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STUDIES OF THE IRRIGATION OF PEAR ORCHARDS ON HEAVY SOIL NEAR MEDFORD,
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# STUDIES OF THE IRRIGATION OF PEAR ORCHARDS ON HEAVY SOIL NEAR MEDFORD, OREG.[1]

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## INTRODUCTION

The practice of irrigating the pear orchards of the Rogue River Valley, wherever water for irrigation is available, has become almost universal in recent years. Commercial orchard experience has demonstrated that irrigation is of value in the production of satisfactory yields of fruit of marketable size, but no definite information has been available to the orchardists as to the proper frequency, amount, or time of application of irrigation water.

Within the past few years the competition of other districts in the somewhat limited winter-pear market has made it more and more evident that the pear industry of the Rogue River Valley can survive only by meeting such districts in a price competition. It has been shown by Besse, Brown, and Wilcox (*2*)[3] in a study of production costs, that "yield is the dominant factor in reducing cost per box."

[1] This bulletin is a report of investigations carried on under a cooperative agreement between the Bureaus of Agricultural Engineering and Plant Industry, U.S. Department of Agriculture and the Oregon Agricultural Experiment Station.

[2] Sincere thanks are due F. C. Reimer, superintendent of the Southern Oregon Branch Experiment Station, and to C. L. Powell, formerly junior physiologist, Bureau of Plant Industry, for studies of the dessert and keeping qualities of the pears grown in these experiments. The cooperators, Chester Fitch, owner of the Fitch orchard, and Wood & Riddle, of the Klamath orchard, extended every facility to further the progress of the experiments.

[3] Italic numbers in parentheses refer to Literature Cited, p. 33.

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Recent experiments show that the amount of irrigation has a marked effect on both the size and the total yield of fruit.

The water supply in the Medford district is distinctly limited, and it is highly desirable that information as to the best use of this limited supply be available. In some years the supply is far below normal, and the small quantity available should be applied at times when it will be most useful. In considering the possibility of increasing the water supply by expensive works, definite information as to the value of heavier irrigation in increasing the yield of fruit is essential.

## FORMER IRRIGATION STUDIES

Irrigation investigations have been conducted in the Rogue River Valley at various times. The early workers (*4, 5, 8*) were interested primarily from the engineering point of view and obtained information from studies of soil and climatic conditions and from observation of results secured by pioneer irrigation farmers. They were convinced that irrigation would undoubtedly prove profitable, if not essential, to successful farming and fruit growing. The first extensive experimental investigations of the results of irrigation on the yield of fruit were conducted during the years 1907 to 1911, inclusive, by Lewis, Kraus, and Rees (*3*). Their endorsement of irrigation is somewhat qualified. Among their conclusions regarding the effects of irrigation are the following:

> Irrigation aided in giving a larger percentage of fruit that came up to good packing size. In several cases it was found that irrigation had an influence on the succeeding crop. The irrigated trees had more numerous and stronger fruit buds. Some of the heavier types (of soil) such as the stickies or adobes have shown best results under cultivation without the use of water. The soils of medium texture have shown a direct benefit from light irrigation . . . . When Bartlett pear trees from 7 to 8 years of age which are in good vigor and planted on strong soils are irrigated, the trees have a tendency to become more susceptible to disease. The use of an excessive amount of cold water in the irrigation of pear trees on sticky soil is a questionable practice. It did not increase the size or quality and the result on the tree was detrimental rather than beneficial. Experiments were conducted with Winter Nelis, d'Anjou and Bartlett pear trees 18 years of age located on a heavy type of soil of varying depth and quality. The orchard was so divided that the poorer soils received irrigation while the better soils were given intensive cultivation but no irrigation. The results were in favor of the nonirrigated plot, showing that irrigation cannot be made to make up for poor quality of soil.

Their conclusions as to the value of irrigation on the sticky soil appear to be based on the results obtained in the orchard described in the last conclusion just quoted. It is possible that if the soil had been equally good on the two plots their conclusions as to the value of irrigation would have been reversed.

Studies on the rate of penetration of irrigation water were carried on by Hartman[4] in 1925 and McCormick[5] in 1926. Both found that in the heavy soils it was difficult to secure proper penetration of irrigation water into the deeper subsoil by the methods of irrigation in common use. In neither case did the investigations include records of either the yield or the growth of fruit. McCormick noted in respect to one plot that by July 15, 30 days after the second and last irrigation, the fruit on the trees near the head ditch, which had

[4] HARTMAN, C., JR. Unpublished report of cooperative irrigation studies. U.S. Dept. Agr., Bur. Pub. Roads, and Oreg. Agr. Expt. Sta. 1925.

[5] MCCORMICK, J. B. Unpublished report of cooperative irrigation studies. U.S. Dept. Agr., Bur. Pub. Roads, and Oreg. Agr. Expt. Sta. 1926.

received the larger quantity of irrigation water, was growing much more rapidly than the fruit on trees farther from the ditch. He concluded that ". . . three 4-inch irrigations would be none too much on this soil type during such a hot, dry season as 1926." He also found that a cover crop of vetch "seemed to aid penetration and absorption of water."

## NEW IRRIGATION STUDIES

The series of irrigation studies described in this report covers the growing seasons of 1930, 1931, and 1932. It was started in the spring of 1930 under a cooperative agreement between the Bureau of Agricultural Engineering, United States Department of Agriculture, and the Oregon Agricultural Experiment Station and was carried on by them jointly during the seasons of 1930 and 1931. The Bureau of Plant Industry, United States Department of Agriculture, also was a party to the cooperative agreement in 1932.

The investigations covering the 3-year period were made in two commercial pear orchards belonging respectively to Chester Fitch and the Palmer Corporation of which David Wood is manager, the owners assisting whole-heartedly in the studies. Work in these two orchards was discontinued in the fall of 1932 and as information believed to be of material value to the pear-growing industry has been obtained it is believed desirable to report the results at this time, although more detailed studies were initiated in 1932 at the Medford Experiment Station. It is planned to carry on these studies under the triparty cooperative plan for a number of years and to publish the results from time to time.

### THE MEDFORD DISTRICT

The Medford district is situated in the upper Rogue River Valley in Jackson County, southwestern Oregon. The principal agricultural lands of the area lie on the floor of the valley of Bear Creek, a tributary of Rogue River, and on the low foothills bordering that valley.

The climate is semiarid, with a comparatively long growing season and with sunshine nearly every day during the summer months. Precipitation data for Medford for the past 4 years, with normals as reported by the United States Weather Bureau, are shown in table 1.

TABLE 1.—*Monthly and annual precipitation at Medford, Oreg., 1929–32* [1]

| Month | Normal | 1929 | 1930 | 1931 | 1932 |
|---|---|---|---|---|---|
| | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* |
| January | 2.78 | 1.47 | 2.45 | 1.39 | 2.03 |
| February | 2.42 | .24 | 1.59 | 1.06 | .26 |
| March | 1.70 | .03 | .40 | 1.16 | 2.43 |
| April | 1.25 | 1.54 | 1.00 | 1.23 | 2.44 |
| May | 1.21 | .41 | .82 | .23 | 3.05 |
| June | .73 | 2.54 | .12 | 3.49 | 1.77 |
| July | .30 | .00 | T | .00 | .04 |
| August | .24 | .00 | T | T | .12 |
| September | .52 | T | 1.56 | 1.23 | .00 |
| October | 1.34 | 1.14 | .30 | 1.74 | .70 |
| November | 2.48 | .02 | 2.17 | 3.12 | 3.64 |
| December | 3.11 | 6.45 | 1.06 | 4.21 | 2.93 |
| Annual | 18.14 | 14.74 | 11.67 | 18.86 | 19.41 |

[1] From U.S. Weather Bureau Records.

The soils of the Medford district are extremely varied, having a very wide range in texture and other characteristics. Locally the soils are grouped in three classes, designated "granite", "free", and "sticky." The "granite" soils, as the name indicates, are derived from disintegrated granite and have a coarse porous surface soil, often underlaid at depths of 2 or 3 feet with practically impervious subsoil. The "free" soils, which occur chiefly along the stream beds, are easily worked and are alluvial deposits of medium to coarse texture. The "sticky" soils are heavy clays, clay loams, silty clay loams, and clay adobes, which are but slightly pervious to water and are difficult to work. When the soil survey of this area was made in 1911 (*6*), 43 soil types were described and mapped.

A detailed survey of the orchards in the area west of Bear Creek and south of Rogue River was made in 1930. The map showing the results of this survey was compared with the soil survey map and the areas of pear orchards on the various classes of soils were determined. It was found that of the 7,360 acres of pear orchards in the area, 1,375 acres were on light soils (sands and sandy loams), 2,655 acres were on medium soils (loams and gravelly loams), and 3,330 acres were on heavy soils (clay loams, silty clay loams, clays, and clay adobes). It is estimated that two-thirds of the 4,000 acres of pear orchards not included in this survey are on heavy soils. It appears, therefore, that about one-half of the pear orchards of the valley are on heavy soils. This estimate agrees with the earlier study made by Besse, Brown, and Wilcox (*2*) which showed that in 1924 to 1927 48.7 percent of the bearing pear trees were on heavy soil.

As is usual in irrigation practice, both the heavy and the light soils of this area cause trouble in irrigation. The application of water to the soils of medium texture presents no especial difficulties. The experimental results by Hartman [6] and McCormick [7] and the experience of the orchardists indicate clearly that more difficulty is met in the irrigation of the heavy soils than with the lighter soils.

As stated above, approximately half of the acreage in pear orchards has heavy soil. A much smaller proportion has very light soil. It appears, moreover, that the orchards on the heavier soils bear more heavily than those on the light soils. Therefore, the proportion of the crop produced on the "sticky" soils is even larger than the survey figures of acreage indicate. For these reasons it was decided that the first experimental work should be done on heavy soil.

## ORCHARDS STUDIED

Two orchards were selected for cooperative investigations. In selecting these orchards the following factors were considered: (1) Availability of irrigation water, (2) uniformity of trees in the portion of the orchard available for plots, (3) willingness of the orchardist to cooperate, (4) uniformity of soil type, (5) importance of the variety of pears in the valley crop, (6) depth to the water table, and (7) typicalness and suitability of the soil type.

The Fitch orchard is located on the lower slope of the hills bordering the southeastern side of the Bear Creek Valley. The Klamath orchard, owned by the Palmer Corporation, is on the floor of the

[6] HARTMAN, C., Jr. See footnote 3.
[7] McCORMICK, J. H. See footnote 4.

valley not far from the same hills, the former about 3 miles and the latter about 1½ miles south of the city of Medford.

The Fitch orchard soil is classed (*6*) as Meyer silty clay loam. It is very sticky when wet, hard to work, and but slightly pervious to water. The trees are Bartlett pears in full bearing. The orchard has been well cared for and, as far as is known, all of that portion used in these experiments had been uniformly handled up to the beginning of these studies.

The soil of the Klamath orchard is classed (*6*) as Meyer clay adobe and is uniform throughout the area covered by the plots. This soil is similar to that of the Fitch orchard in that it is but slightly pervious, sticky when wet, and hard to work. The trees are Anjou pear trees in full bearing. This orchard also has been well and uniformly cared for in the past.

The soils of both orchards lie on somewhat disintegrated sandstone or shale from 3 to 6 feet beneath the surface. The water table is below the surface of the rock at all times, except occasionally just after a heavy irrigation, when it may rise above the rock surface for a few days.

## PLAN OF COOPERATIVE EXPERIMENTS

Experience has shown that experiments intended to determine the proper time and quantity of irrigation must be based on the moisture content actually present in the soil. Experiments based solely on different numbers of irrigations, different quantities of water applied in a fixed number of irrigations, or any combination of these two factors do not yield satisfactory results. In these studies the different irrigation treatments were based on the soil-moisture content of the upper 3 feet of soil. This depth was chosen, more or less arbitrarily, because it was thought that most of the roots would be found within that zone. Later investigations [8] have confirmed that opinion.

Definitions of certain terms used in this report, given from the standpoint of field practice and for farmers rather than for laboratory practice, are as follows:

"Field capacity" is the quantity of water retained, following plentiful precipitation or irrigation, by one or all of the upper 3 feet of soil, as designated, after the surface has been sufficiently drained to permit the taking of samples under field conditions.

This may be from 1 or 2 days for sandy loams to much longer periods for clay soils, the length of the period varying both with nature of soil and climatic conditions. It relates to the quantity of water normally stored in the soil prior to material reduction thereof by plant transpiration, but is not to be confused with the gross quantity held by the soil when saturated.

"Permanent wilting percentage" refers to the quantity of water remaining in the soil at the stage when the root hairs of the plant can no longer obtain enough moisture to prevent permanent wilting.

