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CONTENTS

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GROWTH AND COMPOSITION OF DEGLET NOOR DATES IN RELATION TO WATER INJURY[1,2]

A. R. C. HAAS[3] AND DONALD E. BLISS[4]

INTRODUCTION

UNDER THE PRESENT ECONOMIC CONDITIONS the quality of fruit is of more importance than the quantity produced. One of the chief factors affecting the quality of dates is a physiological disease known as "water injury" which consists of two types: checking, which predisposes the fruit to blacknose (see p. 328); and tearing, which exposes the pulp to microorganisms that bring about fermentation and decay.

Studies were made on the growth and chemical composition of date fruits at various stages of development. Growth was measured quantitatively as to length, diameter, fresh weight, dry weight, and ash content. Determination of the inorganic constituents and the sugars, together with the discovery regarding the location of the meristematic tissue in the fruit, form a basis for the study of water injury. The analyses furnish some concept regarding the amounts of the various constituents in the fruit and the portion of these amounts wasted as a result of late thinning of the fruit bunches.

Experiments were conducted in the field and in the laboratory to study the factors influencing the cause and control of checking and tearing. These experiments involved the following factors and their relation to water injury and fruit quality: the measurement of water loss due to transpiration of the fruits, the effect of time and type of bagging, and the results of aeration. As a result of these studies, it has been possible

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to both increase and decrease the amount of water injury in dates and to suggest a principle which governs it. The present paper therefore deals with growth studies and chemical composition in relation to water injury in fruit of the Deglet Noor variety.

GROWTH STUDIES

Natural and Artificial Thinning.—One characteristic of the Deglet Noor variety of the date palm is that of setting more fruits than can be matured properly. Because of this it is necessary to thin the bunches artificially. The number of fruits to be produced on the bunches is materially reduced at the time of pollination by shortening the fruit strands. Usually

TABLE 1

THE LOSS OF FRUITS BY JUNE DROP FROM A BUNCH OF DATES AS A PERCENTAGE OF THE NUMBER OF ATTACHED FRUITS ON JUNE 10, 1932

Date	Number of attached fruits	Total fruit drop, per cent
June 10	1,198	0.0
July 1	1,108	7.5
July 22	1,070	10.7
August 12	1,070	10.7
September 1	1,066	11.0
September 19	1,057	11.8

this operation of thinning is repeated about May or June after the percentage of fruits pollinated has been determined; it includes both the shortening of the strands that appear to be too long and the removal of those in the center. This second thinning is usually delayed somewhat until the extent of natural thinning (commonly called June drop) becomes evident. At the present time many growers leave bunches consisting of 30 strands each bearing 30 fruits. Approximately 200 pounds of fruit are harvested from an average palm. The tendency of most growers is toward producing a smaller number of fruits per palm with the purpose of increasing the quality, although the exact limits are not known.

In 1932 a bunch was thinned so that on June 10 it contained 1,200 fruits. At various times throughout the season, an actual count of the number of attached fruits was made (table 1).

It will be seen that the major portion of the fruit drop occurred between June 10 and July 22, a period coincident with the most rapid growth of an average fruit (see fig. 2).

Various investigators have shown that growth measurements of certain fruits conform to an S-shaped type of curve. Gustafson[9] found this to be true of the fruit of dicotyledonous plants, such as scalloped summer squash, muskmelon, cucumber, and tomato.

Very little is known regarding the growth of the fruit of monocotyledonous plants. Crawford[4] has reported studies on mean length, breadth, and weight of the flesh and seeds of fresh fruit obtained from the Deglet Noor variety of date palm. The size and weight of the entire

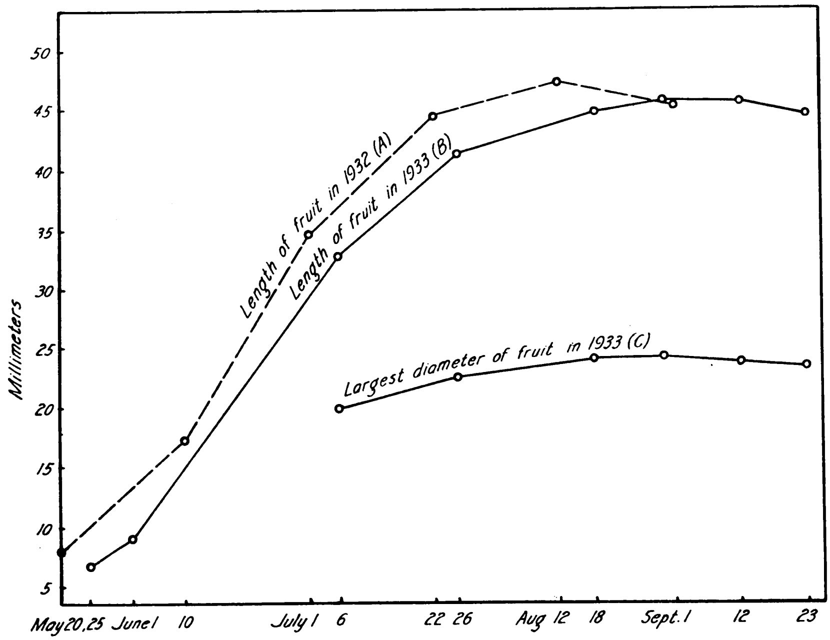

Fig. 1.—The growth of an average Deglet Noor date: Curve *A*, length of fruit in 1932; curve *B*, length of fruit in 1933; curve *C*, largest diameter of fruit in 1933.

date were greatest at approximately the time (August 23, 1932) when the red color of the khalal stage[5] was most vivid. A decrease in size and weight accompanied the later stages of ripening.

The writers measured Deglet Noor dates during the years 1932 and 1933 in a garden adjoining that in which Crawford made his measurements. Crawford obtained his data from detached fruits, a method which constituted a gradual thinning of the bunch, whereas the measurements of length and breadth reported in the present paper were made on certain fruits which remained attached throughout the season.

During 1932 the length of 10 fruits, and in 1933 both the length and largest diameter of approximately 30 fruits were measured at intervals

[5] Stages of maturity in date fruit: Khalal—the fruit has changed from green to red or yellow; rutab—from beginning of softening to completely soft; tamar—cured to a point where fruit will keep.

ranging from 1 to 5 weeks. These measurements were made by means of a Glogan's vernier caliper, accurate to $\frac{1}{10}$ millimeter. The curves shown in figure 1 represent the average length of fruit for the years 1932 and 1933.

Length and Diameter of Date Fruits, and Weight of Pulp and Seed.—The growth curves indicate that the season of 1932 was one to two weeks more advanced than that of 1933.

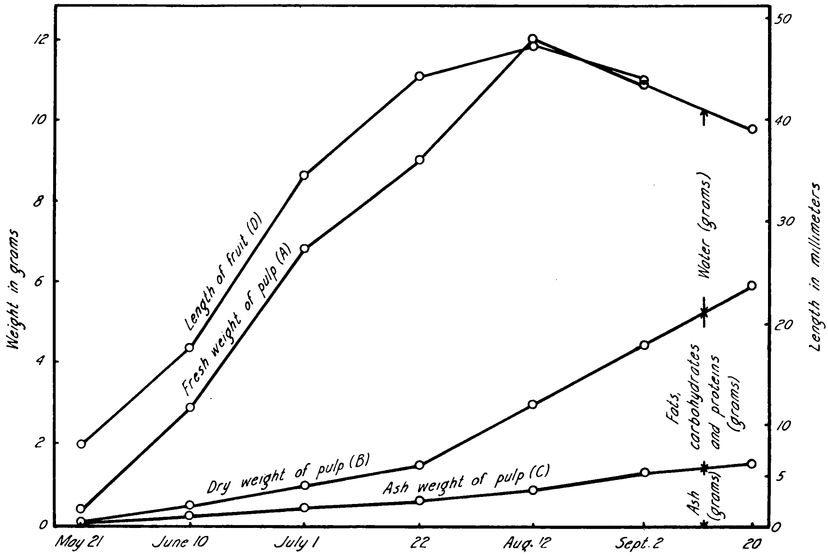

Fig. 2.—The growth of an average Deglet Noor date in 1932: Curve *A*, fresh weight of pulp; curve *B*, dry weight of pulp; curve *C*, ash weight of pulp; curve *D*, growth in length.

It is of interest to note in figure 1 the fairly uniform lag in the curve for 1933 as compared with that for 1932. This may indicate that fruit late in starting may become late-maturing fruit. The fruit reached its maximum length about August 12, 1932, and August 30, 1933. The maximum diameter in 1933 also occurred on August 30. Approximately 75 per cent of the growth occurred during June and July. The trend of the curves was the same for both years and confirms the results of Crawford.

Further quantitative measurements of the average growth, expressed as for one fruit, as indicated by the fresh and dry weights, and ash content of the pulp (whole fruit without calyx or seed) were obtained at intervals of three weeks between May 21 and September 20, 1932 on samples ranging from 300 to 640 fruits each.

The data for these samples are represented graphically in figure 2, which includes also a corresponding growth curve for length of fruit.

Two distinct types of curves are revealed: those for length and fresh weight, which after reaching a maximum on August 12, fall gradually thereafter as maturation progresses; and those for dry weight and ash content, which show a gradual but uninterrupted rise.

The slope of the curve for the ash content was nearly uniform throughout the entire season. The rate of influx of carbohydrates, fats, and proteins prior to July 22 was distinctly less than after that date, but the rate was very uniform in any one period. It may be significant that the time at which the increased rate of influx of carbohydrates occurs is nearly coincident with the time at which the maximum length is attained.

At any given time the length of vertical lines between curves *A* and *B* (fig. 2) represents quantitatively the average amount (grams) of water expressed as for one fruit; similarly, between curves *B* and *C*, is shown the content of organic material, mainly carbohydrates, fats, and proteins; and likewise between curve *C* and the horizontal axis, is found the weight of ash.

The average amounts of dry matter and ash per fruit (either whole or halved) calculated as percentages of the fresh weight of the pulp (without calyx or seed) are given in table 2. It is evident that the percentage of dry matter in the fruit decreases gradually until about July 1, after which it increases rapidly with increasing age of the fruit. Since the fresh weight is the sum of the dry weight plus the water content, the percentages of water in the fruit are largest about July 1, after which they progressively decrease. This turning point in the percentage of water in the fruit is coincident with the greatest rate of growth, as shown in figure 1. Such results lend further support to the belief that growth is largely a matter of hydration.[16]

The most significant change in the percentage composition of the fruit during its development is the substitution of organic materials for water after about July 22. The rate of increase in the average weight of ash in the pulp (without calyx or seed) per fruit is rather uniform throughout the season. When, however, the amount of ash is calculated as a percentage of the fresh weight, it is seen that the percentage on May 21 approximates that of September 2, and that about July 1 when the percentage of water is greatest, the percentage of ash is least.

A similar number of fruits from the sample collected on any one date was used for the purpose of comparing the amounts of water, dry matter, and ash in the stem and tip halves. Some error may have resulted from the unequal division of the fruit, but this would affect only the absolute amounts present and not the percentage composition. In table 2 the percentages of dry matter and ash in the fresh pulp (without calyx or

TABLE 2

Average Dry Weights and Ash per Fruit (Whole or Halved) as a Percentage of the Fresh Weight of Pulp (Without Calyx or Seed)

Date of collection (1932)	Number of fruits	Whole fruit					Stem half					Tip half				
		Fresh weight	Dry weight		Ash		Fresh weight	Dry weight		Ash		Fresh weight	Dry weight		Ash	
		grams per fruit	*grams per fruit*	*per cent*	*grams per fruit*	*per cent*	*grams per fruit*	*grams per fruit*	*per cent*	*grams per fruit*	*per cent*	*grams per fruit*	*grams per fruit*	*per cent*	*grams per fruit*	*per cent*
May 21	600	0.3650	0.0677	18.54	0.0046	1.25	......	......	......	......	......	......	......	......	......	......
June 10	320	2.8891	0.4969	17.19	0.0240	0.83	1.5055	0.2594	17.22	0.0141	0.94	1.3500	0.2438	18.06	0 0096	0.71
July 1	300	6.8300	0.9800	14.34	0.0469	0.69	3.3867	0.4700	13.92	0.0234	0.69	3.0733	0.4633	15.08	0.0198	0 64
July 22	244	9.0369	1.4549	16.15	0.0632	0.70	4.6107	0.7254	15.72	0.0329	0.71	4.3955	0.7213	16.44	0.0286	0.65
August 12	183	12.0218	2.9781	24.77	0.0872	0.73	6.1967	1.5628	25.22	0.0473	0.74	5.8880	1.5246	25.85	0.0409	0.70
September 2	222	10.9189	4.4685	40.92	0.1314	1.20	5 9324	2.1216	35.76	0.0661	1.11	5.4854	2.2027	40.12	0.0543	0.99
September 20	100	9.8100	5.9600	60.75	0.1488	1.52	5 0400*	2.8750	57 05	0.0801	1.59	4.9300*	2.8125	57.03	0.0703	1.43

* Sample consisted of 200 fruits.

seed) of stem and tip halves vary in a manner similar to those of the whole fruit. It is of interest, however, that the percentages of dry matter in the tip halves exceed those in the stem halves, but that the converse is true in regard to the percentages of ash in the fresh weight.

Seeds obtained from the fruit samples in 1932 showed the greatest fresh weight on August 12, although this was but slightly more than on July 22. The average fresh weight per seed calculated as a percentage

TABLE 3

RELATION OF THE AVERAGE FRESH WEIGHT OF ONE SEED TO THAT OF ONE WHOLE FRUIT AT VARIOUS TIMES THROUGHOUT THE SEASON

Time of weighing (1932)	Number of fruits weighed	Fresh weight of one seed	Fresh weight of one whole fruit (pulp and seed, without calyx)	Relation of fresh weight of one seed to that of one whole fruit (pulp and seed, without calyx)
		grams	*grams*	*per cent*
June 10	640	0.2291	3.1182	7.35
July 1	600	0.7608	7.5908	10.00
July 22	488	1.0518	10.0887	10.42
August 12	366	1.0642	13.0860	8.13
September 2	444	0.9764	11.8953	8.22
September 20	300	0.9250	10.7350	8.70

of the fresh weight of one whole fruit (pulp plus seed, without calyx) varied between 7.35 and 10.42, as shown in table 3.

Character of Growth.—For the purpose of studying the regions of growth, ink marks (fig . 5) were placed on young fruit on May 20, 1932. It was soon found that the region of most rapid growth was that enclosed by the calyx.

