INVESTIGATIONS ON THE RELATION BETWEEN LEAF AREA AND SIZE OF PEACHES

Thesis for the Degree of M. S.

William Clyde Brown

1935

Peaches,
Tuite

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V. R. Gardner

THESIS

Introduction

Commercial peach growers realize that the price for peaches depends in no small measure upon the size. Large fruits will bring better returns to the producer than small ones. Many factors influence the size of peaches, such as soil, rainfall, climatic conditions and the relative load the trees carry. This latter factor is under the control of the grower, and for many years peach growers have practiced the removal of surplus fruits in striving to produce a better grade of marketable product.

Review of Literature

Section I. Fruit Removal, Pruning and Fertilizers As Factors which Influence the size of Peach Fruits.

During the past 35 years there have been a number of studies for the purpose of establishing definite methods and affording more or less fixed rules that could be successfully followed in thinning peaches. Early investigators recommended thinning peaches to some arbitrary distance apart on the branches. They (1), (2), (8), (11), (12), (29), (30), (31), (32), (27, and (37), agreed that thinning should not be done until after the "June drop". Jordan (27) in 1898 wrote on"Pruning and Thinning" of peaches: " These operations exercise a great influence on the life of the tree and the size and the color of fruit. Thinning is not practiced to the extent that it deserves,for direct experiments are wanting, the fact remains that the removal of one third or one half of the number of fruits on the tree, as the occasion demands, greatly increases the size and quality of the remaining fruits. Thinning is secured in two ways either by hand picking all the small imperfect fruit and sufficient number of the remainder to leave none

closer than three or four inches (this is best done after what is called "June drop" occurs), or annual cutting off with pruning shears at regular time of trimming from a quarter to half as required of each years growth. The first method is best."

Close, (10) wrote in 1902; "The thinning of peaches is not practiced in Delaware to the extent that it should be. Where thinning was undertaken, there has been an influence which has caused the thinned trees to set a good load of uniformly distributed fruit, while adjoining unthinned trees set either an excessively heavy load or avery light load. The points in favor of thinning are an even distribution of fruit on the tree, larger size, brighter color, better quality and flavor, more fancy fruits which are first class, less culls, higher prices, and the trees are in better condition for a crop the following year. 'Common' thinning four inches, 'Medium' six inches, and 'Severe' eight inches apart. were used in the thinning tests. Unthinned Elberta trees gave forty eight per cent fancy, and forty nine per cent first grade fruit, and the thinned

tree produced eighty per cent fancy, and twenty per cent first grade."

Walker (36) writing on peach growing in Arkansas says: "Some effective thinning is done at the time of pruning the tree each spring, but this is not sufficient. The best practice requires that the peaches on the limb shall not be closer than four to six inches. Thinning increases the size of the remaining fruit and is a saving of strength to a tree in reducing the number of pits borne."

Barden and Eustace (1) in 1913 wrote: "The best results are obtained by thinning peach varieties in order of ripening. Various rules are sometimes given as to the distance apart to leave the fruits, but they should be regarded as very elastic. Varieties that are inclined to bear heavily and that ordinarily produce small fruit must be thinned severely. If a tree has one part full and the other light the heavier portion may be thinned less than it would be if the whole tree were full. Trees that are for any reason regarded as 'weak' should not be allowed to bear heavily. If a tree has been well pruned the fruits may be left nearer together upon the twigs than would be permissable with poor pruning. It must be remembered that the production of peach

pulp does not draw heavily upon the tree, but it is the formation of pits and seeds that taxes the vitality. Hence, the most pulp that can be produced per tree, with the smallest number of pits possible will not only give the most economical production per tree but better fruits for the market. Care should be taken in thinning to remove all of the inferior or injured specimens. The earlier the thinning is done after it can be determined which are the permanent fruits the better will be the results. The size of the remaining fruits will be increased when the thinning is done late, but it will be far less beneficial to the trees." They (2) state: "The financial record of twelve years of a fifteen acre orchard will be of value and interest. The total cost of thinning for the twelve years was $154.30. There was no thinning the first three years and the eleventh and twelfth. The total cost of orchard expense was $ 7,831.37. Two percent of the orchard expense was thinning. The total production was 16,972 bushels. Therefore the cost of thinning was approximately one cent per bushel."

Gardner, Bradford and Hooker (21) 1927, in

their book "Orcharding", say:"Actual count showed an eight year old unpruned peach tree to have 37,582 fruit buds. Many factors operate to reduce greatly the number of fruits that a tree actually matures, below that which theoretically is provided for by its fruit buds. In this particular case bud killing amounted to approximately thirty per cent and only one fifth of the blossoms set fruit, This tree actually matured 1,213 fruits that averaged slightly under two inches in diameter and slightly over two ounces in weight, and numbered about two hundred and seventy five to the bushel."

Gardner, Marshall and Hootman (22) studied the relationship between size of peaches and size of crop. Some of the results of their investigation are: "Two principal cultural practices, pruning and thinning, are used to produce large fruits. Also, soil fertility is generally recognized as an important factor affecting the vigor and productivity of peach trees. Experiments have demonstrated the value of nitrogenous fertilizers in the peach orchard, and many growers have found that these applications have paid good dividends. At current prices for the different sizes and assumed average cost per tree of ten cents for material and labor of application, fertilization increased the return from each

unpruned tree from $1.59 to $3.09 in 1924." The following two years similar investments in fertilizer increased the returns on thinned and unthinned peach trees. The experiment indicates that generally fertilizer applications yield larger returns on lighter soils with old trees, than with more vigorous trees.

"Experimental tests were made on the influences of pruning on shoot lenght and size of peaches. It will be noted that the pruning that was afforded resulted in practically doubling the average shoot length and the average number of buds per shoot. The buds on the longer shoots were also more susceptible to frost injury and indicated clearly that severe pruning is of doubtful benefit from the standpoint of increasing the bearing surface. On the other hand it affects the distribution of the bearing wood making it more vigorous in the center of the tree. The importance of this latter influence is usually underestimated in the case of the peach, whose wood breaks easily and whose crotches split so easily. Some of the pruning treatments resulted in slightly increased returns and others in slightly decreased returns. However it will be noted that half of the crop borneby unpruned trees was without commercial value. The tree appearence justified the pruning

process by keeping the trees within reasonable bounds and thereby reducing vigorous production costs.

"Thinning of friut is regularly employed as a means of improving grade. Thinning experiments were carried out in three orchards. An attempt was made in the thinned plots to remove enough surplus fruit so that no two remaining fruits would touch each other and in most instances they were thinned so as to be about four or five inches apart. The thinning was done comparatively early in the season to give the fruits which remained the greatest possible opportunity to profit by the removal of their competitors."

"Results that were obtained in 1926. In most instances thinning resulted in a reduction in total yield, in one plot this reduction amounted to forty seven per cent. Where comparatively light thinning was practiced on heavily loaded trees, however,there was no reduction in total yield and in one instance a slight increase. Thinning invariably resulted in an increase in the percentage of large fruits and in most instances in an increase in absolute amount of the larger sizes. The data indicate that the amount of the increase in the size of fruit is determined by the number of fruits borne by the tree during the

later part of the growing season rather than by the percentage of the fruits removed in the process of thinning, because no close relationship is evident between the degree or the severity of thinning and the increase in the size of fruits. This statement is supported by the fact that an unthinned tree carrying two thousand fruits may be expected to produce fruit of the same average size as one of equal vigor with 4,000 fruits of which half are removed in early summer. The practice of thinning fruits so that certain arbitrary distances exist between those that remain is sound. Fruit thinning resulted in decreased net returns per tree in those instances where the total yield was materially reduced, but, where the thinning was less severe and yield remained approximately the same, returns were increased.

"In the Elberta orchard near Berrien Springs in 1926, fertilized and moderately pruned but unthinned trees averaged 2.8 bushels each and it required an average of 189 peaches to make a bushel. Corresponding trees whose fruit was moderately thinned averaged 2.4 bushels each and it required 169 to make a bushel. In 1927, the same group of trees averaged four and three tenths bushels, respectively. The thinned fruit

sold at a premium of thirty cents per bushel in 1926, just compensating the grower for the reduction in yield. In 1927, there was a slightly greater difference in the price between the two sizes, the general price range was higher, the trees yielded more heavily, and fruit thinning resulted in a net profit of about twenty five cents per tree. Therefore moderate thinning of fruit resulted in increased size and greater returns per tree when the trees have set a heavy crop."

Section II. The Rate and Manner of Fruit Growth as Related to the Size of Peach Fruits. During the past twenty years some studies have been made of the physiological factors influencing the growth of peaches. In 1905 Biglow and Gore (3) studied the chemical composition of the peach during its different stages of development. In 1914 Blake and Connors (7) studied the causes of the "June Drop" of peaches. They wrote: "This shedding of falling of fruit has been largely attributed to such factors as a lack of pollination, and insect and disease attacks. If eggs of plum curculio hatch and infest the fruit it is certain to fall and severe feeding punctures

by the same insect near the stem of the fruit may produce a similar effect.

"The cause for these fruits being small and their failure to develop has been attrubuted to the lack of pollination in most instances. This does not appear to be true, however, from observations and studies at the New Jersey experiment station. It has been noted that these small fruits have developed from smaller fruit buds upon the twigs. The work of Huber shows that the pollen in these smaller buds which, also bloom later than the larger buds, is just as viable at that of the larger buds except in instances where the twig, is greatly deficient in vigor and it appears certain that as perfect pollination occurs with the smaller buds as with the larger. It is also known that the peach is self fertile. During cold wet weather at blooming time the fruit may fail to set upon the peach from the lack of pollen, but, this is not believed to be the common cause of the small fruits which fall."

Blake (4) in 1919 made growth measurements of various varieties of peaches to determine the period at which growth takes place. Measurements were made weekly, starting three and one half weeks after blossoming. Average fruits were selected and measurements

made in the widest median axis. The measurements were as follows :

Date	May 29	June 5	June 12	June 19	June 26	July 2
Elberta	1.18"	1.35"	1.44"	1.48"	1.50"	1.51"
Hale	1.36"	1.56"	1.67"	1.70"	1.75"	1.75"

	July 9	July 15	July 23	August 3	August 15	August 23	August 30
E.	1.57"	1.62"	1.83"	1.96"	2.13"	2.32"	2.36"
H.	1.80"	1.84"	2.00"	2.32"	2.66"	2.95"	3.05"

According to a number of investigators (4), (11),(12), (13), (20), (22), (28), (30), (32, (37), and (39) the growth of peaches is definitely divided into three stages. This statement applies to all varieties, but certain modifications must be made for early clingstone varieties. First.--- Rapid development of the fruit, apparently due mainly to increase in size of seed part, up to 68 days after blossoming.

Second.-- Rest period during which the seed is formed and the stone becomes hard.

Third.-- Period of rapid growth of flesh to maturity, beginning 4 to 5 weeks before ripening time.

"The second stage shows the greatest amount of

variation. It may last for only one or two weeks in case of the early varieties, or for four to seven weeks in case of the later ripening varieties.

