PRUNING OF ANJOU PEAR
In Relation to
IRRIGATION PRACTICE
In a Clay Adobe Soil

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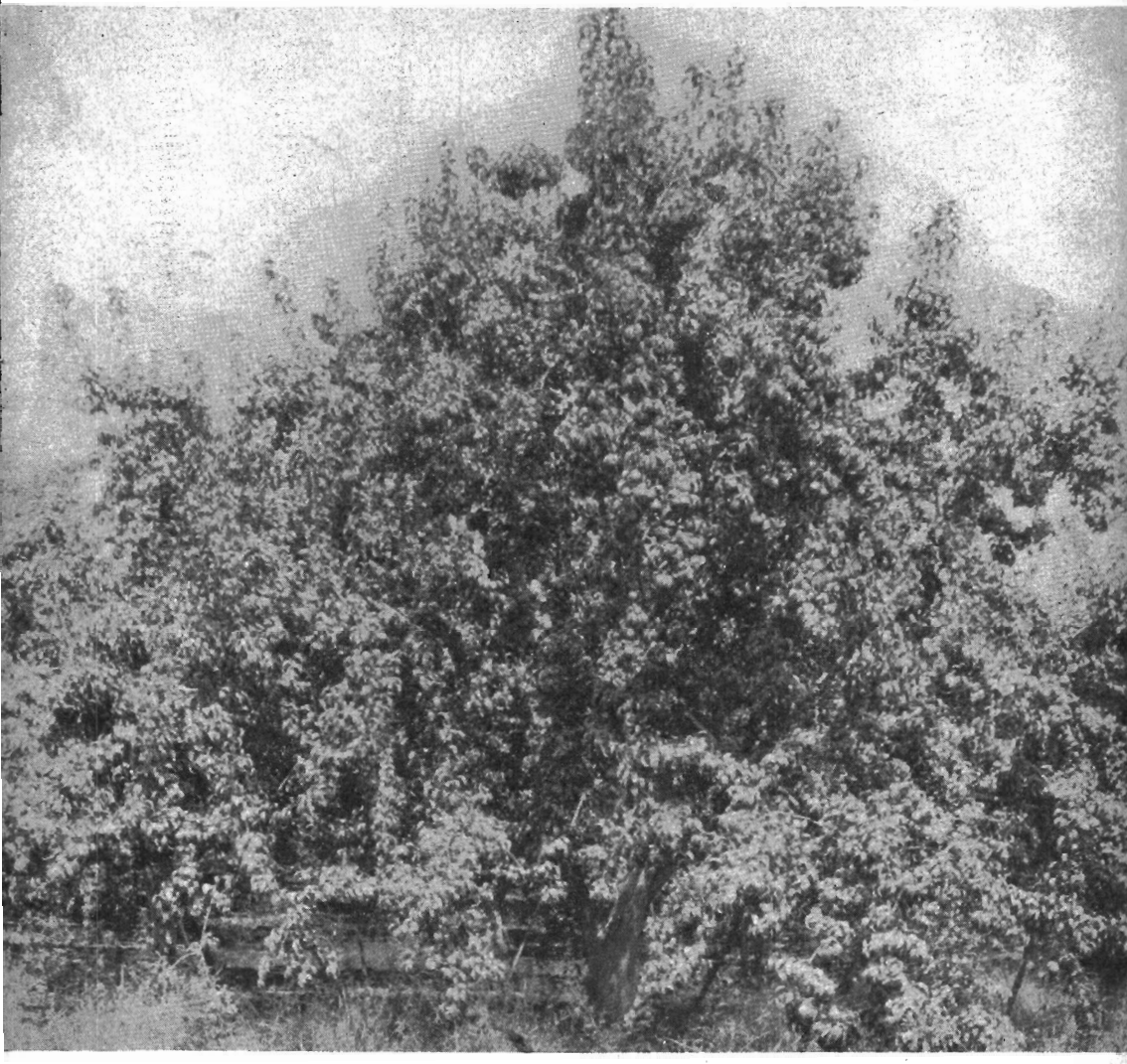

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Pruning of Anjou Pear in Relation to Irrigation Practice in A Clay Adobe Soil[1]

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THE total production of the Anjou variety of pear in the Pacific Northwest varies from about 1,000,000 to about 2,500,000 boxes a year. The principal factor causing low production in some years is that not more than 1 or 2 per cent of the blossoms set fruit. On the clay adobe soils in the Medford district the frequent failure of Anjou to set more than a light crop is particularly serious. As a means of stimulating fruit set of Anjou and also obtaining large fruits of uniform shape, growers have adopted the practice of annual heavy pruning.

To determine the value of pruning in maintaining satisfactory production of Anjou pears, experimental work was started at Medford, Oregon, in 1933. This experimental work included studies on the effect of pruning on set of fruit, size of fruit, and yield per tree. Since irrigation investigations (*5*)* had already indicated that the more frequent irrigation of clay adobe soil could be used to increase fruit size and tree vigor, particular emphasis was placed on the determination of whether heavy pruning of Anjou would stimulate set and size of fruits on frequently irrigated trees as much as it would on trees suffering from a soil moisture deficiency. The more important features of the experimental results obtained during the 1933-42 period are summarized in this bulletin.

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* Italic numbers in parenthesis refer to Literature Cited, page 24.

EFFECT OF PRUNING ON PERCENTAGE OF BLOSSOMS SETTING FRUIT

A number of experiments were conducted in different orchards in the Medford district to measure the effects of dormant pruning of pears in increasing the percentage of remaining blossoms that set fruit. Representative data from earlier reports (*1, 2*) are presented in Table 1.

