THE RELATION OF LEAF AREA TO SIZE AND COLOR OF APPLE FRUITS

by

YUN SUH KIM

B. S., Kansas State College of Agriculture
and Applied Science, 1933

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

KANSAS STATE COLLEGE

OF AGRICULTURE AND APPLIED SCIENCE

1934

TABLE OF CONTENTS

INTRODUCTION

The primary purpose of this investigation is to determine the relationship which exists between the leaf area and the size and color of apple fruits under Kansas conditions. It should prove of practical importance to fruit growers in that it shows the desirability of the thinning of fruits in seasons of heavy set soon after the "June drop" or after the fruits are definitely set, in order to increase the proportion of high quality fruit at harvest.

REVIEW OF LITERATURE

The apple trees used in Howe's (10) ringing experiment in 1911 produced 95 per cent of a crop and in 1912 only 43 per cent of a crop per tree. The second year's ringing did not increase the yield. The ringing had no apparent influence on the size, color, and maturity of fruits. The healthy trees suffered no harmful effects, but the weak trees, those lacking vigor and hardiness, failed to survive even a single operation. The leaves on the ringed, weak trees lost their color and fell from the branches four to six weeks earlier than those on ringed, vigorous trees.

The roots on the ringed trees were smaller and not as extensive as those on unringed trees. Ringing for increasing productiveness seems to be too drastic a practice for the good of the trees.

Drinkard and Ingham (6) stated that the time of ringing may vary from May 24 to July 26, depending on the locality and the seasonal conditions. The healing of the ringed wound is hastened if it is coated with paraffin. Ringing can be done without great danger or injury to the trees, providing the proper precautions are used.

In connection with ringing, Wiggans (17) concluded that regardless of the season of ringing, it caused an accumulation of food in the parts above and a decreased amount in parts below. Ringing affected the parts near by, the effect being lessened as the distance increased.

Curtis (4) studied the upward translocation of foods in woody plants of several species, namely: Philadelphus pubescens, Ligustrum ovalifolium and Pyrus malus (Northern Spy, Wealthy, and Rhode Island Greening). He proved that some substances necessary for growth pass upward through the phloem. If the leaves above the ring continue to function, they are able to supply food to the tissues above the ring. These foods may function as an osmotically active agent, thereby enabling the tissue to grow successfully if water is supplied. The experiment with the double ringing proved that the xylem does not serve as a tissue for the longitudinal translocation of carbohydrates stored in it. The amount of starch and sugar between the two rings is high. It would be seen that the removal of carbohydrates from the xylem occurs readily through the medullary rays only, and longitudinal transfer in either direction through the phloem only. The mineral nutrients move primarily through the xylem. This has been proved by placing a stem in a solution of dye, the dye will rise rapidly through the xylem.

Curtis (5) also studied the effect of ringing a stem on the upward transfer of nitrogen and ash constituents with peach, cherry and lilac. He found that the ringing hindered the upward movement of nitrogen and ash constituents into the tissue above the ring. The nitrogen and ash constituents move chiefly through the phloem instead of the xylem. The rate of transpiration of water from the ringed branches is usually less than that from non-ringed branches.

The influence of thinning fruits on size was demonstrated by Auchter (2) from 1912 to 1919 with the Rome Beauty, York Imperial and Baldwin varieties. By thinning, not only the size of the individual apples was increased, but also the total yield per tree was greater on thinned trees, due to the increased size of fruit. In 1912, practically all of the York Imperial leaves fell early in the spring due to the cedar apple rust. That year none of the fruits became larger than a walnut, thus emphasizing the fact that the leaves are essential for fruit development when the tree as a whole is considered.

Cummings and Jenkins (3) studied the rate increase in size of large and small apples to determine the rate of growth of small apples in relation to the thinning operation. They concluded that, in terms of percentage increase in size, the smaller apples grew faster than the larger ones. However, the little apples were still small at harvest. Some apples are small due to being over-crowded, which decreases the leaf area per fruit. The other cause for small size was incomplete fertilization of the blossom which resulted in only a few seeds per fruit. In general, the larger apples grew where there was the greater number of leaves per fruit.

Aldrich (1) stated that heavy thinning increased the size and color of fruit and affected the vigor and productivity of the trees. Oldenburg and Rome Beauty trees thinned before June 20 showed an increased growth of the twigs as compared with the unthinned trees. Even when the thinning was done as late as July 1, the surplus of synthesized products from the leaves increased the fruit bud formation. As compared with the unthinned trees, thinning increased the accumulation of carbohydrates in the woody parts.

Fletcher (7) concluded that a result of thinning was an increase in the percentage of larger fruit and a slight increase in the development of the color of the fruit. The experiment with the Jonathan proved that thinning did affect color development. With the larger leaf area the fruits had better quality and color. The application of nitrogen fertilizer plus thinning resulted in an increase in size and a brighter color of the fruits.

Haller and Magness (8, 13) were the first to investigate the relationship between the leaf area and the growth and composition of apple fruits. They used Ben Davis, Delicious, Jonathan, Rome Beauty and Winesap varieties. Small branches were ringed and either leaves or fruits were thinned until a desired number of leaves per fruit was obtained. The diameter of each apple was measured at intervals of ten days throughout the season. The volume of the fruit was determined from the equation $1/6 \pi D^3$. Apples which were fed by a large leaf area ripened earlier, were of higher quality and larger size than those fruits which were fed by small leaf area. The size of the fruit is greatly influenced by leaf area. Delicious and Winesap required at least 40 leaves per apple to produce a medium to large size fruit of high quality and color. With the Jonathan 20 to 25 leaves were sufficient to produce fruit of the best market size and quality.

Murneek (14) stated the relative number of leaves on the branches did not influence the composition or weight of the seed, but it did affect the size and quality of fruit up to a certain point. The number of leaves on the ringed branches affected the time of ripening of the flesh and the seed. A larger leaf area on the ringed branches increased fruit bud formation and induced greater vegetative growth.

Haller and Magness (9) further investigated the relation which exists between the leaf area and the size of apple fruits. The experiment dealt with apples grown on both ringed and unringed branches, with different leaf areas per fruit. The leaf area had little or no influence on the composition and size of fruit on unringed branches. On ringed branches increased leaf area was accompanied by increased fruit size. They stated and emphasized clearly that the development of desirable size, color, dessert quality, and firmness of fruits was correlated with leaf area.

As the leaf area increased, the fruit increased in size, the maximum size and good dessert quality being obtained from 30 leaves per apple. Increasing the number from 30 leaves to 50 leaves per fruit produced a highly flavored fruit of crisp texture. Fruits grown with fewer than 20 leaves per fruit were lacking in flavor. As the leaf area was increased up to 30 leaves per apple, the red color was increased on the fruit. Above this number, the color was reduced due to the shading of the fruit. The most striking result in this investigation was the finding of the translocation of synthesized food materials from a considerable distance. The size and composition of the fruit were not affected when the fruit and leaves (20 leaves per apple in each case) were grown four and one-half feet apart on the ringed branch for Grimes, six feet apart for Ben Davis, six feet apart for York Imperial, and six and one-half feet apart for the Jonathan. The fruits drew elaborated food whether the fruit was above or below the leaves or whether the leaves were on a separate branch.

