

T H E S I S

ON

THE RELATION OF SPUR LEAF AREAS TO
BUDS AND FRUITS

Submitted to the

O R E G O N A G R I C U L T U R A L C O L L E G E

On Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

In

THE SCHOOL OF AGRICULTURE

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May 15, 1916.

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The Relation of Spur Leaf Areas to Buds and Fruits.

There has been much work done along the line of fruit bud studies. Some of these investigations have traced the development of the various fruit bud parts from their earliest stages. Some have dealt with the relations of certain cultural practices to fruit bud formation. Others have been concerned mainly with the variations due to variety or seasonal conditions. Few have given careful consideration to the relation of the leaf system of the spur to its formation of flower or fruit buds.

However it is quite natural to expect that, the leaves on a fruit spur bear some relation, at least, to the way in which it functions. The investigation upon which this is a report was begun with the object of finding out something about this relation between fruit spur production and its leaf system.

Gourley (1) in an investigation of fruit bud formation made a study of the relative weight and area of apple leaves from a bearing and non-bearing tree. His data were obtained by measuring one hundred ^{average} leaves from each tree. The results are shown in the following table taken from his bulletin.

Table I

Leaves taken August 20, 1913 and June 23, 1914

Average weight and area per leaf.

Sample	Year	Air Dry wt. in grams	Area in sq. in.	Average difference in sq. in.
Bearing tree	1913	.2535	4.7320	
	1914	.2010	5.1633	
Non- bearing tree	1913	.4226	7.0584	
	1914	.3150	6.9972	2.0802

Gourley (1) says, "When a tree is not bearing the leaves can manufacture and lay up a reserve and bring about the formation of fruit buds while in the bearing year the leaves run smaller and use much of their energy developing the crop of fruit and as a result not sufficient reserve is formed to 'finance' another consecutive crop."

The preceding data were obtained from two Yellow Transparent Trees. "The tree that bore in 1914 had absolutely no fruit in 1913 and has formed no fruit buds for 1915, while the other tree alternates with it in all respects."

Another study conducted by Gourley (1) on leaf area and weight ~~lead~~ to conclusions similar to those drawn from the work with two Yellow Transparent trees. In this case there was an average difference of practically one and one half inches in area per leaf for the orchard, between a year when a light crop was produced and the consecutive year when a heavy crop was produced.

Jones (2) in his report on sap studies with sugar maple states that the leaf area the preceding year determines, to a large extent the sugar content of the sap the following spring. He estimates the leaf area of a maple tree for two successive years and calculates the difference in total area to be about 6084 sq. ft. This large difference in area he assumes

to be due to the fact that one year was especially favorable to foliage development, while the other season was unfavorable.

It seems, from the work done by Gourley (1) and Jones (2) that the leaves on a tree do have an influence upon the production the following year. Fruit in the case of the apple and sugar content in the case of the sugar maple.

However this relation has been shown to exist only for the tree as a whole. Is there a similar relation between leaf system and production in particular parts of the tree?

Object of the Experiment

As suggested in the last paragraph the object of this study is to determine if possible if there is any relation between the leaves on a fruit spur and the way in which that spur performs. Is there any relation between leaf area and the kind of bud formed? If a fruit bud is formed is there any relation between the leaves and the number of flowers in the cluster, the number that set and the size or weight of fruit produced?

Materials Used.

The following varieties of apples were selected for this study. Black Ben Davis, Wagener, Yellow Newtown, Yellow Bellflower, Grimes and Shiawassee.

In the fall of 1914 the leaves were collected from spurs as follows:-

Black Ben Davis	550
Wagener	1200
Yellow Newtown	350
Yellow Bellflower	100
Grimes	100
Shiawassee	200
Total	<u>2500</u>

In the fall of 1915 the leaves were again collected from as many of the same spurs as had not accidentally lost their respective labels. The records were as follows:

Black Ben Davis	384
Wagener	844
Yellow Newtown	216
Yellow Bellflower	82
Shiawassee	129
Grimes	40
Total	<u>1695</u>

Condition of the Trees.

Black Ben Davis:- The trees, four in number, are about ten years old. They are located in the college orchard and have received ordinary treatment as to cultivation, pruning, etc. and are in a good vigorous condition. Since 1914 they have received

only a very light pruning, which consisted mainly in heading back the new growth and a little thinning out. However they were not pruned as much as they should have been under ordinary conditions because it was desired to leave as many of the fruit spurs as possible.

