STATION BULLETIN 347 JUNE 1936

Influences of Irrigation Upon Important Small Fruits

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SUMMARY

Results of a 10-year experiment with irrigation for loganberries, Evergreen blackberries, certain varieties of red raspberries, black raspberries, and strawberries are presented in this bulletin. In the experiment comparisons were made between irrigated and unirrigated small fruits, the following factors being taken into consideration: 1. Yields. 2. Quality. 3. Costs of production and harvesting. 4. Gross income. 5. Net profits.

Due to damage by insects and disease, the experiment with red raspberries and black raspberries did not yield dependable results after the fifth year.

Rainfall for the five growing months, April to August inclusive, was below average for each of the 10 years, though only slightly in some seasons. Summer temperatures were well suited for growth and production throughout the experimental period.

Soils used were of the Chehalis and Newberg series of sandy loam and loam that is well suited to irrigation. More than 300,000 acres of these types of river bottom land are to be found in Oregon.

The cost for labor and power was relatively high during the experiment due to the fact that the pumping plant was not used to its full capacity. A further saving could have been made if it had been possible to use a stove-pipe type of drilled well, thus saving the cost of digging, cribbing, and cementing the pit.

On the soil type used, applications of water at depths of 18 to 24 inches appear desirable for brambles, with slightly smaller amounts sufficient for strawberries, due to earlier fruiting.

During the first 5 years of the experiment, prices for berries were relatively good, but during the financial depression which continued during the second half of the experiment prices frequently were lower than the cost of production. In the first period the larger the yields of good quality the greater the profits; in the second period the larger yields sometimes gave the greater losses. Yields were stressed for the initial period and economy of operations, the most important factor in farm management during the second half of the experiment, received primary attention for that period.

EVERGREEN BLACKBERRIES

It cost approximately $300 and $235 an acre respectively, to bring irrigated and unirrigated Evergreen blackberries into bearing with relatively high labor and equipment costs.

The highest net profit from Evergreen blackberries ($415.42) came in 1930 when the heaviest yield per acre was coupled with the good price of 5¢ a pound. The excellent yield of 1932 showed the greatest loss per acre ($246.21) due to the lowest price received during the decade—1¢ per pound.

SUMMARY—*Continued*

Irrigation made possible the highest average net profit ($120.76) per acre during the first 3-year bearing period and contributed to the greatest average loss ($104.50) during the succeeding 5-year period.

Irrigation causes Evergreen blackberries to ripen somewhat earlier than unirrigated berries; bear larger fruit in dry seasons than the unirrigated canes; and in dry summers to develop a considerably improved grade of fresh blackberries.

Both the acid and the sugar content of unirrigated berries were slightly higher than those of irrigated berries but not enough greater to be noticeable to the taste.

"Drip" tests of canned Evergreen blackberries indicate no material difference in the "holding-up" qualities of irrigated and unirrigated berries in the can.

Irrigated blackberries are more inviting for the fresh fruit trade than the unirrigated fruits because the druplets are plumper and more glistening.

LOGANBERRIES

The cost of establishing loganberries was only about $30 more per acre for the irrigated than for the unirrigated plants. Loganberries bore a crop the second year after planting.

The loganberry canes were severely injured by winter kill in 1930 and 1933, the entire crop being lost in 1930. Fortunately the crowns of the plants were not severely injured.

Owing to higher costs of labor and heavier applications of fertilizers, the average cost per pound to produce the fruit was considerably higher for the first 5-year period than for the second 5-year period. Profits, however, were greater in the first period because prices received were considerably higher than in the second period.

Irrigated loganberries pruned full-length averaged 36 per cent larger yield and 52 per cent larger gross income than irrigated vines pruned very short—six feet. Under normal economic conditions the net profit would be five times greater with long pruning.

Irrigation appears to be unprofitable with short six-foot pruning.

Contrasts between the extremes of short-pruned unirrigated and full length irrigated canes showed an increase per acre in gross income of approximately $100 in favor of the latter method. This represents what growers may expect to gain in many instances by a change in their production methods.

Size of loganberries grown on short-pruned canes will average as large in years of normal rainfall as irrigated fruit, but in dry seasons the irrigated berries show considerable advantage in size.

No substantial differences in grade are shown between irrigated loganberries and short-pruned unirrigated loganberries.

SUMMARY—*Continued*

Chemical analyses showed no significant differences in acid or sugar content of the irrigated and unirrigated fruit.

In canned loganberries the unirrigated fruit showed a slightly higher per cent of solids than the irrigated but not enough to make any difference in the appearance of the contents of the can.

Irrigated loganberries show a brighter, snappier red color, which makes them more attractive for marketing fresh.

STRAWBERRIES

It cost $50 more per acre to establish and to bring into bearing irrigated strawberries than unirrigated.

During the experiment records were kept on the Marshall, Ettersburg 121, Narcissa, and Corvallis varieties. All varieties showed an increase in yields under irrigation except the Ettersburg 121.

Irrigation slightly delays the time of picking strawberries.

Strawberries, except Ettersburg 121, showed a profit each production year, due largely to the fact that prices received for the fruit, although sometimes low, always were a little higher than the cost per pound.

Irrigated strawberries will average from 25 to 100 per cent larger in size than unirrigated, depending upon the season. Irrigation also has a pronounced influence on the grades of strawberries. A substantial increase of 5 to 36 per cent in No. 1's with a corresponding decrease in culls resulted from irrigation.

Use of water resulted in no noticeable difference in the acid content of the fruit for any of the varieties tested. Sugars were slightly greater in unirrigated Marshall and Corvallis varieties than in the irrigated. The reverse was true of the Narcissa.

"Drip" tests for irrigated and unirrigated fruits showed no material difference in the solids of the canned stock.

Irrigated strawberries were superior in attractive red color, size, and smoothness.

Irrigation, as employed under the conditions of this experiment, caused average gains in yields as follows: Evergreen blackberries, 36.3; loganberries, 58.4; strawberries, 91.5; red raspberries, 58.4; and black raspberries, 110.5 per cent.

Black raspberries on the average failed to make profits, either with or without irrigation, during the period of good prices. Evergreen blackberries and loganberries made good net profits before the depression, but lost heavily enough during the last 5 years to show an average net loss for the entire period of the experiment. Red raspberries more than doubled their net income by the use of irrigation and made very satisfactory returns when prices were good. Strawberries consistently made money throughout the entire experiment, use of water doubling the net profits per acre.

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W. S. Brown

INTRODUCTION

This bulletin presents the results of a 10-year experiment, 1926 to 1935, conducted at Corvallis to determine the practicability of irrigating small fruits under the soil and climatic conditions of the Willamette Valley in Western Oregon. A preliminary report covering results for the first five years was published in 1931.[1] It has been estimated there are approximately half a million acres of free working soil suitable for irrigation in the Willamette Valley.[2] The soil types best adapted to irrigation are the Newberg and Chehalis series found along the bottoms of the Willamette River and several of its tributaries and the lighter types of soils on the valley floor, such as the Willamette loam or silt loam.

This bulletin covers the findings of the experimental work upon certain small fruits with reference to such factors as soils and water supply, yields of fruit, quality, costs of production and harvesting, and net profits. It aims to show (1) the influence of climatic factors such as rainfall and temperature upon the practice and necessity of irrigation, (2) differences in amounts of water applied as such different amounts affect yields and profits, (3) the effect of different amounts of pruning upon yields, (4) the differences in net profits during the first 5-year period of good prices contrasted with net loss in some cases during the second 5-year period when low prices prevailed, and (5) the influence of irrigation upon the quality of the fruit.

Rainfall and temperatures. During the entire 10-year period of the experiment the rainfall for the five months of active plant growth, April to August inclusive, has been below average with the exception of that of 1932, which practically equaled the average. For this reason it may be concluded that irrigation may have had more than an average chance to show beneficial results. Even in 1932, however, rainfall (Table 1) was light in June and July and seldom is there a summer that gives all the timely rainfall needed for maximum production.

As shown in Table 2, the spring and summer temperatures are quite even and well suited for growth. In no case did any serious loss result during the last five years of the experiment from fruit scalding on the vines. When moisture is present in sufficient amounts the climate may be considered almost ideal for small fruit production.

[1]Schuster, C. E., Besse, R. S., Rygg, G. L., and Powers, W. L. Preliminary Report on Effect of Irrigation on Major Berry Crops in the Willamette Valley. Ore. Expt. Sta. Bul. 277. 1931.

[2]Powers, W. L. The Economic Limit of Pumping for Irrigation. Ore. Expt. Sta. Bul. 235. 1928.

Table 1. ACTUAL AND NORMAL PRECIPITATION DURING 10 GROWING SEASONS, 1926-1935

Month	Average for five years 1926-1930[1]	Average normal for 41 years	Second 5-year period 1931-1935					Average for five years 1931-1935	Average normal for 46 years
			1931	1932	1933	1934	1935		
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
April	2.70	2.70	1.28	2.36	.76	1.94	2.00	1.67	2.59
May	1.13	1.88	.19	2.24	3.70	1.28	.52	1.59	1.85
June	1.03	1.15	3.35	.24	.84	.24	.21	.98	1.13
July	.01	.30	T.	.61	.00	.26	.51	.28	.30
August	.38	.42	.00	.83	.69	.10	.10	.34	.42
Total	5.25	6.45	4.82	6.28	5.99	3.82	3.34	4.86	6.29

[1] Station Bulletin 277 for complete yearly record.

Table 2. MONTHLY MEAN TEMPERATURES AND DEPARTURES FROM NORMAL TEMPERATURES, 1931-1935

Month	Monthly mean and departure						Normal monthly mean for 46 years
	1931	1932	1933	1934	1935	Average	
	Degrees	*Degrees*	*Degrees*	*Degrees*	*Degrees*	*Degrees*	
April							
Mean	55.3	51.3	51.6	55.8	50.5	52.9	50.3
Departure	+5.0	+1.0	+1.3	+5.4	+0.1	+2.6	.....
May							
Mean	61.3	56.1	52.0	58.3	55.9	56.7	55.2
Departure	+6.1	+0.8	—3.2	+3.1	+0.6	+1.5	.....
June							
Mean	62.0	64.8	60.8	61.4	63.4	62.5	60.5
Departure	+1.6	+4.3	+0.3	+0.8	+2.8	+2.0	.....
July							
Mean	69.3	63.8	67.2	65.0	66.2	66.3	65.7
Departure	+3.6	—1.9	+1.5	—0.7	+0.5	+0.6	.....
August							
Mean	68.1	67.6	68.3	66.8	68.4	67.8	65.9
Departure	+2.2	+1.7	+2.3	+0.8	+2.4	+1.9	.....