According to Magness (12) the development of color in apples is influenced by the degree of maturity, the chemical composition, and light exposure. The amount of red color was increased as the fruits reached a certain degree of maturity and the sugar content was increased. Fruits with low sugar content failed to develop satisfactory color. In color the fruits were dull and bronze-red rather than the bright red in comparison with the fruits of high sugar content. To a certain extent light exposure is essential in order to develop the color of fruits. The fruits on overloaded branches with poor light exposure developed a poor color. Such fruit will not develop color under the most favorable light conditions.

Schrader and Marth (15) stated that the amount of light is a major factor in the development of the red color of an apple. Slight shading of the fruit may decrease the development of red color; also size is decreased by shading, possibly due to a decrease in the photosynthetic activity of the chlorophyll in the fruit.

According to Kimball (11) the moisture supply was the main factor in controlling fruit color during his experiment. An application of only nitrogen resulted in fruit being poor in color but an application both nitrogen and potash gave better results, good to excellent color.

METHODS AND MATERIALS

Some of the commercially important apple varieties grown in Kansas were selected for this investigation, namely; Delicious, Jonathan, Winesap and York Imperial. The work was carried on during the summer of 1933 at Kansas Agricultural Experiment Station orchard at Manhattan.

In organizing the experiment the number of leaves and fruits on typical bearing branches was determined soon after the "June drop". By that time, June 7, the apple fruits were one-half inch to one inch in diameter. Five typical, vigorous branches which had a fairly good set of fruit were selected on each of five or six trees of each of the above varieties. The defoliating, ringing and thinning were completed June 24, and on June 25 a severe hail storm damaged the fruits and leaves of the experimental trees.

Either leaves or fruits were then removed until a desired number of leaves per fruit was obtained, 10, 20, 30, 40, 50 leaves being left per fruit. All the under-sized and deformed leaves and fruits were removed leaving only representative ones. The apples were numbered so that individual volume and diameter measurements could be secured throughout the remainder of the season. During the experiment, if any fruits or leaves on the ringed branches dropped, a number of fruits or leaves were removed, so the average number of leaves per fruit was not changed.

In order to study the effect of the foliage on the size and color of fruit, it is important to prevent the movement of synthesized materials out of or into the portion under the test. Therefore it was necessary to ring the branches. In ringing, a strip of phloem and cambium was removed one-fourth to one-third inch in width, depending on the diameter of the branches. The ringed areas were covered with grafting wax to prevent infection and drying out of the exposed tissues.

The volume and diameter of the fruits were measured at intervals of two weeks until harvest. The volume of the fruit was determined by the use of a graduated glass cylinder partially filled with water. The fruit was submerged in the cylinder, and the rise of the water level was noted. To get the final measurement of the volume, a beaker was filled with water and the fruit was submerged. The overflow was measured with a graduated cylinder. This was done in the laboratory after the fruits were harvested.

The diameter of each fruit was measured with calipers at the widest point.

The experimental trees were sprayed with a knapsack sprayer, using lead arsenate, two pounds to 50 gallons of water, soon after the measurements of volume and diameter were taken. During the summer of 1933 the orchard was heavily infested with codling moth, therefore, it was necessary to give these trees special attention.

The method of determining the leaf area was as follows. A random sample of 100 leaves from each variety was collected and blue prints were made. A planimeter was used to measure the area of the leaves. The width of the leaves was determined with a ruler. The probable errors of these means were calculated from the formula $PE_m = .6745\ (\sigma)$ where $\sigma = \sqrt{\frac{\Sigma X^2}{N} - M^2}$ and where M is the mean, ΣX^2 is the summation of the squares of the observations and N is the number of observations.

An example is shown with the Jonathan leaves.

x = width $\qquad$ y = area

$M_x = 1.33$ $\qquad$ $M_y = 2.49$

$M_x^2 = 1.7689$ $\qquad$ $M_y^2 = 6.2001$

$\Sigma x^2 = 184.1675$ $\qquad$ $\Sigma y^2 = 671.13821$

$N = 100$ $\qquad$ $N = 100$

$$\sigma = \sqrt{\frac{\Sigma x^2}{N} - M_x^2} \qquad \sigma = \sqrt{\frac{\Sigma y^2}{N} - M_y^2}$$

$$= \sqrt{1.84675 - 1.7689} \qquad = \sqrt{6.7113821 - 6.2001}$$

$$= \sqrt{.072775} \qquad = \sqrt{.5112}$$

$$= .269 \qquad = .7149$$

$$PE_m = .6745 \cdot \sigma \qquad PE_m = .6745 \cdot \sigma$$

$$= .6745(.269) \qquad = .6745(.7149)$$

$$= 0.18 \qquad = .0472$$

$$\therefore M_x = 1.33 \pm 0.18 \qquad \therefore M_y = 2.49 \pm 0.47$$

The scatter diagram for determining the coefficient of correlation between leaf area and leaf width of Jonathan leaves is presented on page 13 to show the method used.

WIDTH

	.70–.84	.85–.99	1.00–1.14	1.15–1.29	1.30–1.44	1.45–1.59	1.60–1.74	1.75–1.89	1.90–2.04	Σ
fdx dy	28	51	84	36	0	19	98	144	64	524 D
Σfd	-7	-17	-42	-36	18	19	49	48	16	48 C
fd²	16	27	48	29	0	9	44	63	32	268
fd	-4	-9	-24	-29	0	9	22	21	8	-6 B'
d	-4	-3	-2	-1	0	1	2	3	4	
f	1	3	12	29	26	9	11	7	2	100 A'

AREA

Area	fdx dy	Σfd	fd²	fd	d	f	.70–.84	.85–.99	1.00–1.14	1.15–1.29	1.30–1.44	1.45–1.59	1.60–1.74	1.75–1.89	1.90–2.04
.90–1.09	28	-4	49	-7	-7	1	1								
1.10–1.29	36	-6	72	-12	-6	2		2							
1.30–1.49	35	-7	75	-15	-5	3		1	2						
1.50–1.69	48	-12	112	-28	-4	7			5	2					
1.70–1.89	30	-10	63	-21	-3	7			3	4					
1.90–2.09	18	-9	40	-20	-2	10			1	7	2				
2.10–2.29	9	-9	16	-16	-1	16			1	8	6	1			
2.30–2.49	0	-3	0	0	0	12				4	7	1			
2.50–2.69	-2	-2	3	3	1	3				2	1				
2.70–2.89	2	-1	40	20	2	10				2	5	3			
2.90–3.09	30	10	81	27	3	9					3	2	4		
3.10–3.29	24	6	96	24	4	6					2	2	2		
3.30–3.49	35	7	75	15	5	3							2	1	
3.50–3.69	102	17	216	36	6	6							2	3	1
3.70–3.89	35	5	98	14	7	2							1	1	
3.90–4.09	0	0	0	0	8	0									
4.10–4.29	54	6	162	18	9	2								2	
4.30–4.49	40	4	100	10	10	1									1
Σ	524 D	-6 B	1298	48 C		100 Ay									

