THE LEAF-TISSUE FLUIDS OF EGYPTIAN COTTONS[1]

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INTRODUCTION

In 1921 a series of determinations of the physicochemical properties of the leaf-tissue fluids of Egyptian and Upland cottons and of their F_1 hybrid (*3*)[2] showed that, when grown under irrigation at Sacaton, in the Gila River Valley of southern Arizona, the leaf-tissue fluids of Pima Egyptian cotton are characterized by higher osmotic concentration, higher specific electrical conductivity, and higher hydrogen-ion concentration than those of Meade or Acala Upland cotton (*3*).

In subsequent studies it has been shown that the differentiation is also clearly marked in chloride (*4*) and in sulphate (*7*) content, and that the absorption of these two ions is differential (*5*).

The question will naturally arise, however, as to whether the sap properties found for Pima may be considered wholly typical of the Egyptian type in this regard. Kearney has shown (*8, 9, 10, 11*) that the Pima variety has a long history as an American-grown cotton. It seems quite possible that the differences between its tissue-fluid properties and those of the upland varieties with which it was compared may have arisen during this period in America.

The plausibility of this suggestion is emphasized by Balls' (*1*) conclusion that in Egypt the different strains of cotton differ in the salinity of their tissue fluids.

One purpose of the present investigation has been to determine whether varieties of Egyptian cotton other than Pima differ from Acala, Meade, and Lone Star Upland cotton in their tissue-fluid properties, or whether this difference is characteristic only of the American Egyptian variety, Pima.

MATERIALS AND METHODS

In 1922 plantings of seeds of five Egyptian varieties imported in that year from Egypt were made for comparison with Pima Egyptian and Meade upland cotton from American-grown seed. In 1924 the new

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[2] Reference is made by number (italic) to "Literature cited," p. 1033.

varieties were grown from seed which had been rendered more uniform by self-fertilization of plants selected as true to type. Three Upland varieties—Meade, Acala, and Lone Star—as well as Sea-Island cotton—were introduced in the comparison.

The exact cultural details need not be discussed here. The plantings were made in a manner similar to those adopted in earlier experiments. This involves the distribution of all of the varieties over the field in short subrows or subplots. Samples of mature leaf tissue were taken from all of the varieties of a subplot at the same time.

The leaf-tissue fluids were extracted and the physicochemical constants determined in a manner described in an earlier paper (*3*).

PRESENTATION AND ANALYSIS OF DATA

In the presentation of the results only the averages are given. Probable errors have been omitted for the following reasons: (*a*) The number of determinations on any one variety is small, and this renders the interpretation of the probable errors difficult under any conditions, particularly under the conditions of the present experiment; (*b*) the chief use of the probable errors of the means would have been in connection with the determination of the probable errors of the differences between any two varieties.

Such probable errors can be determined only if the correlation between the constants for the two varieties under comparison be known. The determination of such correlations on the basis of as large a number of varieties and as wide a spacing of varieties as are found in these experiments presents considerable difficulty.[3]

In the determination of the averages a somewhat different method has proved to be desirable for the two experiments.

While the plot utilized in the experiment of 1922 showed great irregularities of soil conditions, which were strikingly evident in the characteristics of the plants, a fairly uniform stand was obtained for the whole plot.

In the experiment made in 1924 the southern portion of the experimental plot carried a fairly uniform stand, but toward the northern end of the field many sections produced no plants at all. These differences in the salinity and texture of the soil, to which the diversities in stand are due, doubtless play an important part in determining the physicochemical properties of the plant-tissue fluids. It has seemed desirable, therefore, to prepare two sets of averages for the determinations made in 1924, the first comprising the southern end of the field, where materials could be obtained for all of the varieties, and the second including the northern end of the field, the stand there being not as good as that on the southern end. These two averages, with indications of the number of determinations on which these are based, are given as "partial" and "whole" series in the tables.

[3] It might seem that these difficulties should have been overcome by a different arrangement of the plantings. This, however, was impossible with the number of varieties involved in the present experiments without so reducing the number of plants per subplot that the determinations would have been based on tissues from one or but a very few individuals. In the organization of this experiment it seemed best, all things considered, to increase the size of the individual cultures, even though this resulted in the separation of the groups of plants to be compared.

