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Maturity Studies of Marsh Seedless Grapefruit in the Lower Rio Grande Valley

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A good quality grapefruit of full maturity is characterized by a relatively thin rind, regular segments, a large volume of juice, tender flesh, absence of bitterness, and a blending of solids to acids to give a tart to sweet taste.

The percentage of rind was constant in the grapefruit during each of the two seasons investigated. The percentage of rag decreased, and the percentage of juice increased as the seasons advanced.. As the rag decreased, the juice increased. The total soluble solids, as degrees Brix, was approximately constant for all plats. Citric acid decreased, and the ratio of solids to acid increased as the season advanced.

In a study of the seasonal changes in fruit from various locations, fruit from widely separated orchards on different soil types and under different soil management matured at approximately the same time. Other factors may possibly exert more influence on maturity of grapefruit than soil type, cultural practices, and increments of age from time of blossoming.

The best measures of maturity of grapefruit found thus far are (1) the content of total soluble solids as determined in degrees Brix, (2) the ratio of solids to acids, and (3) the volume of juice.

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MATURITY STUDIES OF MARSH SEEDLESS GRAPEFRUIT IN THE LOWER RIO GRANDE VALLEY

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Early season grapefruit is often inferior in edible quality to that harvested in mid-season and later. Texas Citrus Maturity laws prior to 1936 have received considerable adverse comment because they allowed inferior quality fruit to flood the early markets. The majority of the growers would willingly withhold shipments until the fruit is more palatable, but so long as some ship the unpalatable fruit, the industry will suffer. Although early season shipments usually command a high price, the unpalatable fruit reduces the demand for the product and lowers the price for some time. Taking the industry as a whole, the first high prices do not offset the later low prices.

Texas Citrus Maturity Laws

The first citrus maturity law in Texas was passed in 1927. The requirements for grapefruit were a minimum of 10 per cent total solids and a minimum ratio of solids to acid of 7 : 1 in the juice. This law required the testing to be done at the packing sheds (11). Considerable loss was occasioned to both growers and shippers when fruit already in the sheds was condemned. A new law was drafted in 1929 requiring testing on samples taken from the groves (12). This law, known as House Bill No. 500, set up the following legal standards:

Juice of Seedy Grapefruit

Minimum solids (degrees Brix*)	Minimum ratio (Brix to acid)
9	6.5 : 1
10	6.0 : 1
11	5.5 : 1
12	5.0 : 1

Seedless grapefruit was required to have a minimum solids of 10° Brix and a minimum ratio of 7 : 1 until November 15, after which time the requirements were the same as for seedy fruit. All testing ended December 15. During the first year of operation it was found that fruit meeting the requirements was often low in juice. Consequently the Commissioner of Agriculture, by the power invested in him by this law, set up the following juice requirements:

*The terms Brix and Brix readings as used in this publication refer to the total soluble solids content of the juice.

Fruit size (No. fruit per standard box)	Fruit diameter (inches)	Juice requirement per fruit (c. c.)
126	3½	115
96	3¾	135
80	4	145
70	4⅛	150
64	4¼	170
54	4½	190
46	4¾	207
36	5	220
28	5¼	235

In the early part of the 1934 citrus season there was considerable criticism again of the shipping of immature fruit from the Rio Grande Valley. As a consequence, an amendment to House Bill No. 500 was drawn up and passed by the legislature in January, 1935 (13). This law put both seedy and seedless grapefruit on the same basis and set up the following requirements:

Minimum solids (degrees Brix)	Minimum ratio (Brix to acid)
9	7.2 : 1
10	7.0 : 1
11	6.8 : 1
11.5 and above	6.5 : 1

The juice requirements were increased 10 c. c. for the 126 size, 15 c. c. for the next four sizes, and 20 c. c. for the last four sizes. Slight differences have been made in the juice requirements for seedy and seedless fruit in order to compensate for the space occupied by the seed in the first type. The maturity law as amended in 1935 is in effect at the present time (1937).

The determination of such complex matters as taste and quality in citrus fruit is very difficult. The changes which have been made in the Texas Citrus Maturity law, as knowledge was gained concerning tests of palatability of grapefruit, have reduced the percentage of fruit of inferior quality offered for sale. It is hardly likely that a maturity law can be devised that will entirely prevent the shipment of immature grapefruit. However, it seems possible that a law can be so devised that the percentage of immature fruit offered for sale will be negligible.

Studies of Maturity

During the seasons 1934-35 and 1935-36, studies were made (1) to accumulate fundamental data on the physical and chemical changes occurring in Texas Marsh Seedless grapefruit during the ripening season which might serve as criteria of maturity, (2) to investigate the effects of various cultural practices on the maturity of the fruit, and (3) to substantiate or improve the existing maturity standards and tests.

Methods Employed

Ten fruits, two from each cardinal compass point of the tree and two inside fruits, were considered an adequate sample from a single tree. Thirty fruits, ten from each of three trees, were considered an adequate sample from a single plat. Check plats of comparable trees, in close proximity to their respective treated plats, were used for comparison. The data reported in this bulletin were secured during the 1934-35 and 1935-36 fruit seasons.

All analyses were made within twenty-four hours from the time the sample was taken. The juice was extracted with an aluminum hand-powered reamer and strained through cheesecloth. The fruit and various parts of the fruits were weighed on a balance which was accurate to one gram. The specific gravity of the fruits was determined by calculation from their displacement of water at room temperature. The volume of juice in cubic centimeters was measured and its weight was calculated from its specific gravity. Thickness in millimeters represented the average of three measurements. The total soluble solids were determined by means of Brix hydrometers graduated in one-tenth divisions and standardized at 17.5° C. Brix determinations were made on deaerated juice except in a few cases where comparisons were made with non-deaerated juice. The acidity was determined by duplicate titrations with standard sodium hydroxide solution. Sugars in the juice were determined before and after inversion with hydrochloric acid by the Munson and Walker method (1). Sucrose was calculated by difference. Amino acid titrations were made by the A. O. A. C. method of Sörenson (2) using formaldehyde. The pH and buffer indexes were determined with a Leeds and Northrup calomel electrode "acidity meter." The buffer index was determined by the method of Van Slyke (15.) The "electrolytic value" of the fruit was determined by means of a Westinghouse Electrynx. A tasting committee tasted each sample of fruit taken for analysis in an attempt to correlate all empirical tests with edibility.

A study of the effects of various cultural practices on maturity was made during the 1934-35 season, and a study of the seasonal changes of fruit from various locations in the Lower Rio Grande Valley was made during the 1935-36 season. A description of all of the plats on which the fruit was grown is given in Table 1.

STUDY OF CRITERIA OF MATURITY

Amino Acid Determinations

Amino acid determinations were made on the juice of several grapefruit of varying maturity (Table 2). The highest quantity was obtained on the juice from the greenest fruit and the lowest quantity on the juice from the ripest fruit. These results indicated that the test might be of value in

Table 1. Description of plats

(Marsh Seedless grapefruit on sour orange rootstock)

Plat	Year	Owner	Location	Soil type	Tree age (years)	Date of bloom	Tree condition	Crop estimate per cent normal	Cultural treatments
Soil Amendments....	1934	Tex. Agr. Exp. Sta.	Substa. No. 15 near Weslaco	Victoria fine sandy loam	15	March	Fairly healthy and vigorous	25	See text
Differential Irrigation.	1934	Tex. Agr. Exp. Sta.	Substa. No. 15 near Weslaco	Victoria fine sandy loam	15	March	Fairly healthy and vigorous	25	See text
Spray Applications...	1934	Tex. Agr. Exp. Sta.	Substa. No. 15 near Weslaco	Victoria fine sandy loam	15	March	Fairly healthy and vigorous	25	See text
Tree Age: Y........	1934	Tex. Agr. Exp. Sta.	Substa. No. 15 near Weslaco	Victoria fine sandy loam	10	March	Healthy and vigorous	60	See text
35........	1934	Tex. Agr. Exp. Sta.	Substa. No. 15 near Weslaco	Victoria fine sandy loam	15	March	Fairly healthy and vigorous	25	See text
Alamo...............	1935	E. H. Reichert & Sons	1.75 mi. W. of Alamo, 1.5 mi. S. of highway	Hidalgo fine sandy loam	12	March	Large, healthy and vigorous	85	8 tons per acre goat manure, Dec. 1934, 200 lbs. per tree Vigoro, Jan., 1935, light pruning following 1935 freeze.
La Feria...........	1935	Geo. Ross; J. S. Shearer, manager	¾ mi. E. of La Feria on highway	Victoria clay loam	11	March	Foliage scant, much dead wood, trees undersized, not healthy	25	No irrigation, pruning, spraying, dusting or fertilizing in 1935, entomogenous fungi present.
Mission............	1935	John H. Shary	½ mi. E. of Mission on highway	Hidalgo fine sandy loam	7	May	Healthy and vigorous	60	3.75 lbs. sulphate of ammonia per tree, Jan., 1935, irrigated Sept. 6, 7, 8, 1935; dusted .2 lb. sulphur per tree Oct. 11, 1935, disced Oct. 14, 1935.
Engelman Gardens...	1935	J. C. Engelman, Jr.	Engelman Gardens, Inc., N.E. Hidalgo Co.	Brennan fine sandy loam	9	March	Healthy and vigorous	25	Irrigated Nov. 25, 1935.

maturity work and it was therefore included in most of the analyses during the 1934-35 season.

Table 2. Total Acid and Amino Acid titrations on juice from fruit of varying size and maturity.
(10 cc. sample used; determinations made in duplicate.)

Description of fruit	Acid titre (cc.)	Amino acid titre (cc.)	Ratio titratable acid to amino acid
About 2 inches in diameter, green and hard......	24.25	1.83	13.2 : 1
About 3 inches in diameter, green and hard......	18.75	1.48	12.7 : 1
About 3 inches in diameter, green and hard......	18.23	1.50	12.1 : 1
About 3 inches in diameter, but partially colored and less hard...........................	17.16	1.38	12.3 : 1

Naringen Tests

Naringen is the bitter principle of grapefruit. Since the bitterness disappears as the season advances, it was thought that a simple test for naringen might be of use in determining maturity. The reaction of chemically pure, powdered naringen dissolved in water, in water, acidified with citric acid, and in 47.5% alcohol acidified with citric acid was tested with various reagents (Table 3). None of the reactions were characteristic enough to be of any value. Baier (3), working with California and Arizona Marsh Seedless grapefruit, concluded that neither amino nitrogen nor naringen content held any promise as criteria of maturity.

Table 3. The visible reaction obtained with various reagents acting on naringen in solution in three different solvents (1934-35)

Reagent	Water	Water acidified with citric acid	47.5% alcohol acidified with citric acid
Hydrochloric acid...........	none	none	none
Sulfuric acid.................	none	none	none
Nitric acid..................	none	none	none
Ammonium hydroxide........	lemon yellow color	lemon yellow color	lemon yellow color
Starch.......................	none	none	none
Starch-iodine...............	decolorized	none	none
Ammonium nitrate..........	none	none	none
Calcium acetate............	none	none	none
Potassium sulfate..........	none	none	none
Picric acid..................	yellow color	yellow color	yellow color
Methylene blue.............	faint blue color	faint blue color	faint blue color
Methylene blue + hydrogen peroxide.................	none	none	none
Ferrous sulfate..............	light brown color	light green color	light green color
Ferric sulfate................	light brown color	light green color	light green color
Oxalic acid..................	none	none	none
Tannic acid..................	none	none	none
Lead acetate................	none	white precipitate	white precipitate
Zinc + hydrochloric acid......	none	none	none
Magnesium nitrate..........	none	none	none
Stannous chloride...........	none	none	none

Total Solids Determinations on Deaerated and Non-deaerated Juice

Total solids determinations were made on nine samples of juice before and after deaeration. It was assumed that the determination on the deaerated juice was the more nearly correct since the buoyant effect of the entrapped air was eliminated. Brix readings of the non-deaerated juice were sometimes higher and sometimes lower than those of the deaerated juice, ranging from —.20 to +.10 degrees Brix (Table 4). These results indicate that the slight variability of the determinations of the Brix of non-deaerated juice may just as likely be due to the error in reading the Brix hydrometer as to the buoyant effect of the entrapped air. However, care should be exercised in extracting the juice to avoid excessive whipping and consequent entrapping of air. For this reason it is advisable to use hand-powered rather than motor-driven juice extractors.