The coefficient of correlation between leaf area and leaf width was calculated by the following formula:

$$r = \frac{\Sigma f dx dy - N C_x C_y}{N \sigma x \sigma y}$$

Substituting in this formula the values found in the scatter diagram on page 13, the coefficient of correlation is determined as follows:

$$C_x = \frac{6}{100}$$

$$= 0.06$$

$$C_y = \frac{48}{100}$$

$$= .48$$

$$\sigma x = \sqrt{\frac{\Sigma f d^2}{N} - \left(\frac{fd}{N}\right)^2}$$

$$= \sqrt{2.6766} = 1.63$$

$$\sigma y = \sqrt{\frac{\Sigma f d^2}{N} - \left(\frac{fd}{N}\right)^2}$$

$$= \sqrt{\frac{1298}{100} - \left(\frac{48}{100}\right)^2}$$

$$= 3.57$$

$$PEr = \frac{1 - r^2}{\sqrt{N}} .6745$$

$$= .02256(.6745)$$

$$= \pm .001$$

$$r = \frac{524 - 100(-.06)(48)}{100(1.63)(3.57)}$$

$$= \frac{526.88}{581.91} = +.88$$

$$\therefore r = .88 \pm .001$$

The line of regression of the graph was drawn by the following formula, where h is the class interval on the scatter diagram. $y = r \frac{\sigma y (h)}{\sigma x (h)}$

Solving for y in terms of x we find:

$$y = .88 \; \frac{3.57(.2)}{1.63(.15)}$$

$$= .88 \; \frac{.714}{.2445}$$

$$= .88 \; (2.92)$$

$$= 2.5695$$

$\bar{y}$ = mean of the y

$\bar{x}$ = mean of the x

$$y - \bar{y} = 2.5695\ (x-\bar{x})$$

$$y = \bar{y} + 2.5695\ (x-\bar{x})$$

$$= 2.492 + 2.5695\ (x) - 2.5695\ (1.33)$$

$$= 2.5695\ x - 0.925$$

If x = 1.9

Then $y = 2.5695\ (1.9) - 0.925$

$= 4.88 - 0.925$

$= 3.95$

If x = 1.30

Then $y = 2.5695\ (1.30) - .925$

$= 2.41$

If x = 1

Then $y = 2.5695 - .925$

$= 1.644$

The width of all the leaves on the ringed branches was measured and the area of each leaf was calculated from the line of regression on the scatter diagram.

In Table I are presented the average width, average area, coefficient of correlation between leaf width and area, and the regression value of y in terms of x for each of the four varieties used in this study.

Table I. Leaf measurements.

Variety	Av. leaf width 100 leaves inches	Av. leaf area 100 leaves sq. in.	Coefficient of correlation between width and area	Regression
Delicious	1.63 ± 0.16	3.41 ± .065	+0.86 ± .017	y = 2.829x - 1.1
Jonathan	1.33 ± 0.18	2.49 ± .048	+0.88 ± .001	y = 2.5695x - 0.92
Winesap	1.32 ± 0.17	2.15 ± .015	+1.87 ± .014	y = 2.44x - 1.07
York	1.63 ± 0.16	3.36 ± .083	+0.86 ± .017	y = 3.29x - 2

The results which are presented in Table II show the number of leaves per fruit, the total and average leaf area in square inches, final size in volume and diameter of the fruits, and the approximate number of fruits per box.

Table II. Relation between leaf area and size of apple, 1933.

Variety	Leaves per apple No.	Fruits No.	Leaf area sq. in.	Av. area per leaf sq. in.	Leaf area per fruit sq. in.	Av. volume mature fruits c. c.	Av. diameter mature fruits inches	Size of fruits No. per box
Delicious	10	32	770.50	2.30	23.0	119.0 ± 3.29	2.54 ± .020	200
Delicious	20	23	1373.86	2.03	40.6	163.0 ± 4.94	2.82 ± .032	138
Delicious	30	27	2045.60	2.09	62.7	170.0 ± 2.95	2.86 ± .015	125
Delicious	40	22	2205.42	2.62	104.8	174.0 ± 4.21	2.86 ± .020	125
Delicious	50	16	2396.99	2.44	112.0	220.0 ± 4.73	3.13 ± .032	104
Jonathan	10	25	626.03	2.21	22.1	69.8 ± 2.32	2.14 ± .021	*
Jonathan	20	19	1186.10	2.20	44.0	98.8 ± 3.62	2.39 ± .023	*
Jonathan	30	23	1636.01	2.25	67.5	129.3 ± 3.46	2.69 ± .027	163
Jonathan	40	22	2019.97	2.22	88.8	129.0 ± 3.98	2.65 ± .014	175
Jonathan	50	23	2650.99	2.17	108.5	141.0 ± 4.94	2.68 ± .029	163
Winesap	10	22	447.48	1.72	17.2	75.6 ± 1.95	2.18 ± .024	*
Winesap	20	21	998.30	1.78	35.6	93.2 ± 1.81	2.32 ± .012	*
Winesap	30	18	1249.04	1.75	52.5	112.0 ± 2.79	2.50 ± .021	200
Winesap	40	20	1708.61	1.78	71.2	131.0 ± 4.74	2.60 ± .023	175
Winesap	50	17	1577.53	1.85	92.5	122.0 ± 4.64	2.50 ± .024	200
York	10	31	850.42	2.56	25.6	92.0 ± 3.98	2.36 ± .011	*
York	20	22	1421.87	2.42	48.4	123.0 ± 5.38	2.53 ± .030	188
York	30	29	2683.43	2.30	69.0	148.0 ± 6.34	2.67 ± .023	163
York	40	23	3099.35	2.30	92.0	155.0 ± 5.68	2.76 ± .021	150
York	50	26	3555.22	2.20	110.0	156.0 ± 5.55	2.76 ± .020	150

* Below marketable size

The rate of growth of each variety of fruit together with the different numbers of leaves per fruit are shown in Figures 1 to 4 inclusive. The relationship between leaf area and diameter of fruit at harvest is shown graphically in Figure 5 and in Figure 6 is shown the influence of leaf area on volume of fruit at harvest.

The maximum rate of increase in volume and diameter of the fruit was during the months of July and September, while in August the size of fruit increased only slightly, due to dry soil. The fruits started to grow soon after a rain about the middle of August.

Apples grown with the various number of leaves per fruit are shown in Figure 7. Each individual apple represents the average size of fruit for each apple leaf ratio of the variety. Numbers refer to number of leaves per fruit.

