many cultures were started from other cultures to test their purity; in this case a minute quantity of the fluid containing the germs or a fragment of the zoogloœa was transferred to the surface of the tuber.

Beef broth was used for a culture medium before the agar agar was obtained. It was prepared as follows: Lean beef was chopped up fine and allowed to soak all night in cold water; then it was boiled for perhaps an hour, the fat skimmed off, and the remaining fluid strained through a cloth to separate the particles of meat; then the liquid was filtered into a sterilized flask, and usually made neutral by adding carbonate of soda. The flask was then stopped with a plug of sterilized cotton. The flask and contents both were now heated to boiling for from fifteen minutes to half an hour for several successive days; by this time all contained germs had been killed. Sterilized test tubes, likewise stopped with cotton, were now partially filled with the broth, and were ready to be used in cultures.

The cultures were started by removing the plug an instant and touching the liquid with the infected platinum needle. It was, however, more difficult to obtain pure cultures, as any foreign germs were not restricted in their growth, but also spread all through the fluid. Only five beef broth cultures were inoculated directly from diseased parts, and only two of these gave pure cultures of *Bacillus Sorghi.* The cultures used in inoculating were always started from a zoogloœa on some solid medium.

Agar agar cultures were made with beef broth which had been solidified by adding about one per cent. of agar agar or Japan isinglass. This causes the broth to solidify at a temperature of about 40° C. (104° F.) It was treated the same as beef broth, except that it was poured into the test tube while warm, and the tubes were inclined while the medium solidified. This gave an increased surface. The growth of the bacteria on this medium is not so rapid as on potatoes, but otherwise much the same. The agar agar was not obtained till about the middle of August, when the disease was not so severe. Sixteen cultures were inoculated directly from diseased tissue, and of these eight gave the *Bacillus Sorghi,* four remained sterile, and four were impure or contained other organisms.

A few cultures were made in sorghum juice, but owing to the great difficulty encountered in filtering it they were abandoned. In one of the cultures made, cells of *Bacillus Sorghi* were observed in motion. The motion was very slow compared to that of some other bacteria, but was clearly perceptible. For instance, in one case a cell moved 25 μ, or 9 times its length, in fifteen minutes, while inorganic particles in the fluid at the same time showed only the Brownian movement.

Early in September, a few cultures were made on portions of rather young sorghum stems treated much the same as potatoes; that is, the long pieces were boiled a considerable time, and then cut up into small portions and placed under tumblers. They were used with the hope of obtaining the characteristic stain, but nothing of the kind was observed.

In general, the cultures made early in the season gave much better results than those made later. Most of the cultures were made from diseased plants grown on the College farm, but a few were from other sources. About a dozen were made from diseased canes sent from Sterling, Rice county, but owing to the moulded condition of the parts when they arrived, but few of the cultures were entirely pure, although *Bacillus Sorghi* was obtained in at least half the cultures. One of the cultures from diseased cane sent from Sterling gave a *Micrococcus,*

shown in Plate IV, Fig. 4, which, however, had nothing to do in causing the blight.

In one case, a chinch bug was taken from a badly blighted plant and a culture started from its body. In this case, three species of micro organisms were obtained, one of them being *Bacillus Sorghi.*

INOCULATION EXPERIMENTS.

To prove that Bacillus Sorghi really causes the sorghum blight, several inoculation experiments were made, of which the following is a condensed account:

Inoculation No. 1. The middle part of a leaf of Kansas Orange, almost entirely free from disease, was wetted on both surfaces with a beef-broth culture containing the organism. This was on July 28. On August 2, the leaf was examined. It had been scratched across with lead pencil to mark the portion inoculated. These scratches were now visible as distinct red marks running across the leaf, but most prominent on the midrib. On the lower surface, especially, many minute red specks could be seen, which were more numerous at the end of the area inoculated. This may be explained by the fact that the leaf hung down, and the inoculating fluid had run to the end of the part wetted. In one place, a drop had run beyond the area inoculated, and its track was made manifest by a line of red specks. Where the leaf had not been touched by the inoculating fluid, it was yet free from disease.