Table 4. Determination of Brix on deaerated juice and non-deaerated juice (1934)

Sample	Date	Deaerated juice (degrees Brix)	Non-deaerated juice (degrees Brix)	Difference (degrees Brix)
35	October 22....................	10.80	10.65	—.15
37	October 22....................	10.70	10.60	—.10
39	October 22....................	10.90	10.98	+.08
14A	October 29....................	11.30	11.30	0.00
16A	October 29....................	11.30	11.20	—.10
18A	October 29....................	11.00	11.00	0.00
35	November 6..................	10.80	10.90	+.10
37	November 6..................	10.90	11.00	+.10
39	November 6..................	11.20	11.00	—.20

Variation in the Composition of Juice from the Stem and Blossom End of the Same Fruit

Grapefruit from Plat Y were picked on two different dates, halved, and the juice of each half analyzed separately (Table 5). Taking an average of the analyses for the two dates, the juice from the blossom end of the fruit was higher in solids, in ratio of Brix to acid, in sugar content, and in pH; but it was lower in acid and in buffer index. In addition it was slightly more sweet to the taste than the juice from the stem end. Haas and Klotz (9) found that under California conditions, the juice from the blossom end of oranges, grapefruit, and lemons, contained more total sugars than that from the stem end of the fruit. Baker (4), working with Texas grapefruit, found the same relation and also reported that the juice from the center portion of the fruit was higher in acid and Brix than the juice from the outer portion of the fruit.

Table 5. Chemical composition of juice from the stem-end and blossom-end of fruit.
(Plat Y—untreated, 10 years old, 1934.)

Determination	Stem-end			Blossom-end			Both Av.
	Nov. 8	Nov. 22	Av.	Nov. 8	Nov. 22	Av.	
Soluble solids (degrees Brix)	11.00	10.95	10.98	11.00	11.05	11.02	11.00
Citric acid anhydrous (%)	1.70	1.64	1.67	1.49	1.44	1.46	1.56
Brix to acid ratio	6.47	6.68	6.57	7.38	7.67	7.55	7.05
Invert sugar (%)	4.20	4.20	4.20	4.48	4.30	4.39	4.30
Sucrose (%)	2.66	2.52	2.59	2.76	2.76	2.76	2.68
Total sugars (%)	6.86	6.72	6.79	7.24	7.06	7.15	6.90
pH[1]	3.20	3.15	3.18	3.20	3.20	3.20	3.19
Buffer index[1]	1.013	1.140	1.076	1.013	1.073	1.043	1.058
Taste*[1]	SS-S VSB	A-T NB	T-SS VSB-NB	SS-S VSB	SS NB	SS-S VSB-NB	SS-S VSB-NB
Invert sugar to acid[1] (ratio)	2.47	2.56	2.51	3.01	2.99	3.01	2.76
Sucrose to acid[1] (ratio)	1.56	1.54	1.55	1.85	1.92	1.89	1.72
Total sugars to acid[1] (ratio)	4.04	4.10	4.06	4.86	4.90	4.90	4.42
Invert sugar to sucrose[1] (ratio)	1.58	1.63	1.62	1.62	1.56	1.59	1.60
Citric acid anhydrous[2] (%)	15.45	14.98	15.22	13.54	13.03	13.28	14.25
Invert sugar[2] (%)	38.18	38.35	38.26	40.73	38.91	39.82	39.04
Sucrose[2] (%)	24.18	26.48	25.33	25.09	24.98	25.04	25.18
Total sugars[2] (%)	62.36	64.83	63.60	65.82	63.89	64.86	64.22

[1]On wet basis.
[2]On dry basis.
*A-acid, SA-slightly acid, T-tart, SS-slightly sweet, S-sweet.
B-bitter, SB-slightly bitter, VSB-very slightly bitter, NB-non-bitter.

These results indicate that the composition of the juice from grapefruit is not uniform throughout the fruit and that all of the juice from both halves of the cut fruit must be used in order to obtain a representative sample of juice for analysis.

Variations Between Samples of Fruit from the Same Tree

Ten-fruit samples were picked from each of the cardinal compass points of a tree, and one ten-fruit sample from the inside of the same tree. The acidity, volume of juice, Brix and Brix to acid ratio determined from each of these, were compared to a check sample consisting of two fruits from each of the cardinal compass points and two fruits from the inside of the same tree (Table 6).

Table 6. Maturity tests on juice of fruit picked from different locations on same tree. (1935-36)

Location on tree	Number of fruits	Juice in 3 fruits (cc.)	Brix	Acid (per cent)	Brix to acid ratio
Inside	10	496	9.30	1.38	6.74
North side	10	504	9.45	1.50	6.30
South side	10	418	9.90	1.50	6.60
East side	10	500	9.50	1.51	6.29
West side	10	494	9.50	1.46	6.51
Average of five locations		428.4	9.53	1.47	6.48
Average sample—8 outside, 2 inside		496	9.80	1.52	6.45
Variation from average sample		+ 13.6	+ .27	+ .05	— .03

The variation among the five ten-fruit samples was greater than the variation between the average of these samples and the check sample. This is interpreted to mean that a ten-fruit sample taken in this manner is as reliable as a comparable fifty-fruit sample. Baker (4) found differences in maturity of fruit from the north and south sides of the tree and from the inside and outside of the tree. The above results indicate that the method used in sampling for the maturity tests gave samples which were fairly representative of the fruit on the tree.

The Electrynx as a Means of Determining the Maturity of Grapefruit

An attempt was made to determine by means of an "Electrynx" the relation between the electrolytic value of the whole fruit and its maturity. This instrument, manufactured by Westinghouse, is described as a sensitive microammeter, which, when used with electrodes of dissimilar metals, is capable of measuring the relative electrolytic effect of the substance being tested. The instrument is equipped with these six electrodes given in the order of their electromotive force: aluminum, iron, nickel, tin, copper and silver. Aluminum, the most negative electrode, is considered zero, and silver, the most positive electrode, 2.047. The instrument scale read pl. from zero to 100. The readings, when divided by five, give the approximate number of microamperes. The electrodes were inserted to the same depth each time through the rind of whole grapefruit. The readings were taken one minute after insertion. The data are summarized in Table 7. When a reading slightly exceeded the 100 mark on the scale it was recorded as 100+. It will be noted from the average value of fruit with a reading of 100 or less that there is no relation between the readings and the date of harvest. No relation was shown between the readings and any other factor studied. These results are in agreement with those of Baker (4), who concluded that the measurement of electrical conductivity of grapefruit juice as measured by a modified Wheatstone soil bridge offers little promise as a means of determining grapefruit maturity. Gordon (8), however, reported that the Electrynx could be used to measure the ripeness of sugar cane. A few readings were made on extracted grapefruit juice, but these were more variable than on the whole fruit.

Table 7. Determinations on fruit by means of the Electrynx. (1935-36)

Date	Plat	Electrodes	No. fruits tested	Per cent of fruits with readings greater than 100	Average value of fruits with readings of 100 or less
Dec. 9, 1935	Shary.......	Nickel and aluminum.	30	0.0	60.83
Jan. 2, 1936	Shary.......	Nickel and aluminum.	30	0.0	68.70
Dec. 9, 1935	Engelman...	Nickel and iron......	26	30.8	92.66
Jan. 2, 1936	Engelman...	Nickel and iron......	30	0.0	80.27
Dec. 13, 1935	La Feria....	Nickel and iron......	30	10.0	79.96
Jan. 6, 1936	La Feria....	Nickel and iron......	30	0.0	79.57

EFFECT OF CULTURAL TREATMENTS

Soil Treatments

The various soil treatments had been applied in the spring, for two consecutive years (1933 and 1934). Plats of five trees each, of Marsh Seedless grapefruit, were used and samples were taken from the middle three trees. An untreated check plat in close proximity to the treated plats was used for comparison. Sulfur and 9-27-9 fertilizer were applied to the soil at the rate of 10 pounds per tree, iron sulfate at the rate of 5 pounds per tree, and manure at the rate of 20 tons per acre (Tables 8 and 16). The seasonal averages of the total solids, citric acid, and solids to acid ratio are based on 120 fruits, comprised of 4 samples of 30 fruits each.

Table 8. Effect of soil treatments on the juice. (1934-35)

Date	Plat	Treatment	Soluble solids (degrees Brix)	Citric acid anhydrous (per cent)	Brix to acid ratio	Taste*
Oct. 17	27B	5 lbs. 9–27–9 per tree.......	10.75	1.56	6.89	....
Nov. 14	27B	5 lbs. 9–27–9 per tree.......	11.51	1.43	8.05	T NB
Dec. 17	27B	5 lbs. 9–27–9 per tree.......	11.19	1.34	8.35	S NB
Jan. 18	27B	5 lbs. 9–27–9 per tree.......	11.35	1.30	8.73	S NB
Av.....	27B	5 lbs. 9–27–9 per tree.......	11.20	1.40	8.00	SS-S NB
Oct. 17	29B	5 lbs. iron sulfate per tree...	10.95	1.53	7.16	....
Nov. 14	29B	5 lbs. iron sulfate per tree...	11.01	1.40	7.86	T-SS NB
Dec. 17	29B	5 lbs. iron sulfate per tree...	11.19	1.40	7.99	S NB
Jan. 18	29B	5 lbs. iron sulfate per tree...	11.35	1.24	9.15	S NB
Av.....	29B	5 lbs. iron sulfate per tree...	11.12	1.39	8.00	SS NB
Oct. 17	31B	10 lbs. sulfur per tree.......	10.88	1.59	6.84	....
Nov. 14	31B	10 lbs. sulfur per tree.......	11.01	1.54	7.15	T VSB
Dec. 17	31B	10 lbs. sulfur per tree.......	11.14	1.42	7.84	S NB
Jan. 18	31B	10 lbs. sulfur per tree.......	11.20	1.37	8.18	SS-S NB
Av.....	31B	10 lbs. sulfur per tree.......	11.05	1.48	7.47	SS-S VSB-NB
Oct. 17	33B	20 tons manure per acre.....	10.95	1.58	6.30	....
Nov. 14	33B	20 tons manure per acre.....	11.41	1.46	7.82	T-VSB-NB
Dec. 17	33B	20 tons manure per acre.....	11.39	1.36	8.38	S NB
Jan. 18	33B	20 tons manure per acre.....	11.55	1.35	8.56	S NB
Av.....	33B	20 tons manure per acre.....	11.32	1.43	7.92	SS-S VSB-NB
Oct. 17	35B	Untreated check...........	10.65	1.55	6.87	....
Nov. 14	35B	Untreated check...........	10.81	1.44	7.51	T-SS NB
Dec. 17	35B	Untreated check...........	11.05	1.37	8.06	S NB
Jan. 18	35B	Untreated check...........	11.15	1.32	8.45	S NB
Av.....	35B	Untreated check...........	10.91	1.42	7.68	SS NB

*A-acid, SA-slightly acid, T-tart, SS-slightly sweet, S-sweet, B-bitter, SB-slightly bitter, VSB-very slightly bitter, NB-non-bitter.

Table 9. Physical measurements on fruits from normally irrigated plats

(Averages on 30-fruit sample, 1934-35.)

Determination	Oct. 22	Nov. 6	Nov. 19	Dec. 4	Dec. 21	Jan. 7	Jan. 29	Av.
Weight fruit (gm.)	337.0	363.5	358.5	407.5	409.5	422.2	421.2	388.48
Volume fruit (cc.)	414.0	432.0	423.5	485.0	505.2	520.2	500.0	468.55
Thickness rind (mm.)	7.2	6.7	6.7	6.7	7.6	7.2	6.9	7.0
Weight rind (gm.)	89.1	91.0	88.6	101.4	114.6	111.8	109.7	100.88
Weight of rag (gm.)	80.1	81.0	75.0	73.9	77.3	82.4	74.9	77.80
Volume of juice (cc.)	137.0	159.0	160.0	184.0	175.6	189.3	200.8	172.24
Specific gravity fruit	0.814	0.841	0.846	0.840	0.810	0.811	0.842	0.829
Specific gravity juice[1]	1.043	1.043	1.045	1.046	1.046	1.045	1.044	1.0445
Weight juice (gm.)	142.89	165.83	167.20	192.46	183.67	197.81	209.63	179.90
Rind[2] (%[3])	26.43	25.03	24.71	24.88	27.98	26.48	26.04	25.96
Rag[2] (%[3])	23.76	22.28	20.92	18.13	18.87	19.51	17.78	20.02
Juice[2] (%[3])	42.40	45.62	46.63	47.23	44.85	46.85	41.92	46.30

[1]Based on temp. of $\frac{17.5° C.}{17.5° C.}$

[2]These do not total 100% because of loss of seeds.

[3]By weight.

Table 10. Chemical analyses of fruits from normally irrigated plats

(Averages on 30-fruit sample, 1934-35.)

