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Bulletin No. 86 - The Right Way to Irrigate

John A. Widtsoe

EXPERIMENT STATION

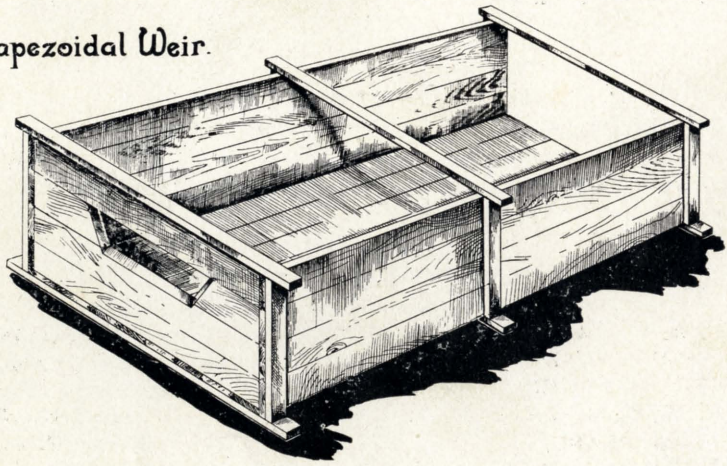
—OF—

THE AGRICULTURAL COLLEGE

OF UTAH.

BULLETIN NO. 86.

Trapezoidal Weir.



The Right Way to Irrigate.

(Results of 1901)

DECEMBER, 1903.

LOGAN, UTAH.

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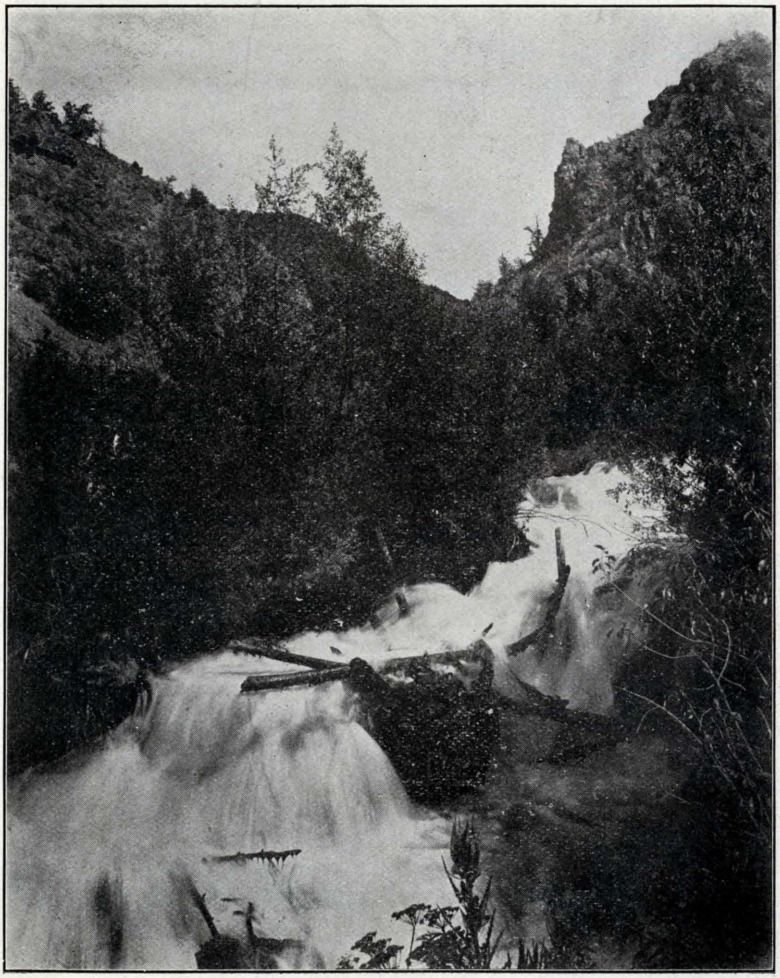


Plate 2. A Utah Mountain Stream in July.

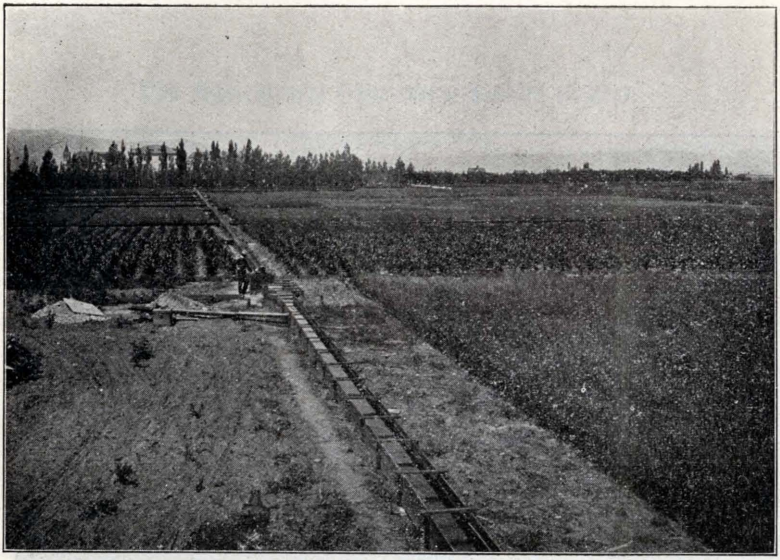


Plate 3. The approach to the head weir, showing the main flume and laterals of the irrigation system.

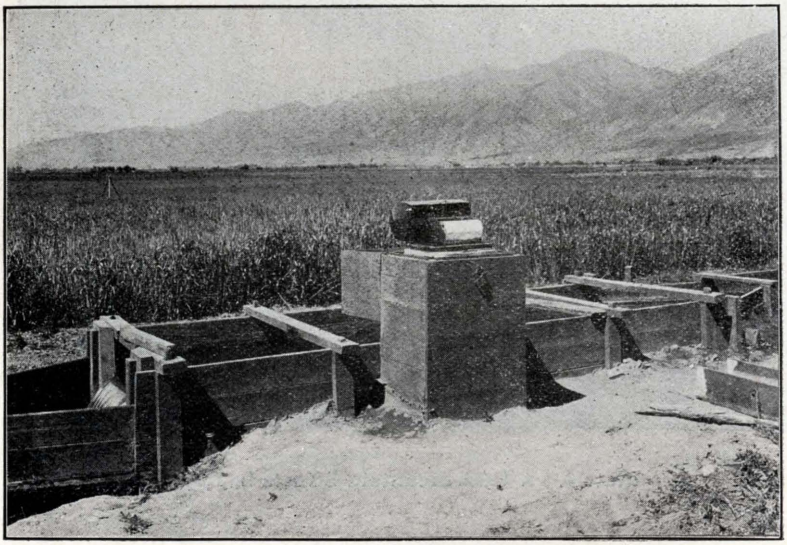


Plate 4. Head weir and Register.

Plate 5. A part of the irrigation system. (Looking south-east.)