In the fall of 1914 these trees bore a fair crop of fruit for their age. In 1915 the crop was about the same as in 1914, possibly a little larger.

It was thought that it would be best not to do any thinning but to let the tree nature all fruit that set.

Grimes, Shiawassee and Yellow Bellflower:- These trees, also located in the College Orchard, are about twenty years old and have received regular care as regards to cultivation, pruning, etc. They are in a good vigorous condition.

In 1914 the Grimes bore a heavy crop. In 1915 the Shiawassee bore no fruit at all but the Grimes bore a fair crop. The Yellow Bellflower bore a good crop in 1914 but only a fair crop in 1915 .

Wagener and Yellow Newtown:- These trees are located in the Corvallis Orchard Company's orchard about two miles west of Corvallis. They are about seven years old and have received very good care as regards cultivation, pruning, etc. The trees are in a very good vigorous condition. In 1914 they bore only a few scattered fruits and in 1915 they bore only

a very light crop. At the time of their winter pruning these threes had a number of their spur-bearing branches removed, thus materially reducing the number of spurs, from which complete records could be made.

Methods.

Collecting leaves.

In the fall of 1914 just before the leaves began to drop, the leaves from the fruit spurs were gathered. In choosing the spurs for study it was decided to take them just as they came. As in most cases, the trees were small, it was though best not to include a consideration of their location in the tree.

The spurs may be divided into two classes:-

1. Those bearing fruit in 1914.
2. Those not bearing fruit in 1914.

Only two hundred bearing spurs were studied, Namely:- one hundred Grimes and one hundred Shiawassee. The remaining twenty-three hundred spurs were all non-bearing in 1914.

The leaves were gathered from the spur and put into paper sacks containing numbered tags. At the same time similarly numbered tags were attached to the spurs.

The leaves were removed from the paper sacks as soon as possible, fastened together, and put away on apple box layer paper, in trays to dry.

Weighing and measuring the Leaves.

Sometime before the leaves were to be weighed they were brought into the laboratory and allowed to dry out thoroughly at ordinary room temperature. The leaves were then counted and weighed to the nearest .01 gram and were then put back into paper sacks with their respective tags.

In order to measure the area of the leaves it was necessary to sack them in water for several hours. They were then removed and the excess water allowed to drain off. The leaf areas were then determined by means of a polar planimeter.

The leaf data the second year were secured the same way as the first year except that it was found that, the leaves could be left in the paper sacks until ready to weigh if the sacks were put in a dry place.

When collecting the fruits from the spurs they were put into paper sacks, numbered to correspond to the numbers of their respective spurs. As soon as possible after collecting, the fruit was weighed to the nearest five grams.

Presentation and Discussion of Data.

As the data collected bear upon several quite distinct, though closely related, questions, these different questions will be considered separately.

What Relation does the leaf area of the spur one season bear to its Leaf Area the next Season?

One of the first questions to arise is regarding the relation that the leaf area of the spur one season may bear to its leaf area the following season. Is there or is there not, a relation between the two, and if there is a relation how great or important is it? The data bearing directly upon this question is brought together in Tables 2 and 3.

Table 2 presents the average weights and areas of leaves per spur for several varieties and for two seasons. (1914 and 1915) The records are for the same individual spurs the two season.

Table 2.

Average Weight and Area of Leaves per Spur.

Variety	No. of Spurs	1 9 1 4		1 9 1 5	
		Ave. weight per spur wt. in grams	Ave. area per spur area in sq. in.	Ave. weight per spur wt. in grams	Ave. area per spur area in sq. in.
Black Ben Davis	384	1.4437	19.46	1.4088	16.74
Wagener Yellow Newtown	844	1.1882	18.55	.9847	18.12
Yellow Bellflower	216	.7696	10.32	.7752	11.61
	82	1.0453	14.96	.8645	13.02
Grimes	40	.6995	13.05	1.006	20.75
Shiawassee (1)	49	.8998	12.00	1.5025	18.33
Shiawassee (2)	76	.9192	10.45	1.4221	17.24

Note Shia 1. -All spurs produced fruit in 1914
 Shia 2 - No spurs produced fruit in 1914
 Grimes -All spurs produced fruit in 1914
 Y.B. - No spurs produced fruit in 1914
 Wag. - No spurs produced fruit in 1914 nor 1915.
 B.B.Davis -No spurs produced fruit in 1914

From an examination of table 2 it is seen that the greatest seasonal difference is both weight and area occurs in Grimes and Shiawassee (1) and (2). It will be remembered Grimes and Shia (1) are the trees that produced fruit in 1914 but not in 1915, while the production of the other trees was about the same both years.