History. Approximately 40 years ago Mr. Frank Chase of Eugene commenced irrigating small fruits and vegetables in a limited way. A few other farmers tried irrigation upon fruit and farm crops to supplement the natural rainfall.[1] The Oregon Agricultural Experiment Station began in 1907 to study the value of supplemental irrigation upon pastures and field crops. California has irrigated small fruits for many years and in 1916 the California Agricultural Experiment Station published an excellent circular upon the different practices used in the irrigation of small fruits.[2]

The effect of irrigation in the Willamette Valley upon such factors as yields, quality, costs, and profit or loss was not known at the time the Oregon experimental project began in 1926.

[1] Powers, W. L. Twenty-five Years of Supplemental Irrigation Investigations in the Willamette Valley. Ore. Expt. Sta. Bul. 302. 1932.
[2] Hutchins, Wells A. Irrigation Practice in Growing Small Fruits in California. Cal. Expt. Sta. Circ. 154. 1916.

OUTLINE OF THE EXPERIMENT

Soil used. For the purpose of testing the effects of irrigation upon small fruits, the Oregon Agricultural Experiment Station in cooperation with the Oregon Committee on the Relation of Electricity to Agriculture established an irrigation experiment on river bottom land near Corvallis in 1926. The soils of this location are known as the Chehalis and Newberg series, of which there are approximately 300,000 acres in the state. The soils are rather open, friable, and loamy, with Chehalis having finer and Newberg coarser subsoil. They may be underlaid with gravel at varying depths and their texture and natural drainage make them well suited for irrigation.

Where possible it is best to level the soil and irrigate by surface ditches, but many of the Newberg soils are too rolling to make this type of irrigation feasible. Where flood irrigation cannot be used some other method may be necessary in applying the water. Water from ditches or furrows was used in this experiment to flood the land.

When leveling the experimental tract care was exercised to prevent the removal of too much of the top soil on the high spots which would leave the less fertile soil too near the surface. The farm had been seeded to grain crops for several years before being used for the experiment and it had not been fertilized immediately before being set to small fruits. Annual applications of manure, however, ranging from 10 to 20 loads per acre, were applied from the start of the experiment through 1932, economic conditions forcing suspension of the practice for the final three years.

Arrangement of plots. Six acres were used during the first five years of the experiment. Later this acreage was reduced when the red raspberries and the black raspberries were removed because of serious attacks from crown borers and verticillium wilt disease. The original layout included strawberries, Evergreen blackberries, loganberries, red and black raspberries.

Each plot of cane fruit comprising 22/100 of an acre consisted of four rows, nine feet apart, and 264 feet long. The distance apart in the row varied for each kind of fruit, black raspberries being set four feet apart; red raspberries, 30 inches; loganberries, nine feet; and Evergreen blackberries, 15 feet.

Strawberries at first were set on a 3-foot square but that spacing did not give enough plants per acre under irrigation, so the different varieties were allowed to make matted rows. It was found that three feet between the rows was not distance enough for matted rows under irrigation. A later planting was made with rows 42 inches apart and plants 15 inches apart in the row for irrigated berries. Unirrigated fruit was set on a 3-foot square. During the last two years of fruiting, irrigated strawberries were planted in matted rows approximately 15 inches wide with about 27 inches of open space between rows. The unirrigated strawberries required careful cultivation and hoeing and as a result had to be set on a 3-foot square.

Irrigated and unirrigated plots were separated by guard rows, the space being 18 feet between the brambles and about 15 feet between irrigated and unirrigated strawberries. From borings made in the soil, it is

believed that no appreciable side movement of water from irrigated to unirrigated plots occurred, though it may be possible that water in small amounts could have traveled laterally through an occasional mole hole.

The spring of 1926 was very early and dry. Loganberry plants dried out and perished before the irrigation system was ready to deliver water, and unirrigated strawberries failed to survive. These failures were not charged against the project, however, because they would not normally occur.

During the planting, bringing into bearing, and the production periods, careful accounts of all labor, materials and supplies, power, interest and depreciation have been kept for all these fruits. This practice was followed throughout the entire 10-year period.

IRRIGATION EQUIPMENT AND PRACTICE

The irrigation well. A well pit 6 by 8 feet was dug 20 feet deep and two 30-foot holes eight inches in diameter were drilled in the bottom of this pit. A pumping unit consisting of a five-inch centrifugal pump, connected directly to a 10 horsepower motor, was placed in this well 18 feet below the surface of the ground.

Cost of well and irrigation equipment. In the set-up for irrigation the cost of digging the well, purchasing and installing equipment, and installing the distribution system were computed.

Table 3. COST OF WELL AND IRRIGATION EQUIPMENT

Items	Cost
Well	
Digging and cribbing well pit (6x8x20 feet)	$ 483.89
Drilling and casing two 30-foot holes, eight inches in diameter at bottom of pit (casing perforated)	341.30
Cementing walls of well pit	311.38
Pumping Unit	
10 horsepower motor and five-inch Fairbanks-Morse pump	440.00
Fittings and installation	497.84
Distribution System	
Concrete pipes, valves, standpipes, field laterals, and installation	599.59
Total	$ 2,674.00

If a stove-pipe type of well driller with an 18-inch diameter had been available, a deep-well type of turbine pump would have been used with the motor set above high water. The operation would thus have been simplified and priming eliminated. The cost of digging, cribbing, and cementing the well pit also would have been eliminated.

Investment per acre in irrigation system and farm equipment. The average investment for the first five years of the experiment amounted to $151.85 per acre for the irrigated plots and $7 an acre for the unirrigated plots (Station Bulletin 277). This bulletin, "Effect of Irrigation on Major Berry Crops," is a preliminary report on the first 5-year period of this experiment.

During the second period the cost for the irrigated plots dropped to $132.36, due to the fact that during this time the amount of land irri-

gated by this equipment had increased from less than 20 acres to 24 acres. The cost of farm machinery, however, rose to $21.41 per acre, chiefly because a power sprayer had to be added to control red berry mite on black berries and leaf spot on loganberries.

The cost per acre of the irrigation system was comparatively high because the equipment, designed to irrigate from 80 to 100 acres, was not used to capacity.

Table 4. INVESTMENT PER ACRE, 1931-1935
(Not including land and buildings.)

Items	Irrigated	Unirrigated
Irrigation well	$ 47.16	.....
Irrigation equipment	63.79	.....
Farm machinery	21.41	$21.41
Total	$132.36	$21.41
TOTAL, 1926-1930[1]	$151.85	$ 7.00
10-YEAR AVERAGE	$142.10	$14.20

[1] Taken from Station Bulletin 277.

Investment in land and buildings is not included in the analysis of costs of this experiment. Rental of $15 an acre was paid for the land and this amount is estimated to cover depreciation and interest on the land investment.

Table 5. AMOUNT AND DATES OF IRRIGATION

	1931		1932		1933		1934		1935	
Crop	Date	Depth	Date	Average depth[1]	Date	Depth	Date	Average depth[1]	Date	Average depth[1]
		Inches		*Inches*		*Inches*		*Inches*		*Inches*
Evergreen blackberries	5/11	6.3	6/18	2.5	7/19	3.8	6/6	7.7	6/13	2.8
	6/12	6.7	6/25	2.6	8/15	4.5	6/18	5.9	7/2	7.2
	7/8	4.5	7/8	2.5	8/18	3.5	7/3	3.2	7/18	1.5
	7/23	7.1	7/28	2.1	.....	.....	7/17	8.7	8/2	6.4
	8/5	3.5	8/5	1.3	.....	.....	8/5	5.8	8/28	3.6
	8/17	3.9	8/23	1.6	.....	.....	8/17	6.1	.....	.....
Total	.....	32.0	.....	12.6	.....	11.8	.....	37.4	.....	21.5
Loganberries	5/10	5.9	6/20	5.4	7/13	6.6	6/1	8.7	6/4	1.8
	6/12	6.7	6/25	3.2	8/12	7.7	6/5	2.2	7/3	7.4
	7/9	4.7	7/2	4.2	.....	.....	6/12	9.8	7/18	3.5
	.....	.....	7/19	5.4	.....	.....	6/15	1.7	.....	.....
	.....	.....	.....	.....	.....	.....	6/18	2.0	.....	.....
	.....	.....	.....	.....	.....	.....	7/3	1.8	.....	.....
	.....	.....	.....	.....	.....	.....	7/6	5.6	.....	.....
	.....	.....	.....	.....	.....	.....	7/7	1.4	.....	.....
Total	.....	17.3	.....	18.2	.....	14.3	.....	33.2	.....	12.7
Strawberries	5/16	4.4	6/11	3.3	7/18	4.4	5/17	3.5	6/14	1.9
	6/3	4.6	6/17	2.4	7/21	3.9	5/18	1.5	6/25	6.9
	6/11	4.6	.....	.....	7/28	3.2	5/24	2.2	7/31	7.4
	8/1	6.7	.....	.....	8/16	5.8	6/7	5.8	.....	.....
	.....	.....	.....	.....	.....	.....	6/12	4.1	.....	.....
	.....	.....	.....	.....	.....	.....	6/15	1.5	.....	.....
	.....	.....	.....	.....	.....	.....	6/17	3.5	.....	.....
	.....	.....	.....	.....	.....	.....	7/21	8.4	.....	.....
Total	.....	20.3	.....	5.7	.....	17.3	.....	30.5	.....	16.2

[1] Represents the average of light, medium, and heavily irrigated plots of blackberries in 1932, 1934 and 1935. All blackberry plots were irrigated alike in 1931 and 1933.

Irrigation practice. Application of irrigation water was under the supervision of the Soils Department at the State College. The data concerning irrigation during the last five years of the experiment are shown in Table 5. It will be noted that the quantity of water used has varied with the kind of small fruit and with the season. A much larger amount of water than that usually applied was used in 1934 on all the fruits of the experiment. A comparison of yields during that period indicates that the extra amount of water used resulted in little, if any, increase per acre in returns of fruit and, therefore, did not pay for itself. In normal years applications of 18 to 24 inches of water on soils of this type are indicated for small fruit production. Early fruiting strawberries will require somewhat less than these amounts.

During the period 1932 to 1935 inclusive, a study of Evergreen blackberries was made to determine the influence of light, medium, and heavy applications of water upon yields. Studies of pruning, or the amount of vines that can be supported per acre under irrigation, made it impossible to obtain better than general correlations between yields and amounts of water applied (Table 6). Further studies are needed on this subject.