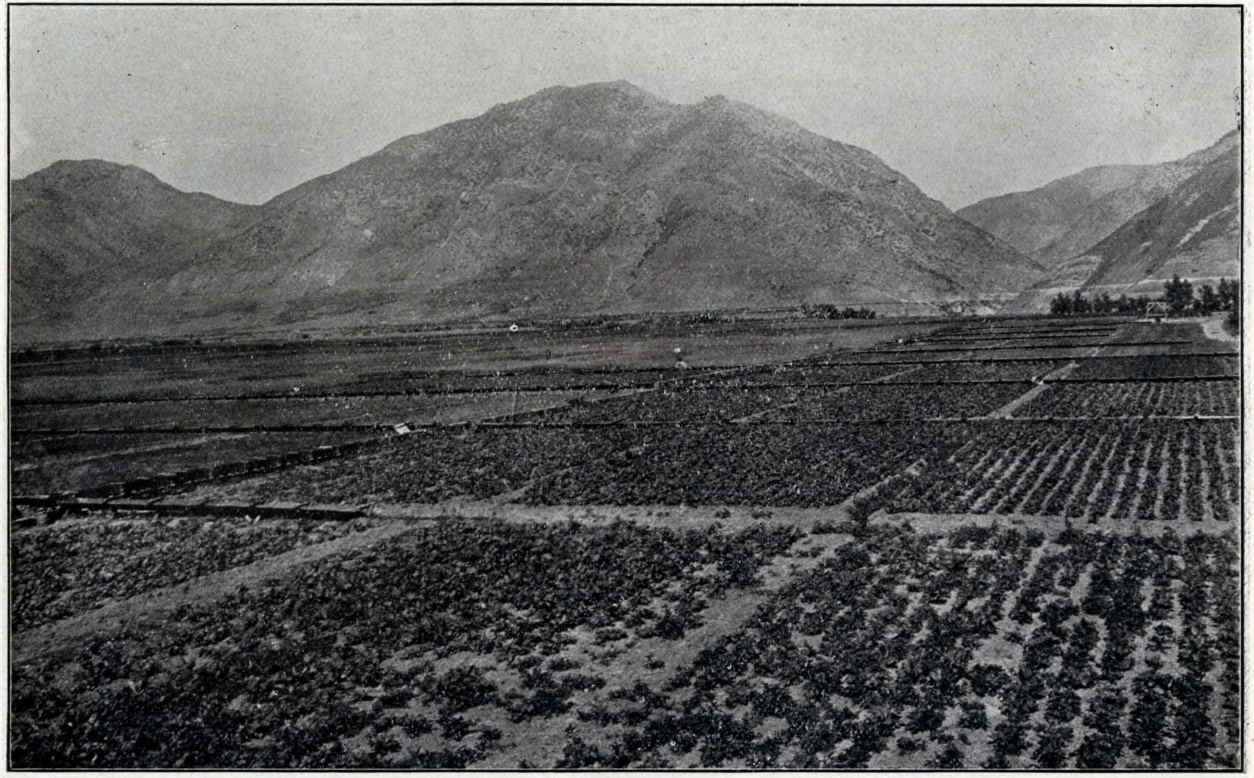


Plate 6. A part of the irrigation system. (Looking north-east.)

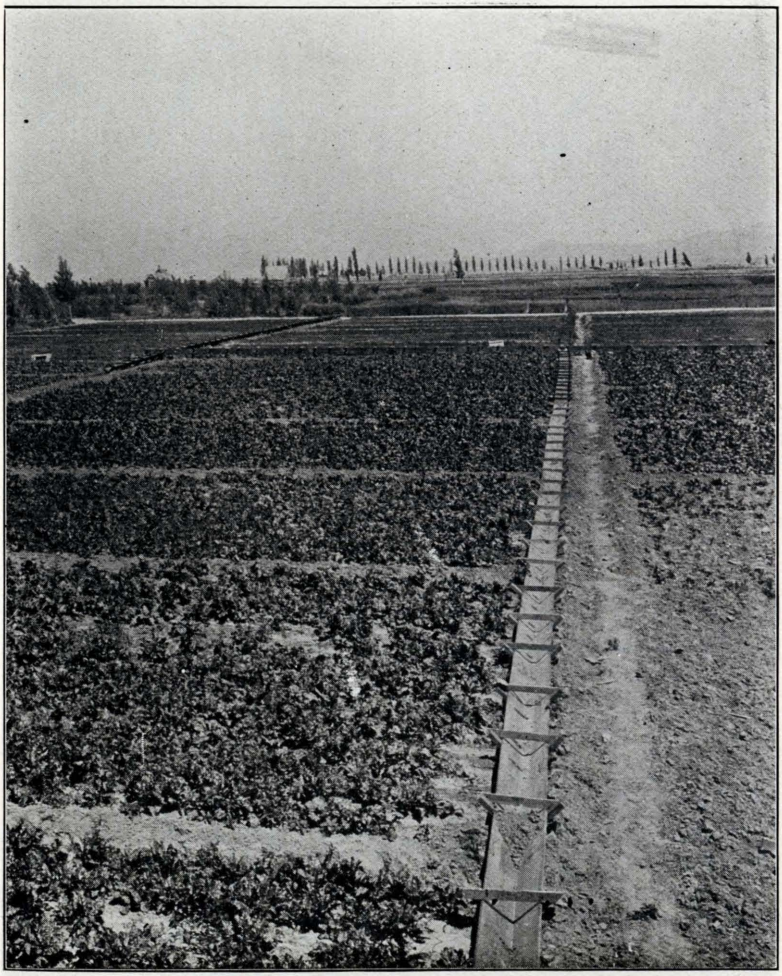
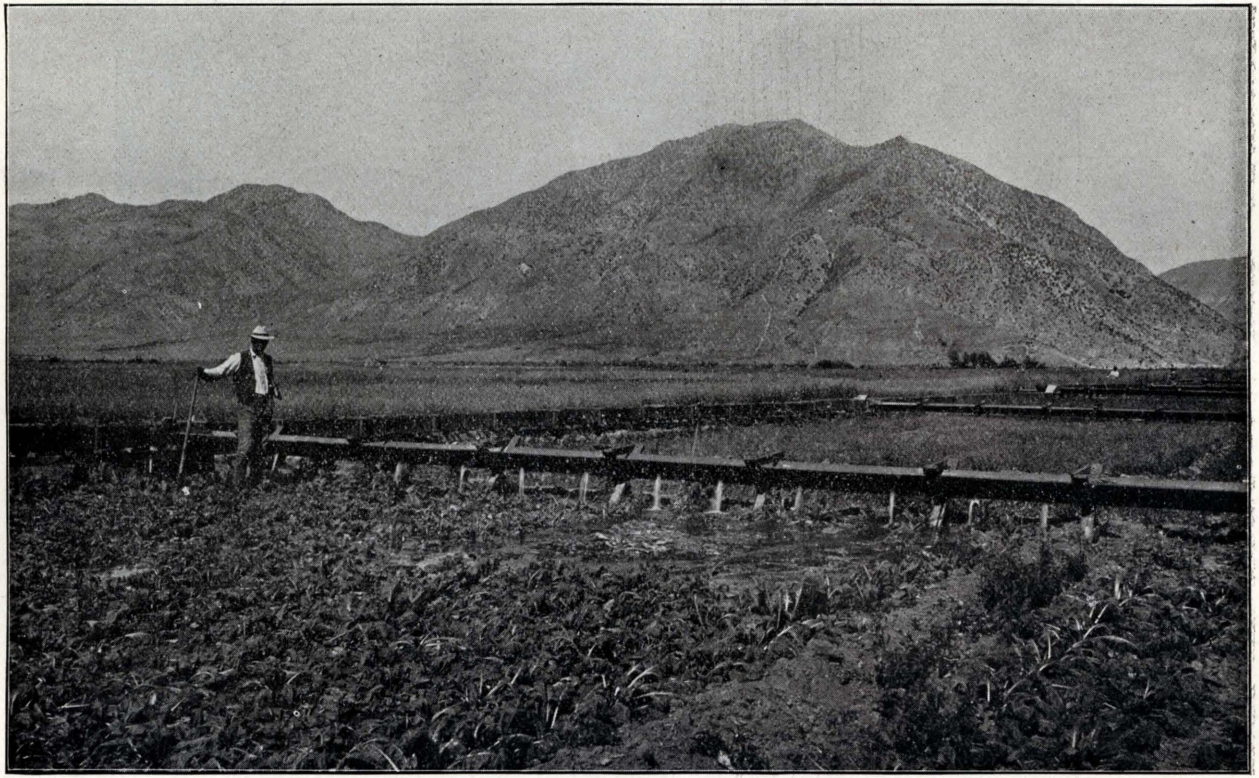


Plate .7 A lateral flume.