In 1933, similar experiments were conducted on fruit at different times throughout the season. A wide band of India ink of varying width, more or less covering the fruit, was painted along each of 10 to 40 fruits from the attachment of the calyx to the stylar tip. At three later times during the season, similar ink marks were made on fruits of other strands in the same bunch. As growth proceeded, the painted epidermis drew away from the calyx, leaving a zone of unpainted tissue. The width of the unpainted zone, parallel to the longitudinal axis, was measured at various times, and the average distances recorded are presented graphically in figure 3.

The measurements plotted in curve *A* (point taken at extreme tip) represent the total length of the fruit at the various stages of development. The curves *B, C, D,* and *E* represent the migration of points which were at the edge of the calyx on May 25, June 1, July 26, and August 18, respectively, and are similar in shape to homologous portions of curve *A*. The distance of curve *A* from curve *B* on May 25 represents the length of the fruit on that day. In comparing these two curves, it will be noted that as the season progresses they show a slight divergence. This is due to secondary growth or expansion of the fruit portion between the ink mark and the tip. The same comparison holds true for the

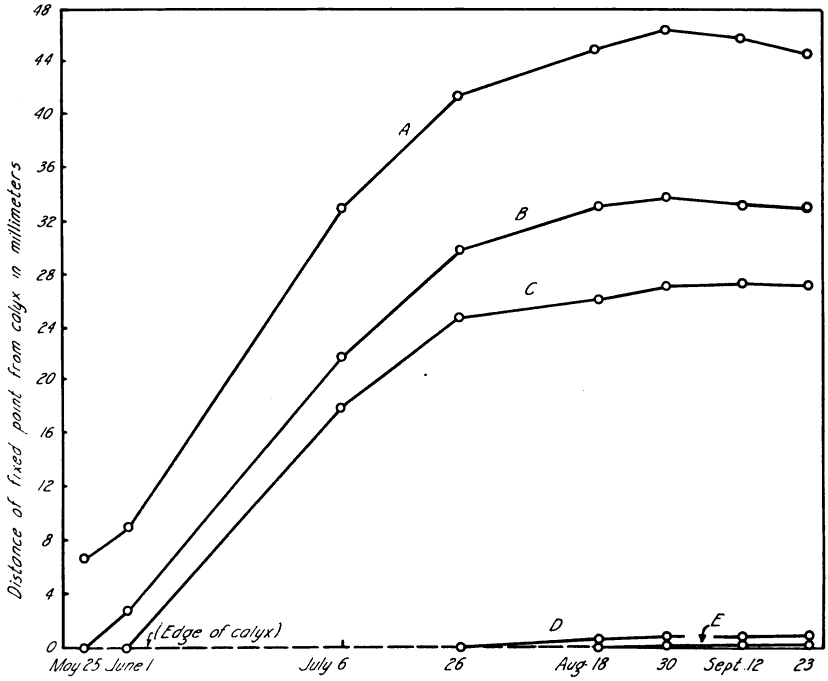

Fig. 3.—The migration from the calyx of fixed points marked on the surface of fruits at various times throughout the season of 1933: Curve *A*, a point at the tip; curves *B*, *C*, *D*, and *E*, points located at the edge of the calyx on May 25, June 1, July 26, and August 18, respectively.

other curves. The rapidly increasing distance between the calyx and the fixed point constitutes the entire longitudinal growth except for the slight secondary growth of that portion between the ink mark and the tip, as was mentioned above.

Figure 4 is a graphic representation of the average amount of migration on the surface of a fruit of two parallel marks, 2.5 mm long and 2.5 mm apart, one of which (*B*), when drawn on May 25, 1933, touched the edge of the calyx. The drawings represent the comparative sizes of an average fruit (calculated) at six stages of development. The migration of these two marks (*A* and *B*) is shown by curves *AA* and *BB*, which remain a relatively uniform distance apart throughout the season.

On May 25, line *B* touched the edge of the calyx (part of the thickness of the line being on the edge of the calyx and part on the pulp epidermis), but with the elongation of the fruit, the components of line *B* separated, one part migrating along the path of curve *BB* and the other remaining at the edge of the calyx. Since the distance from line *B* to the fruit tip remained relatively uniform throughout the season, it is apparent that the meristematic tissue is in that portion of the fruit that is enclosed by the calyx.

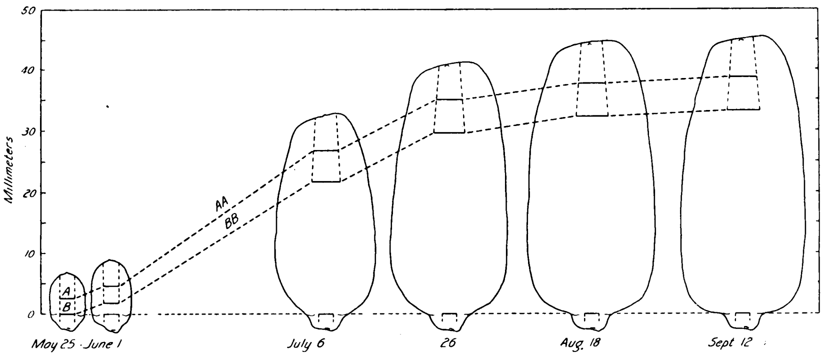

Fig. 4.—The migration on the surface of a fruit of two parallel marks, *A* and *B*, 2.5 mm long and 2.5 mm apart, one of which (*B*) when drawn on May 25, 1933, touched the edge of the calyx. The drawings represent the comparative sizes of an average fruit at six stages of development.

The lateral growth of the fruit is indicated by the length attained by the lines *A* and *B*, each of which on May 25 was 2.5 mm long. The parallel marks, 2.5 mm apart, were made by means of two ruling pens tied rigidly together. It was comparatively easy, therefore, to draw two lines 2.5 mm apart but relatively difficult to draw them 2.5 mm long. Nevertheless, this was readily accomplished on another lot of fruit by drawing two vertical lines (2.5 mm apart) from the edge of the calyx to the fruit tip. The migration apart of these vertical lines is indicated by the length of the lines homologous to *A* and *B* at the different stages of development of the fruit. As the season progressed, the lines homologous to *A* and *B* increased in length, but those included in curve *BB* increased the most; or, the two parallel vertical lines originally 2.5 mm apart, diverged more and more toward the calyx end as growth progressed.

It may be of interest to note in figure 5 the growth at the tip of the fruit. The marks were made on May 25, 1933, and the fruits were photographed August 19. The lines which originally were 2.5 mm apart had become 4.42 mm apart, which illustrates the relatively small increase in growth at the stylar as compared with that of the calyx end.

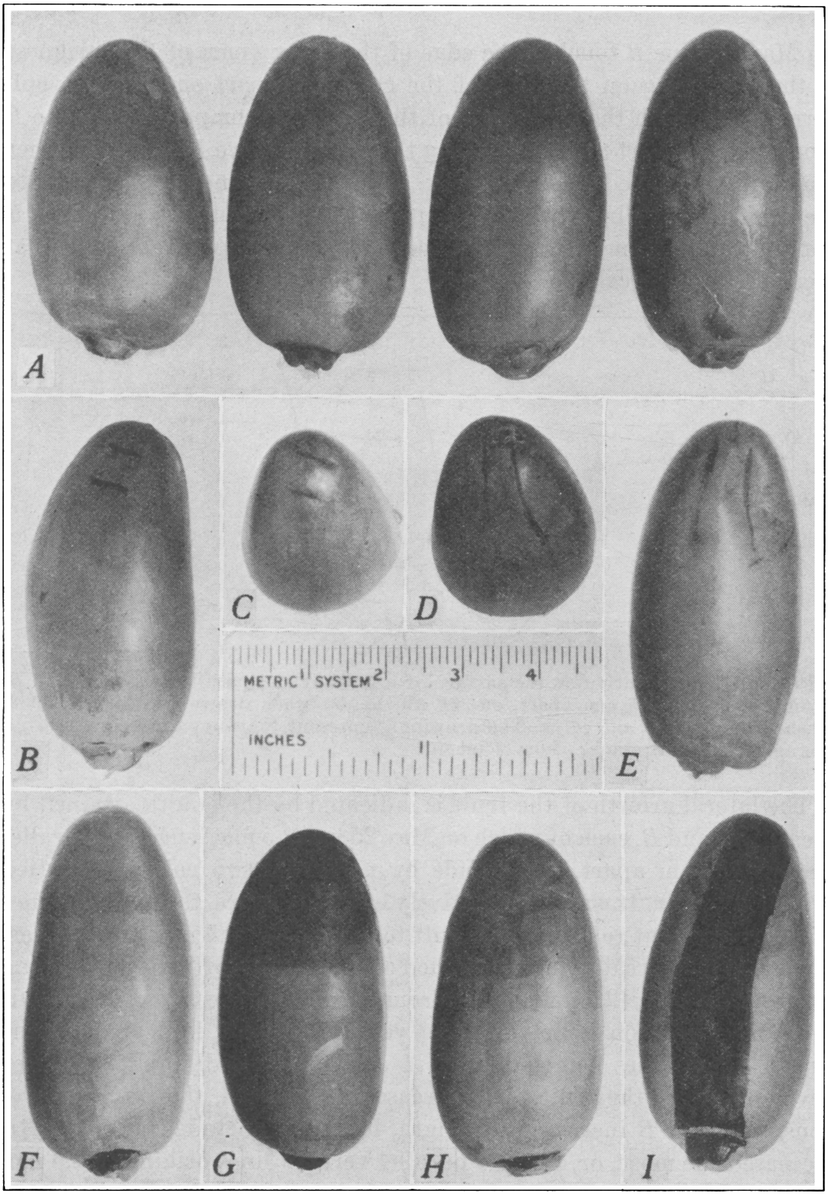

Fig. 5.—Migration of ink marks on dates: *A,* unmarked fruits measured as to length and diameter increments; *B,* migration of lines, one of which touched the calyx edge May 25; *C,* similar lines, one drawn across the stylar end; *D,* lines drawn from the edge of calyx to the stylar end, parallel to the longitudinal axis; *E,* fruit marked May 20, 1932, with lines 3.2 mm apart from calyx to tip, photographed September 26. *F* to *I,* Fruits painted from calyx to tip at different times: *F* (ink very faint) and *G,* May 25; *H,* June 1; and *I,* July 26. The distance from the calyx to the painted zone represents the amount of primary growth made after painting.

CHEMICAL COMPOSITION

During 1932, fruit samples consisting of several hundred fruits each were collected near Indio, California, at intervals of three weeks. The bunches of fruit used were selected for uniformity of age and were obtained from a small group of healthy palms seven years of age. The fruits were wrapped in waxed paper and were immediately brought to the laboratory at Riverside, while still attached to the strands. They were then removed from the strands and were wiped free of dust, after which the calyx was cut off. Only pollinated and uninjured fruits were used. The lot of fruit prepared on any given date except May 21 was divided into two equal parts and the seeds removed. One of these lots supplied the material for the analyses of the whole fruit without calyx or seed, while the fruits in the other lot were cut into stem and tip halves along the equator. The number of fruits, together with the average fresh, dry, and ash weights per fruit, have been given in table 2. The fresh and dry weights were obtained during the preparation of the samples for analysis. The fruits were then cut into pieces of small dimensions in order to facilitate rapid drying.

The samples were placed in very wide, flat, glass dishes and were dried rapidly in a large, well ventilated oven at about 80° C. When nearly dry the pieces were crushed in folds of diaper cloth placed between sheets of heavy wrapping paper and were further dried to constant weight. The samples were allowed to cool and were ground immediately in a tinned grinder. It should be stated that unless allowed to cool before being ground, the gumming of the warm samples made grinding almost impossible. This was also true when the cooling was too prolonged, in which case the absorbed moisture brought about stickiness. However, if the samples were thoroughly dry, and were ground immediately upon becoming cool, very little difficulty was encountered. The ground samples were thoroughly mixed and stored in tightly sealed Mason jars until analyzed. Prior to analysis the samples were further dried at 40° C for a few hours, and the weighed samples of dry matter were taken immediately thereafter. Caution was observed during this last drying to avoid the cohesion of the ground particles into a solid, hard mass, a result liable to follow prolonged heating at higher temperatures.

In reporting the chemical composition of date fruits, the results have been presented both as percentages and as grams per fruit. A better concept of the significance of the data is thus afforded. For the most part, the samples of dry matter used were about 40 grams each, but in

TABLE 4

FRESH AND DRY WEIGHTS AND THE CALCULATED NUMBER OF FRUITS IN THE ANALYZED ALIQUOTS OF THE FRUIT SAMPLES COLLECTED AT VARIOUS TIMES THROUGHOUT THE SEASON

Date of collection (1932)	Whole fruits			Stem halves			Tip halves		
	Fresh weight of pulp	Dry weight of pulp	Number of fruits in sample	Fresh weight of pulp	Dry weight of pulp	Number of halves in sample	Fresh weight of pulp	Dry weight of pulp	Number of halves in sample
	grams	*grams*		*grams*	*grams*		*grams*	*grams*	
May 21	130.7	24.2229	358.00	....	....	....	....	....	....
June 10	233.7	40.1932	80.89	233.3	40.1825	154.9	268.6	48.4892	198.9
July 1	280.8	40.2907	41.11	293.6	40.7418	86.7	268.0	40.4065	87.2
July 22	250.7	40.3612	27.70	255.8	40.2500	55.5	243.8	40.0090	55.5
August 12	163.2	40.4164	13.60	159.9	40.3366	25.8	156.6	40.5378	26.6
September 2	99.3	40.6401	9.10	111.9	40.0309	18.9	101.0	40.5550	18.4
September 20	66.4	40.3547	6.80	70.6	40.2762	14.0	70.6	40.2840	14.3

order to present the data in terms of grams per average fruit, it was necessary to determine the number of average fruits that corresponded with the aliquot used. The corresponding weight of fresh pulp was also determined in order to make the data available on the basis of fresh weight. These data are presented in table 4.

It is seen that on June 10, 40 grams of dry pulp were equivalent to the amount of dry pulp in 81 fruits, while on September 20, a similar sample corresponded to about 7 fruits.

Inorganic Constituents of Pulp and Loss of Elements Due to Late Thinning of Fruit Bunches.—The weighed samples of dry pulp were ashed in silica dishes at low heat, and after cooling the soluble ash was taken up with hot water and the insoluble residue was returned to the dishes and reignited until free from carbon. The white ash was then digested on a hot plate with 25 cc of 1:1 hydrochloric acid and was filtered free of insoluble material. Both filtrates were combined, and the silica was dehydrated several times; 1:1 hydrochloric acid was added, and after hot digestion the solution was filtered. The material insoluble in hydrochloric acid was treated with hydrofluoric acid and a drop of sulfuric acid in order to volatilize the silica. The residues left after the hydrofluoric acid treatment were digested with hot 1:1 hydrochloric acid and the filtrate was added to the acid filtrate left after the silica separation. The combined solutions were then made up to volume. This solution was used for the determination of potassium, sodium, calcium, magnesium, iron, and manganese, while other samples of dry matter were used for the determination of the other constituents.

