
Oregon Agricultural College Experiment Station

A Study of Variation in Apples During the Growing Season

BY

W. E. WHITEHOUSE



CORVALLIS, OREGON

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A STUDY OF VARIATION IN APPLES DURING THE GROWING SEASON

By W. E. Whitehouse.

Oregon Agricultural College Experiment Station.

Introduction.

Until comparatively recent years little study has been made of the development of individual fruits on the tree during the growing season. Much attention has been devoted to a consideration of the influence of various factors upon the growth of the tree, upon its flowering, upon the setting of its fruit, and upon the whole crop that it produces. In other words, the tree or vine has been taken as a unit; and we know comparatively little about how the individual fruit grows. Interest in the individual fruit has been limited largely to the part it plays in total yield and average grade and quality. Yet without doubt, its various stages of growth represent a life-history of interest and importance to the grower. Shaw¹ has made a study of the variation in size and form of apples growing in different parts of the tree, and on different trees. He finds that some trees show "a fairly constant tendency to produce apples larger or smaller than the average; others fluctuate from season to season. Ben Davis apples from the upper south quarters of the trees run constantly larger than those from the other parts; those from the opposite quarters were generally smallest." Continuing the investigation through a number of seasons, some indication was found of a relationship between size and the average summer temperature. Likewise, "some trees showed quite constant individuality in form of fruit, while others were variable. There seems to be no strong evidence that individuality in size and form are to be found in the same tree. The apples from the upper south parts of the trees, which were largest, were also constantly the most flattened. There is a pretty constant relationship between the form of the apple and the temperature for a period following bloom; the cooler the period, the more elongated the apple." Riviere and Baillache² have found that in the case of pears there are more or less definite growth periods for the developing fruit, winter and many fall varieties making their main increase in size just previous to the time for picking, and summer and some fall varieties making their main increase in size toward the middle of their vegetable life. This seems to be quite independent of cultural or climatic conditions.

1. Shaw Repts. Mass. Expt Sta.: 22, Pt. I. (1910), P. 194; 23, Pt. I. (1911), P. 177; Bulletin No. 149 (1914).

2. In *Revue Horticole*. Vol. 80. p. 53 (1908).

Object of This Investigation.

The object of this investigation has been to determine whether there are more or less definite periods when apples under Oregon conditions make their main increase in bulk and other periods when their characteristic color markings are developed; or whether increases in size and color are both quite uniform throughout the growing season. Do individual fruits that for one reason or another are larger than their neighbors early in the season, maintain this lead during the summer and at maturity? Is the tendency for such differences to become intensified or suppressed? Do fruits showing peculiarities of shape early in the season, show the same peculiarities at maturity, and are such peculiarities more or less pronounced? The answers to these and closely related questions, especially when given consideration along with environmental conditions, should afford a better understanding of the practice of thinning fruit and of the principles underlying it.

Methods

The method employed to determine size and form of fruit was to record the largest transverse and longitudinal diameters of each individual fruit every two weeks throughout the growing season, beginning June 25 (1914). These measurements were made with vernier calipers reading to the closest tenth of a millimeter. The "form index" for the shape of each apple is obtained by dividing its transverse by its longitudinal diameter. Thinking it possible that increases in longitudinal and transverse diameters might not afford a true index to the increase in weight of the fruit, average fruits were taken at intervals from each of the trees under observation, weighed, and curves plotted, to serve as a check.

No exact method that would be practicable for determining the amount of color possessed by the individual fruits could be found. The method employed was to estimate, every two weeks, the percentage of the surface of the fruit covered by its overlying color. Though this method is certain to have resulted in rather large errors for individual fruits, it is believed that the average amount of color estimated for the fruits of a certain tree on a certain date is approximately correct.

Records were kept of the temperature, rainfall, and approximate amount and intensity of sunshine, throughout the growing period, so that it might be possible to correlate any marked variation in rate of growth or color development with weather conditions.

Materials

The investigation was carried on in the orchard of the Oregon Agricultural College, Corvallis, Oregon. The trees are approximately 25 years old, moderately thrifty and healthy. The soil is a heavy clay loam. The orchard has been afforded clean cultivation early in the

season and then seeded with a cover crop in late summer for a number of years.