Determination	Oct. 22	Nov. 6	Nov. 19	Dec. 4	Dec. 21	Jan. 7	Jan. 29	Av.
Soluble solids (degrees Brix)	10.79	10.82	11.11	11.42	11.45	11.21	11.05	11.12
Citric acid anhydrous (%)	1.65	1.50	1.53	1.50	1.49	1.44	1.30	1.48
Brix to acid ratio	6.54	7.21	7.26	7.61	7.68	7.78	8.50	7.51
Invert sugar (%[1])	4.31	4.51	4.52	4.61	4.64	4.61	4.77	4.56
Sucrose (%[1])	2.58	2.60	2.47	2.73	2.73	2.66	2.62	2.62
Total sugars (%[1])	6.89	7.11	6.99	7.34	7.37	7.27	7.39	7.19
Amino acid titra. as N (%[1])	....	....	0.0242	0.0204	0.0229	0.0210	0.0239	0.0224
pH	3.10	3.20	3.10	3.10	3.10	3.20	3.40	3.17
Buffer index	1.014	1.140	1.140	1.140	1.140	1.111	0.909	1.084
Taste*[1]	A B	T-SS VSB	T-A NB	T NB	SS-S NB	SS-S NB	SS-S NB	T-SS VSB-NB
Invert sugar to acid[1] (ratio)	2.61	3.01	2.95	3.07	3.11	3.25	3.67	3.08
Sucrose to acid[1] (ratio)	1.56	1.73	1.61	1.82	1.83	2.17	2.02	1.77
Total sugars to acid[1] (ratio)	4.17	4.74	4.57	4.89	4.95	5.05	5.68	4.86
Invert sugar to sucrose[1] (ratio)	1.67	1.73	1.83	1.65	1.70	1.32	1.82	1.74
Citric acid anhydrous (%[2])	15.29	13.86	13.77	13.13	13.01	12.84	11.76	13.88
Invert sugar(%[2])	39.94	41.68	40.68	40.37	40.52	41.12	43.17	41.06
Sucrose (%[2])	23.91	24.02	21.23	23.90	23.84	23.73	23.71	23.47
Total sugar (%[2])	63.85	65.70	61.91	64.27	64.36	64.85	66.88	64.54
Amino acid titration as N[2]	....	....	0.218	0.179	0.200	0.187	0.216	0.200

[1]On a wet basis.

[2]On a dry basis.

*A-acid, SA-slightly acid, T-tart, SS-slightly sweet, S-sweet, B-bitter, VSB- very slightly bitter, NB-non-bitter.

Table 11. Physical measurements of fruit from heavily irrigated plats

(Averages on 30-fruit sample, 1934-35.)

Determination	Oct. 22	Nov. 6	Nov. 19	Dec. 4	Dec. 21	Jan. 7	Jan. 29	Av.
Weight fruit (gm.)	347.0	379.0	343.0	389.4	400.6	409.1	414.3	383.2
Volume fruit (cc.)...........	432.0	457.0	411.5	465.8	494.0	508.5	495.1	466.27
Thickness rind (mm.)........	7.5	6.9	6.6	6.8	7.5	7.3	6.9	7.07
Weight rind (gm.)	94.5	97.6	87.4	99.4	111.7	110.9	108.6	101.4
Weight rag (gm.)...........	84.0	87.6	72.4	68.3	73.5	78.2	75.5	77.07
Volume juice (cc.).........	134.0	161.0	149.0	178.0	167.5	183.7	196.6	167.11
Specific gravity fruit.........	0.803	0.829	0.833	0.835	0.810	0.804	0.836	0.821
Specific gravity juice[1]........	1.043	1.044	1.045	1.046	1.046	1.046	1.046	1.0451
Weight juice (gm.)...........	139.76	168.08	155.70	186.18	175.20	192.15	205.64	174.64
Rind[2] (%[3]).................	27.23	25.75	25.48	25.52	27.88	27.10	26.21	26.46
Rag[2] (%[3])...................	24.20	23.11	21.10	17.53	18.34	19.11	18.22	20.11
Juice[2] (%[3]).................	40.27	44.34	45.39	47.81	43.73	46.96	49.63	45.57

[1]Based on temp. of $\frac{17.5^\circ \text{ C.}}{17.5^\circ \text{ C.}}$

[2]These do not total 100% because of loss of seeds.

[3]By weight.

Table 12. Chemical analyses of fruit from heavily irrigated plats

(Averages on 30-fruit sample, 1934-35.)

Determination	Oct. 22	Nov. 6	Nov. 19	Dec. 4	Dec. 21	Jan. 7	Jan. 29	Av.
Soluble solids (degrees Brix)..	10.72	10.91	11.24	11 52	11.53	11.34	11.35	11.23
Citric acid anhydrous (%)....	1.62	1.50	1.57	1.51	1.50	1.41	1.31	1.48
Brix to acid ratio...........	6.62	7.27	7.16	7.66	7.69	8.04	8.66	7.58
Invert sugar (%)[1]...........	4.31	4.49	4.55	4.69	4.69	4.59	4.79	4.58
Sucrose (%)[1]...............	2.76	2.74	2.49	2.64	2.88	2.82	2.74	2.72
Total sugars (%)[1]...........	7.07	7.23	7.04	7.33	7.57	7.41	7.53	7.40
Amino acid titra. as N (%)[1]..	....	....	0.0229	0.0214	0.0231	0.0190	0.0243	0.0221
pH......................	3.10	3.20	3.10	3.15	3.00	3.20	3.35	3.15
Buffer index...............	1.014	1.140	1.140	1.073	1.303	1.111	0.952	1.104
Taste*[1]..................	A B	T-SS SB	T-SS NB	T-SS NB	SS-S NB	SS-S NB	S NB	T-SS VSB-NB
Invert sugar to acid[1] (ratio)..	2.66	2.99	2.90	3.11	3.13	3.26	3.66	3.09
Sucrose to acid[1] (ratio)......	1.70	1.83	1.58	1.75	1.92	2.00	2.09	1.83
Total sugars to acid[1] (ratio)..	4.36	4.82	4.48	4.85	5.05	5.26	5.75	5.00
Invert sugar to sucrose[1] (ratio)	1.56	1.64	1.82	1.78	1.63	1.63	1.75	1.68
Citric acid anhydrous[2] (%)...	15.11	13.74	13.96	13.11	13.01	12.43	11.54	13.27
Invert sugar[2] (%)..........	40.20	41.15	40.48	40.71	40.68	40.48	42.20	40.84
Sucrose[2] (%)..............	25.74	25.11	22.15	22.92	24.98	24.87	24.15	24.27
Total sugars[2] (%)..........	65.94	66.26	62.63	63.63	65.66	65.35	66.35	65.12
Amino acid titration as N[2](%)	....	....	0.204	0.186	0.200	0.168	0.214	0.194

[1]On a wet basis.

[2]On a dry basis.

*A-acid, SA-slightly acid, T-tart,
SS-slightly sweet, S-sweet,
B-bitter, VSB-very slightly bitter,
NB-non-bitter.

Table 13. Physical measurements of fruit from lightly irrigated plats

(Averages on 30-fruit sample, 1934-35.)

Determination	Oct. 22	Nov. 6	Nov. 19	Dec. 4	Dec. 21	Jan. 7	Jan. 29	Av.
Weight fruit (gm.)	359.0	339.0	360.4	411.8	440.2	419.9	394.0	389.18
Volume fruit (cc.)	437.5	396.0	432.6	484.7	535.8	511.7	470.5	466.97
Thickness rind (mm.)	7.1	6.5	6.9	6.8	7.6	7.3	6.9	7.01
Weight rind (gm.)	91.3	84.0	93.0	102.3	119.6	111.6	104.2	100.85
Weight rag (gm.)	82.6	66.5	73.1	77.9	84.0	82.3	71.9	76.90
Volume juice (cc.)	148.0	163.0	159.0	193.0	194.0	191.7	190.6	177.04
Specific gravity fruit	0.820	0.856	0.833	0.849	0.821	0.820	0.837	0.833
Specific gravity juice*	1.044	1.045	1.046	1.046	1.047	1.046	1.046	1.0457
Weight juice (gm.)	154.51	170.33	166.31	201.87	203.11	200.51	199.36	185.13
Rind (%[1])	25.43	24.77	25.80	24.84	27.16	26.57	26.44	25.91
Rag (%[1])	23.00	19.61	20.28	18.91	19.08	19.59	18.24	19.75
Juice (%[1])	43.03	50.24	46.14	49.02	46.14	47.75	50.60	47.56

*Based on temp. of $\frac{17.5° C.}{17.5° C.}$

[1]By weight.

Table 14. Chemical analyses of fruits from lightly irrigated plats

(Averages on 30-fruit sample, 1934-35.)

Determination	Oct. 22	Nov. 6	Nov. 19	Dec. 4	Dec. 21	Jan. 7	Jan. 29	Av.
Soluble solids (degrees Brix)	10.92	11.17	11.54	11.52	11.62	11.54	11.45	11.39
Citric acid anhydrous (%)	1.65	1.64	1.64	1.53	1.58	1.52	1.43	1.57
Brix to acid ratio	6.62	6.81	7.04	7.53	7.35	7.59	8.01	4.27
Invert sugar[1] (%)	4.59	4.81	4.74	4.72	4.69	4.87	5.01	4.77
Sucrose[1] (%)	2.40	2.47	2.50	2.66	2.83	2.70	2.46	2.57
Total sugars[1] (%)	6.99	7.28	7.24	7.38	7.52	7.57	7.47	7.35
Amino acid titra. as N[1] (%)	....	....	0.0235	0.0231	0.0221	0.0210	0.0243	0.0228
pH[1]	3.10	3.10	3.10	3.10	3.00	3.20	3.20	3.11
Buffer index[1]	1.014	1.303	1.140	1.140	1.303	1.111	1.111	1.160
Taste*[1]	A B	T-SS SB	SS NB	SS NB	SS-S NB	SS-S NB	SS-S NB	T-SS VSB-NB
Invert sugar to acid[1] (ratio)	2.79	2.93	2.89	3.08	2.97	3.20	3.50	3.04
Sucrose to acid[1] (ratio)	1.45	1.51	1.52	1.74	1.79	1.78	1.71	1.64
Total sugars to acid[1] (ratio)	4.24	4.44	4.41	4.82	4.76	4.98	5.22	4.68
Invert sugar to sucrose[1] (ratio)	1.91	1.95	1.90	1.77	1.66	1.80	2.04	1.86
Citric acid anhydrous[2] (%)	15.11	14.68	14.21	13.28	13.60	13.17	12.49	13.79
Invert sugar[2] (%)	42.03	43.06	41.07	40.98	40.36	42.20	43.76	41.92
Sucrose[2] (%)	21.97	22.11	21.66	23.09	24.35	23.40	21.48	22.58
Total sugars[2] (%)	64.00	65.17	62.73	64.07	64.71	65.60	65.24	64.70
Amino acid titra. as N[2] (%)	....	....	0.204	0.201	0.190	0.182	0.212	0.197

[1]On wet basis.
[2]On dry basis.
*A-acid, SA-slightly acid, T-tart,
SS-slightly sweet, S-sweet,
B-bitter, VSB-very slightly bitter,
NB-non-bitter.

Table 15. Chemical analyses of fruit from plats receiving different spray treatments

(Average on 30-fruit sample, 1934-35.)

Date	Plat	Treatment	Soluble solids (degrees Brix)	Citric acid anhydrous (per cent)	Brix to acid (ratio)	Taste*
Nov. 14	20A	1.5% lime sulfur	11.41	1.67	6.83	T-SS NB
Dec. 17	20A	1.5% lime sulfur	11.42	1.59	7.18	T-SS NB
Jan. 18	20A	1.5% lime sulfur	11.55	1.43	8.01	S NB
Av.	20A	1.5% lime sulfur	11.46	1.56	7.35	SS NB
Nov. 14	22A	Untreated check	11.21	1.63	6.88	SA VSB
Dec. 17	22A	Untreated check	11.47	1.56	7.35	SS NB
Jan. 18	22A	Untreated check	11.55	1.40	8.25	S NB
Av.	22A	Untreated check	11.41	1.53	7.46	T-SS VSB-NB
Nov. 14	26A	Soluble phosphate	11.31	1.62	6.98	T NB
Dec. 17	26A	Soluble phosphate	11.47	1.44	7.96	SS NB
Jan. 18	26A	Soluble phosphate	11.45	1.46	7.84	S NB
Av.	26A	Soluble phosphate	11.41	1.50	7.61	SS NB
Nov. 14	28A	Untreated check	11.51	1.66	6.93	T-A NB
Dec. 17	28A	Untreated check	11.57	1.64	7.05	SS-S NB
Jan. 18	28A	Untreated check	11.65	1.48	7.87	S NB
Av.	28A	Untreated check	11.57	1.59	7.28	SS NB
Nov. 14	30A	Tank mix oil	11.01	1.61	6.84	T VSB
Dec. 17	30A	Tank mix oil	11.02	1.53	7.20	SS NB
Jan. 18	30A	Tank mix oil	11.25	1.47	7.65	SS-S NB
Av.	30A	Tank mix oil	11.09	1.53	7.25	T-SS VSB-NB
Nov. 14	32A	Zinc sulfate and lime	11.11	1.49	7.46	T NB
Dec. 17	32A	Zinc sulfate and lime	11.30	1.60	7.06	S NB
Jan. 18	32A	Zinc sulfate and lime	11.35	1.45	7.83	SS-S NB
Av.	32A	Zinc sulfate and lime	11.25	1.51	7.45	SS NB

*A-acid, SA-slightly acid, T-tart, SS-slightly sweet, S-sweet, B-bitter, SB-slightly bitter, VSB-very slightly bitter, NB-non-bitter.

