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THE CHEMICAL COMPOSITION OF SORGHUM ROOTS AND ITS RELATION TO CHINCH BUG INJURY

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BY

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Considerable study of the macrochemical changes in sorghum plants has been made at the Oklahoma Agricultural Experiment Station in an attempt to determine the nature of varietal differences in chinch bug resistance. These results have been reported by Webster, *et al.* (7, 8, 9, 10*), who were unable to correlate insect resistance with changes in constituents determined.

Conrad (2, 3) reported marked variations in the sugar content, particularly sucrose, in the roots of different varieties of sorghum at maturity. Therefore, it was deemed advisable to broaden this investigation by relating the chemical composition of sorghum roots with chinch bug injury.

EXPERIMENTAL PROCEDURE

Materials

Several varieties of sorghums at various stages of growth were used by the Station for this study. The two varieties originally selected were Atlas, which is relatively resistant to chinch bugs during early growth, and Dwarf Yellow Milo, a highly susceptible variety during the same stage of growth. Later, two other varieties were added: Darso, a resistant variety throughout its entire growing period; and Feterita, a susceptible variety.

The four varieties represented not only different degrees of chinch bug resistance, but also different types of growth habit. Atlas is a tall

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* Numbers in parentheses refer to Literature Cited, page 9.

form, Feterita and Darso are medium sized plants, and Milo is a dwarf type.

The crops were planted on fine sandy loam near Perkins, Oklahoma, in rows 42 inches apart with hills 42 inches apart in the rows, for the 5-year period 1940-1944. In two of these years, the susceptible varieties were so severely injured at an early stage of growth that further harvesting was precluded. Only two varieties were grown during the first year. Consequently, complete data are available for two years only—1942 and 1943. Only these data are presented in detail, but composition of the roots in all five years is considered in the discussion.

Sampling

The roots were dug by hand and sifted from the sandy soil from an area two feet in diameter and eight inches deep. This is an incomplete sample of the whole root system (4,6), but represents—during the earlier stages of growth— nearly all the fine roots.

Roots were uniformly obtained by collections beginning at seven in the morning. They were freed from the greater part of the soil and taken to the laboratory. There they were washed or brushed free of sand, the cleaning technique being consistent for any given year. The cleaned roots were cut into small pieces and aliquots taken directly for the determination of solids, ash, and total nitrogen, and for preservation in alcohol. Total top growth was obtained by weighing the whole stalks. Samplings were stopped when the heads began to form, because serious chinch bug injury is rare after this time unless the infestation is overwhelming.

Chemical Methods

Solids were secured by drying a 5 gram sample to constant weight in an oven held at 105° C.

Ash was determined by incinerating at 600° C. until a white ash was secured.

Total nitrogen was determined using the Kjeldahl-Gunning procedure (1), and **soluble nitrogen** was obtained by the same method on aliquots of the alcohol extracts.

Insoluble nitrogen was calculated by subtracting soluble from total nitrogen.

The samples preserved in alcohol were exhaustively extracted (36 hours) with 80 percent alcohol in a Soxhlet-type extractor. The extracts were used for sugars and soluble nitrogen.

Reducing sugars were determined on aliquots of the alcohol extract after the alcohol had been removed on a boiling water bath. The samples were cleared with neutral lead acetate and sugars were determined on the cleared samples by the Shaffer-Hartman procedure (5).

Sucrose was determined on these same extracts after inversion with HCl.

Total sugars values were secured by summating the reducing sugar and sucrose percentages.

Ash-free solids were calculated by subtracting ash from the total solids.

RESULTS AND DISCUSSION

Complete data for two years (1942, 1943) are presented in Tables I and II, and incomplete data for three other years will be considered in the following discussion. No insect injury to the plants was apparent in either of the two years for which complete data are given.

Root/Top Ratio

Generally speaking, the root/top ratios in any one year were quite similar for the four varieties. They did not indicate any lack of roots in relation to tops that might be significant in relation to insect injury. The much higher ratio in 1943 is explained by a severe drought that stunted top growth. In other years for which data are not given, the ratio was much lower for the tall-growing Atlas and the medium-growing Feterita.

Ash-free Solids

The agreement among varieties in solids content at any one sampling time was remarkably close. There were no significant differences between varieties when the plants were young (the period when resistance is most variable).