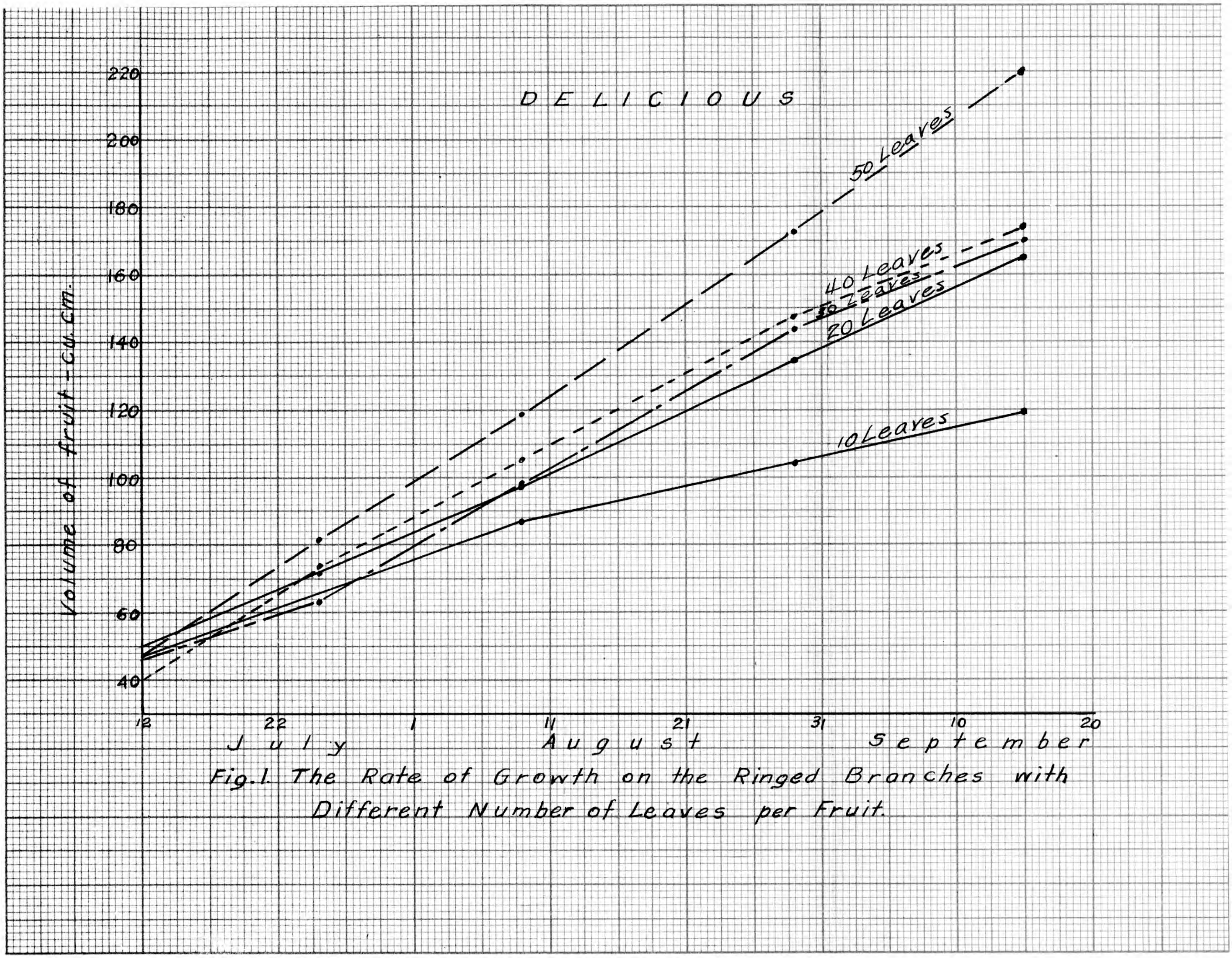


Fig. 1. The Rate of Growth on the Ringed Branches with Different Number of Leaves per Fruit.

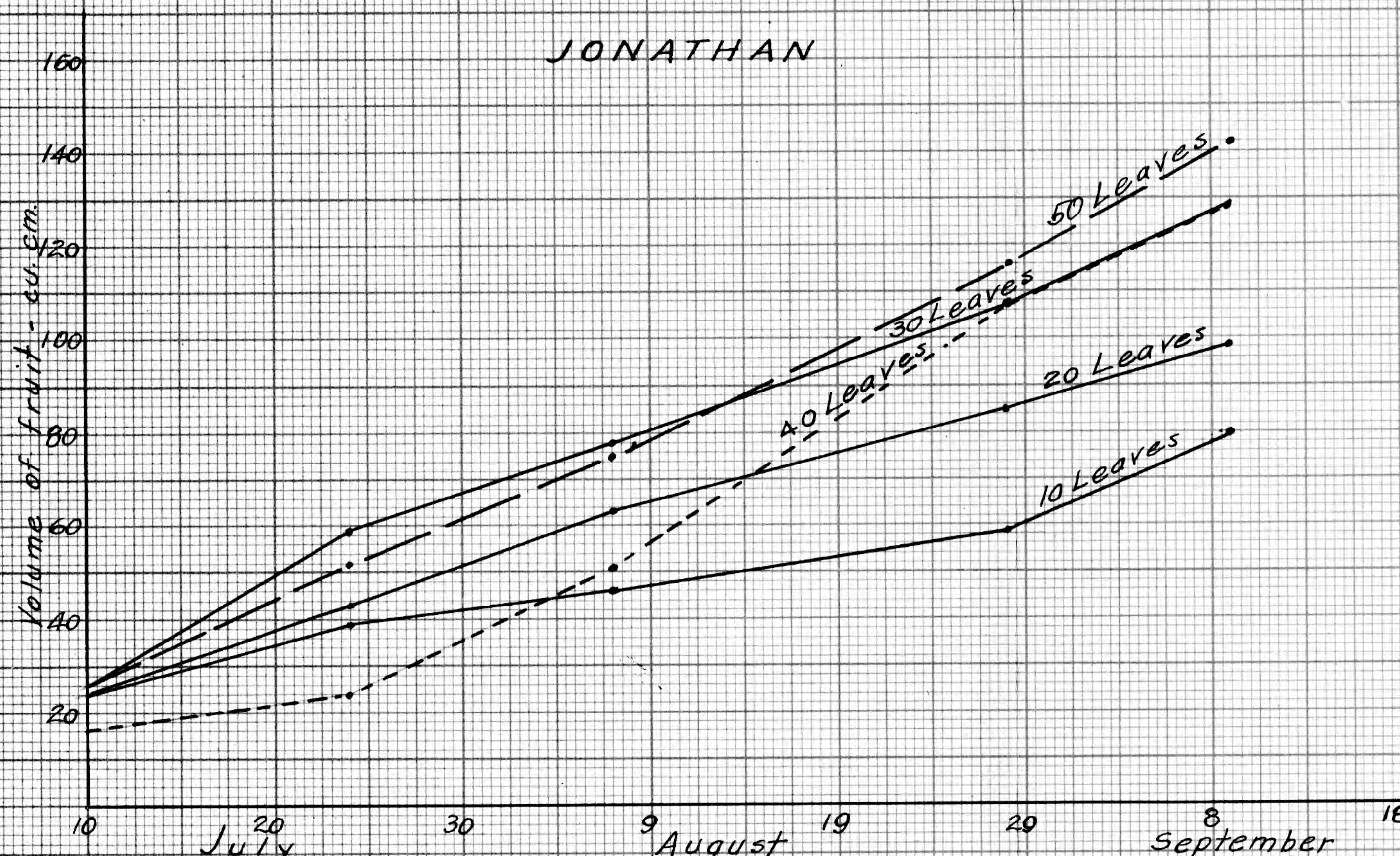


Fig. 2. The Rate of Growth on the Ringed Branches with Different Number of Leaves per Fruit.