Farley (18) in 1923 studied, "The Factors Influencing the Effectiveness of Thinning". Thinning experiments were carried out on a comparatively large number of trees by six methods :--

July 7-8	1. Early light	4. Early heavy
July 21-22	2. Medium light	5. Medium heavy
July 5	3. Late light	6. Late heavy

Light thinning consisted of removing the green fruits so that those left on the tree spaced 4 to 6 inches along the branches, while the heavily thinned fruits were spaced 6 to 8 inches. In light thinning 36.56 % or 787 fruits were removed. The time of thinning did not make any difference. Results were as follows:--

Thinning	Date	Value of Carmine	& Belle
4 to 6	June 7	$ 172.00	$ 351.00
4 to 6	June 21	171.00	461.00
4 to 6	July 5	138.40	335.00
6 to 8	June 7	191.60	269.00
6 to 8	June 21	176.70	339.25
6 to 8	July 5	138.70	345.00
Unthinned check plot		112.00	309.75

Summary

1. The statement commonly made that peaches should be thinned before the pits hardened to secure satisfactory results was not substantiated in this experiment.

2. Early thinning was particularly effective with comparatively early ripening varieties.

3. This experiment indicates a direct relation between the degree of thinning and the size of the fruit.

4. The degree of thinning may be carried to such extent that the advantage gained in size of fruit will be lost by a decrease in yield.

Detjen (11) in 1926 made a study of the physiological dropping of peach fruits. He found that the embryo in the early stages is very small in proportion to the rapidly developing ovule. None of the peaches that fell during the week of the heavy drop had disintegrated ovaries. This should clear the idea regarding the importance of pollination or fertillization and the relative importance of embryo abortion of fruit shedding.

Dorsey and McMunn (12) in 1926 made a study of, "The Development of Peach Seed in Relation to Thinning". "First there is a period of rapid development of the fruit apparently due mainly to increase in the size of

seed part. In Elberta this took place 35 days following bloom during which time this variety had reached the average diameter of 1.44 inches. Since the stone begins to harden at about the end of this time, this period is characterized by the outlining of the stone in the flesh to nearly its full size.

"The second, or 'rest period', extending from the 36th to the 68th day after bloom is featured by a relatively slight increase in diameter and by hardening of the stone. The average increase in diameter from 1.44 to 1.62 inches (measured through the suture of the peach fruits), volume increase during the second period would be about forty three per cent.

"The third, 'flesh forming period', extending from about the 69 day to maturity. During this time the volume of flesh increases very rapidly, (in diameter from 1.62" to 2.36" or 209 per cent.)

"The stone reaches nearly its maximum size by the 42 day. As in the stone there is a rapid growth at first in the seed coats and in the nucellus, except for plumpness of kernel which begins to harden. Before the kernel is one-fourth the

size it reaches at maturity the embryo sac has extended full length of the nucellus. With further growth in the seed there is an enlargment and lengthening of the canal accompanied by further elongation of the embryo sac. Therefore the rapid growth in the stone and is an outstanding feature of early growth of the seed.

"The embryo and cotyledons develop late in the peach. Two months after bloom the embryo is not often more than one-sixteenth inch in length in the Elberta, and can be seen as a small white spot in the extreme tip of the nucellus. The Table No. I on the following page shows, "Sequence of Development of the Fruit and Seed of Elberta."

Dorsey and McMunn (15) in 1931 made an extensive study of seed size in relation to fruit size in the peach, as related to peach thinning. Table No. II on page 18 gives measurments showing the increase in growth of the different parts of the peach. An Elberta peach 1½ to 1¾ inches diameter has 86.9% flesh. An Elberta peach 2 inches or more in diameter has 94.% flesh. Two important facts are to be noted; (a) The flesh increases in amount relative to the 'seed' as maturity is approached. (b) While the larger peaches

Table I. Sequence of Development of the Fruit and Seed of Elberta (After Dorsey and McMunn).

Fruit Part	Number of Days after Bloom					
	34	42	59	69	83	119 Mature
Size of fruit long diameter	5/8 to 1"	1 5/8"	1 5/8"	1 7/8"	2 to 2 1/4"	2 1/8 to 2 5/8
Length of stone	Not formed	1 1/8" hardening at tip	1 5/8" hard	same	same	same
Length of kernel	5/16"	3/4"	same	same	same	same
Length of embryo sac.	Length of nucellus	same	same	same	Expanded size of cotyledons endosperm	Size of cotyledons
Length of endosperm	Slightly visible	3/16" across	3/8" across	Supressed by cotyledons, and larger	Mostly absorbed	Absorbed
Length of	Very small spherical	Slight growth sph'l	1/16"	1/8 to 9/16"	5/8 to 7/8"	same

tend to have larger "seeds" the proportion of the peach which is flesh increases with size.

Table II. Measurements showing the increase in growth of different parts of peach. (After Dorsey and McMunn).

Measurements	Dates						
	June 23	June 28	July 7	July 13	July 20	July 26	Aug. 8
Average suture diameter in inches.	1.51	1.53	1.57	1.62	1.82	1.95	2.26
Av. weight of fruit in grams	30.0	34.1	35.9	39.9	47.1	59.2	125.
Average weight of seed in grams	6.6	7.5	6.5	6.9	8.2	7.5	11.1
Per cent flesh by weight	78.8	78.2	81.7	82.5	82.6	87.4	91.1

It appears, therefore, from a number of angles that the size of the "seed" or stones and the size of the fruit are more or less closely related.

Summary and Conclusions

I. The stone does not increase in size after the hardening process is under way.

II. The larger peaches tend to have larger "seeds". The significance of this relationship commercially is that conditions should prevail during the first period which favor "seed" development or early growth in the peach as a whole.

III. Early thinning did not, within a given tree condition, increase the size of the stones in the fruit of a given size class as might be expected.

IW. The general growth conditions of the tree (ie.) whether high in carbohydrate or high in nitrogen, influenced the stone size more than early thinning.

Section III. The Relation of Fruit Size to Leaf Area. Jones (26) in 1931-1932 reported that an increase in the number of leaves per fruit was attended by the following results:

I. When the leaf ratio was 10 to 1 vs. 45 to 1 increasingly large fruit though not in proportion to leaf area was produced.

II. Increase in sugar content.

III. Larger fruit mature earlier.

IW. Improvement in color of fruit.

W. Improvement in flavor of fruit.

Weinberger and Cullian (37) in 1932 studied ratios of 10, 20, 30. 40 60, and 80 leaves per fruit on branches of 10 Elberta trees. The branches were girdled June 13. The branches with the lower leaf ratios, 10 and 20, produced by far the greatest number of new leaves after girdling. With 10 leaves per fruit,

the peaches attained a size of 2.2 ounces (approximately two inches in diameter), while with 20 leaves per fruit, the final size was 3.6 ounces (2½ inches). A greater number of leaves produced larger fruits though not directly proportionately. Pit measurements were made when the fruits matured and on the whole the heaviest pits were produced with the 80 leaf ratio, averaging 6.92 grams, and the lightest with 10 leaf ratio averaging 6.09 grams. The other pit weights were directly correlated with leaf area. It was also noted that fruit on girdled branches were over 20 per cent larger than on normal branches. Thus the effect of thinning of fruit on girdled branches is not strictly comparable to thinning on normal branches. The accumulation of food caused by girdling the bark increases the efficiency of the individual leaf in sizing the fruit. The larger the leaf area per fruit, the more noticeable is this effect. Allowance should be made for this factor in interpreting results of this type on a practical basis.

Objective

Since the leaves of the tree manufacture the plant foods for the fruit and tree growth, it seems reasonable that the number of leaves per fruit (remaining on the tree after thinning) should be a good basis for the removal of excess fruit. The literature cited shows that the different varieties of peaches vary in time of ripening and size. The object of these experiments is to add something to the present information concerning the methods and time for the removal of surplus peach fruits when the trees set a full crop. More specifically this investigation aimed to determine the number of leaves needed to produce fruit of a good size and quality without undue reduction in quantity.

Description of Experiments Conducted

Orchard.-- The studies were made on trees in the "Mountain View Orchard" located west of the city limits of Romeo, Michigan, planted in 1927. The land has a gradual slope toward the northwest. The orchard was fertilized by broadcasting sulphate of ammonia which was harrowed into the soil. Clean cultivation was practiced during the spring and early summer, when the orchard was sown to buckwheat as a cover crop, and the large sturdy plants held the snow in the orchard during the winter. Trees that had been injured or did not seem to have normal vigorous growth were not used in this investigation. The trees received uniform spray treatments and uniform treatment for peach borer. They were set 18 by 18 feet apart and were given moderate to light pruning each year.

Season.-- The seasons (1930-1931 and 1931-1932) were favorable for both heavy set and good survival of peach fruit buds. The thermometer rarely reached the zero point during the winter. The summer of 1931 was rather hot and dry, with a light rainfall. The summer of 1932 was warm with an average rainfall.

Methods of Investigation.-- The experiments were begun during the summer of 1930 when records were collected from branches about three fourths of an inch in diameter. They gave the number of leaves, and the number and weight of the fruits. These records showed that branches of the same tree did not produce peaches of the same size in proportion to the ratio of leaves per fruit. These great differences made it apparent that practical tests should be made on girdled branches. In June 1931 twenty five branches were girdled on each of three varieties;-- Dewey, Rochester. and South Haven. These girdles were about one fourth inch wide on branches about one half inch in diameter. The girdles were wrapped with adhesive tape to prevent evaporation. Two weeks after the girdles were made the variations in growth of leaves and fruits were so great that it was decided to count the leaves on whole trees. This was done in July, 1931. The data showed some relation between leaf area and size of friuts and the work was repeated in 1932.

The common way of recording peach size is transverse diameter in inches. In this work, however, the fruits were weighed and the size recorded in

ounces. Furthermore photographs were taken with the fruits laid on a graduated scale, as shown in Figure I. For general comparison the weights and sizes of ripe peaches are given as follows: Table III.

8 ounce peach 3 in. in diameter 100 per bushel
6 ounce peach 2 3/4 in. in diameter 130 per bushel
4 ounce peach 2 1/4 in. in diameter 200 per bushel
3 ounce peach 2 1/8 in. in diameter 260 per bushel
2 ounce peach 2 in. in diameter 400 per bushel
1 ounce peach 1 1/2 in. in diameter 788 per bushel

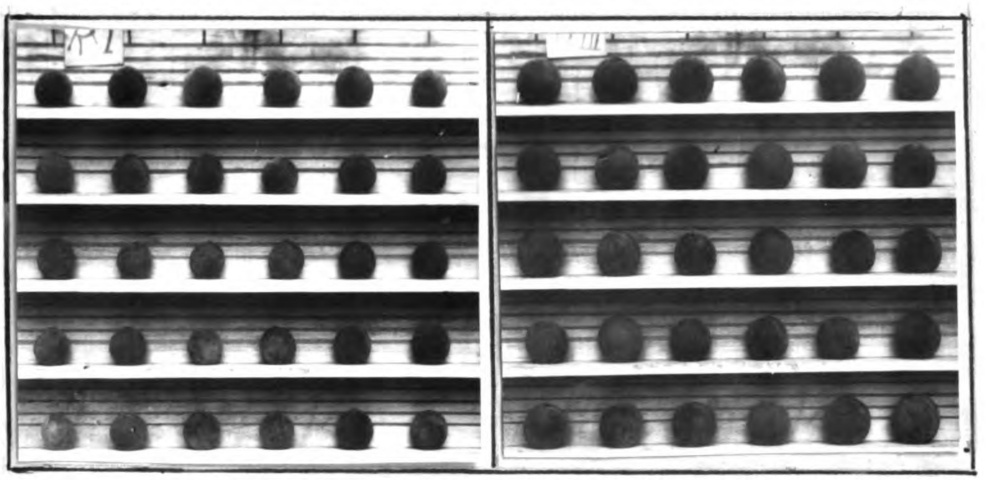


Figure I. Rochester Peaches from Thinned and Unthinned Trees.

