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RELATIONSHIP OF LEAF AREA TO
TOTAL WEIGHT AND AVERAGE WEIGHT
OF FRUIT IN BLUEBERRIES

THESIS FOR THE DEGREE OF M. S.

Duncan A. Byrd

1930

THESIS

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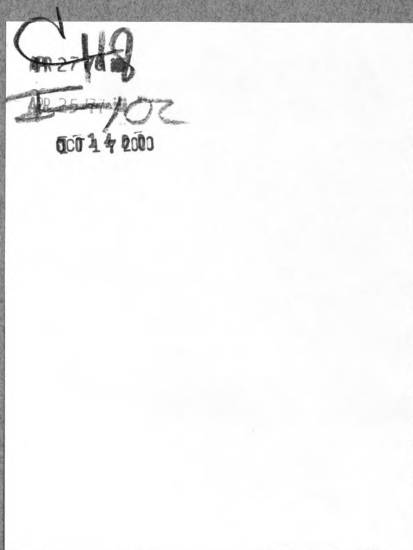


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Relationship of Leaf Area to Total Weight and
Average Weight of Fruit in Blueberries.

Thesis

Presented to the faculty of the Michigan State
College of Agriculture and Applied Sci-
ence as partial fulfillment of
the requirements for the
degree of
Master of Science

by

Duncan A. Byrd.

1930

*Approved June 5, 1930
V. R. Gardner*

THESIS

INTRODUCTION

Realization of the full importance of leaves to fruit bearing plants has come but slowly. Since earliest times gardeners and botanists have been aware that plants draw moisture and nutrients from the soil. Transpiration was recognized as a leaf function comparatively early, but understanding of other functions of the leaves almost entirely depended on the development of the chemistry of the air and of the plants. Even when the intake of carbon was demonstrated by plant physiologists, gardeners were slow to recognize the significance of the leaves and, with few exceptions, pruning was still practised on the basic conception of economizing on nutrients taken from the soil. Defoliation, as occasioned by fungi and insects, was recognized as injurious, but up to the appearance of the work by Kraus and Kraybill⁽¹⁾ on the relationship of nitrogen and carbohydrates to fruitfulness, the significance of leaves was regarded lightly by horticulturists in general.

It is generally known that the leaf area of a plant bears a certain relation to the degree a plant is fruitful. Pruning trees, bushes, and thinning of fruit has been practised for years, but it was not until recently that data were presented to show that a certain definite

leaf area is necessary in order to allow for the proper development of a given quantity of fruit. By thinning of fruit, gardeners and horticulturists know that the size and quality of the fruit is improved. However, just what ratio should exist between the leaf area and the number fruits has not been known. Without this ratio in mind the grower cannot thin fruit to the best commercial advantage. Neither was it known, until recently, to what extent the fruit is dependent upon the closely adjoining leaf area, or whether for its development it may draw upon foods which are elaborated at considerable distances. Definite information about these matters is fundamental to studies of growth and chemical compositions of fruit, and the general productivity of a plant.

- REVIEW OF LITERATURE -

In 1924 Haller and Magness started certain experiments in order to throw some light on these problems. During 1924 these workers used Winesap, Ben Davis, Delicious, and Rome Beauty varieties. Twigs were ringed to prevent translocation of food materials. The results in 1924 were variable but clearly indicated a relationship between the leaf area and size of fruit.

During 1925, the varieties used were Delicious, Ben Davis, and Grimes. The leaf area was increased for each fruit. The results of this work show there was a marked correlation between the leaf area and the increase in volume of fruit, up to a certain point, beyond which a further increase in the leaf area did not result in a corresponding increase in volume. For the Grimes and Ben Davis it was found that thirty to forty medium sized leaves per fruit were necessary to obtain apples of good size and quality.

Data gathered in these experiments seem to indicate that apples are able to draw upon leaves which are as much as one hundred centimeters away, and upon leaves which are adjacent to the fruit with almost equal facility.

A high percentage of dry weight, sugars and acids, is associated with apples grown with large leaf area as compared with apples of the same variety grown with small leaf area.

In 1926 Magness conducted an experiment in the state of Washington similar to the earlier work in Virginia, working with Delicious, Winesap, and Jonathan varieties. Detailed tests were made on the Delicious with limited observations on Winesap and Jonathan.

