DIVISION OF HORTICULTURE

Oregon Agricultural College
Experiment Station

CORVALLIS, OREGON

ORCHARD IRRIGATION STUDIES IN THE ROGUE RIVER VALLEY

By

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INTRODUCTION.

For the past five years the Division of Horticulture of the Oregon Agricultural College Experiment Station has been conducting orchard irrigation investigations in the Rogue River Valley. In these investigations we have considered such factors as soil, water, tree and fruit, and we have considered such problems as the best dates as well as the best amounts and ways of applying the water under the various soil and orchard conditions found in the Rogue River Valley.

In connection with the water studies we have made a close investigation of its changes in temperature and its influence on the soil temperatures and have also included such phases as percolation and spread of moisture through the soil.

In studying the relation of irrigation to the tree development we have considered such problems as color and growth of foliage, the date at which the foliage falls, the amount of wood produced and the date at which this wood matures, while with the fruit we have considered such problems as the influence of the water on its color, form and size, the size of the crop and the date of maturity.

It has, of course, been impossible to investigate completely all these problems in one season, or in the five seasons at our disposal. The problem of irrigation in the Rogue River Valley becomes somewhat complex due to the large number of soil types found in the valley, as they vary from the lightest granitic to the heaviest adobe. Often these extreme types are closely adjacent and it is not uncommon to find four or five different types of soil in the same orchard.

The trees vary in age since there have been large plantings annually and both apples and pears are grown over large areas. These facts coupled with unexpected climatic conditions, such as more rainfall in the summer than normally expected have made the problem a more or less difficult one.

We wish at this time to thank the growers of the Rogue River Valley who so kindly assisted us in every way possible. It was only owing to their hearty co-operation that we were
enabled to work on tracts of sufficient area to give us conclusive results.

Through these five years a number of men have assisted materially especially in the field work. During 1907 we were assisted by Mr. S. L. Bennett; 1908, by Mr. R. W. Allen; 1909, Messrs. C. C. Vincent and E. J. Kraus; 1910 and 1911, by Messrs. E. J. Kraus and R. W. Rees.

The Department of Agronomy has co-operated with the Horticultural Division in certain soil studies but this work is not ready for publication at this time.

The Department of Chemistry has co-operated with us in making chemical studies of the fruit. This work is of such a nature that it will be necessary to conduct investigations for a series of years before conclusive data can be collected.

CLIMATIC CONDITIONS.

As shown by the records of the Jacksonville weather station the average annual rainfall of the Rogue River Valley for a period of 20 years is 28.8 inches. Of this amount 17.9 inches fall during the months of November, December, January, and February. At this season the trees are dormant and a comparatively small amount of this water is actually utilized by them. During the months of June, July, August and September, when such fruits as pears and apples are making their greatest wood growth, producing fruit-buds for the succeeding year, and maturing their crop there is a precipitation of but 2.61 inches. At this time the temperature is relatively high, the humidity low, and the occasional showers are largely lost by evaporation. But a small amount of the moisture reaches the feeding area of the roots. This division of the year into two seasons, a dry and a wet, has an influence on the time and amount of artificial watering necessary for the best results in commercial orcharding.

SOILS.

Few sections the size of the Rogue River Valley contain such a diversity of soils, and these vary greatly with respect to their capacity to retain moisture. Here we find pumice,
granitic and free soils, loams ranging from clay through sandy to gravelly, as well as the heavier clays, stickies, and adobies. It is obvious that the amounts of water and the times at which it should be applied will vary with these different soil types and their physical properties. These types will be discussed later with regard to irrigation, and methods of handling to retain moisture.

GENERAL ORCHARD PRACTICE.

Of the previously mentioned soil types there are almost no two that are adapted to exactly the same methods of cultivation and handling; each grower must study and handle his particular soil type or types as required. The heavy sticky soils have to be worked at just the proper time in the spring, when the surface is dried off a little, but before a hard crust is formed. If worked at this time, and properly harrowed down, a very fine mulch is formed. It is very important that the sticky soils be plowed each spring rather than disced. Their physical make-up is of such a nature that it is almost impossible to secure a good deep moisture-holding mulch without the use of the plow. These sticky soils when so handled that a perfect mulch is formed are probably the most capable of retaining moisture of any to be found in the valley.

The granitic soils and lighter loams are not so exacting as to the time of cultivation so far as the formation of a mulch is concerned, but on these types, which dry out very badly, it is extremely important that cultivation be given just as soon as the soil is dry enough to be worked in the spring, thus conserving the winter rainfall. This also puts the soil into condition to receive and retain spring showers. The black loams not bordering on the sticky, such as occur along the Bear Creek Bottom, may be treated in a similar manner to the lighter loams, in all cases it being very important that cultivation be such as to conserve moisture.

Importance of Cultivation.—The importance of cultivation cannot be over-estimated either as to its effect in conserving moisture or in producing a proper physical condition of the soil. As a great percentage of soil moisture is often lost through evaporation one of the fundamental reasons for cul-
Cultivation is to form a dust mulch that will break up the capillary tubes, thus causing the moisture to remain just below the surface where it may be taken up by the feeding roots of the trees. Among the other numerous benefits of thorough cultivation may be mentioned its great aid in the aeration of the soil, thus promoting bacterial action, admission of light and the making of a greater amount of plant food available. Cultivation improves the physical condition of the soil by breaking up the larger clods, and fining the soil so that it is better adapted for the growth of plants.

There is a wide range in the methods and amount of cultivation practiced by different fruit growers throughout the Rogue River Valley. Practically all the soils should be plowed each spring. Following the plowing they should be cultivated with a spike-tooth harrow, or in some instances with a spring-tooth until a fairly deep mulch is formed. On some of the medium clay loams and lighter soils, especially if they have been packed during the winter, it is good policy to follow plowing with a brillion or corrugated roller. This tends to compact the soil, and also to crush the larger clods. After this treatment it is well to deepen the mulch with a spring-tooth, following by thorough cultivation with a spike-tooth harrow. During the summer months a dust mulch may be maintained by the use of a harrow, and on some of the
lighter soils Kimball and Acme weeders have been used very successfully. This early plowing and maintenance of a good soil mulch are of great advantage in retaining soil moisture during the growing season.

Where irrigation is practiced it is very important that thorough cultivation follow each irrigation. As soon as the soil is dry enough to allow horses and cultivating implements upon it without danger of puddling, cultivation should be given. This will prevent baking and cracking of the soil and likewise greatly reduce the amount of moisture that would otherwise be lost by evaporation. In cultivating after irrigation it is well to use a spring-tooth harrow and a day or two later fine the mulch with a spike-tooth or surface cultivator.

Cover Crops.—The growing of cover crops is becoming a more general practice throughout the Rogue River Valley, and is a very important phase of the orchard problem. Cover crops add humus and fibre to the soil. The fibre adds to the moisture-holding capacity of the light soils and makes the heavier types more friable and more easily handled. Any soil of high clay or silt content and low in organic matter, is not only difficult to handle with respect to cultivation but also irrigation. This type of soil takes up water very slowly. Percolation is so slow that a large number of furrows are necessary if a sufficient amount of water is to be supplied. Thus a greater surface for evaporation is exposed and such soils bake and crack badly on drying out. A good cover crop either natural or sown, if plowed under early in the spring will aid greatly in overcoming these difficulties.

It was very noticeable in the experiments of 1910 that when a late irrigation was given there was a good natural cover crop of chickweed, alfilaria, and various grasses. In the Heimroth orchard cover crops of vetch and rye, also barley, sown early in September, 1911, following late irrigations started readily and made a fine growth. An early cover crop of this nature not only adds its own fibre to the soil, but prevents the leaves from blowing away, thus keeping them where they will be of benefit. Those cover crops which get a good start early in the fall, make the best kind of protection for the soil during the winter.
PRESENT STATUS OF IRRIGATION.

The practice of irrigation in the Rogue River Valley is increasing. In the past the principal water sources have been ditches from Rogue River, Bear Creek, Fish Lake, and small streams tributary to Rogue River. Artesian and other wells have been used to supply small acreages. At the present time the principal source of irrigation water for the Rogue River Valley is Fish Lake Ditch, owned by the Rogue River Valley Canal Company. This ditch gets its water supply from Fish Lake and Four-Mile Lake near the base of Mt. McLaughlin. The Hopkins Lateral, now complete, covers about 27,000 acres. In 1909 this ditch delivered water to approximately 1,500 acres of land. The company's main canal now completed, will carry 269 second feet of water. It is 17½ feet at the top, 13 feet at the bottom, and 4½ feet deep, with a grade of 3 to 5 feet per mile. When the system is complete there will be more than 400 miles of canal, covering about 55,000 acres of land surrounding the city of Medford.