The average values of osmotic concentration, as expressed in terms of freezing-point depression (Δ) in the various series of determinations made in the two years, are set forth in Table I. In the experiment of 1922, in both the first and the second series of determinations, all six of the Egyptian cottons show a greater freezing-point depression than the single variety (Meade) of Upland cotton.

TABLE I.—*Comparison of osmotic concentration in terms of freezing-point depression (Δ) in Egyptian, Sea-Island, and Upland cotton, as grown at Sacaton, Ariz., in 1922 and 1924 (E_1–E_5 are field key letters)*

Variety	Determinations made in 1922				Determinations made in 1924							
	First series, Aug. 10 to Aug. 13		Second series, Aug. 17 to Aug. 20		First partial series		Second partial series		First whole series		Second whole series	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Egyptian:												
Ashmuni, E_1	8	1.275	8	1.285	8	1.233	8	1.166	12	1.243	14	1.230
Zagora, E_2	8	1.298	8	1.291	8	1.238	8	1.134	12	1.240	14	1.215
Sakel, E_3	8	1.345	8	1.378	8	1.371	8	1.374	12	1.379	15	1.444
Pelion, E_4	8	1.338	8	1.335	8	1.309	8	1.274	12	1.349	13	1.314
Assili, E_5	8	1.274	8	1.396	8	1.311	8	1.314	12	1.368	15	1.430
Pima	8	1.380	8	1.417	8	1.267	8	1.300	11	1.261	13	1.353
Sea island					8	1.151	8	1.134	8	1.151	11	1.152
Upland:												
Acala					8	1.112	8	1.061	8	1.112	11	1.078
Meade	8	1.251	8	1.247	8	1.147	8	1.086	8	1.147	11	1.146
Lone Star					7	1.106	8	1.037	7	1.106	11	1.102

In the series of determinations carried out in 1924 the averages based on the partial series and the entire series of determinations must be considered separately. In both the first and second partial series the freezing-point depression is higher in each of the six Egyptian varieties than in any one of the three different Upland varieties (Acala, Meade, and Lone Star).

In only one instance is the freezing-point depression of an Egyptian variety as low as that of Sea-Island cotton.

In both the first and the second whole series the averages of each of the six Egyptian varieties are numerically higher than those for the Upland varieties or for the Sea-Island cotton.

While the Egyptian varieties differ to some extent among themselves, taken as a class they are all characterized by distinctly higher osmotic concentration than the Upland varieties with which they are compared. These results show that higher osmotic concentration is not a peculiarity of the American Egyptian variety, Pima, but that it is characteristic of Egyptian varieties in general.

The experiments are not sufficiently extensive to justify final conclusions concerning the relative values of osmotic concentration in the Egyptian varieties themselves. It appears, however, that Ashmuni and Zagora have lower osmotic concentrations than the other four types, although in the first series of determinations Assili has about the same average freezing-point depression as the two just mentioned.

Turning now to the values of specific electrical conductivity as expressed in reciprocal ohms, we have the constants set forth in Table II. In all 12 comparisons which may be based upon the series of determinations made in 1922, the value of κ for the Egyptian type is higher than that for the single variety of the Upland type. In 1924 the same result is found for the comparison between the six Egyptian and the three upland types. Thus there can be no question that while the Egyptian varieties differ to some extent among themselves, they are, so far as investigated, characterized by higher specific electrical conductivity than the Upland types which have been grown under similar conditions in the investigations which have hitherto been possible.

TABLE II.—*Comparison of specific electrical conductivity* (κ) *in Egyptian, Sea-Island, and Upland cotton, as grown at Sacaton, Ariz., in 1922 and 1924*

Variety	Determinations made in 1922				Determinations made in 1924							
	First series, Aug. 10 to Aug. 13		Second series, Aug. 17 to Aug. 20		First partial series		Second partial series		First whole series		Second whole series	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Egyptian:												
Ashmuni, E_1	8	0.03282	8	0.03212	8	0.02949	8	0.02871	12	0.02936	14	0.02960
Zagora, E_2	8	.03255	8	.03170	8	.02977	8	.02776	12	.02970	14	.02878
Sakel, E_3	8	.03364	8	.03319	8	.03085	8	.03170	12	.03139	15	.03226
Pelion, E_4	8	.03463	8	.03307	8	.03149	8	.03135	12	.03223	13	.03231
Assili, E_5	8	.03288	8	.03199	8	.03000	8	.03070	12	.03109	15	.03208
Pima	8	.03449	8	.03339	8	.02948	8	.02991	11	.02878	13	.03034
Sea island					8	.02647	8	.02750	8	.02647	11	.02782
Upland:												
Acala					7	.02601	8	.02445	7	.02601	11	.02562
Meade	8	.03163	8	.03066	8	.02734	8	.02539	8	.02734	11	.02619
Lone Star					8	.02511	8	.02431	8	.02511	11	.02417