Unless otherwise stated the inorganic constituents were determined in accordance with methods approved by the Association of Official Agricultural Chemists.[2] The total nitrogen was determined by the Kjeldahl method modified to include nitrates. Potassium was determined by the chloroplatinate method in which sodium was obtained by difference. Total chlorine was determined as silver chloride obtained by ignition of a dry sample previously saturated with 5 per cent sodium carbonate solution. Calcium was obtained by the titration of the oxalate with potassium permanganate; magnesium was weighed as the pyrophosphate; and total sulfur and phosphorus were determined by the magnesium nitrate method.

Manganese was determined by the method employed by Samuel and Piper;[19] iron, after the removal of the phosphate, by the method of Elvehjem and Hart;[5] and copper by the method described by Haas and Quayle.[12]

The iron and copper determinations were the last to be made, and because the supply of material was nearly exhausted, the samples avail-

TABLE 5

Inorganic Constituents in Pulp (No Seed or Calyx) Expressed as Milligrams Per Average Fruit (Calculated) and as a Percentage of Dry Matter

Date of collection (1932)	Part of fruit analyzed	Potassium in: One average fruit	Potassium in: Dry matter	Total nitrogen in: One average fruit	Total nitrogen in: Dry matter	Total chlorine in: One average fruit	Total chlorine in: Dry matter	Sodium in: One average fruit	Sodium in: Dry matter	Calcium in: One average fruit	Calcium in: Dry matter	Total phosphorus in: One average fruit	Total phosphorus in: Dry matter
		mg	*per cent*	*mg*	*per cent*	*mg*	*per cent*	*mg*	*per cent*	*mg*	*per cent*	*mg*	*per cent*
May 21	Whole	1.905	2.81	1 07	1.58	....	....	0.547	0.81	0.219	0 323	....	....
June 10	Whole	10.435	2.10	5.56	1.12	3 67	0.74	2.553	.51	0.558	.112	0.805	0.162
	Stem half	6.436	2.48	2.96	1.14	2.14	.83	1.602	.62	0.323	.125	0.851	.328
	Tip half	4.066	1.67	2.32	0.95	1.64	.67	1.020	.42	0.238	.098	0.558	.229
July 1	Whole	17.929	1.83	9.28	0.95	6.93	.71	....	......	1.511	.154	1.663	.170
	Stem half	10.197	2.17	7.53	0.99	5.48	.72	2.663	.56	0.879	.187	1.227	.162
	Tip half	7.956	1.72	4.17	0.90	3.01	.65	2.198	.47	0.576	.124	0.685	.148
July 22	Whole	23.276	1.60	11.26	0.77	9.29	.64	7.406	.51	2.305	.158	1.977	.136
	Stem half	12.843	1.77	5.25	0.72	4.70	.65	3.637	.50	1.453	.200	1.001	.138
	Tip half	11.616	1.61	5.62	0.78	4.52	.63	2.860	.40	0.773	.107	1.046	.145
Aug. 12	Whole	33.485	1.13	16.58	0.56	10.41	.35	7.521	.25	3.581	.120	2.958	.099
	Stem half	17.966	1.15	8.12	0.52	5.15	.33	4.527	.29	2.202	.141	1.510	.097
	Tip half	15.517	1.02	9.56	0.63	5.35	.35	4.267	.28	1.143	.075	1.668	.110
Sept. 2	Whole	52.956	1.19	20.70	0.46	21.96	.49	13.692	.31	4.835	.108	3.506	.079
	Stem half	28.264	1.33	9.36	0.44	10.53	.50	7.144	.34	2.810	.133	1.604	.076
	Tip half	21.509	0.98	10.21	0.46	8.83	.40	5.373	.24	1 793	.081	1.889	.086
Sept. 20	Whole	65.273	1.10	26.62	0.45	18.44	.31	17.061	.29	3.560	.060	4.548	.076
	Stem half	35.060	1.22	12.65	0.44	8.01	.28	9.062	.32	2.050	.071	2.214	.077
	Tip half	30.151	1.07	13.40	0.48	9.00	0.32	7.794	0.28	1.399	0.050	2.385	0.085

TABLE 5—(*Concluded*)

Date of collection (1932)	Part of fruit analyzed	Total sulfur in		Magnesium in		Iron in		Copper in		Manganese in	
		One average fruit	Dry matter	One average fruit	Dry matter	One average fruit	Dry matter	One average fruit	Dry matter	One average fruit	Dry matter
		mg	*per cent*	*mg*	*per cent*	*mg*	*per cent*	*mg*	*per cent*	*mg*	*per cent*
May 21	Whole	......	......	0.140	0.206	......	......	......	......	0.0011	0.00160
June 10	Whole	0.676	0.136	0.400	.081	......	......	......	......	.0051	.00102
	Stem half	......	......	0.405	.156	......	......	......	......	.0017	.00064
	Tip half	......	......	0.362	.148	......	......	......	......	.0028	.00110
July 1	Whole	1.520	.155	1.333	.136	0.017	0.0017	0.0081	0.00083	.0075	.00077
	Stem half	1.235	.163	0.586	.125	......	......	......	......	.0024	.00052
	Tip half	0.651	.140	0.697	.150	......	......	......	......	.0055	.00020
July 22	Whole	2.225	.153	1.733	.119	.019	.0013	.0134	.00092	.0090	.00062
	Stem half	1.195	.165	0.789	.109	......	......	.0059	.00082	.0027	.00038
	Tip half	0.864	.120	......	......	.012	.0017	.0047	.00066	.0069	.00095
Aug. 12	Whole	2.865	.096	2.230	.075	......	......	.0178	.00059	.0130	.00044
	Stem half	1.621	.104	1.093	.070	.013	.0008	.0099	.00063	.0049	.00031
	Tip half	1.267	.083	1.444	.094	.029	.0019	.0087	.00057	.0119	.00078
Sept. 2	Whole	4.122	.092	3.209	.072	.036	.0008	.0238	.00053	.0159	.00036
	Stem half	2.194	.103	1.339	.063	......	......	.0120	.00057	.0049	.00023
	Tip half	1.795	.081	1.760	.080	......	......	.0118	.00053	.0123	.00056
Sept. 20	Whole	4.622	.078	3.721	.063	.059	.0010	.0162	.00027	.0186	.00031
	Stem half	2.344	.082	1.535	.053	.041	.0014	.0099	.00035	.0042	.00015
	Tip half	2.090	0.074	2.224	0.079	0.024	0.0009	0.0161	0.00057	0.0111	0.00040

able were not of the desired size and in some cases the determinations were not attempted. However, the few determinations that were made may serve to give some indication of the amounts present.

The analytical results reported in table 5 are expressed as the average number of milligrams per fruit and as a percentage of dry matter. Analyses of whole fruit (without calyx or seed) were made on all 7 samples; with the exception of the sample collected on May 21, additional analyses were made on stem and tip halves. If we assume that the fruits were divided equally by weight into stem and tip halves, then the sum of the amounts of any one constituent in the two halves should equal that for one average whole fruit (calculated). To a considerable degree, such were the results obtained.

The amount of potassium in the pulp (no calyx or seed) of an average fruit is far in excess of any of the other inorganic constituents reported in table 5. An average fruit contained two or more times as much potassium as total nitrogen, and over ten times the amount of total phosphorus. The values obtained for sodium closely resemble those for chlorine. When plotted, the results for the inorganic constituents in the fruit pulp reported in table 5 arrange themselves in three groups as shown in figure 6, which indicates the seasonal influx of various constituents into the pulp of fruit. Group I consists of potassium, total nitrogen, total chlorine, and sodium; group II, calcium, magnesium, total sulfur, and phosphorus; and group III, iron, copper, and manganese. For the purpose of distinguishing the curves of elements present in relatively small amounts, the ordinates of groups II and III are magnified 10 and 500 times, respectively.

It is seen from a comparison of figures 2 and 6 that the fresh weight reached a maximum on August 12 and decreased thereafter. On the other hand, the amounts of inorganic constituents increased at a more or less constant rate throughout the season, and when graphically represented, their curves resemble those of dry weight and ash.

The percentages of the various constituents in the dry matter are given in table 5. The percentages of potassium, sodium, calcium, and total sulfur in the stem half exceed in every case those in the tip half. For total nitrogen and total phosphorus the percentages in the stem half exceed those in the tip only until July 1, after which the converse is true.

The amounts of potassium, sodium, calcium, magnesium, and manganese in fruit (no calyx or seed) of various ages are represented in figure 7 as percentages of ash. The two largest percentages of potassium in the ash occurred on June 10 and September 20, at which times the percentages were approximately equal. The lowest percentage was

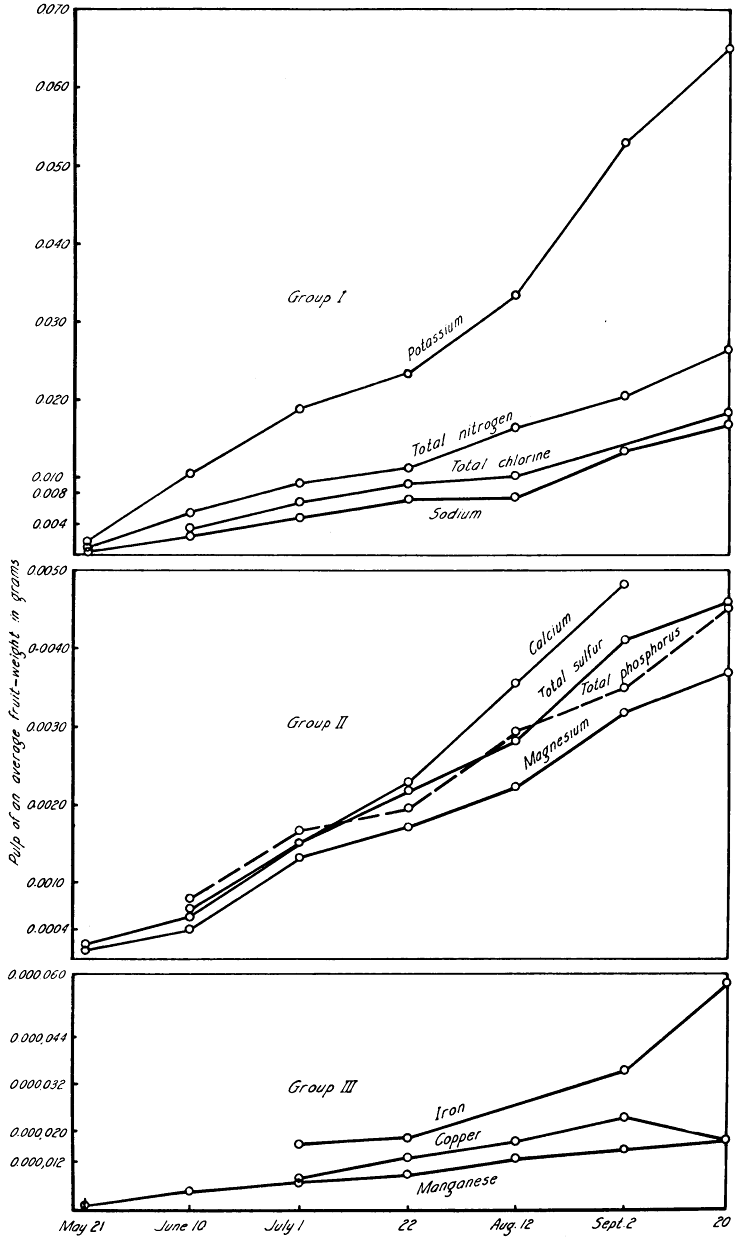

Fig. 6.—The seasonal influx of constituents into the pulp of an average fruit in 1932. The ordinates of groups II and III are magnified 10 and 500 times, respectively, and that of group I, as indicated by the spacing of the absolute amounts.

reached on July 22. The potassium in the ash showed a total seasonal variation of only 6.6 per cent, which is a relatively small variation considering the large percentage present at all times. The curves for the percentages of sodium, calcium, magnesium, and manganese in the ash show a remarkable uniformity, indicating that the relative amounts of ash constituents entering the fruit remain fairly constant throughout the season.

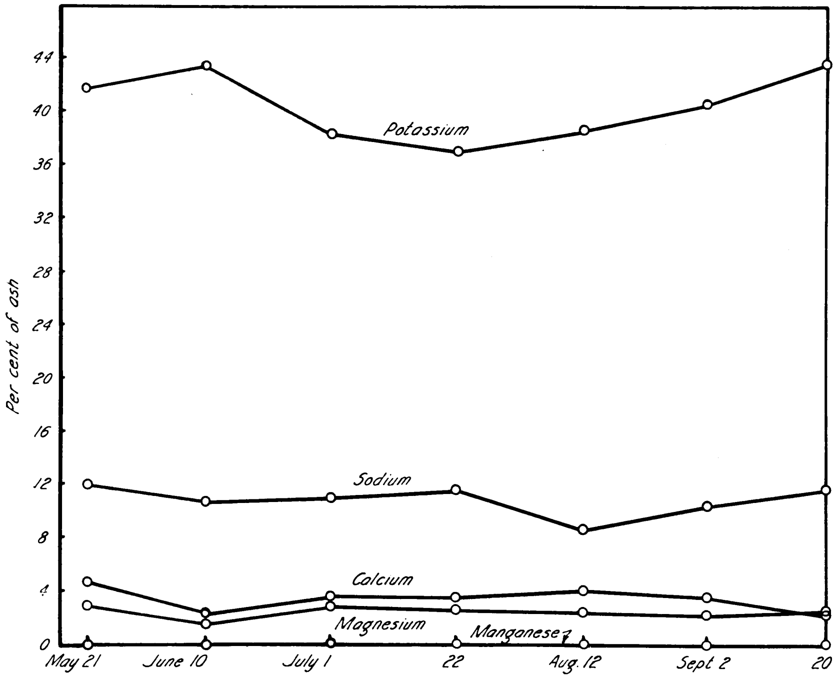

Fig. 7.—The amounts of potassium, sodium, calcium, magnesium, and manganese as percentages of ash in the pulp of an average fruit at different stages of development during the season of 1932.

The curves shown in figure 7 indicate that calcium and magnesium are present in the ash in approximately equal amounts, although the former is slightly greater in 6 of the 7 three-week samples. This relation is not the same as that found by Cleveland and Fellers[3] in the analysis of fruit of the Halawy and Sayer varieties, or by Lecoq[14] in fruit of the Deglet Noor variety. The former investigators found a slightly greater percentage of magnesium than calcium in the ash, while the latter found four times as much magnesium as calcium.

Cleveland and Fellers[3] noted the high percentage of potassium in the ash of fruit pulp of the Halawy and Sayer varieties grown in Iraq. Their results are shown in table 6 together with some obtained on samples of 6 varieties collected at different locations in Coachella Valley, California.