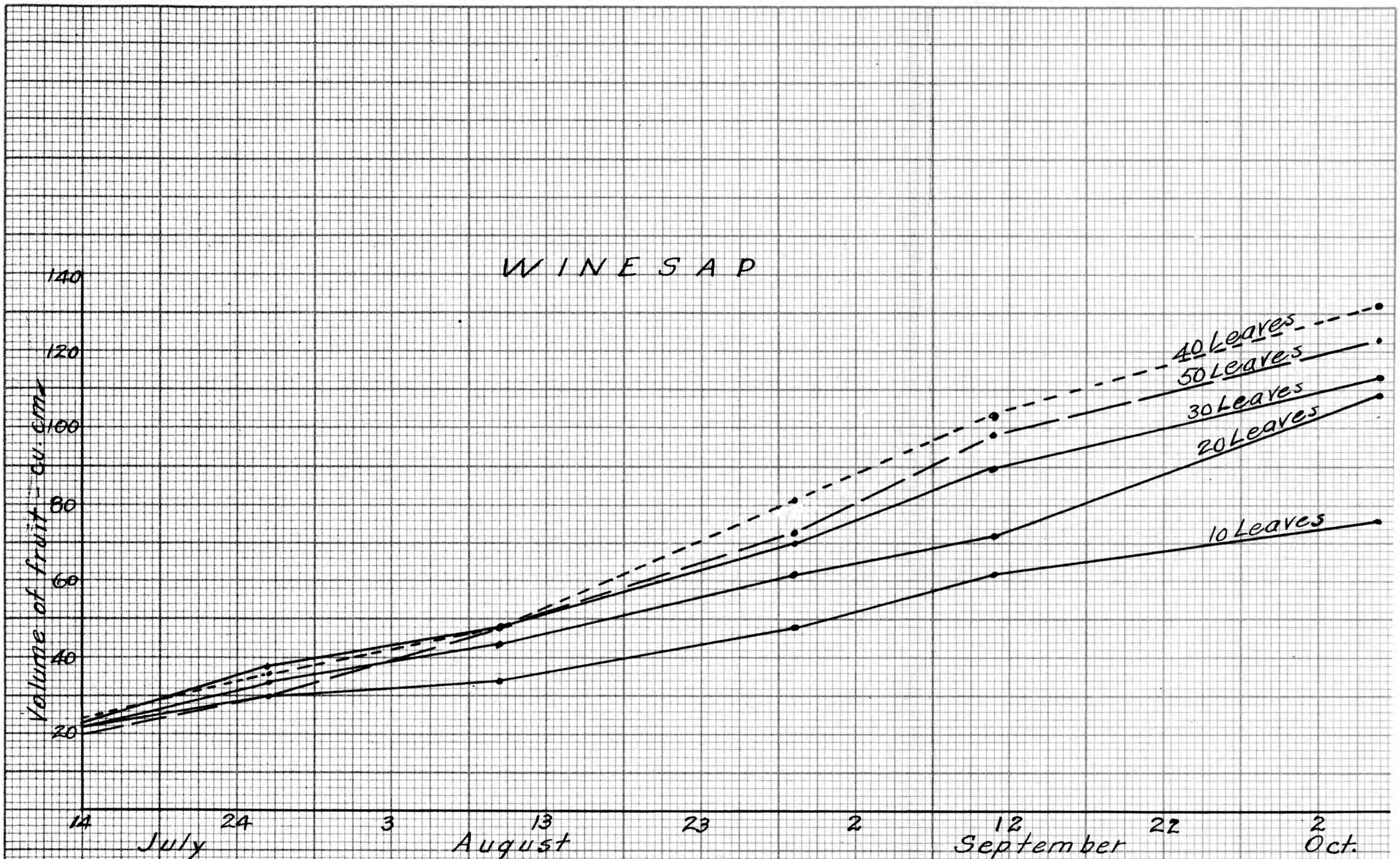


Fig. 3. The Rate of Growth on the Ringed Branches with Defferent Number of Leaves per Fruit.