In both the first and second series of determinations of 1924, as epitomized in the averages for both the partial and the entire series, specific electrical conductivity for the Sea-Island cotton is lower than that of any of the Egyptian varieties. It may be higher or lower than that of the associated Upland cultures.

We now consider the ratio of specific electrical conductivity to freezing-point depression, κ/Δ. The averages are given in Table III. For the first series of determinations the average ratio for the six different Egyptian varieties is identical with that for the Upland type in so far as can be determined by the examination of averages not provided with probable errors. This result is in accord with the findings of an earlier investigation (*3*) on Pima Egyptian and Meade and Acala Upland cotton, in which the conclusion was drawn that there is no certain differentiation of the two types with respect to the ratio κ/Δ.

We now have to consider the concentration of two anions, for which absorption has been shown to be differential (*5*).

The results of an earlier investigation (*4*) have shown conclusively that Pima Egyptian cotton differs from Meade, Acala, and Lone Star Upland cotton in the chloride content of its leaf-tissue fluids.

Apparently Egyptian cotton has a greater capacity for the accumulation of chlorides with the march of the season (*6*) than has Upland cotton.

TABLE III.—*Comparison of the ratio of specific electrical conductivity* (κ) *to freezing-point depression* (Δ) *in Egyptian, Sea-Island, and Upland cotton, as grown at Sacaton, Ariz., in 1922 and 1924*

Variety	Determinations made in 1922				Determinations made in 1924							
	First series, Aug. 10 to Aug. 13		Second series, Aug. 17 to Aug. 20		First partial series		Second partial series		First whole series		Second whole series	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Egyptian:												
Ashmuni	8	0.02578	8	0.02506	8	0.02397	8	0.02461	12	0.02366	14	0.02421
Zagora	8	.02520	8	.02470	8	.02401	8	.02447	12	.02394	14	.02389
Sakel	8	.02512	8	.02426	8	.02254	8	.02311	12	.02278	15	.02250
Pelion	8	.02596	8	.02490	8	.02406	8	.02461	12	.02392	13	.02460
Assili	8	.02596	8	.02486	8	.02291	8	.02336	12	.02278	15	.02253
Pima	8	.02510	8	.02375	8	.02329	8	.02301	11	.02282	13	.02254
Sea island					8	.02304	8	.02425	8	.02304	11	.02417
Upland:												
Acala					7	.02348	8	.02360	7	.02348	11	.02334
Meade	8	.02537	8	.02473	8	.02390	8	.02340	8	.02390	11	.02296
Lone Star					8	.02261	8	.02291	8	.02261	11	.02246

The question naturally arises as to whether the higher chloride content is peculiar to the Pima variety of Egyptian cotton, which has developed in the Southwest from a long series of ancestors which had been grown under the frequently saline conditions of this region, or whether it is a characteristic common to Egyptian cottons in general. The results for a series of analyses carried out by a method proposed by Lawrence and Harris (*12*) appear in Table IV.

TABLE IV.—*Comparison of the chloride content (in terms of grams of Cl per liter) in Egyptian, Sea-Island, and Upland cotton, as grown at Sacaton, Ariz., in 1922 and 1924*

Variety	Determinations made in 1922				Determinations made in 1924							
	First series Aug. 10 to Aug. 13		Second series, Aug. 17 to Aug. 20		First partial series		Second partial series		First whole series		Second whole series	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Egyptian:												
Ashmuni, E_1	7	6.51	8	7.04	7	3.54	8	3.98	11	3.48	14	3.95
Zagora, E_2	8	6.14	8	6.82	8	3.56	8	3.66	11	3.56	14	4.04
Sakel, E_3	7	6.07	8	6.50	8	3.50	8	3.82	11	3.60	13	3.94
Pelion, E_4	7	6.86	8	6.95	8	4.12	7	4.73	12	4.30	11	4.82
Assili, E_5	8	6.21	8	6.59	7	3.16	7	4.20	11	3.79	13	4.50
Pima	7	7.44	8	7.89	7	3.02	8	3.59	10	3.05	13	3.53
Sea island					7	2.21	7	2.09	7	2.21	10	2.12
Upland:												
Acala					7	2.35	8	2.79	7	2.35	10	2.65
Meade	8	4.61	8	4.61	8	1.88	8	2.32	8	1.88	11	2.33
Lone Star					7	1.45	7	1.56	7	1.45	11	1.58