There are very many factors which affect the time, the amount, and the methods of irrigation. From our experiments of the past five years we have indications of the maximum, minimum and optimum amounts of water for certain types of soils. These amounts, of course, are not to be taken as absolute, but they will serve to give the grower a standard on which to base his own work. The grower will be able to modify these general amounts of water and time of application to meet his particular needs. The leading factors which affect these variations are climatic conditions, nature of soil, age of trees, previous cultivation, and amount of crop that the
trees are carrying. Climatic conditions are indeed very important. In some seasons when there is considerable rainfall late in the spring, irrigation will not need to begin so early, and in some cases where cultivation is properly carried on may not be needed at all during the season. In other years with this same soil type, and the same trees, if the precipitation is small in the early spring and the conditions favorable for evaporation of soil moisture, irrigation will be needed comparatively early.

As to soil there is a great variation in the amount of irrigation necessary. The light granitic soils as a rule will require a considerable amount of water. The loamy soils where exposed to strong winds and bright sunshine if not properly cultivated to conserve the moisture will also need comparatively early and heavy irrigation. However, this same soil if properly located, and especially if it receives some natural sub-irrigation, may mature a crop very well without artificial irrigation.

As stated above, cultivation is a very important factor in determining the amount of water to be applied to any soil. It is the general failing wherever irrigation is practiced to use too great an amount of water. There is a tendency on the part of some growers to try to substitute irrigation for cultivation, thinking that if soil moisture is lost through the neglect of early and thorough cultivation it can be as well added by artificial means. This flooding of the soil later in the season not only tends to carry down plant food below the depths where it can be taken up by the feeding roots of the trees, but also greatly damages the physical condition of the soils. When cultivation is practiced early in the season, and a good mulch maintained, a good soil will not require so great or so early an application of water, as the same type if not cultivated at the proper time.

In determining the best times for irrigation we must not only consider the previously mentioned factors, but keep in mind in a general way that most soils will retain sufficient moisture to keep the trees in good vigorous condition up to the middle of July. Some of the lighter soils will need water before this
date and in most cases the heavier types will retain sufficient moisture until the last of July or early August. If one waits until the trees begin to show decidedly the effect of the lack of moisture they will not revive and make the wood growth, or produce the quality of fruit that would have resulted had water been given at the proper time.

*Drainage.*—Drainage, either natural or artificial, is very important for the successful growing of pears and apples.

Although most sections of the Rogue River Valley have good natural drainage some would be further benefited were this supplied artificially. The importance of proper drainage is a factor with which every fruit grower should become familiar if he is to make the greatest success as an orchardist. A few of the benefits of drainage are: That it removes the surface water from the soil, which if allowed to remain would be very injurious to the plant because it excludes air which helps make
plant food available; injurious salts, which if allowed to accumulate, often make land unproductive, are removed; early and more thorough cultivation is made possible, thus preventing soils from baking and also decreasing the liability to drought.

Although the problem of drainage is of importance at present, the more general practice of irrigation in the future will bring with it new problems. If drainage is not properly attended to the seepage water from higher soils to the lower will have a tendency to cause water-logged conditions. The presence of this standing water will interfere with the natural chemical and physical changes which should take place and thus thwart the natural functions of the roots. As a result of these conditions there may follow certain forms of winter injury and physiological troubles.

IRRIGATION WORK OF 1907.

Irrigation investigations of the Department of Horticulture of the Oregon Agricultural College Experiment Station were begun in the Rogue River Valley in the summer of 1907. The work was taken up in co-operation with J. G. Gore, W. A. Norcross, Edward Judy, and T. Panky.

The season of 1907 was unusual with respect to the climatic conditions prevailing in the Rogue River Valley. A heavy three days rain occurred early in August. This heavy rain took the place of a second irrigation, tended to destroy the effect of the dry checks and made the results of the work somewhat confusing. Nevertheless a certain benefit was noted as a result of the earlier irrigations, and also subsequent irrigations following the rainfall. The varieties used were the Yellow Newtown and the Spitzenburg.

The following results were noted especially in relation to the fruit: Fruits taken from the irrigated plots averaged larger, were, as a whole, slightly more elongated, somewhat more angular, and while not as intense in color were brighter and more attractive than those taken from the nonirrigated plots.
IRRIGATION WORK OF 1908.

During the season of 1908 the irrigation experiments were carried on in co-operation with J. G. Gore, Edward Judy, S. L. Bennett, and Tronson & Guthrie. The object of the work that season was to determine: First, the best date for irrigating when only one application of water was to be made, and second, the best dates on which to apply water for three irrigations. Studies were also made relative to wood growth as affected by irrigation, and the action of water on the soil and the fruit. The season of 1908 was considered a dry one. From experiments carried on in that year it was concluded that water should not be allowed to stand in large quantities, at or near the base of the trees. Investigations further indicate that for medium loam soils one irrigation with intensive cultivation produces a better quality of fruit than systematic cultivation alone. When only one application of water is to be made the indications are that the best results are obtained when the water is applied during the latter part of July or early in August.

Three irrigations produced a greater growth of wood, prolonged the growing season, but did not give the red apples quite as deep a color as they took on in the dry check. The quality of the fruit showed no appreciable difference, with the exception of that from two dry checks on granitic soil. In these cases the unirrigated fruit was small and insipid. As a general rule the percentage of marketable sized fruit ran higher on irrigated plots than on nonirrigated. There was a greater proportion of wind-falls on dry checks than on irrigated plots. This may have been due partly, however, to the fact that the fruit on the dry checks matured earlier, and was allowed to hang too long on the trees.

IRRIGATION WORK OF 1909.

Granitic Soil.—During the season of 1909 experiments were conducted on granitic soil in the orchard owned by Charles Pope. If located so that it can be supplied with an abundance of water, which can be put on slowly, this soil produces good fruit. When applied in large quantities to this type of soil
the water seeps away very rapidly, and is soon lost by percolation. Unless there is a large supply of water available, at least up to the first or middle of August, it is probably not advisable to attempt to grow apples on these loose soils. On trees which are suffering from a lack of water, or without irrigation, the fruit is very inferior in size and in color; the color being intense but dead. Most of the fruit will average five tier, or less, if an abundance of water is not supplied. It is doubtful whether apples can be grown successfully on these granitic soils unless a minimum of 1,000 gallons of water per tree per season is available. The exact amount will depend upon the season, and the fruit on the trees.

**Pumice Soil.**—As a result of experiments in co-operation with Colonel Washburn, whose orchard is located near Table Rock, it can be stated without hesitation that water is absolutely essential to mature properly a crop of apples when grown on pumice soil. It is evidently best to apply the water early, beginning by the middle of June, although this will also be somewhat dependent upon the season. Make at least two other applications, the second from the middle to the latter part of July, and the third from the middle to the last of August. A total of approximately 3,500 gallons should be applied, distributed about equally through the three irrigations. It was found that where water was entirely withheld throughout the growing season the trees suffered very materially, the leaves dried up and fell off early, and none of the fruit went over five tier. In general appearance it was darker but without life to the color, and more or less shriveled and corky in texture. Apparently no advantage was gained by applying more than 4,000 gallons per tree.

In irrigating this type of soil one must use considerable care in applying the water. It is best to start with a very small stream until the ground becomes thoroughly saturated for the upper few inches, when the furrows can readily be made deeper, and a much larger head of water turned in. If a large head is used to begin with it simply skims over the surface, and will not wet down for more than a half inch to an inch and a half, after running a couple of hours. The soil often has a tendency to become baked very hard at the surface, but
this baked surface is readily broken up if a very small amount of water is run over it, and allowed to soak in. When the soil is once wetted up, or opened up, one can use a very large head, and in fact it is almost necessary to do so, for the water seeps away so rapidly that an amount less than four inches would scarcely go more than 100 feet unless the land had considerable slope.