Inoculation No. 2. On the same day, another plant, also of Kansas Orange, was inoculated from the same culture fluid. In this case, the inside of the sheath was wetted by pulling the sheath a short distance from the stalk and dropping in the culture fluid. No effects could be seen in this instance.

Inoculation No. 3 was made the same evening, with same culture fluid, on a variety said to be Red Top, growing on a farm at a distance from the College. In this experiment, the upper sheaths were wetted all over on the outside.

Inoculation No. 4 was the same as No. 3, except that a single leaf was wetted on both surfaces.

On August 8, they were examined. No. 3 showed a few red streaks where the edges of the sheaths overlapped, and also the ligule was discolored, though the stains did not in most cases extend down on the inside of the sheath. But one sheath was considerably discolored.

In No. 4 no effect could be seen.

Inoculation No. 5. On August 8, a healthy leaf of Red Top was inoculated by scratching and pricking with a previously heated needle. Then the middle third of the leaf was wetted on both surfaces with a beef-broth culture of Bacillus Sorghi. On August 15, the leaf was examined. The holes, especially on the under side. were surrounded by a narrow red margin. The scratches were not very red, except where they crossed the midrib, where there was a pronounced red stain, perhaps 1/10 inch wide. Where the midrib was pricked, there were small fusiform red specks.

Inoculation No. 6. On August 8, another plant in the same field was inoculated as follows: A healthy leaf was selected, and injured with a needle, which was from time to time plunged into a diseased sheath from another plant. On August 15, the leaf was removed and examined. Where scratched, and especially where the scratches crossed the midrib, there was a red stain. In this case the most prominent stains were on the lower surface.

On August 9, several sorghum plants (variety unknown), growing in another field, and also a grass and Indian corn, were inoculated from the same broth used in No. 5.

Inoculation No. 7. A leaf and sheath of sorghum were wetted, having previously been injured by a sterilized needle. On August 15, the plant was examined. About the holes were seen pronounced red spots, which extended much farther lengthwise of the leaf than crosswise.

Inoculation No. 8. A head, nearly if not quite past blooming, was placed in the culture fluid. When examined, no effect of the inoculation could be seen.

Inoculation No. 9. was on a corn plant. The leaves were injured and wetted, but in no case was any injury produced.

Inoculation No. 10. A plant of wood grass *(Chrysopogon nutans)* was thoroughly wetted, but no effects were seen.

Inoculation No. 11. On August 18, two pots of Early Amber sorghum, grown in pots in the greenhouse, from soil obtained there, were selected for the inoculation. They had been intended for use in soil tests, and had been raised in large, unprotected pots. At the time of inoculation, a few showed red stains on the axis cylinder. In all cases, however, the leaves were entirely healthy. A bell jar was now placed over each pot, and the plants in the one were thoroughly wetted with a beef-broth culture of the micro-organism, while those in the other were not disturbed. The leaves of the ones inoculation resisted wetting, and the fluid collected in drops or ran down to the junction of the leaf and sheath. By August 21, the effects of the disease could be clearly seen on the inoculated plants. The leaves showed slight red stains and streaks of lighter green, while some of the sheaths also had red stains. Wherever a drop of the inoculating fluid had collected there was a red spot. The plants which had not been inoculated showed no signs of the disease. A few days later, two of the inoculated plants were figured as seen in Plate III, Figs. 3–6.

It will be seen from these few experiments, that of the nine sorghum plants inoculated six showed the stains of the disease; that corn and Wood grass, when similarly treated, showed no signs of any injury. It will be seen from No. 11, that young as well as old plants are capable of being artificially diseased.

SOIL TESTS.

Early in August, experiments were begun to determine whether the disease germs had the power of remaining in the soil and afterwards transmitting the blight directly to other sorghum plants.

The first six experiments were made as follows: Soil collected on the College farm in April was used for Nos. 1, 3

and 5, and soil from the greenhouse for Nos. 2, 4 and 6. The soil from the farm was collected for another purpose on the site of a sorghum field of the previous year. Sorghum (series D) planted here after this soil was collected was very much diseased. The soil from the greenhouse was obtained far from any sorghum fields.