The procedure was similar to the work previously carried on in Virginia. Magness states that unless forty to fifty leaves per fruit are available on Delicious, best market sizes and quality fruit cannot be produced. However, the total efficiency of the foliage at Wenatchee, Washington, seemed to be greater. This is accounted for by the more intense and continuous sunshine, and the greater daily insolation.³

Johnston of the South Haven Experiment Station, South Haven, Michigan, in the work on the winter pruning of black raspberries found that the highest total yields of berries were found on the shoots with the most foliage and likewise the average weight per berry was proportionately larger.⁴

- Object of Experiment -

As has been shown in the review of literature, there has been little work carried on to show just what relationship exists between the leaf area and fruitfulness. These investigations were restricted to the apple and raspberry. The purpose of this investigation was to study the relationship between the leaf area and the total weight and average weight of fruit of the blueberry plant on selected individual shoots. Very little work has been done in respect to pruning of the blueberry bush and a knowledge of this relationship is fundamental in order to prune intelligently.

- Materials and Methods -

This work was started July 1st, 1929. The plants used in connection with this experiment were growing on one of the experimental plots at the South Haven experiment station, South Haven, Michigan. These plants were growing in a Saugatuck loamy fine sand, and the soil apparently was uniform and possessed the requirements for good blueberry growth. Seven varieties were used in gathering the data presented in this paper.

	<u>Name</u>	<u>No. Shoots.</u>
Early Varieties	Adams	28
	Cabot	24
	Katherine	58
Midseason Varieties	Pioneer	28
	Sam	27
Late Varieties	Rubel	43
	Harding	27

The plants selected were average plants growing on the plot. Shoots were selected from different portions of the plant and were tagged with a paper tag bearing a number. A cage constructed of mosquito netting was placed

about each selected bush, this serving to prevent destruction of the berries by outside agencies.

The berries were harvested once a week after ripening had commenced and were picked only on dry days.

After all data had been assembled the coefficient of correlation was worked out for each variety.

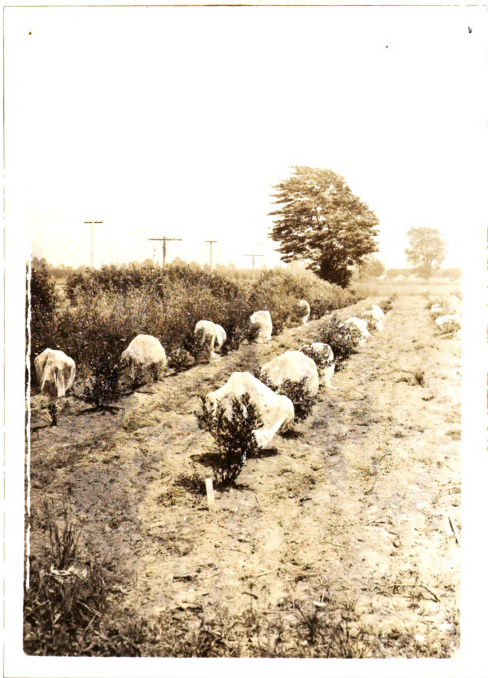


Figure #1.

A portion of the blueberry
plants used in the investigation.

Records Taken

The following records were taken:

1. Total weight of the berries, at each picking.
2. Total number of berries.
3. Leaf area on shoot upon which the berries were borne.

The berries were weighed upon balance scales which registered in sixteenths of ounces. After all the berries were harvested from the tagged shoots the leaves were collected and measured by the use of a planimeter.

The data collected is recorded in tables one to seven inclusive.

Table #1

- ADAMS VARIETY -

Comparison of leaf areas, total weights and
average weights of fruit.