Table 1. EFFECT OF DORMANT PRUNING ON PERCENTAGE OF FLOWER BUDS REMOVED AND PERCENTAGE OF REMAINING BLOSSOMS THAT SET FRUIT

Year, variety, and extent of pruning	Approximate percentage of flower buds removed	Percentage[1] of blossoms that set fruit
	Per cent	*Per cent*
1933—Anjou		
Light	5	3.3
Shoot removal only	5	4.4
Heavy	25	5.8 } [2]
Dehorning	....	5.7 }
1934—Anjou		
None	0	1.5
Spur removal only	50	2.5 } [2]
Very heavy	50	3.3 }
1934—Bartlett		
None	0	6.5
Spur removal only	50	6.5
Very heavy	50	12.2
1934—Bosc		
None	0	10.3 } [2]
Spur removal only	50	8.3 }
Very heavy	50	19.2
1934—Winter Nelis		
None	0	4.0
Spur removal only	50	4.7
Very heavy	50	6.8
1935—Anjou		
None	0	0.9
Moderate	10	2.1
Heavy	30	3.0
1936—Anjou		
None	0	1.4
Very heavy	50	4.9
1936—Anjou		
Moderate	15	1.4
Heavy	50	2.6
1937—Anjou		
Moderate	15	1.3
Heavy	50	3.3
1940—Anjou		
Moderate	15	1.3
Heavy	50	3.2
1941—Anjou		
Moderate	15	.7
Heavy	50	1.4
1942—Anjou		
Moderate	15	1.6
Heavy	50	1.8

[1]Since there was generally an average of about 7 blossoms per spur the "percentage of blossoms that set fruit" should be multiplied by 7 to show "percentage of blossoming points setting fruit."

[2]The differences between bracketed values are not considered to be statistically significant.

In the case of the varieties Bartlett, Bosc, and Winter Nelis, the unpruned trees set sufficient fruits for a full crop. On the unpruned Anjou trees, however, so few blossoms set fruit that the trees carried only a light crop. Such a low fruit set on unpruned Anjou is apparently typical for that variety on heavy clay or on clay adobe soil.

The very heavy pruning of Bartlett, Bosc, and Winter Nelis, as compared with no pruning, did not sufficiently increase the fruit set of the remaining blossoms to compensate for the flower buds removed, and therefore resulted in a reduction of the total number of fruits per tree.

In the case of Anjou, on the other hand, the pruning increased the percentage of blossoms setting fruit sufficiently more than to compensate for the reduction of flower buds incident to pruning, and consequently increased the number of fruits per tree. With Anjou on adobe soil heavy pruning may increase the percentage of blossoms setting fruit sufficiently more than does light pruning to result in more fruits per tree for heavy than for light pruning. There is some evidence that this much greater stimulation of fruit set by heavy than by light pruning is likely to occur in years with high temperatures during the spring, particularly with trees that have previously been pruned only lightly. When the heavy pruning of Anjou trees is repeated year after year, however, the number of fruits per year may be less than with only light pruning, as shown in Table 1 for one experiment.

In a series of plots with Anjou trees on adobe soil continued under test for eight years, the unpruned trees averaged 6.8 field boxes per tree per year, while moderately pruned trees averaged 9.9 boxes and heavily pruned trees averaged 10.2 boxes. After 2 or more years the unpruned Anjou trees produced 50 per cent more flower buds annually than the moderately pruned trees, yet continued to set light crops; while moderately pruned trees produced moderate crops. In spite of the large leaf area per fruit each season on the unpruned trees, the fruits were smaller than those on the moderately pruned trees.

Somewhat different results were obtained with relatively vigorous Anjou trees on a silt loam with permanent water table at a depth of about 6 feet. Over a 5-year period unpruned trees produced about the same amount of fruit as the heavily pruned trees, with moderately pruned trees producing more than either unpruned or heavily pruned trees (odds 369:1). Thus although pruning of Anjou does not always increase the number of fruits per tree, some pruning of Anjou trees on heavy clay or clay adobe soil seems to be necessary to avoid a very light set of fruit.

SEVERITY OF PRUNING IN RELATION TO IRRIGATION

Methods

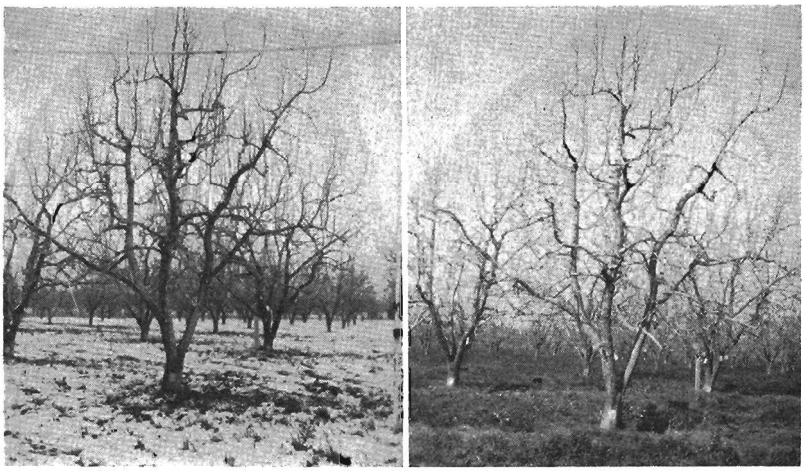
To determine whether a relatively heavy pruning is necessary as an annual practice for well irrigated Anjou trees on clay adobe soil, a comparison of heavy with light pruning was started on 16-year-old Anjou trees at the Medford Experiment Station in 1933. This comparison of heavy with light pruning was repeated in each of the three 5-row blocks, each block receiving a different irrigation treatment. In the "frequent" irrigation treatment the average soil moisture in the top 3 feet was maintained above 70 per cent of the available capacity (*4*, *7*, *10*), usually necessitating 7 irrigations during the growing season. In the "moderate" irrigation treatment the average soil moisture was maintained above 50 per cent of the available capacity, necessitating 3 to 4 irrigations. This treatment corresponded to the irrigation practice in the better-cared-for orchards. In the "deficient" irrigation treatment, the average soil moisture in the top 3 feet was allowed to approach the permanent wilting percentage. During the 2 or 3 weeks prior to irrigation, soil moisture deficiency became so acute as greatly to reduce tree functioning, with many spur leaves dropping. This treatment required 1 to 2 irrigations during late summer.