Table 6. INFLUENCE OF AMOUNT OF IRRIGATION UPON YIELDS PER ACRE OF EVERGREEN BLACKBERRIES

	Date and depth of water applications							Yield per acre
	6/18	6/25	7/18	7/28	8/5	8/23	Total	
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Pounds*
1932								
Plot 1[1]	....	....	....	....	....	....	....	10,859
Plot 2	2.5	2.6	2.4	1.8	1.3	1.6	12.2	12,352
Plot 3	1.8	2.2	1.5	1.3	.5	1.0	8.3	12,523
Plot 4	2.5	2.6	2.4	1.8	1.3	1.6	12.2	12,695
Plot 5	3.1	2.9	3.5	3.1	2.0	2.1	16.7	13,352
	6/6	6/18	7/3	7/17	8/5	8/17		
1934[2]								
Plot 1	....	....	....	....	....	....	....	10,516
Plot 2	7.7	5.9	1.6	4.4	4.2	4.6	28.4	12,098
Plot 3	7.7	5.9	2.5	7.3	5.0	6.1	34.5	13,795
Plot 4	7.7	5.9	3.8	13.1	6.6	7.6	44.7	16,341
Plot 5	7.7	5.9	4.8	10.2	7.5	6.1	42.2	10,266
	6/13	7/2	7/18	8/2	8/28			
1935								
Plot 1	....	....	....	....	....	....	....	5,116
Plot 2	1.8	5.4	.6	4.8	2.4	....	15.0	7,309
Plot 3	3.0	7.2	1.3	6.4	3.6	....	21.5	8,957
Plot 4	3.7	9.0	2.6	8.0	4.8	....	28.1	10,016
Plot 5	2.7	7.3	1.3	6.4	3.6	....	21.3	7,677

[1] Plot 1 was unirrigated. Each plot equalled .22 A.
[2] Damage from the severe freeze of 1933 made it inadvisable to draw any conclusions from irrigation records that year.

The 1935 seasonal range of soil moisture for Evergreen blackberries is shown in Figure 1.

Influence of irrigation on quality. In 1931 additional funds were made available to conduct chemical and other tests upon small fruits to determine if possible to what extent irrigation influences the appearance and sale of small fruits and their keeping, shipping, and eating qualities.

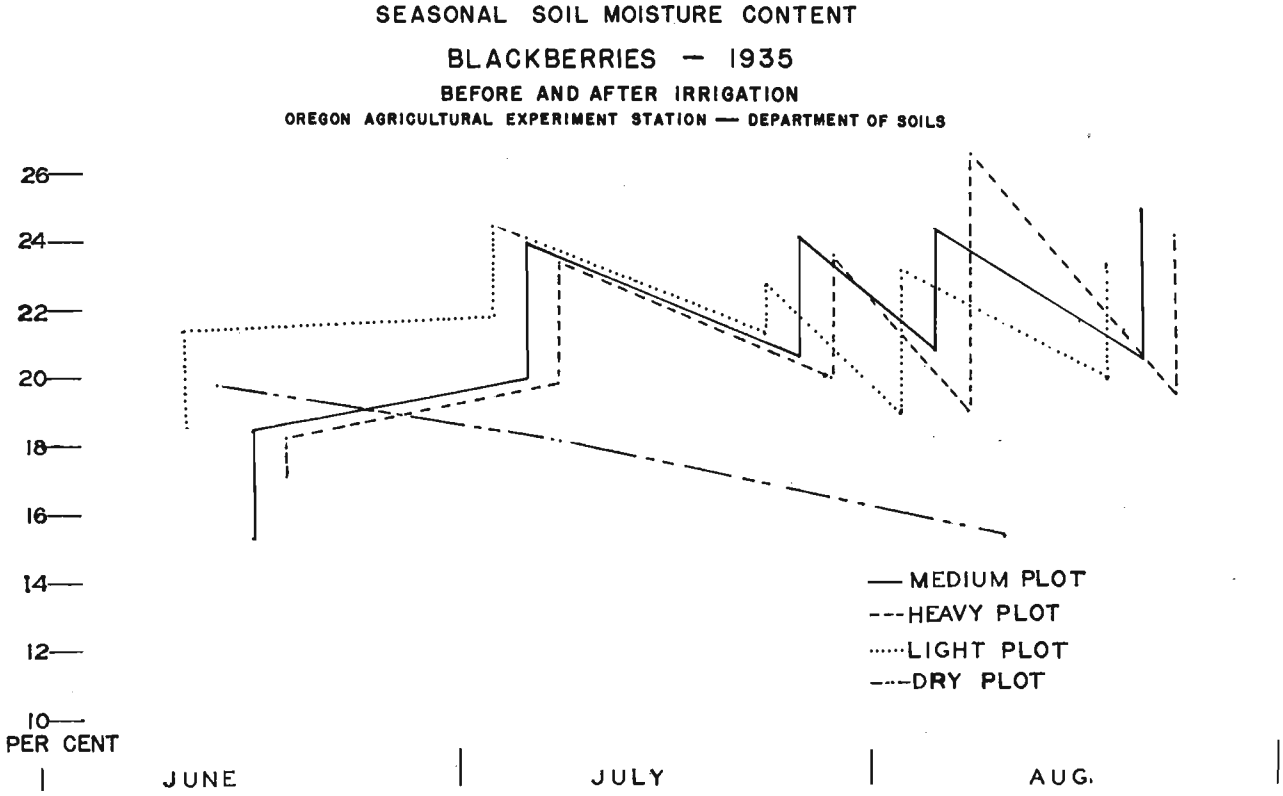

Figure 1. Seasonal range of soil moisture in Evergreen blackberry plots.

THE EXPERIMENT AS AFFECTED BY ECONOMIC CONDITIONS

During the first five years of this investigation the country was enjoying a period of prosperity. Although prices received by farmers for their products were lower in proportion than prices for the things they bought, small fruits generally were selling well above the cost of production.

Under such conditions *yield* and *quality* are the dominant factors in bringing about satisfactory net incomes. The greater the yield of marketable fruit, the greater the profit. All phases of fruit farm management, such as cover cropping, fertilizing, irrigation coupled with careful pruning and cultivation, paid well because the yield was increased and quality improved. Work was plentiful and wages were relatively high—35 to 40 cents an hour.

During the second five years of the investigation the full effect of the 1929 crash was being experienced throughout the country. Prices received for small fruits seldom covered the costs of production and, in some instances, harvesting costs were little more than met by the returns.

Such conditions demand careful analysis in farming, and saving in cost of production is of paramount importance. But on the other hand, quality has to be maintained because buyers are prone to grade more closely under such economic conditions.

Although yield was the greatest factor contributing to net profits during the first half of the experimental period, in many instances it became the greatest factor contributing to large losses during the final 5-year period. If the cost per pound to produce berries is greater than the amount received per pound, loss increases in proportion to increased production.

Under depression conditions, wages dropped rapidly to 20 and 25 cents an hour. No fertilizing was done on any of the plots after 1932 and no cover cropping was done throughout the entire five years. Careful cultivation, pruning, and irrigation, however, were not slighted.

Spraying operations attained considerable importance during the last five years of the experimental period. The spittle bug on strawberries, the red berry mite of the blackberries and the leaf spot infesting loganberries demanded attention that increased the cost of spraying.

ANALYSES OF RESULTS

The following discussion will show the influence of irrigation on (1) costs both of establishing and of operating a small fruit planting, (2) yields, (3) gross and net incomes, and (4) the quality of the product.

Although it is conceded that small areas of land frequently show larger yields than are commonly found in commercial plantings, it must be acknowledged at the same time that costs of operation may be slightly higher due to greater pains that must be taken in experimental work. These two factors offset each other to some extent and the results obtained, therefore, may be considered accurate and practical enough to give reasonably true comparisons between irrigated and unirrigated small fruits.

In order to obtain a clear idea of the entire 10-year period of this experiment, it will be necessary to use some of the data found in Station Bulletin 277 for comparison between the two periods, and to follow as

much as possible the same order of subject matter treatment used in that bulletin.

EVERGREEN BLACKBERRIES

Starting the planting. The plowing and leveling of the land in the spring of 1926 cost $27.27 an acre. Evergreen blackberry plants were set in rows nine feet apart, with plants 15 feet apart in the rows. The trellis used consisted of two parallel wires on crossarms 40 inches above the ground. Spreaders made of ½ x 1 inch material notched on one side, were fitted over the wires and used for holding up the mature vines. The young vines were trained on the ground underneath the wires and held from spreading by sharpened sticks or by heavy curved wires shaped like a short shepherd's crook.

Evergreen blackberries usually produce a light crop the third year. Although this crop may not be large enough to pay the costs of operation, it limits the period of establishing the plantation to the first two years. The itemized costs of bringing the patch into bearing are needed to give a complete presentation of the enterprise and are taken from Table 4 of Station Bulletin 277.

Table 7. COST PER ACRE OF ESTABLISHING IRRIGATED AND UNIRRIGATED EVERGREEN BLACKBERRIES

Items	1926		1927		Total cost from planting to bearing age	
	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated
Preparing land	$ 27.27	$ 27.27	.....	.....	$ 27.27	$ 27.27
Plants (323 per acre)	4.36	4.36	.....	.....	4.36	4.36
Setting plants	8.95	8.95	$ 2.00	$ 2.00	10.95	10.95
Cultivating	13.32	13.32	34.11	34.09	47.43	47.41
Trellis	59.68	59.68	.....	.....	59.68	59.68
Trellising	.....	.....	16.68	16.68	16.68	16.68
Irrigating—labor only	10.73	.....	8.99	.....	19.72	.....
Power cost for irrigating	5.24	.....	4.20	.....	9.44	.....
Cover crop seed	.....	.....	1.75	1.75	1.75	1.75
Cover cropping	.....	.....	2.10	2.09	2.10	2.09
Pruning and training	.....	.....	4.41	4.41	4.41	4.41
Supplies and repairs[1]	11.36	11.36	16.36	16.36	27.72	27.72
Land rental	15.00	15.00	15.00	15.00	30.00	30.00
Interest (on equipment)	11.90[2]	.45	6.50	.40	18.40	.85
Depreciation (on equipment)	13.00[2]	.90	7.71	.90	20.71	1.80
Total cost per acre	$180.81	$141.29	$119.81	$93.68	$300.62	$234.97

[1] Includes such items as hallocks, crates, carriers, gas, oil, repairs, fruit hauling, and other miscellaneous expenses.

[2] Heavier first year due to small acreage irrigated.

Note: Man labor is charged at the rate of 40 cents per hour and horse labor at 13 cents per hour.

It will be noted in Table 7 that it cost approximately $65 more an acre to bring the irrigated blackberries into bearing than the unirrigated. This extra charge is attributed to such irrigation costs as labor for irrigating, electric power, and interest and depreciation on irrigating equipment.

Costs of production. The itemized production costs of the years 1928 to 1930 are to be found on page 45 of Station Bulletin 277. The totals of these costs per acre for irrigated berries were $238.50 for the baby crop year, 1928; $391.14 in 1929; and $441.23 in 1930. In contrast, the unirrigated costs were $168.74 in 1928; $260.45 in 1929; and $318.31 in 1930.