Table 16. Cultural treatments—seasonal average. (Summary 1934-35)

Plat	Treatment				Increase over check						Increase over check			Specific gravity of fruit	Increase over check
		Brix	Acid	Ratio	Brix	Acid	Ratio	Rind*	Rag*	Juice*	Rind	Rag	Juice		
	Soil Treatments:														
27	5 lbs. per tree 9–27–9...	11.20	1.40	8.00	+0.29	—0.02	+0.32								
29	5 lbs. per tree iron sulfate	11.12	1.39	8.00	+0.21	—0.03	+0.32								
31	10 lbs. per tree sulfur....	11.05	1.48	7.46	+0.14	+0.06	—0.22								
33	20 tons per acre manure..	11.32	1.43	7.92	+0.41	+0.10	+0.24								
35	Untreated check.........	10.91	1.42	7.68	......	......	......								
	Irrigation:														
35	Normal irrigation (check)	11.12	1.48	7.51	......	......	......	25.93	20.17	46.17	......	......	......	0.829	....
37	Heavy irrigation........	11.23	1.48	7.58	+0.11	+0.00	+0.07	26.45	20.23	45.44	+0.52	+0.06	—0.73	0.821	—0.008
39	Light irrigation.........	11.39	1.57	7.27	+0.27	+0.09	—0.24	25.85	19.81	47.58	—0.08	—0.36	+1.41	0.833	+0.004
	Spray Applications:														
20	1.5% lime sulfur..........	11.46	1.56	7.35	+0.05	+0.03	—0.11								
22	Untreated check..........	11.41	1.53	7.46	......	......	......								
26	Soluble phosphate.........	11.41	1.50	7.61	0.0	—0.03	+0.15								
28	Untreated check...........	11.57	1.59	7.28	......	......	......								
30	Tank mix oil..............	11.09	1.53	7.25	—0.48	—0.06	—0.03								
32	Zinc sulfate and lime.......	11.25	1.51	7.45	—0.32	—0.08	+0.17								
	Tree Age:														
Y	Untreated 10 years old.....	11.01	1.50	7.38	—0.11	+0.02	—0.13	26.21	18.25	48.78	+0.28	—1.92	+2.61	0.832	+0.030
35	Untreated 15 years old.....	11.12	1.48	7.51	......	......	......	25.93	20.17	46.17	......	......	......	0.829	....

***Per cent.**

The seasonal averages of the Brix on fruit grown on all of the treated plats were higher than that of the untreated plat (Figure 1). Manure gave the greatest increase and sulfur the least increase. There was an increase in the seasonal average of the Brix to acid ratio over the check plat on all of the treated plats with the exception of the sulfur plat which showed a decrease.

It will be noted from Figure 1 that the Brix readings of all of the fruit from the treated plats were higher throughout the season than were those of the untreated plat. All of the samples contained more than the required minimum solids of 10 on the first date analyzed. The general trend of the solids was upward as the season advanced. The iron sulfate plat was the only one above the required 7 : 1 ratio on the first date analyzed (Figure 2). On the second date, all treatments except sulfur gave a higher solids to acid ratio than the check plat and remained as high or higher throughout the season.

The data indicate that applications of 9-27-9 fertilizer, iron sulfate, and manure hastened maturity in this experiment, whereas sulfur retarded maturity. It is believed that the conclusions drawn are justified since the various treatments had a cumulative effect on the Brix and on the ratio as the season advanced. A study of the data in Table 8 shows that the Brix to acid ratio of the 9-27-9 plat was .02 higher than the check plat on the first date and .28 higher on the last date; iron sulfate was .29 higher

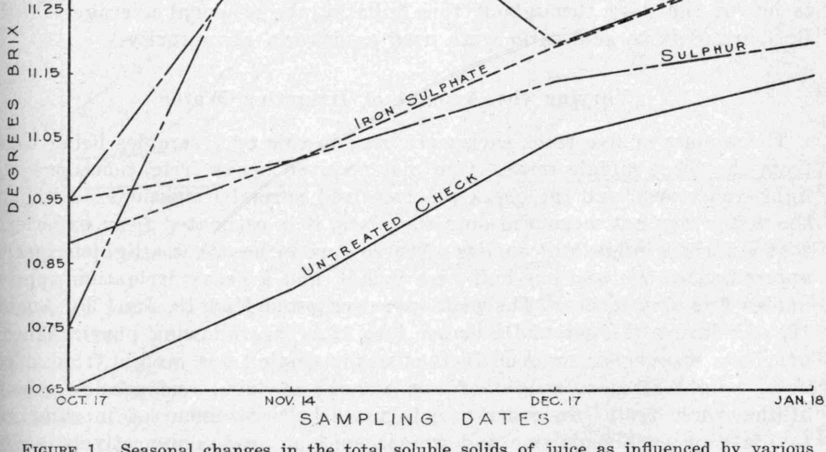

FIGURE 1. Seasonal changes in the total soluble solids of juice as influenced by various soil treatments.

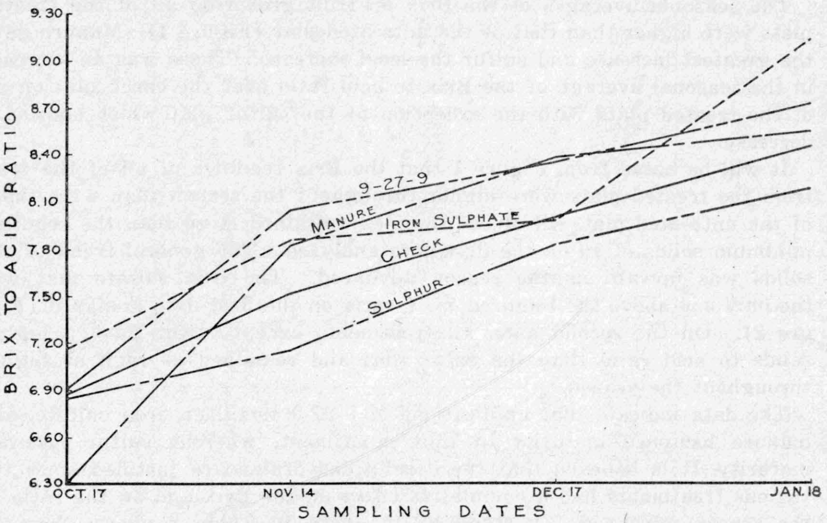

FIGURE 2. Seasonal changes in the total soluble solids to acid ratio of juice as influenced by various soil treatments.

to .70 higher, and manure .57 lower to .11 higher. The exceptional sulfur treatment decreased from .29 higher to .27 lower. The trends, though variable, are evident. The soil treatments were still having an effect at the time the tests were made; otherwise the changes in ratio would have had a tendency to be more nearly alike. This was not a static condition which caused one lot to start maturing sooner, but appeared to be in effect throughout the season, as indicated by the fact that there was a spread in the ratio during the period of time covered by the tests. In the interpretation of the data throughout this bulletin, the seasonal averages of the Brix and Brix to acid ratio were used as criteria of maturity.

Varying the Amount of Irrigation Water

Three plats of five trees each were used in this test, samples being taken from the three middle trees. One plat received heavy irrigations, one plat light irrigations, and the check plat received normal irrigations. Although the water was not measured onto the plats, it is estimated from experience that a normal irrigation consists of three acre inches, that a light irrigation approximates one and one-half acre inches, and a heavy irrigation approximates five acre inches. The plats were irrigated May 19, June 30, August 16, and during the period December 6 to 17. The following physical measurements were made on each fruit of each sample: size, weight, rind thickness, weight of rind, weight of rag, volume of juice, and specific gravity of the whole fruit. In order to minimize the error incurred in sampling, the data on each fruit size and weight are not used comparatively. With the exception of the specific gravity, the remainder of the physical data are expressed in per cent by weight. Seven samples were taken from these plats at approximately two-week intervals from October 22, 1934, to January 29, 1935 (Tables 9 to 14 inclusive). The seasonal averages are based on the individual measurements of 210 fruits (Table 16).

There was a slight increase in the average total solids of fruit from the heavily irrigated plat over those from the normal check and a very slight widening of the average Brix to acid ratio (Tables 9, 10, 11, 12), whereas fruit from the lightly irrigated plat showed an increase in average Brix but a narrowing in the Brix to acid ratio (Tables 9, 10, 13, 14). There was a slight increase in specific gravity on the heavily irrigated plat and a slight decrease on the lightly irrigated plat as compared with the check. Total solids, acid, and solids to acid ratio were affected very slightly by heavy irrigation. Light irrigation apparently deterred maturity to a certain extent in this case. The lightly irrigated plat had less rind, less rag, and more juice than the check plat, whereas the heavily irrigated plat showed the reverse to be true.

Fruit from all plats were above the solids requirement of 10 on the first date analyzed (Figure 3). With the exception of the first date, both heavy and light irrigations gave higher Brix readings throughout the season than did the check plat. The Brix of fruit from the lightly irrigated plat was consistently higher than that of the other plats. After December 21, the Brix readings on fruit from all plats were lowered, perhaps partly because the only irrigations applied during the period of analysis were between the December 4 and December 21 readings.

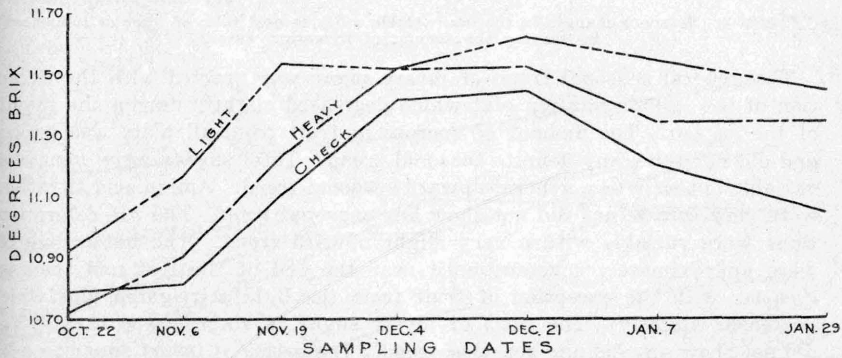

FIGURE 3. Seasonal changes in the total soluble solids of juice as influenced by varying the amount of irrigation water.

Figure 4 shows the general seasonal trend of the solids to acid ratio to be upward. None of the plats had reached the legal requirement of a ratio of 7 : 1 on the first date analyzed. On the second date fruit from the light irrigation plat was the only one with a ratio below 7 : 1. On the third date and thereafter to the close of the test, all plats showed ratios above 7 : 1. References to the ratings of taste in Tables 10, 12 and 14, show fruit from all three plats to be acid and bitter on the first date analyzed. Fruit from all plats became less acid and less bitter on the second date and by the third date bitterness had disappeared and was not encountered again during the test. Fruit from the light irrigation plat had the highest Brix and the lowest ratio throughout the season, with the exception of the first date, and the acidity was consistently higher than was that of the other plats. The increased acidity resulted in a lower ratio than that of either the heavy or normal irrigation plats, and it may be assumed, in this instance, that light irrigation deterred maturity. The effect of heavy irrigation, when compared to that of normal irrigation, was so slight as to be negligible.

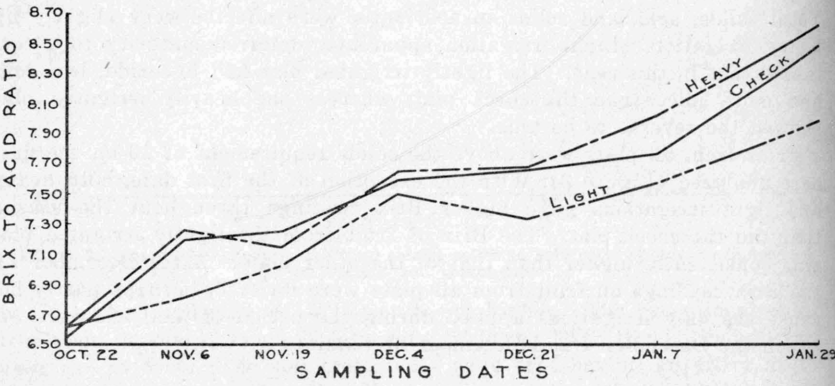

FIGURE 4. Seasonal changes in the total soluble solids to acid ratio of juice as influenced by varying the amount of irrigation water.

The general seasonal trend of invert sugar was upward with the exception of the light irrigation plat which decreased slightly during the middle of the season. The amount of sucrose in fruit from all plats was erratic and did not show any definite seasonal trend. Total sugars were somewhat variable but showed a general upward seasonal trend. Amino acid titrations were very erratic and did not show any seasonal trend. The pH determinations were variable with a very slight upward trend. The buffer indexes were approximately constant until near the end of the test and then increased, with the exception of fruit from the lightly irrigated plat which decreased slightly. The ratio of invert sugar to sucrose was erratic and did not show any definite seasonal trend. The ratios of invert sugar to acid, sucrose to acid, and total sugars to acid, though somewhat variable, showed general seasonal increases.