The varieties selected were Fameuse, Grimes, Oldenburg and Tompkins King—a list including summer, fall and early winter apples; some averaging below medium and some above medium size, one being a variety that ordinarily does not show any overlying color, the others usually developing considerable overlying color. It will also be noted that these four varieties represent four distinct pomological groups of apples, the Fameuse, Reinette, Oldenburg, and King respectively. Immediately after the normal June drop, the fruits on these trees, which had set quite heavily, were thinned to a single specimen to the spur. All the fruits were removed from some of the spurs, so that the trees bore just about a normal crop. Originally 100 apples on each tree were selected for study and the spurs bearing them marked with metal-rimmed tags. The selection included specimens well distributed throughout the tree, some being quite completely shaded, others being well exposed to the sun. Accidents befell a number of the fruits under observation so that of the 400 selected at the start, only 293 reached maturity.

Weather conditions during the season of 1914 were normal or nearly so. The season was perhaps slightly drier, and summer temperatures ranged slightly higher than usual, causing fruits of nearly all kinds to mature from a week to ten days earlier than customary. June, July, and August were characterized by bright sunny weather and very little cloudiness. Fall rains commenced early in September, and there were a number of cloudy days during the ripening season of the three later varieties.

Presentation of Data

It does not seem practicable to present in detail all of the data collected in this investigation. Small portions of some of the detailed tables and summary tables will serve to show the methods employed in bringing the data together and, in a way, will also indicate the relative amount of data collected.

Table I.—Showing Length Measurements in Centimeters for Grimes.

Apple No.	June 14	June 28	July 12	July 26	August 9	August 23	Sept. 6	Sept. 20
1.....	3.33	3.96	4.43	4.99	5.45	5.74	6.13	6.23
2.....	3.45	4.03	4.56	5.17	5.62	6.07	6.38	6.55
3.....	2.96	3.50	4.02	4.50	4.97	5.29	5.67	5.88
5.....	3.08	3.69	4.20	4.56	5.09	5.28	5.66	5.95
7.....	2.90	3.40	4.00	4.53	4.98	5.42	5.71	5.91
8.....	2.44	3.00	3.54	3.98	4.37	4.67	4.95	5.18
11.....	3.17	3.79	4.39	4.95	5.48	5.82	6.05	6.45
12.....	3.25	3.87	4.52	5.06	5.56	5.95	6.29	6.52
13.....	3.64	4.16	4.78	5.26	5.87	6.34	6.72	6.91
14.....	3.10	3.60	4.32	4.82	5.29	5.68	5.97	6.22

40.....	3.08	3.66	4.39	4.95	5.47	4.74	6.22	6.44
41.....	2.87	3.41	3.98	4.44	4.87	5.28	5.41	5.83
43.....	2.55	3.24	3.75	4.20	4.65	4.95	5.24	5.54
44.....	2.50	2.99	3.65	4.17	4.53	4.85	5.14	5.37
45.....	3.00	3.68	4.09	4.51	5.05	5.38	5.72	5.94
46.....	2.78	3.30	3.88	4.28	4.71	5.07	5.35	5.59
47.....	2.76	3.34	3.87	4.42	4.83	5.20	5.58	5.71
48.....	2.90	3.40	3.98	4.25	4.64	4.97	5.29	5.53
49.....	2.72	3.26	3.88	4.30	4.69	5.07	5.39	5.64
50.....	3.18	3.60	4.28	4.74	5.24	5.54	5.92	6.19
83.....	3.08	3.68	4.32	4.73	5.28	5.59	5.92	6.13
84.....	3.20	3.75	4.33	4.83	5.31	5.68	6.04	6.29
85.....	2.89	3.62	4.16	4.71	5.15	5.52	5.89	6.09
86.....	2.95	3.55	4.19	4.69	5.12	5.58	6.03	6.12
87.....	2.90	3.49	4.07	4.47	4.93	5.22	5.53	5.81
88.....	3.12	3.63	4.19	4.73	5.22	5.59	5.93	6.34
89.....	2.95	3.46	4.05	4.47	5.00	5.25	5.58	5.85
91.....	2.93	3.65	4.07	4.48	4.81	5.15	5.35	5.52
93.....	3.14	3.76	4.27	4.68	5.14	5.40	5.75	5.88
96.....	3.35	3.92	4.53	4.99	5.52	5.81	6.18	6.54
Mean.....	3.006	3.576	4.156	4.629	5.095	5.437	5.767	6.008

Table II.—Showing Diameter Measurements in Centimeters for Grimes.