The pots were placed in the greenhouse, and watered with the other plants from a tank of rain water. Nos. 1 and 2 were African Sorghum in the two soils used; Nos. 3 and 4 African Millet; and Nos. 5 and 6 Rural Branching Sorghum. The plants came up, and grew with apparently equal vigor in both kinds of soil. No stains could be observed on the upper leaves, but the plants in soil from the old sorghum field frequently showed stains on the lowest leaf. It may be that the blight would have appeared on the other leaves if the plants could have been kept longer, but owing to their rank and slender growth it was necessary to throw them out in about a month.

In one respect a great difference was observed in regard to the plants grown in the different soils. In those raised in soil from the old sorghum field, the portion of the stem (axis cylinder) between the seed and the surface of the soil became very speedily stained of a deep red color; while the same variety planted in soil from the greenhouse, but otherwise under the same conditions, showed such injuries not at all or only to a slight extent. Thus, on August 10th, ten plants of African millet were pulled up from both Nos. 3 and 4. The ten plants from No. 3 were *all but one diseased* in the manner described, while the ten plants from No. 4 were *all but one free* from disease. The African Sorghum and Rural Branching Sorghum, being varieties less liable to the disease than African Millet, showed fewer stains, and, hence, less difference between the plants grown in the two soils. Cultures were made at once from these diseased stems, and gave a remarkably large per cent. of pure cultures of a *Bacillus* which seemed to be very much like the usual form of *Bacillus Sorghi,* though it differed

in some respects, especially in that when young the cells had the appearance of being granular within. However, in older cultures, this difference disappeared. This form of the organism was used in inoculation No. 11 and produced the stains shown on Plate III, Figs. 3-6. The same plate also shows (Fig. 2) the appearance of a healthy plant of African millet (soil test No. 4) grown in greenhouse soil, and a diseased one (Fig. 1) grown in soil from old sorghum field (soil test No. 3).

When the plants in these soil tests became older, all became more or less diseased, though in all cases those grown in greenhouse soil were less blighted. It may be that the disease spread from one pot to another, since they were close together, and not protected in any way. In the older plants, not only was the axis cylinder diseased, as shown in Plate III, Fig. 1, but also the principal roots of the plant, starting from just below the surface of the ground.

These experiments are especially interesting from the fact that the sorghum planted later on the soil used in Nos. 1, 3 and 5 was very much blighted.

In case of soil tests Nos. 7 and 8, Late Orange sorghum was planted on August 22. In No. 7 the soil was collected on the same day, from the field which in April furnished the soil for Nos. 1, 3 and 5. The soil for this test was obtained about the roots of a plant of Yellow Milo Maize that had been killed by the blight. The soil for No. 8 was obtained at the same time and at the same place, but was heated to 160° C. (220° F.) for several hours, to kill any contained germs. Both were placed under bell jars in the greenhouse as soon as planted, and watered from a tank of rain water. The soil in No. 8 did not, however, remain sterile, probably because of the water used; and the experiment was further vitiated by the fact that the seed planted was very poor, and only three plants grew in No. 8 and nine in No. 7. Moreover, the Late Orange is one of the varieties but slightly susceptible to the blight; yet, when the plants were removed and examined, on September 13, a great difference could be observed between the plants in the

two pots. Those grown in heated soil were almost free from stains, while the axis cylinders of those grown in soil not so heated were deeply stained, and even in some cases shriveled.

Soil tests Nos. 9, 10 and 11, planted on October 18 with Yellow Milo Maize, were conducted on much the same plan as in Nos. 7 and 8, but with more care. The soil in No. 9 was collected as in No. 7— about the roots of plants of Yellow Milo Maize killed by the blight. In No. 10, the soil was from the same place, but was carefully sterilized by heating six hours to a temperature of 200° C. (392° F.). In No. 11, the soil was from the greenhouse. All were placed under sterilized bell jars in a new part of the greenhouse. Nos. 9 and 11 were watered from the tank at the greenhouse, but No. 10 with sterilized distilled water.