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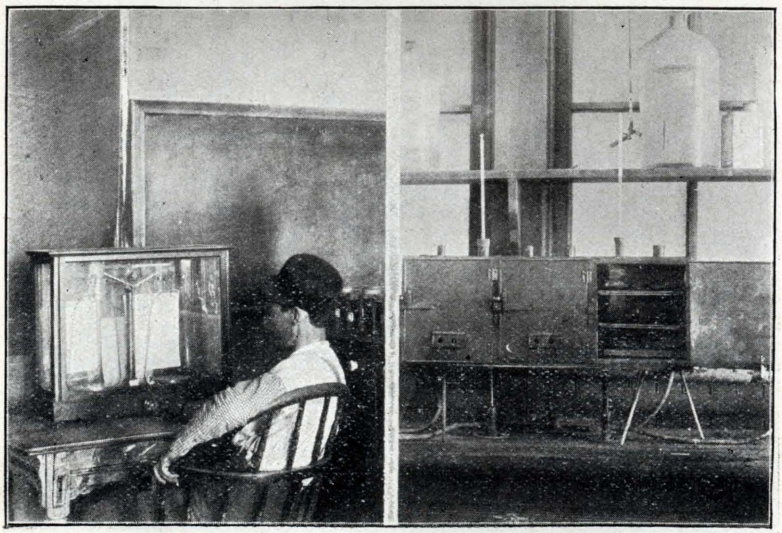

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THE RIGHT WAY TO IRRIGATE.

RESULTS OF 1901.

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1. Prefatory Note.

This bulletin has been written by John A. Widtsoe and W. W. McLaughlin. It is a popular exposition of some of the results found in Bulletin No. 80 of this station entitled "Irrigation Investigations on the College Farm in 1901," by John A. Widtsoe, Geo. L, Swendsen, L. A. Merrill, W. W. McLaughlin, W. D. Beers and Osborne Widtsoe.

The irrigation investigations of the Utah Experiment Station were instituted in 1901; and have been continued since that year. The results promise to be of the highest importance in the establishment of correct practices in the use of water on the farms.

The results in this bulletin were obtained in 1901; the results for 1902 and 1903 are not yet ready for publication, but it is hoped to have them in the hands of the farmers within a few months.

In studying the diagrams and statements of the following pages it must be borne in mind that the experiments were performed on shallow, gravelly bench land, and that, therefore, in many cases, the results on the predominating, deep valley lands will be somewhat different. Since 1901, the experiments have been conducted on an especially provided farm, the soil of which is deep and uniform in texture.

Correspondence and suggestions concerning the irrigation needs of the State of Utah are invited by the Experiment Station.

JOHN A. WIDTSOE,
Director.

2. INTRODUCTION: THE RELATIVE VALUE OF LAND AND WATER IN UTAH.

The State of Utah covers an area of 82,190 square miles, on which only 1,613 square miles, or 1.96% are improved farm land. The area actually irrigated covers 983 square miles of the improved land; or 1.15% of the area of the whole state.

The reason for this small proportion of improved land lies not in the quality of the soils, for they are among the most fertile in the world, or in the conditions of temperature and sunshine, for they approach the ideal, but in the lack of rain and river water to cover the land, sufficiently to produce profitable crops.

The irrigated area of this state may be largely increased, without the building of another canal or reservoir, by the adoption of more rational and economical methods of irrigation. The quality of the crops raised may likewise be improved, to the benefit of Utah's reputation.

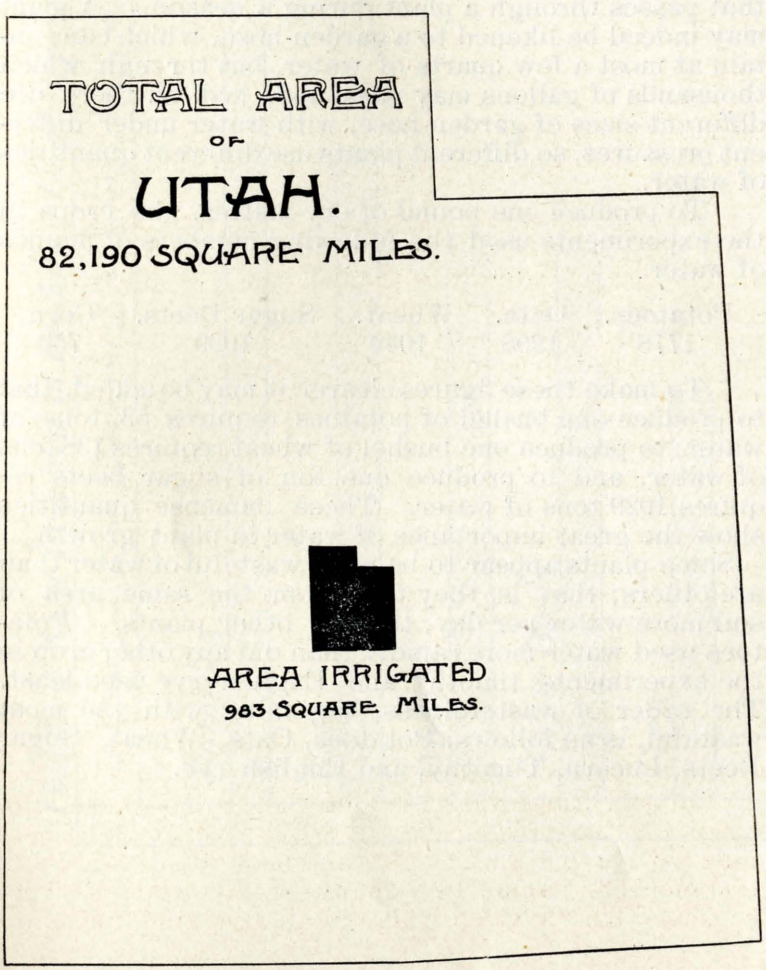
Neither the world at large, nor the irrigation farmers realize at all fully the wonderful control of the quality and yield of crops that is made possible by irrigation. The art of irrigation has never been studied systematically; but, in the development of the great West, the time has come when a science of irrigation must be established, which will govern the practices of the farmer.

If all this be so, no further excuse is needed for the inauguration of the elaborate experiments on the relation of water to crops and soils, that have been continued by the Station since the spring of 1901.

True, much of the unused land of the State furnishes scanty stock ranges; and true, also, thousands of square miles will be made to yield profitable crops without irrigation when proper methods of culture shall have been determined. The certain growth of this state will come, however, with the storage of all the waters in the state, and their proper use during the season of growing plants.

Lands without water, though rich in plant foods, go begging at the present day at $1.50 to $2.50 per acre; lands with ample water right, and near the railroads or good markets, cannot be bought for $100.00 to $200.00 per acre. The average value of all irrigated farms in

the State with poor, good or first class water rights,' is not far from $50.00 per acre. The conclusion is evident: *The value of a farm in Utah does not reside largely in the land, but rather in the quantity of water under the control of the owner.* The smaller the possible returns of the farm without irrigation, the greater the value of a water right for it.



3. HOW MUCH WATER DO CROPS USE?

The correct answer to this question will surprise many a first class irrigation farmer.

In the soil and well hidden from view, are the tiny plant rootlets which are constantly abstracting water from the soil and passing it into the plant. Once in the plant, the water rises in the stem, performs many offices, and finally reaches the leaves, whence it is evaporated, and escapes into the air as an invisible vapor.