The costs of producing irrigated and unirrigated Evergreen blackberries for the period 1931 to 1935 are shown in Table 8.

Table 8. Itemized Cost of Producing Irrigated and Unirrigated Evergreen Blackberries, 1931-1935

Items	Cost per acre									
	1931		1932		1933		1934		1935	
	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated
Man and horse labor										
Spraying—man labor[1]	.....	.....	$ 12.23	$ 12.23	$ 7.82	$ 7.82	$ 5.99	$ 5.05	$ 1.45	$ 1.45
Spraying—horse, truck	.....	.....	5.55	5.55	2.18	2.18	2.51	2.00	.36	.36
Pruning and training—man labor	$118.89	$ 53.95	74.12	50.77	46.20	46.68	45.43	42.64	56.22	35.91
Cultivating—man labor	33.86	29.64	52.28	65.41	29.99	31.45	18.85	22.45	31.77	32.45
Cultivating—horse, tractor	8.36	7.18	5.16	7.32	4.45	4.91	5.59	7.77	8.40	8.64
Irrigating—man labor	16.33	.....	7.74	.....	7.84	.....	15.37	.....	25.56	.....
Irrigating—horse	.68	.....	.80	.....	1.14	.....	.27	.....	2.00	.....
Fertilizing—man labor	.....	.....	34.14	31.18	.....	.....	.....	.....	.....	.....
Fertilizing—horse, truck	.....	.....	13.98	13.05	.....	.....	.....	.....	.....	.....
Harvesting—man labor	88.59	70.51	95.48	81.44	10.48	27.71	131.25	105.16	90.24	54.73
Harvesting—horse, truck	2.35	1.80	2.53	2.15	.28	.75	2.61	2.10	1.19	.70
Materials										
Fertilizer	.....	.....	30.00	30.00	.....	.....	.....	.....	.....	.....
Supplies and repairs[2]	.....	.....	8.59	8.59	4.45	4.45	23.82	20.07	11.68	11.68
General										
Land rental	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Power cost for pumping	3.31	.....	2.88	.....	2.71	.....	6.29	.....	10.88	.....
Interest and depreciation										
Interest—irrigation and farm equipment	6.11	.60	6.25	.70	6.88	1.33	7.00	1.44	6.85	1.29
Depreciation—irrigation and farm equipment	6.59	1.21	6.78	1.38	8.04	2.63	8.27	2.84	7.99	2.56
Total	$300.07	$179.89	$373.51	$324.77	$147.46	$144.91	$288.25	$226.52	$269.59	$164.77

[1] Spraying for red berry mite began in 1932.

[2] Hallocks and crates for harvesting were supplied by a cannery at no extra charge. Gasoline and oil are placed under costs for truck.

Note: Wages for men varied from 40 cents an hour in 1931 to 20 and 25 cents an hour in 1933-1935. Horse labor is on the basis of 10 cents an hour. Cost of picking per pound, 1931-1933, ¾¢; 1934-1935, 1¢.

"Table 8 for Evergreen blackberries and similar tables include a rather high labor charge for irrigation. This is due to the fact that one-third of the full time of an irrigator is charged to this project. Cost of some soil moisture studies have been added to the duties of the irrigator as well as to operation of the pumping plant and measurement of water. The labor item for these is somewhat higher, therefore, than for common farm labor and is greater than the grower might normally incur. The power cost for pumping is included. This has been higher per kilowatt than would be the case if the pumping plant could be operated to nearly full capacity."[1]

Interest was charged on irrigation and farm equipment at the rate of 5 per cent. Depreciation on farm equipment averaged about 10 per cent, 7 per cent on the irrigation equipment, and 2 per cent on the well itself.

The first fact to note in a study of Tables 9 and 10 is that the highest yield for any year in the first period (1930) multiplied by the highest price received gave the highest annual net income ($415.42) of the entire 10 years. In contrast the good yield of 1932 multiplied by the lowest price received during the experiment, gave the greatest loss per acre ($246.21). During the eight years these blackberries were in bearing, the price paid per pound for the fruit exceeded the cost per pound in only three seasons for irrigated berries and only two for unirrigated fruit. Good yields coupled with satisfactory prices mean net profits, whereas greater losses are incurred with higher yields and unsatisfactory prices.

The second fact is brought out by a study of yields, costs, and prices received in 1934 contrasted with 1935. The prices were 3¢ a pound in 1935, the highest paid during the second period, and although the costs of operation were lower than in 1934 the year ended with a small loss per acre, whereas 1934 showed a small net profit. Owing to the fact that wages and other costs were practically the same for the two years, the conclusion must be reached that the much larger yields of 1934 made it possible to produce blackberries for approximately 1¢ per pound less than they cost in 1935. This difference was enough to show a small profit for both the irrigated and unirrigated fruit.

High costs do not necessarily mean low net profits. The highest cost per acre for irrigated berries came in 1930, the year of highest net profits. In this case the price per pound was sufficiently high to overcome the large cost of production. With the exception of 1933 when light yields followed a severe winter, the costs of production during the second period averaged less than costs during the first period and still only one year, 1934, showed a small net profit. The answer is found in comparing the average net profits per acre for the three years of bearing during the first period, with the losses in the 5-year averages of the second period. Average net profits per acre in the first period were $120.76 for irrigated and $38.51 for unirrigated blackberries. In the second period the average losses per acre were $104.50 for irrigated and $68.30 for unirrigated fruit.

These experiments show that under the economic conditions of the depression irrigation was not a profitable practice. In times of normal prices, however, similar to those of the first period, the results of irrigation would indicate that use of water might be expected to pay well.

[1]From a statement prepared by W. L. Powers.

Table 9. Evergreen Blackberries. Summary of Costs, Yields, Prices, and Income per Acre for the First 5-Year Period of a 10-Year Experiment, 1926-1930[1]

Items	Cost of establishing 1926-1927		Three bearing years 1928		1929		1930		Yearly average for three bearing years		Total for five years	
	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated
Yields per acre—pounds	.....	.....	4,445	2,377	11,079	5,286	17,133	11,606	10,886	6,423	32,657	19,269
Price per pound	.....	.....	$ .03	$ .03	$ .04	$ .04	$ .05	$ .05	$ .044[3]	$ .045[3]	.....	.....
Gross income	.....	.....	133.35	71.31	443.16	211.44	856.65	580.30	477.72	287.68	$1,433.16	$863.05
Total costs	300.62	$234.97	238.50	168.74	391.14	260.45	441.23	318.31	356.96	249.17	1,371.49	982.47
Net income	.....	.....	-105.15	-97.43	52.02	-49.01	415.42	261.99	120.76	38.51	61.67	-119.42
Cost per pound	.....	.....	.0536	.071	.0353	.0492	.0257	.028	.033[4]	.039[4]	.....	.....

Table 10. Evergreen Blackberries. Summary of Costs, Yields, Prices, and Income per Acre for the Second 5-Year Period of a 10-Year Experiment, 1931-1935

Items	1931		1932		1933		1934		1935		5-Year average	
	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated	Unirrigated
Yields per acre—pounds	11,812	9,402	12,730	10,859	1,397[2]	3,695[2]	13,125	10,516	8,489	5,116	9,511	7,918
Price per pound	$ .0125	$ .0125	$ .01	$ .01	$ .0225	$ .0225	$ .0225	$ .0225	$ .03	$ .03	$ .018[3]	$ .0177[3]
Gross income	147.65	117.52	127.30	108.59	31.43	83.14	295.31	236.61	254.67	153.48	171.27	139.87
Total costs	300.07	179.89	373.51	324.77	147.46	144.91	288.25	226.52	269.59	164.77	275.77	208.17
Net income	-152.42	-62.37	-246.21	-216.18	-116.03	-61.77	7.06	10.09	-14.92	-11.29	-104.50	-68.30
Cost per pound	.0254	.0191	.0293	.030	.106	.0392	.022	.0215	.0317	.0322	.0289[4]	.0263[4]

[1] Taken from Station Bulletin 277.
[2] Light yields caused by severe freeze of preceding winter brought about high cost per pound.
[3] Weighted average price—average total gross income divided by average total yields.
[4] Weighted average cost—average total costs divided by average total yields.
Note: The figures given in "Irrigated" columns represent averages of four irrigated plots reduced to an acreage basis.

Influence of irrigation on growth of canes and time of ripening. During the second 5-year period the canes were pruned by removing weak laterals in late summer, cutting back strong laterals to two buds, and shortening the main canes to a length of 10 feet for plots 1 and 2; 12 feet for plots 3 and 4; and leaving canes in plot 5 at full length.

Throughout the second period, as was found during the first period, a somewhat larger portion of irrigated berries ripened earlier than the unirrigated. This was especially noticeable on the plot receiving the heaviest irrigation.

Figure 2. Growers of small fruits inspecting irrigated Evergreen blackberries.

The winter of 1932-1933 was particularly severe on small fruits, grains, and other crops, due to a lack of snow at the time of severe freezing. Under these conditions the unirrigated canes came through the winter in much better shape than those irrigated and produced nearly three times as much fruit, though the crop on all plots was relatively small. No damage to the crowns of the plants resulted from the freeze and the canes produced a good yield the following year.

This subject is more completely discussed in Station Bulletin 277.

Quality as affected by irrigation. As already stated, the experiment was to determine the effect of irrigation on quality of the fruit crop.

SIZE OF BERRY. The factor of size varied considerably throughout the second 5-year period. Table 11 indicates there is a correlation between size and weather conditions. In 1932 the summer rainfall (Table 1) was

practically normal and under this condition the irrigated berries showed no increase in size over unirrigated fruit.

In 1933, as already noted, the irrigated canes suffered much more from the freeze of the preceding winter, this being reflected in the total yields and the comparative size of the fruit. That season was the only one in the 10-year period when the unirrigated berries excelled the irrigated. During the two dry seasons of 1934 and 1935 the irrigated berries showed pronounced increases in size over the unirrigated fruit. Irrigated Evergreen blackberries ran 186 to the pound in 1934, and 211 to the pound in 1935; while unirrigated fruit averaged 230 to the pound in 1934, and 263 to the pound in 1935.

Table 11. COMPARATIVE SIZE OF IRRIGATED AND UNIRRIGATED EVERGREEN BLACKBERRIES

Year and treatment	Number of pickings	Total weight of berries	Number of berries	Average size of berries	Gain	Loss
1932		*Pounds*		*Pounds*	*Per cent*	*Per cent*
Irrigated	4	4.408	1,193	.0036	.....	.....
Unirrigated	4	4.408	1,208	.0036	.....	.....
1933						
Irrigated	4	8.816	2,240	.0039	.....	.....
Unirrigated	4	4.408	990	.0044	.....	12.8
1934						
Irrigated	6	48.55	9,041	.0054	22.7	.....
Unirrigated	6	48.36	11,110	.0044	.....	.....
1935						
Irrigated	4	16.79	3,540	.0047	23.7	.....
Unirrigated	4	17.15	4,516	.0038	.....	.....