*Sticky Soil.—*Experiments were carried on with three varieties of eighteen year old pear trees located on gravelly gray sticky soil. Varying amounts of water were applied, the largest amount being applied on the poorer soil. The attempt was to show whether an abundance of water on poor soil would produce as good a crop as a light amount of moisture, with more thorough cultivation, on a better grade of soil. The water was applied twice during the season, early in July, and again about the first week in August. The results of this experiment go to show that in order to secure the best fruit one cannot depend on water entirely, for the trees which received no water, but which were on good soil, produced not only more but larger fruit than those on poorer soil which had an abundance of water. This result was especially noticeable on the Winter Nelis pears, slightly less so on the d'Anjou and to some degree on the Bartlett.

The practice of irrigating young pear trees on either the red or gray sticky soils is questionable. In some experiments carried on with eight year old Bartlett trees at the Bear Creek Orchard the results showed no advantage gained in either the amount or size of the fruit produced. Trees which were not irrigated produced as heavily as those which received a considerable amount of water. Seven hundred gallons per tree were applied about the middle of July. In fact, subsequent results have shown that it is probably a detriment rather than an advantage to irrigate trees of this character on the soils in question. The irrigated trees seem to be much more susceptible to blight. Just what changes are brought about in the tree to render it more susceptible, whether it is due to a coarser, more sappy growth, brought about by the irrigation, or due to some other factor, is still an open question.
In regard to irrigating the black sticky soils, and in fact any soils that crack badly we have not as yet conducted extensive experiments. The notes which we have been enabled to collect from growers who have irrigated such soils would lead to the following conclusions: It is an unwise practice as a rule, and at times even dangerous, to irrigate such soils heavily, especially if the water is cold. These soils have a tendency to crack badly, the cracks becoming large and deep, and consequently they will take up an enormous amount of water. Should the irrigation water be cold and allowed to run rapidly into these cracks there would be no chance for it to be warmed by the surface soil. Furthermore its distribution would be poor. The tendency would be, therefore, to chill the soil. It is also true that soil similar to black sticky gives out moisture very slowly by evaporation. There would undoubtedly result a large amount of free water in the soil which would prevent proper aeration and interrupt the chemical or other changes which would naturally take place.

Clay Loam Soil.—During the year 1909 experiments were conducted on a clay loam soil almost sticky in character in the eighteen years old Red Cheek orchard of G. E. Marshall. The orchard was divided into four plots. Plots I, II, and III, respectively, received 500, 1,000 and 1,500 gallons per tree, at each of two irrigations, July 28th and August 28th. This made a total application of 1,000, 2,000 and 3,000 gallons respectively per tree. The fourth plot was used as a dry check.

Results from this experiment show that where no water is applied the yield is very low. In fact, practically no marketable fruit was produced, the fruit being inferior in color and size, and showing an especially large percentage of calyx cracks. On the irrigated plots, however, the fruit was much superior, although there was very little difference to be observed between the fruit grown on the plot having the 1,000 gallons per tree, and on that having 3,000 gallons per tree throughout the growing season.

The soil irrigates very readily with the exception that it frequently has a tendency to crack, in which case care must be used in applying water to obtain an equal distribution,
for if the water encounters one of these seams it will pour into it and not spread evenly over the orchard.

Investigations and experiments were conducted at the Judy orchard with mature Newtown and Spitzenburg trees. These were on a clay loam which was considerably deficient in organic matter. The results seemed to indicate that there is little or no advantage in the case of Newtowns in applying

1,400 gallons per tree over an application of 1,200 gallons per tree, these applications made the last of June and the last of July. However, there was a decided increase in yield and size of fruit produced on these two plots over that produced on a dry check which had no water whatever throughout the summer. There seemed to be a secondary advantage; for the following year there was a heavier set of bloom, on both of the irrigated plots than on the unirrigated plot, where it was exceedingly light. With the Spitzenburgs the water was applied at the rate of 300, 400, and 450 gallons per tree in each of two applications, the first made about the first of July, and the second about the first of August. There was little, if any difference, between any of the irrigated plots, although there was a marked advantage over the dry check, on which the fruit was small, none of it fitted for market, and in general appearance it was somewhat darker, but of a dull red color and of shrivelled, corky texture.

An experiment was conducted on the clay loam of the Talent Orchard Co., to determine the best time for irrigating such soil. The first plot was irrigated early in June, another received a similar amount in July and a third a like amount in August. Those plots which were irrigated early in the season received a second irrigation either in late July or by
the middle of August. The results of these experiments indicate that with a sufficient amount of water applied there was very little difference either in amount of yield, or size of fruit produced. Even a dry check gave fairly good results. Eighteen years old Yellow Newtown trees were used in this experiment.

In the eighteen years old Newtown orchard of S. L. Bennett, located on Bear Creek Bottom soil an experiment was undertaken to show the effects of varying amounts of water in two applications, the first about the latter part of July, and the second the latter part of August. The plots respectively received 1,600; 2,000; 3,000; and 4,000 gallons per tree. There was also a dry check. On all of the irrigated plots there was very little difference in the matured fruit either in size or quantity. There was a slight difference observable on the dry check. However, several of these trees were carrying very light load, and produced apples which would compare favorably with the irrigated plots. Two of the trees were
heavily loaded, and the fruit from these trees was comparatively small, most of it averaging 4½ to 5 tier. These two trees were in rather poor vigor which may also have accounted in some measure for the small size of the fruit.

The average yield of the entire orchard was small, and unfortunately the crop was scattered; that is, some trees would have an exceedingly light crop, not more than one-half or a box of apples, whereas others would be carrying a normal load, which naturally would in some measure influence the results of the experiment.

**IRRIGATION WORK OF 1910.**

*Scope.*—During the season of 1910 we were able to secure larger plots than in former years. The advantage of large plots lies in the fact that the greater number of trees there are in each plot, the less danger there will be of the results being affected by the individual variation of the trees on any given plot.

It was our aim that season to determine the amount of water that would give the best results on different types of soil for trees that are fully matured. It is obvious that trees of the same age on soils of entirely different types and water holding capacities will require different amounts of water. We believe that the tree cannot make a good growth and properly mature a heavy crop of fruit if it does not have a certain amount of moisture during the growing season, but on the other hand, if trees receive too heavy watering we are led to believe from previous years' experiments that results will be equally unsatisfactory.

**NEWTOWN BLOCK OF S. L. BENNETT, NOW KNOWN AS THE GEORGE ANDREWS ORCHARD.**

*Exposure.*—This orchard is located on the Bear Creek Bottom, one mile north of Medford. The land is almost level, but slopes slightly to the north. The air circulation is very good, as the valley is broad at this point.

*Soil.*—The soil is a dark alluvial loam, containing a good supply of humus. No cover crops are grown, but there is a
fair growth of weeds during the winter, which are plowed under each spring. The orchard is also given an annual dressing of stable manure. The sub-soil is of a sandy nature intermixed with some small gravel. A considerable area of this block has a stratum of almost pure sand at 7 1/2 to 8 feet below the surface, while in a few spots the sub-soil at that depth contains much more silt than the surface soil.

Trees.—The trees were nineteen years old, and set 25 x 25 feet. They are of the open head type and during the season of 1909 were heavily summer pruned. The trees branch at 18 inches to three feet from the ground, with an average of 28 inches. The orchard with the exception of a very few trees, is in good vigor.

Plot I.—This plot consisted of six rows of trees located on the west part of the block. There were seventy-three trees, twelve being of other varieties. Nine of the Newtown trees were below average size.

Plot II.—This plot consisted of seven rows of trees on the east side of the block. There were fifty-five average sized Newtows and in addition nine bearing trees that were undersized, and three young trees.

Methods, Time and Amount of Irrigation.—In all of the irrigation experiments carried on in the Rogue River Valley during the season of 1910 we used the furrow system of irrigation, or some modification of it, the idea being to have deep rills or furrows so that the moisture could percolate through the soil from the bottoms and sides of these without spreading over the entire soil surface. The great advantage of this system over that of flooding is that it does not puddle the soil to so great an extent; also there is a much less loss of moisture by evaporation, both from the water surface while it is being applied, and from the soil afterward.

The annual rainfall of the Rogue River Valley is about 29 inches, most of which comes during the winter months. If the soil is in proper condition to receive this water, any but the very light types should with good cultivation retain a sufficient amount to supply the tree with necessary moisture for growth and fruit development up to the middle of July or the first of August. The amount of moisture contained in the
soil at this time, however, will depend largely on the nature of the soil, the cultivation, sub-irrigation and the size of the trees.