The peaches in the figure at the right were thinned to twenty five leaves per fruit. The photographed background scale lines are drawn so that the lines are 1", 1½", 2", 2½",and 3" from the base.

One hundred fruits of each variety were selected at random and weighed each week. Table IV, and Figures 2, 3, 4, 5 and 6 indicate the progress of growth made by each variety. These records of

Table IV. Weights in Ounces of 100 Thinned and Unthinned Fruits at Weekly Intervals

Variety	Days after Blossoming														
	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133
	Weights of 100 Fruits in Ounces														
Thinned Dewey	24	26	29	42	60	78	180	221	293						
Unthinned	24	26	30	40	45	56	80	98	141						
Thinned Rochester	30	33	39	49	61	70	100	114	256	341					
Unthinned	30	31	35	43	52	57	68	86	96	148					
Thinned South Haven	34	38	43	60	68	69	98	109	136	224	384				
Unthinned	34	35	39	48	54	56	76	89	101	160	184				
Thinned Elberta	37	40	49	59	68	86	102	106	111	149	199	251	348	432	
Unthinned	37	39	45	56	66	81	94	100	104	133	167	190	261	287	
Thinned J.H.Hale	37	39	41	58	70	89	106	114	125	147	205	357	498	657	704
Unthinned	37	39	42	47	66	80	96	104	109	128	191	274	338	403	415
Day of Month	20	27	4	11	18	25	1	8	15	22	29	5	12	19	26
	June		July				August					September			

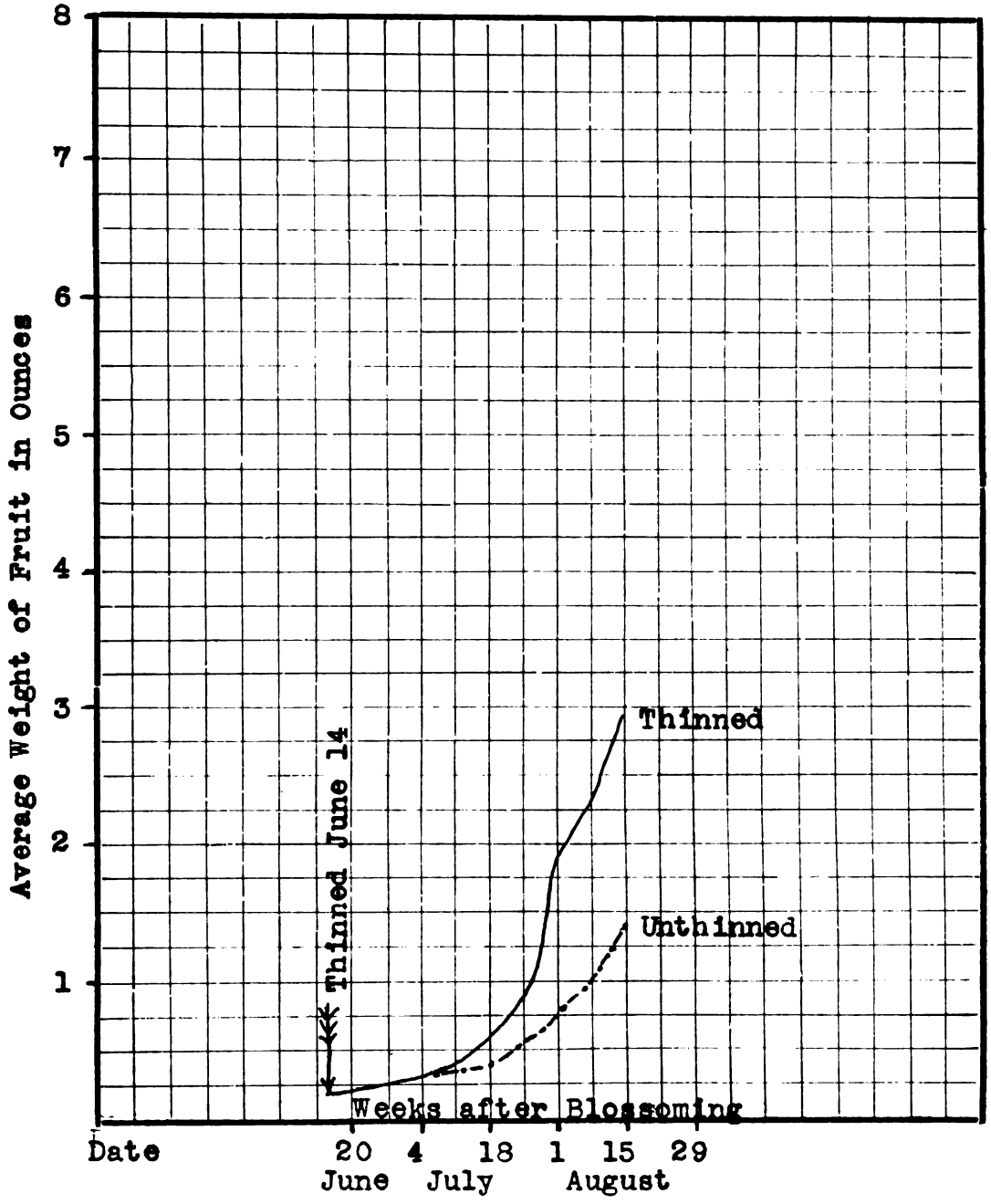


Figure II. Graphs showing the rate of growth of Dewey peaches from thinned and unthinned trees.

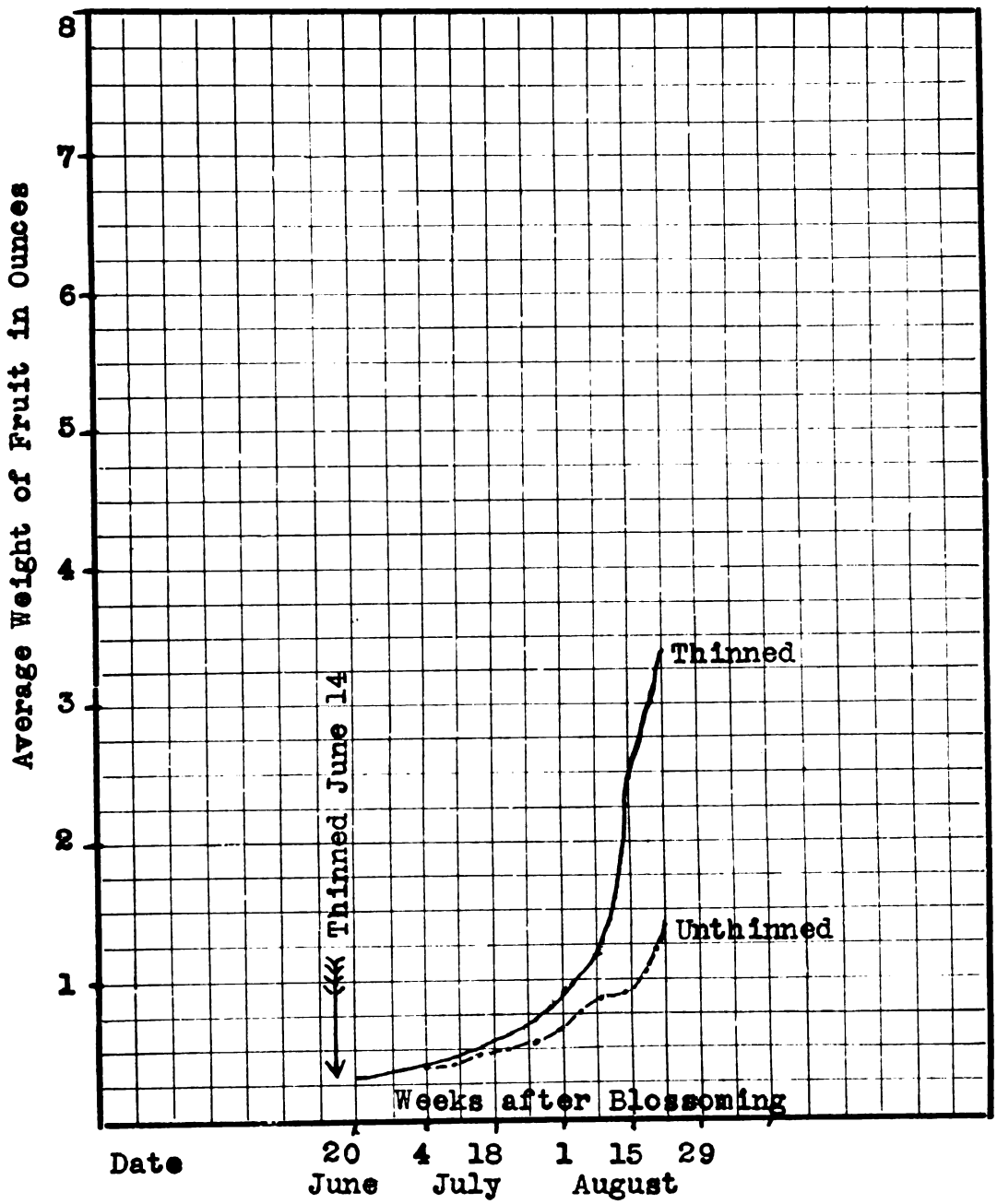


Figure III. Graphs showing the rate of growth of Rochester peaches from thinned and unthinned trees.