INFLUENCE ON GRADES. During the harvesting periods of 1934 and 1935 berries were sorted into two grades, No. 1 and culls, conforming with state grades. Representative samples of irrigated and unirrigated fruit were taken on six different picking dates in 1934 and on four different dates in 1935. The results of grading and the influence of irrigation are shown in Table 12.

In 1935 the percentage of culls for the unirrigated berries was nearly twice that for the irrigated fruit. Results obtained for 1934 indicated there might be little difference in this respect during certain seasons.

Table 12. GRADES OF EVERGREEN BLACKBERRIES INFLUENCED BY IRRIGATION

Year and treatment	Number of pickings	Total weight of samples	Number of berries	Grades	
				No. 1	Culls
1934		*Pounds*		*Per cent*	*Per cent*
Irrigated	6	48.55	9,041	91.2	8.8
Unirrigated	6	48.36	11,110	89.8	10.2
1935					
Irrigated	4	16.79	3,540	81.9	18.1
Unirrigated	4	17.15	4,516	64.4	35.6

TESTS ON FROZEN AND CANNED FRUIT. Preliminary work along this line was begun late in the summer of 1931, but it was not definite enough to include in this bulletin, serving more as a lead toward the work of succeeding years than anything else. During the seasons 1932 to 1935,

duplicate samples of blackberries were graded carefully for uniformity in ripeness, sealed in No. 2 tin cans, frozen solid, and subsequently tested for sugar, acid, and moisture content. The procedure used in making these tests is briefly as follows:

Samples for analysis were prepared by grinding the frozen berries finely through a Russwin food chopper. In sugar and acid determinations, 35 gram duplicate samples were prepared, the sugars and acids being determined from aliquot portions of the prepared material. Reducing sugars were determined according to the method of Lane and Eynon on the unclarified extract, and were calculated as invert sugar. Total acids were determined electrometrically with a quinhydrone electrode, titrating to pH 7, using N/10 NaOH. Total acidity was calculated as citric. All calculations were on a fresh weight basis. For moisture determinations 10 gram samples of prepared material were weighed and dried to constant weight in a Freas vacuum oven, after which percentages were figured. The results of these analyses are summarized in Table 13.

Table 13. CHEMICAL ANALYSES OF EVERGREEN BLACKBERRIES

Year and treatment	Number of samples	Total sugars as invert	Total acid	Water
1932		*Per cent*	*Per cent*	*Per cent*
Irrigated	3	5.40	1.12	82.54
Unirrigated	3	6.40	1.19	81.82
1933				
Irrigated	8	7.39	1.01	78.75
Unirrigated	4	7.25	1.14	78.70
1934				
Irrigated	6	7.88	1.04	83.28
Unirrigated	6	9.13	1.09	81.41
1935				
Irrigated	4	8.00	.84	82.84
Unirrigated	4	8.03	.83	80.24

A study of Table 13 indicates that the acid content of unirrigated berries averages slightly higher than for irrigated Evergreen blackberries, although the difference is so small as to be insignificant. The records show there is a tendency for the acid to be slightly lower in amount near the end of the picking season.

Sugar content on the average is greater in unirrigated berries, but during some years, as in 1933 and 1935, there is very little difference between irrigated and unirrigated fruit. The amounts of sugar hold up well during the season unless picking is prolonged into the latter part of September, in which case the percentage of sugar is likely to drop perceptibly. The lowering of sugar content together with lessened acid content near the end of the season has a pronounced effect on the eating quality of the fruit, making it more insipid.

Although the water content is greater in irrigated berries in every case there is not enough difference to affect the eating quality of the fruit. Under chemical and refractometer tests during 1931 to 1933, canned blackberries failed to show any significant difference between the irrigated and unirrigated fruit.

During 1934 and 1935, "drip" tests were made on blackberries canned in water to discover whether any material difference in breakdown of canned fruit from irrigated and unirrigated plots could be noted. During the picking season of 1934 12 samples each of irrigated and unirrigated fruit were put up in No. 2 cans, each can containing .75 pounds of fruit and .40 pounds of water. For 1935 eight samples each of irrigated and unirrigated berries were put up in a like manner.

The fruit was first exhausted in the cans for eight minutes at 200° F. and then cooked eight minutes at 212° F. "Cut-outs" of the 1934 and 1935 fruit were made, January 11, 1935; and December 2, 1935, respectively. The fruit was emptied into a coarse mesh copper strainer and allowed to "drip" the standard (usually accepted by cannerymen) two minutes. At the end of that time fruit and berries were weighed separately. The percentage of solids (berries) was obtained by dividing the total weight of solids by the total weight of solids plus juice. The results were: In 1934 and 1935 irrigated berries showed 60.6 and 60.0 per cent solids respectively, whereas unirrigated berries gave 61.4 and 60.9 per cent respectively for those years.

The net result of all the "drip" tests indicate that the firmness of canned Evergreen blackberries is not affected to any appreciable degree by irrigation, the irrigated berries "standing up" as well in the can as unirrigated fruit.

OTHER QUALITY TESTS. A study was made in 1933 and 1934 to determine whether irrigated berries had larger or smaller seeds in proportion to total weight of berries than the unirrigated fruit. In 1933, four 500 gram samples of irrigated berries and two similar samples of unirrigated fruit were taken for the study. The pulp was removed from the seeds by boiling berries for one-half hour in a 5 per cent solution of hydrochloric acid. The berries were then thoroughly macerated, the pulp squeezed through a double thickness of cheese cloth, and the seeds spread out to dry in room temperature.

After drying, the seeds were rubbed over a fine screen until all pulp was removed and then weighed. The seeds of the irrigated fruits equalled 6.47 per cent of the total weight of the berries, while the seeds of unirrigated berries averaged 6.85 per cent. In 1934 the irrigated fruit had 4.86 per cent of its weight in seeds and the unirrigated berries contained 5.55 per cent of their weight in seeds. The irrigated fruit in both these seasons had slightly smaller percentages of seeds and larger percentages of pulp than the unirrigated berries, but apparently not enough more to make any difference in eating quality.

The appearance of irrigated fruit, however, usually is better than that of the unirrigated. The color is a more glistening black and the drupelets are more plump and inviting. Although this benefit of irrigation is difficult to measure, it nevertheless is one of the greatest from the standpoint of fresh sales on the retail market.

LOGANBERRIES

Establishing the planting. The preliminary costs of plowing and leveling the land in the spring of 1926 were the same as for the Evergreen blackberries. Unfortunately the spring season was so early and dry that a large proportion of the young loganberry plants died and the balance grew

poorly. It was thought best, therefore, to start over again with vigorous plants and the field was reset in the early spring of 1927. The maintenance costs of 1926 were not charged against the project. Fruiting plants were trained in the spring upon a two-wire vertical trellis and young plants were held in place along the row by wires and stakes.

To obtain an idea concerning the cost of establishing the loganberry planting, it is necessary to reprint Table 9 of Station Bulletin 277 (Table 14).

Table 14. COST PER ACRE OF ESTABLISHING IRRIGATED AND UNIRRIGATED LOGANBERRIES, 1927[1]

Items	Irrigated	Unirrigated
Preparing land	$27.27	$27.27
Plants ($38 per acre)	5.50	5.50
Setting plants	11.77	11.77
Cultivating	22.34	22.32
Trellising	61.28	61.27
Staking	3.27	3.27
Irrigating (labor only)	12.43	.....
Power cost for irrigating	4.20	.....
Cover cropping	1.12	1.09
Cover crop seed	1.75	1.75
Land rental	15.00	15.00
Supplies and repairs[2]	16.36	16.36
Interest (on equipment)	6.50	.40
Depreciation (on equipment)	7.71	.90
Total	$196.50	$166.90

[1] Only one year was required in this test to establish loganberry planting.
[2] Includes such items as hallocks, crates, carriers, gas, oil, repairs, fruit hauling, and other miscellaneous expenses.
Note: Man labor is charged at the rate of 40 cents per hour and horse labor at 13 cents per hour.

As the loganberries produced a good crop for young vines in their second year, the first year only was allowed as the starting period of the plants. From Table 14 it is noted that the cost for the irrigated berries was only approximately $30 more per acre than for the unirrigated fruit.

Costs of production. During the fourth year, 1930, the crop was killed by a severe winter freeze. The total costs per acre for irrigated berries were $224.44 in 1928 and $360.15 in 1929. Similar costs per acre for unirrigated berries were $153.20 in 1928 and $224.93 in 1929. Costs per acre were $152.97 for irrigated and $122.90 for the unirrigated vines in 1930 when no crop was produced (Table 16).

During the 5-year period, 1931 to 1935, the itemized costs of producing loganberries are shown in Table 15.

The costs of operation per acre averaged considerably lower for both the irrigated and unirrigated berries during the period 1931 to 1935 than the average costs for the two bearing years 1928 and 1929, due chiefly to a lower wage scale.

It will be noted in Tables 16 and 17 that the average cost per pound for producing irrigated loganberries is approximately 3.5 cents for years of normal production (1929), while the cost of producing the unirrigated fruit is about one-third of a cent higher per pound.

When prices per pound received for the fruit held a reasonable margin of profit as they did in 1928, 1929, and 1931, when berries sold for approximately 5 cents a pound, there was a good net income per acre from normal crops. Irrigation more than doubled the net income in 1929 and 1931, and paid for itself handsomely.