The soil in this orchard took water more freely than any other block irrigated during the season, and as there was a broad spread of water from capillarity, except during the last irrigation a plain furrow system was used. A furrow 6 to 8 inches deep was made on either side of all the rows at a distance of 6 feet from the trees, thus dividing the surface between the trees about equally. The water was delivered from a large main furrow running across the end of the orchard.

Plot I.—This plot received an irrigation of 600 gallons per tree in each of two applications, the first July 13th to 16th, and the second August 12th. The early cultivation of the entire block was very slight, and although on July 13th, the date of the first irrigation the moisture content of the soil was good it was in poor physical condition. It was impossible to get the cultivation attended to for two weeks after the water was applied. The weather at this time was very hot; there was a large loss of water by evaporation, both of that applied during the irrigation and of that already contained in the soil. At the time cultivation was finally given it was impossible to create a good soil mulch. After the second irrigation cultivation was given as soon as the soil was in proper condition to work and the moisture was fairly well conserved but we were unable to get as good a mulch as desired.

On September 12th, the date on which we had planned to give the third irrigation, the soil seemed to contain a good supply of moisture. The trees were heavily loaded, and props could
not be removed to allow furrowing without breaking off many branches. After a consultation with Mr. Andrews we decided to omit this third irrigation.

Plot II.—This plot received 1,500 gallons of water per tree at each of two irrigations, the first July 18th to 19th, and the second August 25th to 26th. In the first irrigation the plot was furrowed in the same way as described above. For the second irrigation the plot was also cross furrowed, the cross furrows being made at about six feet on either side of the trees. This threw the entire plot into a series of blocks 12x12, and 13x13 feet, giving a large furrow surface through which the soil could take up water, and also making a very even distributing system.

RESULTS IN THIS ORCHARD.

Water Temperatures.—It is interesting to note the increase in temperature of water as it flows from its source to the orchard, and the further increase as it flows down the furrows through the latter. At the Andrews' orchard the water is received from the Rogue River Valley Canal Co.'s ditch. It has flowed for many miles in an open ditch, so that it is at almost the temperature of the surface soil on reaching the orchard. The most interesting feature in connection with these temperatures is the difference in the morning and afternoon readings.

<table>
<thead>
<tr>
<th>Date</th>
<th>Weir Box Deg. F.</th>
<th>Head of Furrow Deg. F.</th>
<th>Lower End of Furrow Deg. F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-16</td>
<td>72</td>
<td>73</td>
<td>74.5</td>
</tr>
<tr>
<td>7-18</td>
<td>70</td>
<td>70</td>
<td>73</td>
</tr>
<tr>
<td>7-19</td>
<td>74.5</td>
<td>74.5</td>
<td>75</td>
</tr>
<tr>
<td>8-12</td>
<td>65</td>
<td>65</td>
<td>68</td>
</tr>
<tr>
<td>Averages</td>
<td>70.37</td>
<td>70.62</td>
<td>72.38</td>
</tr>
</tbody>
</table>

3 P. M.

<table>
<thead>
<tr>
<th>Date</th>
<th>Weir Box Deg. F.</th>
<th>Head of Furrow Deg. F.</th>
<th>Lower End of Furrow Deg. F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-16</td>
<td>84.5</td>
<td>84.5</td>
<td>86</td>
</tr>
<tr>
<td>7-18</td>
<td>87</td>
<td>87</td>
<td>84.5</td>
</tr>
<tr>
<td>7-19</td>
<td>88</td>
<td>88</td>
<td>85</td>
</tr>
<tr>
<td>8-12</td>
<td>83.5</td>
<td>84.5</td>
<td>84</td>
</tr>
<tr>
<td>Averages</td>
<td>85.75</td>
<td>86</td>
<td>84.88</td>
</tr>
<tr>
<td>Dif. in Tem.</td>
<td>15.38</td>
<td>15.38</td>
<td>12.5</td>
</tr>
</tbody>
</table>
These figures show that there was a two degrees rise in the temperature of the water in flowing from the weir box to the lower end of the furrow in the morning and in the afternoon there was an actual decrease of almost one degree. At 10 o'clock in the morning the water and surface soil were at approximately the same temperature, the soil being 0.5 degrees warmer. The temperature of the air was greater than that of the water, so in flowing very slowly down the furrow the water took up enough heat to make the two degrees rise. At 3 o'clock in the afternoon the water temperature had increased 15.38 degrees at the weir box, but the soil temperature was about the same as in the morning. The warm water flowing onto the cooler soil, shaded by the trees, was naturally cooled. It is interesting that in the afternoon the water ranged from 12.5 degrees to 15.38 degrees warmer than in the morning.

Soil Temperatures.—Considerable work was carried on to determine the effect of irrigation water on the temperature of the soil. To make these determinations borings were made before and after the various irrigations and the temperatures read at each foot.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Two Days Before Deg. F.</th>
<th>Three Days After Deg. F.</th>
<th>Difference Deg. F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>73.5</td>
<td>71</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>69</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>69</td>
<td>68</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>67</td>
<td>66.3</td>
<td>0.7</td>
</tr>
<tr>
<td>5</td>
<td>65.5</td>
<td>65.1</td>
<td>0.4</td>
</tr>
<tr>
<td>6</td>
<td>64.5</td>
<td>64.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>

It will be noted by comparing this table with the preceding one that though the water averaged warmer than the soil when applied the soil was cooled 2.5 degrees at the surface, ranging less the deeper the temperatures were read. This cooling may have been caused by evaporation.

Depth of Percolation and Spread of Water.—There is a great range in the depth to which water will percolate; also in the distance to which it will spread by capillarity. These variations are affected more by the physical composition and condition of the soil than by any other factor. In the Andrews' orchard the soil is a loose loam, and one which takes water
very readily. The water percolates through this soil much more rapidly than through the heavier soils.

The following figures show the time required and the distance water traveled through the soil of this orchard when an application of 600 gallons per tree was given August 12th:

<table>
<thead>
<tr>
<th>Hours After Irrigation</th>
<th>Side Spread</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>22 in.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>3 ft. 2 in.</td>
<td>4 ft. 2 in.</td>
</tr>
<tr>
<td>24</td>
<td>4 ft.</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>4 ft.</td>
<td>6 ft. 10 in.</td>
</tr>
</tbody>
</table>

This table shows that the side spread had reached its maximum in 24 hours. In this orchard the water undoubtedly goes down to the sandy stratum at 7\(\frac{1}{4}\) to 8 ft.

**Wood Growth.**—A majority of the soils in the Rogue River Valley under proper treatment will retain a sufficient amount of moisture for the trees to make a fair wood growth, if they are properly pruned, cultivated, and are not carrying an excessive crop.

In the orchard under investigation the trees are close together and have been bearing heavily for the past few years. They have not had much winter pruning, but have been pruned more or less in the summer. The past care of the orchard has tended to check wood growth, so that the growth this year was light.

The following figures show the average terminal growth, fruit spurs not being included in securing these figures. The growths of six average trees were taken on each plot, and the plot averages made up from these. The trees selected were under as near similar conditions as possible, and in all respects representative of the plot.

The trees on Plot I made a growth of 4.25 inches, while those on Plot II made a growth of 4.99 inches. This shows a growth of approximately three-fourths of an inch in favor of the heavier irrigated plot. Evidence is not conclusive that this variation in growth was wholly due to irrigation, but the fact that the plots had other conditions similar would indicate the results due largely to the use of water.

**Cover Crops.**—In this orchard, there was much heavier growth of natural cover crop (alfilaria and chick weed) on
Plot II than on Plot I. This is undoubtedly due to the later and heavier irrigation, which gave sufficient moisture to germinate the seed.

Effect of Irrigation on the Foliage.—On October 4th the foliage of trees on Plot I was beginning to color in many cases, and was dropping from some trees, while on Plot II, with the exception of a very few trees, it was still of good dark green color. By November 1st most of the trees on Plot I had shed a large percentage of their foliage, while there were some trees on this plot under exactly the same conditions that were still green. At this date there were a few trees on Plot II from which the leaves were falling heavily, but on most of these trees the foliage was just beginning to turn. It was very noticeable that the leaves colored, and fell much earlier from trees that had a very light crop than from those that were carrying a heavy load of fruit. This was true on both plots without regard to irrigation. Taking the whole block into consideration the heavier irrigated plot showed the drop and coloring of the foliage to be retarded by irrigation.
Effect of Irrigation on the Fruit.—In considering the relation of irrigation to the size and quality of fruit, it must be remembered that when the crop is light, the fruit will probably be better in regard to size and appearance than when the trees are overloaded. The following table shows the yield and relative grades of the fruit from the two Newton plots.