This is evidence that in the "off year" the average leaf weight and area on a spur is much greater than in a bearing year and that this difference holds for spurs that do not bear as well as for those that do bear the productive year. That this difference in leaf weight and area is to be attributed to the alternate bearing habit of the tree rather than to differences in seasonal conditions is indicated by the uniformity in leaf area of spurs of the other trees from season to season. This agrees completely with the findings of Gourley (1).

In order to secure, if possible, a more accurate measure of the relation, if one exists, between the leaf system of individual spurs for two consecutive years, correlation tables were made for the following groups of spurs.

Black Ben Davis without fruit in 1914 or 1915
 Black Ben Davis with fruit in 1915 but not in 1914
 Wagener without fruit in 1914 or 1915
 Yellow Newtown without fruit in 1914 or 1915

The means, standard deviations, probable error, and coefficient of correlations, were calculated as follows:

Table 3.

Showing Correlation between Leaf Systems of Individual
Spurs for the Seasons 1914 and 1915.

Variety	No. of Frequen- ces.	Mean		Probable Error of Mean.		Standard Deviation		Probable Error of Standard Dev.		Coef. of Cor- relatio
		1914	1915	1914	1915	1914	1915	1914	1915	
Blk. Ben Davis without fruit	336	18.489	16.635	± 0.3694	± 0.3696	10.04	10.056	± 0.2612	± 0.2615	.35266
Bl. Ben Davis with fruit	73	23.144	17.699	± 0.8674	± 0.8734	10.991	11.072	± 0.6136	± 0.6187	.2151
Wagener with- out fruit	820	19.300	17.917	± 0.2006	± 0.2837	8.548	12.246	± 0.1440	± 0.2038	.3900
Y. Newtown without fruit	215	10.698	12.000	± 0.2351	± 0.4195	5.112	9.118	± 0.1630	± 0.2966	.2266

Table 3 indicates that there is a marked correlation between the leaf areas of the same spurs for two successive years. It is of interest to note that the different varieties differ considerably in this respect. Wagener shows a high degree of correlation and Yellow Newtown a much lower degree. The correlation in case of the Black Ben Davis spurs bearing fruit one of the two seasons is much less than for spurs of the same variety that bore neither season.

What Influence has Leaf Area of the Spur upon the Kind of Bud Formed?

The evidence bearing upon this question may be presented best in tabular form. Table 4 summarizes the data for several varieties, arranging the spurs in groups, with leaf areas above or below the mean areas for those varieties.

(See next page for table 4.)

Table 4

Showing Relation of Leaf Areas to Bud formed
1914

Variety	No. of Spurs	No. of Spurs with Fruit Buds	% of Spurs with Fruit Buds	Mean Area	No. of Fruit- ing Spurs with leaf area below mean	% of Fruit- ing Spurs with leaf area below mean	No. of Fruit- ing Spurs with leaf area above mean	% of Fruit- ing Spurs with leaf area above mean
B. Ben								
Davis	404	351	86.8 %	19.46	179	51.6	172	48.4
Wagener	850	23	2.7 %	18.55	10	43.5	13	56.5
Y. Newtown	226	6	2.65%	10.32	2	33.3	4	66.6
Y. Bell- flower.	81	69	85.4 %	14.96	30	43.4	39	56.6
Grimes	41	0	0	10.45	0	0	0	0
Shia. 1	49	0	0	13.05	0	0	0	0
Shia. 2	76	0	0	12.00	0	0	0	0
1915								
Blk. Ben								
Davis	306	250	81.3	16.74	155	62	95	38
Wagener	498	96	19.2	18.12	29	30.2	67	69.8
Y. Newtown	174	77	38.5	11.61	20	26	57	74
Y. Bell- flower	67	58	86.6	13.02	33	56.9	25	43.1
Grimes	39	33	84.5	20.75	13	39.4	20	60.6
Shia. 1	65	56	86.4	18.33	30	53.6	26	46.4
Shia. 2	24	19	79.2	17.24	6	31.5	13	68.5

From a study of table 4 it is impossible to discover any relation between the leaf area of Spurs and the kind of buds that they form, though one would expect that spurs with large leaf areas would have a greater tendency to form fruit buds than those with smaller leaf areas.