Table 15. Itemized Costs of Producing Irrigated and Unirrigated Loganberries, 1931-1935

Items	Cost per acre									
	1931		1932		1933		1934		1935	
	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated
Man and horse labor										
Spraying—man labor[1]	.....	.....	.....	.....	$ 6.64	$ 6.64	$ 5.86	$ 5.86	.....	.....
Spraying—horse, truck	.....	.....	.....	.....	2.55	2.55	1.82	1.82	.....	.....
Pruning and training—man labor	$ 87.39	$ 91.77	$ 83.17	$ 94.09	39.61	49.59	73.20	55.91	$ 50.34	$ 39.82
Pruning and training—horse, etc.	.....	.....	.....	.....	.....	.....	.18	.18	.....	.....
Cultivating—man labor	14.52	8.91	13.98	17.86	24.30	25.55	13.50	10.77	15.77	11.36
Cultivating—horse, tractor	3.93	1.64	3.40	4.36	3.00	3.00	5.24	5.18	6.47	6.59
Irrigating—man labor	9.59	.....	9.10	.....	9.66	.....	15.45	.....	13.76	.....
Irrigating—horse	.50	.....	.49	.....	1.82	.....	.55	.....	.77	.....
Fertilizing—man labor	9.27	9.27	6.05	6.05	.....	.....	.....	.....	.....	.....
Fertilizing—horse, truck	3.09	3.09	1.36	1.36	.....	.....	.....	.....	.....	.....
Harvesting—man labor	87.52	42.25	102.30	78.84	11.85	11.40	50.26	50.90	110.67	63.06
Harvesting—horse, truck	1.70	.80	2.06	1.60	.16	.15	1.00	1.00	2.78	1.59
Materials										
Fertilizer	15.00	15.00	15.00	15.00	.....	.....	.....	.....	.....	.....
Supplies and repairs[2]	.....	.....	.....	.....	5.61	5.61	8.65	8.65	4.78	4.78
General										
Land rental	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Power cost for pumping	3.31	.....	2.88	.....	2.71	.....	6.29	.....	6.05	.....
Interest and depreciation										
Interest—irrigation and farm equipment	6.11	.60	6.25	.70	6.88	1.33	7.00	1.44	6.85	1.29
Depreciation—irrigation and farm equipment	6.59	1.21	6.78	1.38	8.04	2.63	8.27	2.84	7.99	2.56
Total	$263.52	$189.54	$267.82	$236.24	$137.83	$123.45	$212.27	$159.55	$241.23	$146.05

[1] Spraying for leaf spot necessary for two seasons only.
[2] Cartons and crates for harvesting supplied by cannery at no extra charge. Gas and oil charged under truck expense.
Note: Wages for men varied from 40 cents an hour in 1931 to 20 and 25 cents an hour in 1933-1935. Horse labor is on a basis of 10 cents an hour. Cost per pound for picking was 1¢, except for the short crop in 1933 when the cost was 1½¢ per pound.

Table 16. LOGANBERRIES. SUMMARY OF COSTS, YIELDS, PRICES, AND INCOME PER ACRE FOR THE FIRST 5-YEAR PERIOD OF A 10-YEAR EXPERIMENT, 1926-1930[3]

Items	Cost of establishing, 1927		Two bearing years				Yearly average for two bearing years		Frost—No crop 1930		Total for four years	
			1928		1929							
	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated
Yields per acre—pounds			3,436	1,186	10,666	5,831	7,051	3,508			14,102	7,017
Price per pound			$ .05	$ .05	$ .05	$ .05	$ .05[1]	$ .05[1]				
Gross income			171.80	59.30	533.30	291.55	352.55	175.42			$705.10	$350.85
Total costs	$196.50	$166.90	224.44	153.20	360.15	224.93	292.29	189.06	$152.97	$122.90	934.06	667.93
Net income			−52.64	−93.90	173.15	66.62	60.26	−13.64	−152.97	−122.90	−228.96	−317.08
Cost per pound			.0653	.129	.034	.038	.041[2]	.054[2]				

Table 17. LOGANBERRIES. SUMMARY OF COSTS, YIELDS, PRICES, AND INCOME PER ACRE FOR THE SECOND 5-YEAR PERIOD OF A 10-YEAR EXPERIMENT, 1931-1935

Items	1931		1932		1933		1934		1935		5-Year average	
	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated, average	Unirrigated	Irrigated	Unirrigated
Yields per acre—pounds	8,752	4,230	10,230	7,884	790	760	5,026	5,090	6,797	3,872	6,319	4,367
Price per pound	$ .051	$ .051	$ .02	$ .02	$ .03	$ .03	$ .02	$ .02	$ .032	$ .032	$ .0314[1]	$ .0285[1]
Gross income	446.36	215.73	204.60	157.68	23.70	22.80	100.52	101.80	217.51	123.90	198.54	124.38
Total costs	263.52	189.54	267.82	236.24	137.83	123.45	212.27	159.55	241.23	146.05	224.53	170.96
Net income	182.84	26.19	−63.22	−78.56	−114.13	−100.65	−111.75	−57.75	−23.72	−22.15	−25.99	−46.58
Cost per pound	.030	.045	.026	.030	.174	.162	.042	.031	.036	.038	.0355[2]	.0391[2]

[1] Weighted average price—average total gross income divided by total average yields.
[2] Weighted average cost—average total costs divided by the total average yields.
[3] Taken from Station Bulletin 277. Cost figures for 1926 not used due to destruction of plants by drought.
Note: The figures given in "Irrigated" columns represent averages of four irrigated plots reduced to an acreage basis. Yields of 1933 very light due to damage from freezing.

During the four years from 1932 to 1935 inclusive, the cost per pound was greater than the selling price with the result that irrigated loganberries showed greater net losses for three of the four years than for the unirrigated. As with the Evergreen blackberries the higher the production the greater the loss, provided each pound of fruit loses money. A relatively narrow margin of profit per pound, however, will cause the profit per acre to show up well where the yield is good.

Influence of pruning on yields. During the second 5-year period plot 1 of the unirrigated area and plot 2 of the irrigated area were pruned alike. They were given the shortest pruning, canes being cut back to a length of six feet and all strong canes allowed to remain. Plot 5, irrigated, was always pruned the longest, being left full length with all strong canes and laterals remaining, except in 1931 when the vines were cut back to 10-foot lengths.

Plot 5 produced the heaviest yields in 1931, 1932, and 1934, and the highest average for the five years, 1931 to 1935. Plots 2 and 5 had equal amounts of water applied. All other factors of growth and harvesting were the same for both plots. Differences in yield, therefore, may be assumed to be due to differences in pruning.

Table 18. INFLUENCE OF SHORT vs. LONG PRUNING OF LOGANBERRIES UPON YIELDS, COSTS, AND PROFITS
(Five-year averages per acre)

	Plot 2, short pruned	Plot 5, long pruned
Yields per acre—pounds	5,113	6,979
Price per pound[1]	$ .029	$ .032
Gross income	147.46	223.67
Total costs	209.69	236.12
Net income	−62.23	−12.45
Cost per pound[2]	.041	.034

[1]Price per pound obtained by dividing average gross income by average yield.
[2]Cost per pound obtained by dividing average total costs by average yield.

The outstanding conclusion from Table 18 is that throughout the 5-year period, including four years with depression prices, the long-pruned area averaged 36 per cent higher yield and 52 per cent greater gross income per acre than the short-pruned area. While neither plot made a net profit the short-pruned lost five times as much as the long-pruned block. Considering the fact that wages, interest, and depreciation are figured in this tabulation, the loss per acre on long-pruned vines is not great.

Plots 3 and 4 (not shown in tables) which were pruned 10 feet long except in 1931 when they were eight feet long, occupied an intermediate position in yield and returns, yielding better than the short pruning, but not so well as the canes left full length. It may be concluded, therefore, that with an ample supply of water on soils suitable for irrigation, long pruning is the most desirable practice.

Influence of irrigation upon yield when the pruning is similar. Plots 1 and 2 as has been stated, were pruned alike by removing very weak growth and cutting back the remaining canes to 6-foot lengths. This "short pruning" is in conformity with the pruning of many commercial growers

who desire to obtain berries of good size without irrigation. All factors of treatment except the application of water were similar and it may be concluded, therefore, that differences shown in yields, money returns, etc., are due to irrigation.

Table 19. INFLUENCE OF IRRIGATION UPON YIELDS, COSTS, AND PROFITS OF LOGANBERRIES PRUNED ALIKE
(Five-year averages per acre)

Items	Plot 1, unirrigated	Plot 2, irrigated
Yields per acre—pounds	4,367	5,113
Price per pound[1]	$ .028	$ .029
Gross income	124.38	147.46
Total costs	170.77	209.69
Net income	−46.39	−62.23
Cost per pound[2]	.039	.041

[1]Weighted averages (gross incomes divided by yields).
[2]Total costs divided by yields per acre.

The increase in yields of the irrigated fruit over the unirrigated (Table 19) is 746 pounds, 17 per cent; and the increase in gross income is $23.08, 19 per cent. The cost of producing the irrigated berries, however, is so much greater that the net loss is 34 per cent, or one-third more for irrigated than for unirrigated. Irrigation apparently is not profitable with short pruning.

Comparison of yields between unirrigated and longest-pruned irrigated canes. Figures shown in Tables 16 and 17 represent yields, costs, and returns from the average of all the irrigated plots receiving short, medium, and long pruning, the inference being that this average represents the results that may be expected from a medium long type of pruning under irrigation.

Contrasts to this medium long pruning are shown in Tables 18 and 19 where short pruning is employed. Comparative results for unirrigated loganberries pruned short, as is the usual custom, and the irrigated fruit pruned full length as determined from further experiments are shown in Table 20.

Table 20. CONTRAST BETWEEN SHORT-PRUNED UNIRRIGATED AND LONGEST-PRUNED IRRIGATED LOGANBERRIES
(Five-year averages per acre)

Items	Plot 1, short-pruned	Plot 5, longest-pruned
Yields per acre—pounds	4,367	6,979
Price per pound[1]	$ .028	$ .032
Gross income	124.38	223.67
Total costs	170.77	236.12
Net income	−46.39	−12.45
Cost per pound[2]	.039	.034

[1]Gross income divided by yields.
[2]Total costs divided by yields.

Table 20 brings out the fact that use of irrigation together with the longest type of pruning produces average increases in the yield of 2,612 pounds, 60 per cent, per acre. Gross income also is increased $99.29, 80 per cent, per acre through use of this system. The net loss per acre is only

approximately 25 per cent as much for the irrigated as the unirrigated, owing to the fact that the greater yields and long pruning under irrigation have reduced the cost price per pound below the cost for unirrigated fruit. It is evident, therefore, from the facts brought out in the last three tables, that long pruning combined with irrigation shows the greatest promise as a system of training loganberry vines.

Table 21. COMPARATIVE SIZE OF IRRIGATED AND UNIRRIGATED LOGANBERRIES

Year and treatment	Number of pickings	Total weight of berries	Number of berries	Average size of berries	Gain	Loss
1932		*Pounds*		*Pounds*	*Per cent*	*Per cent*
Irrigated	8	8.816	1,168	.0075	.....	.....
Unirrigated	5	5.500	696	.0079	.....	5.3
1933						
Irrigated	8	8.816	1,351	.0065	.....	.....
Unirrigated	4	4.408	679	.0066	.....	1.5
1934						
Irrigated	8	58.93	8,148	.0072	16.1	.....
Unirrigated	8	61.65	9,922	.0062	.....	.....
1935						
Irrigated	4	16.08	2,102	.0076	15.1	.....
Unirrigated	4	16.64	2,508	.0066	.....	.....

Comparative size of unirrigated and irrigated fruit. Effect of the amount of pruning on the size of loganberries is discussed at some length in Station Bulletin 277. During the second 5-year period comparisons were made between the unirrigated short-pruned canes and the averages of irrigated plots (Table 21).