Apple No.	June 14	June 28	July 12	July 26	August 9	August 23	Sept. 6	Sept. 20
1.....	3.26	3.96	4.74	5.34	5.89	6.25	6.68	6.90
2.....	3.35	4.03	4.88	5.48	6.07	6.56	6.89	7.19
3.....	3.14	3.50	4.48	5.02	5.54	6.00	6.35	6.64
5.....	3.08	3.69	4.36	4.78	5.28	5.59	6.05	6.35
7.....	3.08	3.40	4.34	4.98	5.48	5.85	6.28	6.44
8.....	2.66	3.00	4.04	4.55	5.09	5.47	5.77	6.07
11.....	2.95	3.79	4.54	5.12	5.63	6.06	6.37	6.59
12.....	3.07	3.87	4.52	5.15	5.69	6.07	6.47	6.69
13.....	3.56	4.16	5.13	5.62	6.27	6.69	7.11	7.37
14.....	3.24	3.95	4.73	5.32	5.89	6.28	6.68	6.87
40.....	3.26	3.98	4.74	5.37	5.91	6.29	6.68	6.92
41.....	3.12	3.69	4.53	5.04	5.64	6.01	6.38	6.67
43.....	2.74	3.29	4.00	4.55	5.05	5.44	5.78	6.04
44.....	2.70	3.50	4.18	4.68	5.32	5.67	6.12	6.32
45.....	2.90	3.48	4.20	4.83	5.38	5.72	6.15	6.35
46.....	2.85	3.50	4.22	4.73	5.23	5.65	6.04	6.17
47.....	3.07	3.79	4.49	4.97	5.47	5.79	6.06	6.23
48.....	2.89	3.40	4.10	4.65	5.17	5.54	5.92	6.14
49.....	3.09	3.50	4.34	4.85	5.33	5.75	6.12	6.35
50.....	3.20	3.79	4.53	5.03	5.55	5.97	6.32	6.60
83.....	3.29	4.06	4.79	5.38	5.72	6.25	6.57	6.87
84.....	3.36	3.98	4.67	5.28	5.88	6.29	6.64	6.93
85.....	3.08	3.74	4.44	5.01	5.54	5.84	6.26	6.58
86.....	3.15	3.80	4.55	5.08	5.68	6.05	6.37	6.65
87.....	2.90	3.62	4.28	4.82	5.38	5.75	6.12	6.42
88.....	3.10	3.80	4.54	5.17	5.77	6.02	6.59	6.74
89.....	3.13	3.83	4.35	4.98	5.39	5.77	6.15	6.36
91.....	3.04	3.72	4.34	4.80	5.24	5.59	5.94	6.15
93.....	3.16	3.75	4.43	4.91	5.42	5.73	6.03	6.15
96.....	3.49	4.20	4.91	5.44	5.93	6.32	6.73	6.88
Mean.....	3.097	3.726	4.479	5.031	5.561	5.942	6.321	6.554

Tables I and II bring out the fact clearly that, at least in the case of the Grimes apples growing under the conditions of this experiment, there is a comparatively steady increase in size from the time of the setting of the fruit until full maturity. There is no period of specially rapid growth, like that reported by Riviere and Baillache¹ for pears. This statement is supported by the figures for individual fruits from

(1) Loc. Cit.

time to time through the growing season and by the means for all the fruits. Though at first glance one might infer that as the season progresses increase in size is slightly, but nevertheless steadily, retarded, it must be remembered that the tables present only increases in diameter; and that an increase of a fifth or a tenth of a centimeter late in the summer when the diameter is 5 centimeters, is accompanied by a much greater increase in volume than the same increase in diameter early in the season when the total diameter is only 3 centimeters. Corresponding tables for the other varieties studied point to the same general conclusion. Were seasonal conditions abnormal, different results might be obtained. However, it may be pointed out that since there was not a specially marked increase in size after the first of the fall rains in early September, one should hardly expect to find such increases following rain or irrigation during the growing season.