Some of the plants in the tests were collected on October 27, and the remainder on October 31. The total number of sound and of diseased plants in each case is as follows: In No. 9, one healthy and fourteen more or less diseased; in No. 10, thirty-three sound and eight slightly diseased; in No. 11, seven healthy and eight diseased.

The presence of so large a number of diseased plants in No. 11 would seem to indicate that either the soil or water, or both, had become infested with the disease, producing *Bacilli.*

These soil tests seem to warrant the conclusion that the disease is transmissible, to some extent at least, through the agency of the soil.

CONCLUSION.

It will be seen from the foregoing, that the causes and symptoms are for the most part already known; yet there are several questions in reference to the disease that demand further investigation; and a report of subsequent work will be given when additional data or conclusions warrant publication.

It should be observed, however, that prevention of the disease to a greater or lesser extent is certainly possible. The minute organisms, or *Bacilli*, which cause the disease continue to live in the old stalks, as successful cultures at the time of

this writing clearly proves. Prof. Burrill found them in the stalks that had remained in the field the entire winter. It is evident, therefore, that the old stalks and stubble should be destroyed. It is not sufficient to plow them under, as in such case the disease-producing germs will not likely be destroyed. THEY SHOULD IN ALL CASES BE BURNED. The more carefully the diseased plants are collected, and in this manner destroyed, the more effectually the disease is likely to be checked.

A rotation of crops is also advisable, and in no case should land that may probably contain the micro-organisms be planted to sorghum. Prof. Burrill observed that the disease was more abundant in those fields in which diseased plants had grown the previous year. In one field of the College farm, (plats in series D,) the disease in a mild form prevailed the previous year. However, in the field containing the other plats, more than a quarter of a mile distant, and where the severest form of the disease prevailed among some of the varieties, no sorghum had ever been planted. The field was previously in grass. Neither had sorghum been cultivated in any of the fields immediately adjacent. While, therefore, the mode of infection from year to year is still obscure; it is yet perhaps safer in practice to assume that this may occur through the medium of the soil. Prudence would, therefore, dictate an observance of the above suggestion.

EXPLANATION OF THE PLATES.

PLATE I. — SORGHUM BLIGHT.

FIG. l. —Portion of the leaf sheath (Late Orange), showing an early stage of the disease, with stains on the ligule and inner surface.

FIG. 2. — Portion of the sheath (Kansas Orange), with stains on the blade, ligule and inner surface, with a downward extension of the disease.

PLATE II. — SORGHUM BLIGHT.

FIG. 1. —Portion of stalk (Kansas Orange), with the discoloration on the external surface of the sheath, showing an advanced stage of the disease.

FIG. 2. — Portion of inner surface of sheath (Kansas Orange), showing a very advanced stage of the disease.

PLATE III. — SORGHUM BLIGHT.

FIG l. — Young plant (African Millet), grown in soil from field of diseased sorghum, showing diseased portion. — Soil Test No. 3.

FIG. 2.— Young plant grown in soil supposed to be free from the disease-producing *Bacilli*. — Soil Test No. 4.

FIGS. 3, 4, 5 and 6. — Portions of young plants (Early Amber), showing stains characteristic of the disease, all artificially produced. — Inoculation No. 11.

PLATE IV. — SORGHUM BLIGHT AND HACKBERRY KNOT.

FIG. 1. — Ordinary actively growing cells of *Bacillus Sorghi* BURRILL, showing variation in size and shape; x 2, 000.

FIG. 2. — The same in chains, from fluid cultures; x 2,000.

FIG. 3. — The process of spore formation and mature spores; x 2,000.

FIG. 4. — A *Micrococcus* obtained in cultures from diseased sorghum (from Sterling); x 2,000.

FIGS. 5 and 6. — *Bacilli* occasionally found as impurities in cultures, from diseased sorghum; x 2,000.

FIG. 7.— A conidiophore of *Sphaerotheca phytoptophila* KELL. and SW., showing the formation of conidia: x about 250.

FIG. 8.— A conidium, or summer spore; x about 250.

FIG. 9.— A perithecium, with appendages: x about 250.