In each of the 5-row irrigation blocks the entire center row received "heavy" pruning, the adjacent row to the west "light" pruning, and the adjacent row to the east either "light" or "heavy" pruning. The two outside rows constituted border rows between irrigation treatments. "Heavy" pruning consisted in the removal of about 75 per cent of the new shoots and the heading back of about 60 per cent of the remaining shoots, to give a total removal of about 90 per cent of the total length of new shoots. During the first two years a great deal of old wood and spurs was also removed, but subsequently most of the pruning was confined to shoot removal. "Light" pruning consisted in the removal of about 55 per cent of the new shoot growth and the heading back of about 30 per cent of the remaining number of shoots, to give a total removal of about 60 per cent of the total shoot length. Only a slight amount of old wood was removed each year. Representative trees before and after pruning in 1936 are shown in Figures 1, 2, and 3.

Total shoot length for a specific year was determined the following spring by measuring the length of each shoot on the tree after pruning and the length of each shoot removed. All blossoming points were counted each March on 3 to 6 trees in each treatment, and at harvest time the fruits from these trees were counted. Rate

Before pruning (Tree E-19) After pruning (Tree E-19)

Light pruning



Before pruning (Tree C-20) After pruning (Tree C-20)

Heavy pruning

Figure 1. Frequent irrigation: Anjou pear trees at the end of 4 years of differential pruning (February and March 1936). Note greater number and length of shoots with "heavy" as compared with "light" pruning.

Before pruning (Tree I-24) After pruning (Tree I-24)

Light pruning

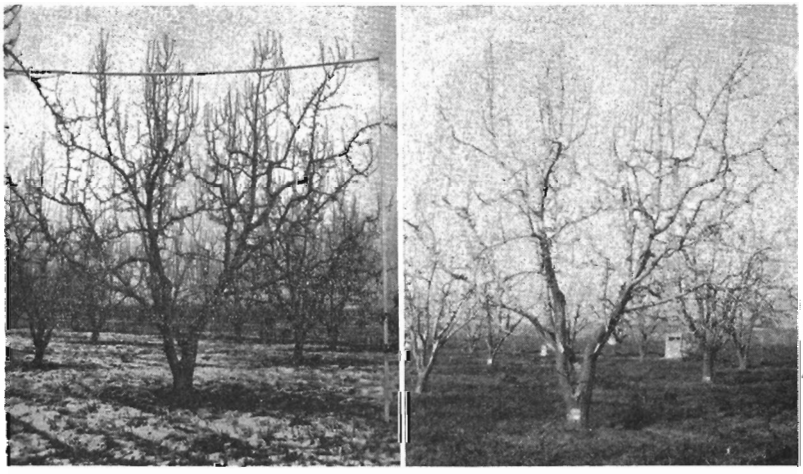
Before pruning (Tree H-25) After pruning (Tree H-25)

Heavy pruning

Figure 2. Moderate irrigation: Anjou pear trees at the end of 4 years of differential pruning (February and March 1936). Note that trees in moderate irrigation treatment showed only slightly less shoot growth than comparable trees in frequent irrigation treatment.

Before pruning (Tree E-29) After pruning (Tree E-29)

Light pruning



Before pruning (Tree B-30) After pruning (Tree B-30)

Heavy pruning

Figure 3. Deficient irrigation: Trees at the end of 4 years of differential pruning (February and March 1936). Note the conspicuously less shoot growth, with both light and heavy pruning, in deficient irrigation plot than in frequent irrigation and moderate irrigation plots.

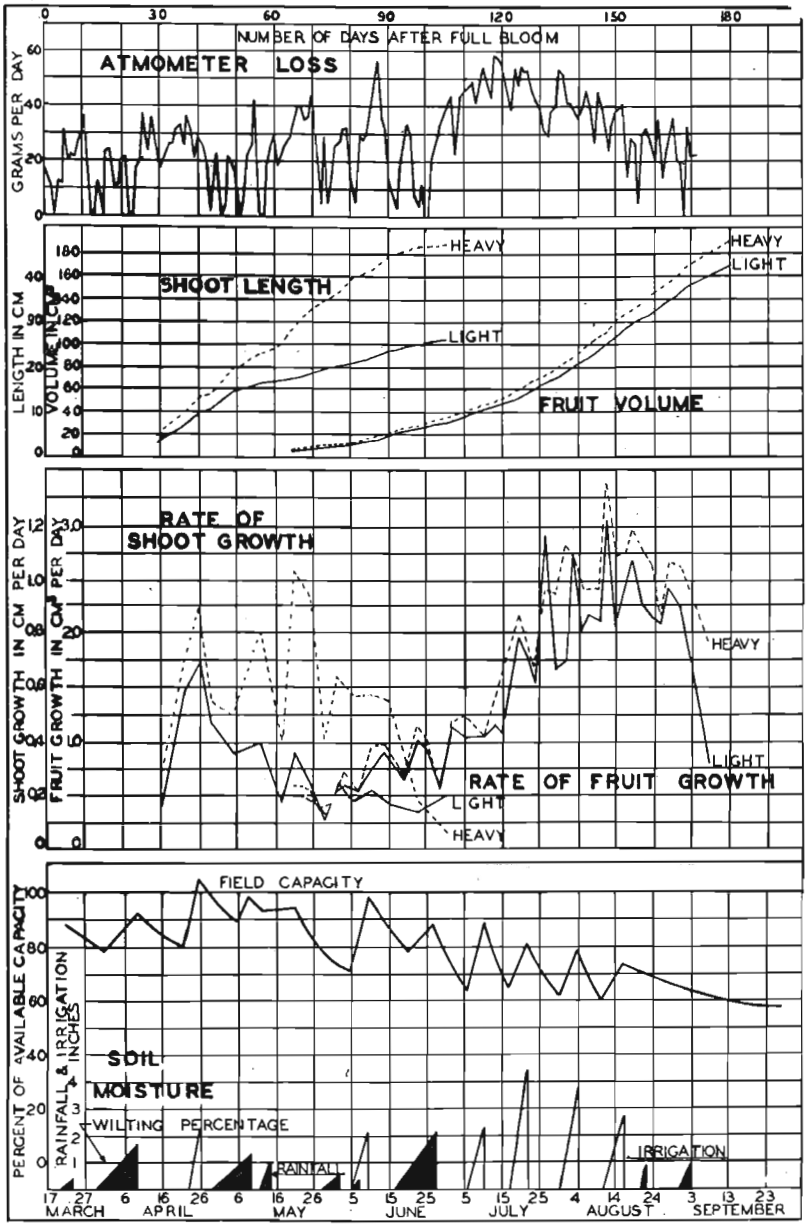


Figure 4. Comparison of heavy with light pruning in relation to rate of shoot growth, shoot length, rate of fruit growth and fruit volume in "frequent" irrigation treatment; with data upon daily atmometer loss and upon average "available" soil moisture in upper 3 feet of soil.