Table III.—Showing Relative Lengths of Selected Groups of Fameuse Apples at Different Periods in Their Growth.

Apple No.	Rank June 25	Rank July 9	Rank July 23	Rank Aug. 6	Rank Aug. 20	Rank Sept. 3	Rank Sept. 17
72	1	1	4	3	4	6	3
10	2	3	6	4	9	10	4
92	3	2	1	2	3	4	2
54	4	16	15	13	12	12	13
65	5	5	7	9	2	3	8
16	30	29	29	32	32	29	25
24	31(a)	26	19	18	17	14	10
61	32(a)	34	29	27	46	27	33
71	33(a)	28	32	32	28	33	31
87	34(a)	31	27	34	25	32	30
15	69	69	71	71	71	70	68(b)
28	70	71	70	70	70	71	71
22	71	70	68	65	64	68	68(b)
20	72	72	72	72	72	72	72
9	73	73	73	73	73	73	73

a. Tied for 30th place

b. Tied for 68th place

Table IV.—Showing Relative Diameters of Selected Groups, (the same groups listed in Table III.) of Fameuse Apples at Different Periods in Their Growth

Apple No.	Rank June 25	Rank July 9	Rank July 23	Rank Aug. 6	Rank Aug. 20	Rank Sept. 3	Rank Sept. 17
72	17(a)	25	21	28	31	26	32
10	4	3	3	3	3	1	1(c)
92	2	2	2	2	2	3	1(c)
54	17(a)	21	25	25	21	24	23
65							
16	38	46	45	43	40	41	38
24	9	8	5	6	5	5	5
61	24	25	21	23	20	22	20
71	12	13	13	15	16	19	13
87	30	34	34	31	36	37	33
15	68	71(b)	72	73	73	72	71
28	64	64	63	63	60	62	63
22	69	69	69	68	67	69	69
20	70	71(b)	71	71(b)	70	70	70
9	71	73	73	71(b)	72	73	72

(a) Tied for 17th place.

(b) Tied for 71st place.

(c) Tied for 1st place.

Table V.—Showing Relative Lengths of Selected Groups of Tompkins King Apples at Different Periods of Growth

Apple No.	Rank June 28	Rank July 12	Rank July 26	Rank Aug. 9	Rank Aug. 23	Rank Sept. 6	Rank Sept. 20
7	1	3	5	6	7	11	10
95	2	2	3	2	2	4	5
11	3	1	1	1	3	5	2
31	4	4	4	3	1	1	1
21	5	5	12	14	11	21	16
33	30	28	30	32	36	34	22
57	31	31	27	43	43	38	37
82	32	28	25	22	19	17	15
25	33	37	38	42	41	41	41
62	34	38	37	41	34	27	28
46	70	70	73	73	73	73	73
43	71	66	66	65	66	65	67
50	72	72	70	71	70	69	72
38	73	73	71	70	69	72	68
12	74	74	74	74	74	74	74

Table VI.—Showing Relative Diameters of Selected Groups (the same groups listed in Table V.) of Tompkins King Apples at Different Periods in Their Growth

Apple No.	Rank June 23	Rank July 12	Rank July 26	Rank Aug. 9	Rank Aug. 23	Rank Sept. 6	Rank Sept. 20
7	24	16	35	25	29	28	37
95	2	10	8	16	8	7	10
11	10	8	7	6	22	25	27
81	3	3	4	2	1	1	1
21	32	29	35	49	35	35	40
33	40	63	42	50	43	44	41
57	32	41	43	36	38	45	45
82	35	36	30	31	31	33	34
25	44	48	55	53	57	49	50
62	47	36	27	32	26	25	24
46	74	74	72	73	72	73	72
43	73	71	71	71	71	71	70
50	69	65	64	61	59	50	51
38	58	45	47	36	38	23	25
12	61	72	74	74	74	74	74