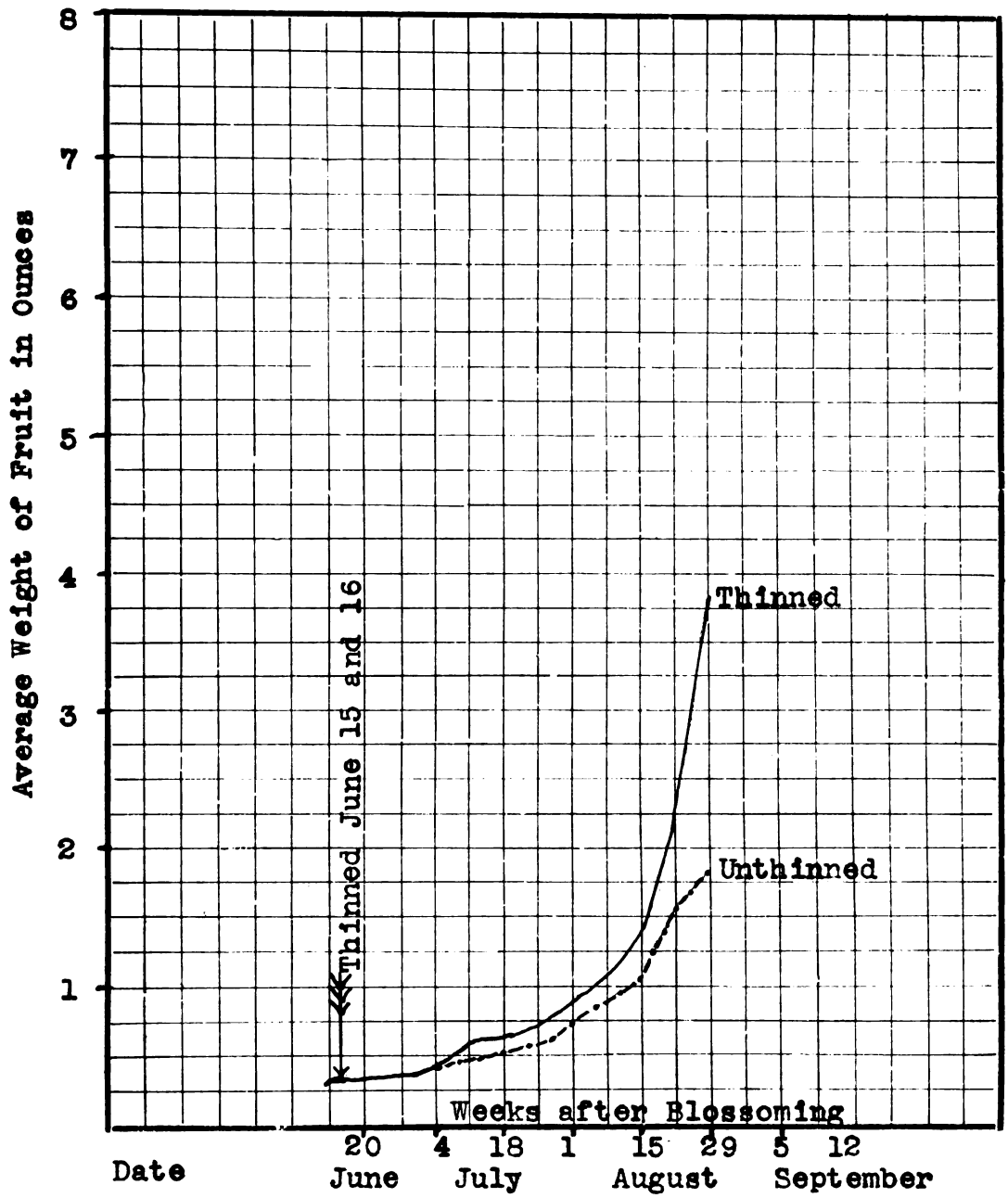


Figure IV. Graphs showing the rate of growth of South Haven peaches from thinned and unthinned trees.

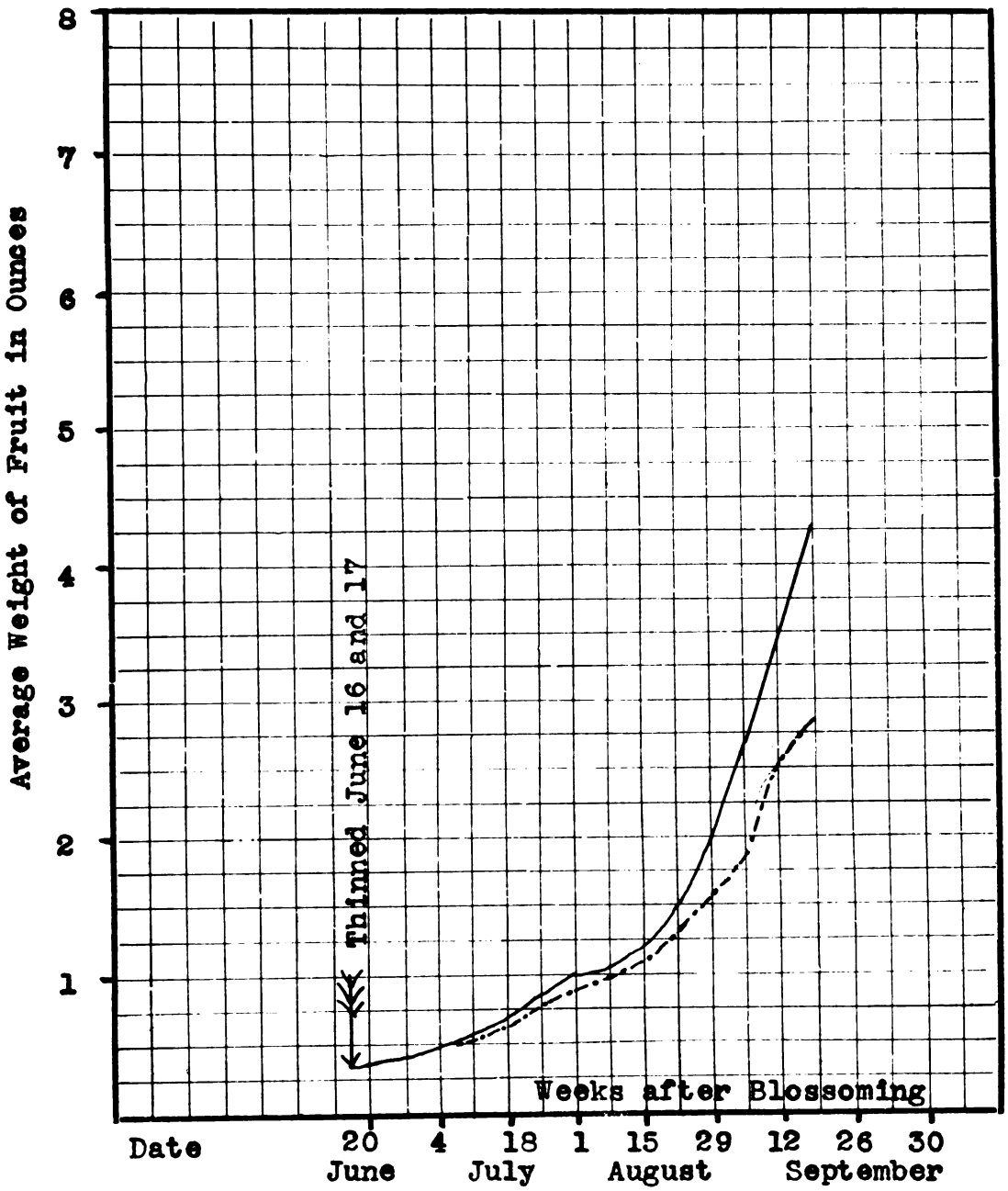


Figure V. Graphs showing the rate of growth of Elberta peaches from thinned and unthinned trees.

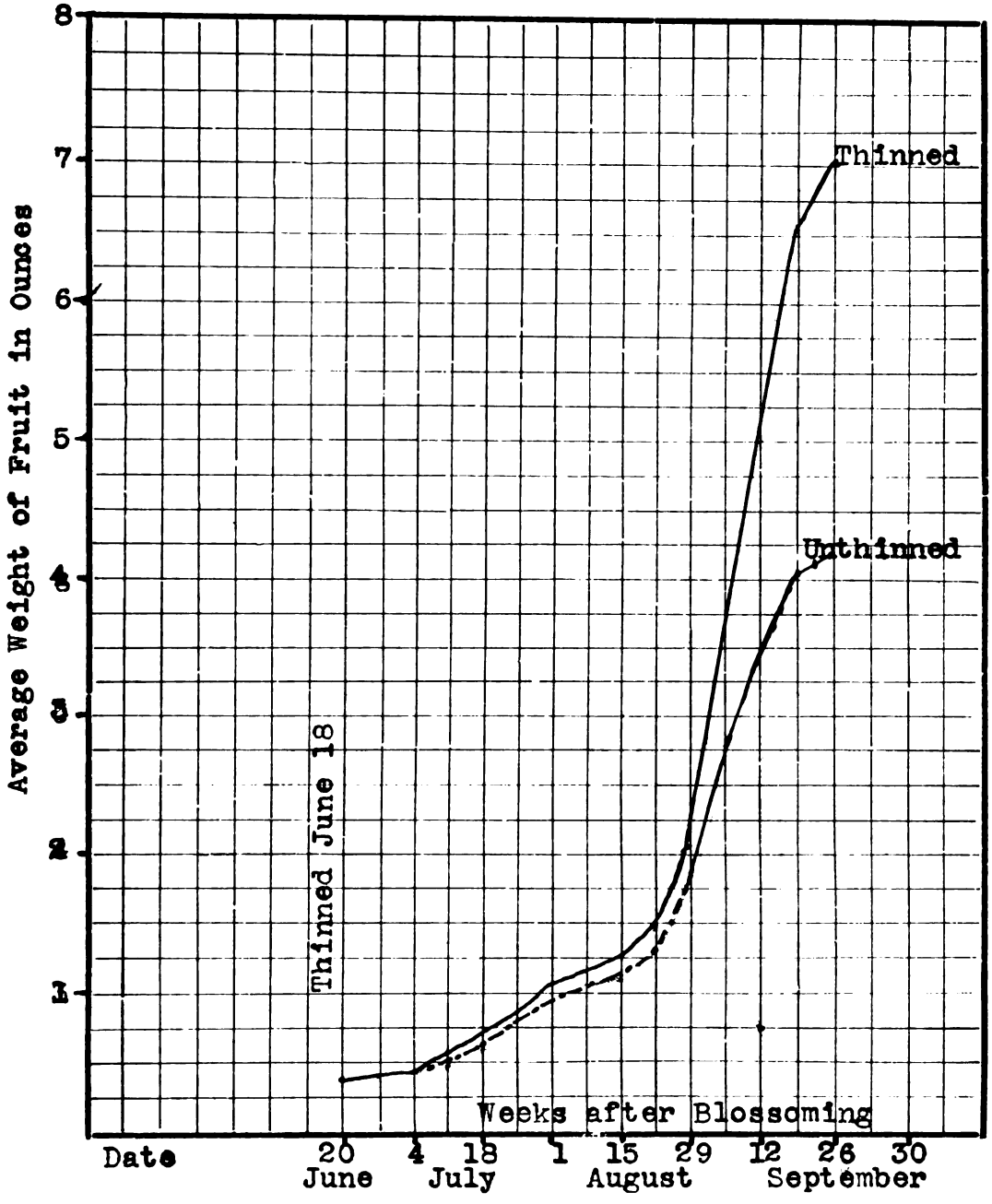


Figure VI. Graphs showing the rate of growth of J.H.Hale peaches from thinned and unthinned trees.

growth for each week and the graphs showing a comparison of the growth on thinned and unthinned trees makes it quite apparent that peaches do not vary a great deal in size until the rapid growing or, "flesh forming period" is reached shortly before maturity. They also indicate that peaches increase in weight very slowly during the pit hardening and seed formation period. According to Dorsey and McMunn (12) "the stone reaches nearly its maximum size by the forty second day after bloom." It is interesting to note the uniformity in growth during both the rest period and the flesh forming periods for the different varieties of peaches.

The Relation of Leaf Number and Leaf Area to Size of Peaches

Records were collected on branches one-half inch to three fourths inch in diameter. The week the fruits came to maturity the leaves were counted and the terminal growth for the season measured in inches. When the fruits ripened the records were completed for each branch by counting and weighing the fruits in ounces. The records were collected from each tree and are shown on the following pages.