<table>
<thead>
<tr>
<th>Plot I.</th>
<th>Number of Boxes.</th>
<th>Per cent of Crop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culls</td>
<td>112</td>
<td>16.5</td>
</tr>
<tr>
<td>Windfalls</td>
<td>200</td>
<td>29.2</td>
</tr>
<tr>
<td>Packed Fruit</td>
<td>368</td>
<td>54.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>680</strong></td>
<td></td>
</tr>
<tr>
<td>Average yield per tree</td>
<td>11.3 boxes.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plot II.</th>
<th>Number of Boxes.</th>
<th>Per cent of Crop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culls</td>
<td>151</td>
<td>21.8</td>
</tr>
<tr>
<td>Windfalls</td>
<td>100</td>
<td>14.5</td>
</tr>
<tr>
<td>Packed Fruit</td>
<td>441</td>
<td>63.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>692</strong></td>
<td></td>
</tr>
<tr>
<td>Average yield per tree</td>
<td>11.5 boxes.</td>
<td></td>
</tr>
</tbody>
</table>

The culls were weighed in at 50 pounds per box, and the windfalls estimated at the same rate.

There was approximately twice as great a percentage of windfalls on the lightly irrigated plot as on Plot II. This was undoubtedly caused largely by lack of irrigation, as the exposure to the wind and other conditions were exactly the same with respect to both plots. There was a larger percentage of culls on Plot II than on Plot I. This was probably largely due to the fact that the crop was not so evenly distributed on the former plot. A few trees were so overloaded that their fruit did not make size.

There was no noticeable difference in the appearance of the two plots of this orchard up to September 15th, but at about this date the fruit of the more lightly irrigated plot fell behind in growth. During the next month its growth was very slow and there was fully twice as great a drop on this
lightly irrigated plot as on Plot II. At picking time the division between the two plots could be very easily distinguished by the difference in the amount of fruit under the trees. Although the fruit did not make the best size on either plot, this was probably partly due to the lack of proper thinning. If at least one-fourth more of the fruit had been removed at thinning time there would likely have been not only a much larger percentage of commercial fruit, but there would actually have been a greater number of boxes of first class apples.

This experiment indicates that the crop of fruit on Plot I would have been benefited by the use of more water, and while the results from Plot II were not entirely satisfactory, we believe that the amounts of water were very nearly correct, taking into account the nature of the season, and the condition of the soil.

**JUDY'S SPITZENBURG ORCHARD.**

*Exposure.*—This block slopes slightly to the north, to the east on the east side, and to the west on the west side. It is protected from strong winds on the south and southwest by hills; and to some extent on the north and northwest by oak trees and an orchard.

*Soil.*—The soil is rather heavy loam somewhat deficient in humus. There is some fine gravel in the surface soil, especially at the east side of the block. The sub-soil varies on different parts of the block, tending to be shallower at the east side. It is of a more yellowish color than the surface, and at 5½ to 6 feet there is a gravel layer that shows a slight tendency to cement.

*Trees.*—The trees were eighteen or nineteen years old; set 25x25 feet. They are headed at 18 inches to 3 feet, averaging about 2 feet, and of the open head type. They had been winter pruned annually, and had an especially heavy pruning in the winter of 1909. They were making good growth and of good color.

*The Source of Water.*—The water supply for the Judy orchard is a spring located at the south side of the tract. An excavation reservoir approximately 10 feet wide, 20 feet long
and 10 feet deep serves as a water storage. A rotary pump with a capacity of 45 gallons per minute propelled by a gasoline engine, is used for pumping the water onto the orchard. The water is carried to the high points in wooden troughs.

**Time and Amounts of Irrigation.**—The soil in this orchard being somewhat heavy and compact was rather hard to irrigate. Owing to the slowness with which the soil took up water a modification of the furrow system was used. Furrows were made on either side of the rows, at a distance of 6 feet from the trees. These furrows were connected by cross rills on either side of the trees, the first rill being about 3½ feet from the tree, and the second about 7 feet.

*Plot I.*—This plot received two irrigations of 600 gallons each per tree. The first was given July 13th to 14th, and the second August 22nd to 24th.

*Plot II.*—This plot received an irrigation of 1,000 gallons per tree July 16th to 21st, and 900 gallons per tree August 30th.

**Water Temperature.**—The temperature of the water in the spring at Mr. Judy’s remained 61 degrees all summer. During July and August the temperature of the water in flowing 200 feet through wooden troughs to the orchard was increased to 65 degrees. In flowing 300 feet through a soil furrow in the orchard the temperature was further raised to 69.5 degrees, making a total increase of 8.5 degrees.

**Soil Temperatures.**—Observations were made to determine the effect of irrigation water on the temperature of the soil.
To make these determinations borings were made before and after the various irrigations and the temperatures read at each foot.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Two Days Before</th>
<th>Three Days After</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deg. F.</td>
<td>Deg. F.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>72</td>
<td>69</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>68.5</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>69</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>69</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>66.5</td>
<td>66</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>66</td>
<td>65.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

These figures show a general decrease in the temperature of the soil after the water was applied.

*Depth and Spread of Water by Percolation.*—In this orchard the soil is medium heavy and is inclined to puddle with irrigation. This makes percolation rather slow. On the average with an application of 1,000 gallons per tree, there was a spread of moisture on either side of the furrow to a distance of 3 feet 6 inches in four days, and a percolation to a depth of 5 feet 10 inches.

*Effect on Wood Growth.*—This block was heavily winter pruned during the winter of 1909-1910. It received medium good cultivation and had a fair, but not heavy crop of fruit.

*Plot I.*—Growth of 20.6 inches (light irrigation).

*Plot II.*—Growth of 20.4 inches (heavy irrigation).

On this block there was a growth of 0.2 inches in favor of the more lightly irrigated plot. The crop per tree was practically the same on both plots. The growth though very heavy for trees twenty years of age did not seem to have been affected by the varying amounts of water.

*Foliage.*—With the exception of three or four trees the foliage of this entire block was a good deep green, the leaves being of good size indicating good vigor. There was no noticeable difference in the appearance of the foliage on the two plots of this block, until late in September when that on Plot I began to turn, while that on Plot II retained the same deep green color. By the last of October there was a noticeable difference in color of the foliage, and the number of leaves that had fallen. A greater percentage had fallen from Plot I,
and those remaining showed more autumn color than on Plot II.

Effect on Crop.—In speaking of the yield in this orchard, the fancy and choice were all packed boxes, the culls and windfalls were weighed and counted at an average of 50 pounds per box.

<table>
<thead>
<tr>
<th>PLOT I.</th>
<th>No. Boxes Fancy</th>
<th>Size</th>
<th>No. Boxes Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>80</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>88</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>96</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>104</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>112</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>125</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>135</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>150</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>165</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>175</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td></td>
<td>41</td>
</tr>
</tbody>
</table>
Culls 34 boxes—24.11%.
Windfalls 33 boxes—23.40%.
Choice 41 boxes—29.07%.
Fancy 33 boxes—23.40%.
Total boxes 141.
The average yield was 4.7 boxes per tree.

PLOT II.

<table>
<thead>
<tr>
<th>No. Boxes Fancy</th>
<th>Size</th>
<th>No. Boxes Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>64</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>72</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>80</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>88</td>
<td>19</td>
</tr>
<tr>
<td>6</td>
<td>96</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>112</td>
<td>11</td>
</tr>
<tr>
<td>—</td>
<td>125</td>
<td>3</td>
</tr>
<tr>
<td>—</td>
<td>135</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>150</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>165</td>
<td>1</td>
</tr>
<tr>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>47</td>
</tr>
</tbody>
</table>

Culls 22 boxes—16.54%.
Windfalls 28 boxes—21.05%.
Choice 47 boxes—35.33%.
Fancy 36 boxes—26.84%.
Total boxes 133.
The average yield was 4.75 boxes per tree.

It will be noticed that there was practically no difference in the yield per tree on these two plots. There was a difference in the percentage of choice and fancy, in favor of Plot II, and a larger percentage of culls and windfalls on I than II. These percentages indicate about the proper relation of the light and heavy irrigation. The large total percentage of culls and windfalls on both plots was caused to a great extent by insect injuries and a very heavy wind in August. These causes of faulty apples were the same on both plots.
The system of grading fancy and choice in the Spitzenburgs was based largely on color and freedom from blemish. Fancy were required to have 70% or more red and to be almost free from blemish while choice would run under this color percentage and have a few small blemishes.