An examination of Tables III - VI brings out a number of interesting facts regarding the manner of growth of Fameuse and Tompkins King apples. The first is that, on the average, individual fruits maintain about the same relation in both transverse and longitudinal diameters (i. e. in size) to other fruits on the same tree throughout the growing season. Barring accident, the fruits that are largest early in the season will be among the largest on the tree at maturity, and those that are smallest early in the season will be among the smallest at harvest. For instance, (of the 73 measured) three of the largest five Fameuse apples June 25 were among the largest five September 17; and three of the smallest five June 25 were among the five smallest September 17. An even more striking instance of the holding of place of individual specimens is the rank of 30, 31, and 33 respectively on September 17 of three Fameuse apples tied for thirty-first place June 25. Of course some fluctuation in the rank of individual fruits in the course of the growing season is to be expected and the tables afford some measures of how great is that fluctuation. It is believed, however, that the tables tend to make such variation appear greater, rather than less, than it really is, because often a difference in reading of only a few tenths of a millimeter lowered or raised the rank of an individual fruit several places. Furthermore, it was practically impossible to measure every fruit at the same place and with the same degree of accuracy each time.

Another point brought out by the tables is that while those fruits comparatively long to start with, remain long, and those comparatively broad, remain broad, great breadth and length sometimes do and sometimes do not go together. This indicates that apples remain fairly constant in form, as compared with each other, throughout the growing season. The form indices furnish further evidence on this question.

It should be mentioned that while for the sake of brevity Tables III-VI present only a small part of the data obtained for Fameuse and Tompkins King, the complete tables for those two varieties, and for Grimes and Oldenburg as well, furnish much additional evidence pointing in the same direction.