Shoot No.	No. Berries	Total Weight (wt. in ounces)	Average Weight	Leaf Area in Sq. Inches.
1	23	.71	.030	20.70
2	43	1.40	.032	34.09
3	40	1.36	.034	27.66
4	30	1.09	.036	19.84
5	20	.30	.080	13.88
6	36	1.36	.037	11.11
7	19	.62	.037	7.43
8	16	.68	.042	11.99
9	28	1.09	.042	32.63
10	22	.79	.035	30.89
11	8	.24	.030	14.30
12	12	.34	.028	3.02
13	11	.38	.034	29.82
14	15	.54	.038	12.66
15	10	.34	.034	10.05
16	11	.42	.038	11.69
17	8	.30	.027	22.39
18	27	1.09	.043	2.79
19	21	.72	.034	25.12
20	11	.42	.038	15.74
21	13	.42	.032	13.09

Twig No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
22	10	.20	.020	13.98
23	21	.68	.032	24.15
24	23	.85	.036	14.28
25	7	.26	.037	20.58
26	15	.44	.029	16.81
27	13	.53	.040	7.27
28	12	.40	.033	6.57

The coefficient of correlation for this variety is found to be as follows:

Total weight $r = .377 \pm .108$

Average weight $r = .114 \pm .125$

Table #2

- CABOT VARIETY -

Comparison of leaf areas, total weights and
average weights of fruit.

(weight in ounces)

Shoot No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
1	27	.91	.034	32.72
2	20	.72	.036	11.62
3	15	.62	.041	3.62
4	17	.71	.041	22.82
5	30	1.68	.056	19.35
6	19	.64	.033	13.20
7	45	1.09	.024	10.11
8	5	.15	.030	15.37
9	44	1.62	.036	20.96
10	39	1.60	.041	67.32
11	24	.68	.028	6.90
12	18	.65	.036	.85
13	13	.46	.027	1.20
14	46	1.42	.030	82.41
15	26	.78	.029	40.12
16	24	.71	.028	1.03
17	58	2.	.034	33.52
18	57	1.79	.031	26.25
19	32	.85	.026	18.
20	23	.91	.039	36.10
21	34	1.34	.039	9 66
22	16	.68	.042	17.90

Shoot No.	No. Berries	Total Weight	Average Height	Leaf Area in Sq. Inches
23	24	.78	.032	14.36
24	28	.86	.030	12.80
25	23	.92	.040	3.35

Total Weight $r = .374 \pm .118$

Average Height $r = -.011 \pm .204$

Table #3

- KATHERINE VARIETY -

Comparison of leaf areas, total weights and
average weights of fruit.

(weight in ounces)

Shoot No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
1	19	.64	.033	16.18
2	26	.84	.032	17.91
3	32	1.26	.039	16.22
4	14	.79	.056	2.22
5	13	.53	.040	27.95
6	18	.68	.037	9.57
7	6	.30	.05	20.23
8	9	.22	.024	17.01
9	11	.42	.038	12.17
10	18	.54	.03	22.11
11	24	.94	.039	7.22
12	17	.71	.041	16.01
13	17	.65	.038	5.12
14	14	.52	.037	25.18
15	6	.21	.037	9.57
16	13	.53	.040	3.22
17	6	.30	.05	13.27
18	10	.36	.036	10.61
19	21	.78	.037	17.65
20	33	1.36	.041	34.59

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- KATHARINE VARIETY -

Shoot No.	No. Berries	Total Height	Average Height	Leaf Area in Sq. Inches
21	31	1.12	.035	3.42
22	12	.54	.045	11.60
23	26	1.09	.042	1.68
24	18	.84	.046	12.06
25	17	.56	.032	8.66
26	26	1.06	.040	19.35
27	13	.54	.033	2.92
28	46	1.46	.031	.82
29	15	.46	.030	1.89
30	13	.32	.024	3.47
31	20	.71	.035	4.35
32	32	.84	.026	4.16
33	19	.53	.027	.84
34	15	.54	.036	11.69
35	45	1.64	.036	9.67
36	14	.42	.030	14.23
37	26	1.15	.044	10.54
38	2	.06	.03	15.72
39	39	1.53	.049	26.56
40	14	.62	.044	2.36

- KATHERINE VARIETY -

Shoot No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
41	11	.46	.041	9.07
42	11	.42	.035	17.98
43	20	.62	.031	6.01
44	14	.38	.027	10.65
45	8	.46	.051	14.34
46	44	1.32	.030	15.22
47	13	.46	.035	11.80
48	45	1.80	.040	12.51
49	45	1.06	.023	2.46
50	37	1.62	.041	17.65
51	22	.91	.041	21.69
52	31	.80	.025	1.83
53	37	1.09	.029	1.62
54	14	.46	.032	12.56
55	51	1.53	.026	9.93
56	26	.94	.035	13.95
57	40	1.28	.032	1.09

Total Weight $r = .139 \pm .086$

Average Weight $r = .030 \pm .088$

Table #4

- PIONEER VARIETY -

Comparison of leaf areas, total weights and
average weights of fruit.