The averages for the determinations made in 1922 [4] show that all six of the Egyptian varieties have a higher chloride content than the Meade Upland cotton grown as a control, and that in both the first and second series of determinations the chloride content of the Pima Egyptian plants is slightly higher than that of any other Egyptian variety.

Because of certain analytical difficulties, the determinations based on the plants grown in 1924 must be regarded as only approximate. They indicate clearly, however, that all of the Egyptian varieties have a higher chloride content than either Sea-Island or the three Upland varieties included in this experiment.

In another place the writers have shown (*7*) that the sulphate content of the leaf-tissue of Pima Egyptian cotton is lower than that of the Meade or Lone Star varieties of upland cotton. Determinations on the sulphate content of other Egyptian varieties, made by the method of Gortner and Hoffman (*2*), are available for the experiment of 1924 only.[5] The determinations must be regarded as more or less approximate. They show clearly, however, that the sulphate content of the Upland varieties is higher than that of any of the Egyptian varieties considered, and higher than that of Sea-Island cotton.

TABLE V.—*Comparison of the sulphate content (in terms of grams of SO_4 per liter) in Egyptian, Sea-Island, and Upland cotton, as grown at Sacaton, Ariz., in 1924*

Variety	Determinations made in 1924							
	First partial series		Second partial series		First whole series		Second whole series	
	N	Mean	N	Mean	N	Mean	N	Mean
Egyptian:								
Ashmuni, E_1	8	10.14	8	8.58	12	10.44	13	8.93
Zagora, E_2	8	9.92	6	10.14	12	10.02	12	10.26
Sakel, E_3	8	10.15	8	10.01	12	10.41	14	10.19
Pelion, E_4	8	9.91	7	9.33	12	10.09	11	9.28
Assili, E_5	8	10.44	7	9.64	12	10.35	10	9.81
Pima	8	10.34	8	9.32	10	10.29	13	9.70
Sea-island	8	9.95	7	10.08	8	9.95	10	10.42
Upland:								
Acala	7	11.61	8	11.08	8	11.61	11	12.00
Meade	8	11.89	8	12.04	8	11.89	11	12.80
Lone Star	8	13.00	7	13.38	7	13.00	10	13.73

SUMMARY

The purpose of the present study has been to determine whether Pima Egyptian cotton, a variety of American origin, is unique in that it is different from at least some of the Upland varieties in the physico-chemical properties of the leaf tissue fluids as shown in earlier investigations (*3*, *4*, *5*, *6*, *7*), or whether all of the varieties of the Egyptian type differ from those of the Upland type of cotton.

The constants here considered represent, in addition to Pima, five Egyptian varieties grown from seed imported from Egypt in 1922. These are Ashmuni, Zagora, Sakel, Pelion, and Assili.

[4] The determinations of the chloride content of the samples of this series were made by Dr. and Mrs. John V. Lawrence.

[5] The analytical work on this series has been done by Clara T. Hoffman.

The results show that while the Egyptian varieties apparently differ among themselves, all of the six varieties here considered have a higher osmotic concentration and specific electrical conductivity than the upland varieties (Acala, Meade, and Lone Star) with which they have been compared. The two types apparently do not differ in the ratio of specific electrical conductivity to freezing-point depression.

All of the Egyptian forms considered have a higher chloride content and a lower sulphate content than the upland types. It may be recalled in this connection that Balls (*1*) concluded that the salt content of leaf tissues is specific in the varieties of cotton grown in Egypt.

It seems probable that differences between the individual varieties of the Egyptian type and between the individual varieties of the upland type may be demonstrated, but this will require more extensive and more refined experimentation for final proof. Constants for one series of sea-island cotton are given, but since other investigations on this type are under way the results will not be discussed in detail here.

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