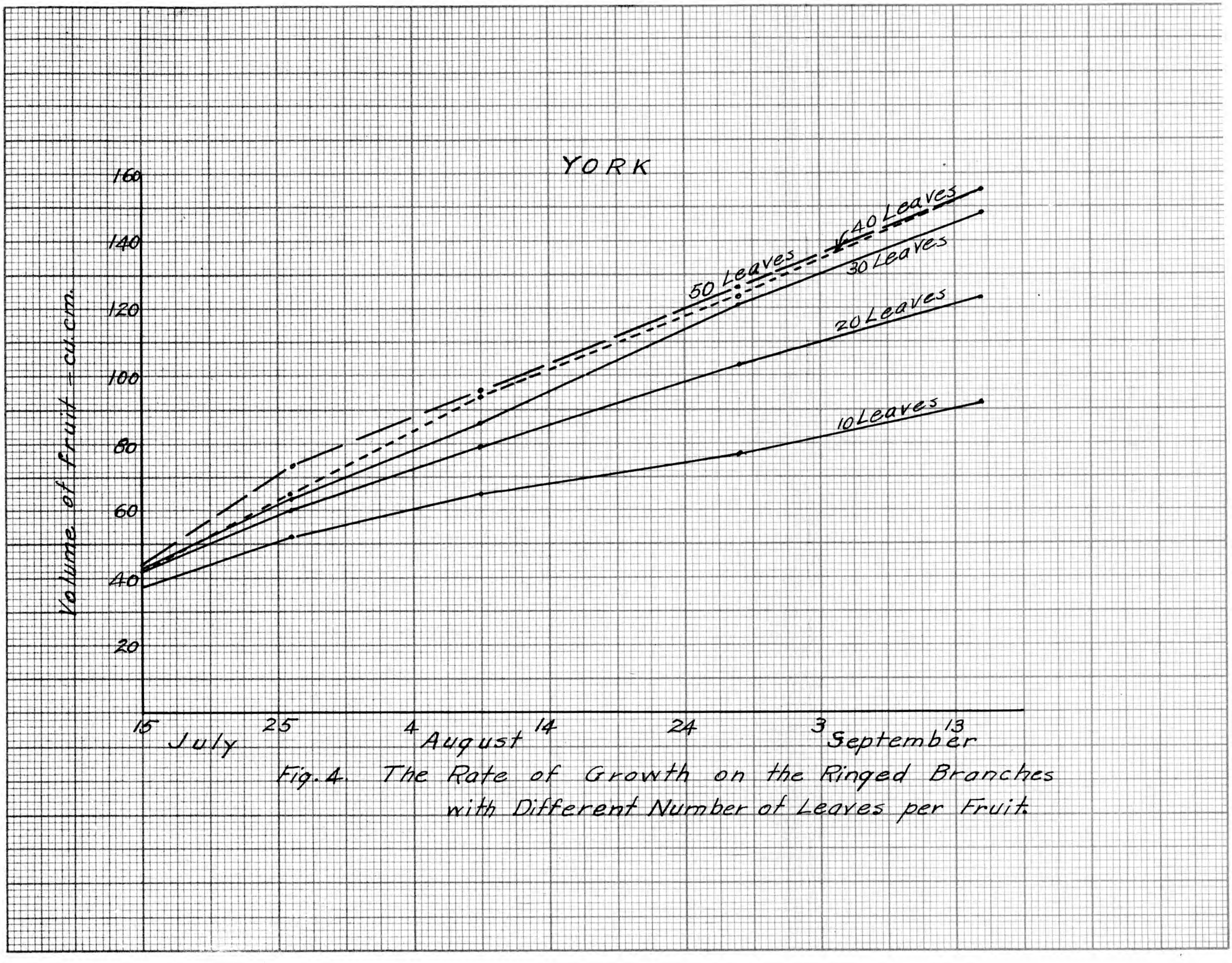
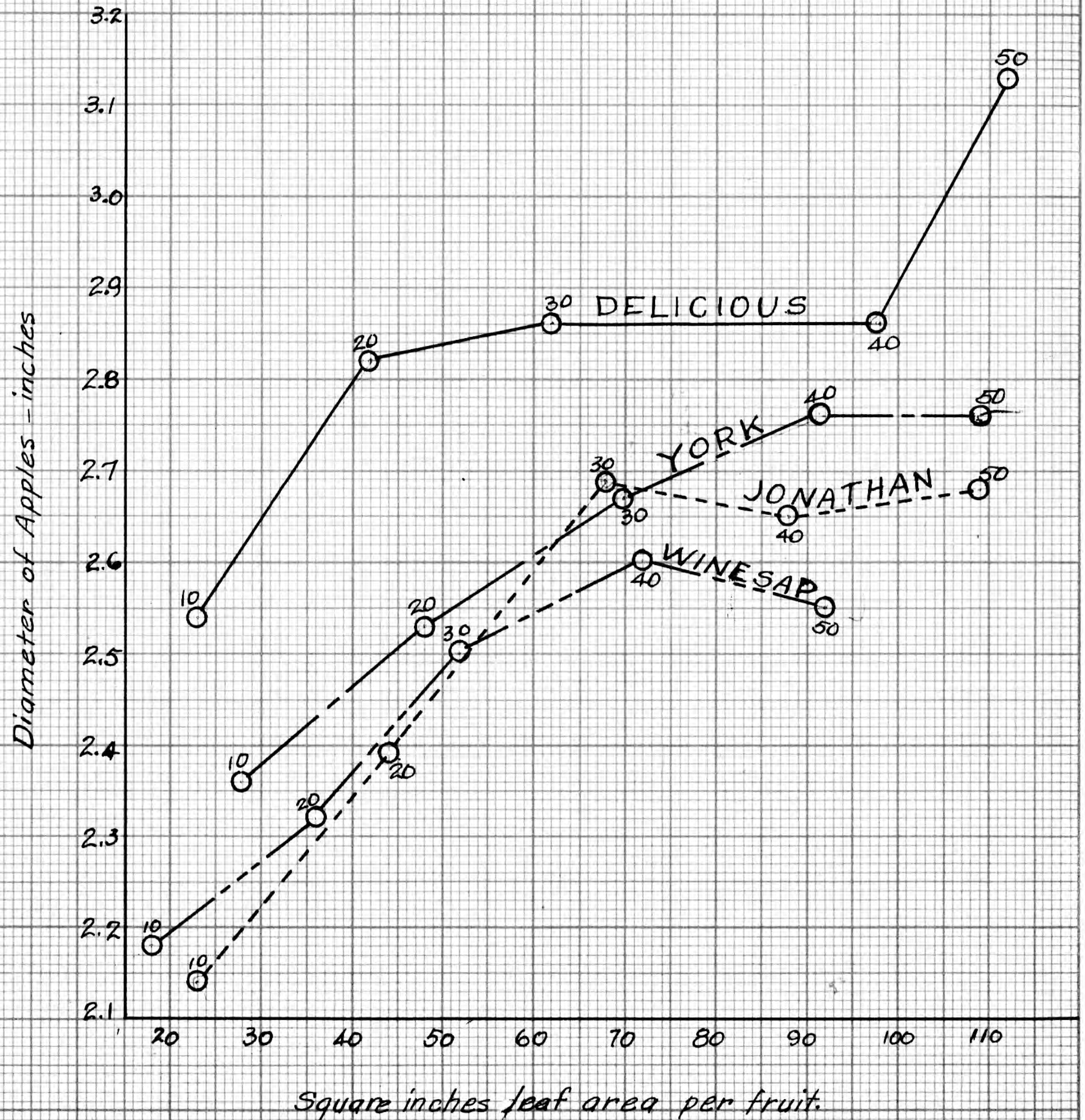
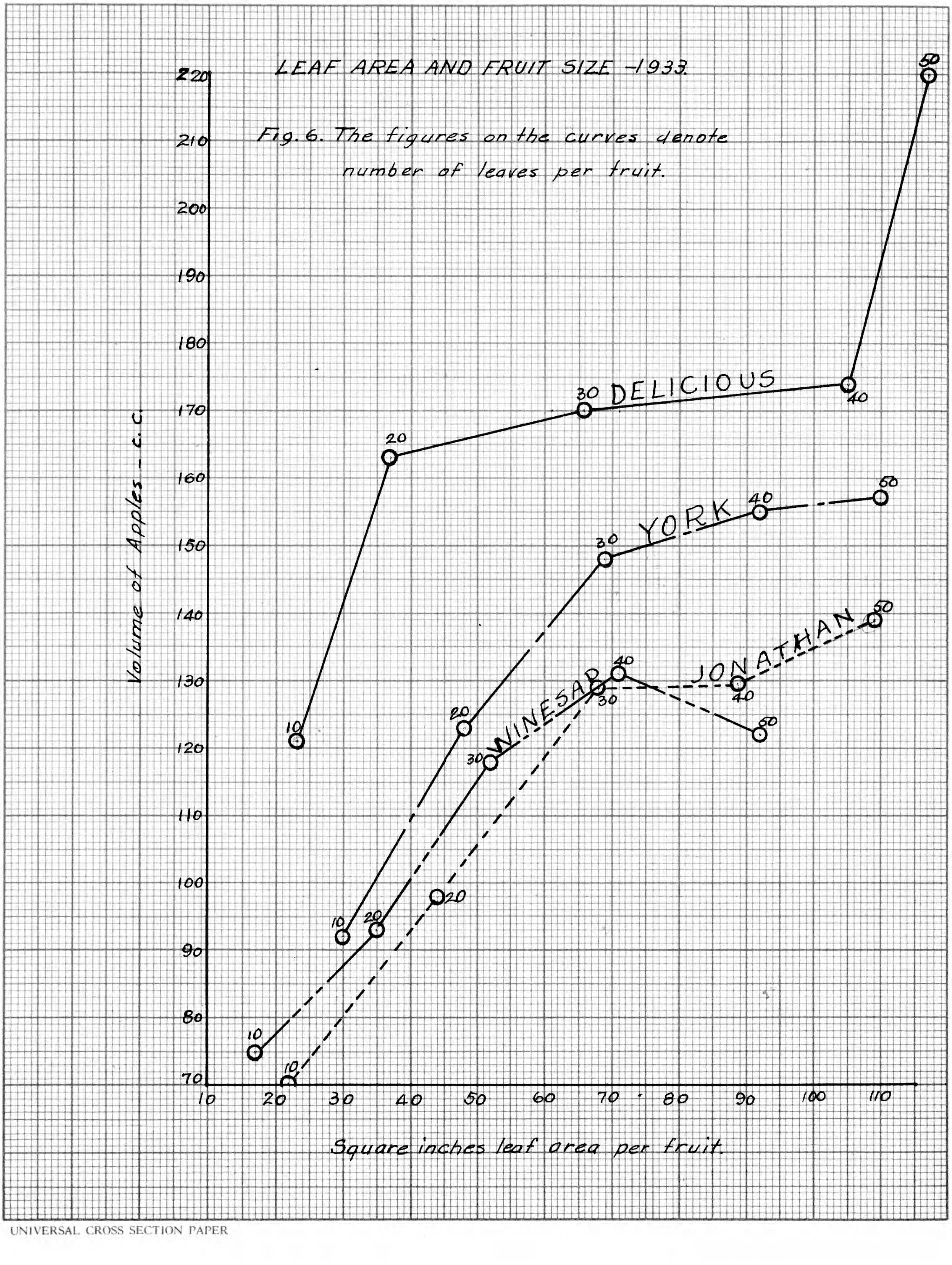