JUDY'S NEWTOWN ORCHARD.

The general slope of this block is slightly to the north, but on the east side it dips to the east, and on the west side to the west. There is a shallow draw running to the north through the center. The block is protected from strong winds on the south, and southwest by hills, but is somewhat exposed on the north. The air drainage seems to be good.

The soil is a silt and clay loam with more or less gravel and small stone. It would be improved as an orchard soil if it contained considerably more organic matter. The sub-soil is of a more yellowish color, and contains some sand and gravel. In some places at 6 feet it shows a slight tendency to cement, while on most of the block there seems to be merely a stratum of gravel and loose stone.

The trees were eighteen or nineteen years old, and set 25x25 feet. They are headed at 18 inches to 3 feet, averaging about 2 feet. The open head system of pruning has been practiced. The trees have not received regular pruning from year to year but were heavily pruned during the year 1909-1910. The vigor varies with the individual trees, but averages good. It is probably best on Plot I and poorest on Plot IV, with Plots II and III ranging between the extremes. The size of the trees, also the crop, varies individually.

Plot I—This plot was located on the east side of the Newtown block, and had a decidedly eastern and northern slope. There was a total of thirty-six trees, four being other varieties, and four being under the average size. These four small trees about equaled two of the average size trees, so that estimates were based on a plot of thirty trees.

Plot II.—This plot consisted of forty-four trees of which thirty are average sized Newtoms; the remainder were of other varieties and undersized trees. The plot was located just west of Plot I.
Plot III.—This plot was located on the west part of the block. The soil was about the same, but for some reason the trees did not average quite so good in vigor and size as on Plot I. There were two trees of other varieties, eight small Newtows, and thirty-six of average size.

Plot IV.—This plot was used as a dry check. It was located at the southwest corner of the block, and part of it had a pronounced western exposure. It was irregular in shape, part of it being the highest portion of the entire Newton block. The soil was probably the best of the entire orchard. There were fifteen bearing Newton trees in this plot, and of these several were slightly lacking in vigor.

Methods and Time of Irrigation.—The same system of irrigation was used with the Newtown as on the Spitzenburg block. Owing to a shortage of water it was necessary to use it when it could be obtained, and in some instances the period of irrigating was extended over several days as shown by the following dates:

Plot I received 1,200 gallons per tree August 4-14.
Plot II received 865 gallons per tree July 22-27.
Plot III received 555 gallons per tree July 27-August 3.
Plot IV used as a dry check.

Effect on Wood Growth.—The trees of this block though winter pruned were not cut nearly so heavily as those of the Spitzenburg orchard. The pruning and cultivating was uniform on all parts of the block, but there was some difference in the natural vigor of trees, and the amount of fruit they were carrying. These factors should be taken into account in considering the wood growth.

Plot I, which received an irrigation of 1,200 gallons per tree made a growth of 15.11 inches. Plot III, which received 555 gallons per tree, made a growth of 12.72 inches, while Plot IV of the dry check made a growth of 6.61 inches.

The heaviest irrigated plot made the best wood growth, and at the same time carried the heaviest crop of fruit. The trees on this plot were very healthy and vigorous. The fact that they were probably slightly more vigorous than the average
tree on any other plot in a measure accounts for the growth they made.

Plot III, the lightly irrigated plot, also made a very good wood growth, but that of the dry check which is located next to this was very short and slender. The average vigor of the trees of the dry check was not of the best but the growth would without doubt have been greater had they been irrigated. From our observations of this experiment we believe the wood growth of the various plots of this block were affected to a considerable extent by irrigation.

Foliage.—On the dry check the leaves began to color and fall by September 20th. This was followed by Plots II and III, the foliage of these plots maturing about the same time. On Plot I the foliage remained green much later than on other plots, and had not all fallen late in November. The maturity
of the wood and foliage on this block seemed to be affected to a greater or less extent by irrigation.

There is little doubt but that it was the supply of soil moisture that caused the trees to keep the color and hold their leaves so late in the season.

Effect on Crop.—An interesting feature in connection with the four Newtown plots is in regard to the sizes of the packed fruit.

Plot I, heavy irrigated, average 96-112.
Plot II, medium irrigated, average 112.
Plot III, lightly irrigated, average 125.
Plot IV, dry check, average 125-135.

In regard to percentage of windfalls and small apples there was not as much difference between the various irrigated plots, but all averaged better than the dry check. The crop was not uniform as the number of boxes of packed apples shows. Plot I averaged 8.16 boxes per tree; Plots II and III, 4.25 boxes per tree; and Plot IV, the dry check, 2.66 boxes.

TALENT ORCHARD—NEWTOWN BLOCK.

Exposure.—This Newtown block of the Talent Orchard Company's holdings has a gentle northern slope shading almost to a level at the north end. The orchard is somewhat protected by hills but these are at a distance so the air circulation is satisfactory. Though not tiled the water drainage is good.

Soil.—The soil is a silt clay loam containing more or less gravel. There are some slight variations in its depth and physical composition in various parts of this block. The plots were so arranged that they would contain approximately the same percentages of the various soil types.

Plot I.—This plot was located on the north end of the block and contained one hundred and three trees.

Plot II.—This plot was located on the south end of the block and contained one hundred and twenty-five trees, of which one hundred and twenty were in bearing.

Plot III.—This plot, the dry check, was located on the east side of the block, and contained eighteen trees, of which number seventeen were Newtowns.
System of Irrigation and Amounts of Water Used.—The
plain furrow system of irrigation was used in this orchard as
described above for Mr. Andrews' orchard.
Plot I received 600 gallons per tree July 31st to August 1st,
and a similar amount August 22nd to 24th. Plot II received
an application of 1,200 gallons per tree July 29th to 31st, and
a 1,000 gallon application per tree August 19th to 22nd.

Water Temperatures.—At the Talent orchard the water
came from an artesian well and averaged 65 degrees, or four
degrees warmer than at the spring on the Judy orchard men-
tioned above. An interesting observation made here was in
regard to the relative temperature of the water in the morning
and afternoon. The averages during July and August were:
At 10:30 A. M., at well 65 degrees; head of furrow 66.5
degrees; lower end of furrow 69 degrees.
At 3:30 P. M., at well 65 degrees; head of furrow 69 degrees;
lower end of furrow 72.5 degrees.

This shows that the water remained at a constant temper-
areture in the well during the day and that there was a rise of
2.5 degrees in the afternoon over the morning temperature
after a flow of a distance of 300 feet in a wooden trough, and
3.5 degrees increase in the afternoon where the flow was in
the furrow. The total averages of the morning and afternoon
gains were 2.75 degrees at the head of the furrow and 5.75
degrees at the lower end of the furrow. Though the distances
were greater here than in the Judy orchard there was a smaller
increase in temperature probably due to the fact that the
water was 4 degrees warmer in the well than in the Judy
spring.

The following table shows the influence of irrigation water
on soil temperature at this orchard:

<table>
<thead>
<tr>
<th>Feet</th>
<th>Three Days Before Deg. F.</th>
<th>Two Days After Deg. F.</th>
<th>Difference Deg. F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>73</td>
<td>70.5</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>70.5</td>
<td>69.5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>68.5</td>
<td>68.5</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>66.5</td>
<td>66.5</td>
<td>0</td>
</tr>
</tbody>
</table>
As shown by this table there was, after irrigation a decrease in soil temperature in the first two feet and in the third and fourth feet the temperature remained unchanged. This was the only case during the season where there was not a continuous decrease in temperature to a depth of 6 feet.

The wood growth was very good for mature Newtown trees, but seemed to be affected more by the variations in soil than by irrigation. The following measurements are the averages from ten trees on representative parts of each plot:

- Plot II, heavily irrigated, 12.88 inches.
- Plot I, lightly irrigated, 12.15 inches.
- Plot III, dry check, 9.96 inches.

The above shows there was very little difference in the amount of growth on the two irrigated plots while both were better than the dry check. Unfortunately it was necessary to locate the dry check on soil that was not quite so retentive of moisture as the average of the other two plots. If the soil conditions had been identical with the other plots there might not have been the difference indicated in the above table.