"Available water capacity" or "available moisture capacity" is the difference between field capacity and permanent wilting percentage, and relates to the quantity of water that the plant can normally take from the soil.

Four similar plots having 5 or 6 suitable trees in inner rows were selected in uniform orchards growing on uniform soil. Soil moisture was to be maintained at high, medium, and low states in three of the

[8] ALDRICH, W. W., WORK, R. A., and LEWIS, M. R. PEAR ROOT CONCENTRATION IN RELATION TO SOIL MOISTURE EXTRACTION IN HEAVY CLAY SOIL. Unpublished manuscript.

plots, and the fourth plot was to be treated as in general commercial practice. It has been shown by Veihmeyer and Hendrickson (7) that it is impossible to maintain the moisture in the root zone of growing crops at any definite moisture content below the field capacity and above the permanent wilting percentage. The plan adopted called for permitting a definite portion of the available soil moisture—that held between the field capacity and the permanent wilting percentage—to be withdrawn from the soil of each plot before applying water. At each irrigation a measured quantity of water, calculated to be sufficient to bring the moisture content of the whole soil mass up to the field capacity was applied. On plot E the limit below which the moisture content was not allowed to drop was 80 percent of the available moisture capacity; on plot D, 50 percent, and on plot B, 20 percent. Plot C, the check plot, was irrigated at the same time and with the same quantity of water as the owner used on the portion of the orchard not included in the experiments. Since the permanent wilting percentage of these soils was not known when these experiments were initiated it was assumed to be one-half of the field capacity.

The crop from each plot was harvested separately and records were kept of the quantities of the different sizes. Samples of fruit from each plot were examined for dessert quality at the time of picking, and other samples were stored for different periods and the storage and dessert qualities were determined.

## PLOT LAYOUT

It was realized that duplication of plots would be desirable. However, funds and personnel have been distinctly limited throughout these studies and the plan adopted with single, fairly large plots has certain advantages. The labor involved in measuring and applying irrigation water was reduced to a minimum, it was possible to sample the soil intensively, and, perhaps most important of all, the area required for the experimental work was small enough to assure reasonable uniformity of trees and soil and not unduly burden the cooperating orchardists. Since there appeared to be some danger that horizontal percolation of irrigation water and distribution of the roots of individual trees would permit the irrigation treatment applied to one row of trees to affect trees in more than one adjoining row it was thought desirable to provide double guard rows between plots, where feasible. Subsequent experience confirmed that opinion. Figure 1 shows the arrangement of the plots in the two orchards. The locations of the record trees (those from which yield and other records were obtained), the soil sample holes, the irrigation flumes, and the direction of the slope of the land and of the irrigation furrows, are shown on this figure.

## SOIL MOISTURE

As was the case in determining the number of plots to be used, financial limitations precluded the use of either as many samples for each determination of the moisture content of the soil of a plot or as frequent sampling as seemed desirable. The plan adopted was to sample each plot before and after each irrigation and at intervals of 1 to 2 weeks at other times. Five holes were used in each plot for each determination. These holes were so located that all parts of the root zones of the individual trees and all parts of the plot were represented. Samples were taken in 1-foot increments with the King soil tube.

During 1930 and 1931 the moisture content was determined separately for each foot of each hole. During the 1932 season the corresponding foot samples for all five holes in each plot were placed in a single large can and the moisture content of the composite sample determined. Moisture-content determinations were made by weighing and drying the whole sample as it came from the field. Samples were dried for approximately 48 hours at 110° C., a number of trials having shown that drying for that length of time resulted in constant weight. Samples were taken to bedrock in all cases.

Large samples for use in determining permanent wilting percentages of the soil were secured with a post-hole auger at each sampling point. These constants were determined separately on each foot of soil from

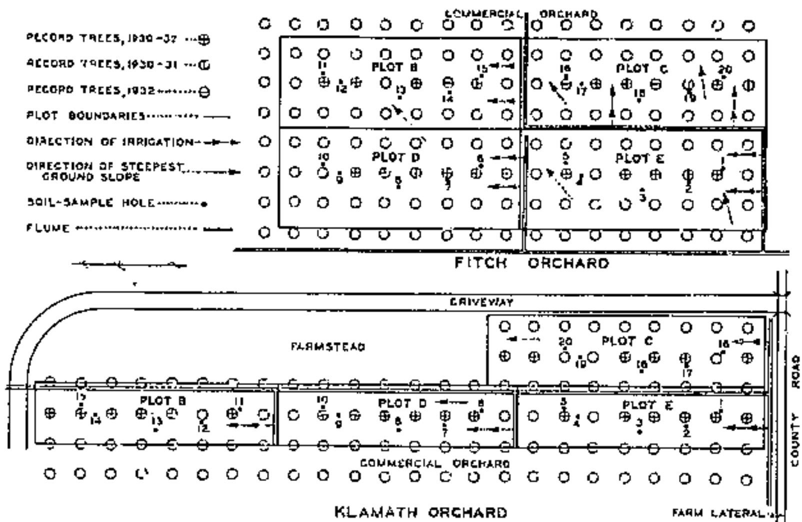


FIGURE 1.—Experimental plots in Fitch and Klamath orchards.

each hole. By making both moisture content and soil moisture constant determinations separately for the individual samples, a better picture of the variation in conditions throughout the plots is secured.

## IRRIGATION

Irrigation water for the Fitch orchard is secured from the Talent Irrigation District. The Medford Irrigation District serves the Klamath orchard. Irrigation water was available for these experiments throughout each season except during the late summer of 1931, when no water was available for the Fitch orchard after July 1 and none for the Klamath orchard after the middle of July.

Water was applied in both orchards by the furrow method. All water applied was measured either by means of adjustable miner's-inch boxes under a constant head of 4 inches or over a 90° triangular notch weir. No surface waste was permitted from the plots except in one or two instances when small quantities of water escaped by accident.

### CROP PRODUCTION

The fruit from each record tree was picked separately (data not presented) and the yield in lug boxes was recorded. The fruit from all of the record trees of each plot was then combined in one lot and run through grading machines in the packing houses. A record was kept of the number of pounds of each commercial size of fruit from each plot, as well as of the weight of culls.

Samples of the fruit from each plot were saved for study of the dessert and keeping quality of the fruit each season.

### TREE RESPONSES

In February 1932 the junior writer became actively associated in these studies, and during the 1932 season it was possible to make additional observations of the responses of the trees to different conditions of soil moisture. These studies have included the measurement of the circumference of 15 pears on each of three trees in each plot at semiweekly intervals from the time the pears were large enough to measure almost to picking time. The same pears were measured every time.

The lengths of spur and shoot growth for the seasons of 1931 and 1932 were determined by measuring 50 to 100 typical spurs and shoots on each of three trees in each plot in March and November.

Bloom and set of blossom data for 1929, 1930, and 1931 were obtained during March 1932 by a careful examination of 120 spurs on each of five trees in each plot. Data for 1932 were obtained from actual count of growing points, blossoms, and fruits on three small limbs on each of five trees in each plot.

## DATA AND DISCUSSION

It has seemed desirable to follow the presentation of each section of the data by its discussion, rather than to present the whole mass of data and follow that with a discussion of all of it. Certain types of data applicable to all three seasons are presented apart from the discussion for each year.

### SOIL-MOISTURE CONSTANTS

The values of the field capacity, permanent wilting percentage, and available water capacity for the soil of these plots are shown in table 2. The ratios between these constants and a discussion of their determination and meaning are given by Work and Lewis.[9]

TABLE 2.—*Field capacity, permanent wilting percentage, and available water capacity of the soil at different depths on each plot of the Fitch and Klamath orchards*

| Plot | 0-1 foot depth | | | 1-2 foot depth | | |
|---|---|---|---|---|---|---|
| | Field capacity | Permanent wilting percentage | Available water capacity | Field capacity | Permanent wilting percentage | Available water capacity |
| Fitch orchard: | | | | | | |
| E | 25.0±0.00 | 13.8±0.20 | 11.2 | 26.3±0.16 | 14.7±0.17 | 11.6 |
| D | 25.2± .23 | 12.9± .20 | 12.3 | 27.2± .15 | 16.7± .23 | 11.5 |
| B | 24.8± .14 | 13.2± .10 | 11.6 | 28.6± .14 | 16.3± .16 | 12.3 |
| C | 26.8± .20 | 16.3± .20 | 10.5 | 27.5± .14 | 15.9± .18 | 11.6 |
| Klamath orchard: | | | | | | |
| E | 29.7± .14 | 16.0± .23 | 13.7 | 28.7± .04 | 17.0± .25 | 11.7 |
| D | 29.9± .10 | 16.8± .22 | 13.1 | 28.0± .06 | 17.1± .19 | 10.9 |
| B | 27.0± .24 | 15.6± .23 | 11.4 | 27.1± .13 | 17.7± .10 | 9.3 |
| C | 28.2± .27 | 14.7± .10 | 13.5 | 28.2± .09 | 16.9± .25 | 11.3 |

[9] WORK, R. A., and LEWIS, M. R. MOISTURE EQUIVALENT, FIELD CAPACITY AND WILTING POINT AND THEIR RATIOS IN A HEAVY SOIL. Unpublished work.

TABLE 2.—*Field capacity, permanent wilting percentage, and available water capacity of the soil at different depths on each plot of the Fitch and Klamath orchards*—Con.

| Plot | 2-3 feet depth | | | 0-3 feet depth | | |
|---|---|---|---|---|---|---|
| | Field capacity | Permanent wilting percentage | Available water capacity | Field capacity | Permanent wilting percentage | Available water capacity |
| Fitch orchard: | | | | | | |
| E | 28.6±0.18 | 17.1±0.40 | 11.5 | 26.6±0.09 | 15.2±0.16 | 11.4 |
| D | 28.2± .21 | 17.2± .30 | 11.0 | 26.9± .12 | 15.3± .14 | 11.6 |
| B | 27.5± .24 | 17.5± .21 | 10.0 | 27.0± .10 | 15.7± .11 | 11.3 |
| C | 29.6± .12 | 17.8± .21 | 11.8 | 27.0± .09 | 15.7± .11 | 11.3 |
| Klamath orchard: | | | | | | |
| E | 27.4± .12 | 16.9± .17 | 10.5 | 28.6± .06 | 16.6± .12 | 12.0 |
| D | 26.6± .20 | 18.0± .27 | 8.6 | 28.2± .11 | 17.3± .13 | 10.9 |
| B | 26.1± .13 | 15.3± .28 | 10.8 | 26.7± .10 | 16.2± .14 | 10.5 |
| C | 29.0± .11 | 16.6± .20 | 12.4 | 28.5± .11 | 16.1± .11 | 12.4 |

These data indicate that in the two orchards the average capacity for moisture in available form in the upper 3 feet of the soil is about the same, but that at certain depths in each orchard the available capacity may be as much as one fifth larger in one plot than it is in another. The data also show marked differences in the field capacities and permanent wilting percentages of the soil at different depths in each orchard. In the Fitch orchard both of these values increase with greater depth, while the reverse is true of the field capacity in the Klamath orchard. In the latter orchard the first foot has the highest capacity for available moisture. This variation in the field capacity and permanent wilting percentage for different depths in the soil made it necessary to adopt some method of plotting soil-moisture conditions that would permit a more direct comparison of the relative availability of moisture at different depths and between the two orchards.

The plan adopted shows the moisture content of the soil as a percentage of the available water capacity. In other words, the moisture present at the field capacity is taken as 100 percent and the moisture present at the permanent wilting percentage is taken as zero. The moisture content of the soil at any time may then be expressed as the available moisture present in terms of the percentage of the capacity of the particular soil zone to hold available moisture.

### RATE OF PENETRATION OF IRRIGATION WATER

The rate of penetration of water into this soil is very slow and this constitutes one of the difficulties in practical orchard management. It was found that the rate of penetration was as good with shallow as with deep furrows. Furthermore, in making shallow furrows fewer roots were cut and less power was required than for making deeper furrows.