This seemed such a reasonable supposition that it was thought desirable to submit the same data to a more critical examination. Consequently the Black Ben Davis spurs were divided into a number of groups, the grouping being based upon their leaf areas. The division lines between these groups were purely arbitrary. Black Ben Davis records were taken for this study because of the larger number available.

Table 5.

Relation of 1914 Leaf Area to Blossoms in 1915.

Mean Area 1915.

Groups.	No. of Spurs	% of total No. of Spurs are Blossom Buds	No. of Spurs which are Blossom Buds	% of Spurs which are Blossom Buds	No. of Blossoms in 1915	Ave. No. of Blossoms per Spur.
5 in. or less	14	3.4	4	28.5	24	6
5.1 - 10 in.	61	14.9	39	64	233	6
10.1 - 15 in.	85	20.8	67	78.8	409	6
15.1 - 19.5 in.	64	15.6	59	92.1	354	6
19.6 - 25 in.	74	18.1	71	96.7	445	6.2
25.1 - 30 in.	52	12.8	47	90.3	302	6.4
30.1 - 35 in.	33	8.1	32	97	204	6.3
35.1 - 40 in.	14	3.4	13	92.8	81	6.2
40.1 - 45 in.	5	1.2	5	100	31	6.2
45 or more	6	1.4	5	83.3	29	5.8
Total less than the mean	224	55.0	169	75.4	1020	6.03
Total more than mean	184	45.0	173	94	1092	6.31

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A study of table No. 5 suggests that there is a greater tendency among those spurs having a larger leaf area to develop fruit buds than among spurs with small leaf areas. Table 5 also suggests a slight increase in the number of flowers per cluster with an increasing leaf area.

Table 6

Relation of 1915 Leaf Area to 1916 Blossoms.

Mean Area 16.7 sq. in.

Groups.	Total No. of Spurs	No. of Spurs with Blossoms	% of Spurs with Blossoms	No. of Blossoms	Ave. No. of Blossoms per Spur.
5.5 sq.in. or less	35	17	48.3	96	5.6
5.6 - 11 sq.in.	56	35	62.2	203	5.8
11.1 - 16.7 sq.in.	74	60	81	390	6.5
16.8 - 21.5 sq.in.	57	49	86	311	6.3
21.6 - 26 sq.in.	35	32	91.5	231	7.2
26.1 - 32 sq. in.	30	25	83.3	177	7.1
32.1 - 37.5 sq.in.	9	9	100	62	6.9
37.6 - 45 sq.in.	10	8	80	58	7.2
45.1 or more	3	3	100	25	8.3
Total less than mean	165	112	67.9	689	6.2
Total more than mean	144	126	86.2	864	6.8

Table 6 brings together similar records for the same variety for the seasons of 1915 and 1916. Here again is evident the same general tendency for spurs with large leaf areas to surpass in flower production those with a smaller leaf area. Eighty-six per cent of the spurs with leaf areas greater than the mean produced flower buds against only sixty-nine per cent of those with a leaf area lower than the mean. The difference is not a great one but it is large enough to be of some significance.

Relation of Leaf Area of Spurs to
"Setting" of Fruit.

Tables 5 and 6 have indicated, at least, some relation between leaf area and flower production. What influence has leaf area upon the number of blossoms that set fruit? Data bearing upon this question are summarized in Table 7.