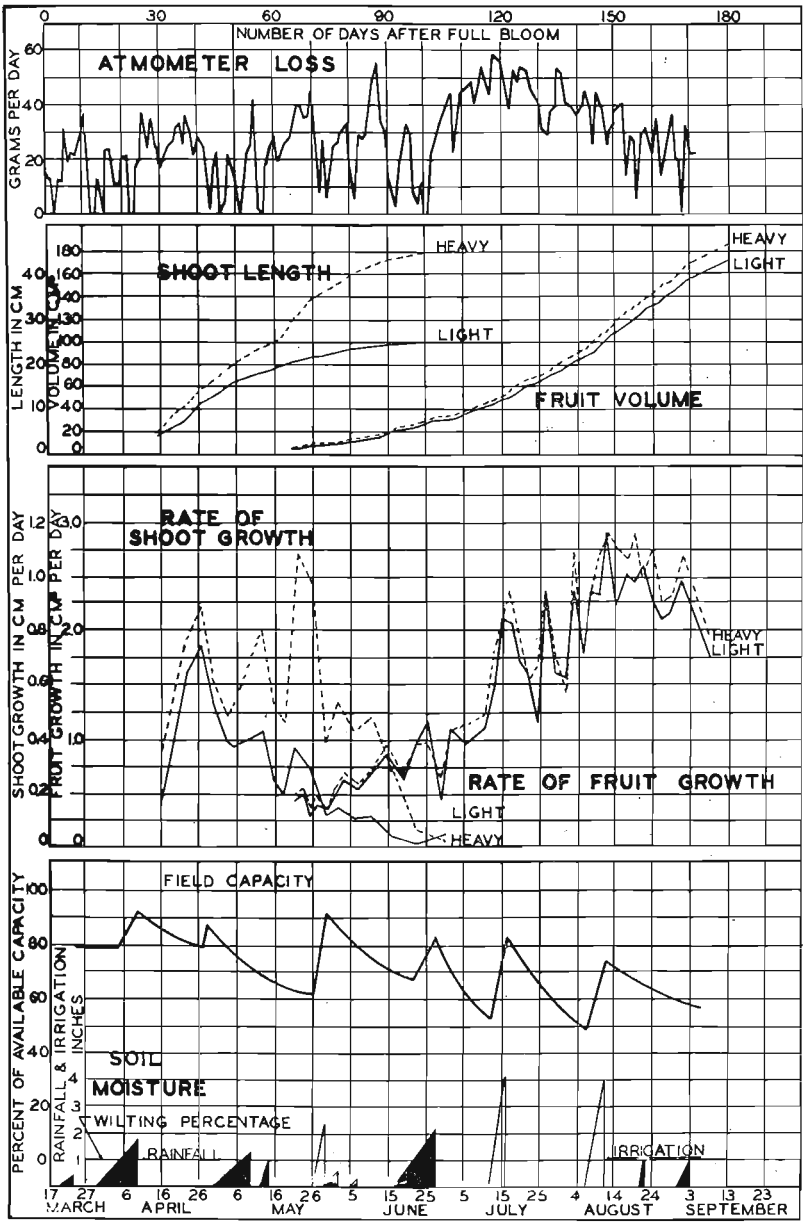


Figure 5. Comparison of heavy with light pruning in relation to rate of shoot growth, shoot length, rate of fruit growth, and fruit volume in "moderate" irrigation treatment; with data upon daily atmometer loss and upon average "available" soil moisture in upper 3 feet of soil.