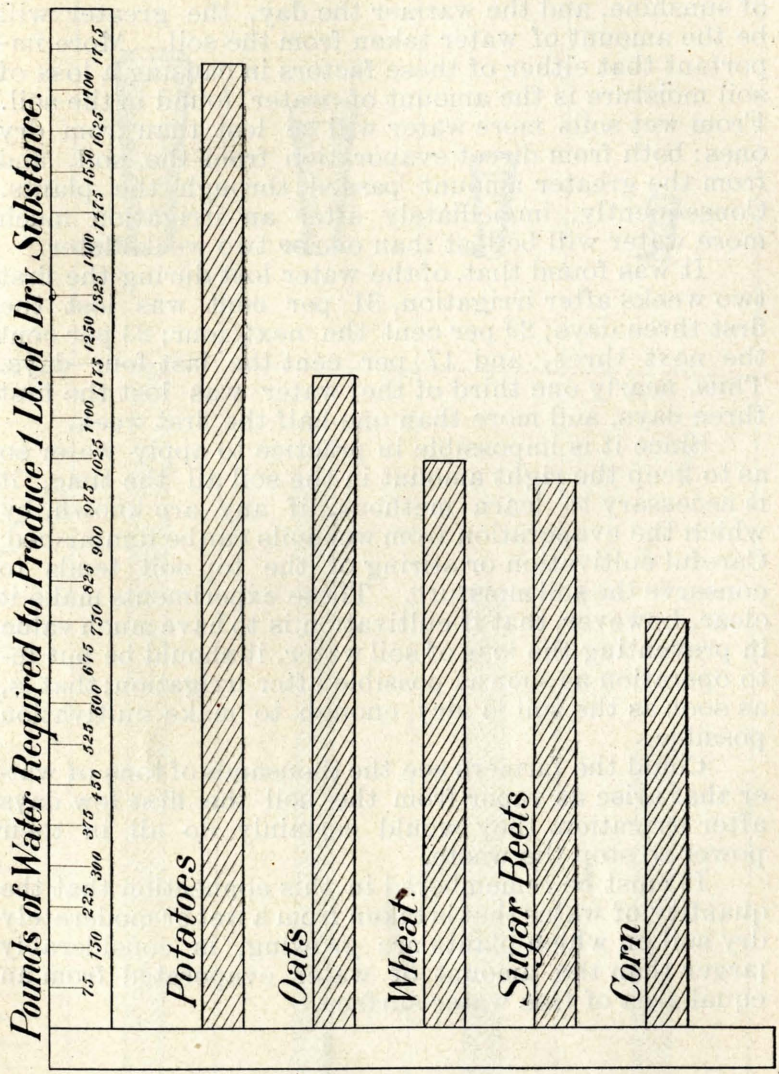
This almost imperceptible process is so persistent that it is difficult to realize the large quantity of water that passes through a plant during a season. A plant may indeed be likened to a garden-hose, which can contain at most a few quarts of water, but through which thousands of gallons may pass; and, just as there are different sizes of garden-hose, with water under different pressures, so different plants use different quantities of water.

To produce one pound of dry matter, the crops in the experiments used the following numbers of pounds of water.

Potatoes.	Oats.	Wheat.	Sugar Beets.	Corn
1778	1208	1049	1029	753

To make these figures clearer it may be added, that to produce one bushel of potatoes requires 53 tons of water; to produce one bushel of wheat requires 138 tons of water, and to produce one ton of sugar beets requires 1029 tons of water. These immense quantities show the great importance of water in plant growth.

Some plants appear to be more wasteful of water than are others; that is, they take from the same area of soil more water per day, than do other plants. Potatoes used water more rapidly than did any other crop in the experiments; timothy and English rye used least. The order of wastefulness, beginning with the most wasteful, is as follows: Potatoes, Oats, Wheat, Sugar Beets, Lucern, Timothy, and English rye.


Pounds of Water Required to Produce 1 Lb. of Dry Substance.
75 150 225 300 375 450 525 600 675 750 825 900 975 1025 1100 1175 1250 1325 1400 1475 1550 1625 1700 1775
Potatoes
Oats
Wheat.
Sugar Beets
Corn

4. WHEN DOES THE SOIL LOSE MOST WATER?

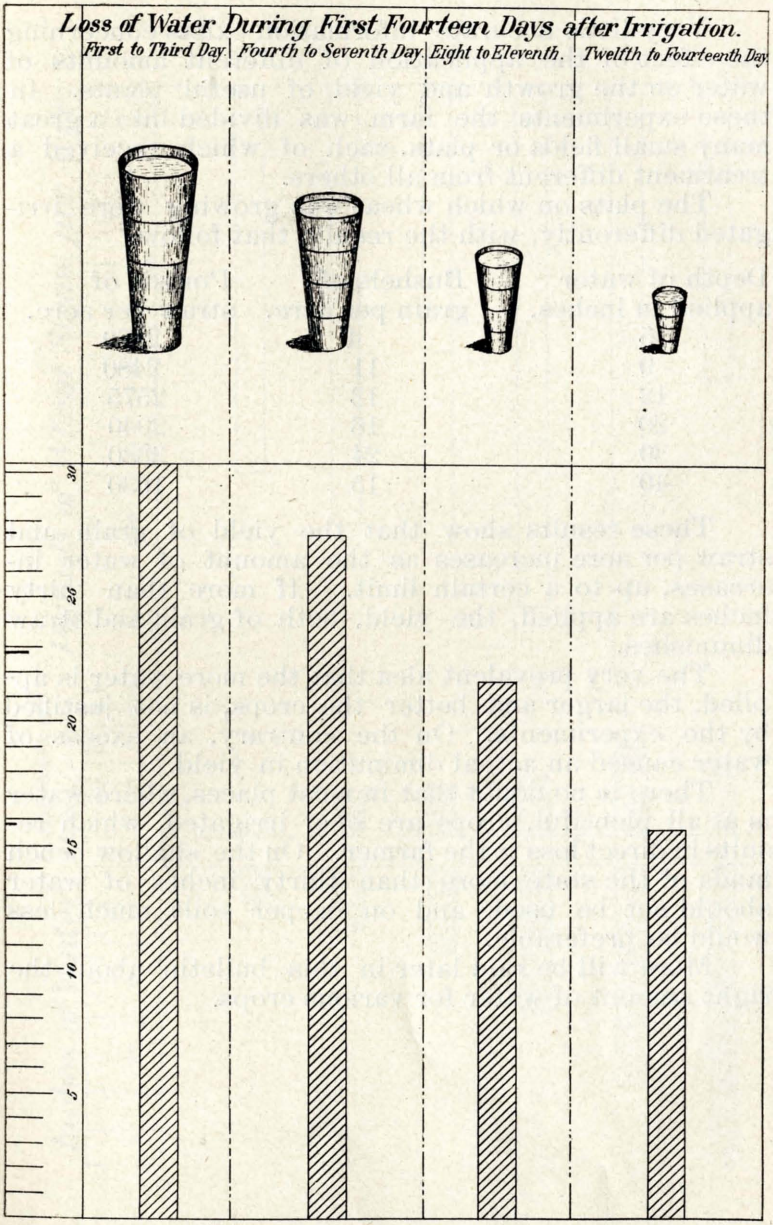
The quantity of water sucked out of the soil by plants, in any one day, depends upon many conditions. The drier the atmosphere and the greater the amount of sunshine, and the warmer the day, the greater will be the amount of water taken from the soil. More important that either of these factors in causing a loss of soil moisture is the amount of water found in the soil. From wet soils more water will be lost than from dry ones; both from direct evaporation from the soil, and from the greater amount passed through the plants. Consequently, immediately after an irrigation much more water will be lost than one or two weeks later.

It was found that, of the water lost during the first two weeks after irrigation, 31 per cent was lost the first three days; 29 per cent the next four; 23 per cent the next three, and 17 per cent the last four days. Thus, nearly one third of the water was lost the first three days, and more than one half the first week.

Since it is impossible in practice to apply water so as to keep the right amount in the soil all the time, it is necessary to learn methods, if any are known, by which the evaporation from wet soils can be diminished Careful cultivation or stiring of the top soil tends to conserve the soil moisture. These experiments make it clear, however, that if cultivation is to have much value in preventing the loss of soil water, it should be put into operation as soon as possible after irrigation; that is, as soon as the soil is dry enough to make cultivation possible.

Could the farmers see the thousands of tons of water that arise as vapor from the soil the first few days after irrigation, they would certainly do all in their power to stop the waste.

It must be remembered in this connection that the quantity of water that is taken from a wet or moderately dry soil on which plants are growing, is considerably larger than the amount of water evaporated from an equal area of free water surface.