Fig. 4. The Rate of Growth on the Ringed Branches with Different Number of Leaves per Fruit.

LEAF AREA AND FRUIT SIZE - 1933.

Fig. 5. The figures on the curves denote number of leaves per fruit.




LEAF AREA AND FRUIT SIZE -1933.
Fig. 6. The figures on the curves denote number of leaves per fruit.
DELICIOUS
YORK
JONATHAN
WINESAP
Volume of Apples - c.c.
Square inches leaf area per fruit.

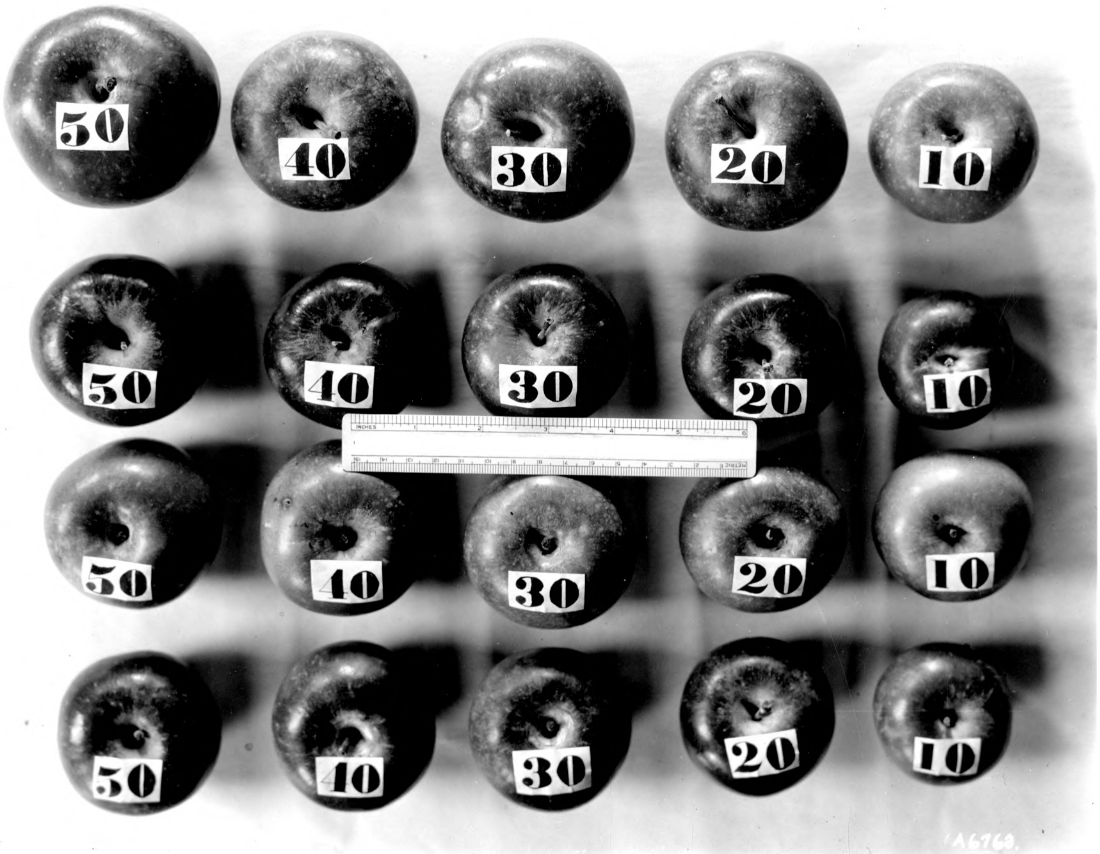


Fig. 7. Number of leaves and size of fruit. The numbers refer to the number of leaves per fruit. Top row, Delicious; second row, Jonathan; third row, York; fourth row, Winesap.

DISCUSSION OF RESULTS

The development of apples is influenced by the amount of carbohydrates formed in a given leaf area, which in turn is governed by many factors, such as moisture, temperature, duration and intensity of sun light, and the presence of carbon dioxide in the surrounding atmosphere. On account of the dry hot season of 1933, the fruits were smaller in size than normal.

Delicious apples grown with 20 leaves per fruit gave larger fruit than the largest of the other varieties. On the other hand, this ratio on the Delicious also produced practically as large fruit as the 30 to 1 or the 40 to 1 ratio. However, there is a noticeable increase in size of fruit between the 40 to 1 ratio and 50 to 1 ratio with Delicious.

With the Jonathan, the largest fruit was produced with the 30 to 1 ratio. The differences between the 30 to 1, 40 to 1, and the 50 to 1 ratios are not significant.