In the first irrigations an attempt was made to secure uniform absorption by turning a comparatively large stream down each furrow at the beginning of the irrigation and as soon as this stream reached the end of the furrow to reduce it to the amount that would just maintain a trickle of water to the end of the furrow without causing any run-off from the lower end of the plot. This method was found to be unsatisfactory, probably because the initial large stream of water flowing in the furrow silted over the absorbing area of the furrow, and

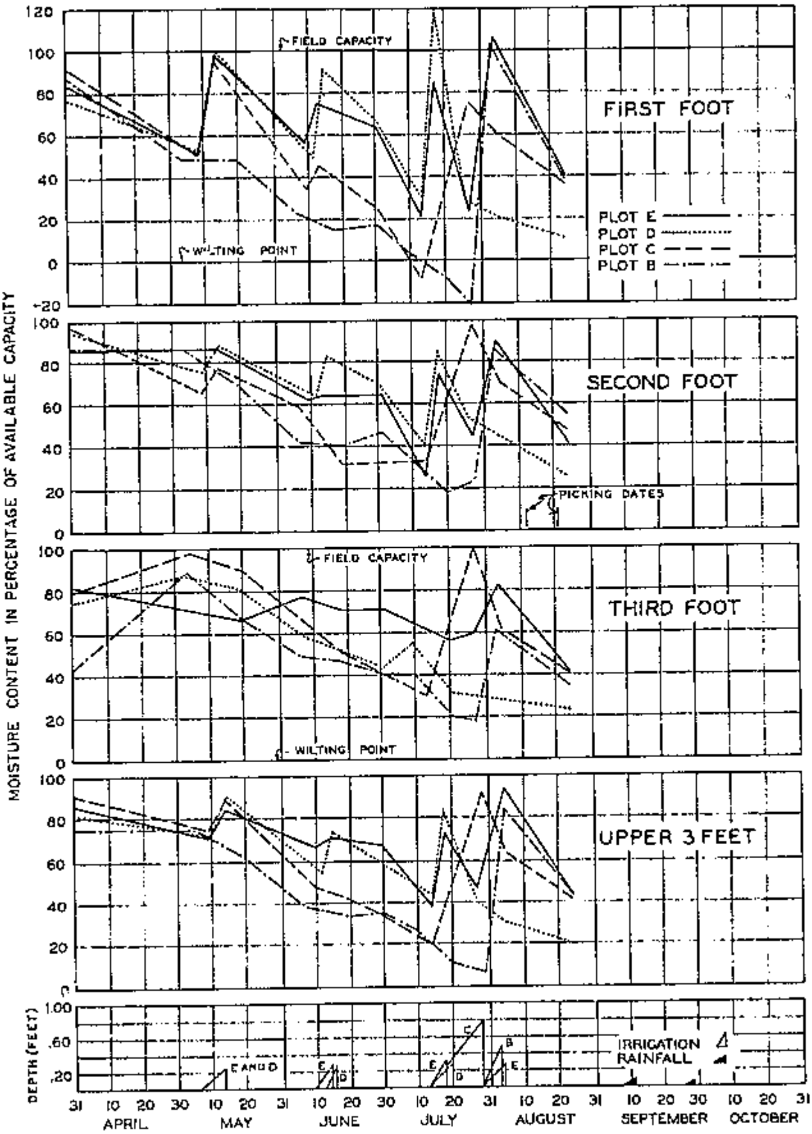


FIGURE 2.—Moisture content, expressed as a percentage of the available capacity, of each of the upper 3 feet and the average thereof, also rainfall and irrigation water applied, for the plots in the Fitch orchard in 1939. The heights of the triangles represent the depths of water applied by either irrigation or rainfall, and the bases show the periods of application.

this resulted in an even lower rate of water penetration. In later irrigation, very small streams were turned into each furrow, with the result that a longer time was required for the streams to reach the lower ends of the furrows, but in spite of that fact, it took less time to make application of a given depth of water by this method.

The extremely low degree of perviousness of this soil is illustrated by the fact that, after it became wet, a stream of 3 gallons per minute sufficed to keep a trickle for the full length of each one of the furrows in a plot containing about one third of an acre. This represents a rate of percolation of less than one half inch in 24 hours. It is probable that a large part of this amount was taken up by evaporation into the atmosphere. No attempt was made to correct the quantities of water applied in irrigation for the loss by direct evaporation.

Soil-moisture samples taken 2 to 5 days after each irrigation showed that in most cases the water applied had penetrated to the third and fourth feet. However, a number of instances when the moisture content of the fourth foot, and a few cases when that of the third foot, did not show any increase 2 to 5 days after irrigation were noted, whereas samples taken several days later did show an increase. Such results indicate that several days were required for the water to penetrate into the deeper subsoil.

### FITCH ORCHARD, 1930

The moisture content of the soil in each of the upper 3 feet in each plot in the Fitch orchard during the season of 1930 and the average of the 3 are shown in figure 2. In this figure and in figures 4 to 8 inclusive, moisture content is shown as percentage of the available capacity of the soil mass. Rainfall and irrigation water applied also are shown. The heights of the rainfall triangles indicate the total depth of rain falling during each storm period that furnished more than one half inch of rain. For irrigations the height of each triangle likewise represents the depth of water applied during that irrigation. In both cases the bases of the triangles represent the periods during which the water was applied. The dates on which the fruit was picked also are shown.

Perhaps the most striking feature shown in figure 2 is the much more rapid loss of moisture, after irrigations, in the upper foot than in the second foot, and in the second than in the third foot. While it is very probable that this difference is due in part to loss of moisture from the first foot, both upward by evaporation and downward into the lower strata, it is not likely that such losses occur to an appreciable extent after the moisture content of the upper foot has fallen materially below the field capacity. The more rapid rate of moisture loss from the first foot as compared with the rates of loss from greater depths appears to continue when the moisture content in the upper foot is approaching the permanent wilting percentage, long after an irrigation.

The differences in rates of decrease of moisture at different depths appear to result mainly from differences in root concentration. Aldrich, Work, and Lewis [10] have shown that in soil 4 to 6 feet deep about 35 percent of the roots in the top 4 feet were in the upper foot, about 25 percent in the second foot, and about 20 percent in the third foot. The loss of moisture was much less in the deeper subsoil than from the upper soil and root concentration was very low. Since most of the feeding roots seem to be in the upper 3 feet, the moisture content of only this part of the soil mass is shown on the charts and considered in correlating soil moisture with the response of the trees.

[10] ALDRICH, W. W., WORK, R. A., and LEWIS, M. R. See footnote 8.

Examination of the curves for plots B and C in figure 2 shows that the moisture content of the first foot fell below the permanent wilting percentage about July 10. In plot C this condition could have continued for only 4 or 5 days as this plot was irrigated beginning July 14. In plot B irrigation did not start until July 28 and the soil moisture in the first foot was below the permanent wilting percentage for about 2 weeks. The slope of a line representing the moisture content shows the rate at which the soil was losing water at any time, the steeper the slope the greater being the rate of loss. These curves do not indicate any slowing up in the loss of water from the first foot of soil when the moisture content approaches, and even when it falls below the permanent wilting percentage. In only a few cases has this continued rapid rate of loss been noted in these investigations.

The more usual condition found in these studies is brought out by the fact that in every case the curves of figure 2 show that before the soil moisture in the second and third feet and the average for the upper 3 feet dropped to 10 percent of the available capacity the rate of loss of moisture decreased. In most instances the break in the curves occurs at 20 or 30 percent of the available capacity. The significance of this break in the rate of withdrawal of water by the trees is that it helps to explain some of the effects of moisture content on the rate of growth of the fruit.

Table 3 shows the yield of fruit of each of the commercial sizes from each plot in the Fitch orchard in 1930.

TABLE 3.—*Yield of each size of pears from each plot in the Fitch orchard, 1930*

| Commercial size (number of pears per standard box) | Yield from plot— | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E | | D | | B | | C | |
| | First picking | Second picking | First picking | Second picking | First picking | Second picking | First picking | Second picking |
| | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| 228 | 23 | 233 | 23 | 212 | 111 | 241 | 78 | 145 |
| 210 | 65 | 220 | 45 | 213 | 102 | 192 | 117 | 173 |
| 195 | 110 | 311 | 85 | 270 | 125 | 266 | 172 | 222 |
| 180-165 | 241 | 397 | 158 | 235 | 110 | 244 | 225 | 283 |
| 150 | 101 | 221 | 45 | 81 | 36 | 101 | 68 | 128 |
| 135 | 57 | 60 | 30 | 17 | 18 | 15 | 38 | 33 |
| 120 | 8 | 23 | 7 | 6 | 3 | 4 | 5 | 12 |
| Total, each picking | 614 | 1,480 | 393 | 1,043 | 511 | 1,066 | 703 | 996 |
| Total for each plot | 2,094 | | 1,436 | | 1,577 | | 1,699 | |
| Total, 180's or larger | 1,114 | | 582 | | 537 | | 792 | |
| Percentage 180's or larger | 53.2 | | 40.5 | | 34.1 | | 46.7 | |

The important feature of these data is the very much larger yield of pears of size 180 or larger from plot E, the most heavily irrigated plot. Bartlett pears of these sizes (180 and larger) are desirable for two reasons. (1) The size of the individual pears is a major factor in the yield in that a given number of pears of size 150 will fill 30 percent more boxes than will the same number of size 195. (2) The medium sizes (135 to 165, inclusive) are usually in greater demand on the markets and therefore bring better prices.

During the 1932 season, detailed studies were made of the effect of variations in soil moisture on the rate of growth of pear fruits in the Fitch and Klamath orchards and also in the Medford Experiment Station orchard. These investigations are reported in greater detail elsewhere (*1*).[11] The results for 1932 show that as the season progressed the fruit grew more rapidly, with the most rapid growth occurring during the latter part of July for the Bartletts and during August for the Anjous. The Bartletts appeared to slow up slightly just before harvest.

Comparison of the rate of growth with the average moisture content for the upper 3 feet of soil showed that as the moisture content dropped the rate of growth also dropped. This is well shown by the two curves of figure 3 which indicate the rate of growth of fruit on plots E and B of the Klamath orchard in 1932. Reference to figure 8 will show that the soil moisture in plot B was not much below that in plot E before the middle of June, but that from then until July 23 plot B was much the drier of the two. During this period the rate of growth of the fruit on plot B was much slower than on plot E. Between July 23 and 25 plot B was irrigated and for about a week thereafter had as

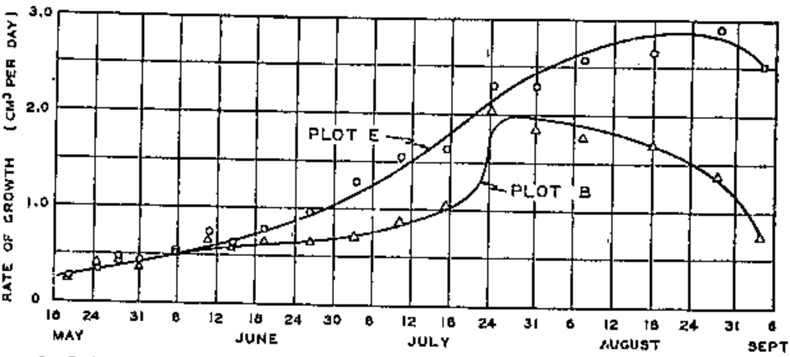


FIGURE 3.—Rate of growth of pears on plots E and B in the Klamath orchard in 1932, measured in cubic centimeters.

much moisture as did plot E. As a result the rate of growth on plot B was twice as great on July 25 as on July 18 and was nearly as rapid as it was on plot E. For the remainder of the season both moisture content and rate of growth fell off rapidly.

The data shown in figure 3 are somewhat typical of the results obtained on all three orchards. Since the rate of growth of pears is low in midseason as compared with late season, even when there is ample moisture in the soil, the effect of soil moisture on growth in the latter part of the season is relatively more important than it is in midseason.

The total yield in 1930 (table 3) was largest on plot E, the plot having the highest average moisture content during the season. There was very little difference in the yields of the other plots. One heavy irrigation was applied to plot C which seemed effective in increasing the size of fruit, hence plot C ranked second in the production of size 180 and larger.

At the time the plots in this orchard were selected it was thought that the size of the trees in the four plots was nearly the same. However, the fact that the yield of pears from plot D was smaller than the

[11] LEWIS, M. R., WORK, R. A., and ALDRICH, W. W. THE INFLUENCE OF DIFFERENT QUANTITIES OF MOISTURE IN A HEAVY SOIL ON THE RATE OF GROWTH OF PEARS. Unpublished report.

yield from any of the other plots, while the moisture content was intermediate between that of plot E on the one side and plot B on the other, led to a search for an explanation. An estimate of the top volume of the record trees in these plots was made by photographing each tree from two points so chosen that the lines of sight from the camera to the tree made angles of 90° at the tree. All photographs were made at the same distance from the trees. The total volumes of the tops of the five record trees in each plot as estimated from these photographs were as follows: Plot E, 1,904 cubic feet; plot D, 1,744 cubic feet; plot B, 1,983 cubic feet; and plot C, 1,848 cubic feet. Thus plot D had the smallest volume of top and this may explain the relatively low yield from this plot.