Spray Materials

The various spray treatments were applied with a power sprayer in October, 1934. Five trees were sprayed in each instance and data taken from the three middle trees. Lime-sulfur was applied in a 1.5 per cent solution. The soluble nitro-phosphate spray was made by dissolving 20 pounds of 11-48-0 fertilizer in 100 gallons of water. The zinc-lime spray was made by dissolving 4 pounds of zinc sulphate and 4 pounds of hydrated lime in 100 gallons of water. The oil spray was of the tank-mix type and conformed to Smith's grade 4 (10). It was applied in a two per cent solution. Two untreated check plats in close proximity to their respective treated plats were used for comparison (Tables 15 and 16.) A spray consisting of 2 pounds of iron sulphate in 100 gallons of water did considerable damage to the foliage and fruit. The fruits from this plat were so severely injured that no attempt was made to analyze them.

Fruit from the plats receiving tank-mix oil and zinc-lime sprays showed a decrease in the average Brix as compared with the check. The other treatments produced only slight differences in average Brix. The lime-sulfur, soluble nitro-phosphate and tank-mix oil produced a narrowing in the average Brix to acid ratio, and the zinc-lime plat showed a widening.

Differences between Brix readings for the lime-sulfur, soluble nitro-phosphate, and their check plat (22 A) were even less than the difference between the two checks (Table 15, Figure 5). The tank-mix oil plat had the lowest Brix readings of any of the plats. All plats showed a total solids of 11 or higher and met the required 6.8 : 1 ratio throughout the test. The ratio of total solids to acid on the zinc-lime plat was highest on November 14 and much lower on December 17 (Figure 6). The soluble nitro-phosphate plat had a high ratio on December 17 and a low ratio on January 18. The differences in ratios on the other treated plats and their respective check plats were small. From these data it was concluded that very slight if any effect on the maturity of the fruit was caused by the various spray materials.

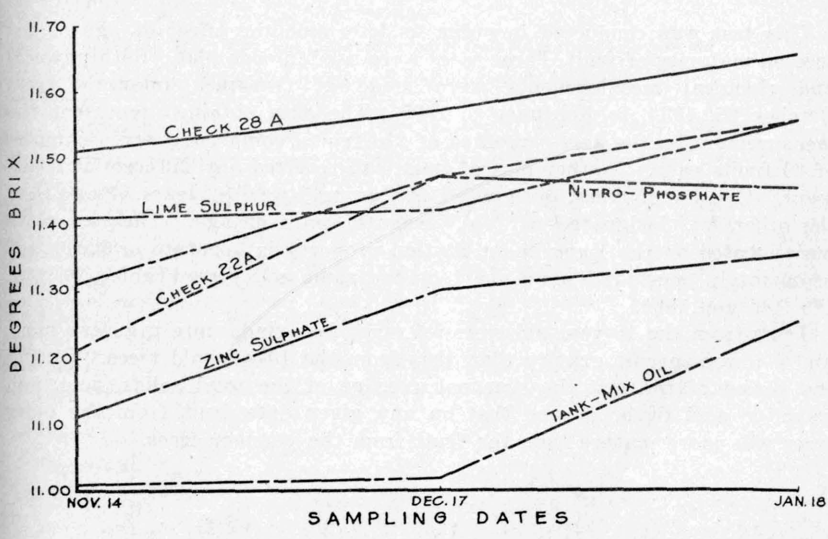

FIGURE 5. Seasonal changes in the total soluble solids of juice as influenced by fall applications of various spray materials.

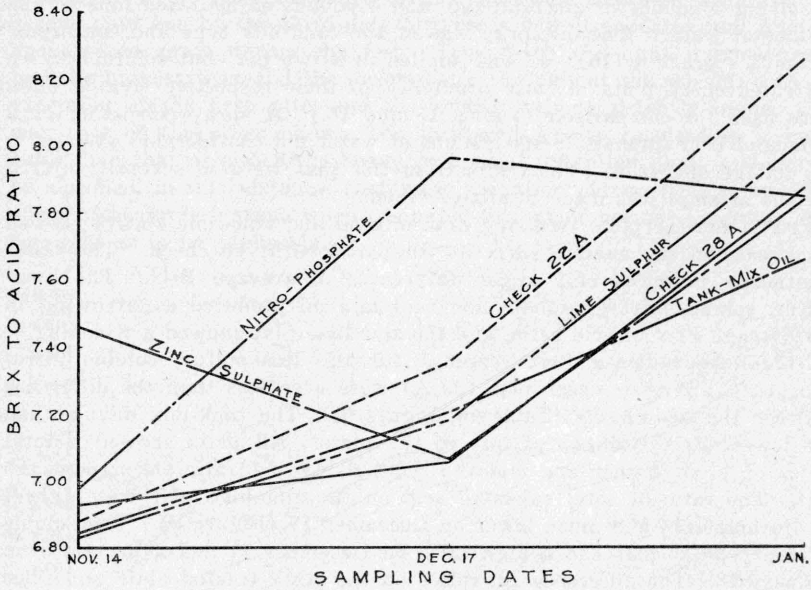

FIGURE 6. Seasonal changes in the total soluble solids to ratio of juice as influenced by fall applications of various spray materials.

THE EFFECT OF AGE OF TREE

This test was conducted in order to determine the effect of age of the tree on maturity of fruit. Three trees were used in each plat. Both physical and chemical measurements were made at two-week intervals from October 25, 1934, to February 6, 1935. The data obtained represent the measurement on the dates specified of 210 fruits, comprising seven samples of 30 fruits each. Neither plat of trees had received any differential treatment. One lot of trees, designated as "young," was 10 years of age, and the other lot, designated as "old," was 15 years of age. The two plats were located on the Experiment Station property in separate orchards approximately one-fourth mile apart on the same soil type (Tables 16, 17a, 17b, 18a and 18b).

Fruit from the 15-year-old trees averaged less rind, more rag, less juice, and a lower specific gravity than that from the 10-year-old trees. During the period of the test the seasonal average of the total solids, acid, and solids to acid ratio, showed that on any given date fruit from the older trees was more mature than the fruit from the younger trees.

Table 17a. Physical measurements of fruit from trees 10 years old

(Plat Y—averages on 30-fruit sample, 1934-35.)

Determination	Oct. 25	Nov. 8	Nov. 22	Dec. 13	Dec. 31	Jan. 15	Feb. 6	Av.
Weight fruit (gm.)	295.0	349.0	360.0	392.0	431.0	385.0	417.0	375.57
Volume fruit (cc.)	357.0	414.0	423.0	471.0	531.0	461.0	502.0	451.28
Thickness rind (mm.)	6.5	6.5	6.3	6.8	7.2	6.5	7.1	6.7
Weight rind (gm.)	76.5	88.5	92.0	101.0	114.5	101.0	114.7	98.31
Weight rag (gm.)	65.6	66.5	71.0	67.6	72.2	65.7	71.3	68.55
Volume juice (cc.)	127.0	163.0	166.0	183.0	204.0	190.0	201.0	176.28
Specific gravity fruit	0.826	0.842	0.851	0.834	0.811	0.835	0.830	0.832
Specific gravity juice[1]	1.044	1.044	1.044	1.045	1.045	1.044	1.044	1.0442
Weight juice (gm.)	132.58	170.17	173.30	191.23	213.18	198.36	209.84	184.07
Rind (%[2])	25.93	25.35	25.55	25.76	26.56	26.23	27.50	26.17
Rag (%[2])	22.23	19.05	19.72	17.24	16.75	17.06	17.09	18.25
Juice (%[2])	44.94	48.75	48.13	48.78	49.46	51.52	50.32	49.01

[1]Based on temp. of $\frac{17.5^\circ\text{ C.}}{17.5^\circ\text{ C.}}$

[2]By weight.

Table 17b. Physical measurements of fruit from trees 15 years old

(Plat 35—averages on 30-fruit sample, 1934-35.)

Determination	Oct. 22	Nov. 6	Nov. 19	Dec. 4	Dec. 21	Jan. 7	Jan. 29	Av.
Weight fruit (gm.)	337.0	363.5	358.5	407.5	409.5	422.2	421.2	388.48
Volume fruit (cc.)	414.0	432.0	423.5	485.0	505.2	520.2	500.0	468.55
Thickness rind (mm.)	7.2	6.7	6.7	6.7	7.6	7.2	6.9	7.0
Weight rind (gm.)	89.1	91.0	88.6	101.4	114.6	111.8	109.7	100.88
Weight rag (gm.)	80.1	81.0	75.0	73.9	77.3	82.4	74.9	77.80
Volume juice (cc.)	137.0	159.0	160.0	184.0	175.6	189.3	200.8	172.24
Specific gravity fruit	0.814	0.841	0.846	0.840	0.810	0.811	0.842	0.829
Specific gravity juice[1]	1.043	1.043	1.045	1.046	1.046	1.045	1.044	1.0445
Weight juice (gm.)	142.89	165.83	167.20	192.46	183.67	197.81	209.63	179.90
Rind (%[2])	26.43	25.03	24.71	24.88	27.98	26.48	26.04	25.96
Rag (%[2])	23.76	22.28	20.92	18.13	18.87	19.51	17.78	20.02
Juice (%[2])	42.40	45.62	46.63	47.23	44.85	46.85	41.92	46.30

[1]Based on temp. of $\frac{17.5^\circ\text{ C.}}{17.5^\circ\text{ C.}}$

[2]By weight.

Table 18a. Chemical analyses of fruits from trees 10 years old

(Plat Y—averages on 30-fruit sample, 1934-35.)

Determination	Oct. 25	Nov. 8	Nov. 22	Dec. 13	Dec. 31	Jan. 5	Feb. 6	Av.
Soluble solids (degrees Brix)	10.84	10.97	10.98	11.15	11.11	11.05	10.99	11.01
Citric acid anhydrous (%)	1.64	1.60	1.54	1.55	1.44	1.41	1.32	1.50
Brix to acid ratio	6.61	6.86	7.13	7.19	7.72	7.84	8.32	7.38
Invert sugar (%[1])	4.44	4.34	4.25	4.15	4.09	4.31	4.45	4.29
Sucrose (%[1])	2.44	2.71	2.64	2.76	3.05	2.83	2.56	2.71
Total sugars (%[1])	6.88	7.05	6.89	6.91	7.14	7.14	7.01	7.00
Amino acid titra. as N (%[1])	....	....	0.0240	0.0223	0.0189	0.0220	0.0217	0.0217
pH[1]	3.15	3.20	3.18	3.20	3.20	3.25	3.40	3.22
Buffer index[1]	1.073	1.013	1.106	1.013	1.111	1.176	0.909	1.057
Taste*[1]	A	SS-S	T	T-SS	T	S	SS-S	T-SS
	NB	VSB	NB	NB	NB	NB	NB	NB
Invert sugar to acid[1] (ratio)	2.71	2.71	2.76	2.68	2.84	3.06	3.37	2.86
Sucrose to acid[1] (ratio)	1.49	1.69	1.71	1.79	2.12	2.01	1.94	1.81
Total sugars to acid[1] (ratio)	4.20	4.41	4.47	4.46	4.96	5.06	5.31	4.63
Invert sugar to sucrose[1] (ratio)	1.82	1.60	1.61	1.50	1.34	1.52	1.58	1.58
Citric acid anhydrous (%[2])	15.13	14.58	14.02	13.90	12.96	12.76	12.01	13.62
Invert sugar (%[2])	40.95	39.56	38.70	37.22	36.81	39.00	40.49	38.96
Sucrose (%[2])	22.50	24.70	24.04	24.75	27.45	25.61	23.23	24.61
Total sugars (%[2])	63.45	64.26	62.74	61.97	64.26	64.61	63.72	63.57
Amino acid titration as N (%[2])	....	....	0.218	0.200	0.170	0.199	0.197	0.196

[1]On wet basis.
[2]On dry basis.
*A-acid, SA-slightly acid, T-tart,
SS-slightly sweet, S-sweet,
B-bitter, VSB-very slightly bitter,
NB-non-bitter.

Table 18b. Chemical analyses of fruits from trees 15 years old

(Plat 35—averages on 30-fruit sample, 1934-35.)