Table V. Records from Dewey Peach Trees 1932

Tree label	Number of leaves	Terminal growth in inches	Number of fruits	Pounds of fruit	Average weight of each fruit oz.	Leaves per fruit	Leaves per pound	Terminal growth per 1,000 leaves
D.A. 2	5935	2410	219	38.0	2.77	27.	156	406
D.A. 1	7325	3335	322	52.25	2.6	22.	141	453
D.A. 9	4719	1545	233	32.4	2.2	22.	148	313
D.A. 11	4135	1565	209	30.3	2.3	20.	137	378
D.A. 15	8050	2620	428	62.0	2.3	18.8	130	325
D.A. 7	5118	1880	288	32.8	1.9	18.	156	361
D.A. 13	7670	2595	467	60.2	2.1	16.4	126	338
D.D. 1	6080	2030	387	38.75	1.6	15.	150	333
D.D. 5	4225	1550	347	35.	1.6	12.	120	366
D.D. 7	5900	1800	489	47.7	1.5	11.8	123	305
D.D. 3	7605	2500	714	48.	1.1	10.6	158	329
D.D. 13	5305	1960	534	47.7	1.4	10.	106	369
Averages for Thinned (D.A.) and Unthinned (D.D.) trees.								
Thinned	6132	2278	309	45.	2.31	20.6	142	352
Unthinned	5812	1968	494	43.4	1.44	11.9	131	340

Productions at these averages from 10,000 leaves.

Trees	Leaves per fruit	Production pounds	Value per pound cents	Total value
Thinned	20.6	69.8	2½	$ 1.64
Unthinned	11.9	76.0	3/4	$ .57

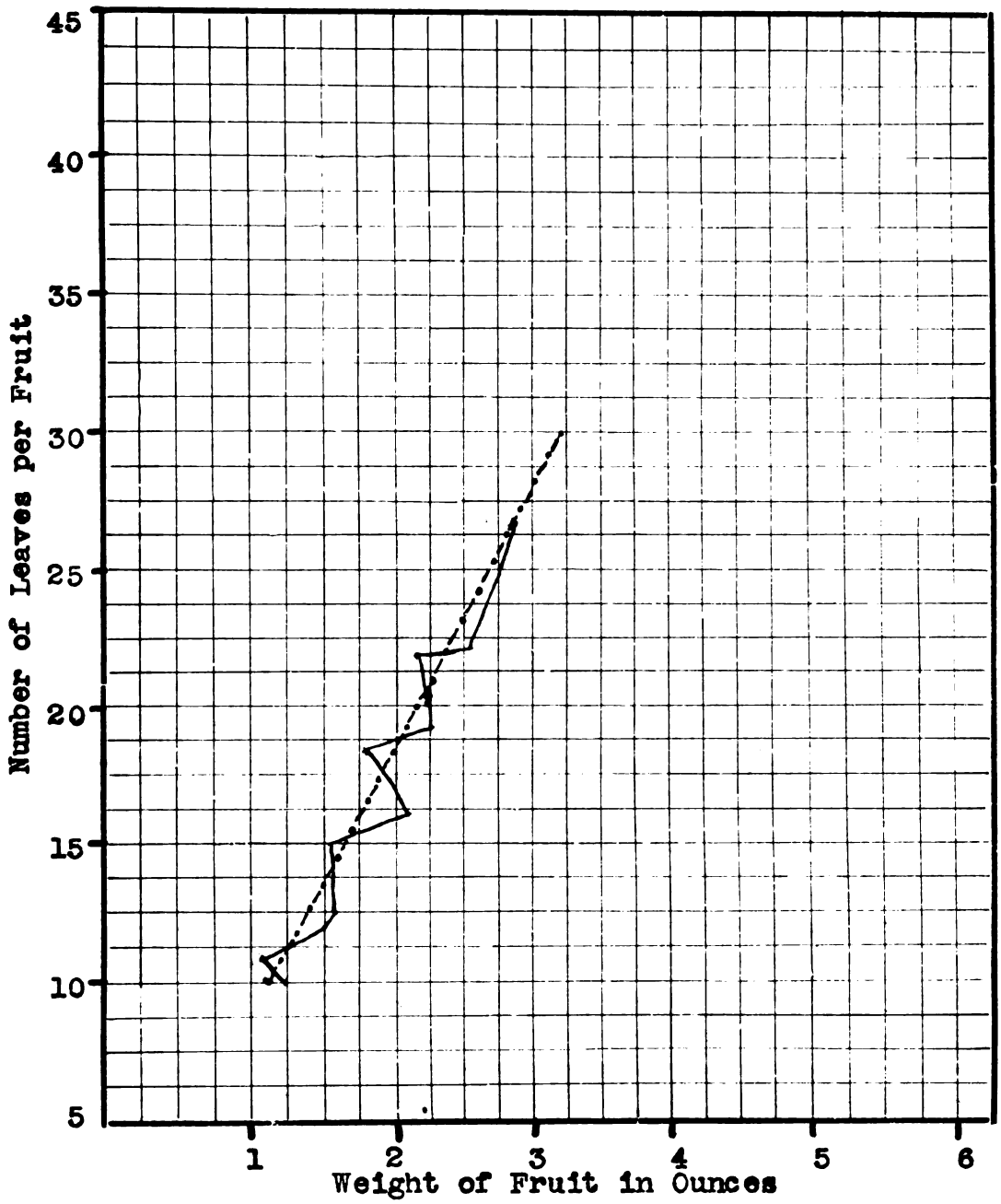


Figure VII. Graphs showing how size of Dewey peaches increases with the number of leaves.

——— As shown by tree records. -.-.-.-Smoothed curve.

Dewey

The Dewey is one of Michigan's most highly colored early market peaches and when the season is favorable the trees develop a large number of fruits. The trees do not have a heavy June drop and hand thinning and moderately heavy pruning are necessary to produce fruits of good size. The fruits on the trees in the test plot were thinned so that there would be approximately from 20 to 25 leaves per fruit. By actual count the number varied from 16 to 27. The average production for 10,000 leaves on thinned trees was 69.8 and for unthinned trees 76 pounds of fruit. Highest production was reached by tree D.D.13 on which 106 leaves on the average produced a pound of fruit. The ratio of leaves per fruit per fruit was 10 to one. The fruits averaged (1.4 ounces) each and were too small for marketing. The largest (2.77 ounce) fruits were produced by tree D.A .2 on which there were 156 leaves to each pound of fruit. The average size of thinned fruits was 2.31 and of unthinned fruits 1.4 ounces, each. The increased value of fruit produced by 10,000 leaves due to thinning was $1.07.

Table VI. Records from Rochester Peach Trees 1932

Tree label	Number of leaves	Terminal growth in inches	Number of fruits	Pounds of fruit	Average weight of each fruit oz.	Leaves per fruit	Leaves per pound	Terminal growth per 1,000 leaves
R.A. 3	7030	2930	289	66.	3.7	29	125	401
R.A. 7	5341	2115	181	43.8	3.8	29	122	398
R.A. 1	7032	2930	289	66.	3.6	24	106	416
R.A. 9	6475	2120	259	56.6	3.5	25	114	327
R.A. 5	6055	2580	253	55.7	3.5	24	109	414
R.D.11	5615	1970	304	41.6	2.2	15	110	405
R.D. 1	6261	2025	476	62.0	2.1	13	101	322
R.D. 3	6330	2185	576	68.5	2.0	11	101	322
R.D. 7	4910	1800	431	47.4	1.7	11	103	429
R.D. 5	6205	2160	585	73.8	2.0	10.6	84	348
R.D.11	5280	1935	632	61.8	1.6	8.5	84	366
	Averages for Thinned (R.A.) and Unthinned (R.D.) trees.							
Thinned	6386	2535	254	57.6	3.6	26.	115	396
Unthinned	5600	2012	501	59.2	1.9	11.5	96	365

Productions at these averages from 10,000 leaves.

Trees	Leaves per fruit	Production pounds	Value per pound cents	Total value
Thinned	26	87	2½	$ 2.18
Unthinned	11.5	105	1	$ 1.05

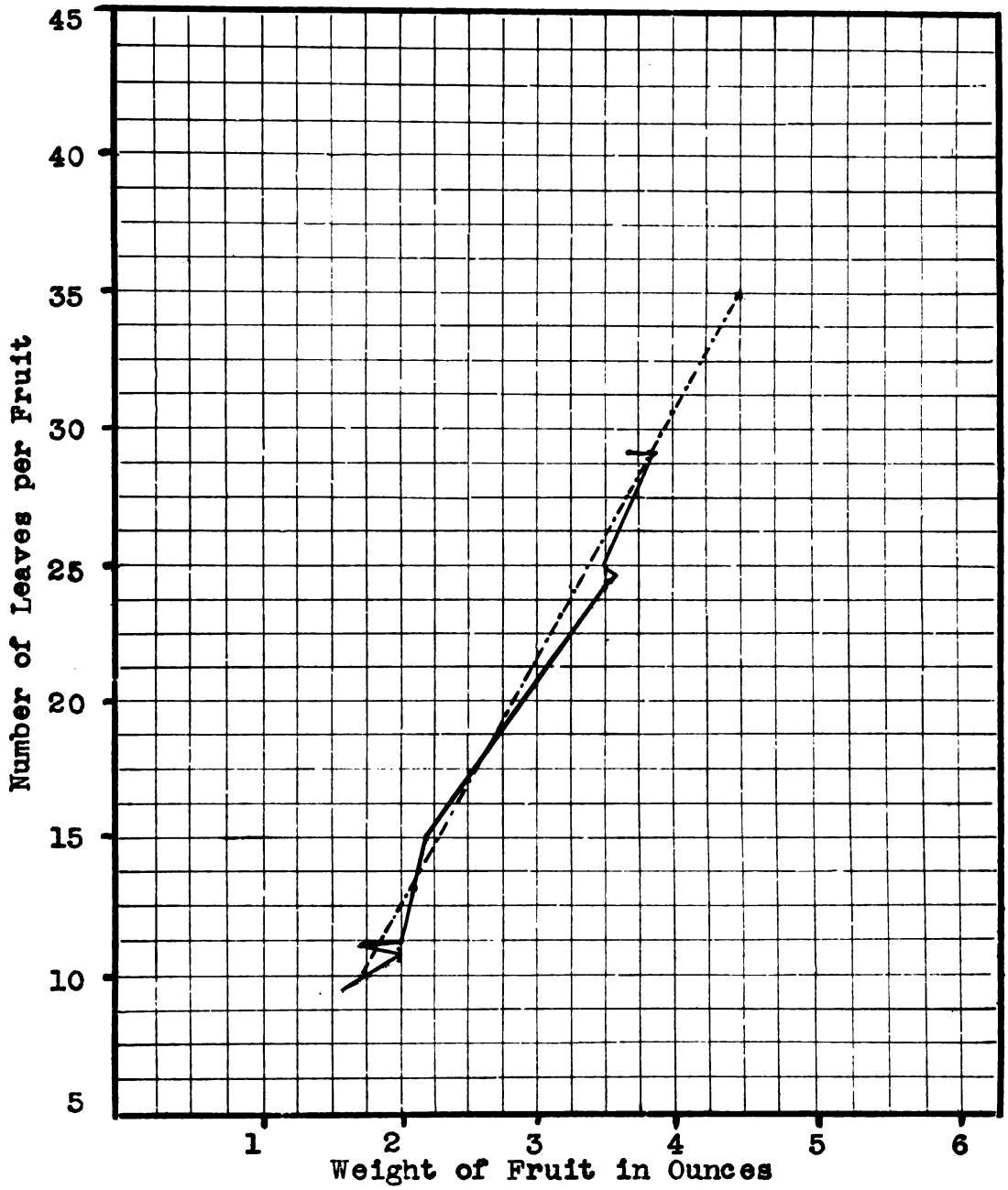


Figure VIII. Graphs showing how size of Rochester peaches increases with the number of leaves.