*Effect on Fruit.*—The crop was comparatively light on all plots of this orchard and practically all the fruit made packing size. A close examination of the fruit at picking time showed no marked difference in color, size, or quality, that could be attributed to irrigation. The fruit of the dry check ripened a little earlier and possibly had a little more intense color than the average of the other plots, but not more so than from trees on similar soils of Plots I and II.

**WORK OF 1911.**

Owing to the light apple crop prevailing throughout the Rogue River Valley during the season of 1911 our irrigation work for this year was not conducted in as many orchards as in the preceding year. The experiments were conducted on the Spitzenburg and Newtown apple blocks and the Winter Nelis pear block of the Judy orchard now owned by Mr. T. Heimroth. The Newtown block is the same as used in 1910 but during 1911 we experimented with the entire Spitzenburg and Winter Nelis blocks.
EXPERIMENTS ON SPITZENBURG BLOCKS.

The Spitzenburg trees received a rather heavy winter pruning and with the exception of a few scattering trees were in very good vigor in July when this Station took charge of the experiments. As in previous years the soil was rather low in organic matter, but had been well handled and there was a good moisture retaining mulch. Although the mulch was very good at this time there had been some loss of moisture, owing to the very drying wind just before and at the time of spring plowing. The orchard was divided into three plots for irrigation, leaving two representative plots for dry checks. Two of the irrigated plots were the same as the plots used the previous year. Plot I consisted of thirty-seven trees and received two irrigations; the first of 600 gallons per tree July 12th to 14th and the second 420 gallons per tree August 17th to 19th. Plot II consisted of twenty-nine trees and received 800 gallons per tree July 14th to 17th and 600 gallons per tree July 21st to 24th. These represent the two plots receiving light and heavy irrigations during the season of 1910 and are described in detail in notes of that year.

Plot III included the entire Spitzenburg block forming the east part of the orchard. The soil of this block is a little lighter in texture and contains more gravel than that of the other plots, and is also low in humus. The trees were of the same age and general character as those described for the other plots, but did not seem to be in quite as vigorous condition. The plot contained one hundred and ten trees and received one irrigation of 700 gallons per tree July 24th to 31st.

Methods of Irrigation.—The combination of furrow and rill system of irrigation used in the orchard in 1910 and described on page 27 was found to be unsatisfactory in several respects, as it necessitated a considerable amount of labor in preparing the furrows and did not give an even distribution of water throughout the soil. A different system was therefore tried in 1911. Percolation of water through soils of this type is very slow and it has been our experience that the best way to get an economical distribution is to use some system with deep furrows near together where the water may be held in
small checks until it soaks into the soil and down to the feeding area of the roots. Six furrows were made between each two rows of trees; each of these furrows extended the entire length of the plot and they were about 4 feet apart. They were made with an ordinary breaking plow and cut to a depth of about 6 inches. The water was received from an iron pipe at the upper end of the furrows and allowed to flow to the lower end. Then a series of check dams were put across the furrows, beginning at the lower end. As soon as a furrow was filled to the top of the dam another would be put in farther up the furrow to shut off the flow of water into the check. These check dams ranged, in distance apart, from 8 to 15 feet according to the slope of the land. This system gave a very even distribution of water over the soil and made it comparatively easy to prevent flooding although it required a considerable amount of hand labor to put in the check dams. We found the best results were obtained by limiting the flow per furrow to a two inch stream. This gives the water a better chance to soak into the soil as it flows down the furrows and also gives more time in handling water in the checks.

Cultivation.—From the time of plowing in the spring the cultivation of the orchard was well handled. The plowing in the spring, however, was possibly a little late and there was more or less moisture lost through evaporation at that time, the ground being rather dry and cloddy when broken up. This soil was put in shape by rolling with a brillion and by the use of spring tooth and smoothing harrow. Before the irrigation was started there was a very good mulch on the orchard. This mulch was medium fine and 3 or 4 inches deep. After each irrigation the furrows were filled and levelled as soon as possible by means of a team and spring tooth. The soil mulch maintained throughout the season was as good as could be desired.

Object of the Experiments.—The primary object of the Spitzenburg irrigation for 1911 was to find the relation of irrigation to the set and development of fruit buds for the crop of 1912. However, a few interesting features in connection
with the season's crop came to notice. Even in a comparatively light year as was 1911 with a yield of but 4 to 5 boxes per tree there was a noticeable influence on the size of fruit but the difference was not so marked in relation to color. Of the total crop produced by Plot II which received 1,400 gallons of water in two applications, there was 14.82% more commercial fruit than on the average of the dry checks. Another interesting feature was the effect of the previous year's irrigation. In 1909 the Spitzenburg plots numbers I and II received practically the same amount of water and in 1910 though the amounts of water were varied as before stated in this bulletin the average yield per tree was the same, varying only 0.05 of a box. In 1910 plot I received 1,200 gallons per tree and plot II 1,900 gallons per tree. The effect was shown in the 1911 crop. The two plots side by side on similar soil with the same exposure, cultivation and pruning showed a difference in the crop. The lightly irrigated plot produced 226 pounds (about 4½ boxes) per tree and the heavily irrigated plot 246 pounds (about 5 boxes) per tree. The wood growth of the trees did not seem to be affected to any great extent by irrigation. As they were all very heavily pruned they made very heavy wood growth and it appeared in November that this growth had been made partly at the expense of fruit buds for the coming year.

**IRRIGATION OF THE NEWTOWN ORCHARD.**

Our experiments were conducted on the same block of Newtowns in 1911 as used at this orchard in 1910. This block was described in last year's notes as being on a medium clay loam which ran rather low in organic matter. The general exposure of this orchard is slightly to the north, dipping to the east on the east side and to the west on the west. The slope at these two sides of the orchard is rather steep for irrigation but by proper methods the water can be controlled without much trouble. The trees of this block were fairly vigorous; however, those on the western part were not in quite as good health and vigor as those on the east. Two plots were irrigated in this block of trees and a small plot left as a dry check. Plot I consisted of eighty-five trees at the east side of the
orchard. These trees averaged in very good condition throughout the season. They were given two irrigations of 400 gallons each, the first application being August 1st to 7th and the second August 25th to 31st. This water was applied by the same method as above described for Spitzenburg blocks of the Heimroth orchard. At the time of the second irrigation the moisture content of the soil was good because of the previous irrigation and after the second irrigation the moisture held up in very good shape throughout the remainder of the season. Plot II consisted of eighty trees in the west portion of the block. These trees, as noted above, though very good on the average contained a number which were more or less affected with "little leaf" and consequently were not in as good condition for crop production as the average trees on the irrigated plots. These trees were irrigated by the same system as used elsewhere in the orchard.

The crop of Plot II averaged $8\frac{1}{3}$ boxes per tree of which 65 per cent were packed and of the remaining 35 per cent more than half were of commercial size, but owing to calyx cracks, stem punctures, and other imperfections of varying nature, they had to be thrown out as culls. Had the trees of this plot been in as good physical condition as those of Plot I they probably would have brought up the average yield to about 10 boxes per tree and possibly these apples would have been of a little better size. The crop on Plot I, the heavier irrigated plot, averaged 11.15 boxes per tree of which 77.02 per cent were packed and of the remaining 23 per cent about two-thirds were of commercial size but were thrown out for reasons mentioned above. The dry check trees were not so vigorous on the average early in the season as those of the two irrigated plots but so far as the trees themselves were concerned were in fair condition at all times. However, the crop of these trees was very light, the yield being but $3\frac{1}{3}$ boxes per tree and of this amount only 20 per cent could be packed. Of the 80 per cent which were not of packing quality more than three-fourths were under size.

The wood growth on both the irrigated plots was very heavy for mature Newtown trees carrying a full crop of apples.
That of the plot receiving two applications was somewhat greater than that of the more lightly irrigated plot. This greater wood growth of Plot I was probably influenced to some extent by the slightly better physical condition of the trees but the fact of its having better soil moisture throughout the season undoubtedly had something to do with the more vigorous growth. The growth on the dry check was about one-half to two-thirds that of the more lightly irrigated block.

Had there been more water available at all times throughout the irrigation season some of the blocks would have received more water. This is especially true in the case of the Spitzenburgs and we are led to believe from the results of 1910 and those of 1911 that on soils of this type, for mature trees carrying a full crop of fruit and under the usual climatic conditions of the Rogue River Valley better results can be obtained by about two irrigations of 800 or 1000 gallons each,
these to be given about July 15th to 30th and August 15th to 30th.

WINTER NELIS BLOCK.