It is seen that the values for the Coachella Valley fruit are consistently higher than those obtained by Cleveland and Fellers.[3] This may indicate that in general the ash of the dates of the Coachella Valley is richer in potassium than the ash of dates from Iraq. This reflects possible differences in soil solution rather than differences in the fruit of the same variety.

TABLE 6

THE PERCENTAGE OF POTASSIUM IN THE ASH OF THE FRUIT PULP OF VARIOUS DATE PALM VARIETIES IN IRAQ AND IN CALIFORNIA

Variety	Results of Cleveland and Fellers* (Iraq)	Authors' results (California)
	per cent	*per cent*
Deglet Noor	....	43.12 43.26 43.47 43.38 43.79
Halawy	35.45	42.57 43.17
Sayer	33.87	....
Kustawy	....	43.37
Barhee	....	40.90
Khadrawy	....	43.68
Zahidi	....	42.09

* Cleveland, M. M., and C. R. Fellers. Mineral composition of dates. Indus. and Engin. Chem., Anal. Ed. 4:267-268. 1932.

It is of interest to compare in table 7 the influx of total nitrogen in dates with that in apples. Archbold[1] has concluded from the analysis of Bramley's Seedling apples collected at various ages, that "a large proportion of the nitrogen is stored during the first few weeks after setting. . ." Some of his data given in table 7 for apples are compared with those for Deglet Noor dates.

In the case of dates the average amount of total nitrogen per fruit increases at a nearly uniform rate throughout the season, but when calculated as percentages of the fresh weight, the nitrogen values decrease from a maximum on May 21 to a minimum on July 22, after which they increase to approximately the maximum value again on September 20. The period at which the lowest values were obtained coincides with the period of rapid increase in water and carbohydrates, while the final rise in the percentage values coincides with the dehydration of the fruit at maturity.

In the case of apples the amount of total nitrogen per fruit increases until September 1 and then declines, while the percentages in the fresh weight are greatest at the beginning of the season and least at the end. Although the percentage of nitrogen on June 22 is greatest, the corresponding weight in grams per fruit is least. The conclusion of Archbold,[1] therefore, that a large proportion of the nitrogen is stored in

TABLE 7

A Comparison of the Influx of Total Nitrogen in Dates with that in Apples

Deglet Noor date (No calyx or seed)			Bramley's Seedling apple (Results of Archbold*)		
Date (1932)	In one whole fruit	In fresh weight	Date (1924)	In one whole fruit	In fresh weight
	grams	*per cent*		*grams* (calculated)	*per cent*
May 21	0.00107	0.2934	.....	.....	.....
June 10	.00556	.1925	June 22	0.01218	0.1450
July 1	.00928	.1358	July 3	.02011	.0882
July 22	.01126	.1247	July 15	.02168	.0485
August 12	.01658	.1378	August 5	.04181	.0496
September 2	.02070	.1896	September 1	.06991	.0490
September 20	0.02662	0.2715	.....	.....	.....
.....	.....	.....	October 22	0.04380	0.0292

* Archbold, H. K. Chemical studies in the physiology of apples. IX. The chemical composition of mature and developing apples, and its relationship to environment and to the rate of chemical change in store. Ann. Bot. [London] **42**:541-566. 1928.

apples during the first few weeks after setting is correct only as regards the percentage in fresh weight and not in regard to the absolute amount.

The amounts of nitrogen, phosphorus, and potassium in the pulp of an average fruit (calculated) have been discussed. Table 8 gives the amounts (in pounds) of these elements in the seed-free pulp of the fruits of an average palm at different stages of development, assuming that only 9,000 fruits are present throughout the season (based on analyses for 1932). These amounts are in addition to those required by the other parts of the palm, such as leaves, trunk, and roots.

It is seen that the amount of potassium in an average crop agrees with that calculated by Haas and Klotz,[10] who obtained the value of 1.5 pounds per palm per year. The data given in table 8 show that the fruits become richer in nitrogen, phosphorus, and potassium with increasing maturity and that the longer the thinning is delayed, the more of these constituents are lost. Thus, for example, if 27,000 fruits are allowed to remain on a palm until June 10, and 18,000 of these remain until July 1 and 9,000 thereafter, the loss of potassium due to late thinning would amount to 0.5625 pound, that of nitrogen 0.2952 pound, and that of phosphorus 0.049 pound, if allowance is not made for the probable competition between fruits of the final crop and those thinned. On an acre basis (50 palms) these losses would amount to 28.125 pounds, 14.76 pounds, and 2.45 pounds, respectively. If such fruits were allowed to remain on the soil, the constituents, while not lost, would of necessity have to undergo the complex reactions in the soil before again becoming available. This example illustrates the desirability of early thinning when viewed solely from a nutritional standpoint.

TABLE 8

NITROGEN, PHOSPHORUS, AND POTASSIUM IN THE SEED-FREE PULP OF AN AVERAGE PALM (9,000 FRUITS) AT VARIOUS TIMES IN THE SEASON

Date (1932)	Nitrogen	Phosphorus	Potassium
	pounds	*pounds*	*pounds*
May 21	0.0213	....	0.0378
June 10	.1111	0.0160	0.2070
July 1	.1841	.0330	0.3555
July 22	.2233	.0394	0.4617
August 12	.3287	.0589	0.6650
September 2	.4105	.0696	1.0510
September 20	0.5280	0.0903	1.2940

Sugar Content of Pulp.—The reducing and nonreducing sugar content of the pulp (no calyx or seed) of an average fruit (calculated) at various times throughout the 1932 season was determined by means of the method of Shaffer and Hartmann,[20] and the results are given in figure 8. The amount of total sugars as dextrose is relatively low until after July 22, when it increases with remarkable rapidity. Prior to July 22 the total sugar content consisted largely of reducing sugars, after which the nonreducing sugars, including sucrose, predominated. On September 20, when some of the fruits in the sample were fully ripe, the nonreducing sugars including sucrose accounted for about 56 per cent of the total sugars. These results dealing with the dry matter of Deglet Noor dates agree with those obtained by Fattah and Cruess.[6] The possibility arises that some of the sucrose was inverted during the drying of the fruit samples. A comparison of the analyses of the average sugar content per fruit, whether determined on fresh or on dried material, showed no appreciable difference, however, which indicates that the amount of inversion during the drying process was not significant.

The curves for the average amounts of potassium and total nitrogen per fruit are also included in figure 8. With an ordinate 62.5 times that for sugar, the curve for potassium resembles that for total sugars as dextrose, especially after August 12. The position of these curves might be taken as indicating a relation between the average amounts of potassium and total sugars as dextrose per fruit at various times throughout the season. However, if the ordinate for the total nitrogen curve were further increased, it would be found that not only this curve, but also those for the other constituents would show a similarity to the curve for total sugars.

Some investigators have suggested that potassium is concerned with the synthesis of carbohydrates and proteins, while others have found no such relation (Janssen and Bartholomew[13]). Takahashi[21] has re-

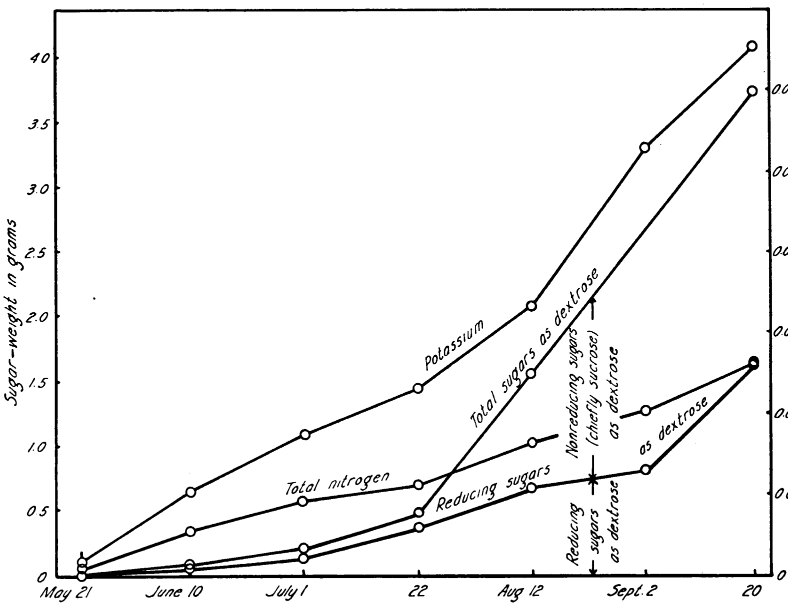

Fig. 8.—The influx of total and reducing sugars reported as dextrose in the pulp of an average fruit in 1932 compared with that of potassium and total nitrogen.

ported that potash fertilization increased the sugar content of citrus fruit. Haas and Klotz[11] found that the greatest concentration of potassium in citrus fruits usually was not found where the concentration of sugars was greatest. Although potassium fertilization of the soil increased the potassium content of the leaves and fruits of prune trees, Lilleland[15] found no increase in the sugar content of the fruits. If in the case of date pulp a relation existed between the synthesis of sugar and the influx of potassium, the same relation would also hold for constituents other than potassium.

The sugar content of whole fruit and of stem and tip halves (no calyx or seed) at various times during the season is given in table 9 where it is expressed as dextrose and is calculated as a percentage of dry matter. In every case the percentages of reducing sugars were higher in the

TABLE 9

REDUCING AND NONREDUCING SUGAR CONTENT OF DATE PULP (NO CALYX OR SEED) REPORTED AS DEXTROSE AND CALCULATED AS PERCENTAGE OF DRY MATTER

Date (1932)	Portion of fruit analyzed	Reducing sugars	Nonreducing sugars (total sugars including sucrose minus reducing sugars)
		per cent	*per cent*
May 21	Whole	3.98	1.89
June 10	Whole	13.59	5.80
	Stem half	12.75	6.69
	Tip half	21.58	3.22
July 1	Whole	14.85	8.43
	Stem half	17.10	9.86
	Tip half	23.10	2.15
July 22	Whole	26.38	7.15
	Stem half	23.10	13.14
	Tip half	26.25	3.87
August 12	Whole	22.86	29.60
	Stem half	13.95	45.23
	Tip half	24.78	28.16
September 2	Whole	18.18	....
	Stem half	18.30	43.50
	Tip half	23.25	39.15
September 20	Whole	27.55	35.13
	Stem half	28.00	31.40
	Tip half	30.53	15.35

TABLE 10

CALCIUM, MAGNESIUM, POTASSIUM, SODIUM, AND MANGANESE CONTENT OF DATE SEEDS

Date of collection (1932)	Calcium in			Magnesium in			Potassium in		
	One seed	Dry matter	Ash	One seed	Dry matter	Ash	One seed	Dry matter	Ash
	mg	*per cent*	*per cent*	*mg*	*per cent*	*per cent*	*mg*	*per cent*	*per cent*
June 10	0.058	0.095	3.05	0.126	0.206	6.85	0.720	1.17	38.27
September 2	0.183	0.028	2.99	0.525	0.082	8.58	1.870	0.29	30.54
September 28	0.188	0.027	2.82	0.588	0.083	8.79	2.052	0.29	30.69
September 28	0.195	0.028	2.85	0.584	0.083	8.54	2.190	0.31	32.10

Date of collection (1932)	Sodium in			Manganese in		
	One seed	Dry matter	Ash	One seed	Dry matter	Ash
	mg	*per cent*	*per cent*	*mg*	*per cent*	*per cent*
June 10	0.188	0.31	9.97	0.0007	0.00121	0.039
September 2	0.443	0.07	7.23	0.0080	0.00125	0.130
September 28	0.462	0.07	6.92	0.0060	0.00089	0.094
September 28	0.418	0.07	7.29	0.0062	0.00088	0.091

tip than in the stem halves, and conversely those for nonreducing sugars, including sucrose, were higher in the stem halves.

Chemical Analysis of Seed.—Calcium, magnesium, potassium, sodium, and manganese were determined in seeds from the regular samples of June 10 (640 seeds) and September 2 (158 seeds) obtained from the Boyer garden. Additional samples (80 and 125 seeds respectively) were collected in two other widely separated gardens (Russel Brothers' and Faries') on September 28. It is seen in table 10 that potassium is very much higher than any of the other ash constituents and that the average amount of potassium per seed increases the most rapidly of any of the five constituents determined. In an average seed the amounts of all of these constituents increase greatly between June 10 and September 2, although on a percentage basis some decreases are in evidence. It is of interest that the values for magnesium on every basis were greater than those for calcium. There is a close agreement of the analytical results for the seed obtained in September from three different gardens.

STUDIES ON THE NATURE OF WATER INJURY

During the years 1930 and 1931 Nixon[17] succeeded in inducing splitting of the epidermis of detached fruits by soaking them in water at various stages of maturity. When the fruits were of a pronounced green color there was very little effect, but in the khalal stage the epidermis was ruptured violently. Between these stages of maturity small transverse checks were produced which resembled those found in the initial stages of blacknose. It was thus possible to imitate various types of checking, according to the maturity of the fruit sample.