Determination	Oct. 22	Nov. 6	Nov. 19	Dec. 4	Dec. 21	Jan. 7	Jan. 29	Av.
Soluble solids (degrees Brix)	10.79	10.82	11.11	11.42	11.45	11.21	11.05	11.12
Citric acid anhydrous (%)	1.65	1.50	1.53	1.50	1.49	1.44	1.30	1.48
Brix to acid ratio	6.54	7.21	7.26	7.61	7.68	7.78	8.50	7.51
Invert sugar (%[1])	4.31	4.51	4.52	4.61	4.64	4.61	4.77	4.56
Sucrose (%[1])	2.58	2.60	2.47	2.73	2.73	2.66	2.62	2.62
Total sugars (%[1])	6.89	7.11	6.99	7.34	7.37	7.27	7.39	7.19
Amino acid titra. as N (%[1])	....	....	0.0242	0.0204	0.0229	0.0210	0.0239	0.0224
pH[1]	3.10	3.20	3.10	3.10	3.10	3.20	3.40	3.17
Buffer index[1]	1.014	1.140	1.140	1.140	1.140	1.111	0.909	1.084
Taste*[1]	A	T-SS	T-A	T	SS-S	SS-S	SS-S	T-SS
	B	VSB	NB	NB	NB	NB	NB	VSB-NB
Invert sugar to acid[1] (ratio)	2.61	3.01	2.95	3.07	3.11	3.25	3.67	3.08
Sucrose to acid[1] (ratio)	1.56	1.73	1.61	1.82	1.83	2.17	2.02	1.77
Total sugars to acid[1] (ratio)	4.17	4.74	4.57	4.89	4.95	5.05	5.68	4.86
Invert sugar to sucrose[1] (ratio)	1.67	1.73	1.83	1.65	1.70	1.32	1.82	1.74
Citric acid anhydrous (%[2])	15.29	13.86	13.77	13.13	13.01	12.84	11.76	13.88
Invert sugar (%[2])	39.94	41.68	40.68	40.37	40.52	41.12	43.17	41.06
Sucrose (%[2])	23.91	24.02	21.23	23.90	23.84	23.73	23.71	23.47
Total sugars (%[2])	63.85	65.70	61.91	64.27	64.36	64.85	66.88	64.54
Amino acid titra. as N (%[2])	....	....	0.218	0.179	0.200	0.187	0.216	0.200

[1]On wet basis.
[2]On dry basis.
*A-acid, SA-slightly acid, T-tart,
SS-slightly sweet, S-sweet,
B-bitter, VSB-very slightly bitter,
NB-non-bitter.

Although the analyses of samples from the two plats were not made on the same dates, the time elapsing between analyses was relatively short, and it is believed that very little error is incurred by comparing the separate dates (Tables 17a, 17b, 18a, and 18b). The Brix readings on both plats were above the minimum requirement of 10 on the first dates analyzed (Figure 7). After the first readings in November, the Brix readings from the older trees remained higher than those from the younger trees. The general trend of the Brix on both plats was upward until the middle of December and downward after that time.

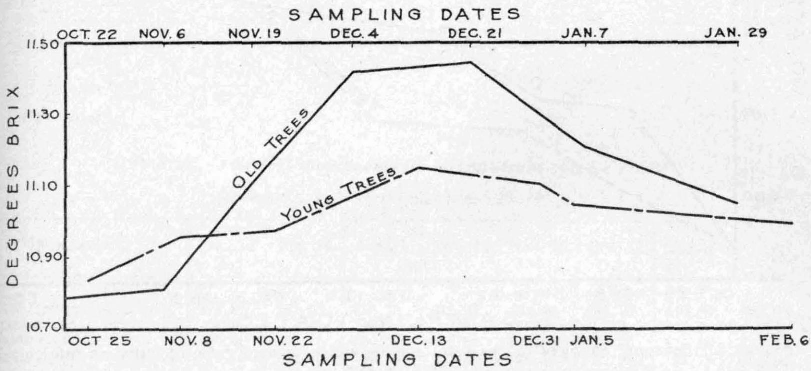

FIGURE 7. Seasonal changes in the total soluble solids of juice as influenced by tree age.

The Brix to acid ratios of both plats were below the minimum requirement of 7 : 1 on the first dates analyzed (Figure 8). On the second date and thereafter the fruit from the older trees passed the requirements. The fruit from the younger trees did not reach the requirement until the third date analyzed. With the exception of one date in January, the ratio from the old tree plat was consistently higher than that from the young tree plat. It may be concluded from these data that the fruit from the older trees matured first and was of relatively higher maturity throughout the test.

Invert sugar in the fruit from Plat 35 (old trees) showed a general upward seasonal trend, whereas it showed a downward trend in the fruit from Plat Y (young trees) until the latter part of the season and then an upward trend. The percentage of sucrose was erratic and showed no definite seasonal trend. Total sugars in fruit from Plat 35, though somewhat variable, showed an upward trend, whereas fruit from Plat Y showed no definite seasonal trend. The amino acid titrations were quite variable with no trend shown. The pH showed a rather indefinite but slightly upward trend. The buffer indexes were approximately constant until near the end of the season when they decreased. The ratios of invert sugar to acid, sucrose to acid, and total sugars to acid, though somewhat variable, showed an upward trend. There was no definite trend in the ratio of invert sugar to sucrose. The bitterness disappeared from the fruit from the old-tree plat

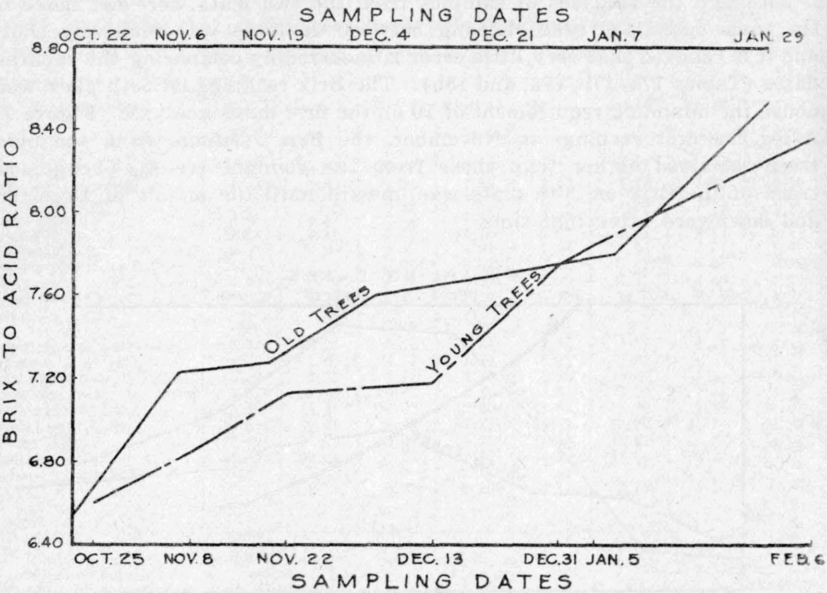

FIGURE 8. Seasonal changes in the total soluble solids to acid ratio of juice as influenced by tree age.

on November 19. Fruit from the young-tree plat, though not showing bitterness on the first date, was slightly bitter on the second date. The bitterness disappeared from this fruit before November 22. The acidity, as recorded by taste, tended to become less as the season advanced, although there was a variation in tartness during the latter part of the test.

SEASONAL CHANGES IN FRUIT FROM VARIOUS LOCATIONS

Physical Measurements

Plats designated as Alamo, La Feria, Mission, and Engelman were the ones used in this study for the 1935-36 season (see Table 1 for the location of these plats). The results of Plat Alamo are based on three determinations on the dates specified and represent the average of the individual measurements of 90 fruits (Table 19). Fruit from this plat was harvested by mistake before the work planned was completed; hence only three readings could be taken. The results of the other three plats are based on seven determinations on the dates specified and represent the averages of the individual measurements of 210 fruits (Tables 20, 21, and 22). In order to facilitate interpretation, the results from all plats are expressed in per cent by weight.

Table 19. Physical measurements of fruit from plat Alamo

(Averages on 30-fruit sample, 1935-36.)

Determination	Oct. 18	Oct. 24	Nov. 1	Av.
Weight fruit (gm.)	406.20	406.06	375.76	396.00
Thickness rind (mm.)	7.6	7.9	7.3	7.6
Weight rind (gm.)	110.33	110.46	104.09	108.29
Weight rag (gm.)	100.93	108.40	86.60	98.64
Volume juice (cc.)	168.80	163.33	174.16	168.76
Specific gravity juice[1]	1.039	1.039	1.039	1.039
Weight juice (gm.)	175.38	169.69	180.95	175.34
Rind (%[2])	27.16	27.20	27.91	27.34
Rag (%[2])	24.84	26.69	23.04	24.90
Juice (%[2])	43.17	41.78	48.15	44.27

[1]Based on temp. of $\frac{17.5° C.}{17.5° C.}$

[2]By weight.

Table 20. Physical measurements of fruit from plat La Feria

(Averages on 30-fruit sample, 1935-36.)

Determination	Oct. 18	Oct. 24	Nov. 1	Nov. 14	Nov. 25	Dec. 13	Jan. 6	Av.
Weight fruit (gm.)	373.96	393.63	408.23	413.93	448.46	404.83	450.23	413.32
Thickness rind (mm.)	7.2	7.1	7.1	7.1	7.4	7.0	7.4	7.18
Weight rind (gm.)	100.40	103.16	109.03	106.30	122.26	106.30	124.13	110.22
Weight rag (gm.)	91.73	106.06	102.50	100.30	98.50	82.63	83.73	95.06
Volume juice (cc.)	153.13	160.40	168.86	184.23	206.56	195.23	216.87	183.61
Specific gravity juice[1]	1.040	1.040	1.040	1.040	1.040	1.040	1.040	1.040
Weight juice (gm.)	159.25	166.81	175.61	191.59	214.82	203 03	225.54	190.95
Rind (%[2])	26.84	26.20	26.70	25.68	27.26	26.25	27.57	26.66
Rag (%[2])	24.52	26.94	25.10	24.23	21.96	20.41	18.59	22.99
Juice (%[2])	42.58	42.37	43.01	46.26	47.90	50.15	50.09	46.19

[1]Based on temp. of $\frac{17.5° C.}{17.5° C.}$

[2]By weight.

Table 21. Physical measurements of fruit from plat Mission

(Averages on 30-fruit sample, 1935-36.)

Determination	Oct. 14	Oct. 21	Oct. 28	Nov. 12	Nov. 22	Dec. 9	Jan. 2	Av.
Weight fruit (gm.)	310.15	306.13	317.23	326.33	356.73	374.26	365.90	336.67
Thickness rind (mm.)	10.4	9.4	9.5	8.6	8.7	8.9	8.6	9.15
Weight rind (gm.)	115.96	105.70	109.86	110.20	111.30	119.86	118.50	113.05
Weight rag (gm.)	84.93	85.43	86.60	83.60	84.63	76.23	71.00	81.77
Volume juice (cc.)	99.53	91.93	99.43	118.66	134.33	153.10	153.10	121.44
Specific gravity juice[1]	1.045	1.043	1.043	1.042	1.042	1.042	1.043	1.042
Weight juice (gm.)	104.00	95.88	103.70	123.64	139.97	159.53	159.68	126.54
Rind (%[2])	37.38	34.52	34.63	33.76	31.20	32.02	32.38	33.57
Rag (%[2])	27.38	27.90	27.29	25.61	23.72	20.36	19.40	24.28
Juice (%[2])	33.53	31.32	32.68	37.88	39.23	42.62	43.64	37.58

[1]Based on temp. of $\frac{17.5° C.}{17.5° C.}$

[2]By weight.

Table 22. Physical measurements of fruit from plat Engelman

(Averages on 30-fruit sample, 1935-36.)

Determination	Oct. 14	Oct. 21	Oct. 28	Nov. 12	Nov. 22	Dec. 9	Jan. 2	Av.
Weight fruit (gm.)	354.20	350.53	366.23	374.23	376.10	402.46	387.53	373.04
Thickness rind (mm.)	7.5	7.4	7.7	7.0	7.2	7.5	7.3	7.37
Weight rind (gm.)	100.06	99.93	107.66	103.10	105.03	111.46	107.47	104.95
Weight rag (gm.)	72.76	82.13	83.00	82.50	77.73	75.63	67.60	77.33
Volume juice (cc.)	145.66	143.00	151.83	169.63	174.10	193.30	191.10	166.94
Specific gravity juice[1]	1.040	1.040	1.043	1.039	1.039	1.039	1.039	1.0398
Weight juice (gm.)	151.48	148.72	158.35	176.24	180.88	200.83	198.55	173.58
Rind (%[2])	28.24	28.50	29.39	27.54	27.92	27.69	27.73	28.13
Rag (%[2])	20.54	23.43	22.66	22.04	20.66	18.79	17.44	20.72
Juice (%[2])	42.76	42.42	43.23	47.09	48.09	49.00	51.23	46.53

[1]Based on temp. of $\frac{17.5° \text{ C.}}{17.5° \text{ C.}}$

[2]By weight.

The seasonal average of the rind ranged from 26.66% for La Feria to 33.57% for Mission. The rag ranged from 20.72% for Engelman to 24.90% for Alamo. The juice ranged from 37.58% for Mission to 46.53% for Engelman. It will be noted that the La Feria plat, which received no irrigation, had the least rind and a high content of juice, which is in agreement with the irrigation tests previously discussed. The Mission plat showed the greatest rind and the least juice. This was to be expected since this plat bloomed two months later than the others and consequently was not as far advanced.

The proportion of rind was relatively constant with the exception of fruit from Plat Mission (Figure 9). This fruit had a consistently thick rind while that from Plat La Feria a consistently thin rind throughout the test.

The general trend of the percentage of rag was upward on all plats from the first to the second dates, but downward thereafter (Figure 10). With the exception of one reading in December, fruit from Plat Mission had a consistently higher proportion of rag than fruit from the other plats. The proportion of rag of fruit from Plat Engelman was consistently lower than that of the other plats.