Loss of Water During First Fourteen Days after Irrigation.
First to Third Day
Fourth to Seventh Day
Eight to Eleventh.
Twelfth to Fourteenth Day
30
25
20
15
10
5

5. THE RIGHT AMOUNT OF WATER FOR WHEAT.

Very little accurate information exists concerning the effect of the application of different amounts of water on the growth and yield of useful plants. In these experiments the farm was divided into a great many small fields or plats, each of which received a treatment different from all others.

The plats on which wheat was growing were irrigated differently, with the results that follow.

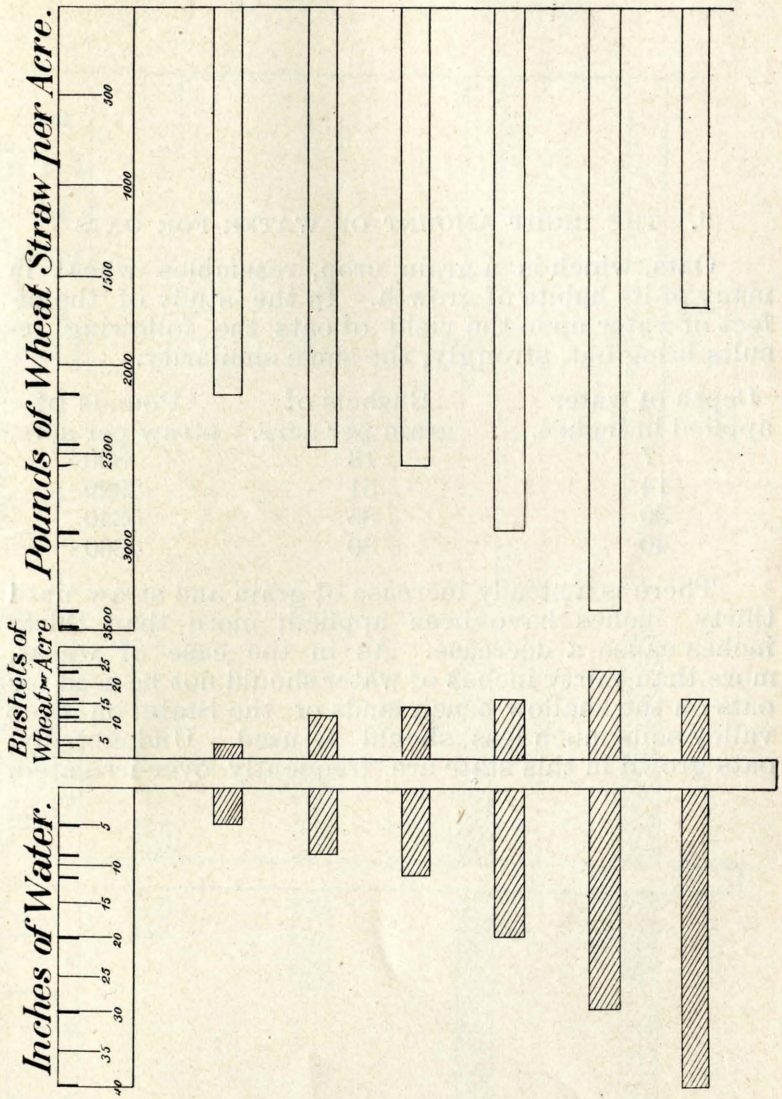
Depth of water applied in inches.	Bushels of grain per acre.	Pounds of straw per acre.
5	4	2270
9	11	2480
12	13	2575
20	16	2940
30	24	3380
40	15	1630

These results show that the yield of grain and straw per acre increases as the amount of water increases, up to a certain limit. If more than thirty inches are applied, the yield, both of grain and straw diminishes.

The very prevalent idea that the more water is applied, the larger and better the crops, is not justified by the experiments. On the contrary, an excess of water caused an actual diminution in yield.

There is no doubt that in most places, where water is at all plentiful, crops are over irrigated, which results in direct loss to the farmer. On the shallow bench lands of the state more than thirty inches of water should not be used, and on deeper soils much less would be preferable.

More will be said later in this bulletin about the right amount of water for various crops.

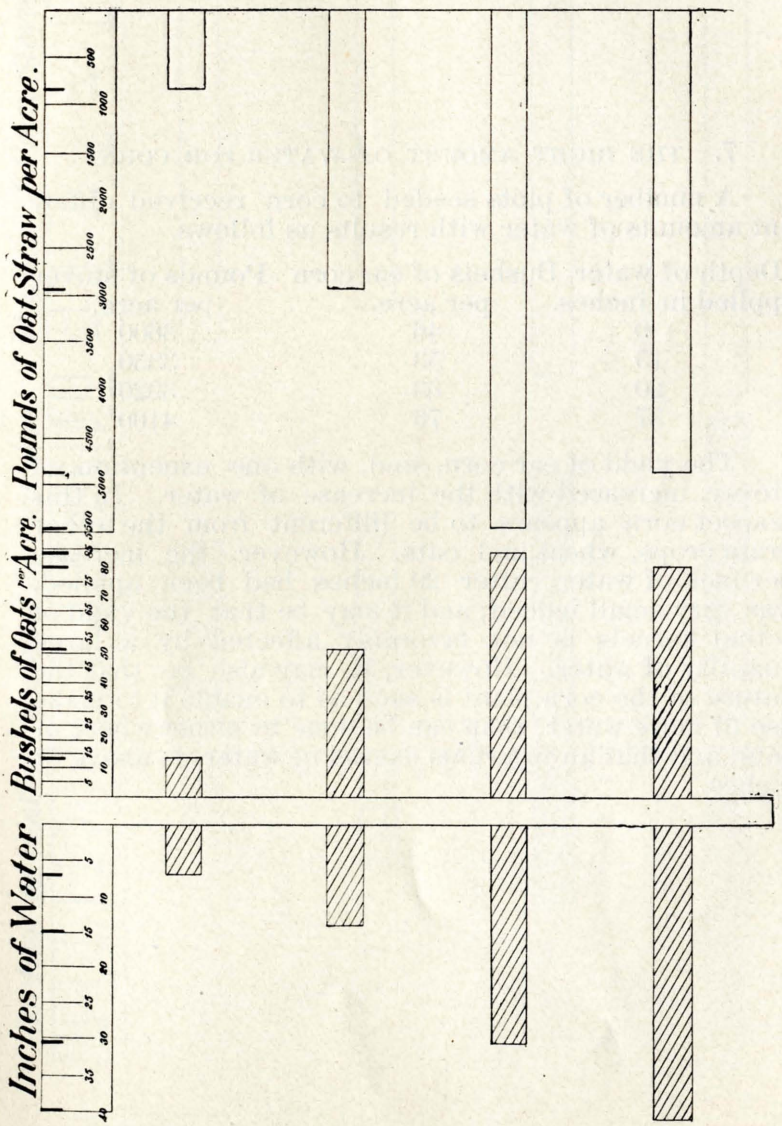

Inches of Water.
40
35
30
25
20
15
10
5
Bushels of Wheat per Acre
5
10
15
20
25
35
Pounds of Wheat Straw per Acre.
500
1000
1500
2000
2500
3000
3500

6. THE RIGHT AMOUNT OF WATER FOR OATS

Oats, which is a grain crop, resembles wheat in many of its habits of growth. In the study of the effect of water upon the yield of oats the following results bring out, strongly, the same similarity.

Depth of water applied in inches.	Bushels of grain per acre.	Pounds of straw per acre.
7	13	800
14	51	2920
30	85	5340
40	80	4860

There is a steady increase of grain and straw until thirty inches have been applied; more than thirty inches cause a decrease. As in the case of wheat, more than thirty inches of water should not be used for oats on the shallow bench lands of the State; on deep valley soils much less should be used. Undoubtedly, oats grown in this state are frequently over-irrigated.