FIG. 10.— A mature perithecium burst open, showing an ascus with spores protruding; x about 250.

FIGS. 11 and 12.— Ripe asci, containing spores: x about 250.

FIG. 13.— Sporidia, or ascospores; x about 250.

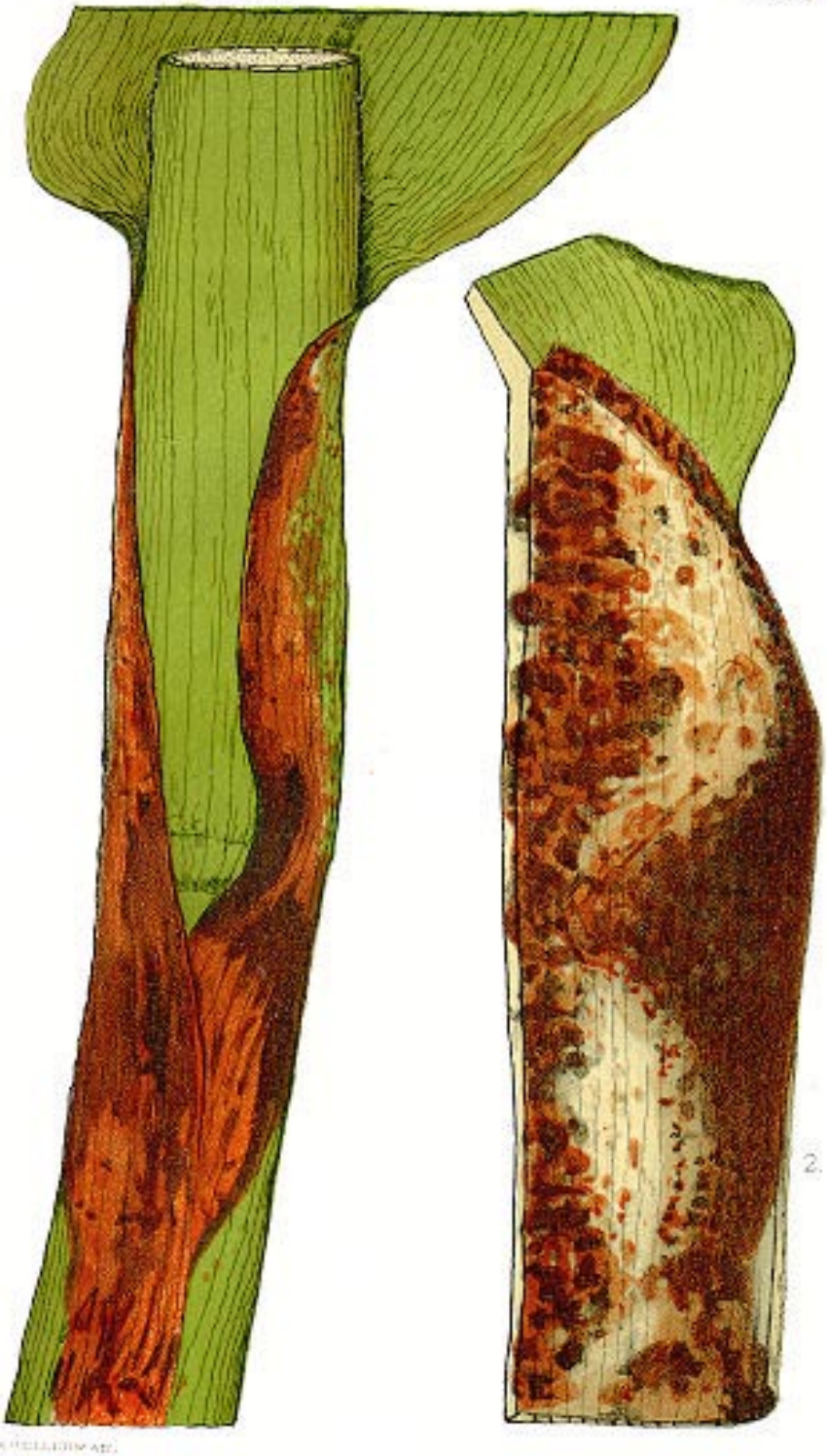
PLATE V. — HACKBERRY KNOT.