The Occurrence and Type of Disease.—In order to learn more of the nature of checking, pieces of the epidermal layer were examined microscopically in surface view and were found to contain ruptures of various sizes. These checks at first involved only the cuticle and outer wall of the epidermal cells and usually did not follow the lateral walls as lines of cleavage. Figure 9 shows a split which extends across only five cells at the most. In cross section these minor checks appear as shallow cell ruptures, but the larger splits in some cases involve tissues as much as 16 cells below the epidermis. These scars in all probability do not heal over, and therefore the underlying tissues are exposed to desiccation to a degree depending on the size of the rupture. Initially, in young fruit the smaller ruptures are not visible except through the microscope. Later, however, the cells which border the splits die, and this necrotic border makes the split more visible. These brown, dead borders may easily be mistaken for callus when in fact no callus has as yet been found. The position and direction of the checks in the epidermis may differ in certain varieties as has already been noted by Nixon.[18] In Deglet Noor dates the checks are mainly in a transverse direction and are located chiefly in the region near the tip. In both Iteema and Tafazwîn dates (fig. 10) the checks are also transverse but for the most part

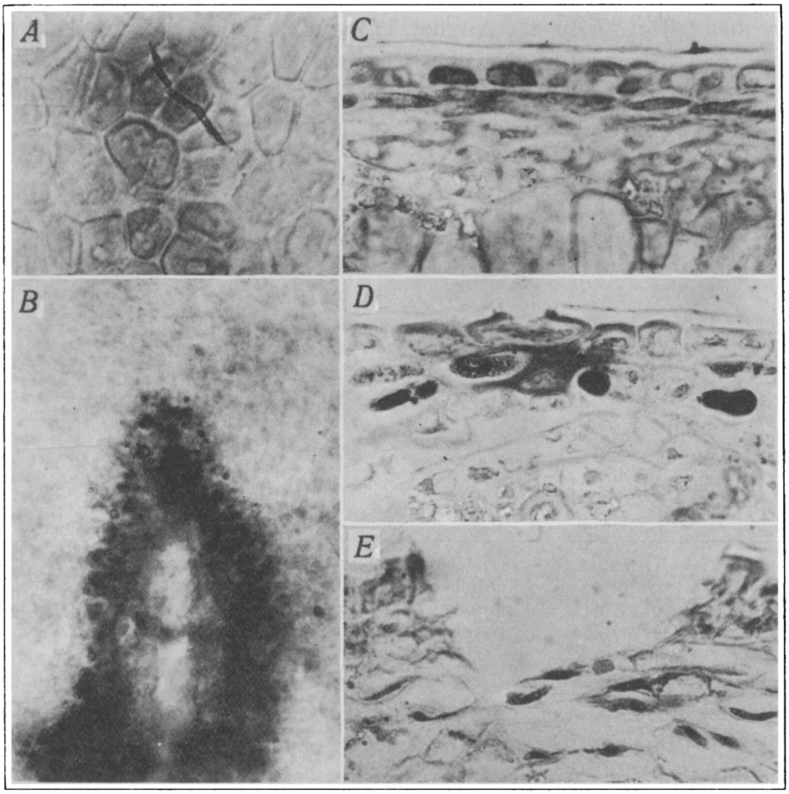

Fig. 9.—Microphotographs of checks in fruits: *A*, Surface view of initial stage in epidermal checking (× 420) ; *B*, surface view of end of check on ripe fruit, the rupture bordered by brown, necrotic tissue 5 to 10 cells in width which is sometimes wrongly described as callus (× 101). *C, D,* and *E*, Cross sections (× 420) of the epidermis and underlying tissue: *C*, healthy fruit; *D*, initial stage of checking; *E*, advanced stage of checking involving underlying tissue.

are situated near the equator, while in Hayany (fig. 10) the checks are largely longitudinal and in the tip half. The checks on the three latter-mentioned varieties appear analogous to those of Deglet Noor which are considered by Nixon[18] as being associated with and probably largely responsible for blacknose, a symptom thus far only associated with the Deglet Noor variety. It is obvious from figure 10 that the checking was not accompanied by a blackening and was not always confined to the tip or "nose" portion of the fruit. According to the definition of "blacknose" given by Nixon,[17] these fruits would not be affected by this malady; however, they all show symptoms of water injury.

Factors Influencing Checking.—During 1932, eight bunches of fruit were selected shortly after pollination in order to study the effect of time and type of bagging on the percentage of checked fruits. Two bunches were bagged on July 22, August 12, and September 1, respectively, while the two remaining bunches were not bagged. The bags used consisted of heavy, ripple kraft, brown paper tubes gathered and tied about

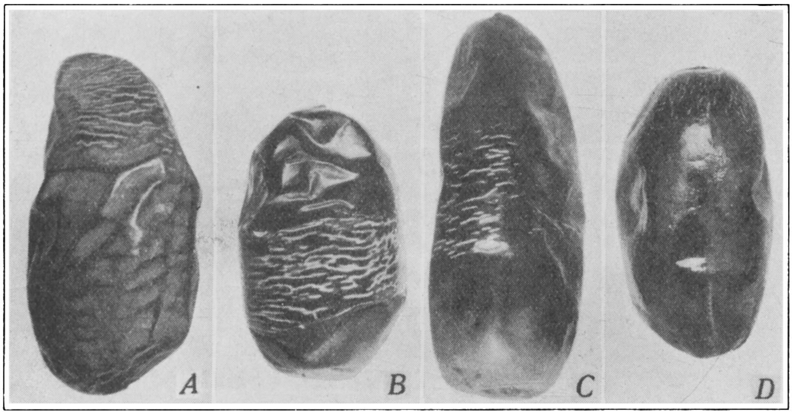

Fig. 10.—Fruits of four varieties variously affected with checking: *A*, Deglet Noor with transverse checks chiefly in the tip half; *B*, Iteema, transverse checks occupying a band near the equator; *C*, Tafazwîn, checks as in Iteema. *D*, Hayany, some longitudinal and transverse checks grouped near the tip.

the fruit stalk just above the separation of the strands to form an umbrella-like protection. The lower edge of the tube (skirt) was folded up under the umbrella in certain bunches in order to give protection from rain, but also to allow more light and air to enter than in other bunches.

Baskets measuring 30 inches square on the bottom were made by folding ⅓-inch mesh hardware cloth. One such basket was suspended beneath each experimental bunch for the purpose of catching any fruits which dropped. Seven pickings of ripe fruit were made between September 20 and November 15. The fruits were brought into the laboratory where the total number was counted and the percentages of fruits affected with transverse checks were determined. Only pollinated and uninjured fruits were considered. Apparently the first actual counts of the fruit affected with checks are those recorded in table 11. In this table the smallest percentages of affected fruits were found in bunches 22 and 23 that were not bagged. Surprisingly high percentages of fruits developed symptoms in bunches 16 and 17 which were bagged early in the season. The fruits in figure 11 (upper row) represent the condition of

Fig. 11.—Fruit of Deglet Noor variety. Upper row, fruit affected with transverse checking produced artificially by early bagging. Lower row, healthy, unbagged fruits from the same garden. Left, khalal stage; right, rutab stage.

TABLE 11

EFFECT OF TIME AND METHOD OF BAGGING (WITH PAPER TUBES) ON THE PERCENTAGE OF FRUITS AFFECTED WITH TRANSVERSE CHECKS* AT VARIOUS TIMES OF PICKING DURING 1932

Bunch No.	Time of bagging	Sept. 20		Sept. 27		Sept. 28		October 5		October 15		October 25		November 15		Total number picked	Checked fruits, per cent
		Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent		
	Skirts down																
16	July 22	43	70	108	87	58	85	120	81	272	90	195	89	106	80	902	86
18	August 12	150	53	275	51	0	....	140	64	203	46	93	56	19	52	880	53
20	September 1	185	49	263	48	0	....	154	45	163	23	57	18	3	33	825	41
	Skirts tucked up inside the umbrella																
17	July 22	293	74	235	74	0	....	141	66	88	67	28	43	0	....	785	71
19	August 12	420	68	245	51	0	....	65	46	28	32	4	50	0	....	762	59
21	September 1	326	69	280	53	0	....	153	61	182	40	43	21	4	50	988	56
	No skirts (control)																
22 and 23		572	51	500	48	61	21	292	49	354	30	345	19	9	20	2,133	40

* These data do not include fruits affected with the tearing of the epidermis associated with rain damage following the khalal stage.

those in bunch 16, while the fruits in the lower row from bunch 22 are healthy. The fruits that were severely checked were later affected with blacknose, the symptoms of which include shrivelling and darkening of the tip in addition to checking. The rate of maturity of the fruits (change from the green to the khalal stage) in bunch 16 was greatly retarded, as compared with fruits in the control bunches.

On July 22, when the first bags were put in place, no checking was observed on any of the fruits in the experimental bunches. Three weeks later on August 12 an estimate showed that about 80 per cent of the fruits in bunches 16 and 17 were affected with small transverse checks near the tip. Approximately 40 per cent of the fruits in bunches that were not bagged were affected also, but to a less severe degree, which indicated that the bagging was responsible not only for the increase, but also for the severity of the disease on individual fruits. Blacknose was pronounced when the bagging was done prior to August 12.

It is evident from the percentages of checked fruits given in table 11 that a method such as bagging, which is employed for the purpose of reducing water injury, may if applied too early, greatly increase the number of fruits checked.

The weather record taken within a few hundred feet of the experimental bunches shows that on July 10 a trace of rain fell on the bunches of fruit reported in table 11 and that on September 29 and 30, 0.07 and 0.15 inch fell, respectively. Because no rain fell during the period between July 22 and September 29, the occurrence of blacknose was evidently due to other factors. Reference to the weather record shows that the per cent of relative humidity at 8 A.M. was 66 on July 30 and that it exceeded 60 on 8 days during August. These humidities probably do not represent the maximums for these days or the relative humidity of the air within the bunch. Under these conditions a high relative humidity would be maintained within the bunch. From June 19 to August 26 the daily maximum temperatures ranged between 99° and 115° F.

As was previously mentioned, no checking was observed in the field on July 22, while on August 12 a large amount was evident. It is probable that the first stages developed at some time during the interim.

When the fruit samples for chemical analyses were collected from the Boyer garden at three-week intervals in 1932, additional fruits were obtained to determine their response to immersion in water at room temperature. Approximately 75 to 120 fruits were used in each experiment, and readings of the percentages of fruits showing transverse checks were made at the end of 48 hours. Figure 12 shows the narrow, transverse checks produced by immersion of fruits in water at room temperature on July 28 and at boiling temperature on September 13.

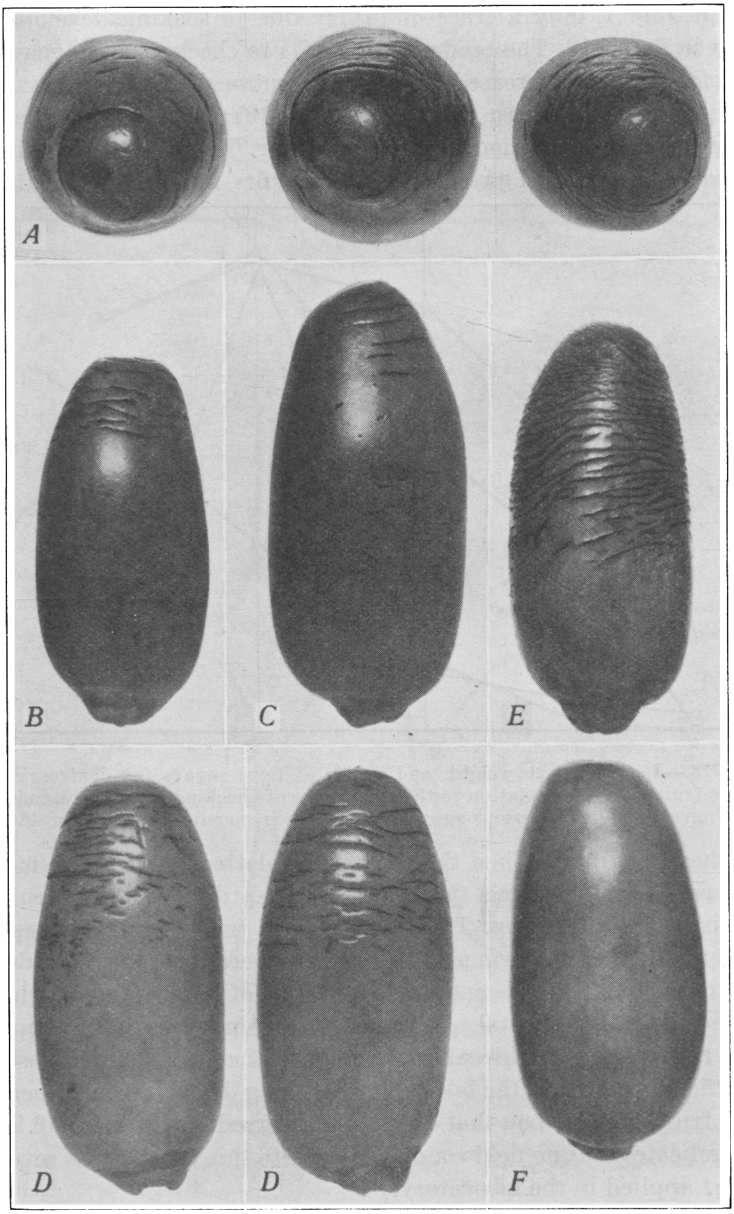

Fig. 12.—Transverse checks produced artificially on immature fruits: *A,* tips of three fruits soaked in water; *B,* fruit scratched with a needle to simulate checking; *C* and *D,* lateral view of fruits soaked in water; *E,* fruit severely checked by immersion in water that reached boiling temperature during a part of a 40-hour immersion; *F,* unchecked control fruit.

Until July 1, only a trace of injury due to soaking developed, as shown in figure 13. The tendency of fruits to check when immersed in water for 48 hours increased from 15 per cent on July 22 to a maximum of 97 per cent on August 12; that of bagged fruits (table 11) was also greater during this period than in any other. The sample of fruits immersed on September 1 gave unexpected results, in that only about 8 per

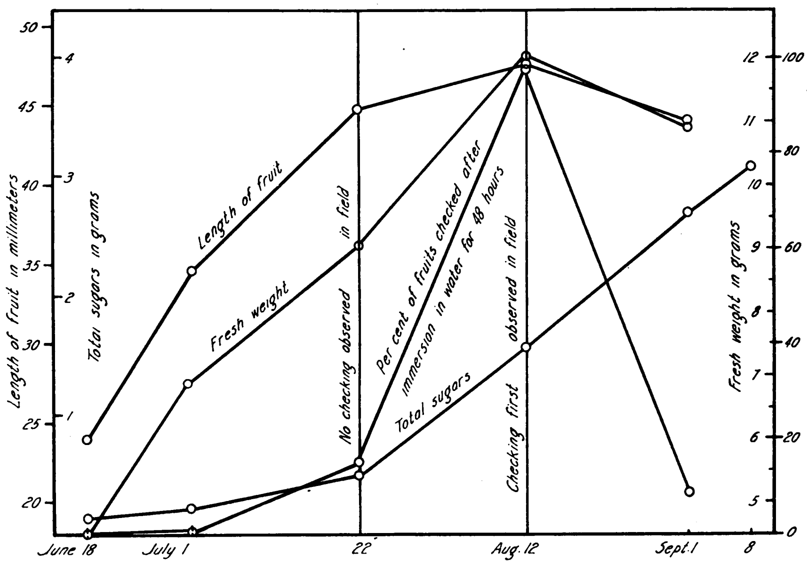

Fig. 13.—Length, fresh weight, and grams of total sugars (as dextrose) of an average fruit in 1932 in relation to the occurrence of checking in the field and to the percentages of fruits of various ages checked after immersion in water for 48 hours.

cent showed injury. When these data are plotted, their curve may be interpreted as indicating the relative susceptibility of the fruits of various ages to checking. The immersion in water for 48 hours subjected the fruit to uniform moisture and temperature conditions during the experimental periods and involved fruits of different ages, while in the field the environmental conditions at different stages of development of the fruit varied considerably. Up to July 22 no checks were observed in the field, whereas in the laboratory checking developed in 15 per cent of the fruits collected on that date and immersed in water for 48 hours. This indicates that no field condition prior to this time was as severe as the test applied in the laboratory.