The largest Winesap fruits were grown when the ratio was 40 to 1, but even the largest Winesaps were smaller than the other varieties at a 30 to 1 ratio. The 50 to 1 ratio Winesaps were smaller than 10 to 1 Delicious apples.

The 40 to 1 ratio with York produced as large apples as the 50 to 1 ratio. The Winesap data lead to the conclusion that the leaves of this variety are not as efficient in producing apples either as to number of leaves or area of leaves per fruit as the other varieties. The Winesap variety naturally produces small fruit, even on young trees.

Leaf performance can be considered on another basis. In the leaf to fruit ratio of 50 to 1 with Winesap, each fruit had an average of 92.5 square inches of leaf surface while with Delicious the 10 to 1 ratio provided each apple with 23.0 square inches of leaf area. Although the Winesap apples had nearly four times the leaf area of the Delicious, per fruit, the Winesap apples were 2.50 inches in diameter and the Delicious were 2.54 inches in diameter at harvest. With Jonathan the 30 to 1 ratio gave 67.5 square inches of leaf surface per fruit and the fruits were 2.69 inches in diameter, slightly larger than the Winesap which had 50 leaves per fruit. The area of the Jonathan leaves per fruit was 37 per cent less than the area for the Winesap. The York ratio of 50 to 1 resulted in 110 square inches of leaf surface per fruit and the fruits were 2.76 inches in diameter which was larger than either Winesap or Jonathan but smaller than Delicious at this ratio.

In this connection, it should be noted that these York trees bore no apples last year.

Although there is a high correlation between the number of leaves per fruit and the size of the fruit it is obvious that doubling the number of leaves per fruit such as from 10 to 20, or from 20 to 40, does not double the size of the apples.

INFLUENCE OF LEAF AREA ON DEVELOPMENT OF COLOR

The relative amount of leaf area influences the development of red color on the apple. Delicious apples in this experiment had as good color when the leaf to fruit ratio was 30 to 1 as when it was 40 to 1 or 50 to 1. With Jonathan the 40 to 1 ratio developed as good color as the 50 to 1 ratio and much better color than the lower ratios. Delicious and Jonathan fruits developed poor color when grown with ten leaves per fruit. With the Winesap, the 20 to 1 ratio produced as good color as the 40 to 1 ratio or the 50 to 1 ratio.

With York, the fruits developed poor color in all instances, although the fruits which were grown with the smaller leaf areas were dull in contrast with those grown with the larger number of leaves. The poor development in color of the York apple may have been caused by the drouth during the month of August.

SUMMARY

The relationship between leaf area, size and color of apple fruits was investigated in the Kansas Agricultural Experiment Station orchard, summer of 1933.

Five typical, vigorous branches which had a fair to good set of fruits were selected on five to six trees of each of several varieties. The branches were ringed from one-fourth to one-third inch in width and the fruits were grown with a fixed number of leaves per fruit. The diameter and volume of the fruits were measured at intervals of two weeks beginning July 10, 1933 until harvest in the fall. A sample of 100 leaves from each variety was measured with a planimeter to get the area of the leaves. The increase in volume and diameter of fruit showed that there was a high correlation between the leaf area and the size of fruit at harvest, but not between leaf area and rate of diameter or volume increase. With Delicious 50 leaves per fruit produced the largest apples but good color was obtained with the 30 to 1 ratio.

The fruit having greatest diameter with Jonathan was produced by the 30 to 1 ratio, but the 40 to 1 developed as good color as the 50 to 1 ratio.

Winesap and York needed 40 leaves per fruit to obtain commercial size. With Winesap, as good color was produced with a 20 to 1 ratio as with the higher ratios. During the month of August the fruit increased very little in size, due to hot and dry weather. The fruits started to grow following rain in the middle of August.

The approximate number and size of leaves would be a more accurate guide for thinning than a specified distance between apples.

ACKNOWLEDGMENT

The author wishes to express gratitude to his major instructor, Professor Wm. F. Pickett, for suggesting the problem and for his advice and assistance throughout the year; to Professor R. J. Barnett, head of the department of Horticulture, and Dr. G. A. Filinger for their timely suggestions; and to Professor H. H. Laude of the department of Agronomy for valuable assistance.

LITERATURE CITED

1. Aldrich, W. W.
Effect of thinning upon carbohydrates accumulation, formation of fruit buds and set of bloom in apple. Proc. Amer. Soc. Hort. Sci., 28: 599-604. 1931.

2. Auchter, E. C.
Some influence of thinning, pollination and fruit spur and on size of fruit produced. Amer. Soc. Hort. Sci., 16: 118-131. 1919.

3. Cummings, M. B. and Jenkins, E. W.
Apple thinning experiments. Vt. Agr. Exp. Sta. Bul. 308, 60 p. 1930.

4. Curtis, O. F.
The upward translocation of foods in woody plants. Amer. Jour. Bot., 7: 101-124. 1920.

5. ______
The effect of ringing a stem on the upward transfer of nitrogen and ash constituents. Amer. Jour. Bot., 10: 361-383. 1923.

6. Drinkard, A. W. and Ingham, A. A.
Studies on methods of protecting ringing wounds on apple trees to promote their healing. Va. Agr. Exp. Sta. Tech. Bul. 17: 132-160. 1917.

7. Fletcher, Lewis A.
Effect of thinning on size and color of apple. Amer. Soc. Hort. Sci., 29: 51-55. 1932.

8. Haller, M. H. and Magness, J. R.
The relation of leaf area to the growth and composition of apple. Amer. Soc. Hort. Sci., 22: 189-196. 1925.

9. ______________________
The relation of leaf area and position to quality of fruit and to bud differentiation in apples. U. S. Dept. Agr. Tech. Bul. 338, 35 p. 1933.

10. Howe, G. H.
Ringing fruit trees. N. Y. State Agr. Exp. Sta. Bul. 391, p. 575-584. 1914.

11. Kimball, D. A.
The influence of soil moisture differences on apple fruit color and conditions of the tree. Scientific Agriculture, 13: 9: 566-575. 1933.

12. Magness, J. R.
Observation on color development in apples. Amer. Soc. Hort. Sci. 25: 289-292. 1928.

13. Magness, J. R., Overley, F. L. and Luce, W. A.
Relation of foliage to fruit size and quality in apple and pears. Wash. Agr. Exp. Sta. Bul. 249, 26 p. 1931.

14. Murneek, A. E.
Relation of leaf area to fruit size and food reserves by apple seeds and branches. Amer. Soc. Hort. Sci. 29: 230-234. 1932.

15. Schrader, A. L. and Marth, P. C.
Light intensity as a factor in the development of apple color and size. Amer. Soc. Hort. Sci. 28: 552-555. 1931.

16. Vyvyan, M. C. and Evens, H.
The leaf relation of fruit trees. Jour. Pom. and Hort. Sci. 10: 4: 228-268. 1932.

17. Wiggans, C. C.
Some factors favoring or opposing fruitfulness in apples. Mo. Agr. Exp. Sta. Res. Bul. 32, 60 p. 1918.