### KLAMATH ORCHARD, 1930

Figure 4 shows the moisture data for the Klamath orchard plots during 1930. Here again the loss of moisture was most rapid in the upper foot of soil, with a progressive decrease in the rate at greater depths, but the differences were not so pronounced as in the Fitch orchard. The curves of this figure clearly show the higher available soil moisture in plot E compared with plot D, and in plot D compared with plots B and C. The higher available soil moisture in plot B compared with plot C is not so readily apparent upon inspection of the figure. Application of the method described in another article [12] is necessary to properly weigh the differences in soil-moisture contents between the two latter plots. Application of that method shows that plot B had the higher available moisture content at the time most favorable to rapid growth of fruit.

The yields of each size of fruit from the plots in the Klamath orchard for 1930 are shown in table 4. In this orchard, as in the Fitch orchard, the yield of pears of the larger and more desirable sizes was much greater on the plots having the higher moisture content throughout the season.

In this case the total yield from the plots is also clearly related to the soil-moisture content during the growing season. The marked effect of a low-moisture content during mid or late season is shown by comparison of the yield and size of the fruit from these plots with the associated soil-moisture content.

The total yield of plot E was about 300 pounds greater, and the yield of pears of size 165 and larger was about 350 pounds greater than that of plot D. This seems clearly related to the fact that in plot D the moisture content, as shown on figure 4, was lower than in plot E from about the middle of August until picking time. Plot B had about the same moisture content as plot D in the late summer, but was much drier during most of July, and the total yield of plot B was much smaller then, and the yield of the more desirable sizes was only half as great as the corresponding yields of plot D. Plot C was the driest of all the plots after about July 25, but had more moisture than plot B during most of July. The total yield on plot C was somewhat larger than that on plot B, but much smaller than on plots E or D. The higher moisture content of the soil of plot B as compared with that of plot C after July 25 may have been responsible for the slightly larger yield of medium-size fruit on the former plot.

[12] See footnote 1.

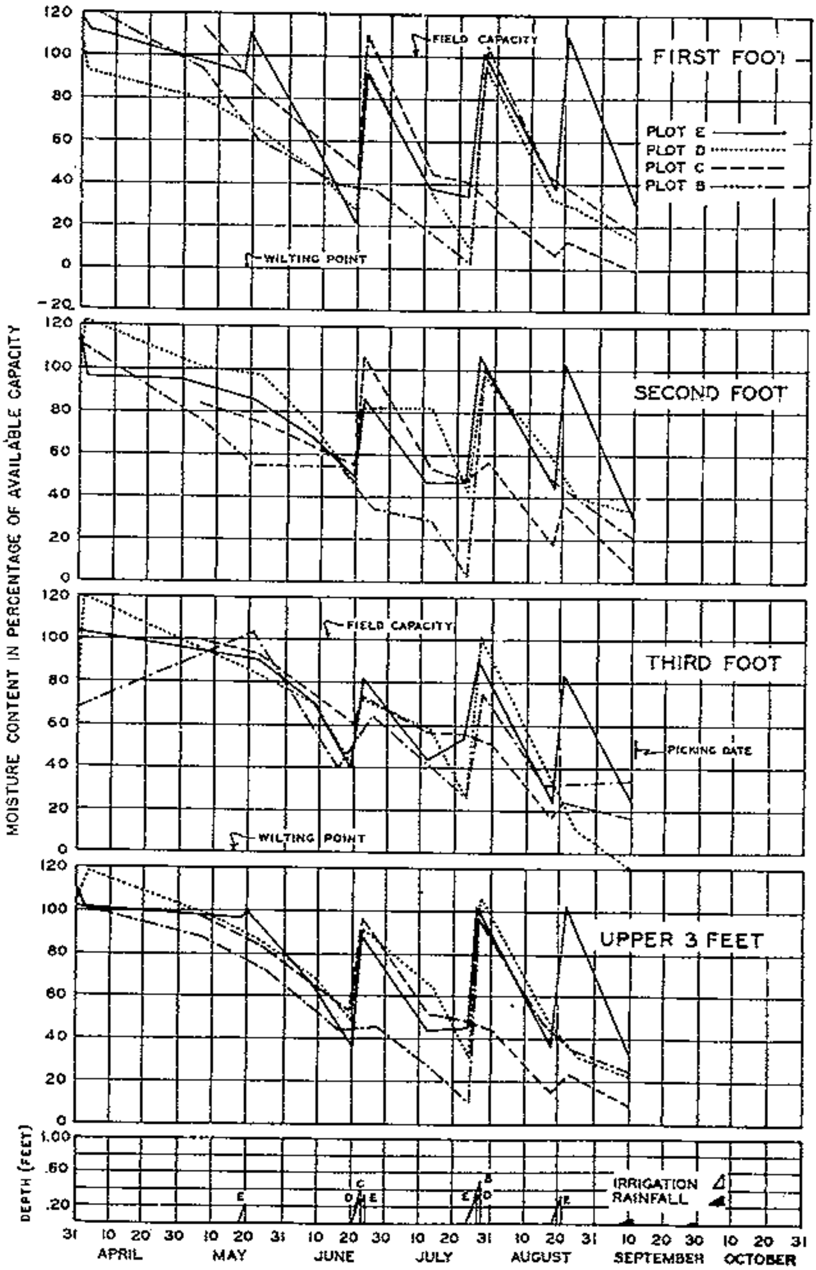


FIGURE 4.—Moisture content, expressed as a percentage of the available capacity, of each of the upper 3 feet and the average thereof, also rainfall and irrigation water applied, for the plots in the Klamath orchard in 1930. The heights of the triangles represent the depths of water applied by either irrigation or rainfall, and the bases show the period of application.

TABLE 4.—*Yield of each size of pears from each plot in the Klamath orchard, 1930*

| Commercial size (number of pears per standard box) | Yield from plot— | | | |
|---|---|---|---|---|
| | E | D | B | C |
| | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| 195 and smaller | 186 | 230 | 301 | 500 |
| 180 | 75 | 87 | 70 | 109 |
| 165 | 226 | 231 | 194 | 204 |
| 150 | 164 | 177 | 109 | 103 |
| 135 | 406 | 423 | 191 | 148 |
| 120 | 229 | 146 | 48 | 38 |
| 110 | 161 | 104 | 20 | 10 |
| 100 | 168 | 65 | 8 | 6 |
| 90 and larger | 86 | 15 | 0 | 0 |
| Total | 1,775 | 1,487 | 1,040 | 1,178 |
| Total 165's and larger | 1,514 | 1,161 | 570 | 509 |
| Percentage of 165's and larger | 85.3 | 78.1 | 54.8 | 43.2 |

FITCH ORCHARD, 1931

The moisture content of the soil of each of the plots in the Fitch orchard during 1931 is shown in figure 5. During that season there was a serious shortage of irrigation water in the Rogue River Valley and no irrigation water was available for these plots after June 25. As a result the moisture content in all the plots decreased after that date until the winter rains came. By August 5 all plots had reached about the same moisture content, with an average of 20 percent of the available capacity in the upper 3 feet. With low rainfall during the preceding winter and spring, the moisture in all of the plots was comparatively low in the early part of the season.

Table 5 gives the yield data for the Fitch plots for 1931.

TABLE 5.—*Yield of each size of pears from each plot in the Fitch orchard, 1931*

| Commercial size (number of pears per standard box) | Yield from plot— | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E | | D | | B | | C | |
| | First picking | Second picking | First picking | Second picking | First picking | Second picking | First picking | Second picking |
| | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| 195 and smaller | 10.9 | 4.5 | 21.4 | 15.8 | 21.8 | 24.3 | 38.0 | 29.4 |
| 180 | 24.9 | 24.8 | 35.4 | 46.3 | 30.5 | 125.6 | 58.0 | 146.7 |
| 165 | 240.5 | 111.6 | 187.2 | 91.8 | 248.9 | 310.8 | 199.5 | 176.1 |
| 150 | 118.7 | 12.4 | 77.8 | 11.9 | 75.3 | 69.7 | 71.6 | 79.3 |
| 135 | 170.1 | 2.0 | 58.3 | 6.0 | 58.8 | 13.4 | 100.2 | 12.9 |
| 120 | 250.1 | 23.9 | 71.7 | 23.4 | 39.9 | 4.5 | 48.8 | 17.0 |
| 110 and larger | 71.8 | 1.5 | 7.9 | .0 | 1.5 | .0 | 5.4 | .0 |
| Total for each picking | 887.3 | 180.7 | 450.7 | 195.2 | 476.7 | 518.3 | 523.6 | 462.3 |
| Total for both pickings | 1,068.0 | | 651.9 | | 1,025.0 | | 985.9 | |
| Total 165's and larger | 1,003.0 | | 536.0 | | 822.8 | | 712.9 | |
| Percentage of 165's and larger | 91.0 | | 82.0 | | 80.0 | | 72.3 | |

The total yield of all the plots was much smaller in 1931 than in 1930, but the pears were larger. The fruit of all the plots was heavily thinned in an effort to secure large sizes in spite of the water shortage that was anticipated at the beginning of the season. As in 1930, the total yield and more especially the proportion of pears of the larger sizes was greatest on plot E, which had the highest soil-moisture content throughout the season. The yield from plot D was the lowest. As previously pointed out, this was probably due in part to the smaller size of the trees in this plot. It is known that the moisture content of the soil of this plot was low during the preceding fall, winter, and spring, and this condition may have been partially responsible for the poor yield.

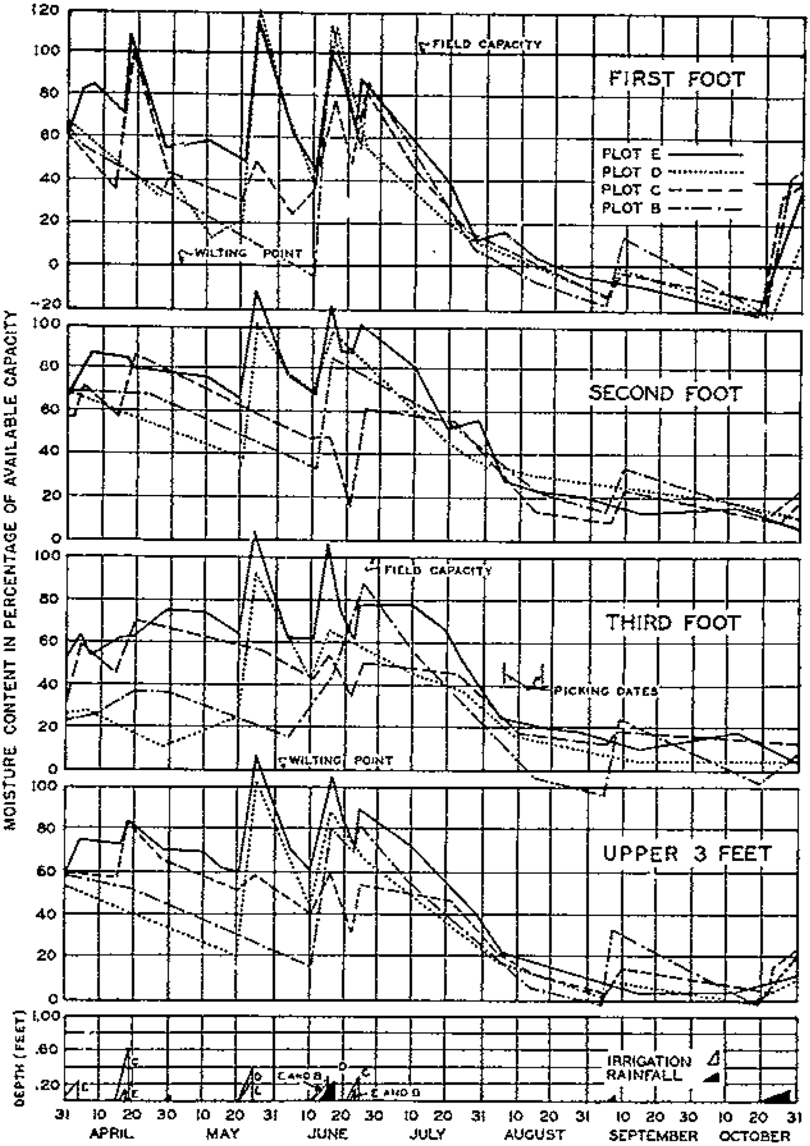


FIGURE 5.—Moisture content, expressed as a percentage of the available capacity, of each of the upper 3 feet and the average thereof, also rainfall and irrigation water applied, for the plots in the Fitch orchard in 1931. The heights of the triangles represent the depths of water applied by either irrigation or rainfall, and the bases show the period of application.