Figure from a photograph showing a knot of the hackberry, of the open type, growing on a vigorous branch.

PLATE VI. — HACKBERRY.

Figure from a photograph of a hackberry knot, more compact, and growing on a less vigorous branch.

SORGHUM BLIGHT.



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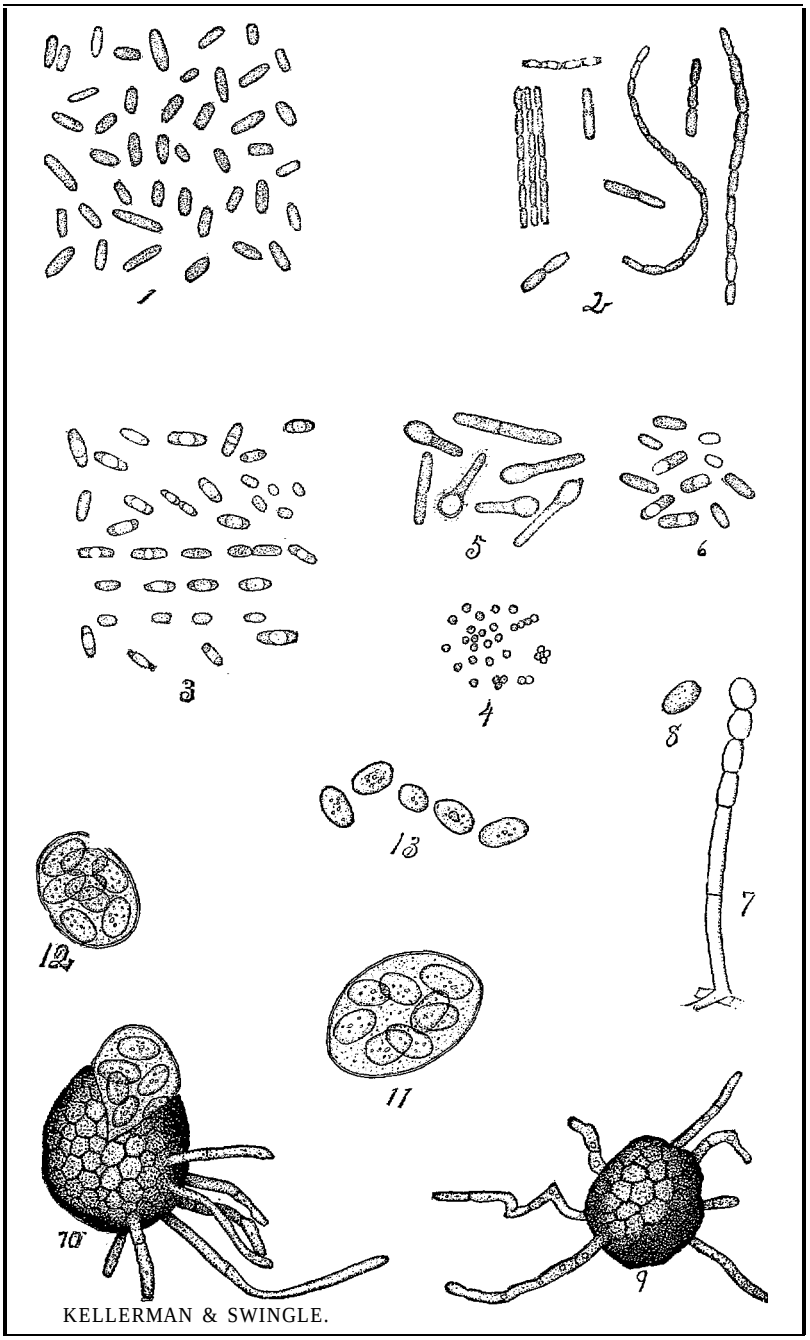
SORGHUM BLIGHT.

SORGHUM BLIGHT



SORGHUM BLIGHT (1 – 6), AND HACKBERRY KNOT (7 – 13).