Shoot No.	No. Berries	Total Weight	Average weight	Leaf Area in Sq. Inches
1	36	.24	.034	.41
2	25	.92	.036	26.95
3	31	1.46	.035	8.11
4	8	.33	.041	1.58
5	11	.48	.043	1.22
6	13	.50	.038	32.02
7	15	.48	.032	13.61
8	40	1.40	.035	.86
9	14	.42	.030	6.49
10	53	1.96	.036	16.10
11	27	.91	.033	10.81
12	52	1.06	.020	1.11
13	31	.88	.028	12.12
14	21	.79	.037	16.92
15	84	1.78	.021	6.72
16	55	1.06	.018	8.48
17	22	1.09	.049	37.08
18	34	.88	.025	.72
19	13	.38	.029	18.54
20	12	.30	.025	9.09
21	7	.21	.030	12.41

Shoot No.	No. Berries	Total Weight	Average weight	Leaf Area in Sq. Inches
22	45	1.07	.023	3.24
23	55	1.53	.027	16.91
24	61	1.91	.031	20.39
25	40	1.28	.033	9.50
26	61	1.86	.030	13.96
27	34	1.15	.030	17.05
28	24	.78	.032	4.14

Total Weight $r = .88 \pm .028$

Average Weight $r = -.025 \pm .186$

Table #5

- SAM VARIETY -

Comparison of leaf areas, total weights and average
weights of fruit.

Shoot No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
1	36	1.28	.035	15.59
2	45	1.36	.030	44.47
3	30	1.09	.030	21.24
4	39	1.33	.034	26.13
5	43	1.40	.032	30.55
6	22	.78	.035	11.17
7	40	1.42	.035	21.12
8	37	.92	.022	38.49
9	19	.46	.024	1.88
10	6	.09	.015	26.56
11	20	.53	.026	8.63
12	15	.30	.02	4.57
13	20	.53	.026	7.44
14	22	.64	.029	3.80
15	14	.33	.023	1.76
16	17	.50	.029	10.38
17	8	.16	.02	2.07
18	33	1.09	.033	15.83
19	31	.70	.022	30.88
20	27	.78	.028	32.93

- SAM VARIETY -

Shoot No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
21	40	.86	.021	45.99
22	29	.48	.015	20.02
23	12	.30	.025	12.81
24	15	.44	.029	5.41
25	50	1.15	.023	8.47
26	7	.18	.025	3.26
27	32	.60	.018	19.26

Total Weight $\bar{x} = .390 \pm .079$

Average Weight $\bar{x} = .253 \pm .004$

Table #6
- RUBEL VARIETY -

Comparison of leaf areas, total weights and
average weights of fruit.

Shoot No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
1	7	.14	.020	2.32
2	21	.26	.012	11.92
3	8	.18	.022	15.17
4	8	.24	.030	44.49
5	27	.59	.021	10.54
6	33	.65	.019	9.79
7	11	.46	.041	3.73
8	10	.33	.033	15.78
9	28	.62	.056	15.31
10	13	.24	.018	7.08
11	36	1.09	.030	.76
12	19	.52	.027	2.09
13	46	1.42	.030	53.47
14	14	.32	.022	25.40
15	8	.24	.020	5.87
16	9	.28	.031	4.76
17	5	.12	.024	2.47
18	18	.40	.022	16.70
19	5	.09	.018	9.11
20	26	.84	.032	15.40