—— As shown by tree records -·-·-·-Smoothed curve.

Rochester

Rochester peaches are somewhat larger and not so highly colored as Dewey. This variety is classed as one of Michigan's best early peaches when the fruit on the tree is properly distributed to obtain good sized fruits. When the season is favorable the trees are heavily loaded and hand thinning and moderately heavy winter pruning are advisable in obtaining marketable fruits. The fruits on the trees in the test plot were thinned so that there would be approximately from 20 to 25 leaves per fruit. By actual count the number varied from 24 to 29. The average production for 10,000 leaves on thinned trees was 87 and for unthinned trees 105 pounds of fruit. The highest production was reached by tree R.D.5 on which 84 leaves, on the average produced a pound of fruit. The fruits averaged 2.0 ounces each. The largest (3.8 ounce) fruits were produced by tree R.A.7 on which there were 122 leaves to each pound of fruit. The ratio of leaves per fruit was 20 to one. The average size of the thinned fruits was 3.6 and of the unthinned fruits 1.9 ounces, each. The increased value of fruit produced by 10,000 leaves due to thinning was $1.13.

Table VII. Records from South Haven Peach Trees 1932

Tree label	Number of leaves	Terminal growth in inches	Number of fruits	Pounds of fruit	Average weight of each fruit oz.	Leaves per fruit	Leaves per pound	Terminal growth per 1,000 leaves
SH.A. 11	8745	2404	332	62.3	3.0	26	137	275
SH.A. 5	7305	2391	299	56.7	3.0	24	128	327
SH.A. 3	7605	2255	335	62.1	3.0	22	122	297
SH.A. 7	8205	3331	361	69.0	3.0	22	118	406
SH.A. 1	8094	2334	355	71.0	3.2	22	114	275
SH.D. 5	6575	1868	503	58.6	1.8	13.1	112	284
SH.D. 7	8947	2420	799	95.0	1.9	11.	94	270
SH.D. 1	7505	2551	643	72.3	1.8	11.	89	323
SH.D. 3	6363	2060	561	71.0	1.8	11.	103	300
SH.D. 9	6521	1767	572	60.8	1.7	9.5	85	271
Averages for Thinned (SH.A.) and Unthinned (SH.D) trees.								
Thinned	7991	2543	336	64.4	3.04	23	124	316
Unthinned	7182	2133	613	71.5	1.8	11.1	96	289

Productions at these averages from 10,000 leaves

Trees	Leaves per fruit	Production pounds	Value per pound cents	Total value
Thinned	23	80.4	2	$ 1.61
Unthinned	11.1	103.0	¾	$ .77

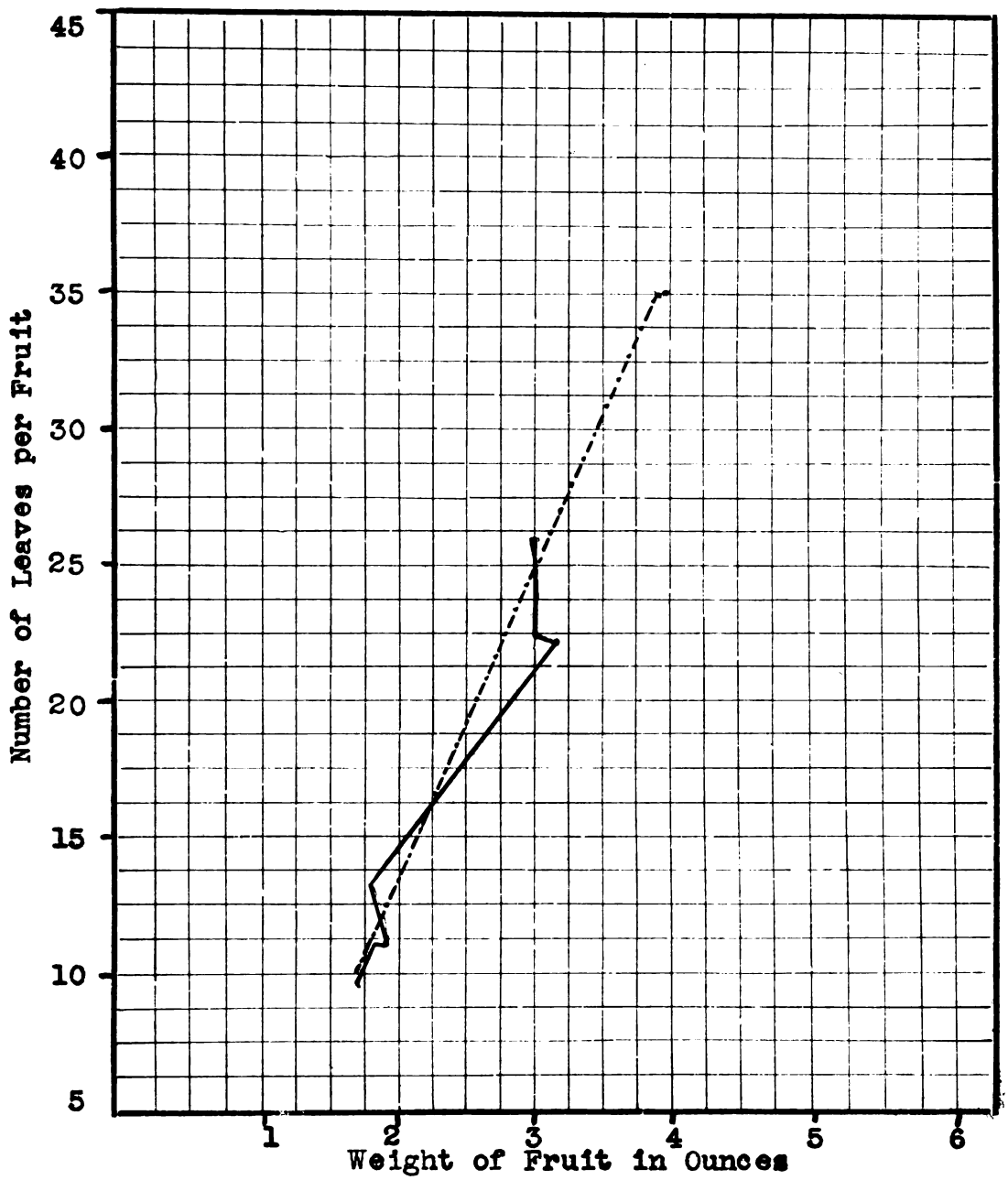


Figure IX. Graphs showing how size of South Haven peaches increases with the number of leaves.

*——As shown by tree records. –·–·– Smoothed curve.

South Haven

The South Haven peach is one of Michigan's highly flavored canning and fresh market varieties. When the season is favorable the trees are very productive, and hand thinning should be resorted to. The trees in the test plot were thinned so that there would be approximately 20 to 25 leaves per fruit. By actual count the number varied from 22 to 26 leaves per fruit. The average production for 10,000 leaves on thinned trees was 80.4 and for unthinned trees 103 pounds of fruit. Highest production was reached by tree SH.D.9 on which 85 leaves on the average produced a pound of fruit. The ratio of leaves per fruit was 9.5 to one. The fruits averaged 1.7 ounces each, which would be too small for much market value. The largest (3.2 ounce) fruits were produced by tree S.H.A. 1 on which there were 114 leaves to each pound of fruit. The ratio of leaves per fruit was 22 to one. The thinned trees averaged 23 and the unthinned trees averaged 11.1 leaves per fruit. The average size of thinned fruits was 3.04 and the unthinned fruits 1.8 ounces, each. The increased value of fruit produced by 10,000 leaves due to thinning was $.84.

Table VIII. Records from Elberta Peach Trees 1932

Tree label		Number of leaves	Terminal growth in inches	Number of fruits	Pounds of fruit	Average weight of each fruit oz.	Leaves per fruit	Leaves per pound	Terminal growth per 1,000 leaves
E.A.	2	5910	2450	157	48.3	4.9	37	122	414
E.A.	10	7395	3354	201	57.6	4.5	36	129	453
E.A.	4	6439	2381	203	51.8	4.1	32	124	352
E.A.	8	6884	2723	260	61.8	3.7	26.5	111	395
E.A.	6	6481	2802	269	71.4	4.2	25.4	95	415
E.D.	2	6480	2305	423	89.6	3.3	15.4	72	356
E.D.	6	5815	2124	425	85.0	3.2	14.	68	365
E.D.	4	6185	1856	596	95.4	2.6	13.	65	300
E.D.	8	5925	1870	548	82.7	2.4	10.5	71	316
Thinned		Averages for Thinned (E.A.) and Unthinned (E.D.) trees. 6695	2742	218	58.9	4.33	31.2	116	406
Unthinned		6101	2039	498	88.2	2.88	13.2	69	334

Production at these averages from 10,000 leaves.