Table VII.—Showing Form Index for Fameuse Apples Throughout the Growing Season

	June 12	June 26	July 9	July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 18
	June 12	June 26	July 9	July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 18
	June 12	June 26	July 9	July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 18
	June 12	June 26	July 9	July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 18
	June 12	June 26	July 9	July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 18
1								
2	1.0250	1.0650	1.0875	1.1350	1.1495	1.1550	1.2040	1.1575
3	1.0875	1.0675	1.1350	1.1650	1.1755	1.1725	1.1785	1.1765
4	1.0795	1.1375	1.1625	1.1900	1.1950	1.1975	1.1925	.....
5	1.0950	1.0635	1.1345	1.1575	1.1655	1.1660	1.1825	1.1725
6	1.0925	1.0965	1.1565	1.1710	1.1595	1.1825	1.1660	.....
7	1.1300	1.1120	1.1525	1.1900	1.2255	1.2275	1.2275	1.2225
8	0.9975	1.0825	1.1360	1.1605	1.1495	1.1675	1.1645	1.1625
9	1.0250	1.1500	1.0850	1.0990	1.1260	1.1370	1.1250	.....
10	1.1150	1.1045	1.1625	1.1965	1.2350	1.2350	1.2410	1.2450
11	1.0250	1.1050	1.1425	1.1650	1.1675	1.1950	1.2275	1.1900
12	1.0510	1.0645	1.1050	1.1160	1.1225	1.1320	1.1410	1.1400
13	1.0925	1.1075	1.1310	1.1360	1.1515	1.1810	1.1500	1.2000
14	1.0475	1.0660	1.1000	1.1125	1.1265	1.1215	1.1575	1.1325
15	1.0475	1.0940	1.1225	1.1440	1.1525	1.1475	1.1500	1.1575
16	1.0300	1.0635	1.0900	1.1140	1.1275	1.1475	1.1375	1.1525
17	1.0825	1.0745	1.0915	1.1150	1.1355	1.1325	1.1475	1.1400
18	1.1145	1.1030	1.1700	1.1875	1.2025	1.2360	1.2325	1.2200
19	1.1250	1.1210	1.1910	1.2000	1.2110	1.2045	1.2075	.....
20	1.1435	1.1400	1.1625	1.2100	1.2225	1.2325	1.2165	1.2410
21	1.1295	1.1265	1.1700	1.1965	1.2075	1.2125	1.2335	1.2205
22	1.1110	1.1510	1.1725	1.1875	1.2000	1.2000	1.1810	1.2000
23	1.0800	1.0965	1.1340	1.1360	1.1410	1.1475	1.1650	1.1860
24	1.1210	1.1400	1.1815	1.2075	1.2150	1.2240	1.2210	1.2260
25	1.0725	1.1670	1.1900	1.2050	1.2125	1.2275	1.2300	1.2100
26	1.0125	1.0800	1.0895	1.1245	1.1500	1.1590	1.1625	1.1500
27	1.0665	1.1210	1.1620	1.1725	1.2000	1.1840	1.1945	.....
28	1.0840	1.1155	1.1325	1.1475	1.1950	1.1895	1.1825	1.1935
29	1.1350	1.1425	1.1755	1.1940	1.2025	1.2300	1.2390	1.2335
30	1.0875	1.1545	1.1775	1.1975	1.2040	1.1960	1.1925	1.1850
31	1.0910	1.1450	1.1695	1.1680	1.2025	1.2050	1.1910	1.1925
32	1.0175	1.0300	1.0850	1.1175	1.1325	1.1385	1.1385	1.1385
33	1.0660	1.1510	1.1885	1.1825	1.1825	1.2025	1.1965	1.1860
34	1.1210	1.1190	1.1760	1.1775	1.1860	1.1675	1.1925	.....
35	1.0575	1.0365	1.0335	1.0815	1.1040	1.1040	1.1065	1.1175
36	1.0710	1.0555	1.1095	1.1555	1.1425	1.1425	1.1475	1.1435
37	1.1375	1.1545	1.1925	1.2075	1.2125	1.1925	1.2035	1.2000
38	0.9925	1.1825	1.0400	1.0525	1.0710	1.0875	1.0860	.....
39	1.0725	1.1025	1.1640	1.1800	1.1825	1.1825	1.1775	1.1745
40	1.0195	1.0545	1.0760	1.1110	1.1275	1.1365	1.1425	.....
41	1.0190	1.0770	1.0930	1.1020	1.1300	1.1240	1.1360	.....
42	1.1390	1.1265	1.2200	1.2250	1.2500	1.2175	1.1755	.....
43	1.0770	1.1085	1.1400	1.1625	1.1725	1.1720	1.1640	.....
44	1.0565	1.0950	1.1300	1.1660	1.1600	1.1640	1.1625	1.1585
45	1.0575	1.1050	1.1300	1.1360	1.1475	1.1610	1.1745	.....
46	1.1150	1.0965	1.1550	1.1860	1.1790	1.2000	1.1655	.....
47	1.1165	1.1395	1.1725	1.1900	1.1975	1.2060	1.2075	.....
48	1.1360	1.1150	1.1400	1.1690	1.1775	1.1675	1.1625	1.1375
49	0.9975	1.0260	1.0565	1.0900	1.1510	1.1125	1.1250	.....
50	1.0825	1.1140	1.1600	1.1825	1.1325	1.1625	1.1925	1.1915
51	1.1325	1.1210	1.1690	1.1860	1.1950	1.2025	1.2035	.....
52	1.0505	1.0720	1.1100	1.1225	1.1375	1.1110	1.1245	.....
53	1.0310	1.0395	1.1150	1.1260	1.1275	1.1375	1.1340	1.1225
54	1.0900	1.1500	1.1910	1.2075	1.2200	1.1925	1.1940	1.2075
55	1.0750	1.1180	1.1375	1.1700	1.1845	1.1840	1.1735	.....
56	1.0750	1.1160	1.0975	1.1550	1.1725	1.1700	1.1985	.....
57	1.0000	1.0260	1.1400	1.1075	1.1225	1.1325	1.1310	1.1325