It is of interest that in 1932 an average fruit reached its maximum length and fresh weight (fig. 13) and its maximum diameter (fig. 1) on about August 12. Following July 22 the average amount of total sugars as dextrose per fruit (fig. 13) increased very rapidly until maturity, which brought about a corresponding rise in the osmotic pressure.

Simultaneous with this initial rapid increase was the slowing up of the growth process. It has been previously shown (fig. 3) that the tip end is the oldest portion of the fruit and shows relatively minor enlargement

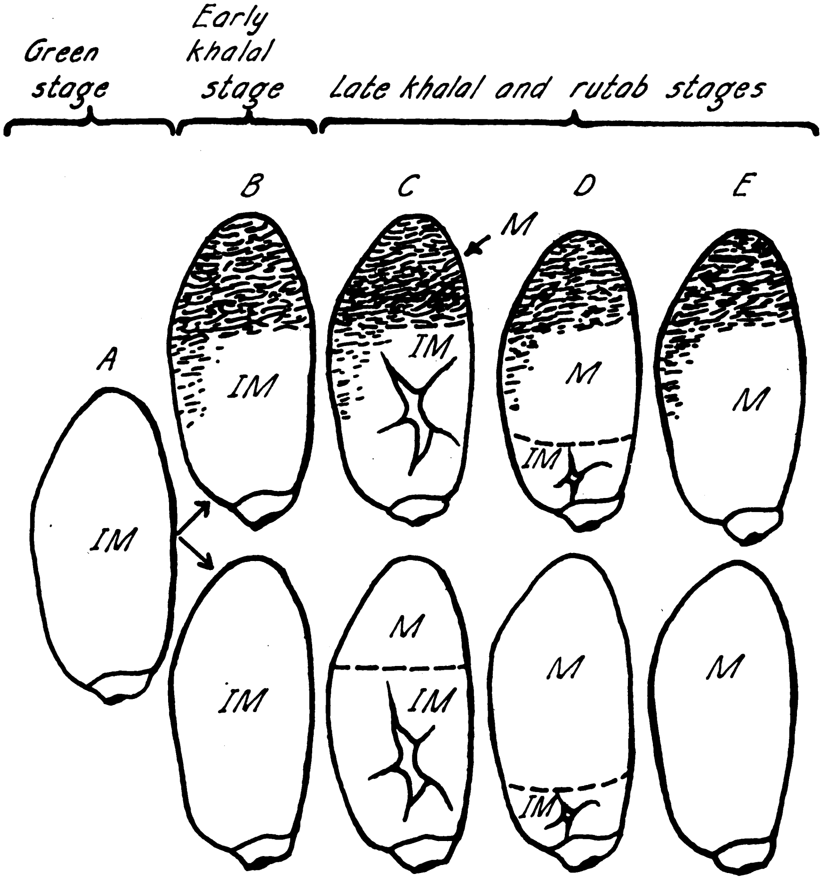

Fig. 14.—Types of injury produced by water on fruits in different stages of maturity. Fruits in the upper row show narrow, transverse checks as a result of rain or high humidity chiefly during the early khalal stage, while *C* and *D* show tears that result from rain on checked fruits in the late khalal and rutab stages. The lower row parallels the upper row except that no checks develop. Fruits *E* and *I* that are completely softened do not split as a result of rain. *M* denotes the mature or softened portion, and *IM*, the immature turgid portion.

after May 25. Thus, the epidermis near the tip is unable to accommodate sudden increases in volume such as occur when fruits are immersed in water.

As shown in figure 2, the decrease in the size of an average fruit is due to the loss of water which is accompanied by a loss of turgidity at the tip end. Older fruits when immersed in water showed less tendency to check at the tip end because they had not fully regained the turgid condition possessed on about August 1.

Factors, therefore, which tended to reduce checking following this critical period in 1932 (after August 12) were principally a decrease

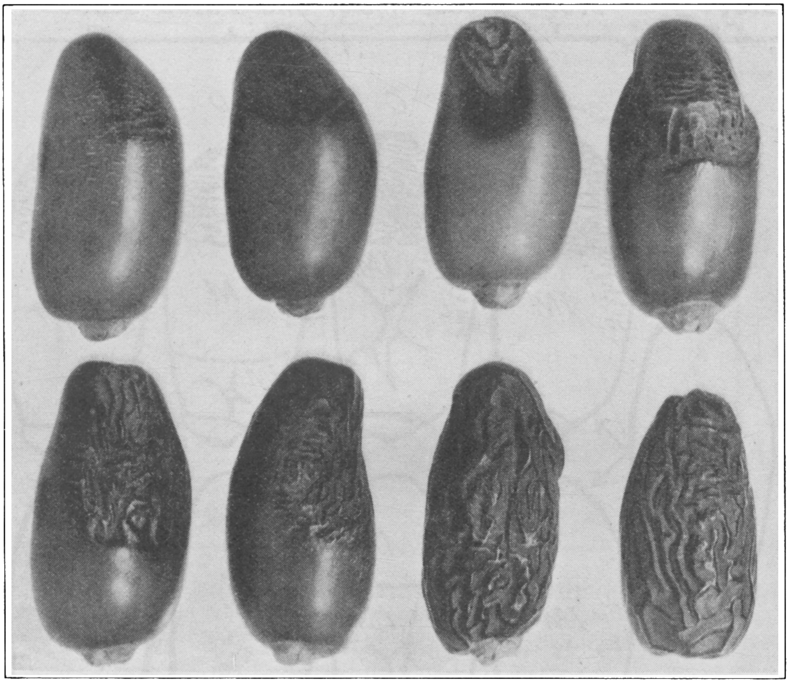

Fig. 15.—Eight fruits showing progressive stages in a peculiar type of blacknose in which the epidermis becomes blackened and adheres to the hardened flesh below. The affected areas on these fruits are located mostly on one side for varying distances from the tip and are associated with checking.

in the length, diameter, and fresh weight of an average fruit accompanied as the fruits mature by a progressive shrinkage of the pulp and a lessening of epidermal tension beginning at the tip end and proceeding toward the base. These factors evidently produced a condition in the fruit whereby sudden increases in volume at the tip were accommodated by the epidermis and no checking resulted.

Factors Influencing Tearing.—Figure 14 shows fruits in various stages of ripeness and the type of water injury found during these stages. It is seen that after the tip of the fruit is ripe ruptures (tears) are confined to the unripe turgid basal portion. Most frequently these tears are large and few in number and run more or less parallel to the longitudinal axis instead of being of the narrow, transverse type. Fawcett

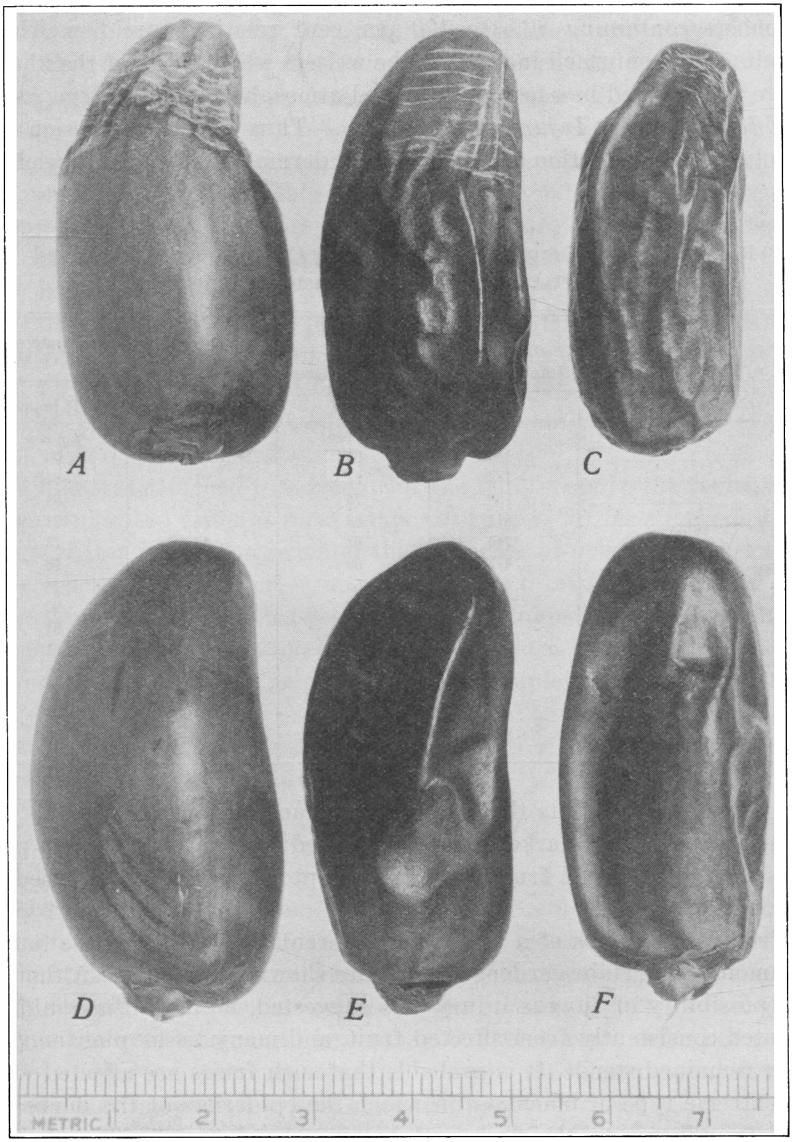

Fig. 16.—Blacknosed and normal fruits photographed October 13. *A* and *B*, Effect of scratching fruits with a needle on September 12: *A*, while fruit was still green (control, *D*), *B*, while fruit was in khalal stage (control, *E*); *C*, natural blacknose as found in the field (control, *F*). The blackening that developed in *A* and *B* following the scratching somewhat resembled that in *C*. The shrivelling was most pronounced in *A*.

and Klotz[7] produced tears artificially in fruits which were placed in chambers containing 80.5 to 100 per cent relative humidity. These results were confirmed in part by the writers when fruits of the khalal stage were placed in a nearly saturated atmosphere.

Effect of Water Injury on Blacknose.—Thus far the discussion has involved the production of transverse epidermal checks and the violent

TABLE 12

RELATION OF THE INCIDENCE OF TRANSVERSE CHECKS TO THAT OF TEARS SUBSEQUENTLY PRODUCED BY IMMERSION IN TAP WATER

Bunch No.	Number of fruits	Fruits with transverse checks	Fruits with tears after immersion in tap water	
			65 hours	118 hours
		per cent	*per cent*	*per cent*
1	580	95	58	73
2	782	91	91	94
3	758	75	81	91
4	811	63	35	71
5	740	62	59	73
6	478	59	90	96
7	1,449	59	67	78
8	521	50	79	90
9	917	48	80	91
10	210	43	50	61
11	913	40	78	88
12	684	12	87	95
13	674	12	52	99
14	847	7	92	95

epidermal tears. Fruits that show many transverse checks usually become shrivelled and darkened in the checked regions as the season progresses. Such affected fruits have the symptoms commonly ascribed to blacknose (fig. 11).

Progressive stages of a somewhat different type of blacknose found commonly in certain gardens in 1933 are shown in figure 15. Although the possibility of fungus injury was suggested, no organism could be isolated consistently from affected fruit, and many tissue plantings on agar remained sterile. It is probable that such fruits are affected with an extreme type of blacknose in which the epidermis of the darkened portion adheres to the flesh and becomes hard and blackened. The affected areas on these fruits are located largely on one side, extending varying distances toward the base, and are associated with checking. In ordinary cases of blacknose the checking and darkening, while frequently on one side, are usually near the tip.

In order to determine the effect of numerous transverse checks on such shrivelling and darkening of the tissue, field experiments were initiated on September 12 in which fruits of different stages of maturity were artificially scratched near the tip by means of needles. Figure 16 shows that shrivelling resulted from these artificial checks and that it was more severe in fruits of the late green than in those of the khalal stage. When observed one month later the fruits that were the most shrivelled also were somewhat darkened, while but little effect resulted from the treatment of fruit in the late khalal stage. The nature of the darkening is not understood, although one may conjecture that these numerous checks when produced relatively early in the development of the fruit may bring about abnormal oxidation.

On September 19, 1932, 14 bunches of fruit from the Boyer garden were brought to the laboratory. All of the attached fruits were counted, and a record was made of the percentage of the total fruits affected with checks. In table 12 the percentages which varied from 95 to 7 are arranged in descending order.

While still attached to segments of the fruit strands, the fruits were immersed in tap water at room temperature (64° F) for a period of 118 hours. After immersion in water the epidermis of many fruits began to tear. These ruptures were usually not of the transverse type, found in laboratory experiments between July 1 and August 12, but were violent in nature and confined to the turgid, immature, basal portion of the fruits (fig. 14). A few fruits had reached complete maturity and these failed to show epidermal tearing of any kind. These data show that little or no relation exists between the percentages of fruits showing transverse checks and those with tears.

EXPERIMENTS ON THE CONTROL OF WATER INJURY

Type of Bagging.—During the bagging experiments of 1932, no rain occurred between July 10 and September 29. On the latter date 0.07 inch and on September 30, 0.15 inch of rain fell. A record was made of the large number of torn fruits, in addition to counts made of fruits affected with transverse checks. In addition to the bunches reported in table 11, 2 bunches were bagged on September 20 with burlap instead of paper tubes. The data given in table 13 indicate the percentages of rain-damaged fruits picked on and after October 15.

It is evident that the use of bags reduced the amount of tearing of fruits following rain and that in most cases with skirts up the damage was less than with skirts down. This latter condition may indicate that the rain fell vertically and that following the rain the drying was increased by better aeration. The relatively high percentage of damaged fruits with the burlap bag (skirts down) may be attributed to the penetration of rain through the bag and to the retention of free water in contact with the bunch. Since rain is frequently driven in a lateral direction by the wind, bagging with skirts up would not always produce better results than with skirts down. However, when the bags are used with skirts down, it may be desirable to increase the aeration of the bunches following rain.

Role of Transpiration Water.—It has been shown that high relative humidity occurred during the period in which fruits were very susceptible to checking near the tip. These measurements were taken in free

TABLE 13

EFFECT OF TYPE OF BAGGING ON THE PERCENTAGES OF TORN FRUITS

Bunch No.	Time of bagging (1932)	Kind of bag	Type of bagging	Number of fruits picked (Oct. 15 to Nov. 15)	Torn fruits, per cent	
					In bunch	In group
16	July 22	Paper	Skirts down	573	8.0	7.2
18	August 12	Paper		315	4.1	
20	September 1	Paper		223	4.9	
24	September 20	Burlap		315	10.5	
17	July 22	Paper	Skirts up	116	1.7	3.3
19	August 12	Paper		32	3.1	
21	September 1	Paper		229	5.6	
25	September 20	Burlap		202	1.5	
22			Not bagged	282	23.4	29.1
23				426	32.8	

moving air. However, it is probable that within a fruit bunch the air was more humid because of the lack of circulation.