During the years 1932 and 1933 when rainfall for the growing season was nearly normal, the average size of unirrigated fruit was slightly larger than for the irrigated. During the two very dry seasons of 1934 and 1935 the gain in size of the irrigated berries was quite appreciable. It must be remembered that unirrigated canes were pruned considerably shorter than the irrigated and, therefore, had fewer berries to mature.

Influence of irrigation upon grades. Throughout 1934 and 1935 counts were made to determine the percentages of No. 1, No. 2, and cull berries according to state standards. As shown in Table 22 there was a considerable increase in No. 1 grade in irrigated fruit in 1934, 15.6 per cent, but in 1935 the increase was insignificant. Apparently loganberries pruned as short as six feet do not produce a large percentage of culls even when not irrigated.

Table 22. EFFECT OF IRRIGATION UPON LOGANBERRY GRADES

Year and treatment	Number of pickings	Total weight of samples	Total number of berries	Grades		
				No. 1	No. 2	Culls
1934		*Pounds*		*Per cent*	*Per cent*	*Per cent*
Irrigated	8	58.93	8,148	77.8	11.8	10.4
Unirrigated	8	61.65	9,922	62.2	24.9	12.9
1935						
Irrigated	4	16.08	2,102	76.2	15.6	8.2
Unirrigated	4	16.64	2.508	74.6	17.6	7.8

Tests given frozen and canned loganberries. The suggestions regarding methods of preparation for frozen and canned blackberries apply to loganberries as well. The results of these analyses are summarized in Table 23.

Table 23. CHEMICAL ANALYSES OF LOGANBERRIES

Year	Irrigated (Averages)				Unirrigated (Averages)			
	Number of samples	Total sugars as invert	Total acid	Water	Number of samples	Total sugars as invert	Total acid	Water
		Per cent	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*
1932	10	4.80	2.22	.....	5	6.44	2.13	.....
1933	8	5.54	2.23	80.71	6	6.16	2.31	80.5
1934	7	6.54	2.21	84.42	7	7.09	2.25	83.84
1935	4	6.94	2.02	84.34	4	7.17	1.84	83.42

Although Table 23 shows a consistently higher percentage of sugars in the unirrigated than in the irrigated fruit, this difference is so slight that in most cases it is hardly perceptible to the taste. The field records indicate that berries became slightly sweeter towards the end of the picking season, although there are plenty of analyses to the contrary. The water content is slightly less in the unirrigated loganberries. This apparently has an influence upon the appearance and "holding up" qualities of the fruit, as described later. There are no consistent differences in the acid content of irrigated and unirrigated berries.

"Cut-outs" were made on canned loganberries in the same manner as for Evergreen blackberries. In 1934 seven samples in duplicate were prepared and in 1935 four samples were taken on different picking dates. The 1934 series was opened January 15, 1935, and "drip" tests made. The 1935 series was given the "drip" test December 2, 1935. The irrigated berries in the 1934 series showed 46.03 per cent solids and the unirrigated contained 49.81 per cent solids. In 1935 the irrigated fruit showed 49.70 per cent solids and the unirrigated 51.70 per cent solids.

It appears from this test that unirrigated loganberries show a little larger percentage of solids after canning than the irrigated berries. Part of this difference is accounted for by the fact that fresh unirrigated fruit shows slightly less water than the irrigated (Table 23). In addition, however, it appears that irrigated fruit loses more of its water in the cans and, therefore, breaks down slightly more than unirrigated berries. Such differences as noted here, however, are not sufficiently great to be of any commercial importance.

Other quality tests. A test to determine the relative weight of seeds in irrigated and unirrigated loganberries similar to those conducted for Evergreen blackberries was carried out during 1933. This test failed to show any consistent difference between the two series of fruits—irrigated and unirrigated. The heaviest seeds were found in one picking of unirrigated fruit but the average of four pickings gave a slightly higher weight to the irrigated berry seeds.

Observations beginning in 1931 and continuing throughout a 5-year period, indicated that irrigated loganberries showed a brighter, snappier red color in hallocks for fresh trade than the unirrigated berries. During

48-hour periods in common storage at 60° F. unirrigated berries settled slightly more and had a duller luster than the irrigated loganberries.

STRAWBERRIES

The costs of establishing strawberry plantings could not be accurately determined in the beginning of this experiment due to unfavorable weather conditions (Station Bulletin 277, page 38). Data taken during 1933 when a new bed was set gave an accurate determination of cost for establishing the strawberry plantings (Table 24).

Table 24. COST PER ACRE OF ESTABLISHING IRRIGATED AND UNIRRIGATED STRAWBERRIES, 1933

Items	Irrigated	Unirrigated
Leveling and preparing land[1]	$ 27.27	$ 27.27
Plants[2]	29.04	19.36
Setting plants	10.98	8.18
Cultivating	43.90	56.91
Irrigating—labor only	36.66	.....
Power cost for irrigating	2.71	.....
Land rental	15.00	15.00
Interest (on equipment)	6.88	1.33
Depreciation (on equipment)	8.04	2.63
Total cost per acre	$180.48	$130.68

[1] Cost of leveling and preparing the land in 1926.
[2] Irrigated set 4 x 1½ feet = 7,260 plants; unirrigated set 3 x 3 feet = 4,840 plants per acre.

Costs of production. Table 25 taken from Station Bulletin 277 gives the annual average costs, yields, income, and profit per acre over a period of two years, 1929 and 1930.

Table 25. STRAWBERRY COSTS, YIELDS, INCOME, AND PROFIT PER ACRE, 1929-1930
(Annual average for two bearing years)

Items	Marshall		Ettersburg 121	
	Irrigated	Unirrigated	Irrigated	Unirrigated
Yields per acre—pounds	7,919	4,337	2,616	2,743
Price per pound[1]	$ .0533	$ .0689	$ .0700	$ .0700
Gross income	422.34	299.02	183.15	192.04
Total costs	241.13	142.62	127.40	108.48
Net income	181.21	86.40	55.75	83.56
Cost per pound[2]	.0304	.0328	.0487	.0395

[1] Weighted average price—average gross income divided by average yields.
[2] Weighted average costs—average costs divided by average yields.

Irrigating the Marshall strawberry increased yields and net profits very materially but the Ettersburg 121 failed to respond to irrigation and showed a loss both in yields and net income. Why Ettersburg 121 did not increase its yield when irrigated is not shown by the facts in this experiment. As Chehalis loam soil is considered to be rather too light for this fruit, possibly this fact may be the explanation.

In the 5-year period, 1931 to 1935, Marshalls were fruited during the years 1931 and 1932; a new strawberry planting was made in 1933, consisting of Corvallis and Narcissa varieties, which fruited in 1934 and 1935. The itemized costs are shown in Table 26.

Table 26. Itemized Cost of Producing Irrigated and Unirrigated Strawberries, 1931-1935

Items	Cost per acre									
	1931		1932		1933		1934		1935	
	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated
Man and horse labor										
Spraying—man labor[1]	.....	.....	.....	.....	.....	.....	$ 4.97	$ 5.09	$ 6.36	$ 4.98
Spraying—horse, truck	.....	.....	.....	.....	.....	.....	1.16	1.45	.....	.....
Planting—man labor	.....	.....	.....	.....	$ 10.98	$ 8.18	.....	.....	.....	.....
Cultivating—man labor	$ 43.93	$ 17.83	$ 23.52	$ 12.86	38.24	51.82	42.76	30.11	27.24	24.25
Cultivating—horse, tractor	2.08	2.51	2.57	1.71	5.66	5.09	2.37	2.55	3.93	3.27
Irrigating—man labor	26.81	.....	13.98	.....	33.89	.....	21.03	.....	21.50	.....
Irrigating—horse	1.66	.....	1.03	.....	2.77	.....	2.49	.....	2.08	.....
Harvesting—man labor	84.20	46.17	125.11	72.29	.....	.....	114.95	88.36	185.27	32.55
Harvesting—horse, truck	1.60	.80	2.50	1.50	.....	.....	1.50	1.15	7.45	1.31
Materials										
Supplies and repairs[2]	.....	.....	.....	.....	.....	.....	.....	.....	34.31	16.69
General										
Land rental	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Power cost for pumping	3.31	.....	2.88	.....	2.71	.....	6.29	.....	6.62	.....
Interest and depreciation										
Interest—irrigation and farm equipment	6.11	.60	6.25	.70	6.88	1.33	7.00	1.44	6.85	1.29
Depreciation—irrigation and farm equipment	6.59	1.21	6.78	1.38	8.04	2.63	8.27	2.84	7.99	2.56
Total	$191.29	$ 84.12	$199.62	$105.44	$124.17	$ 84.05	$227.79	$147.99	$324.60	$101.90

[1] Dusting to control spittle bug.

[2] Hallocks and crates supplied entirely by cannery during 1931-1934; in 1935, hallocks and crates for local sales were purchased. Nicotine sulphate for spittle bug control cost $12.76 per acre. Gas and oil charged to truck expense.

Note: Wages for men varied from 40 cents an hour in 1931 to 20 and 25 cents an hour in 1933-1935. Horse labor is on a basis of 10 cents an hour. Cost of picking per pound, 1931-1932, 1¢; 1934, 1¾¢; 1935, 1¾¢.

Land rental, depreciation, and interest remained as high as in the first five years, but costs of labor and supplies were lower. Strawberries, however, continued to show profits even during the time of severest depression (Table 27).

Figure 3. Irrigated strawberries grown in matted rows.

Apparently the reason for such a satisfactory showing during the last five years is not so much in increasing yields by irrigation, although these are almost doubled, as it is in being able to show a price received per pound that in every year is slightly higher than the cost per pound.

In 1935 unirrigated berries did little better than break even, while irrigated berries gave the highest net profit of any year of the experimental period. Reference to Table 1 shows that the rainfall during the growing season of that year was very low, the lowest ever recorded at Corvallis for a similar period.

Time of ripening. Observations on picking dates for the Corvallis and Narcissa varieties indicate, as with Marshall, that the time of picking is delayed slightly by irrigation. No data, however, were taken during the 1931 to 1935 period to determine the relative amounts of fruit picked early and late in the season.

Influence of irrigation upon size and grades of fruit. The size of Marshall strawberries in 1932 and of the Corvallis and Narcissa varieties in 1934 was materially increased by irrigation; and, in the excessively dry year of 1935, was more than doubled by watering (Tables 28 and 29).

During 1934 and 1935 samples of irrigated and unirrigated fruit were carefully sorted into grades corresponding to those prescribed by the State of Oregon, No. 1, No. 2, and culls. Table 29 shows the comparisons in grades.