The trend of the juice content was downward from the first to the second dates but definitely upward thereafter throughout the test on all plats (Figure 11). Plat Mission shows a consistently lower percentage of juice than the other plats. Plats La Feria and Engelman show relatively little difference in amount of juice throughout the season.

The graphs suggest that a correlation exists between the decrease in rag and the increase in juice; consequently the data for rag and juice for each date on all four of the above mentioned plats were used in this study, giving 24 paired comparisons. It was found that the mean value of the rag was 23.064% with a standard deviation of 3.111. The mean value of the juice was 43.378% with a standard deviation of 5.473. The correlation coefficient, (r), was —0.751. Since there were 24 paired comparisons and two variables, there were 22 degrees of freedom. By the use of

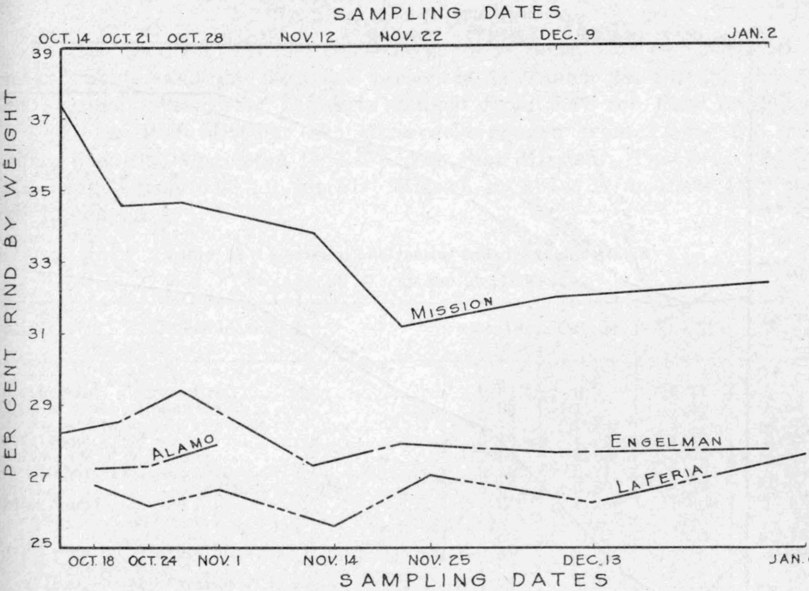

FIGURE 9. Seasonal changes in the per cent of age of rind from various locations in the Lower Rio Grande Valley.

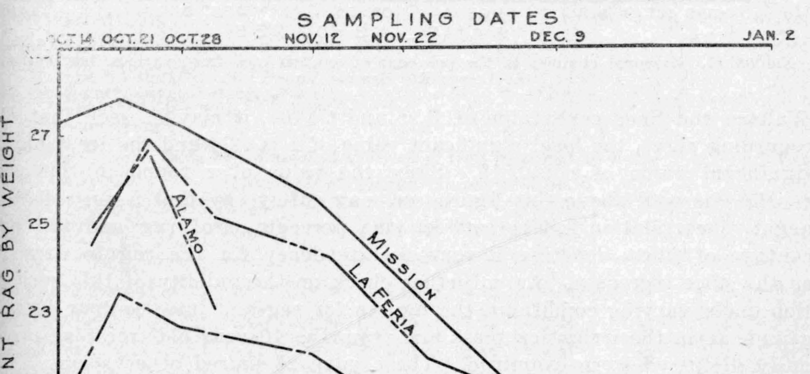

FIGURE 10. Seasonal changes in the per cent of age of rag from various locations in the Lower Rio Grande Valley.

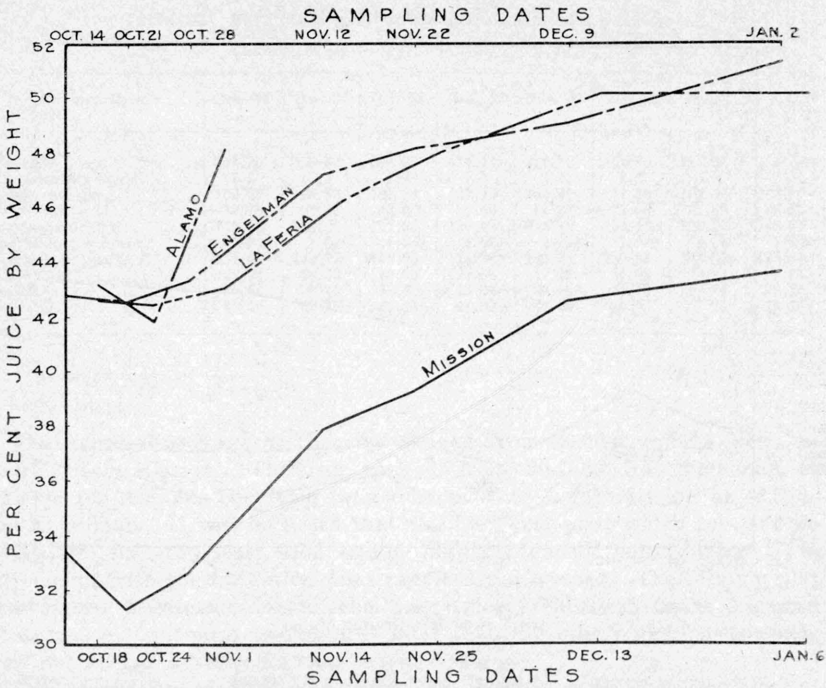

FIGURE 11. Seasonal changes in the per cent of age of juice from various locations in the Lower Rio Grande Valley.

Wallace and Snedecor's table of R, r and t (16), it may be seen that disregarding signs, the least significant value of r is .404 and the least highly significant value of r is .515. Since the value of r found in this case (—.751) is well above this figure, we may safely say that a very definite negative correlation exists between the percentage of rag and the percentage of juice, denoting a very real tendency for the rag to decrease as the juice increases. As a further check on the validity of this correlation under varying conditions, the figures for rag and juice content of each sample from the irrigation plats and from the 10 year old tree plat previously discussed were examined. These gave 28 paired observations. The mean value for the rag was 19.67% with a standard deviation of 2.126. The mean value for the juice was 46.73% with a standard deviation of 2.857. The correlation coefficient was —0.662. With 28 paired comparisons there were 26 degrees of freedom. According to Wallace and Snedecor's table the least significant value of r is .374, and the least highly significant value is .478. Since the correlation coefficient of —0.662 is well above the latter figure and is negative, it is in agreement with the other correlation study.

Chemical Determinations

The plats used for this test were the same as those used for the physical measurements, and the data are presented in Tables 23, 24, 25, and 26. The seasonal average of the Brix ranged from 9.47 for Plat Engelman to 10.65 for Plat Mission. The citric acid ranged from 1.34% for Plat Alamo and Plat Engelman to 1.75% for Plat Mission. The Brix to acid ratio ranged from 6.08 : 1 for Plat Mission to 7.37 : 1 for Plats La Feria and Engelman.

Table 23. Chemical analyses of fruit from plat Alamo

(Averages on 30-fruit sample, 1935-36.)

Determination	Oct. 18	Oct. 24	Nov. 1	Av.
Soluble solids (degrees Brix)	9.81	9.77	9.71	9.76
Citric acid anhydrous (%)	1.38	1.35	1.30	1.34
Brix to acid ratio	7.11	7.24	7.47	7.28
Invert sugar[1] (%)	3.86	3.98	4.13	3.99
Sucrose[1] (%)	2.68	2.63	2.56	2.62
Total sugars[1] (%)	6.54	6.61	6.69	6.61
pH[1]	3.60	3.60	3.80	3.67
Buffer index[1]	1.666	1.250	1.000	1.305
Taste*[1]	VSA NB	T-SS NB	SA NB	T-SS NB
Invert sugar to acid[1] (ratio)	2.80	2.95	3.18	2.98
Sucrose to acid[1] (ratio)	1.94	1.95	1.97	1.96
Total sugars to acid[1] (ratio)	4.74	4.90	5.15	4.93
Invert sugar to sucrose[1] (ratio)	1.44	1.51	1.61	1.52
Citric acid anhydrous (%[2])	14.07	13.82	13.39	13.76
Invert sugar (%[2])	39.35	40.74	42.53	40.87
Sucrose (%[2])	27.32	26.92	24.36	26.87
Total sugars (%[2])	66.67	67.66	68.89	67.74

[1]On wet basis. [2]On dry basis.
*A-acid, SA-slightly acid, T-tart, SS-slightly sweet, S-sweet, B-bitter, SB-slightly bitter, VSB-very slightly bitter, NB-non-bitter.

Table 24. Chemical analyses of fruit from plat La Feria

(Averages on 30-fruit sample, 1935-36.)

Determination	Oct. 18	Oct. 24	Nov. 1	Nov. 14	Nov. 25	Dec. 13	Jan. 6	Av.
Soluble solids (degrees Brix)	9.91	9.95	9.94	9.95	10.05	9.98	9.85	9.95
Citric acid anhydrous (%)	1.45	1.43	1.41	1.34	1.30	1.30	1.25	1.35
Brix to acid ratio	6.83	6.96	7.05	7.42	7.73	7.68	7.88	7.37
Invert sugar[1] (%)	3.96	4.00	3.94	4.06	4.03	4.10	4.06	4.02
Sucrose[1] (%)	2.61	2.64	2.81	2.83	2.91	2.88	2.90	2.80
Total sugars[1] (%)	6.57	6.64	6.75	6.89	6.94	6.98	6.96	6.82
pH[1]	3.50	3.40	3.90	3.30	3.50	3.50	3.60	3.53
Buffer index[1]	1.333	1.666	0.786	1.250	1.111	1.428	1.000	1.225
Taste*[1]	A SB	A VSB	T NB	A-T NB	T-SS NB	T-SS NB	SS NB	T-VSB NB
Invert sugar to acid[1] (ratio)	2.73	2.79	2.79	3.03	3.10	3.15	3.25	2.98
Sucrose to acid[1] (ratio)	1.80	1.84	1.99	2.11	2.24	2.22	2.32	2.07
Total sugars to acid[1] (ratio)	4.53	4.64	4.79	5.14	5.34	5.37	5.57	5.05
Invert sugar to sucrose[1] (ratio)	1.52	1.52	1.40	1.43	1.38	1.42	1.40	1.44
Citric acid anhydrous (%[2])	14.63	14.37	14.18	13.47	12.94	13.03	12.69	13.61
Invert sugar (%[2])	39.96	40.20	39.64	40.80	40.10	41.08	41.22	40.43
Sucrose (%[2])	26.34	26.53	28.27	28.44	28.96	28.85	29.44	28.12
Total sugars (%[2])	66.30	66.73	67.91	69.24	69.06	69.93	70.66	68.55

[1]On wet basis. [2]On dry basis.
*A-acid, SA-slightly acid, T-tart, SS-slightly sweet, S-sweet, B-bitter, SB-slightly bitter, VSB-very slightly bitter, NB-non-bitter.

Table 25. Chemical analyses of fruit from plat Mission

(Averages on 30-fruit sample, 1935-36)

Determination	Oct. 14	Oct. 21	Oct. 28	Nov. 12	Nov. 22	Dec. 9	Jan. 2	Av.
Soluble solids (degrees Brix)	11.02	10.72	10.58	10.50	10.55	10.57	10.63	10.65
Citric acid anhydrous (%)	1.89	1.89	1.93	1.72	1.67	1.60	1.58	1.75
Brix to acid ratio	5.83	5.67	5.48	6.10	6.32	6.61	6.73	6.08
Invert sugar[1] (%)	3.11	3.84	3.79	3.82	3.80	3.83	3.70	3.70
Sucrose[1] (%)	2.56	2.96	2.85	2.92	3.05	3.23	3.35	2.99
Total sugars[1] (%)	5.67	6.80	6.64	6.74	6.85	7.06	7.05	6.69
pH[1]	3.50	3.40	3.60	3.75	3.90	3.95	3.80	3.70
Buffer index[1]	1.250	1.428	2.500	0.952	1.111	1.176	1.666	1.440
Taste*[1]	A B	A VSB	A SB	A-T NB	A NB	A NB	T NB	T-A VSB-NB
Invert sugar to acid[1] (ratio)	1.65	2.03	1.96	2.22	2.28	2.39	2.34	2.11
Sucrose to acid[1] (ratio)	1.35	1.57	1.48	1.70	1.83	2.02	2.12	1.71
Total sugars to acid[1] (ratio)	3.00	3.60	3.44	3.92	4.10	4.41	4.46	3.82
Invert sugar to sucrose[1] (ratio)	1.21	1.30	1.33	1.31	1.24	1.18	1.10	1.24
Citric acid anhydrous (%[2])	17.15	17.63	18.24	16.48	15.83	15.14	14.86	16.48
Invert sugar (%[2])	28.22	35.82	35.82	36.38	36.02	36.22	34.81	34.76
Sucrose (%[2])	23.23	27.61	26.94	27.81	28.91	30.56	31.51	28.08
Total sugars (%[2])	51.45	63.43	62.76	64.19	64.93	66.78	66.32	63.26

[1]On wet basis. [2]On dry basis.
*A-acid, SA-slightly acid, T-tart, SS-slightly sweet, S-sweet,
B-bitter, SB-slightly bitter, VSB-very slightly bitter, NB-non-bitter.