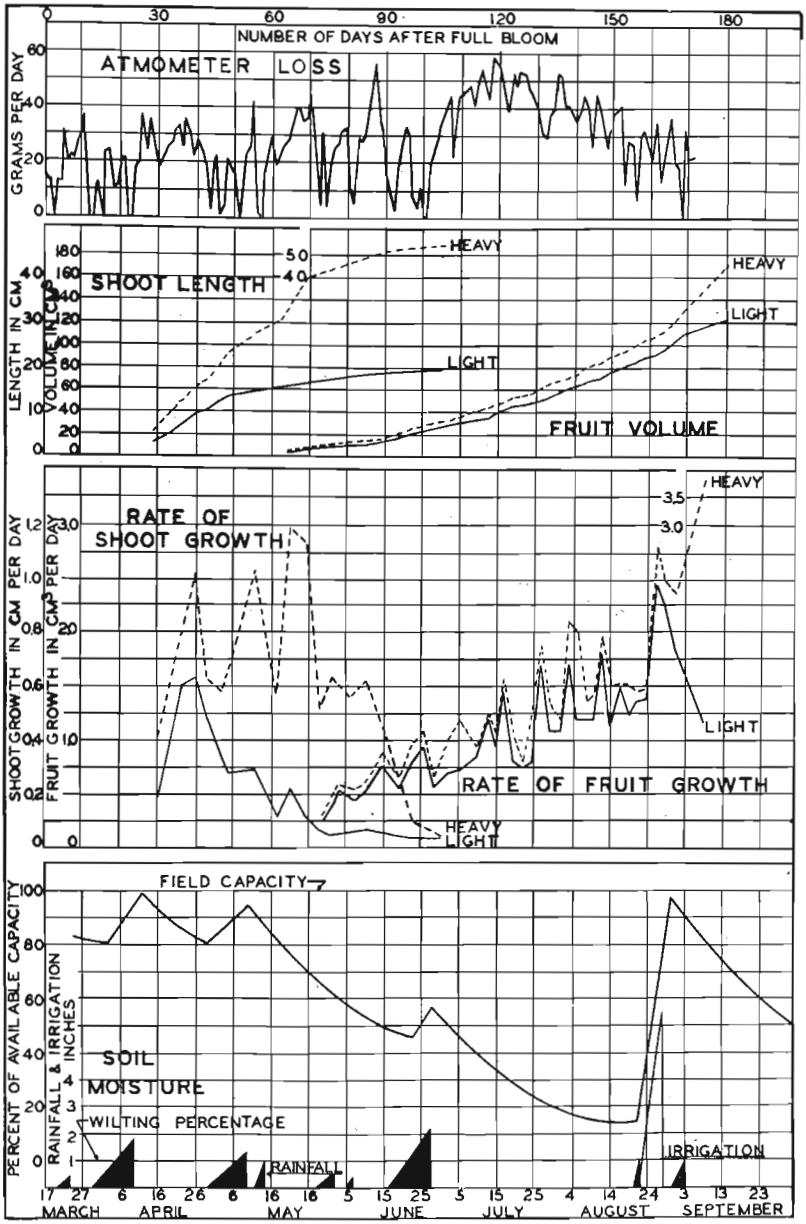


Figure 6. Comparison of heavy with light pruning in relation to rate of shoot growth, shoot length, rate of fruit growth, and fruit volume in "deficient" irrigation treatment; with data upon daily atmometer loss and upon average "available" soil moisture in upper 3 feet of soil.

of shoot growth, trunk growth, fruit growth, and yields were measured in the manner described in an earlier report on tree response to irrigation (*4*).

In 1938 and 1939 the experiment was temporarily suspended and a relatively light pruning was given all trees, so the data for these two years are omitted. In 1940, 1941, and 1942 the comparison of "heavy" with "light" pruning was resumed.

Root Growth

To determine whether the more severe pruning influenced the development of feeder roots, all roots 2 mm. or less in diameter were removed in the summer of 1934 from 20 1-foot cubes of soil in each of the 6 treatments. The average weights of feeder roots per cubic foot given in Table 2 indicate that the more severe pruning in the winters of 1932-33 to 1935-36 had not greatly reduced the development of feeder roots.

Determinations of soil moisture to a depth of 3 feet were made at 5 to 10 locations in each plot from 1933 to 1939, and the rate of decrease in soil moisture was calculated for each treatment. This apparent extraction of soil moisture by the trees was found to be about the same for heavy as for light pruning in any one irrigation treatment. This provides additional evidence that the root development was about the same for both types of pruning.

Shoot and trunk growth

The rates of shoot growth for a typical season are presented in Figures 4, 5, and 6. These results show that shoot growth was about completed by July 1, regardless of pruning or irrigation treatment. During the period of rapid shoot elongation the rate of growth was much greater on the heavily than on the lightly pruned trees. As a result, the total shoot length per tree, given in Table 3, was nearly twice as great with the heavy as with the light pruning. This was

Table 2. COMPARISON OF HEAVY WITH LIGHT PRUNING IN EACH OF THREE IRRIGATION TREATMENTS, IN RELATION TO THE PRODUCTION OF FEEDER ROOTS

Irrigation and pruning treatment	Weight of feeder roots per cubic foot of soil	
	1934	Produced between 1934 and 1936
	Grams	*Grams*
Frequent irrigation		
Heavy	10.9	4.5
Light	12.5	5.4
Moderate irrigation		
Heavy	9.8	5.2
Light	9.7	4.0
Deficient irrigation		
Heavy	8.9	4.0
Light	10.8	4.9

true in each of the irrigation treatments, indicating that the stimulation of shoot growth by heavy pruning was not influenced by irrigation practice in previous years. In years when there was less total shoot growth per tree in the moderate or in the deficient irrigation treatment than in the frequent irrigation, this was probably the result of hold-over effects of appreciable water deficits during the previous summer. The effect of the severity of pruning given in Table 4 was apparently influenced by irrigation practice. Although with moderate irrigation the more severe pruning resulted in reduced trunk growth, with deficient irrigation the more severe pruning seemed to increase trunk growth.

Table 3. COMPARISON OF HEAVY WITH LIGHT PRUNING IN EACH OF THREE IRRIGATION TREATMENTS, IN RELATION TO TOTAL ANNUAL SHOOT LENGTH PER TREE AND AVERAGE NUMBER OF SHOOTS PER TREE

Year	Annual shoot length per tree					
	Frequent irrigation		Moderate irrigation		Deficient irrigation	
	Lightly pruned	Heavily pruned	Lightly pruned	Heavily pruned	Lightly pruned	Heavily pruned
	Centimeters	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*
1932	27,000	25,000	23,000	21,000	21,000	22,000
1933	32,000	53,000	31,000	41,000	29,000	36,000
1934	28,000	61,000	17,000	41,000	16,000	41,000
1935	21,000	50,000	19,000	45,000	13,000	40,000
1936	20,000	49,000	20,000	44,000	20,000	47,000
1937	.....	.....	.....	.....	.....	.....
1938	.....	.....	.....	.....	.....	.....
1939	20,000	36,000	28,000	33,000	47,000	41,000
1940	34,000	62,000	33,000	57,000	21,000	46,000
1941	31,000	55,000	27,000	44,000	15,000	45,000
1933-41 average	26,600	52,300	25,000	43,600	23,000	42,300
Average number of shoots per tree, 1933-41	1,000	1,300	1,100	1,100	1,100	1,200

Table 4. COMPARISON OF HEAVY WITH LIGHT PRUNING IN EACH OF THREE IRRIGATION TREATMENTS, IN RELATION TO ANNUAL INCREASE IN TRUNK CROSS-SECTIONAL AREA

Year	Increase in trunk cross-sectional area					
	Frequent irrigation		Moderate irrigation		Deficient irrigation	
	Lightly pruned	Heavily pruned	Lightly pruned	Heavily pruned	Lightly pruned	Heavily pruned
	Square centimeters	*Square centimeters*	*Square centimeters*	*Square centimeters*	*Square centimeters*	*Square centimeters*
1933	36.1	35.3	34.8	29.7	26.7	28.6
1934	38.5	40.7	35.9	33.6	24.2	24.5
1935	34.8	38.0	36.9	31.5	26.9	28.7
1936	33.4	27.9	34.1	32.5	26.6	27.8
1937	37.4	41.0	39.8	33.5	21.2	25.6
1938	.....	.....	.....	.....	.....	.....
1939	.....	.....	.....	.....	.....	.....
1940	36.5	35.6	33.4	27.2	21.6	24.5
1941	40.3	35.8	44.3	35.9	22.9	26.9
Average	36.0	35.2	36.8	31.9	24.6	27.1