59	1.0725	1.1265	1.1225	1.1620	1.1550	1.1475	1.1525	1.1700
60	1.1140	1.0905	1.1005	1.1495	1.1500	1.1700	1.1860	1.1575
61	1.0950	1.1200	1.1580	1.1725	1.1725	1.2450	1.1775	1.1975
62	1.1140	1.1050	1.1425	1.1915	1.2190	1.2125	1.2000	.....
63	1.0540	1.0835	1.0845	1.1200	1.1075	1.1375	1.1450	1.1375
64	1.0525	1.0845	1.1410	1.1600	1.1825	1.1785	1.1800	1.1925
65	1.0450	1.0475	1.0800	1.0350	1.1140	1.0810	1.0865	1.1175
66	0.9725	1.0525	1.0595	1.1075	1.1075	1.1225	1.1425	.....
67	1.0355	1.1415	1.1160	1.1760	1.1845	1.1870	1.1875	1.1800
68	1.1195	1.1010	1.1200	1.1545	1.1810	1.1710	1.1725	.....
69	1.1500	1.1550	1.1745	1.1835	1.1855	1.2240	1.2375	1.1860
70	1.1155	1.1135	1.1360	1.1560	1.1660	1.1975	1.1900	1.1900
71	0.9625	1.0325	1.1725	1.1910	1.1975	1.1945	1.2025	1.1950
72	0.9855	1.0200	1.0510	1.0825	1.0775	1.0850	1.0925	1.0755
74	1.1000	1.1175	1.1460	1.1640	1.1715	1.1785	1.1820	1.1810
75	1.0160	1.0325	1.0745	1.1250	1.1465	1.1400	1.1375	1.1365
76	1.0710	1.1190	1.1485	1.1500	1.1750	1.1675	1.1460	1.1580
77	1.1595	1.1245	1.1750	1.1815	1.1825	1.1760	1.1645	1.1745
78	1.0940	1.0925	1.1875	1.1550	1.1645	1.1650	1.1675	1.1975
79	1.0525	1.0970	1.1550	1.1740	1.1800	1.1775	1.1825	1.1900
80	1.0715	1.0755	1.1260	1.1650	1.1650	1.1450	1.1275	1.1845
81	1.0000	1.0450	1.1175	1.1360	1.1450	1.1775	1.1610	1.1525
82	1.0175	1.0710	1.0795	1.1075	1.1160	1.1300	1.1425	1.1375
83	1.0370	1.0925	1.1225	1.1075	1.1400	1.1400	1.1400	1.1200
84	1.0395	1.0700	1.1025	1.1330	1.1580	1.1675	1.1540	1.1575
85	1.0300	1.0825	1.1300	1.1695	1.1910	1.1725	1.1875	1.1825
86	1.0395	1.1700	1.1560	1.1670	1.1875	1.1850	1.1700	1.1775
87	1.0795	1.1000	1.1235	1.1400	1.1675	1.1400	1.1375	1.1575
88	1.0625	1.0950	1.1450	1.1400	1.1345	1.1475	1.1435	1.1325
89	1.0945	1.0960	1.1425	1.1450	1.1875	1.1910	1.1775	1.2185
90	1.1065	1.1025	1.1375	1.1320	1.1360	1.1475	1.1525	1.1595
91	1.0995	1.1350	1.1575	1.1500	1.1560	1.1625	1.1945	1.1750
92	1.0690	1.1025	1.1460	1.1500	1.1650	1.1750	1.2075	1.1660
93	1.0640	1.1275	1.1475	1.1 40	1.2075	1.1940	1.240 1/2	1.2025
94	1.0000	1.1375	1.1315	1.1720	1.1725	1.1650	1.1850	1.1785
95	0.9525	1.0140	1.0360	1.0650	1.0675	1.0925	1.1125	1.0925
96	1.1390	1.1040	1.1600	1.1575	1.1900	1.1960	1.2345	1.2525
97	1.0605	1.0900	1.1250	1.1425	1.1665	1.1625	1.1675	1.1675
98	1.0185	1.0770	1.1015	1.1150	1.1400	1.1500	1.1645	1.1645
99	1.1465	1.1825	1.1825	1.1975	1.2025	1.2075	1.2025	.....
100	1.1025	1.1060	1.1775	1.1840	1.1925	1.2060	1.1935	1.1825
Mean	1.0707	1.1085	1.1330	1.1424	1.1536	1.1822	1.1730	1.1899
Standard Deviation	.1458	.1216	.1222	.1179	.1193	.1190	.1101	.1176

(Note: The table is given complete as in the original records. There are blanks for a number of the fruits on the last two dates because of their falling from the trees. The means for the different dates, except the last, are for those apples only that remained on the trees until September 3; the mean for the last date is for those individuals reaching maturity.)