The amount of water transpired from date fruits has not been studied and hence any increase in humidity within a bunch as a consequence of water loss from the fruit has not been given sufficient consideration. Nixon[17] found drops of moisture in the interior of bunches early in the morning following a very humid day. It is not known what portion of such moisture was transpired by the fruit and then condensed.

In order to ascertain the amounts of water transpired by fruit at various temperatures and from different portions of the surface, laboratory studies were made on detached fruits. On September 19, 1933, fruit freshly collected at the Boyer garden was selected for uniformity and freedom from checking, blacknose, and other injuries. The calyx remained attached but was paraffined at the cut surface. The determination of dry matter was made on a representative sample of fruit and was found to be 39.5 per cent of the fresh weight. Twenty-five fruits were held in place on each glass plate by means of a loop of string. Four plates of fruits were used in each group (fig. 17): on one plate the fruit (A) was

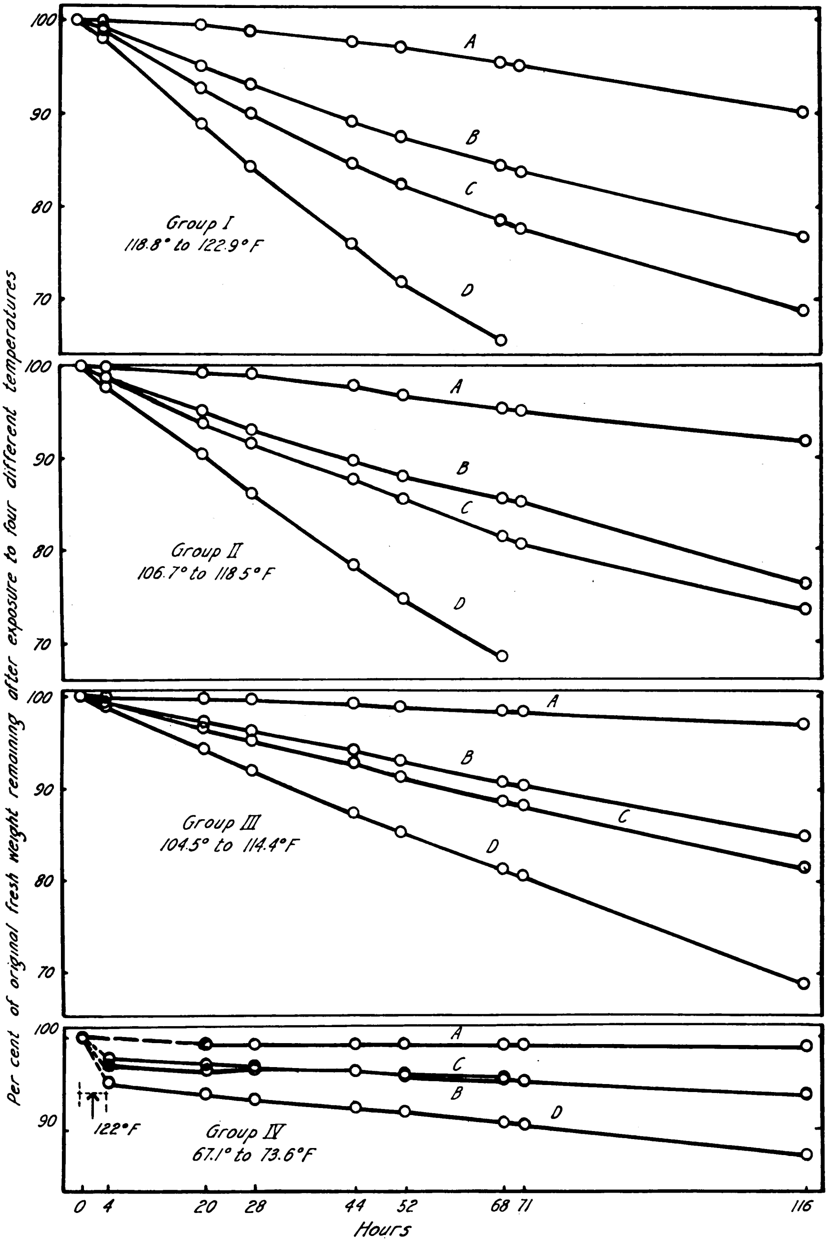

Fig. 17.—Per cent of the original fresh weight of fruit remaining after exposing 16 lots of 25 fruits each at four different temperatures. Each group consisted of four lots: Lot *A*, no portion of the fruit exposed to the air; lot *B*, tip halves exposed; lot *C*, stem halves exposed; lot *D*, whole fruit exposed.

entirely coated with paraffin of low melting point; on a second (*B*) the stem halves were covered; on a third (*C*) the tip halves were coated; and on a fourth (*D*) the flesh was not paraffined. The groups were exposed to various temperatures and at various intervals the plates were weighed to determine the amount of water lost. Group I was maintained

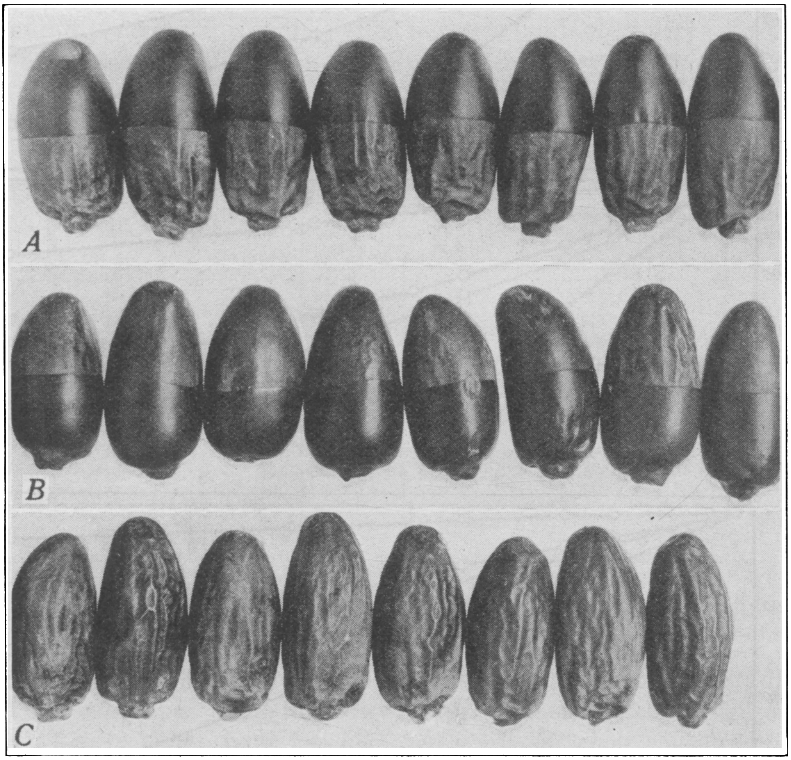

Fig. 18.—The effect of paraffin on the loss of water from detached fruit. Row *A*, tip halves paraffined; row *B*, stem halves paraffined; row *C*, control, no paraffin. The wrinkling due to water loss was largely confined to the unparaffined portion.

at 118.8° to 122.9° F; group II at 106.7° to 118.5° F; group III at 104.5° to 114.4° F; while group IV was at first kept in an oven for 4.5 hours at 122° F and then in the laboratory at 67.1° to 73.6° F. These temperatures more or less cover the fluctuations in daily temperatures in the field during July and August. The data presented graphically in figure 17 gives the percentage of original fresh weight of fruit remaining after exposure at different temperatures.

Figure 18 shows the fruit in which the halves were paraffined and indicates that the wrinkling was confined largely to the unparaffined half. It will be seen that the rate of water loss became greater with increases in temperature, although a considerable loss occurred at the lowest temperature. A slight loss of water occurred from fully paraffined fruits due to the small degree of permeability of the paraffin. In every case the water loss was small in comparison with that from unparaffined fruits. In groups I, II, and III (fig. 17), it is clearly shown that the stem half loses water more rapidly than the tip half. It is possible that this greater water loss of the stem halves may be due to the younger age of that portion of the fruits and to the smaller percentages of reducing sugars as dextrose in the dry matter (table 9).

When the total amount of water lost by a bunch (calculated as containing 900 whole fruits) is determined on the basis of the data given in figure 17, we find the following:

Degrees Fahr.	Water loss in liters, for 24 hours
About 122	3.09
118.8 to 122.9	1.79
106.7 to 118.5	1.52
104.5 to 114.4	0.90
67.1 to 73.6	0.25

These results apply to a sample obtained on September 13, 1933, at which time the fruits contained large amounts of sugars and small amounts of water (fig. 2). During the period between July 22 and August 12, the transverse checking was initiated and the sugar content of the fruits was relatively low; hence the water loss during this period would be considerably greater than the values determined as of September 13. Furthermore, in attached fruits where there is a continuous water supply, the water loss would probably be greater than that found in the detached fruits used in the present experiment. The water lost by transpiration, if held within the bunches would tend to increase the humidity. These data point to the danger of checking as a result of bagging without proper aeration.

Transverse checking has been produced much more easily in the laboratory by means of free water than by water vapor alone. Since free water has been observed by Nixon[17] as occurring in the interior of fruit bunches early in the morning following a humid day, it is reasonable to assume that the transverse checking in the field may be largely the result of contact with free water formed by the condensation of transpiration water as well as by that in the surrounding atmosphere.

Effect of Aeration on Checking.—Thus far fruits affected with dark-colored tips have been observed only in conjunction with transverse checking. Hence, if checking can be prevented, the blackening of the tips will also be controlled.

In preliminary experiments in the control of transverse checking, the attempt was made to reduce the transpiration water by coating the fruits with oil emulsions. It was observed in one garden that the use of heavy oil emulsions prevented normal maturation. In the present experiments, 2.5 cc of a stock emulsion made by adding mixtures A and B were used

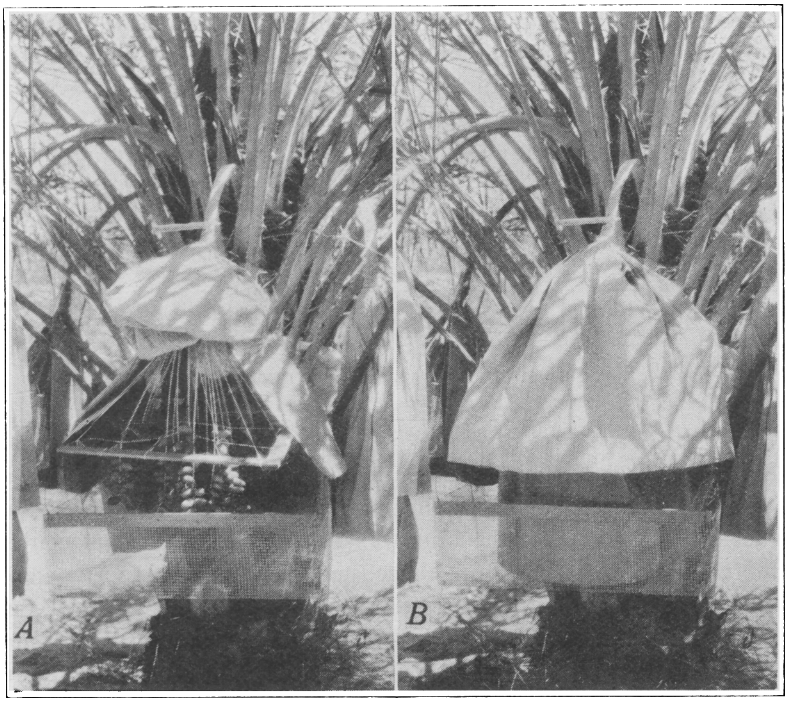

Fig. 19.—Fruit bunch showing the method of fruit-strand separation, the type of baskets used for collecting fruit, and the use of paper tubes as a means of protecting the bunches. To allow better circulation of air a short paper tube was pinned about the fruit and below the net, while above and protruding over this was another tube gathered about the fruit stalk. *A* shows the lower portion of the upper tube tucked under and the lower tube cut open and folded back to show the fruit and net. *B* shows the same bunch with the bags in position.

with 222.5 cc of water. Mixture A consisted of 90 cc of Avon 70 oil and 10 cc of oleic acid. Mixture B was made of 98 cc of water and 2 cc of triethanolamine. Although this emulsion appeared to wet the surface of young dates better than other ratios of the same ingredients tested, it was without marked effect in controlling checking and improving fruit quality. Although experiments in this direction may ultimately lead to a control, the writers abandoned such an approach because of the effect upon the rate of fruit maturity and because of the necessity of removing undesirable residues from the epidermis after harvesting.

TABLE 14

EFFECT OF EARLY-SEASON BAGGING (WITH PAPER TUBES) AND OF FRUIT STRAND SEPARATION UPON FRUIT QUALITY AND PERCENTAGE OF FRUITS AFFECTED WITH CHECKS AT VARIOUS TIMES OF PICKING DURING 1933

Bunch No.	Treatment in addition to bagging all bunches on September 12 against water injury (epidermal tearing)	Sept. 22		October 5		October 19		November 2		November 21		December 6		Total number of fruits picked	Total number of checked fruits, per cent	Total checked fruits in treatment, per cent	Average fruit quality (basis: 10=perfect)
		Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent	Number of fruits picked	Checked fruits, per cent				
	Early-season pollination																
17	Bagged July 26 to August 17	81	57	200	59	226	71	74	80	7	71	0	....	588	66	75	4.4
19		30	77	185	77	145	95	105	95	29	86	3	67	497	86		
1	None (control)	29	69	84	63	199	69	138	63	27	33	2	0	479	64	54	5.9
3		50	56	59	54	157	62	122	61	34	38	1	0	423	58		
5		36	54	115	47	143	44	48	29	166	37	0	....	508	42		
7		50	72	178	56	160	52	55	38	112	53	0	....	555	54		
9	Strands separated July 6	7	43	71	46	180	56	180	49	45	20	2	0	485	48	37	6.4
11		56	23	110	23	184	22	103	24	45	22	0	....	498	21		
13		38	63	151	38	154	37	95	33	14	14	0	....	452	38		
15		64	34	94	52	143	46	115	43	32	9	4	25	452	42		
	Mid-season pollination																
18	Bagged July 26 to August 17	4	50	123	89	87	92	223	95	105	82	4	75	546	90	86	4.8
20		6	50	50	84	166	87	256	81	58	67	3	33	539	82		
2	None (control)	10	60	73	74	132	80	192	76	47	49	0	....	454	74	65	5.6
4		8	25	21	33	90	58	180	59	34	38	13	77	346	53		
6		10	60	43	84	129	85	229	78	8	25	7	43	428	78		
8		7	29	28	39	148	62	204	47	5	20	5	0	397	51		
10	Strands separated July 6	9	44	68	49	93	62	213	58	182	28	13	46	578	48	30	7.5
12		5	80	38	45	94	49	214	40	135	15	24	17	510	35		
14		11	45	8	38	80	35	155	21	166	15	44	16	464	22		
16		1	100	26	54	158	32	118	25	144	14	16	6	463	25		

In 1933, 20 bunches of fruit were selected soon after pollination, 10 of which represented early pollination (first spathes to appear) and 10 medium seasonal pollination. The bunches were thinned on July 6 to 25 strands each bearing about 20 fruits, and large wire baskets were suspended beneath them. Three treatments were used on equal numbers of bunches in the two groups. In each group four bunches of fruit were not bagged and served as controls; 2 bunches were bagged for a period of three weeks following July 26, after which the bags were removed; and

TABLE 15

A Score Card for Rating Fruit Samples

	Character	Perfect score
Appearance	Size and uniformity	1.5
	Color	1.0
	Shape	0.5
Quality	Flavor	2.0
	Texture and shrivel	1.5
Freedom from blemish	Scars and broken skin	1.0
	Transverse checks and blacknose	1.0
	Fungus rot	1.0
	Insect and bird injury	0.5
Total		10.0

4 bunches were treated in a manner to increase aeration between the fruit strands as follows: On July 6, the fruit strands were separated by means of a 5-inch square mesh net made of cord as shown in figure 19*A*.