Almost one-third of the pears on plot E were 120's or larger, too large to bring the best price. It seems probable that somewhat less thinning in that plot would have resulted in a greater yield of the more desirable sizes.

### KLAMATH ORCHARD, 1931

Figure 6 shows the soil moisture in the Klamath orchard during the 1931 season. At this orchard no irrigation water was available after July 15, and as a result the moisture content of all plots decreased after that date, reaching the permanent wilting percentage in September and October. As was the case with the Fitch orchard, the low rainfall during the winter of 1930–31 did not bring the soil moisture up to field capacity and all plots were comparatively dry up to the time they were irrigated.

The soil moisture in plots E and D was above 50 percent of the available water capacity during all of July, while on plots C and B it was below that amount during the last half of the month except in the second foot. Plot B was irrigated only once during the season and had less than 60 percent of the available capacity of soil moisture throughout the season except for the period from June 20 to July 13. The curves of this figure show very clearly the marked slowing up of the rate of moisture withdrawal from these plots when the moisture content in the upper 3 feet was from 20 to 40 percent of the available capacity.

The yields of fruit of the different sizes are shown in table 6. In spite of the fact that irrigation water was not available after July 15 and as a result the moisture content of all the plots fell rapidly after that date, the yield of fruit from the different plots was closely related to the soil-moisture content during the earlier part of the season. In plots E and D two-thirds of the pears were 165's or larger, while on the other two plots only about one-sixth of the fruit was of those sizes. This result appears to be due to the large difference in moisture content during the latter part of July and the smaller difference during August. The greater yield of fruit from plot E than from plot D was in part because of the larger fruit[13] in plot E and in part because of the larger number of pears per tree. The trees in these plots were not thinned during the year.

TABLE 6.—*Yield of each size of pears from each plot in the Klamath orchard, 1931*

| Commercial size (number of pears per standard box) | Yield from plot— | | | |
|---|---|---|---|---|
| | E | D | B | C |
| | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| 228 | 35.6 | 34.6 | 120.4 | 168.6 |
| 210 | 55.2 | 31.0 | 74.2 | 110.8 |
| 195 | 83.2 | 69.2 | 89.2 | 116.4 |
| 180 | 216.6 | 195.6 | 96.3 | 183.6 |
| 165 | 123.4 | 106.8 | 38.0 | 54.6 |
| 150 | 181.8 | 167.3 | 15.0 | 54.6 |
| 135 | 207.6 | 178.6 | 10.0 | 21.6 |
| 120 | 107.8 | 83.8 | 1.0 | 5.0 |
| 110 | 95.8 | 40.6 | .0 | .0 |
| 100 | 54.2 | 10.0 | .0 | .0 |
| 90 and larger | 35.6 | 6.0 | .0 | .0 |
| Total | 1,196.8 | 924.1 | 444.1 | 745.2 |
| Total 165's and larger | 806.2 | 593.1 | 64.0 | 135.8 |
| Percentage of 165's and larger | 67.3 | 64.2 | 14.4 | 18.5 |

### FITCH ORCHARD, 1932

The soil-moisture conditions in the Fitch orchard during the 1932 season are shown in figure 7. The quantity of soil moisture in the different plots during the season did not vary as much as was planned, nor as it did in other years. The most marked difference was in

[13] See footnote 11.

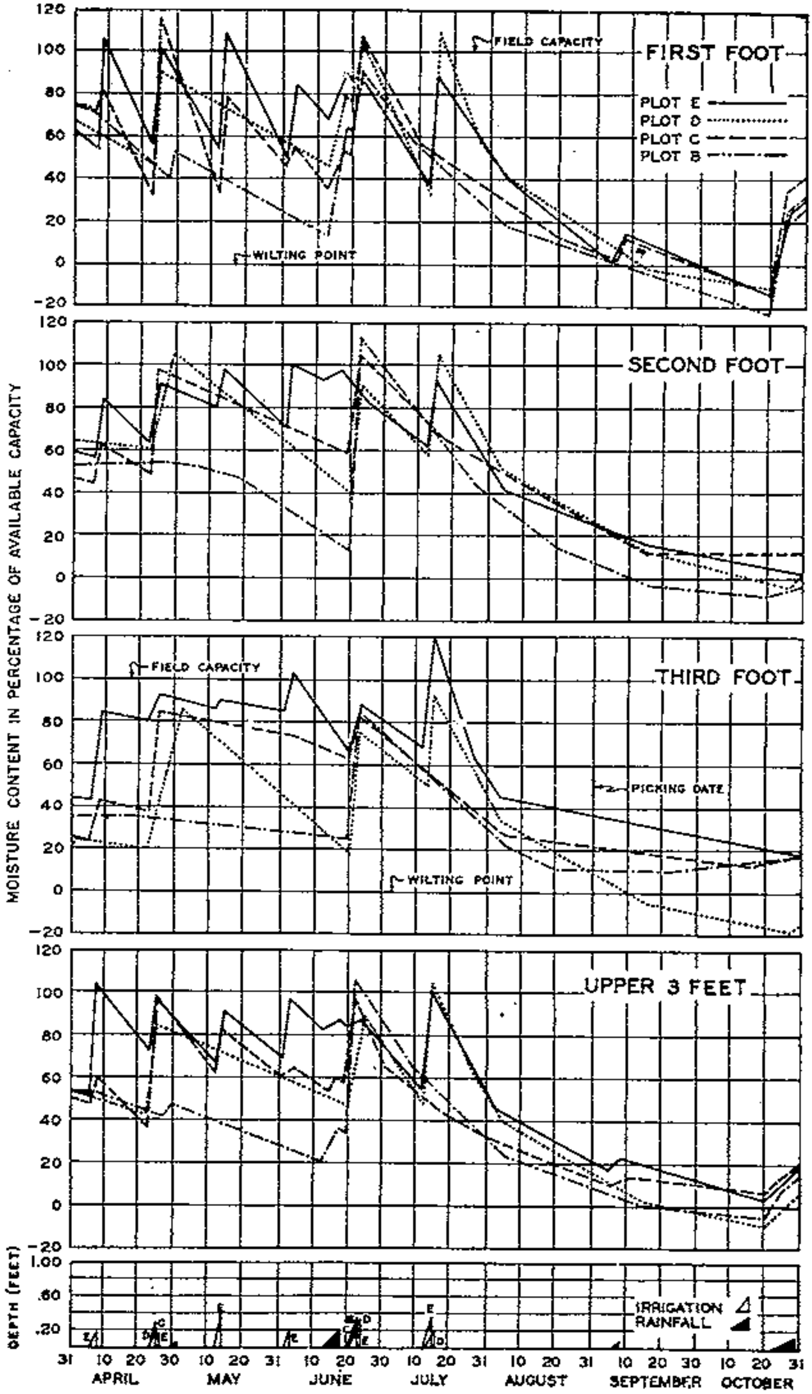


FIGURE 8.—Moisture content, expressed as a percentage of the available capacity, of each of the upper 3 feet and the average thereof, also rainfall and irrigation water applied, for the plots in the Klamath orchard in 1931. The heights of the triangles represent the depths of water applied by either irrigation or rainfall, and the bases show the periods of application.

the low soil moisture content of plot B during the period July 5 to 23. Plot D was materially drier than plot E during the period June 20 to July 5 and a little drier during the period July 5 to 25.

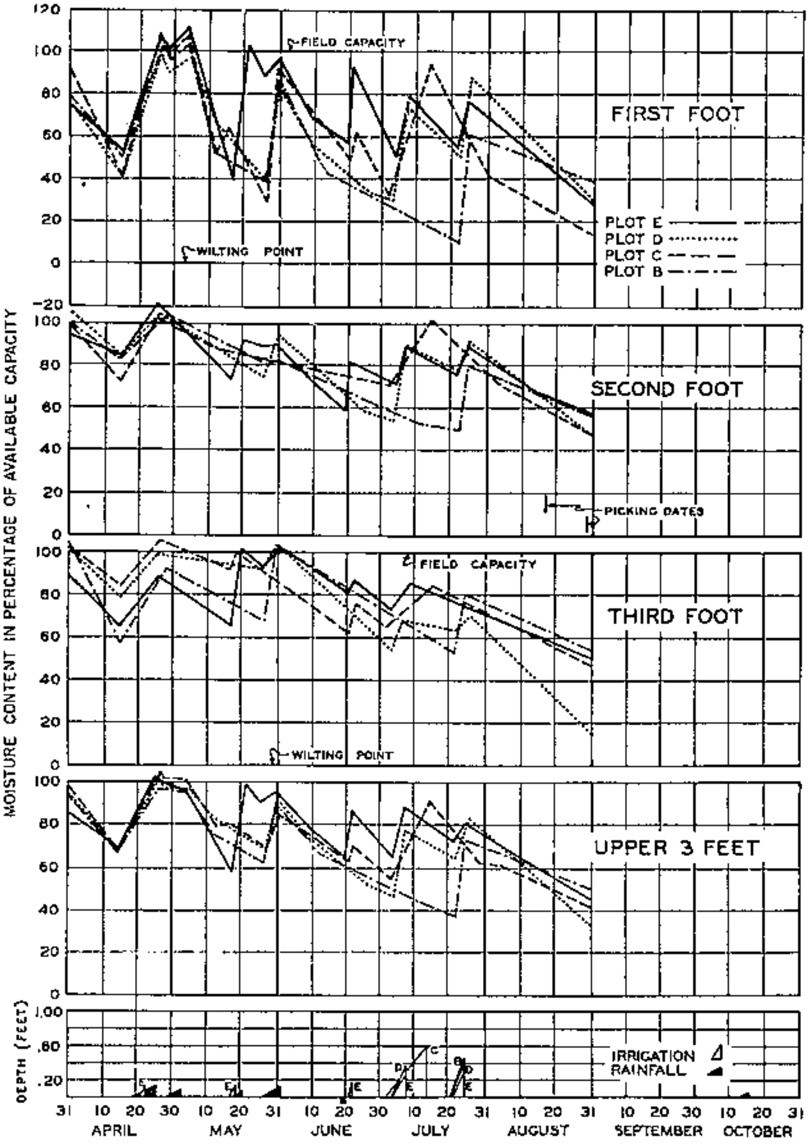


FIGURE 7.—Moisture content, expressed as a percentage of the available capacity, of each of the upper 3 feet and the average thereof, also rainfall and irrigation water applied, for the plots in the Fitch orchard in 1932. The heights of the triangles represent the depths of water applied by either irrigation or rainfall, and the bases show the periods of application.

Comparison of the moisture content of plot B during 1930 and 1931 with that during 1932 typifies the marked effect of both winter and summer rains on the moisture content of the soil in these plots. In mid-April 1930 the moisture content of the upper 3 feet in this plot was 75 percent, and at the same date in 1932, 65 percent, yet in 1930, with no rainfall, the moisture content had dropped to 9 percent by July 23, while in 1932, with rain in late April and May, the content was still up to 38 percent at the corresponding date. During the winter of 1930–31 the highest moisture content reached by this plot was 72 percent of the available water capacity, while in the spring of 1932 the soil moisture was up to its field capacity. There was very little rain in the spring and early summer of 1931 and as a result the moisture content of this plot dropped to 16 percent on June 11 when the first irrigation commenced. For plot C the high moisture content in the spring of 1932 and the rains during April, May, and June made it possible to keep the moisture content above 55 percent of the available capacity in the upper 3 feet throughout the growing season with one heavy irrigation applied in mid-July.

The yields and sizes of fruit from the different plots of the Fitch orchard in 1932 are shown in table 7. The comparatively small differences in the soil-moisture conditions and the relatively high moisture content in these plots during the 1932 season are reflected in the relatively uniform total yield of the plots and the uniformly high percentage of fruit of the larger sizes. As in the two earlier years, plot E had the highest yield as well as the highest moisture content. By computation from the data in table 7 it is found that the number of pears harvested from plot D was larger than the number harvested from any other plot. This fact, taken in connection with the smaller size of the trees on plot D, probably accounts for the smaller size of the fruit from plot D than from plot B in spite of the lower soil moisture in the latter plot during the greater part of July. Periodic measurement of the fruit on these plots showed that until August 11 (about 1 week before the first picking) the fruit on plot C was larger than that on either plot B or plot D. This is in accord with the higher soil-moisture content in plot C up to that time. After August 11 the fruit on plot B seemed to have grown faster, with the result that the yield and fruit size for plot B was greater than for plots C or D. This may be attributed, at least in part, to the higher moisture content in plot B during the last half of August.