Analysis of the data presented in Table VII indicated that on the average there is a tendency for apples to increase in transverse diameter relatively more rapidly than they do in longitudinal diameter. In other words, they become more oblate as the season progresses. This tendency is most marked in the early part of the growing season. In fact, the table would indicate that after August 20 there was little if any change in relative shape of Fameuse apples. The figures, of course, are for an autumn variety. Similar tables constructed for earlier-maturing varieties, Tompkins King and Oldenburg, indicate that with them permanent shape is reached earlier in the season. For instance, in the case of Oldenburg there was little change in shape after July 7. These statements are in line with conclusions reached by Shaw¹ regarding the importance of the period immediately after blooming in determining the shape of the mature apple.

(1) Loc. Cit.

Another interesting point indicated by Table VII is that as the season progresses there is a tendency for the apples on the tree to become more uniform, rather than more variable, in shape. A fairly accurate measure of this increase in uniformity is afforded by the standard deviation of the form indices upon the different dates of measuring. This tendency is well illustrated by fruits 7, 10, and 71 which were especially elongated June 12, but which were much nearer the mean in shape September 18; and by fruits 36, 69, and 75 which were especially flattened June 12, but which were much nearer the average September 18.

Table VIII.—Showing Color Estimates Through Growing Season.
(Percent of Surface Colored.)

OLDENBURG		FAMEUSE		TOMPKINS KING	
Date	Per Cent	Date	Per Cent	Date	Per Cent
June 9	24.	June 12	22.6	June 14	7.5
24	36.5	25	28.4	28	11.0
July 7	27.1	July 9	26.6	July 12	4.8
27	48.3	23	36.8	26	6.5
Aug 7	53.6	Aug. 6	34.4	Aug. 9	5.9
		20	57.4	23	25.1
		Sept. 3	70.6	Sept.	53.0
		18	93.4	20	83.0

Table VIII presents only the averages of the estimates for the individual fruits on the different dates. Detailed tables for the individual fruits would only take up space and the estimates for any particular specimen would be of limited value, because of their inaccuracy compared with the averages for the entire number. The first point noted in examining this table is that a certain amount of coloring matter is deposited in the skin of the apple early in its vegetative growth. Then for a considerable period there is little apparent increase in this amount. In fact, there is a period when the fruit is about half grown when it seems to be less highly colored than earlier in the season. The explanation of this probably lies in the fact that while the fruit is increasing rapidly in size, there is not a corresponding manufacture and deposition of coloring matter. It is to be doubted if the coloring matter already formed is destroyed or absorbed. The importance of the last few weeks, and even few days, before maturity, in the final coloring of the fruit, is very apparent. Contrary to what is true regarding increase in size, there thus seems to be a fairly definite period for the manufacture and deposition of coloring matter in apples.

Discussion of Results and Summary

The results obtained in this investigation suggest several points of interest to the fruit grower.

If steady, gradual increase in size is normal for the apple, cultural conditions should be such that this steady growth will not be checked. In particular it would seem that tillage should be such as to provide a

constant supply of moisture, for without doubt rate of growth is closely related to moisture supply. Where irrigation is practiced, it would seem unsafe to allow apples to become checked, depending upon later applications of water to force along the fruit and make up for deficiencies earlier in the season. Such practice might result in a specially rapid-growth period, but the evidence indicates that this would be abnormal, rather than normal, if it occurred.

Often in thinning apples it is found convenient to remove the largest individual, or individuals, from the spur because of length of stem or some peculiarity of position. This investigation would lead to the belief that such is not good practice. The rank of an individual among its fellows at the time of thinning is a fairly accurate index to its probable rank at maturity. If experience shows that apples of a particular shape pack more easily in the type of package used, or take better in the market, than those of a different shape, a little bias in that direction can be gained by removing the undesirable shapes at the time of thinning.

A large part of the coloring matter of apples is deposited shortly before picking time. From the viewpoint of securing higher color, it would seem that picking could often be delayed several days to advantage.

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