Table 27. Strawberries. Summary of Costs, Yields, Prices, and Income per Acre, 1931-1935

Year and treatment	Yields per acre	Price per pound	Gross income per acre	Total costs per acre	Net income per acre	Cost per pound
1931	*Pounds*					
Irrigated	8,420	$ .041	$345.22	$191.29	$153.93	$ .023
Unirrigated	4,617	.041	189.30	84.12	105.18	.018
1932						
Irrigated	12,511	.027	333.63	199.62	134.01	.016
Unirrigated	7,229	.027	192.77	105.44	87.33	.015
1933[3]						
Irrigated	.....	.....	.....	124.17	.....	.....
Unirrigated	.....	.....	.....	84.05	.....	.....
1934						
Irrigated	7,663	.057	436.79	227.79	209.00	.030
Unirrigated	5,891	.057	335.79	147.99	187.80	.025
1935						
Irrigated	9,258	.065	601.77	324.60	277.17	.035
Unirrigated	1,626	.065	105.69	101.90	3.79	.063
Average four bearing years						
Irrigated	9,463	.0454[1]	429.35	235.82	193.53	.0249[2]
Unirrigated	4,841	.0425[1]	205.89	109.86	96.03	.0227[2]

[1] Weighted average price—average total gross income divided by average total yields.
[2] Weighted average cost—average total costs divided by average total yields.
[3] Costs of 1933 do not enter the 4-year average.

Table 28. Comparative Size of Irrigated and Unirrigated Strawberries

Year and treatment	Number of pickings	Total weight of berries	Number of berries	Average size of berries	Gain	Loss
1932		*Pounds*		*Pounds*	*Per cent*	*Per cent*
Irrigated	3	3.16	207	.0158	26	.....
Unirrigated	3	3.30	265	.0125	.....	.....
1934[1]						
Irrigated	3	17.02	1,218	.0140	27	.....
Unirrigated	3	18.45	1,680	.0110	.....	.....
1935						
Irrigated	5	20.98	1,622	.0129	108	.....
Unirrigated	5	16.33	2,659	.0062	.....	.....

[1] No crop was harvested in 1933.

Table 29. Effect of Irrigation Upon Strawberry Grades

Variety, year, and treatment	Number of pickings	Total weight of samples	Total number berries	Grades		
				No. 1	No. 2	Culls
Corvallis		*Pounds*		*Per cent*	*Per cent*	*Per cent*
1934 Irrigated	1	6.70	453	64.6	12.7	22.7
1934 Unirrigated	1	7.34	704	49.7	14.3	36.0
1935 Irrigated	3	12.45	978	78.6	9.5	11.9
1935 Unirrigated	3	9.62	1,907	42.1	20.4	37.5
Narcissa						
1934 Irrigated	2	21.10	.....[1]	78.1	6.9	15.0
1934 Unirrigated	2	22.20	.....[1]	73.3	8.4	18.3
1935 Irrigated	2	8.53	644	88.2	5.9	5.9
1935 Unirrigated	2	6.91	752	61.2	13.2	25.6

[1] On one picking percentages were figured and recorded, but the number of berries was not recorded.

Apparently irrigation has a marked effect upon the grades of both the Corvallis and Narcissa varieties. The Narcissa, however, judging from the records of two very dry years, seems to stand drought conditions better than the Corvallis. This probably is due to the fact that it is an earlier-season berry and is not subjected to so much dry weather before ripening as is the Corvallis.

Tests of frozen and canned strawberries. Strawberries were weighed, canned, and frozen during the picking season. Samples of these berries were prepared for chemical analysis in the same manner as for Evergreen blackberries. The summary of these analyses is given in Table 30.

Table 30. CHEMICAL ANALYSES OF STRAWBERRIES

Variety and year	Irrigated				Unirrigated			
	Number of samples	Total sugars as invert	Total acid	Water	Number of samples	Total sugars as invert	Total acid	Water
Marshall		*Per cent*	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*
1932	2	5.36	.71	88.96	2	7.64	.89	85.48
Corvallis								
1934	2	5.66	1.04	88.95	2	6.34	1.32	87.32
1935	3	5.78	1.03	88.58	3	8.68	1.12	85.13
Narcissa								
1935	3	7.86	.66	86.83	3	6.61	.55	88.70

With the Marshall and Corvallis in these tests, both the sugars and acids are greater in unirrigated fruit. The difference in acid between irrigated and unirrigated berries is too slight to be noticeable, but the sweet flavor is much more pronounced in the unirrigated berries. Narcissa, on the other hand, has slightly more acid and sugar in the irrigated fruit although not enough to be noticeable.

In "cut-out" tests, strawberries were weighed, canned, and given a two-minute "drip" test in the same manner as that used for blackberries. In 1934 three samples in duplicate were taken from irrigated and unirrigated Corvallis strawberries. The cans were opened January 15, 1935, and the "drip" test given. In 1935 five duplicate samples of irrigated and unirrigated Corvallis, and six duplicate samples of irrigated with three duplicate samples of unirrigated Narcissa, were taken for testing. The "drip" test was given December 2, 1935.

The 1934 series showed 41.41 per cent solids in irrigated Corvallis and 39.49 per cent solids in the unirrigated fruit. The irrigated and unirrigated Corvallis of 1935 showed exactly the same amount of solids, 46.30 per cent. The Narcissa, however, averaged 44.10 per cent solids for the irrigated and 40.30 per cent for the unirrigated fruit.

From these tests it is shown that the irrigated fruit averaged a larger percentage of solids than the unirrigated. These records indicate that irrigated berries stand up somewhat better than the unirrigated fruit.

Other quality tests. During the years 1932, 1934, and 1935, irrigated strawberries were superior in attractive red color, size, smoothness, regular

shape, and freedom from blemishes. After being in storage for 48 hours at 60° F., the unirrigated fruit stood up slightly better in the boxes than the irrigated, but it usually was less attractive in appearance.

RED RASPBERRIES AND BLACK RASPBERRIES

Unfortunately the red raspberries were attacked so severely by the loganberry crown borer (*Bembecia marginata,* Harris) and the strawberry crown borer (*Syanthedon bibionipennis,* Boisd.) during the sixth season that many canes were destroyed and the experiment was abandoned. The canes were pulled up during the following winter.

The black raspberries were attacked during the sixth and seventh seasons by verticillium wilt (*Verticillium albo-atrum,* R. & B.). While the crop was harvested and records were kept during those seasons, the crumbly condition of the fruit as well as the damaged canes made it advisable not to include these records with those of the first five years. The canes were pulled up after the seventh season.

For particulars concerning the influence of irrigation upon these two bramble fruits during the first five years of the experiment, the reader is referred to Station Bulletin 277. It is sufficient to summarize in this bulletin by stating that irrigation increased the size of red raspberries 7 per cent but did not retard the time of ripening. Use of water more than doubled the net income during the 3-year production period, and gave as good a quality of canned fruit as was found among the unirrigated berries. The black raspberries showed 22 per cent gain in size of fruit under irrigation. Only in one year, 1929, did irrigated blackcaps show a profit; as an average a considerable loss was shown throughout the 3-year bearing period. Irrigation did not materially affect the quality of canned black raspberries.

ECONOMIC CONCLUSIONS

A summary covering the bearing years of each fruit (Table 31) shows clearly that strawberries made money consistently even during the depression period. In the case of loganberries and Evergreen blackberries, the losses sustained during the last five years of the experiment more than offset the profits obtained during the period of good prices, though the irrigated loganberries nearly broke even over the 7-year bearing period. Although the red raspberries were not given the acid test of the depression, it is evident from an examination of costs per pound that this fruit probably would have made some profit during the five years, 1931 to 1935, especially if it had been irrigated. Black raspberries, on the other hand, showed considerable loss per acre even during the period of good prices. The main reason for this loss apparently is the very low yields obtained, resulting in high costs per pound.

Based upon these data and under conditions similar to those of this experiment, conclusions may be summarized briefly as follows:

1. The growing of black raspberries is not likely to be profitable on soils of this type either with or without irrigation.

Table 31. SUMMARY TABULATION, 1926-1935

Kind of fruit	Average yields per acre[1]		Gain in yield due to irrigation	Average total cost per acre[2]		Average cost per pound[3]		Average price received per pound[3]		Average gross income per acre		Average net income per acre	
	Irrigated	Unirrigated		Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated
	Pounds	*Pounds*	*Per cent*										
Evergreen blackberries	10,027	7,357	36.3	$306.22	$223.55	$ .031	$ .030	$ .0285	$ .0265	$286.19	$195.30	$–20.03	$–28.25
Loganberries	6,528	4,122	58.4	243.89	176.14	.037	.043	.037	.034	242.54	138.97	–1.35	–37.17
Strawberries[4]	8,948	4,673	91.5	237.59	120.80	.027	.026	.048	.046	427.02	213.60	189.43	92.80
Red raspberries	7,051	4,452	58.4	336.93	250.83	.048	.057	.0785	.078	553.69	349.24	216.76	98.41
Black raspberries	3,042	1,445	110.5	241.73	166.75	.08	.115	.076	.074	230.52	107.42	–11.21	–59.33

[1] Blackberries, average of 8 crops; loganberries, 7 crops; strawberries, 6 crops; red raspberries, 3 crops; black raspberries, 3 crops.
[2] Cost per acre equals average annual cost, not including cost of establishing plots.
[3] Weighted averages per pound, each year weighted according to yield.
[4] Marshall, Corvallis, and Narcissa varieties entered into this compilation.

2. Evergreen blackberries, both irrigated and unirrigated, may be produced with profit when yields are kept high and prices received run from 3½¢ to 4¢ a pound.

3. Loganberries may be expected to pay wages and return 5 per cent on the investment when yields are maintained at a high level and prices range from 4¢ to 4½¢ per pound.

4. Red raspberries do well on this type of soil and will make favorable returns whenever prices run 6¢ to 7¢ or more per pound.

5. Most varieties of strawberries do well on soils of the Chehalis and Newberg series and respond very favorably to irrigation. The Ettersburg 121 is the only variety tested that failed to show an increase in profits from irrigation.

Under the conditions of this experiment strawberries did not fail to make a profit even during the financially lean years. When high yields can be maintained and prices of 5¢ to 6¢ per pound received, there should be very satisfactory returns per acre from most strawberry varieties.

ACKNOWLEDGMENTS

Dr. W. L. Powers, head of the Soils Department of Oregon State College, has had supervision of irrigation operations throughout the 10-year period of this experiment. From irrigation data collected during this period, Table 5 and Figure 1 were prepared under his direction. Dr. Powers has been kind enough to read the manuscript and has made several valuable suggestions regarding its arrangement.

For the chemical analyses of small fruits the author is indebted to J. C. Moore, assistant in horticultural research[1]; Elmer Hansen, assistant horticulturist; and W. E. Martin, fellow in horticulture.[2]

Professor C. E. Schuster, horticulturist, United States department of agriculture, has given valuable suggestions from time to time.

[1]Resigned, August 1935.
[2]Resigned, July 1935.

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