Fruit growth

Each year whenever the average soil moisture in the top 3 feet of the deficient irrigation treatment decreased below about 50 per cent of the available capacity, a lower rate of fruit growth than in the frequent irrigation treatment indicated that soil moisture deficiencies were causing appreciable water deficits in the trees (*4, 7*), and that tree functioning was affected. In the moderate irrigation treatment, only occasionally, just prior to irrigation, did soil moisture deficiency cause an appreciable water deficit in the trees, and then tree functioning was only slightly affected. Of particular significance was the greater rate of fruit growth throughout the summer on heavily pruned than on comparable lightly pruned trees, as illustrated in Figures 4, 5, and 6. This occurred every year in each of the irrigation treatments. To determine whether this could be explained by a larger average leaf area per fruit on the trees with the heavier pruning, careful estimations were made of the number and average area of both spur and shoot leaves on 3 to 6 trees per treatment during each of 4 years. The results of these leaf area estimations, given in Table 5, are remarkable and probably unusual, in showing that the total leaf area per tree was about as great with heavy as with light pruning. In 1933 a few fruits were removed from the heavily pruned trees during the first week of July, to make the average leaf area per fruit as great with heavy as with light pruning; but after 1933 no fruits were removed. The rate of fruit growth during the summer was greater with heavy than with light pruning in the respective irrigation plots in 1933 when the leaf area per fruit was the same and also in 1934 when leaf area per fruit was actually less on the heavily pruned trees. In subsequent years the heavily pruned trees occasionally had a greater leaf area per fruit than comparable lightly pruned trees.

Yield of fruit

The average yield per tree in field boxes for each year for each of the 6 treatments is given in Table 6. The experimental design of these plots does not permit the calculation of the difference in yield between plots necessary for probability odds of 99:1 or more that the observed difference was due to the treatment, but on the basis of the authors' familiarity with trees it is probable that a difference of 1.5 boxes or more is significant.

The low yield each year of the lightly pruned trees with deficient irrigation was usually due almost entirely to the small size of the fruit, although in some years there were also relatively few fruits per tree. In this deficient irrigation treatment, where soil moisture deficiency seriously retarded fruit growth, heavy pruning

Table 5. Comparison of Heavy with Light Pruning in Each of Three Irrigation Treatments in Relation to Total Leaf Area per Tree[1], Total Area of Shoot Leaves, and Leaf Area per Fruit.

Year and type of leaf	Irrigation and pruning treatments					
	Frequent		Moderate		Deficient	
	Light	Heavy	Light	Heavy	Light	Heavy
	Square centimeters	*Square centimeters*	*Square centimeters*	*Square centimeters*	*Square centimeters*	*Square centimeters*
1933						
Total leaf area per tree	930,000	915,000	1,091,000	970,000	1,010,000	847,000
Total area of shoot leaves per tree	340,000	506,000	346,000	388,000	315,000	332,000
Average leaf area per fruit[2]	1,000	1,000	950	950	1,000	900
1934						
Total leaf area per tree	1,246,000	1,514,000	1,225,000	1,605,000	1,071,000	995,000
Total area of shoot leaves per tree	309,000	675,000	232,000	468,000	151,000	366,000
Average leaf area per fruit	1,950	1,600	2,250	1,650	1,700	1,050
1935						
Total leaf area per tree	1,369,000	1,238,000	1,228,000	1,200,000	1,057,000	894,000
Total area of shoot leaves per tree	222,000	524,000	204,000	537,000	173,000	349,000
Average leaf area per fruit	1,200	1,600	1,400	1,200	950	1,350
1936						
Total leaf area per tree	1,533,000	1,511,000	1,445,000	1,427,000	1,284,000	1,214,000
Total area of shoot leaves per tree	211,000	450,000	280,000	543,000	216,000	466,000
Average leaf area per fruit	1,850	2,050	1,900	2,100	1,750	2,300

[1]These data for total leaf area per tree probably are accurate only within about 15 per cent.

[2]About July 4, in 1933, sufficient fruits were removed from the heavily pruned trees to make the leaf area per fruit about the same as on the lightly pruned trees.

usually resulted in higher yields than light pruning, with the average annual yield 31 per cent higher. Furthermore, with heavy pruning almost all the fruits were "180's" (180 fruits per packed box) or larger, whereas with light pruning many were too small for even the "193" pack.

Table 6. COMPARISON OF HEAVY WITH LIGHT PRUNING IN EACH OF THREE IRRIGATION TREATMENTS, IN RELATION TO AVERAGE YIELD PER TREE

Year	Average yield per tree in field boxes					
	Frequent irrigation		Moderate irrigation		Deficient irrigation	
	Lightly pruned	Heavily pruned	Lightly pruned	Heavily pruned	Lightly pruned	Heavily pruned
	Boxes	*Boxes*	*Boxes*	*Boxes*	*Boxes*	*Boxes*
1933	9.9	8.0	7.6	10.8	3.2	4.7
1934	12.3	12.7	7.6	9.7	6.7	9.2
1935	9.5	7.9	6.5	9.3	5.7	6.7
1936	10.9	9.2	11.0	9.0	6.5	6.8
1937	8.9	7.0	6.8	7.9	3.3	3.3
1938	.....	.....	.....	.....	.....	.....
1939	.....	.....	.....	.....	.....	.....
1940	9.4	10.8	8.8	11.6	7.2	8.6
1941	10.8	8.2	10.1	11.4	5.2	7.6
1942	12.6	11.6	12.3	11.4	7.3	10.8
Average	10.5	9.4	8.8	10.1	5.6	7.2

During the first three years (1933-4-5) of the experiment the short periods of appreciable water deficits in the trees in the moderate irrigation treatment reduced the rate of fruit growth below that in the frequent irrigation treatment and, in the case of the lightly pruned trees, this resulted in a considerable reduction in yield. In 1936, however, the yield was as great, and after 1936 usually nearly as great, in the moderate irrigation as in the frequent irrigation treatment, largely because of heavier flowering and more fruits per tree in the former. In 4 of the 8 years of heavy pruning in the moderate irrigation treatment, the heavily pruned trees had considerably higher yields than the lightly pruned, but in 2 years the heavily pruned trees had a lower yield. Thus the evidence does not show consistently greater production with the more severe pruning under the type of irrigation followed in the better commercial orchards whenever water supply is normal.