Table 7

Relation of 1914 Leaf Area to Blossoms that Set Fruit

Mean Area 19.5

Groups	No. of Spurs with Blossoms.	No. of Spurs on which Blossoms Set Fruit	% of Spurs on which Blossoms Set Fruit	Total No. of Blossoms on these Spurs	No. Blossoms Set	% Blossoms Set of the Total No. of Blossoms
5 in. or less	11	0	0	24	0	0
5.1 - 10	48	9	18.7	233	9	3.8
10.1 - 15 sq.in.	63	17	26.9	409	19	4.65
15.1 - 19.5	48	18	37.5	354	28	7.9
19.6 - 25	58	29	50.0	445	55	12.3
25.1 - 30	41	18	43.9	302	30	9.9
30.1 - 35	17	17	100	204	24	11.2
35.1 - 40	13	5	38.4	81	8	9.87
40.1 - 45	5	2	40	31	5	16.1
45 or more	3	3	100	29	3	10.3
Less than Mean	170	44	25.9	1020	56	5.48
More than Mean	137	74	54.0	1092	125	11.4

Of the total number of spurs with a leaf area below the mean only 25.9 % of them set fruit, while of those above the mean 54% set fruit. Of the total number of blossoms, the spurs with a leaf area greater than the mean have 11.4% set, while only 5.47% of the blossoms on spurs with a leaf area below the mean set fruit. It would seem from these figures that leaf area of individual spurs is more important in determining their set of fruit than in determining whether or not they shall produce flowers.

Relation of Leaf Area of Spurs to Their
Fruit Production.

Table 8

Relation of 1914 Leaf Area to Fruit of 1915

Groups	No. of Spurs with Blossoms	No. of Spurs on which Fruit Matured	% of Spurs on which Fruit Matured	No. of Fruit Matured	No. of Blos- soms	% of Blossoms which matured Fruit	Ave. wt. of Fruit.
5 in. or less	11	0	0	0	24	0	0
5.1 - 10	48	7	14.5	7	233	2.0	250
10.1 - 15	63	9	14.2	10	409	2.44	180
15.1 - 19.5	48	11	22.9	12	354	3.39	220
19.6 - 25	58	18	31.	29	445	6.52	145
25.1 - 30	41	10	24.4	13	302	4.32	155
30.1 - 35	17	12	70.5	12	204	5.89	200
35.1 - 40	13	4	30.7	5	81	6.19	285
40.1 - 45	5	2	40	2	31	6.45	200
45 or more	3	2	66.6	2	29	6.89	165
less than mean	170	27	15.8	29	1020	2.84	215
more than mean	137	48	35.0	63	1092	5.77	165

Table 8 indicates that a relation exists between leaf area and number of fruits "Setting" but no apparent relation seems to exist between average weight of fruit and leaf area of the preceding year. Evidence upon how the leaf area of individual spurs affect the average weight of fruits they are producing the current season is presented in Table No. 9.

Table 9

Relation of 1915 Leaf Area to Fruit Matured in 1915.

Mean Area - 16.7

Groups	No. of Spurs	No. of Spurs maturing Fruit	% of Spurs maturing Fruit	Total weight of Fruit in the different groups. grams	No. of Fruits matured	Ave. wt. of Fruit grams	Ave. wt. of Fruit per Spurs grams
5.5 sq.in.or less	59	13	22	2215	23	90	170
5.6 - 10 sq.in.	71	11	15.5	2365	14	170	215
10.1 - 16.7	98	16	16.3	3440	17	200	215
16.8 - 21.6	68	11	16.2	2165	12	180	195
21.7 - 26	45	8	17.8	2195	10	220	275
26.1 - 32	36	7	19.4	2020	9	225	290
32.1 - 37.5	11	2	18.2	390	2	195	195
37.6 - 45	13	1	7.7	245	1	245	245
45 sq.in or more	3	1	33.3	275	1	275	275
Total less than							
Mean	228	40	14.3	8020	54	150	205
Total more than Mean	176	30	17.0	2790	35	210	245

These data indicate quite a marked influence of leaf area of individual spurs upon fruit produced the same year.

Preceding data have dealt with the relation of one seasons leaf area of individual spurs to their functioning the same or the following year. It was thought advisable to determine if possible, if the leaf area of one season has any influence upon flower and fruit production the second following season or if there is a closer relation between the combined leaf areas two successive seasons and flower and fruit production a year later, than between the leaf area of any one season and the flowering and fruiting of the same or the following season.

The data pertaining to these two questions is presented in tables 10 and 11 respectively.

Table 10

Relation of 1914 Leaf Area to Behavior of Buds in 1916.