Trees	Leaves per fruit	Production pounds	Value per pound cents	Total value
Thinned	31.2	88	3	$ 2.58
Unthinned	13.2	143	1½	$ 2.14

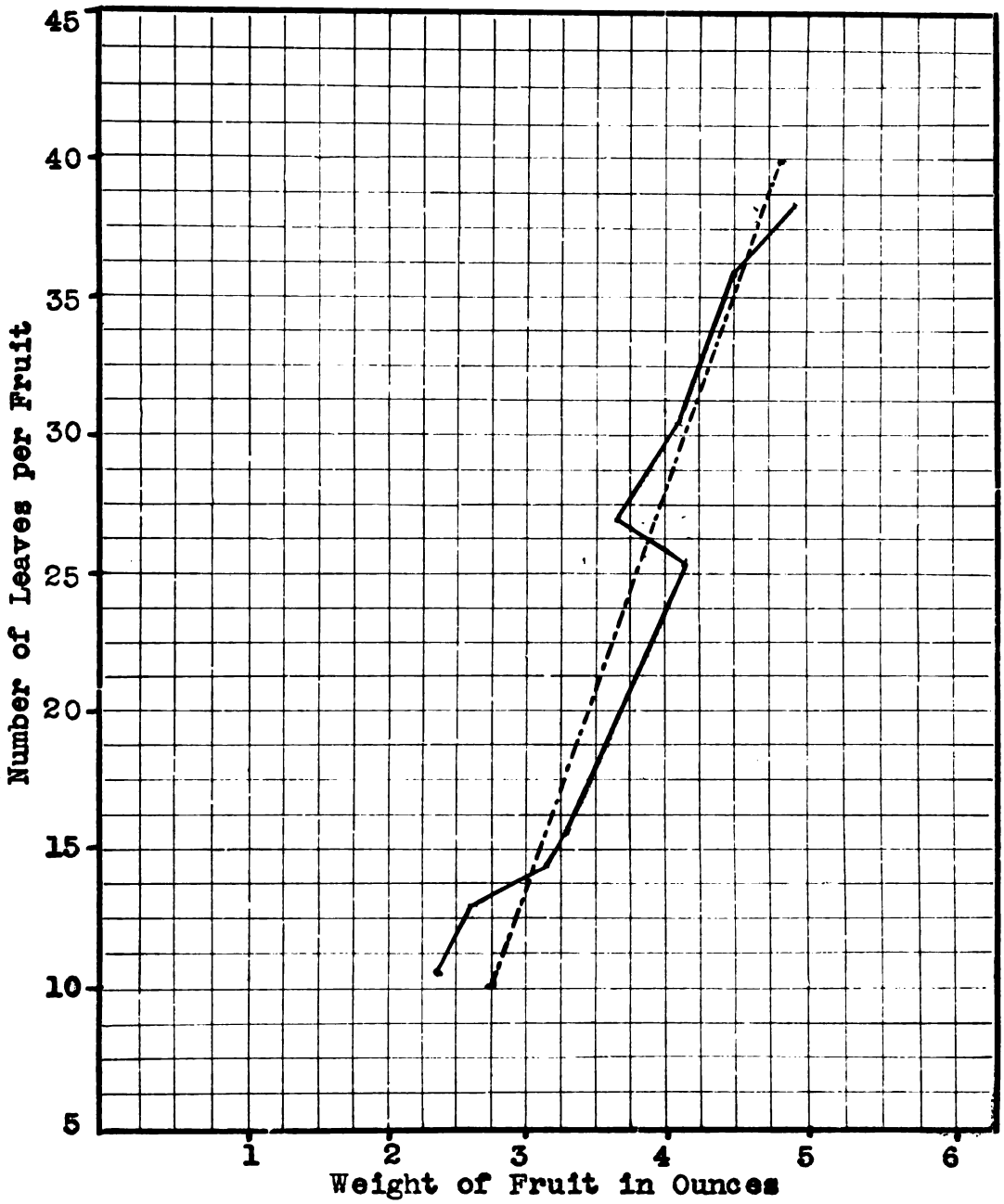


Figure X. Graphs showing how size of Elberta peach increases with the number of leaves.

——— As shown by tree records.-·-·-Smoothed curve.

Elberta

The Elberta peach is one of the most widely cultivated varieties. When the season is favorable the Elberta peach is one of Michigan's most productive fruits. The trees in the test plot were thinned so that there would be approximately 30 leaves per fruit. By actual count the number varied from 25 to 37 leaves per fruit. Average production for 10,000 leaves on thinned trees was 86, and for unthinned trees 143 pounds of fruit. Highest production was reached by tree E.D.8 on which 71 leaves, on the average produced a pound of fruit. The ratio of leaves per fruit was 10.5 to one. The ratio of leaves per fruit was 10.5 to one. The fruits averaged 2.4 ounces each, which was a marketable size. The largest (4.9 ounce) fruits were produced by tree E.A.2 on which there were 122 leaves to each pound of fruit. The ratio of leaves per fruit was 37 to one. The thinned trees averaged 31.2 and the unthinned trees averaged thirteen and two tenths leaves per fruit. The average size of thinned fruit was 43 and unthinned fruits 2.8 ounces, each. The increased value of fruit produced by ten thousand leaves due to thinning was $.44.

Table IX. Records from J.H.Hale Peach Trees 1932

Tree label	Number of leaves	Terminal growth in inches	Number of fruits	Pounds of fruit	Average weight of each fruit oz.	Leaves per fruit	Leaves per pound	Terminal growth per 1,000 leaves
H.A. 1	9370	3392	143	69.2	7.7	65	135	362
H.A. 3	7792	2740	128	56.0	7.0	60	139	351
H.A. 5	7648	2654	161	68.2	6.8	48	112	246
H.A. 7	8599	3021	214	72.0	5.3	40	119	351
H.A. 9	10650	3765	287	115.0	6.4	38	93	340
H.D. 3	7371	2424	247	61.2	3.9	25	120	315
H.D. 5	7319	2326	316	76.0	3.9	23	96	317
H.D. 1	7685	2150	340	80.5	3.5	22	95	279
H.D. 9	8572	2954	522	136.0	4.1	16	61	345
H.D. 7	9123	2905	619	162.	4.1	15	57	316
Averages for Thinned (H.A.) and Unthinned (E.D.) trees.								
Thinned	8812	3114	186	76.1	6.6	50	119	330
Unthinned	8013	2552	409	103.1	3.9	20	86	314

Productions at these averages from 10,000 leaves.

Trees	Leaves per fruit	Production pounds	Value per pound cents	Total value
Thinned	50	85	4	$ 3.40
Unthinned	13.2	143	1½	$ 2.14

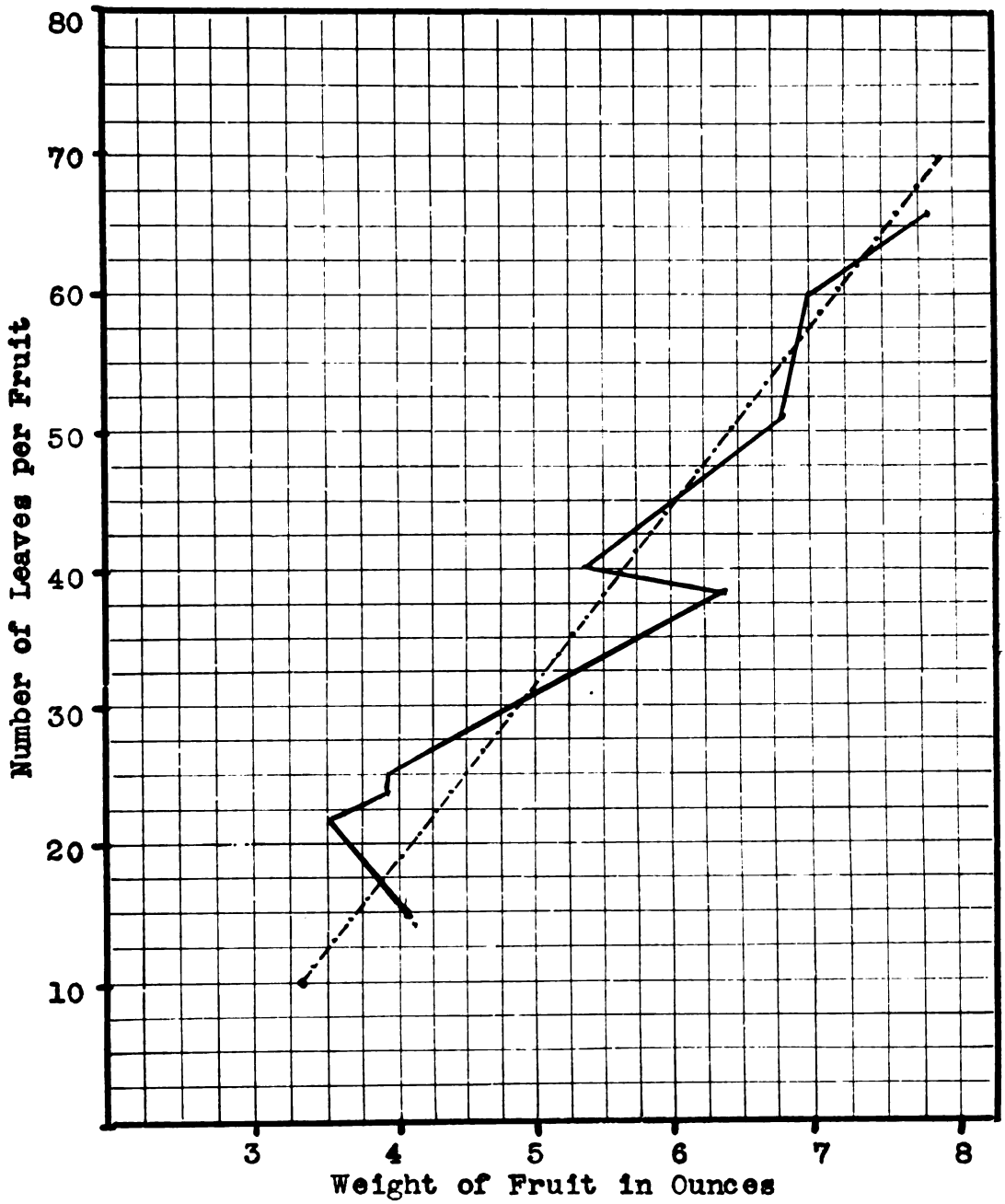


Figure XI. Graphs showing how size of J.H.Hale peach increases in size with the number of leaves.
—— As shown by tree records.-·-·-Smoothed curve.

J.H.Hale

The J.H.Hale peach is one of Michigan's best fancy market varieties, when the fall frosts do not interfere with its maturity. When the season is favorable, the trees are very productive and hand thinning is advisable to produce large fancy fruits. The fruits on the trees in the test plot were thinned so that there would be approximately from 40 to 50 leaves per fruit. By actual count the number varied from 38 to 65. The average production for 10,000 leaves on thinned trees was 85, and the unthinned trees averaged 125 pounds. Highest production was reached by tree H.D.7 on which 57 leaves, on the average, produced a pound of fruit. The ratio of leaves per fruit was 15 to one. The largest (7.7 ounce) fruits were produced by tree H.A.1 on which there were 135 leaves to each pound of fruit. The ratio of leaves per fruit was 65 to one. The thinned trees averaged 50, and the unthinned trees averaged 20 leaves per fruit. The average size of the thinned fruits was 6.6, and the unthinned fruits 3.9 ounces, each. The increased value of fruit produced by 10,000 leaves due to thinning was $.90.

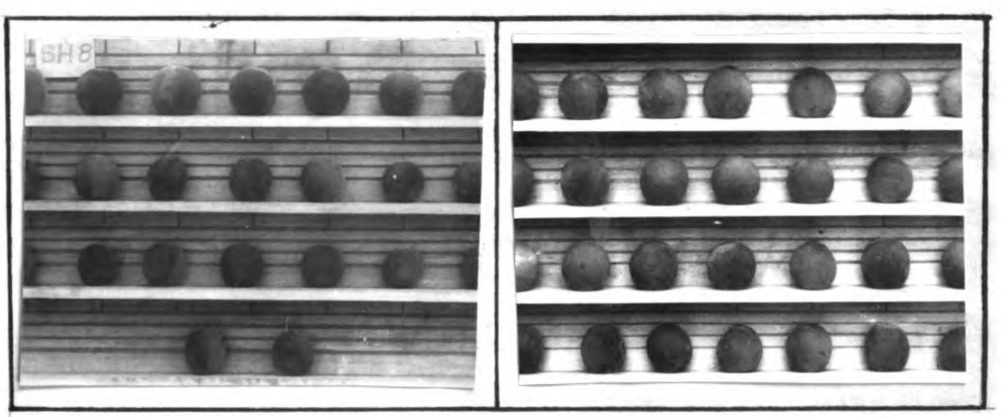
General Observations

Observations made during the 1930 and 1931 seasons seem to indicate that the rapidly growing small fruits made a heavy draft on the trees food supply. The fruits located where there was a sufficient number of leaves to produce good growth, matured to a good size, although they were clustered on the branch. When the fruits were numerous and the foliage insufficient to produce good growth many fruits and leaves drooped (See Figure XV). Many of the leaves on trees bearing a heavy load turned yellow and dropped approximately the same time as the shrunken fruits. This condition is more prevalent with the early varities. Tests were made of the growth of fruits in respect to development when the fruits touched each other. Large clusters of fruit were left unthinned. The fruits were removed from adjacent branches and the leaves were counted so that each fruit had an average ratio of leaves per fruit of 25 to one. The branch was girdled below the food supply. South Haven branches (A) and (B) are shown in the Figure XII. The leaves surrounding the fruits were removed from (B). Branch

(A) originally had 26 peaches. The fruits developed to good uniform size shown by Figure XIII. This demonstrates that peaches do not tend to shrivel and drop if they have a sufficient supply of plant food, which apparently they can obtain from an adjacent branch.