In the frequent irrigation treatment, the slightly lower yields with heavy than with light pruning in 6 out of 8 years are interpreted as showing that there was very little if any influence of the pruning on yield. Thus trees with relatively high vigor resulting from the prevention of appreciable water deficits in the trees by frequent irrigation did not show the slightly greater production with the heavier pruning that was found with trees that had suffered from soil moisture deficiency.

PRUNING IN RELATION TO CORK SPOT

In some years certain Anjou trees produce fruits which, as they approach maturity, develop an uneven surface and brown, corky spots in the flesh. This disorder is called "cork spot." Since Harley and Masure (*6*) found that heavy pruning of such trees increased the percentage of fruits developing cork spot, all fruits from the trees in the pruning experiments at Medford were examined for this disorder. In the comparisons of heavy with light pruning in each of the three irrigation treatments, cork spot of the fruit was observed but once, and then on only two of the heavily pruned trees with the deficient irrigation treatment. Since cork spot did not occur consistently on trees that had suffered from soil moisture deficiencies, acute water deficits in the tree do not appear to be the primary cause.

The results of other pruning experiments, located in two orchards in which cork had been serious in some of the preceding seasons are given in Table 7. In the Dodge orchard, where the trees were small and weak, the pruning had little or no effect on cork spot development in 1934, but greatly increased it in 1935. In the Clancy orchard, with moderately vigorous trees, no cork spot developed, either with or without pruning in 1934; but in 1935, with a slight amount of cork spot on unpruned and lightly pruned trees, the heavy pruning greatly increased this disorder. Thus it appears that pruning does not necessarily cause fruit to develop cork spot, but in years in which cork spot is serious, heavy pruning on trees that have shown the disorder may greatly increase the percentage of fruits affected.

DISCUSSION

These results of an intensive study of pruning of the Anjou variety on rather unusually heavy soils have a great practical significance in the production of this variety in the Medford district, but must be interpreted with caution in relation to other pear varieties, particularly where grown on lighter types of soil. With the Anjou variety on heavy clay or clay adobe soils the purpose of pruning is to stimulate the tree sufficiently to cause the maximum number of flowers to set fruit. With varieties such as Bartlett or Winter Nelis, however, which without pruning usually set an excessively large number of fruits per tree, one of the principal reasons for pruning is to reduce the number of fruits and at the same time stimulate new shoots in order to produce efficient leaf area to help in increasing the size of the remaining fruits. With such varieties, pruning generally reduces the yield, but is necessary to obtain satisfactory fruit size without a great deal of hand thinning of the fruits in June.

Since some pruning of Anjou is necessary for commercial fruit production, the intensive study of Anjou pruning was limited to a comparison of the two extremes in severity in the current practice at the time the investigations were started. Certain conditions were apparently restricting the total amount of growth of the lightly pruned trees. Thus, the new shoot growth and the amount of leaf area produced during the spring on the lightly pruned trees may have been limited by a low rate of intake of mineral nutrients or of water as a result of either unfavorable soil conditions or restricted translocation in the tree. Although these trees received from 1 to 1.5 pounds

Table 7. THE EFFECT OF DORMANT PRUNING UPON THE DEVELOPMENT OF CORK SPOT ON TREES THAT NORMALLY SHOW THIS DISORDER IN SOME SEASONS

Location and type of pruning each February, in 1934 and in 1935	Fruits developing cork spot	
	1934	1935
	Per cent	*Per cent*
Dodge Orchard		
None	46	25
Heavy	51	75
Clancy Orchard		
None	0	4
Light	0	4
Heavy	0	65

of actual nitrogen annually, and in both frequent irrigation and moderate irrigation treatments average soil moisture was maintained above 50 per cent of the available capacity, nitrogen or water intake could have been limited by relatively poor root development or by poor soil aeration. Growth also might have been limited as a result of the failure of photosynthesis during the summer to provide sufficient carbohydrates, in excess of those used in current fruit and limb growth and in respiration, for reserves for use in growth early the following spring. Under such conditions, heavier pruning, by reducing the number of growing points per tree, might provide more water or mineral nutrients for each remaining growing point, as Chandler (*5*) has suggested. Then, as growth started, the stimulation of the more severe pruning might in some way improve the vascular elements formed during early spring growth and thereby provide better translocation of water and mineral nutrients from the roots to the growing points in the top, and later better translocation of carbohydrates and other elaborated growth substances from the newly formed leaves to other parts of the tree. Of course, if the heavier pruning had been sufficiently severe each year to remove portions of scaffold and lateral limbs, the stimulation from such pruning would not have been sufficient to prevent reduction in total leaf area and total yield per tree.

To integrate the effects of the more severe pruning upon trunk, shoot, leaf, and fruit growth, the total dry matter per tree laid down in a year was estimated. Magness and Regeimbal (*8*) have estimated that a 25-year-old apple tree will lay down annually approximately 95 pounds of dry matter in wood and bark, and these pear trees probably produced somewhat less dry matter. It was therefore assumed that the dry weight of the new growth in the trunk and scaffold limbs with light pruning and frequent irrigation was 90 pounds, and that in the other treatments the dry weight was proportional to the increase in trunk cross-sectional area. The dry matter in new shoot growth was estimated as 5 pounds for lightly pruned trees and 10 pounds for heavily pruned trees. The dry matter in the fruits and leaves could be estimated more accurately. These estimations, tabulated in Table 8, indicate about the same dry-matter production with heavy as with light pruning in both the frequent irrigation and the moderate irrigation treatments. In the deficient irriga-

Table 8. ESTIMATED WEIGHT OF DRY MATTER LAID DOWN BY ONE TWENTY-YEAR-OLD PEAR TREE IN ONE YEAR

Treatment	Dry matter per tree				
	New wood and bark in trunk and scaffold limbs	Shoots	Fruits	Leaves	Total
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Frequent irrigation					
Moderate pruning	90	5	84	60	239
Heavy pruning	88	10	72	61	231
Moderate irrigation					
Moderate pruning	92	5	70	59	226
Heavy pruning	80	10	80	61	231
Light irrigation					
Moderate pruning	61	5	45	52	163
Heavy pruning	68	10	58	47	183

tion treatment, however, where dry-matter production was considerably less than with more frequent irrigation, the heavy pruning seemed to result in greater dry-matter production than did the light pruning. Apparently, with trees that had suffered from appreciable water deficits during the summer, heavy as compared with light pruning resulted either in greater photosynthesis per unit leaf area or in more efficient utilization of the carbohydrates produced. Perhaps the leaves on the heavily pruned trees withstood the appreciable water deficits better than leaves on the lightly pruned trees, with the result that in late summer they were more active in photosynthesis whenever irrigation replenished soil moisture.