TABLE 7.—*Yield of each size of pears from each plot in the Fitch orchard, 1932*

| Commercial size (number of pears per standard box) | Yield from plot— E | | D | | B | | C | |
|---|---|---|---|---|---|---|---|---|
| | First picking | Second picking | First picking | Second picking | First picking | Second picking | First picking | Second picking |
| | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| 195 and smaller | 15 | 32 | 21 | 245 | 6 | 100 | 1 | 191 |
| 180 | 103 | 17 | 78 | 105 | 47 | 85 | 37 | 82 |
| 165 | 229 | 64 | 107 | 240 | 183 | 147 | 130 | 215 |
| 150 | 414 | 93 | 178 | 228 | 249 | 245 | 192 | 258 |
| 135 | 133 | 223 | 69 | 138 | 105 | 210 | 81 | 200 |
| 120 | 234 | 57 | 49 | 30 | 102 | 59 | 65 | 53 |
| 110 and larger | 18 | 66 | 1 | 19 | 1 | 20 | 1 | 21 |
| Total each picking | 1,146 | 552 | 503 | 1,011 | 693 | 887 | 507 | 1,020 |
| Total for each plot | 1,698 | | 1,574 | | 1,580 | | 1,527 | |
| Total 165's and larger | 1,531 | | 1,125 | | 1,336 | | 1,210 | |
| Percentage of 165's and larger | 90.2 | | 71.5 | | 84.6 | | 79.6 | |

### KLAMATH ORCHARD, 1932

Figure 8 shows the soil-moisture conditions which obtained in the plots of the Klamath orchard during the 1932 season. Moisture conditions in these plots during this season followed quite closely the prearranged plan.

Table 8 shows the yield of the different sizes of fruit from the Klamath plots in 1932. Perhaps the most striking feature in this tabulation is the close similarity of the percentages of fruit of the larger sizes in plots E, D, and C. While the percentages of 165's and larger in plots E and D are the same, there were more of the very large sizes in plot E and therefore the average size for the plot was larger.

The yields from plots E, D, and B appear to be very closely correlated with the moisture conditions in the plots. The fact that plot C matured only two-thirds as many pears as each of the other plots accounts for the larger size of the fruits on that plot as compared with what might have been expected from the moisture conditions in the different plots.

TABLE 8.—*Yield of each size of pear from each plot in the Klamath orchard, 1932*

| Commercial size (number of pears per standard box) | Yield from plot— | | | |
|---|---|---|---|---|
| | E | D | B | C |
| | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| 210 | 14.5 | 15.0 | 129.5 | 13.0 |
| 195 | 16.5 | 11.0 | 110.0 | 13.0 |
| 180 | 35.0 | 34.0 | 100.6 | 24.0 |
| 165 | 136.5 | 201.5 | 355.5 | 100.0 |
| 150 | 122.5 | 166.0 | 140.0 | 84.0 |
| 135 | 205.5 | 265.5 | 105.0 | 161.0 |
| 120 | 275.0 | 282.0 | 54.0 | 119.5 |
| 110 | 219.0 | 181.0 | 18.5 | 235.5 |
| 100 | 328.0 | 200.5 | 18.0 | 187.5 |
| 90 | 150.0 | 75.0 | 4.5 | 88.0 |
| 80 and larger | 151.5 | 50.0 | 0.0 | 39.5 |
| Total | 1,654.0 | 1,481.5 | 1,041.6 | 1,071.0 |
| Total 165's and larger | 1,598.0 | 1,421.5 | 695.5 | 1,021.0 |
| Percentage of 165's and larger | 96.0 | 95.9 | 66.8 | 95.4 |

### FRUIT GROWTH AND CROP YIELD

The results of the 3 years' experiments on the two orchards are consistent in showing that a high soil-moisture content throughout the season, more particularly during July and August, results in relatively rapid growth of the fruit. As a result the proportion of fruit of the larger sizes was uniformly higher on the more heavily irrigated plots. In the Klamath orchard, where the fruit was not thinned, the total yield of fruit also was greatest on the plots having the highest soil-moisture content. On the Fitch plots the thinning of the fruit, the smaller trees in plot D, and the variability of the yield of the different trees in each plot served to obscure the effect of soil moisture on total yield. Under the conditions that prevailed in connection with the Fitch-orchard experiments there seems to be sufficient reason for the belief that on heavily irrigated plots lighter thinning than that actually done would result in larger yields of Bartlett pears of the more desirable sizes, all other things being equal.

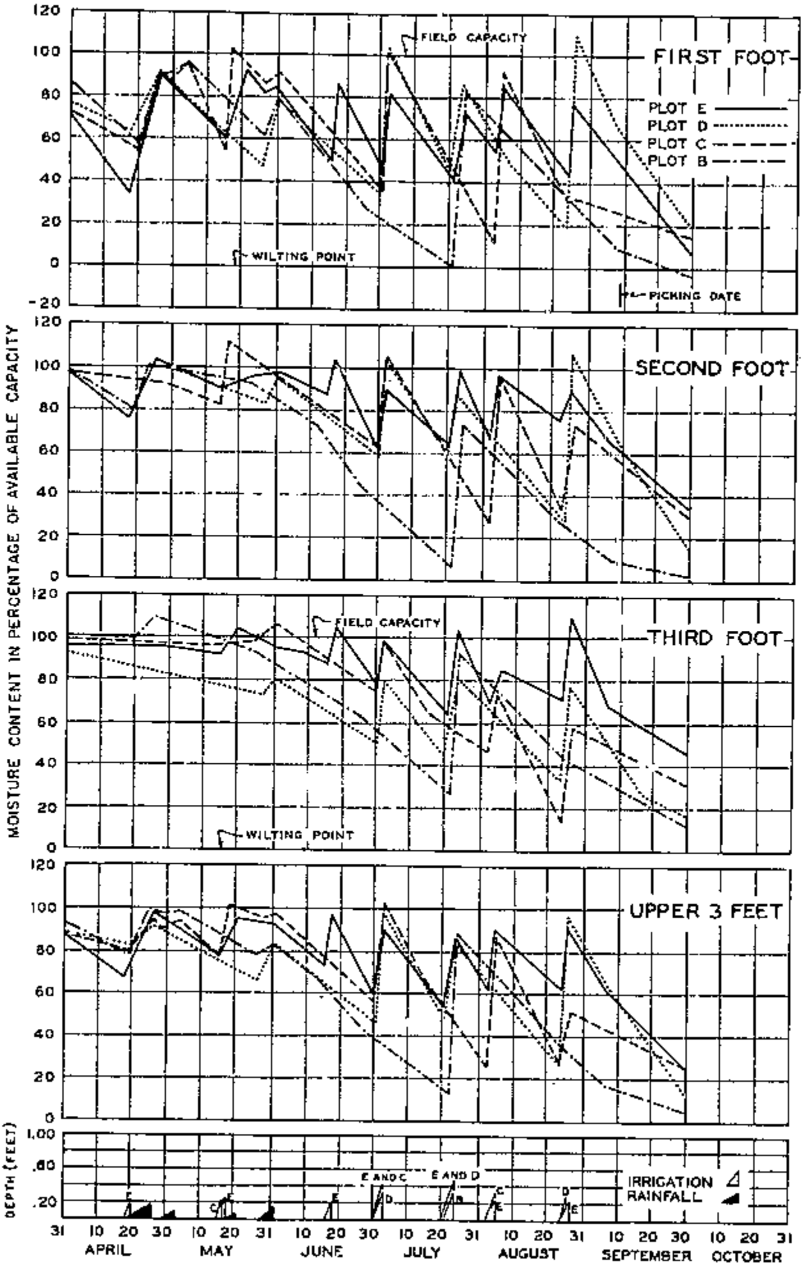


FIGURE 8.—Moisture content, expressed as a percentage of the available capacity, of each of the upper 3 feet and the average thereof, also rainfall and irrigation water applied, for the plots in the Klamath orchard in 1932. The heights of the triangles represent the depths of water applied by either irrigation or rainfall, and the bases show the periods of application.

### SPUR AND SHOOT GROWTH

The average length of spur growth was determined by measuring 120 blossoming spurs on each of five trees in each plot. On the Bartletts in the Fitch orchard, both the spurs that set fruit and those that did not were included in arriving at the averages. For 1931 and 1932 only spurs that blossomed but did not set fruit were used in obtaining the averages for the Anjous in the Klamath orchard.

The average length of shoots in both orchards for 1931 was determined by measuring on each of five trees in each plot the length of 50 lateral or terminal shoots that had not been headed back in pruning. For 1932 the average was derived from 100 measurements for each tree. For 1931, terminals that had made no growth were included in obtaining the averages.

Table 9 gives the lengths of the spurs and shoots in both orchards together with the probable error of the average in each case. Although the length of spur and shoot growths reflects the vegetative vigor of the trees in these experiments, it is impossible to determine what periods of soil-moisture differences between plots resulted in the observed differences in vigor. Therefore, some of the plot differences shown by the data in table 9 cannot be explained. On the Fitch plots, top-volume measurements and yield records suggest a lower vigor in plot D than in the other three plots. Spur and shoot growth, usually least in plot D, also indicates low vigor. The important feature of these data is that in plot E the spur and shoot growth during 1932 was greater than in the other plots indicating increased vigor resulting from the consistently higher available soil moisture.

TABLE 9.—*Length of spur and shoot growths of pear trees in the different plots in the Fitch and Klamath orchards*

FITCH ORCHARD (BARTLETT)

| Year | Growth | Plot E | Plot D | Plot B | Plot C |
|---|---|---|---|---|---|
| | | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* |
| 1931 [1] | Spurs | 1.10±0.024 | 0.67±0.019 | 1.00±0.059 | 1.08±0.028 |
| 1932 [1] | do | 1.54± .017 | 1.34± .014 | 1.38± .015 | 1.45± .015 |
| 1931 | Shoots | 14.0 ± .55 | 8.4 ± .36 | 7.1 ± .34 | 11.8 ± .57 |
| 1932 | do | 36.9 ± .65 | 27.6 ± .51 | 20.9 ± .57 | 32.2 ± .56 |

KLAMATH ORCHARD (ANJOU)

| Year | Growth | Plot E | Plot D | Plot B | Plot C |
|---|---|---|---|---|---|
| 1931 [2] | Spurs | 1.58±0.015 | 1.50±0.015 | 1.30±0.012 | 1.62±0.013 |
| 1932 [2] | do | 1.98± .009 | 1.92± .010 | 1.62± .012 | 1.94± .011 |
| 1931 | Shoots | 33.2 ± .63 | 22.0 ± .59 | 15.4 ± .47 | 11.2 ± .54 |
| 1932 | do | 32.3 ± .46 | 26.5 ± .34 | 20.9 ± .28 | 31.0 ± .42 |

[1] All blossoming spurs, regardless of type, used in average.
[2] Only blossoming, nonsetting spurs used in average.

In the Klamath plots, explanation for the larger spur growth in plot C than in the other plots during 1931 is not readily found. The slightly larger spur growth of plot E compared with plot C in 1932 may be the cumulative effect of the consistently higher available soil moisture in the former plot during three seasons. The shorter spur growth in plot B than in the other plots in 1931 and 1932 indicates the lower vigor resulting from less available soil moisture. The greater shoot growth in plots E and D than in plots B and C during

1931 indicates greater vegetative vigor resulting from higher available soil moisture during 1930 and 1931. In 1932 plots E and D again showed greater shoot length than plot B. The greater relative amount of shoot growth in plot C as compared with the other plots in 1932 than in 1931 can probably be attributed both to larger amounts of soil moisture during June 1932 and to the lighter crop on plot C in 1932. In general, these data indicate larger spur and shoot growth in plots with more available soil moisture.

Figure 9 shows typical trees in plots E and B in the Klamath orchard at the end of the third (1932) season of these experiments. The larger number of long shoots on the tree in plot E than on the tree in plot B indicates the greater vegetative vigor resulting from the greater quantities of available soil moisture during the three seasons in plot E than in plot B.

### BLOSSOM AND SET OF FRUIT

In March 1933 data on the amount of bloom and the set of fruit on the various plots for the previous years were obtained. For this purpose 120 spurs were selected at random from each of the record trees in each plot. The portions of each spur produced in each of the 3 years 1929, 1930, and 1931, were classified as either nonblossoming, blossoming but not setting fruit, or blossoming and holding fruit. The data given in table 10 are derived from this classification.