Carbohydrates

In general, there was a progressive increase in soluble carbohydrates as the season progressed, at least to heading time. This increase was largely accounted for in all varieties by an increase in sucrose. An ap-

Table I.—Seasonal Analyses of Sorghum Roots. 1942

Age (days)	Height (in.)	Percent solids	Percent ash	Percent ash-free solids	Sugars: Percent reducing*	Sugars: Percent total*	Sugars: Percent sucrose*	Nitrogen: Percent total*	Nitrogen: Percent soluble*	Nitrogen: Percent insoluble*	Root/top ratio
Atlas C. I.-899 (Resistant)											
37	11	55.27	42.32	12.95	4.71	6.87	2.16	1.38	.17	1.21	.223
42	19	50.10	38.83	11.27	6.57	9.50	2.93	1.15	.20	0.95	.176
47	27	50.22	36.78	13.44	8.71	11.24	2.53	1.00	.19	0.81	.093
55	36	43.64	29.04	14.60	10.96	14.52	3.56	1.01	.24	0.77	.079
62	48	35.04	17.24	17.80	12.70	18.71	6.01	0.97	.30	0.67	.060
69	65	35.02	14.79	20.23	11.52	20.66	9.14	1.04	.39	0.65	.081
Dwarf Yellow Milo T. S.-338 (Susceptible)											
37	13	56.31	43.02	13.29	3.99	5.57	1.58	1.42	.24	1.18	.162
42	15	50.68	37.55	13.13	4.72	7.46	2.74	1.31	.24	1.07	.207
47	23	53.94	41.64	12.30	5.61	9.68	4.07	1.28	.21	1.07	.133
55	24	50.82	35.68	15.14	5.94	9.90	3.96	1.18	.30	0.88	.122
62	32	43.93	22.89	21.04	5.32	11.74	6.42	1.20	.34	0.86	.077
69	33	42.70	21.92	20.78	5.58	13.33	7.75	1.37	.53	0.84	.073
Feterita C. I.-182 (Susceptible)											
37	13	53.87	40.74	13.13	3.73	7.16	3.43	1.52	.26	1.26	.283
42	13	49.56	37.34	12.22	3.85	7.70	3.85	1.25	.25	1.00	.312
47	23	45.08	30.14	14.94	4.62	8.97	4.35	1.10	.26	0.84	.196
55	23	53.24	40.16	13.08	4.97	9.56	4.59	1.29	.25	1.04	.190
62	35	39.86	18.71	21.15	4.92	12.49	7.57	1.02	.33	0.69	.138
69	38	40.48	17.85	22.62	4.37	13.43	9.06	1.13	.42	0.71	.119
Darso T. S.-28 (Resistant)											
37	11	55.28	40.88	14.40	4.10	7.43	3.33	1.50	.22	1.28	.263
42	13	52.51	41.98	10.53	4.18	8.83	4.65	1.32	.18	1.14	.241
47	20	59.81	49.59	10.22	6.36	9.10	2.74	1.24	.22	1.02	.147
55	25	58.89	47.54	11.35	6.78	11.54	4.76	1.14	.17	0.97	.112
62	32	45.54	30.62	14.92	8.78	22.65	13.87	1.21	.43	0.78	.098
69	40	41.12	23.23	17.89	7.88	20.68	12.80	1.00	.37	0.67	.079

* Percentage of ash-free soils.

Table II.—Seasonal Analyses of Sorghum Roots.
1943

Age (days)	Height (in.)	Percent solids	Percent ash	Percent ash-free solids	Sugars: Percent re-ducing*	Sugars: Percent total*	Sugars: Percent sucrose*	Nitrogen: Percent total*	Nitrogen: Percent soluble*	Nitrogen: Percent insol-uble*	Root/top ratio
Atlas C. I.-899 (Resistant)											
29	8	18.34	5.91	12.43	8.29	11.35	3.06	1.57	.32	1.25	.235
37	11	24.68	10.81	13.87	12.62	17.31	4.69	1.73	.56	1.17	.226
46	22	19.34	7.03	12.31	12.35	18.69	6.34	1.49	.54	.95	.188
53	31	24.68	9.72	14.96	10.36	15.37	5.01	1.41	.41	1.00	.206
60	40	25.98	11.10	14.88	12.16	21.57	9.41	1.56	.65	.91	.222
67	43	22.90	8.61	14.29	12.18	21.63	9.45	1.50	.54	.96	.227
Dwarf Yellow Milo T. S.-338 (Susceptible)											
29	8	18.23	6.95	11.28	7.80	8.07	.27	1.83	.43	1.40	.218
37	13	22.33	9.60	12.73	9.51	18.23	8.72	2.06	.90	1.16	.354
46	16	22.94	9.95	12.99	8.01	16.71	8.70	2.25	1.06	1.18	.317
53	20	24.06	11.05	13.01				2.63	1.20	1.43	.290
60	20	23.67	6.36	17.31	5.49	14.96	9.47	2.60	1.12	1.48	.268
67	29	26.78	11.19	15.59	5.97	14.76	8.79	2.19	.71	1.48	.256
Feterita C. I.-182 (Susceptible)											
29	7	20.42	6.64	13.78	6.39	12.34	5.95	1.50	.42	1.08	.377
37	12	21.75	5.81	15.94	8.59	14.80	6.21	1.45	.44	1.01	.323
46	20	19.34	7.03	12.31	11.21	23.23	12.02	1.94	.67	1.27	.335
53	25	24.22	8.85	15.37	7.22	17.04	9.82	1.35	.48	.87	.308
60	50	28.50	6.67	21.83	6.87	15.57	8.70	1.06	.62	.44	.159
67	50	28.50	5.75	22.75	5.14	22.60	17.49	1.27	.57	.70	.238
Darso T. S.-28 (Resistant)											
29	7	17.99	6.24	11.75	8.26	13.88	5.62	1.57	.34	1.23	.255
37	11	19.48	5.73	13.75	9.75	15.86	6.11	1.60	.44	1.16	.298
46	24	23.45	10.83	12.62	10.22	22.58	12.36	1.53	.56	.97	.216
53	27	21.62	8.58	13.04	9.97	18.64	8.67	1.60	.57	1.03	.224
60	33	25.24	7.06	18.18	8.09	20.03	11.94	1.40	.56	.84	.198
67	40	26.31	8.26	18.05	7.48	29.31	21.83	1.39	.67	.72	.164