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- RUBEL VARIETY -

Shoot No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
21	12	.33	.027	28.47
22	9	.29	.032	2.93
23	22	.48	.021	5.59
24	18	.36	.020	.58
25	15	.29	.019	7.29
26	27	.82	.035	89.31
27	17	.46	.027	17.20
28	15	.50	.033	14.29
29	4	.12	.030	3.28
30	20	.67	.033	37.91
31	9	.28	.031	9.51
32	15	.4	.028	31.44
33	20	.5	.025	21.92
34	11	.23	.020	26.03
35	9	.4	.044	7.04
36	7	.27	.038	3.03
37	5	.15	.030	8.95
38	22	.62	.028	38.24
39	9	.34	.037	10.13
40	25	.65	.026	46.94
41	36	.96	.023	13.89
42	20	.59	.028	32.99
43	21	.70	.033	44.37

- RUBEL VARIETY -

Shoot No.	No. Berries	Total Weight	Ave age Weight	Leaf Area in Sq. inches
44	17	.62	.035	1.03
45	31	.93	.030	43.79

Total Weight r = .189 $\bar{7}$.007

Average weight r = .429 $\bar{7}$.102

Table #7
- HARDING VARIETY -

Comparison of leaf areas, total weights and
average weights of fruit.

Shoot No.	No. Berries	Total Weight	Average weight	Leaf Area in Sq. Inches
1	44	1.50	.034	45.03
2	34	.86	.025	12.70
3	39	1.68	.043	16.96
4	27	.74	.031	5.20
5	11	.24	.025	33.08
6	28	1.09	.039	7.37
7	49	1.30	.026	7.95
8	24	.59	.024	11.42
9	27	.86	.031	20.65
10	27	.74	.024	8.95
11	56	1.74	.031	14.33
12	53	1.40	.026	7.91
13	18	.59	.032	25.28
14	49	1.53	.031	.40
15	13	.53	.040	8.41
16	21	.65	.030	37.10
17	40	1.40	.035	23.97
18	16	.59	.036	2.88

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- HARDING VARIETY -

Shoot No.	No. Berries	Total Weight	Average Weight	Leaf Area in Sq. Inches
19	38	1.09	.028	25.92
20	14	.40	.028	21.65
21	16	.46	.028	65.41
22	31	.84	.027	7.07
23	14	.24	.017	9.15
24	10	.26	.026	41.28
25	40	1.06	.026	58.23
26	26	.82	.031	7.81
27	7	.15	.021	10.13
28	28	.74	.026	10.25

Total Weight $r = -.152 \pm .188$

Average Weight $r = .729 \pm .060$

Table #8

Summary of the Coefficient of Correlation
for the varieties used.

Variety	Correlation	
	Total Weight	Average Weight
Adams	.379 $\pm$.108	.114 $\pm$.125
Cabot	.374 $\pm$.118	-.011 $\pm$.204
Katherine	.129 $\pm$.086	.030 $\pm$.088
Pioneer	.88 $\pm$.028	-.025 $\pm$.186
Sam	.390 $\pm$.079	-.253 $\pm$.004
Rubel	.189 $\pm$.007	.429 $\pm$.102
Harding	-.152 $\pm$.188	.729 $\pm$.060

- RESULTS -

No positive correlations were found in this work except in the following two cases:

1. For the Pioneer Variety, the correlation was $.88 \pm .028$ for the total weight.
2. For the Harding Variety, the correlation was $.72 \pm .060$ for the average weight.

Negative correlations were found in the following cases:

1. Harding - $.15 \pm .188$ for total weight
2. Cabot - $.011 \pm .204$ for average weight
3. Pioneer - $.025 \pm .186$ for average weight
4. Sam - $.253 \pm .004$ for average weight

Discussion and Conclusions

The data presented plainly shows that the relationship between the leaf area and the total weight and the average weight of the fruit on a given shoot is small. The results show that there are great variations in the weights and leaf areas.

Certain shoots bore a very small leaf area and produced a large total weight and average weight of the fruit. Other cases are seen where a large leaf area is accompanied by a small total weight and average weight of fruit.

The bushes used in connection with this investigation had been pruned quite heavily for several years in an effort to secure a supply of propagating stock. This may have upset some of the metabolic functions of the plant to some degree. It is also believed that the berries of a particular shoot are not dependent on the adjacent leaf area for elaborated food, but it may rely on more distant leaves as a source of elaborated food.

The explanation for the increase in total weight and average weight of the fruit of one shoot over that of another is not explainable by the increase or decrease of leaf area. The cause is evidently due to other factors.

Acknowledgments

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