TABLE 10.—*Blossom and set of fruit on the different plots of the Fitch and Klamath orchards, 1929–32*

FITCH ORCHARD (BARTLETT)

| Year | Growth | Plot E | Plot D | Plot B | Plot C |
|---|---|---|---|---|---|
| 1929 | Blossom [1] | 82±2.1 | 81±1.6 | 88±1.9 | 87± 1.9 |
| | Set [2] | 44±1.5 | 41±1.7 | 93±1.0 | 59± 2.6 |
| 1930 | Blossom [1] | 81±2.5 | 72±2.0 | 85±0.8 | 78± 1.2 |
| | Set [2] | 70±2.4 | 60±2.1 | 80±2.3 | 90± 3.4 |
| 1931 | Blossom [1] | 28±3.3 | 25±2.2 | 48±2.8 | 53± 4.0 |
| | Set [2] | 96±2.0 | 75±3.0 | 90±1.8 | 87± 1.8 |
| 1932 | Blossom [3] | 53±4.4 | 54±1.8 | 50±3.5 | 44± 2.3 |
| | Set [4] | 92±5.0 | 87±7.0 | 70±7.5 | 97±10.1 |

KLAMATH ORCHARD (ANJOU)

| Year | Growth | Plot E | Plot D | Plot B | Plot C |
|---|---|---|---|---|---|
| 1929 | Blossom [1] | 70±4 | 79±1 | 83±1 | 87±6 |
| | Set [2] | 59±8 | 48±6 | 34±3 | 49±3 |
| 1930 | Blossom [1] | 82±1 | 83±1 | 80±1 | 88±1 |
| | Set [2] | 64±4 | 45±5 | 38±2 | 48±4 |
| 1931 | Blossom [1] | 76±1 | 76±2 | 84±2 | 92±1 |
| | Set [2] | 30±1 | 11±2 | 8±2 | 16±2 |
| 1932 | Blossom [3] | 25±2 | 20±2 | 45±4 | 33±1 |
| | Set [4] May 17 | 76±5.4 | 82±7.1 | 41±2.6 | 56±3.5 |
| | Set [4] Aug. 15 | 30±4.2 | 32±2.2 | 14±1.0 | 15±1.7 |

[1] Blossom expressed as percentage of spurs blossoming.
[2] Set expressed as percentage of blossoming spurs carrying fruit.
[3] Blossom expressed as percentage of growing points blossoming.
[4] Set expressed as number of fruits carried per 100 blossoming points.

The blossom records for 1932 were determined by counting all growing points and all blossoming points on three small limbs on each record tree in each plot. The set records were subsequently obtained by counting all the fruits on each of those limbs. These data, which give "percent of growing points blossoming" and "fruits per 100 blossoming points", also are shown in table 10.

Some of these data seem inconsistent. More detailed information must be secured as to the time and causes of fruit-bud differentiation

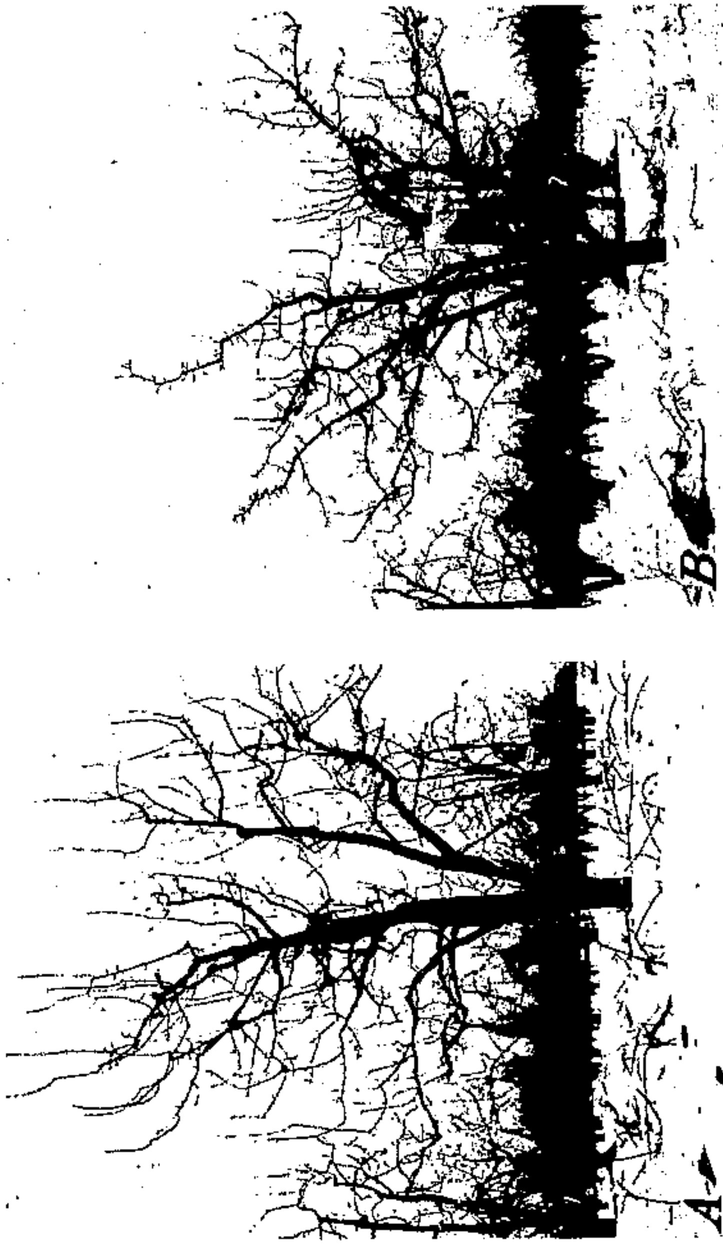


FIGURE 9.—Typical trees in plots E and B of the Klamath orchard in February 1933, showing the longer and more abundant shoot growth on plot E: *A*, Tree in plot E; *B*, tree in plot B.

and of the set and drop of fruit before definite conclusions can be drawn as to the effect of soil moisture on these tree responses.

#### QUALITY OF FRUIT

During each of the 3 years fruit from both orchards was saved from each plot and carefully examined for its dessert and keeping qualities. This study was made by F. C. Reimer, superintendent of the Southern Oregon Branch Experiment Station. Also additional observations on the quality of the Anjou pears from the Klamath orchard in 1932 were made by C. L. Powell, formerly junior physiologist, Bureau of Plant Industry, United States Department of Agriculture.

Slight differences in the fruit from the different plots were noted, but they were of little if any commercial importance. From these studies it seems safe to conclude that the different irrigation treatments carried on in these studies and the different soil-moisture conditions observed have not caused any differences of commercial importance in the quality of the fruit.

#### EFFECT ON VIGOR OF THE TREES

The data regarding the spur and shoot growth on the trees in the different plots show that the trees on the more heavily irrigated plots made the best growth. A similar result is shown in table 11, which gives the average increase in the circumference of the trunks of the record trees in each plot in both orchards.

TABLE 11.—*Average circumference of trunks of record trees in each plot in August 1930 and in March 1933 and the average increase between those dates in the Fitch and Klamath orchards.*

| Orchard | Plot E | | | Plot D | | | Plot B | | | Plot C | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1930 | 1933 | Increase | 1930 | 1933 | Increase | 1930 | 1933 | Increase | 1930 | 1933 | Increase |
| | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* | *Centimeters* |
| Fitch | 53.0 | 55.6 | 2.6 | 51.4 | 52.9 | 1.5 | 53.7 | 56.1 | 2.4 | 53.8 | 55.8 | 2.0 |
| Klamath | 70.0 | 75.6 | 5.6 | 69.6 | 74.1 | 4.5 | 70.6 | 74.1 | 3.5 | 69.1 | 73.8 | 4.7 |

Observation of the trees in the different plots discloses no evidence of injury of any kind on account of the very frequent irrigation of some of the plots. No detailed records have been kept of the incidence of blight or of winter injury, but there seems to have been no difference between the various plots. It should be kept in mind that both of these orchards are well drained and that while the more heavily irrigated plots have been irrigated very frequently each application has been small and there has been no water-logging of the land. It should also be remembered that the experiment has continued for only 3 years and it is impossible to tell what may be the effect of the different irrigation treatments if carried on for many years.

## ECONOMIC ASPECTS OF THE RESULTS

These studies, together with those on the Medford Experiment Station reported in more detail elsewhere (*5*), have shown that whenever the soil moisture in the upper 3-foot average fell much below 70 percent of the available capacity the rate of growth of fruit was reduced.

It necessarily follows that with initially the same amount of crop the plots having the higher moisture content produced the larger average size of fruits and greater tonnage. Other factors, however, such as the difficulty of carrying on the spray program, the cost of irrigation, and the possible bad effect of keeping the soil continuously wet must be considered.

These experiments were not designed to show the effect of thinning in connection with irrigation and the data do not show the relation between the two practices. However, there seems to be no reason to question that the proportion of excessively large Bartlett pears on the most heavily irrigated plots in the Fitch orchard could have been reduced or eliminated by less severe thinning, with a resultant increase in the total yield.

By means of a tabulation of typical sales of Bartlett and Anjou pears from Medford on the New York auction during 1930, 1931, and 1932, the average prices at which pears of four different-size groups sold have been estimated. The data are shown in table 12.

TABLE 12.—*Estimated average price per pound*[1] *paid for Bartlett and Anjou pears from Medford on the New York auction, 1930–32*

BARTLETT

| Year | Price per pound for pears of indicated size | | | |
|---|---|---|---|---|
| | 180's and smaller | 165–150 | 135–120 | 120's and larger |
| | *Cents* | *Cents* | *Cents* | *Cents* |
| 1930 | 3.7 | 4.5 | 4.8 | 4.8 |
| 1931 | 6.1 | 6.0 | 6.2 | 5.9 |
| 1932 | 3.5 | 3.7 | 3.8 | 3.5 |
| Average | 4.4 | 4.9 | 4.9 | 4.7 |

ANJOU

| Year | 180's and smaller | 165–150 | 135–120 | 120's and larger |
|---|---|---|---|---|
| 1930 | 5.0 | 5.0 | 5.9 | 5.7 |
| 1931 | 7.1 | 8.2 | 8.0 | 7.1 |
| 1932 | 3.5 | 4.3 | 3.9 | 3.8 |
| Average | 5.2 | 6.0 | 5.9 | 5.5 |

[1] These prices are based on an estimated net weight of 46 pounds per packed box for the Bartlett and 45 pounds for the Anjou pears.

From these data it is evident that the sizes of fruit that obtain the highest prices vary from year to year but that both very small and very large fruit are nearly always discounted.

Table 13 shows the effect of the different soil-moisture conditions in the various plots on the returns to the grower. This effect would be harder to see and understand if the prices used in the tabulation varied from year to year. For this reason the average values of the various sizes of fruit for the 3-year period shown in table 12 have been used in all 3 years in table 13. In preparing table 13 the value of the actual yield of fruit of each group of sizes for each plot shown in tables 3 to 8, inclusive, was determined. A uniform cost of harvesting and marketing the fruit has been assumed at 4 cents per pound or $1.84 per box.

TABLE 13.—*Estimated returns to grower from pears of different sizes from each plot on the Fitch and Klamath orchards, based on the average New York auction price from 1930 to 1932, inclusive, and on an assumed harvesting and marketing cost of 4 cents per pound or $1.84 per box*

FITCH ORCHARD (BARTLETT)

| Year and plot | 180 and less | 165 and 150 | 135 and 120 | 120 and larger | Total | Estimated yield per acre | |
|---|---|---|---|---|---|---|---|
| 1930 | | | | | | *Boxes* | |
| E | $5.10 | $5.77 | $1.30 | ---------- | $12.35 | 637 | $172.90 |
| D | 4.20 | 2.02 | .54 | ---------- | 7.66 | 437 | 107.24 |
| B | 4.88 | 2.85 | .36 | ---------- | 8.09 | 480 | 113.26 |
| C | 4.63 | 4.06 | .79 | ---------- | 9.48 | 516 | 132.72 |
| 1931 | | | | | | | |
| E | .26 | 4.35 | 4.01 | $0.51 | 9.13 | 325 | 127.82 |
| D | .48 | 3.32 | 1.43 | .06 | 5.29 | 200 | 74.06 |
| B | .81 | 6.35 | .97 | .01 | 8.14 | 310 | 113.96 |
| C | 1.09 | 4.74 | 1.63 | .04 | 7.50 | 300 | 105.14 |
| 1932 | | | | | | | |
| E | .67 | 7.20 | 5.82 | .59 | 14.28 | 518 | 199.92 |
| D | 1.80 | 7.37 | 2.57 | .14 | 11.88 | 480 | 168.32 |
| B | .98 | 7.42 | 4.34 | .21 | 12.95 | 481 | 181.30 |
| C | 1.24 | 7.16 | 3.59 | .15 | 12.14 | 452 | 169.96 |