* Percentage of ash-free soils.

preciably greater increase in reducing sugars was noted in 1942 in the resistant varieties, but was much less pronounced in other years.

As a whole, there was little difference in the soluble sugars content of the roots from different varieties during the earlier stages of growth—the time when differences in resistance are marked and when Milo, particularly, is susceptible. As reported by Conrad (2,3), Milo fails to add to its soluble sugar content at later stages and may even decrease slightly when heading starts.

Nitrogen Fractions

Relatively similar nitrogen values were found both for the resistant and susceptible varieties at the same harvest time. At times, Dwarf Yellow Milo roots contained more nitrogen than the other varieties—particularly Atlas—but the results were too inconsistent to permit concluding a definite trend. Generally, total nitrogen percentages decreased to heading, and soluble percentages increased. At heading time, a slight increase in total nitrogen occurred.

SUMMARY

- Ash-free solids, total sugars, sucrose and soluble nitrogen increased to heading time in the root tissue of four sorghum varieties of varying resistance to chinch bug injury. Total and insoluble nitrogen decreased with growth in all four varieties.

- No significant differences were noted in the composition of the roots during those stages of growth when differences in chinch bug resistance are most pronounced.

- Dwarf Yellow Milo differed from the other three varieties in that sugars ceased to increase at about the time the head started to emerge.

- Differences in the composition of the roots of four varieties of sorghum during early growth were unrelated to varying resistance of these varieties to chinch bug.

LITERATURE CITED

1. Association of Official Agricultural Chemists (compilers).
1940. "Methods of Analysis." 5th ed.

2. Conrad, John P.
1927. Some causes of the injurious after-effects of sorghums and suggested remedies. *Jour. Amer. Soc. Agron.* 19:1091-1111.

3. ——————————
1937. The carbohydrate composition of corn and sorghum roots. *Jour. Amer. Soc. Agron.* 29:1014-1021.

4. Miller, Edwin C.
1916. Comparative study of the root systems and leaf areas of corn and the sorghums. *Jour. Agri. Res.* 6:311-332.

5. Morrow, Clarence Austin.
1927. "Biochemical Laboratory Methods." John Wiley and Sons, N. Y. 350 pp.

6. Weaver, John E.
1926. "Root Development of Field Crops." McGraw-Hill Book Co., N. Y. 1st ed. 291 pp.

7. Webster, James E. and V. G. Heller.
1942. The chemical composition of Atlas and Dwarf Yellow Milo plants in relation to chinch bug resistance. Okla. Agri. Exp. Sta. Tech. Bul. T-12. 32 pp.

8. —————————— and Howard Mitchell.
1940. Determination of the nitrogen fractions in Atlas and Milo sorghum plants. *Plant Physiology* 15:749-753.

9. ——————————, John Sieglinger, and Frank Davies.
1948. Chemical composition of sorghum plants at various stages of growth, and relation of composition to chinch bug injury. Okla. Agri. Exp. Sta. Tech. Bul. T-30. 32 pp.

10. —————————— and Robert Wall.
1942. Electrical conductivities of sorghum juices in relation to chinch bug injury. *Proc. Okla. Acad. Sci.* 22:35-37.