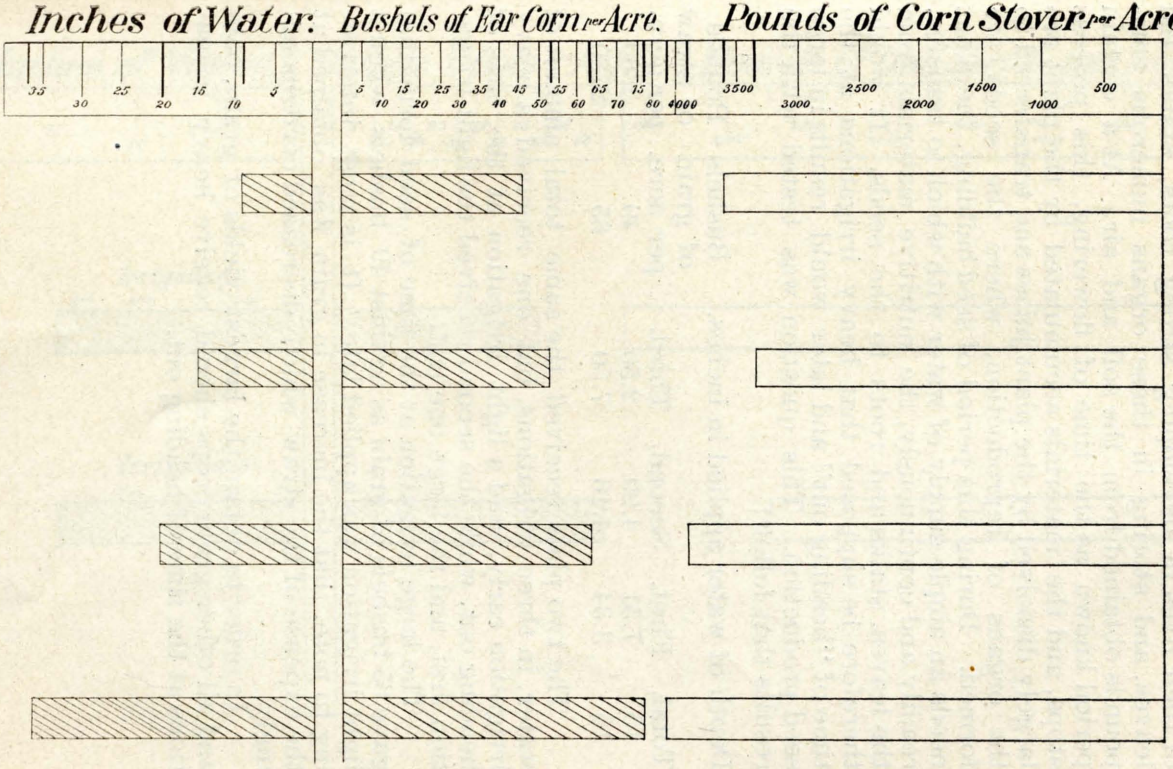

Inches of Water
Bushels of Oats per Acre.
Pounds of Oat Straw per Acre.

7. THE RIGHT AMOUNT OF WATER FOR CORN.

A number of plots seeded to corn received different amounts of water with results as follows.

Depth of water applied in inches.	Bushels of ear corn per acre.	Pounds of stover per acre.
9	46	3600
15	53	3350
20	63	3920
37	76	4100

The yield of ear corn, and, with one exception, of stover, increased with the increase of water. In this respect corn appears to be different from the other grain crops, wheat and oats. However, the increase per inch of water, after 20 inches had been applied, was very small indeed; and it may be that the yield of actual kernels is not favorably affected by a large quantity of water. However, it may also be that the nature of the corn plant is such as to enable it to make use of more water, than can be done by either wheat or oats; and that an injurious excess of water is above 37 inches.


Inches of Water.
35
30
25
20
15
10
5
Bushels of Ear Corn per Acre.
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
4000
Pounds of Corn Stover per Acre.
3500
3000
2500
2000
1500
1000
500

8. THE TIME TO IRRIGATE OATS.

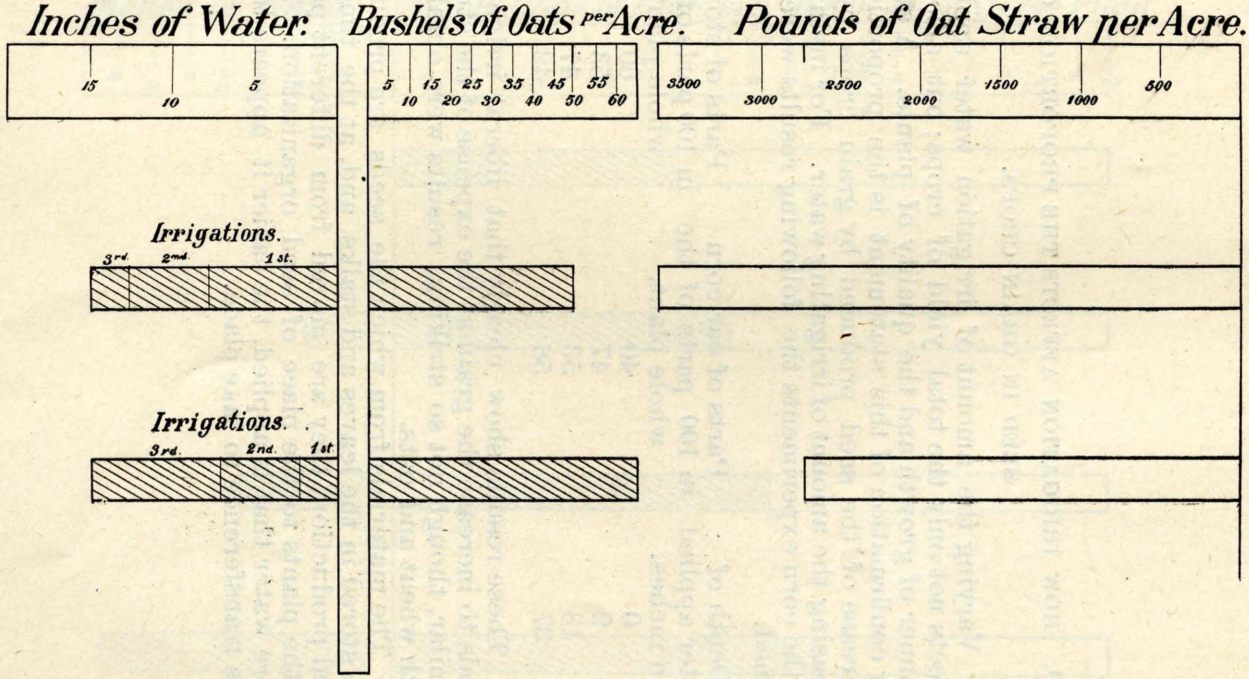
Oats and other grain crops spend the early periods of their lives in developing strong roots, stalks and leaves, and storing in these organs numerous compounds obtained from the soil and air. At a certain period known as the time of flowering, this process stops, and the materials accumulated by the plant are largely dissolved by the plant juices and transferred to the organs of reproduction, where the seeds are formed. During this period of seed building, the plant needs an ample supply of water with which to transfer, readily and continuously, the nutritive materials from the leaves, stalks and roots to the seeds. It would therefore be supposed that heavy irrigations at the time of "heading out" and later would result in large seed production. This question was tested with the results that follow:

Depth of water applied in inches.				Bushels of grain	Pounds of straw
Total.	First.	Second.	Third.	per acre.	per acre.
15	7.51	4.99	2.50	49	3660
15	3.34	4.16	7.50	65	2720

The two plats received the same total amount of water, in three irrigations, but one received a heavy irrigation early, and a light irrigation at the time of heading out, while the second received the light irrigation first, and the large one last.

The large irrigation at the time of seed formation gave 65 bushels of grain as against 49 bushels when a light irrigation was applied late. It is most interesting to note, that the increase in grain was obtained at the expense of the straw which decreased correspondingly.

In order to obtain the largest yields of grain, oats and all other grain crops should receive heavy irrigations at the time of heading out.