Table 26. Chemical analyses of fruit from plat Engelman

(Averages on 30-fruit sample, 1935-36.)

Determination	Oct. 14	Oct. 21	Oct. 28	Nov. 12	Nov. 22	Dec. 9	Jan. 2	Av.
Soluble solids (degrees Brix)	9.90	9.85	10.75	9.70	9.65	9.67	9.68	9.88
Citric acid anhydrous (%)	1.46	1.42	1.37	1.32	1.22	1.29	1.28	1.34
Brix to acid ratio	6.78	6.94	7.12	7.35	7.91	7.50	7.56	7.37
Invert sugar[1] (%)	4.02	3.99	3.94	3.94	3.98	3.93	3.83	3.95
Sucrose[1] (%)	2.56	2.59	2.57	2.62	2.60	2.66	2.83	2.63
Total sugars[1] (%)	6.58	6.58	6.51	6.56	6.58	6.59	6.66	6.58
pH[1]	3.50	3.50	3.80	4.00	3.70	4.20	4.05	3.82
Buffer index[1]	2.500	1.052	1.250	0.769	0.909	0.645	1.333	1.207
Taste*[1]	SA VSB	A-SA NB	SA VSB	T NB	T-SS NB	A-T NB	T-SS NB	T VSB-NB
Invert Sugar to acid[1] (ratio)	2.75	2.81	2.88	2.98	3.26	3.05	2.99	2.95
Sucrose to acid[1] (ratio)	1.75	1.82	1.88	1.98	2.13	2.06	2.21	1.96
Total sugars to acid[1] (ratio)	4.51	4.63	4.75	4.97	5.39	5.11	5.20	4.91
Invert sugar to sucrose[1] (ratio)	1.57	1.54	1.53	1.50	1.53	1.48	1.34	1.50
Citric acid anhydrous (%[2])	14.75	14.42	12.74	13.61	12.64	13.34	13.22	13.53
Invert sugar (%[2])	40.61	40.51	36.65	40.62	41.24	40.64	39.57	39.98
Sucrose (%[2])	25.86	26.29	23.86	27.01	26.94	27.51	29.24	26.67
Total sugars (%[2])	66.47	66.80	60.51	67.63	68.18	68.15	68.81	66.65

[1]On wet basis. [2]On dry basis.
*A-acid, SA-slightly acid, T-tart, SS-slightly sweet, S-sweet,
B-bitter, SB-slightly bitter, VSB-very slightly bitter, NB-non-bitter.

The Brix of fruit from Plat Mission was consistently higher than that of the other plats (Figure 12). Plat Alamo shows the lowest Brix of the test for the period prior to November 1. The general trend of the Brix for all plats was rather erratic and was approximately constant. The Brix readings of Plat Mission were above 10° throughout the test. All other plats showed a Brix reading between 9° and 10° throughout the test.

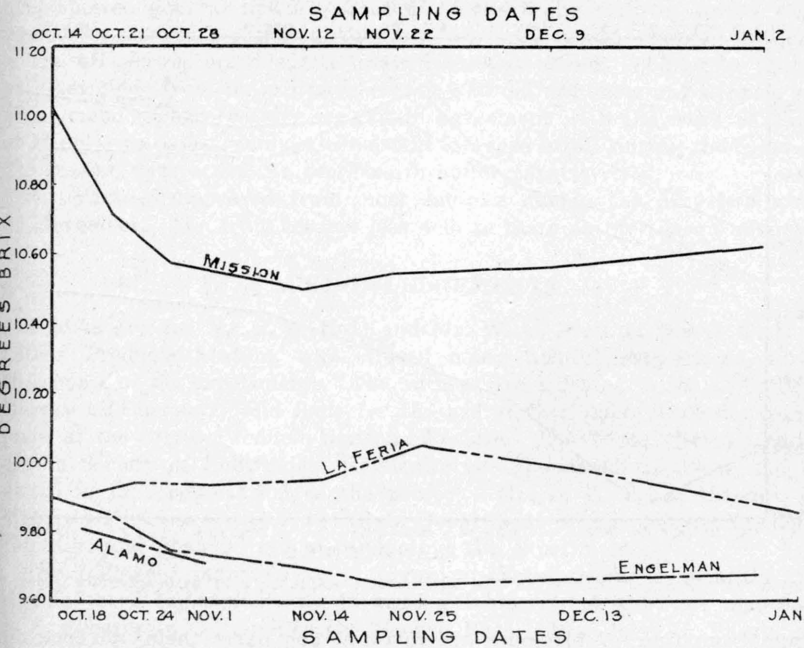

FIGURE 12. Seasonal changes in the total soluble solids of juice from various locations in the Lower Rio Grande Valley.

The Brix to acid ratio of the fruit from Plat Mission was consistently lower than that of the other plats (Figure 13). Plat Alamo had the highest ratio during the first part of the season. Plats La Feria and Engelman were relatively close together in ratio. Although Plat Mission had a Brix above 10° throughout the test, the ratio did not reach the required 7 : 1 during the season. The other plats with a Brix between 9 and 10 are required to have a ratio of 7.2 : 1 in order to pass the maturity requirements. Plat Alamo reached this requirement on October 24, the second date analyzed. Plats La Feria and Engelman did not reach the required ratio until the fourth date analyzed, November 12 and 14 respectively. The general seasonal trend of the Brix to acid ratio on all plats was upward. The readings on Plat Alamo showed that fruit to be more mature during the early part of the season than that of any other plat. Fruit from Plat Mission was less mature during this period. Plats La Feria and Engelman matured their fruit at approximately the same time. It should be borne in mind that these plats differed widely in their location, soil type, and orchard management (Table 1). There is an indication that some factor or set of factors exerts more influence on maturity of grapefruit than soil type and cultural practices. Plat Mission, which bloomed two months later than the other plats, had not made up for these two months in maturity by the end of the test. This indicates that factors other than increments

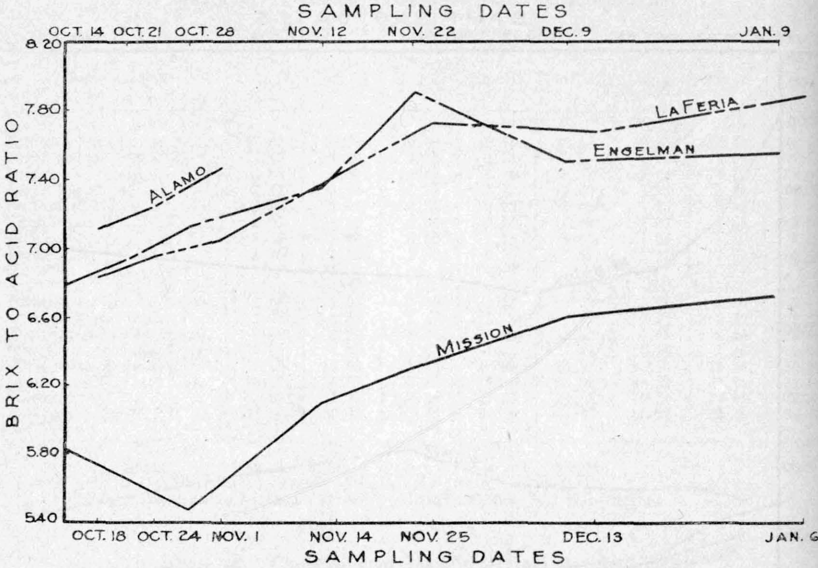

FIGURE 13. Seasonal changes in the total soluble solids to acid ratio of juice from various locations in the Lower Rio Grande Valley.

of age from time of blooming are involved and exert their influence on maturity. These may possibly be soil, climatic conditions such as heat units, or the amount and intensity of sunshine. The Brix readings of all plats were approximately constant, and the Brix to acid ratio showed an upward trend as the season advanced. The trend of the citric acid was downward throughout the test.

Chace and Church (6) showed that the soluble solids in Washington Navel oranges grown in California gradually increases and the acid content gradually decreases during the season, resulting in a rapidly increasing ratio of solids to acid. These same writers have shown that the effect is not so pronounced in grapefruit as in oranges (5). Traub, Fraps, and Friend (14), working in Texas, and Dominguez and Cady (7), working in Puerto Rico, reported that the chemical composition of grapefruit juice becomes relatively stable as the fruit reaches maturity. These writers also reported that the general tendency in grapefruit juice is for the total solids to decrease slightly or remain practically the same throughout the season, and for the acid content to decrease, which results in a gradual increase in the solids to acid ratio. These conclusions are in agreement with the tests herein reported.

Total sugars showed a very slight upward trend throughout the season. Invert sugar did not show any definite upward or downward trend, but remained approximately constant. Sucrose showed a slight upward trend.

The ratios of invert sugar to acid, sucrose to acid, and total sugars to acid showed general upward seasonal trends. The ratio of invert sugar to sucrose showed a rather indefinite downward seasonal trend.

The pH showed an indefinite upward seasonal trend. The buffer indexes as determined from the pH were erratic and did not show any definite seasonal trend. These results are not in agreement with the work of Traub et al (14), since they found a consistent increase in pH during the course of the season, with a definite decrease in buffer capacity.

Bitterness disappeared from most samples during the first two weeks of November. The fruit became less acid to taste as the season advanced.

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SUMMARY AND RECOMMENDATIONS

The quantity of amino acid was erratic throughout the season and did not show any definite seasonal trend.

The human error in tasting is probably too great to be of use in determining the amount of naringen, or degree of bitterness, in grapefruit juice. Attempts to find a simple chemical reaction which would indicate the amount of naringen were not successful.

Brix readings made on non-deaerated juice are sufficiently accurate for practical use in testing for maturity, provided care is exercised to avoid excessive whipping and incorporation of air with the juice.

The composition of the juice from grapefruit is not uniform throughout the fruit, and it is necessary to take all of the juice from both halves of the cut fruit in order to obtain a representative sample of juice for analysis.

Variations were found in the chemical composition of fruit taken from the inside of the tree and from different locations on the outside of the same tree. The error in sampling can be reduced by taking an equal number of fruits from the inside and from each cardinal compass point on the outside of the same tree.

No correlation could be found between maturity or any other factor studied and the readings obtained by means of an "Electrynx."

Soil applications of 9-27-9 fertilizer, iron sulfate, and manure each hastened maturity, whereas sulfur retarded maturity.

The total solids, acid, and solids to acid ratio were affected very slightly by heavy irrigation. Light irrigation seems to deter maturity to a certain extent. Fruit from the lightly irrigated plat had less rind, less rag, and more juice, and fruit from the heavily irrigated plat had more rind and rag and less juice than fruit from the normally irrigated check plat.

Fall spray applications of lime sulfur, soluble nitro-phosphate, zinc-lime, and tank-mix oil had little or no effect on the rate of maturity.

Fruit from fifteen year old trees matured first and was of relatively greater maturity throughout the season than was fruit from ten year old tees. The older trees averaged less rind, more rag, less juice, and a lower specific gravity.

Fruit from widely separated orchards on different soil types and under different soil management matured at approximately the same time. Other factors may exert more influence on maturity of grapefruit than soil type and cultural practices. The various cultural practices exerted more influence on the physical characteristics than on the chemical composition of the fruit.

Other factors may exert more influence on the maturity of the fruit than do increments of age from time of blossoming.

During the two seasons, the percentage of rind was relatively constant. The proportion of rag decreased, and the amount of juice increased. A definite correlation was found between the decrease in the percentage of rag and the increase in the percentage of juice as the seasons advanced.

The seasonal trend of total soluble solids determined as degrees Brix was approximately constant for each plat. The citric acid decreased and the ratio of solids to acid increased as the seasons advanced.

The seasonal trends of invert sugar and of total sugars were upward on all plats. The amount of sucrose remained almost constant. The ratios of invert sugar to acid, sucrose to acid, and total sugars to acid, showed general upward seasonal trends. No definite seasonal changes in the ratio of invert sugar to sucrose could be found. The total sugars and ratio of sugar to acid could be used in determining maturity, but this procedure would require elaborate equipment and special technicians and would have no advantage over the Brix and the Brix to acid ratio.

The pH values increased slightly as the season advanced but the trend was not as definite as it was with some of the other measurements. The buffer indexes, as determined from the pH, did not show any definite seasonal change.

The taste of the fruit changed from acid to sweet as the season advanced. Bitterness disappeared from most samples during November each season.

Based on the studies and observations of the two seasons, a good quality grapefruit of full maturity should be characterized by a relatively thin rind, regular segments, a large volume of juice, tender flesh, absence of bitterness, and a blending of solids to acid to give a tart to sweet taste.

The total soluble solids content, as determined in degrees Brix, and the solids to acid ratio, in conjunction with a volume of juice requirement, appear to be the most practical and the best measures of grapefruit maturity found thus far.

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