Groups	No. of Spurs	% of Total No. of Spurs	No. of Blossoms 1916	% of Total No. of Blossoms	No. of Spurs with fruit Buds	% of Spurs with Fruit Buds	Ave. No. of Blossoms per Spur.
5 sq.in or less	11	3.9	65	4.2	10	90.9	6.5
5.1 - 10 sq.in.	48	15.6	283	18.2	44	91.7	6.43
10.1 - 15	63	20.5	369	23.2	57	92	6.49
15.1 - 19.5	48	15.6	229	14.8	34	70.4	6.73
19.6 - 25	58	18.8	279	18.0	42	72.4	6.69
25.1 - 30	41	13.0	192	12.3	32	78	6
30.1 - 35	17	5.5	56	3.6	10	58.8	5.6
35.1 - 40	13	4.2	57	3.7	8	61.5	7.12
40.1 - 45	5	1.6	12	.7	2	40.0	6
45 sq.in or more	3	.9	7	.3	1	33.3	7
Total less than mean	170	55.4	946	61.1	145	85.3	6.52
Total more than mean	137	44.6	602	38.9	95	69.4	6.33

A study of table 10 does not show any marked relation of the 1914 leaf areas of individual spurs to their flower production in 1916.

Table 11.

Relation of the Combined 1914 and 1915 Leaf Areas to

Flower Production in 1916.

Mean Area 35 sq. in.

Groups	11.5 sq.in. or less	11.6 -35 sq.in.	23.1 -35 sq.in.	35.1 -46.5 sq.in.	46.6 -58 sq.in.	58 sq.in. or more	Total No. of Spurs with leaf Area less than mean	Total No. of Spurs with leaf Area greater than mean
No. of Spurs	4	40	102	72	22	20	102	115
No. of Spurs with Fruit Buds	3	32	88	62	17	15	89	99
% of Spurs with Fruit Buds	75	80	85.5	86.6	77.1	75	86.5	87

Table 11 indicates very little relation between the combined leaf areas of individual spurs two successive years and their flower production a season later though the number of spurs under observation is too small for the results to be more than suggestive.

Relation of Leaf Area to Pollen Viability.

In order if possible to determine in some other way, if the leaf system of individual spurs materially influences in any other way the functioning or production, pollen viability tests were made from pollen from flowers of the several different groups of spurs. A Standard solution of four per cent sugar and two per cent gelatin was used for all pollen viability tests. Table 12 presents the results of these viability tests.

Table 12.

Relation of Leaf Area to Pollen Viability.

Group	5.5 sq.in. or less	5.6 - 11	11.1 - 16.7	16.8- 21.5	21.6- 26	26.1- 32	32.1- 37.5	37.6 45	45 or more
Ave. % Germ- ination	52%	50.4%	52.%	58.9	71.4	75	75.4	71.4	70.

Here is evidence that the pollen from blossoms produced on spurs with a large leaf area is more viable than that from blossoms on spurs with a smaller leaf area. The difference is not a great one, but like the difference in per cent of fruit setting on spurs of the two classes it is large enough to be of some significance.

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Summary.

There is a wide variation in average leaf weight and area of spurs between the "off year" and the bearing year.

There is a slight variation in average leaf weight and area of spurs between two successive years when the spurs bear no fruit either year.

The leaf weight and area of individual spurs one year shows considerable correlation with the leaf weight and area of the same spurs the preceding year.

There seems to be a relation between the leaf area and the kind of bud, i.e. flower or leaf, and number of blossoms that they produce and the number of blossoms "setting" fruit the following year.

There is no apparent influence of the leaf area of 1914 or the combined leaf areas of 1914 and 1915 upon the bud in 1916.

The viability of pollen from different spurs seems to be dependent, to a small degree at least, upon the leaf area of those spurs.

Acknowledgments

The writer wishes to express his appreciation for the assistance received in this investigation. First to Prof. C. I. Lewis, Chief of the Division of Horticulture, who afforded the opportunity to make the investigation. To Prof. V. R. Gardner, who not only suggested the problem but offered valuable suggestions and criticisms throughout the work. Other members of the Division have also aided in the work. Thanks are also due the Corvallis Orchard Company for permission to do part of the work in their orchard.

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