KLAMATH ORCHARD (ANJOU)

| Year and plot | 180 and less | 165 and 150 | 135 and 120 | 120 and larger | Total | Estimated yield per acre | |
|---|---|---|---|---|---|---|---|
| 1930 | | | | | | | |
| E | $3.13 | $17.72 | $10.41 | $1.20 | $32.46 | 425 | $354.86 |
| D | 3.91 | 16.62 | 5.98 | .22 | 26.73 | 355 | 294.03 |
| B | 5.64 | 9.88 | 1.44 | ---------- | 16.96 | 249 | 186.56 |
| C | 8.03 | 9.10 | .81 | ---------- | 17.94 | 282 | 197.84 |
| 1931 | | | | | | | |
| E | 4.69 | 10.26 | 4.90 | .52 | 20.37 | 280 | 224.07 |
| D | 3.97 | 9.06 | 2.55 | .09 | 15.67 | 221 | 172.37 |
| B | 4.56 | 1.26 | .02 | ---------- | 5.84 | 106 | 94.24 |
| C | 7.19 | 2.62 | .08 | ---------- | 9.89 | 176 | 168.79 |
| 1932 | | | | | | | |
| E | .79 | 9.30 | 15.62 | 4.53 | 30.24 | 395 | 332.64 |
| D | .72 | 12.60 | 12.60 | 1.88 | 27.80 | 354 | 306.46 |
| B | 5.23 | 12.00 | 1.73 | .06 | 19.02 | 270 | 209.22 |
| C | .60 | 7.02 | 10.30 | 1.92 | 19.84 | 256 | 218.24 |

On the basis of market value, the difference between 4.4 and 4.9 cents per pound for Bartletts and between 5.2 and 6 cents per pound for Anjous does not appear highly important but when the cost of harvesting and marketing the fruit—which is practically the same per pound or per box regardless of size—is substracted from the market value the importance of securing fruit of proper size is evident. The difference in the return to the grower would have been that between 0.4 and 0.9 cent per pound for Bartletts and between 1.2 and 2 cents per pound for Anjous. In other words, on the basis of the average value for the 3-year period, Bartletts of sizes 120 to 165, inclusive, would have returned to the grower more than twice as much as those of sizes 180 and smaller, and similarly Anjous of the more desirable sizes would have returned almost twice as much.

As uniform prices were used in making up table 13, the effect of size on growers' returns can be illustrated by comparing the returns per acre of Fitch plot C in 1930 with those of Fitch plot E in 1932. The total yields of these two plots were almost identical, yet, on account of the more desirable sizes of the fruit on the more frequently irrigated plot E, the return was 50 percent greater on that plot. In the Klamath orchard practically the same total yield from plot E in 1931 returned almost 15 percent more than that from plot C in 1930.

The effect of these soil-moisture conditions on the return to the grower is due partly to the effect on size, as discussed above, and partly to the effect of total yield. An inspection of that part of table 13 reporting results from the Fitch orchard shows that in each year the return from plot E has been greatest and that from plot D smallest. The bearing of the smaller size and apparently poorer vigor of the trees in plot D on the yield of that plot has been explained. The returns from plots B and C have been almost the same over the 3 years. On the whole, soil-moisture conditions in the latter two plots have not been very different. The return to the grower emphasizes that (1) a high moisture content will produce larger fruit than a low moisture content, (2) too small a set of fruit or too heavy thinning in connection with a high moisture content will result in fruit of too large size, and (3) a profitable use of frequent irrigation requires that the number of fruits on the trees be great enough to produce a large yield of desirable sizes of pears.

In the Klamath orchard the table shows that in each year the return was best from the plot having the highest moisture content and decreased in the other plots in the same order as the moisture content. These data show very clearly the higher return which may be secured by maintaining a high moisture content in this heavy soil.

The average cost of irrigation on horse and tractor farms as determined by Besse, Brown, and Wilcox (*2*) is $3.34 per acre for each application. It is often considered necessary to cultivate after each irrigation and, although the authors do not believe this to be true, the cost of such cultivation, found in the same study by Besse, Brown, and Wilcox to be $1.35 per acre [14] for each cultivation, may be added to that of applying water. When this is done it is possible to estimate the additional cost per acre of maintaining a high moisture content throughout the season.

Table 14 shows the number of applications of irrigation water and the total depth applied to each plot on the 2 orchards during the 3 seasons.

TABLE 14.—*Irrigations and total depth of water applied on each plot on the Fitch and Klamath orchards, 1930–32*

| Plot | 1930 Irrigations | 1930 Depth | 1931 Irrigations | 1931 Depth | 1932 Irrigations | 1932 Depth |
|---|---|---|---|---|---|---|
| **FITCH ORCHARD** | | | | | | |
| | *Number* | *Feet* | *Number* | *Feet* | *Number* | *Feet* |
| E | 4 | 1.12 | 5 | 1.00 | 5 | 0.95 |
| D | 3 | .92 | 2 | .63 | 2 | .79 |
| B | 1 | .51 | 2 | .48 | 1 | .45 |
| C | 1 | .70 | 2 | .59 | 1 | .60 |
| **KLAMATH ORCHARD** | | | | | | |
| E | 4 | 1.18 | 6 | 1.61 | 7 | 2.02 |
| D | 2 | .64 | 3 | .82 | 3 | 1.09 |
| B | 1 | .48 | 1 | .35 | 1 | .32 |
| C | 1 | .39 | 2 | .57 | 3 | .90 |

Table 15 is designed to show the increased return to the grower by reason of more frequent irrigation. It shows the increases or decreases in dollars per acre in the return to the grower on plots E, D, and C, as compared with plot B, on each orchard, the increased

[14] Unpublished data.

costs of irrigation of plots E, D, and C as compared with those of plot B, and the net gains or losses.

As has been stated before, the trees of plot D in the Fitch orchard were smaller and apparently less vigorous than those on the other plots in that orchard. It is believed that this accounts for the lower returns from that plot.

It should be remembered that the Bartlett pears on the plots in the Fitch orchard were thinned in an attempt to secure comparable leaf-fruit ratios each year. However, in 1930 plot E was not thinned a second time as were the other plots. The result was that in 1930 plot E produced the largest yield of fruit of desirable sizes and made the greatest return to the grower after subtracting the cost of the extra irrigations applied to this plot. In the two later years, while plot E produced the largest yields, many of the pears were too large to bring the highest price with the result that the larger return from this plot as compared with that from plot B was just great enough to take care of the cost of the extra irrigations. It is believed that if this plot had not been so heavily thinned it would have shown a profit by reason of the extra irrigation. Plot C received the same number of irrigations as plot B during each of the 3 years, and the return to the grower over the 3 years was practically the same from each of the two plots.

TABLE 15.—*Increases or decreases per acre between estimated return, cost of irrigation, and net gain or loss to the grower from plots E, D, and C as compared to estimated returns from plot B in the Fitch and Klamath orchards, 1930–32*

| Year and plot | Fitch orchard (Bartlett) | | | Klamath orchard (Anjou) | | |
|---|---|---|---|---|---|---|
| | Return | Cost of irrigation | Gain (+) or (−) loss | Return | Cost of irrigation | Gain (+) or (−) loss |
| **1930** | | | | | | |
| E | +$59.64 | +$14.07 | +$45.57 | +$168.30 | +$14.07 | +$154.23 |
| D | −6.02 | +9.38 | −15.40 | +107.47 | +4.69 | +102.78 |
| C | +19.46 | [1] .00 | +19.46 | +10.78 | [1] .00 | +10.78 |
| **1931** | | | | | | |
| E | +13.86 | +14.07 | −.21 | +153.83 | +23.45 | +130.38 |
| D | −39.90 | [1] .00 | −39.90 | +108.13 | +9.38 | +98.75 |
| C | −8.82 | [1] .00 | −8.82 | +44.55 | +4.69 | +39.86 |
| **1932** | | | | | | |
| E | +18.62 | +18.76 | −.14 | +123.42 | +28.14 | +95.28 |
| D | −14.98 | +4.67 | −19.65 | +97.24 | +9.38 | +87.86 |
| C | −11.34 | [1] .00 | −11.34 | +9.02 | +9.38 | −.36 |

[1] The same number of applications were made on these plots as on plot B.

The results for the Klamath orchard are much more consistent and, it is believed, give a much more accurate picture of the results that can be expected from irrigation on these heavy soils. In each year both plot E and plot D showed a very substantial increase in the per acre return to the grower after subtracting the cost of more frequent irrigation. In 1931 two irrigations on plot C returned an increase over one irrigation on plot B. On the other hand three irrigations on plot C in 1932 did not increase the return over that from plot B enough to make up for the extra cost of irrigation.

The comparison between results obtained on plots D and C in 1932 in the Klamath orchard shows the relatively greater importance of a high soil moisture in the latter part of the season. Both plots received three irrigations and nearly the same total depth of water. However, plot D was irrigated late in August, whereas plot C received its last irrigation early in August. Therefore the moisture content in the soil of plot D was higher during the last month of the growing season. Plot D, with a much larger number of pears than plot C, produced almost as large fruit and a much heavier yield. Estimates of the average size of pears on these two plots from soil-moisture conditions indicate that if the trees had borne the same number of pears those on plot C would have been considerably smaller.

## DUTY OF WATER

By reference to table 14 it will be noted that the maximum depth of irrigation water applied to a plot in the Fitch orchard was 1.12 feet in depth and in the Klamath orchard, 2.02 feet. By reference to table 15 it will be noted that the net return after subtracting the cost of extra irrigations from plot E in the Klamath orchard in 1932, which received the maximum quantity of 2.02 feet of water, was only about $7.50 more per acre than that from plot D which received only 1.09 feet in depth of water. It seems probable that a depth of 1.50 [16] feet will give practically maximum returns under the conditions of these experiments.

The normal duty of water delivered to the farm, in the Medford and Talent irrigation districts is about 1.5 acre-feet per acre; that is, a depth of 1.5 feet over the irrigated acreage. It thus seems evident that the requirement for irrigation water for the production of maximum yields of pears on heavy soils such as those in the Fitch and Klamath orchards is not greater than the normal supply in these districts. Other sections of the Rogue River Valley have more, rather than less water for irrigation.

## SUMMARY AND CONCLUSIONS

The rate of growth of the fruit was found to be very closely related to the moisture content of the upper 3 feet of soil. Studies of the effect of soil moisture on the rate of fruit growth have shown that whenever the moisture content fell below 70 percent of the available capacity, the rate of growth of the fruit was reduced.

The rate of growth of the fruit was greatest during the latter part of the growing season and thus the effect on the size of fruit at harvest of a low moisture content late in the season was greater than the effect of equally low soil moisture earlier in the season.

A high soil-moisture content was conducive to long spur and shoot growth. There appeared to be no correlation between variations in the storage or dessert quality and differences in soil moisture.

High soil moisture was conducive to the production of fruit of the larger and more desirable sizes. When Bartlett pears were heavily thinned, the plots having high soil moisture produced pears that were too large to bring the highest prices.

The thinning practice in the orchard should be coordinated with the irrigation practice in order that pears of the most desirable sizes and heavy yields may be obtained.

The plots having the highest soil moisture produced the largest yields and the greatest return to the grower.

On the Klamath orchard, the cost of the extra irrigation required to maintain high soil moisture was not as great as the return from the

[16] This estimate makes no allowance for surface waste or other losses.

higher yields when the return was based on the average of the New York auction prices for Medford pears for the 3 years of the study.

On the Fitch orchard the results were confused by the small size of the trees in one plot and by the thinning practice but these results are not believed to contradict those found on the Klamath orchard.

The requirement for irrigation water to maintain a high soil-moisture content on the heavy soil of these orchards was no greater than the normal duty of water for which the Medford and Talent irrigation systems were designed.

In some years the water supply to the Medford and Talent Irrigation Districts has been insufficient to meet the requirements. At other times the available supply has been more than sufficient to provide a net duty of 1.5 acre-feet per acre. It would seem to be most profitable in the long run to conserve by storage all water not urgently needed in years of excessive supply, in order that it may be available later in a period of deficiency.

The data reported herein indicate clearly that number of irrigations, depth applied, or both combined are not always reliable indexes of soil-moisture conditions. The data show that it was always difficult, and often impossible, to obtain penetration of irrigation water to the entire root zone in amounts sufficient to raise the soil moisture to field capacity. If methods of securing more adequate penetration were known it is certain that as frequent irrigation as was necessary in the most frequently irrigated plots described herein would not be necessary. It is recommended that an available soil-moisture content of not less than 50 percent of capacity be maintained. The number of irrigations necessary to accomplish this will vary from season to season and from orchard to orchard.

The only known way to be sure that soil moisture is present in readily available form is by frequent examination of the subsoil by the use of a soil auger or similar tool.

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