(A) (B)

Figure XII Clusters of South Haven Peaches.



(A) (B)

Figure XIII Size of South Haven Fruits.

(A) (B) (C)

Figure XIV. Types of Peach Branches.

These three types of branches shown in Figure XIV might be found on any variety of peach trees. The long slender branch (A) with scattered leaves would not produce large peaches, although they were left eight inches apart. The heavily foliated branch (C) with a large number of new shoots has a large number of leaves and on this branch the fruits might be left two inches apart. Also, observations of the past three years indicate that the long slender branch needs more leaves per fruit than branches of type (B) and (C). It would be

good practice in thinning early varieties to leave one peach for each 30 leaves on type (A), one for each 25 leaves on type (B) and one for each 20 leaves on type (E).

Figure XV. Shrunken Fruits and Leaf Dropping

Figure XV of a South Haven branch shows premature defoliation and shrunken fruits. This was a typical branch taken from a heavily loaded tree. Many of the lower lateral branches loaded with fruit lose all of their leaves before there is a natural dropping of the surplus fruit. Also, many of the leaves on the branches adjacent to the shrunken

fruits are discolored. It seems reasonable that early thinning might prevent this premature defoliation and thus increase the productivity of the tree. The photographs also indicate that Nature does not remove enough surplus fruits to complete the thinning process.

The records that have just been presented indicate differences in pruning, in soil fertility or water supply that caused a variation among the trees. This difference in the number of leaves and production had some influence on the size of the fruits, but in spite of these differences, it is apparent that thinning improved the size of fruits. For example a thinned Dewey tree (D.A.11) with 4135 leaves thinned to 20 leaves per fruit produced fruits weighing 2.3 ounces each, and unthinned tree (D.D.5) with 4225 leaves with 12 leaves per fruit produced fruits averaging only 1.6 ounces each. A vigorous Dewey tree (D.A.15) with 8050 leaves thinned to 18.8 leaves per fruit produced 2.3 ounce fruits, and unthinned tree (D.D.3) with 7600 leaves with 10.6 leaves per fruit produced 1.1 ounce fruits. This indicates how fruits approximately the same size are produced by a definite ratio of leaves per fruit. Similar comparisons could be made with other varieties.

It is interesting to compare the percentage decrease in fruit production by 10,000 leaves on thinned trees, with the percentage increase in wood which was measured by shoot growth. Table X indicates that when peaches on the trees having a heavy setting of fruit are thinned more wood growth is produced. It shows that when there is little or no thinning the fruits get the first claim on the food materials manufactured by the leaves, and shoot and wood growth consequently suffer. On the other hand, when the fruits are properly thinned, relatively more food material is left for vegetative growth and consequently the growth of shoots is longer and more vigorous. The 21.5 per cent increase in shoot growth in the Elberta peach tree wood was accompanied by a decrease of forty per cent in fruit production. The 9.3 per cent increase in wood or shoot growth on the South Haven trees was accompanied by a decrease of 18 per cent in fruit production. It is quite probable that this decrease in production and comparative increase in shoot growth according to a number of earlier investigations (1), (19), (20), (20), (24), (32), (30), and (37) conserves the strength of the tree and seems to stimulate fruit bud set. Thinning

Table X. A comparison of the per cent decrease in fruit production by 10,000 leaves from thinning, with the per cent increase in shoot growth.

Average Variety	Production of 10,000 leaves			Shoot growth per 1,000 leavs		
	Pounds of fruit Unthinned	Thinned	Per cent decrease	Growth in inches Unthinned	Thinned	Per cent increase
Dewey	76	69.8	8.1	340	352	3.5
Rochester	165	87.	17.1	365	396	8.5
South Haven	103	84.	18.4	289	316	9.3
Elberta	143	86	39.8	334	406	21.5
J.H.Hale	103	76	26.2	314	330	5.1

gave the smallest decrease of 8.1 per cent in fruit production on Dewey trees, but thinning improved the fruits which showed the greatest difference in market value. This seems to indicate that thinning is most beneficial to early peach varieties, but the later varieties make greater increases in wood growth.

These results are from vigorous, well fertilized, moderately pruned five year old trees. Trees that are lacking in vitality have a heavier "June drop" and if not thinned early, usually have a heavy leaf drop during the pit formation period. Peach fruits of an excellent quality can be produced by Michigan growers when they instruct their thinners in properly removing the surplus fruits from the heavily loaded trees, providing such trees and soil conditions are studied for each variety in its environment.

Table XI. Differences in Varieties of Thinned Peaches.

Variety	Leaves per fruit	Size of fruit	Days growth	Leaves per #	Shoot growth per 1,000 leaves
Dewey	20.6	2.3	91	142	352 inches
Rochester	26.0	3.6	98	118	396 ..
South Haven	23.0	3.04	108	124	316 ..
Elberta	31.2	4.3	126	116	406 ..
J.H.Hale	50.0	6.6	133	119	330 ..

Table XI, indicates the number of leaves needed to produce an excellent quality of each variety of peaches, and some of the variety differences.

The graphs (Figures VII to XI) on the growth of each of these varieties shows that vigorous trees with the indicated leaf ratios would produce approximately the sized peach fruits indicated by Table XIII.

Table XIII. Approximate size of fruit (diamater inches) as produced by the following ratio of leaves per fruit.

Leaf ratio fruit	Inches diameter of fruits produced		
	Early	Mid. season	Late
15-20 to one	1¾ to 2"	1¾ to 2 1/8"	2 to 2 1/8"
20-25 to one	2 to 2 1/8"	2 to 2 1/8"	2 to 2¼"
25-30 to one	2 1/8 to 2¼"	2 1/8 to 2¼"	2 1/8 to 2¾"
30-40 to one		2 1/8 to 2½"	2 1/8 to 2¾"
40-50 to one			2¼ to 3"
50-60 to one			2½ to 3"

This investigation shows that the systematic removal of surplus fruits can be accomplished by first glancing over the branch and estimating the number of leaves. Then leaving the proper number of fruits to attain the desired size. If the tree has set a large number of fruits on the inner slender branches (which are weaker (6)), the ratio of leaves per fruit should be doubled. Those who favor pruning as a thinning process (1), (3), (6), (9), (13), (20), (22), (31) and (32) would remove

most of these slender inner branches by heavy pruning. This process of pruning is favorable to the production of large peaches on rapidly growing shoots which usually have a light set of fruit buds. The long shoots are not possibly so hardy and do not withstand the cold winters as well as the short hardier ones. However, when these inner lateral branches are properly thinned, good sized fruits are produced. The operators should be sure that each branch has a sufficient number of leaves to develop good sized fruit. In the terminal part of the branch (Figure XIV Type (C)),some of the lateral shoots or secondary branches fail to set fruit. In this case the operator should leave many peaches close together on the main part of the branch. Furthermore when only one half of the tree sets fruit the other half can be thinned accordingly because the food materials from one side can help to produce larger fruits on the other.

Peach thinners should accurately estimate the number of leaves on a branch. In doing this they should make a study of the different types of branches. Estimate the number of leaves per branch

then count the number of leaves on the branch. By doing this a few times it is possible to become efficient hand thinners of peach fruits. Such employees are constantly reminded of the fact that the leaves manufacturecthe tree's food supply to growfruits, new shoots, leaves, roots and wood. When good sized fruits develop it is an indication, that the food for good growth is sufficient to supply all parts of the tree. Two to three ounce peaches are easily sold on the early market but the later market demands a four to six ounce peach.

The shoot growth on a tree is an indication of the vigor of its growth. Trees that are neglected produce new shoots less than four inches long. When the peach orchard is unfertilized, light pruning is practiced and the soil poorly tilled the trees have short shoot growth , and very severe thinning should be practiced. Where moderate pruning and good clean tillage are practiced the shoot growth should be between 5 and 10 inches, and quite severe thinning should be practiced. Under ideal orchard conditions, where the soil is fertile or regular applications of fertilizers are made, moderate

pruning is practiced and there is clean tillage with a good cover crop sown every year, the new shoot growth is from 6 to 16 inches, and moderate thinning should produce good sized fruits. Where the same soil conditions exist and heavy pruning is practiced the shoot growth is from 8 to 24 inches and good sized fruits should be produced when light thinning is practiced. Through-out this work tree vigor has been considered because it is an important factor influencing the size of peaches. Ideal orchard conditions produce vigorous trees that usually produce a good crop.

Peach growers hand thin their fruits to produce the largest possible amount of fruit that can attain the highest commercial standard at the greatest profit. The effort of the tree is to produce a large number of seeds. The systematic removal of surplus fruits requires good judgment and it is difficult to give fixed rules that will fit every growers condition. Nevertheless, some general rules are desireable. From this investigation it would seem that the following would apply fairly well to Michigan conditions.

Rules for Thinning

1. Early varieties should be thinned first.
2. Thinning should be started as soon as it it is evident which ones will fall off naturally in the June drop, which occurs approximately 35 days after bloom.
3. The trees should be thinned so that the remaining fruits have the following ratio of leaves per fruit; early varieties 25-35 to one; late varieties 30-50 to one.
4. Thinning should be completed when the tip of the pit begins to harden, but thinning is effective within three weeks of fruit maturity, though it will be less beneficial to the trees.
5. Thinning of fruit buds by annual moderate pruning and a heading back renewal system, when needed to keep the shoot growth vigorous is desirable in producing large peaches.

Summary of the Results of Investigation

1. Size of peaches is greatly influenced by the ratio of leaves per fruit, which manufacture the plant foods for fruit growth.
2. The length of the growing period effects the size of the fruit. For example a leaf ratio of 25 to one, produced a 2.6 ounce Dewey peach in 90 days and a 9.4 ounce Hale peach in 130 days.
3. Thinning reduced the total yield, but at the same time, it increased the value of the crop and produced improved commercial grades of peaches.
4. Improved tree condition as influenced by soil fertility, pruning and heading back increases wood growth and size of the fruit.
5. Laborers who hand thin peaches should be trained to estimate the number of leaves on a branch and thin the fruits to a ratio that will result in the desired size.

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