Inches of Water.
15
10
5
Bushels of Oats per Acre.
5
10
15
20
25
30
35
40
45
50
55
60
Pounds of Oat Straw per Acre.
3500
3000
2500
2000
1500
1000
500
Irrigations.
3rd.
2nd.
1st.
Irrigations.
3rd.
2nd.
1st.

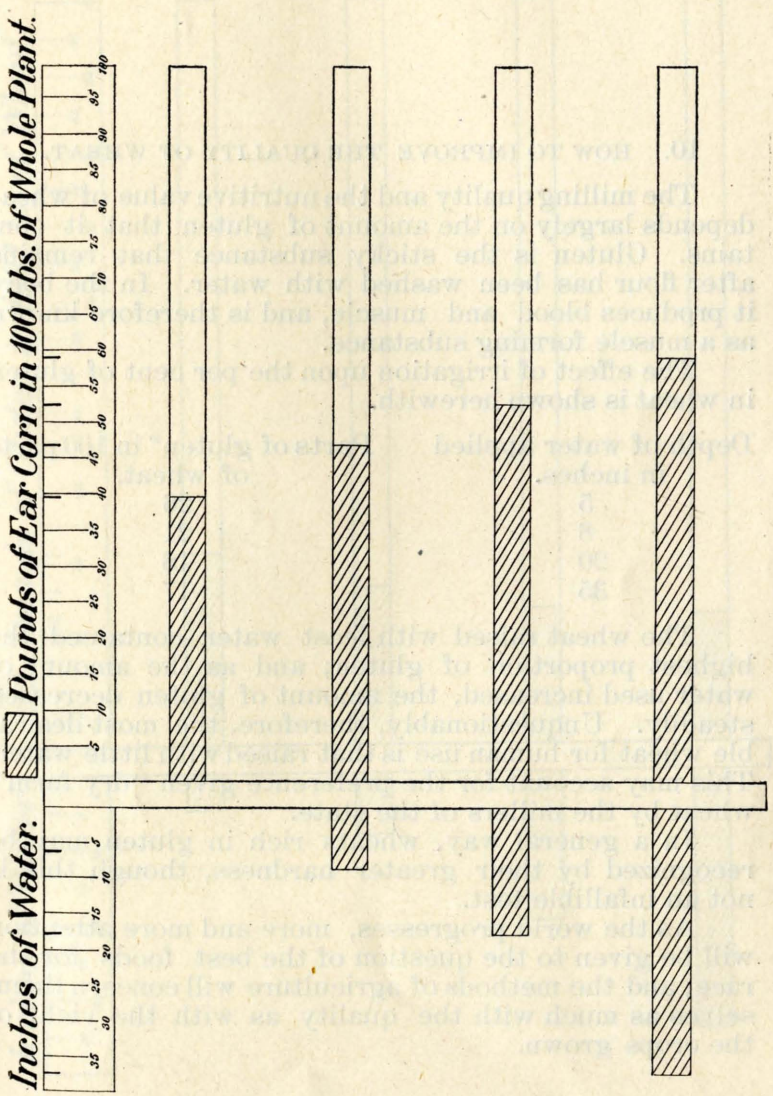
9. HOW IRRIGATION AFFECTS THE PROPORTION OF SEED IN GRAIN CROPS.

Varying the amount of irrigation water applied, affects not only the total yield of crops; but also the manner of growth and the quality of plants. A striking confirmation of this statement is the proportional increase of the seed produced by grain crops by increasing the amount of irrigating water. For instance, in the corn experiments the following results were obtained.

Depth of water applied in inches.	Parts of ear corn in 100 parts of the whole plant.	Parts of stover in 100 parts of the whole plant.
0	40	60
9	47	53
18	53	47
37	58	42

These results show clearly that liberal irrigation tends to increase the grain at the expense of the straw. Similar, though not so striking, results were obtained with wheat and oats.

The materials from which the seeds are produced are stored in the leaves and stalks, and, at the time of seed production, they are moved from different parts of the plants to the place of seed organization. The more water that is applied, the easier it appears to be this transference to take place.


Pounds of Ear Corn in 100 Lbs. of Whole Plant.
Inches of Water.

10. HOW TO IMPROVE THE QUALITY OF WHEAT.

The milling quality and the nutritive value of wheat depends largely on the amount of gluten that it contains. Gluten is the sticky substance that remains after flour has been washed with water. In the body it produces blood and muscle, and is therefore known as a muscle forming substance.

The effect of irrigation upon the per cent of gluten in wheat is shown herewith.

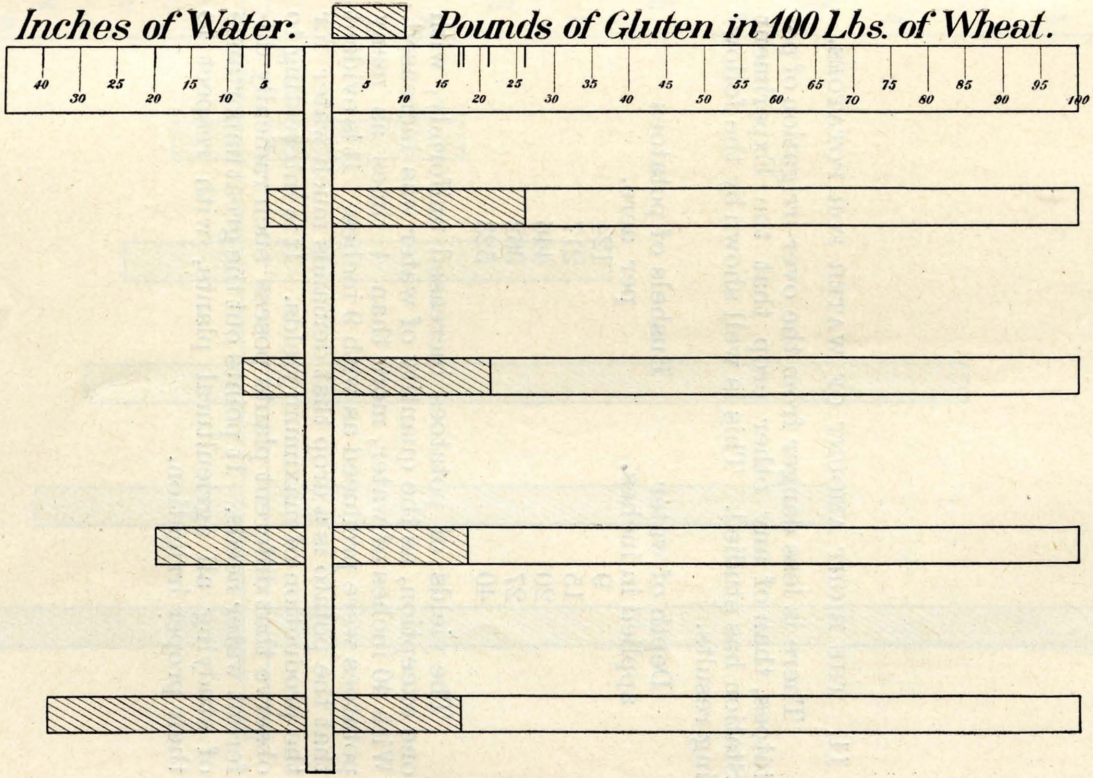
Depth of water applied in inches.	Parts of gluten* in 100 parts of wheat.
5	26
8	21
20	18
35	17

The wheat raised with least water contained the highest proportion of gluten; and as the amount of water used increased, the amount of gluten decreased steadily. Unquestionably, therefore, the most desirable wheat for human use is that raised with little water. This may account for the preference given "dry farm" wheat by the millers of the state.

In a general way, wheats rich in gluten may be recognized by their greater hardness, though this is not an infallible test.

As the world progresses, more and more attention will be given to the question of the best foods for the race; and the methods of agriculture will concern themselves as much with the quality as with the yield of the crops grown.

*Gluten is here used in the sense of protein.