Since the greater rate of fruit growth with heavily pruned than with lightly pruned trees was not, in 1933 and 1934, associated with

greater leaf area per fruit, some other explanation of this effect of more severe pruning must be considered. Observations during late April and early May indicated that on heavily pruned trees there was not only a greater percentage of blossoms setting fruit, but also a great many fruits that were obviously larger than on the lightly pruned trees. Measurement of tagged fruits from petal-fall until harvest in September showed that, with other conditions the same, fruits that initially were relatively large grew at a slightly greater rate than fruits that initially were relatively small. Similar results for apple were reported by Whitehouse (*9*). Thus the heavier pruning had a tendency to stimulate rate of fruit growth, beginning at petal-fall, just as it greatly stimulated rate of shoot elongation.

When it was observed that the more severe pruning greatly increased shoot length (Table 3) and the number of shoot leaves, the efficiency of shoot leaves as compared with spur leaves was studied (*3*). It was found that on ringed limbs of Bartlett, Bosc, and Anjou a unit area of shoot leaves generally resulted in significantly greater fruit growth than an equal area of spur leaves. Therefore, with shoot leaves supplying a larger proportion of the total leaf area per tree on heavily pruned than on lightly pruned trees (Table 5), the total leaf area of heavily pruned trees may have supplied more carbohydrates for fruit growth than an equal leaf area on lightly pruned trees.

The greater rate of fruit growth with the heavier pruning could have been largely the result of improved translocation. Since the daily period of stomatal opening (*4*) of the leaves on heavily pruned trees was usually the same as on lightly pruned trees and never more than 30 minutes longer, the water supply to the leaves probably was not affected. The nitrogen content of the leaves was the same for both types of pruning, so nitrogen level likewise probably was not affected. Therefore, if the effect of the heavier pruning in increasing fruit growth was the result of improved translocation, probably increased rate of carbohydrate movement was involved.

SUMMARY

The effects of pruning bearing Anjou pear trees on clay adobe soil were studied at Medford, Oregon, from 1933 through 1942.

With no pruning either during 1 year or for 8 consecutive years, so few blossoms set fruit that the trees produced only a light crop. Either light or heavy pruning, as compared to no pruning, increased the percentage of blossoms setting fruit more than enough to compensate for the reduction in flower-buds incident to pruning, and consequently greatly increased the number of fruits per tree.

Heavy pruning, as compared with light pruning, greatly stimulated the rate of shoot growth and slightly stimulated the rate of fruit growth. The stimulation appeared to be as great with moderately vigorous trees that had been adequately irrigated as with trees in low vigor because of soil moisture deficiencies.

Heavy pruning, as compared with light pruning, did not appear to influence the amount of feeder roots developed or the capacity of feeder roots to extract soil moisture.

The heavy pruning did not, during the first four years at least, reduce the total leaf area per tree below that on trees with light pruning, but did increase the proportion of the total leaf area supplied by shoot leaves. Since a unit area of shoot leaves appeared to be more effective for fruit growth than an equal area of spur leaves, the increased shoot leaf area on the more heavily pruned trees would tend to increase the rate of fruit growth.

With sufficiently frequent irrigation to maintain adequate available soil moisture, light pruning resulted in as great an average annual yield as did heavy pruning.

In the case of trees with vigor reduced and fruit growth greatly retarded because of soil moisture deficiencies, heavy pruning not only increased the trunk growth and the total average annual yield per tree over that with light pruning, but increased fruit growth sufficiently to yield a large proportion of "180" size (fruits per packed box) or larger commercial sizes.

With trees whose fruits develop cork spot in some years, heavy pruning greatly increased the percentage of fruits affected during a year when that disorder was serious.

PRUNING SUGGESTIONS FOR ANJOU PEAR TREES IN CLAY ADOBE SOIL

Although the set of fruit is influenced by such factors as weather conditions, tree vigor, and cross pollination, some pruning is necessary each year to stimulate sufficient set of fruit for even a moderate crop.

In orchards where fruit growth is retarded by soil moisture deficiencies a relatively heavy pruning is necessary to stimulate fruit growth sufficiently to have a large proportion of the crop in the "180" size or larger commercial sizes.

Under normal conditions of temperature and evaporation and with sufficiently frequent irrigation to maintain adequate available soil moisture for normal fruit growth, a relatively light pruning each year will give as great an average annual yield as heavy pruning. Under such conditions, the severity of the pruning may be modified to favor the more desirable commercial fruit sizes. When the market demand is for the smaller sizes, light pruning will be satisfactory. When the market demand is for the larger commercial sizes of fruit, however, a relatively heavy pruning may be expected to stimulate growth rate of the fruit without appreciably reducing yield per tree.

In the case of trees whose fruits develop cork spot in some years, relatively light pruning each year may prove desirable to avoid the loss of a large proportion of the crop from this fruit malformation during the year when it is serious.

"Light pruning" consists in cutting off suckers and about half of the previous season's shoot growth, cutting back shoots at the ends of scaffold branches, particularly when there are flower-buds at the ends of the shoots, and thinning out a few of the small branches composed of 2-, 3-, and 4-year-old wood. "Heavy pruning" consists in cutting off at least three-quarters of the previous season's shoot growth, cutting back more than half of the remaining shoots, and removing any weak or crowding branches; but where fruit spurs have been stimulated into vigorous growth, this new growth is left to develop strong fruiting wood.

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