Table 14 presents the data for the effect of early-season bagging and fruit strand separation on the percentage of fruits affected with transverse checks. In the table the data for early and late-pollinated fruits are separated. The bunches in each of the two groups were bagged with paper tubes on September 12 as a precaution against water injury (epidermal tearing). Since no rain fell throughout the entire season, the chief advantage obtained was that of preventing injury from birds. Counts made on 4 fruit bunches protected by bagging in contrast with 4 not bagged, showed that the unbagged bunches contained 5.1 per cent bird-injured fruits.

In each of the two groups the effect of early-season bagging (July 26 to August 17) was that of greatly increasing the percentage of checked fruits. In both groups the percentages were increased 21 per cent over those of the control fruits. These results confirm those obtained in 1932 (table 11) and indicate that early-season bagging brought about increased percentages of fruits affected with checks.

In contrast to the increase produced by early-season bagging, the percentages of checked fruits in aerated bunches 9 to 16 inclusive, were decreased 17 per cent in the first group and 35 per cent in the second. This experiment suggests that differences in the degree of aeration affected the percentages of fruits checked. Since by the method of aeration the percentages of checked fruits were decreased below those of the "field run," this line of attack suggests a means of control. The type of apparatus used in separating the strands requires considerable improvement in order to make it of practical use, but it has served to illustrate the principles governing the cause and control of transverse checking and therefore of blacknose.

When the counts were made (table 14) of the total number of fruits picked and the percentages affected with checks, ratings were also made as to the relative quality of the fruit (basis: 10 equivalent to perfect). The score card shown in table 15 was used to determine the rating.

As seen in table 14, early bagging (July 26 to August 17) had a detrimental effect on the market quality of the fruit. On fruit bunches not bagged until September 12, the separation of the strands following July 6 was accompanied by marked improvement in quality over fruit of the "field run." Differences in quality as judged by this score card were caused largely by the occurrence and amount of checking and blacknose, which were accompanied in most cases by inferior color and shape, and by shrivel. The effects of early bagging when compared with those of aeration were so evident that even a person unfamiliar with the treatment could at a glance note the marked differences in the quality of the two lots. In view of the premium which high-quality fruit commands in the market, some modification of the aeration method may prove of considerable value. Certain steps in this direction are already in use, such as the removal of the center fruit strands, the insertion of wire rings between the strands, improved types of material and ventilation of tubes (bags), and the lifting of low-hanging bunches away from the soil.

In the light of the present experiments, the practice of bagging fruit bunches with paper tubes is highly desirable and serves as a protection against rain and birds. However, it is attended with the disadvantage that the covers tend to retain the transpiration water and hinder aeration, thus accentuating water injury. An ideal bag would be one which would protect the fruits from rain and birds and at the same time allow a maximum aeration. However, it should not be installed until necessary as a protection.

TYPES OF WATER INJURY AND THEIR ORIGIN

Nixon[18] distinguishes four types of rain damage: (1) severe splitting of the skin (tearing); (2) fruit spots due to fungi; (3) fermentation and souring of dates; and (4) small, lineal skin ruptures (checks). Although all of these types of injury are associated with periods of rain,

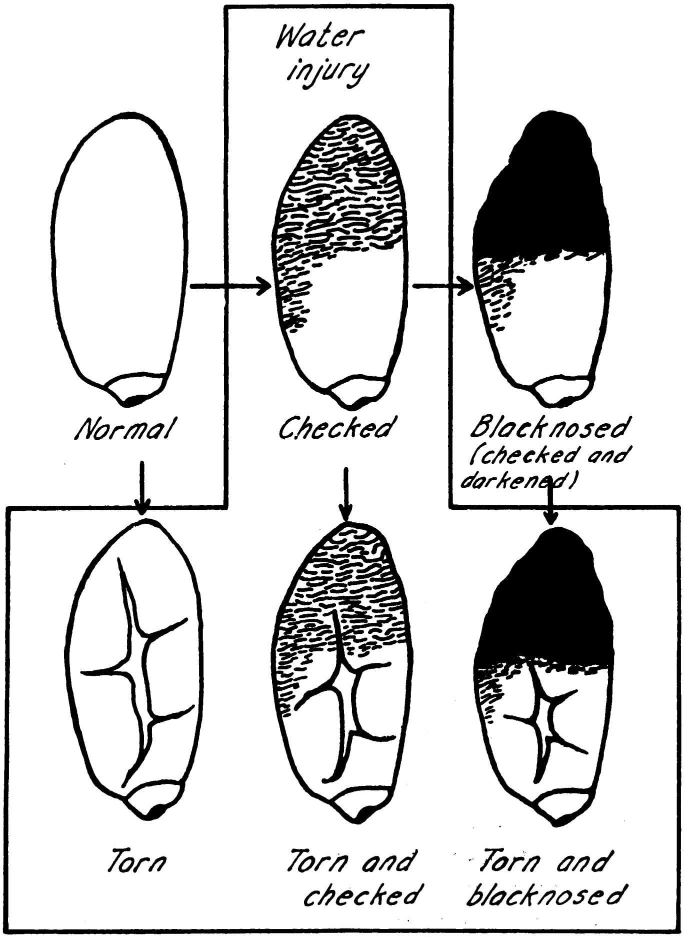

Fig. 20.—Types of water injury and their origin.

only checking and tearing are considered as being primarily due to water injury. Fawcett, Klotz, and Haas[8] found a minute cracking of the cuticle at the stylar end of Washington Navel oranges, which was attributed to the swelling of the underlying rind tissue due to the imbibition of water. Checking of young date fruits is not usually followed by spoilage due to microörganisms, but tears in more mature fruits are quickly followed by decay unless rapid drying occurs. Some doubt exists as to whether the fungus *Alternaria citri* Pierce, the principal cause of side spot, requires a wound in the epidermis for entrance. Free moisture no doubt is essential for the germination of the spores of this fungus.

As shown in figure 20, the writers distinguish only two types of water injury—checking, and tearing. The type of injury depends upon the stage of development in which the fruits are affected. Checking occurs largely in the late green and in the khalal stages, while tearing occurs largely in the late khalal or in the rutab stages. The more severely checked fruits often become dark colored and shrivelled, and in this condition they are said to be blacknosed. Since tearing is not dependent on checking or on blacknose, it may occur on the unripe basal portion of normal, checked, or blacknosed fruits in the late khalal or in the rutab stages. It has been shown that the shrivelling and darkening characteristic of blacknosed fruits may be brought about artificially by scratches made near the tip; consequently, it appears that these symptoms of blacknose following checking may be independent of water injury. For this reason blacknose has been excluded from the types of water injury shown in figure 20. There is no doubt that checking predisposes the fruit to blacknose and because checking is a type of water injury, blacknose may be said to be indirectly caused by water injury.

SUMMARY

In the experiments reported in this paper the chief problems studied have been the nature of growth and chemical composition of dates in relation to water injury.

The growth studies include counts of natural thinning and quantitative measurements of growth increments.

June drop was most pronounced between June 10 and July 22, 1932, which period coincided with the most rapid growth of an average fruit.

Curves for average length and fresh weight per fruit in 1932 were similar. They reached a maximum on August 12 and fell gradually thereafter as maturation progressed, while those for dry weight and ash content showed a gradual but uninterrupted rise throughout the season.

The increased rate of influx of carbohydrates occurred coincident with the maximum length of the fruit. The most significant change in the percentage composition of the fruit during its development was the substitution of organic materials for water after July 22.

The percentages of water in the fresh pulp increased from May 21 until July 1, after which they decreased until maturity. July 1 was coincident with the greatest growth rate. The percentages of dry matter in the tip halves at various stages of development exceeded those in the stem halves, but the converse was true in the percentages of ash in the fresh weight.

The average fresh weight per seed, calculated as a percentage of the fresh weight of one whole fruit (pulp plus seed, without calyx) varied from 7.35 to 10.42 for the period, June 10 to September 20.

The region of most rapid growth in fruit was that enclosed by the calyx.

The amounts of inorganic constituents in the pulp of an average fruit (without calyx or seed) fell naturally into three groups: group I consisted of potassium, total nitrogen, total chlorine, and sodium; group II, calcium, magnesium, total sulfur, and phosphorus; and group III, iron, copper, and manganese. The average amount of potassium per fruit was two or more times that of total nitrogen and over ten times that of phosphorus. The amounts of nitrogen, phosphorus, and potassium contained in an average crop for one palm (9,000 fruits) were determined seven times during the season. The results emphasize the desirability of thinning as early as possible. The percentages of potassium, sodium, calcium, magnesium, and manganese in the ash remained relatively uniform throughout the season. In most of the samples the average amount of calcium per fruit exceeded that of magnesium. The amounts of inorganic constituents increased at a more or less constant rate throughout the season, the curves for which resemble those for dry weight and ash; on the other hand, the curve for fresh weight of an average fruit reached a maximum on August 12 and decreased thereafter.

The influx of potassium, total nitrogen, and other constituents of the pulp bore the same relation to that of total sugars reported as dextrose. Higher percentages of reducing sugars were found more consistently in the tip than in the stem halves of fruit analyzed at different stages of development.

Potassium was found in the seed in much larger amounts than calcium, magnesium, sodium, or manganese. In an average seed the amounts of all of these constituents increased greatly between June 10 and September 2. A larger amount of magnesium than calcium was present.

These studies on growth and composition, together with experiments on checking and tearing, have suggested principles governing water injury.

Checks when examined microscopically consisted of epidermal ruptures which involved only the cuticle and outer wall at first and usually did not follow the lateral walls of the epidermal cells as lines of cleavage. The cells which bordered the larger checks died, thus making the checks more visible, but no callus tissue was found.

In 1932 a study was made of the effect of time and method of bagging with paper tubes on the percentage of fruits affected with checks. The smallest percentages of affected fruits were found in bunches which were not bagged, while the highest percentages were in those bagged on July 22. Symptoms of blacknose developed in severely checked fruits and mostly in bunches bagged prior to August 12. Since no rain fell between July 22 and September 29, the occurrence of blacknose was evidently due to other factors. These results assume greater significance when compared with results of laboratory studies in which the tendency of fruits to check when immersed in water for 48 hours increased from 15 per cent on July 22 to a maximum of 97 per cent on August 12, and then dropped to 8 per cent on September 1. From July 22 to August 12, 1932, the fruit passed through the most critical stage regarding checking. The time at which this critical period occurs may vary in different years. Factors affecting checking during this period are: (1) the length, diameter, and fresh weight of the fruit are at that time approaching a maximum; (2) the epidermis of the tip end shows relatively no growth after May 25 and is therefore unable to accommodate sudden increases in volume that result from the rapid intake of water; (3) after July 22 the average amount of total sugars as dextrose per fruit is small at first but increases rapidly and is paralleled by similar changes in osmotic pressure which are sufficient to cause mild rupturing or checking; (4) owing to the higher transpiration rate, the possibility for the condensation of moisture within the bunch is greater than later, when the content of sugar is very high and that of water low.

Factors which tended to reduce checking following this critical period in 1932 (after August 12) were principally a decrease in the average length, diameter, and fresh weight per fruit accompanied by a progressive shrinkage of the pulp and a lessening of epidermal tension beginning at the tip end and proceeding toward the base as the season advanced. These factors evidently produced a condition in the fruit whereby sudden increases in volume at the tip were accommodated by the epidermis and no checking resulted. During the late khalal and rutab stages, therefore, when the osmotic pressures are enormous, the fruits are not ordinarily affected with checking as a result of water injury but show violent ruptures (tears) in the unripe, turgid, basal portion where the epidermis is unable to accommodate further increases in volume.

Symptoms similar to blacknose were produced by scratching fruits in the late green and in the khalal stages. These symptoms developed in the absence of rain.

After 118 hours' immersion in water in the laboratory, little or no relation was found between the percentages of attached fruits showing checks and those with tears that were produced by the immersion.

In 1932 the bagging of fruit bunches with paper tubes reduced the amount of tearing following rain, and the percentage of torn fruits was further reduced by raising the skirts to allow more aeration. A relatively high percentage of damaged fruits was found in a bunch protected with burlap (skirts down). This may be due to the penetration of rain through the bag and to the retention of free water in contact with the bunch.

A laboratory study of fruits collected September 13, 1933, showed that the rate of water loss from detached fruits was greater with increases in temperature and was considerable even at the lowest temperature (about 72° F). More water escaped from the stem than from the tip half. Calculated on the basis of 900 fruits, an average bunch would lose in a 24-hour period from about 0.25 liters of water at approximately 70° F to about 3.09 liters at approximately 122° F. These amounts of transpiration water would, if held within the bunch, probably not only increase the humidity greatly, but also be a source of condensation moisture.

The aeration of fruit bunches by means of the separation of strands reduced the percentage of checked fruits, whereas early seasonal bagging without aeration greatly increased this percentage. These results suggest a means of control for water injury, and hence of blacknose.

From the studies reported in this paper, two distinct types of water injury were found: checking, which occurs largely in the late green and in the khalal stages; and tearing, which develops largely in the late khalal or rutab stages. Tearing is not dependent on either checking or blacknose and consequently may occur on the unripe, basal portion of normal, checked, or blacknosed fruits in the late khalal or rutab stages. Since the blackening and shrivelling characteristics of blacknosed fruits may be produced by scratching, it appears that these symptoms following checking may be independent of water injury.

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