The Winter Nelis block is located between Plots I and III of the Spitzenburgs. There is a gradual slope toward this block from the east and west, forming a slight draw with a gentle slope to the north. In character the soil is similar to that of Spitzenburg Plot III. The plot for irrigation consisted of fifty-three trees, all mature, and with very few exceptions, in good vigor. Two irrigations were given, the first of 500 gallons per tree July 20th to 23rd, the second 450 gallons August 14th to 17th. The furrow system of applying the water was used as in other parts of this orchard.

Up to August 20th the trees were in fine condition, with a good crop of fruit making fine size. At this time there was a very slight drop of fruit. In most cases this fruit was of good size for the season but almost without exception was seedless though this latter result was due to causes other than irrigation. By September 5th the fruit on a few trees was much under size for that time of the year and the crop in general though doing fairly well was not coming up to expectations in regard to size. There was no time during the season when this plot did not seem to have a sufficient amount of soil moisture, so we do not think this failing to make large size, entirely due to lack of moisture. The crop was packed as follows:

<table>
<thead>
<tr>
<th>4 tier, 12 half boxes</th>
<th>6 boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 tier</td>
<td>85 &quot;</td>
</tr>
<tr>
<td>6 tier</td>
<td>131 &quot;</td>
</tr>
<tr>
<td>Under size, shuffle pack</td>
<td>110 &quot;</td>
</tr>
</tbody>
</table>

Total ........................................ 332 "

Average yield per tree 6.26 boxes.

The dry check of this plot is located just north of the part irrigated. Unfortunately it did not receive quite as careful cultivation as the main block and this may partly account for
the small percentage of large fruit. The yield per tree was not far from the same as on the irrigated plot but none of the fruit went over six tier size, and 75 per cent of the total crop was so small it went into the shuffle pack.

THE EFFECT OF IRRIGATION ON THE CHEMICAL COMPOSITION OF THE APPLE.

To assist in determining the benefit or detriment of irrigation with respect to the development of the fruit itself, it was deemed advisable to study the effect of irrigation on the chemical composition of the apple. In 1910, the problem was outlined in cooperation with Professor Bradley, Chemist for the Oregon Agricultural Experiment Station.

Fruit was taken for analysis at intervals of 15 or 20 days during the period of maturation, beginning September 1st. The fruit for samples was selected from various locations on a number of trees on irrigated plots and dry checks at the Andrews and Judy orchards. When samples were taken, they were immediately wrapped, packed and shipped to the laboratory where analysis was started at once, leaving as little chance as possible for a change to take place in the fruit after being picked.

Professor H. V. Tartar assumed charge of the work in 1911. He worked along the lines suggested in the outline of the preceding year but on a broader basis. Analyses have been made at intervals of four weeks during the winter of 1911-1912 to show the relative chemical changes in irrigated and nonirrigated apples during the storage period. This investigation is to be continued for a period of years and there will be a specific publication on the work at a future time.

SUMMARY.

1. Irrigation aided in giving a larger percentage of fruit that came up to good packing size. There was a smaller percentage of undersized culls on the irrigated than on the nonirrigated plots.

2. By irrigation we were able to reduce the percentage of windfalls. The saving at times amounted to as high as 15 per cent of the crop.
3. The shape of the fruit can be materially changed by irrigation, the moisture thus gained having a tendency to cause the fruit to be more angular and elongated. This same tendency has been secured with Newtwons in our experiments in the home orchard at Corvallis. The apples receiving the best care were more elongated and angular, while those that suffered through lack of moisture had a tendency to become flat.

4. Some influence was noted on color. This was especially true on the lighter soils where red apples were grown. The irrigated apples had a brighter, more attractive color, while those grown on the checks were duller yet deeper in color.

5. 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.

6. Unless the trees have been vigorously pruned irrigation has a tendency to produce more wood growth even on trees that are heavily loaded with fruit. This increase at times is as much as 12 inches.

7. There were less culls on irrigated plots than on the dry checks owing to less calyx cracking. This cracking is probably due to the fact that the fruit hangs on the trees too long, the fruit on the dry check maturing earlier than that on the irrigated plots. The fact that irrigation had a tendency to cause the apples to mature somewhat later meant that the irrigated fruit was in somewhat better condition at picking time than that on the dry checks which was slightly past the proper stage.

8. Irrigation tends to keep the leaves of the trees green later in the fall and it also tends to cause the leaves to hang longer on the trees. In most cases there is a tendency to keep both wood and foliage more active in the fall than where no irrigation is given.

9. By means of irrigation a much better stand of cover crop can be secured in late summer and early fall.

10. Irrigation practices in the Rogue River Valley will vary according to the soil, the kind of fruit grown and the age of the trees. The time, the amount, and the methods of irrigation will vary according to these above-mentioned conditions.
11. Some of the heavier types 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. The lighter types of soil under ordinary circumstances show that a considerable amount of irrigation is necessary for the production of commercial fruit on heavily bearing trees. Best results have been obtained on the pumice soils by the use of about 3,500 gallons of water per tree. This quantity should be distributed in equal amounts through three irrigations, one each in June, July and August. The orchard contained Winesaps from eight to ten years of age. Best results were obtained on these soils by allowing a very small stream to flow down the furrow, increasing the amount up to four inches per furrow as soon as the soil began to take up the water.

12. Experiments were conducted with nineteen-years-old Spitzenburgs and Newtowns on soils which are locally termed free soil. When these soils are properly cultivated they respond best with irrigation to the amount of from 2,400 to 3,000 gallons per tree. This water should be divided about equally in two irrigations, one in July and one in August. This type of soil especially if low in organic matter takes water very slowly. To get a quick and even distribution of water through the soil it is necessary to have a large number of furrows with a small amount of water in each.

13. From experiments conducted with ten-years-old Newtowns on a soil which varies from a medium to slightly heavy texture such as some of the Bear Creek Bottoms, good results were obtained from applying 1,600 to 2,000 gallons per tree, divided equally in two irrigations, the first to begin the fore part of July and the second the middle to the latter part of August. If the moisture has been conserved early in the season and the trees are not carrying a heavy crop one application of 1,200 gallons given the latter part of July or the early part of August should give good results. This type of soil takes up water freely and a comparatively large head per furrow may be used.

14. When Bartlett pear trees from seven to eight 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.

15. The use of an excessive amount of cold water in the irrigation of pear trees on sticky soils is a questionable practice. It did not increase the size or quality and the result on the tree was detrimental rather than beneficial.

16. Experiments were conducted with Winter Nelis, d'Anjou and Bartlett pear trees eighteen 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 non-irrigated plot, showing that irrigation cannot be made to make up for poor quality of soil.

17. Cultivation is a most important feature to be considered in connection with irrigation. With thorough cultivation early in the spring and the maintenance of a good soil mulch during the season the soil will be in better condition to receive water when needed. Irrigation should merely supplement good tillage and the importance of thorough tillage during the season cannot be over estimated.

18. Over irrigation though not a common practice in the Rogue River Valley should be avoided. The presence of a large amount of water in the soil excludes a proper amount of air, leaches out plant food and injures the physical condition of the soil. All of these features are detrimental to the tree and its fruit.

19. Good drainage either natural or artificial is necessary in order to secure the best results from irrigation. Where drainage is poor the seepage of irrigation waters from the higher levels to lower has a tendency to waterlog and sour the soil.

20. Where well water was used for irrigation we found the temperature to remain constant throughout the season. However, the temperature of the water was increased in flowing in open furrows from the well to the point of distribution and further increased while passing through the distribution rills. In some cases this increase was as much as 8½
degrees. There was a much greater increase in the temperature in the afternoon than in the forenoon.

21. When water was used from an irrigation ditch as in the case of the Fish Lake Ditch, during the months of July and August, the water was found to be at the same temperature as the soil early in the morning, but the temperature of the water was greatly increased in the afternoon. In some cases it was increased 15 1/2 degrees over the morning temperature.

22. In cases when the temperature of the water when it reached the orchard was higher than that of the soil there was a slight decrease in the temperature of the water as it flowed through the distribution furrows when these furrows were located under the shade of the trees.

23. In all cases when temperatures were read it was found that the soil had decreased in temperature immediately following irrigation. The decrease was more noticeable in the surface soil than at a greater depth. In some instances there was as much as three degrees difference in temperature in the first foot, and this difference gradually decreased to 0.25 degrees at six feet and in some cases soil temperatures remained constant at a depth of three feet and below.