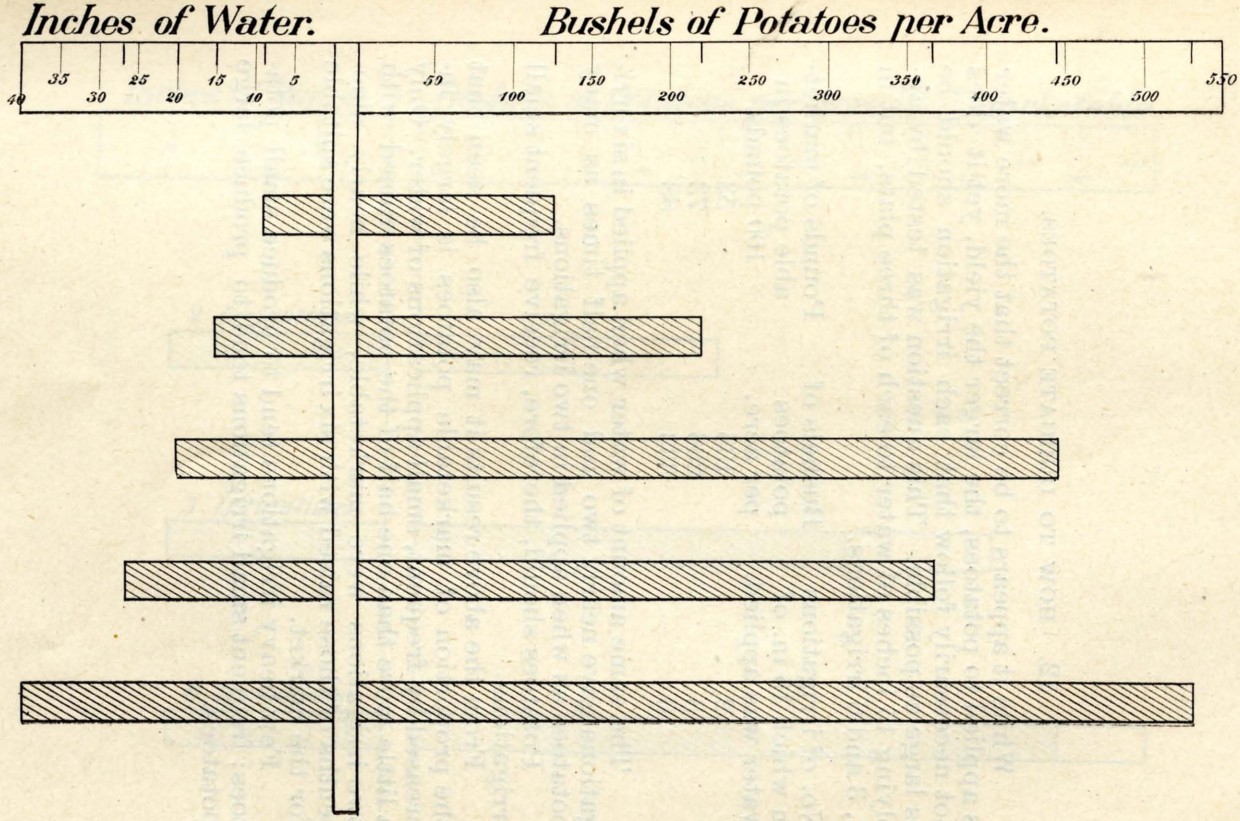

Inches of Water.
Pounds of Gluten in 100 Lbs. of Wheat.
40
30
25
20
15
10
5
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

11. THE RIGHT AMOUNT OF WATER FOR POTATOES.

There is less danger from the over-irrigation of potatoes, than of any other crop that the Experiment Station has studied. This is well shown by the following results.

Depth of water applied in inches.	Bushels of potatoes per acre.
9	124
15	217
20	446
27	362
40	523

The yields of potatoes increased uniformly, with one exception, as the quantity of water was increased. With 40 inches of water, more than 4 times as many potatoes were produced as with 9 inches. It is evident that the potato is a crop that demands much water for the production of maximum yields. It is interesting to observe that different plants posess such radically different water needs. It points out the great importance of studying all agricultural plants, with respect to their proper irrigation.


Inches of Water.
Bushels of Potatoes per Acre.
40
35
30
25
20
15
10
5
50
100
150
200
250
300
350
400
450
500
550

12. HOW TO IRRIGATE POTATOES.

While it appears to be correct that the more water is applied to potatoes, the larger the yield, yet it does not necessarily follow that each irrigation should be as large as possible. This question was tested by applying 15 inches of water to each of three plats, but in 2, 3 and 6 irrigations.

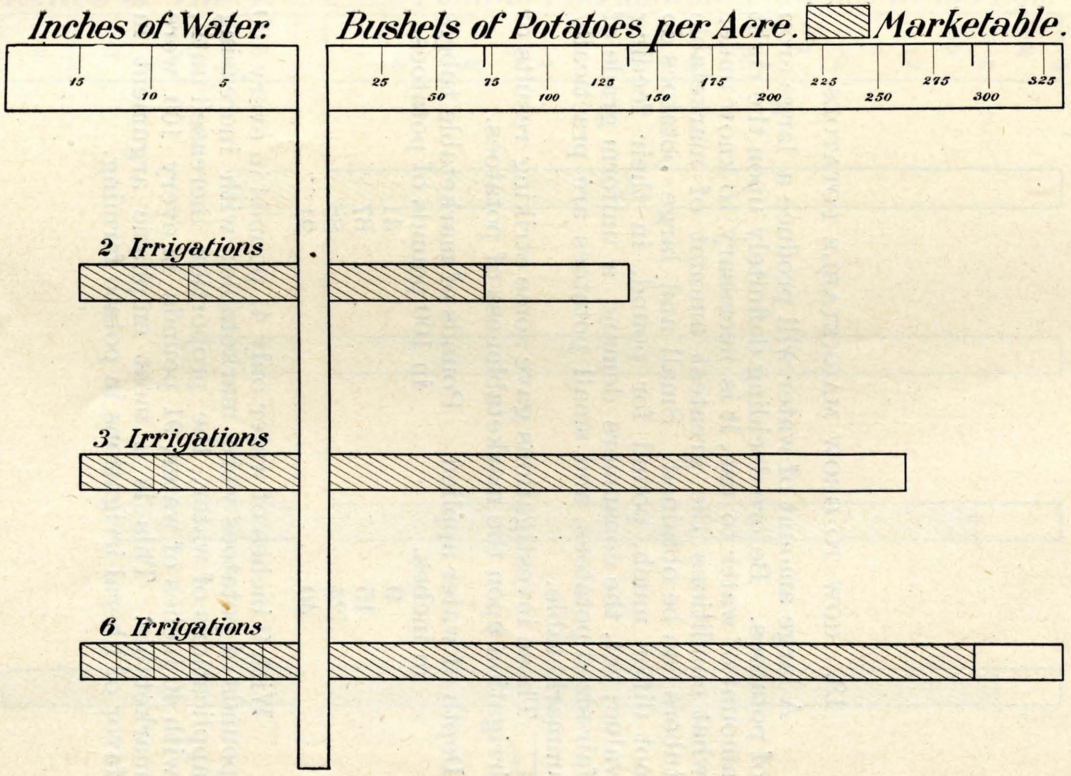
No. of irrigations in which 15 in. of water was applied.	Bushels of potatoes per acre.	Pounds of marketable potatoes in 100 pounds.
2	135	53
3	266	73
6	333	88

The same amount of water when applied in six irrigations gave nearly two and one-half times as many potatoes as when applied in two irrigations.

Potatoes should, therefore, receive frequent small irrigations.

From the above results it may also be seen that the proportion of marketable potatoes is largely increased by frequent, small applications of water. Only a little more than one-half of the potatoes raised with two irrigations were marketable, while nearly nine-tenths of those raised with six irrigations were suitable for the market.

Few heavy irrigations tend to produce small potatoes; frequent small irrigations tend to produce large potatoes.


Inches of Water.
Bushels of Potatoes per Acre.
Marketable.
15
10
5
25
50
75
100
125
150
175
200
225
250
275
300
325
2 Irrigations
3 Irrigations
6 Irrigations

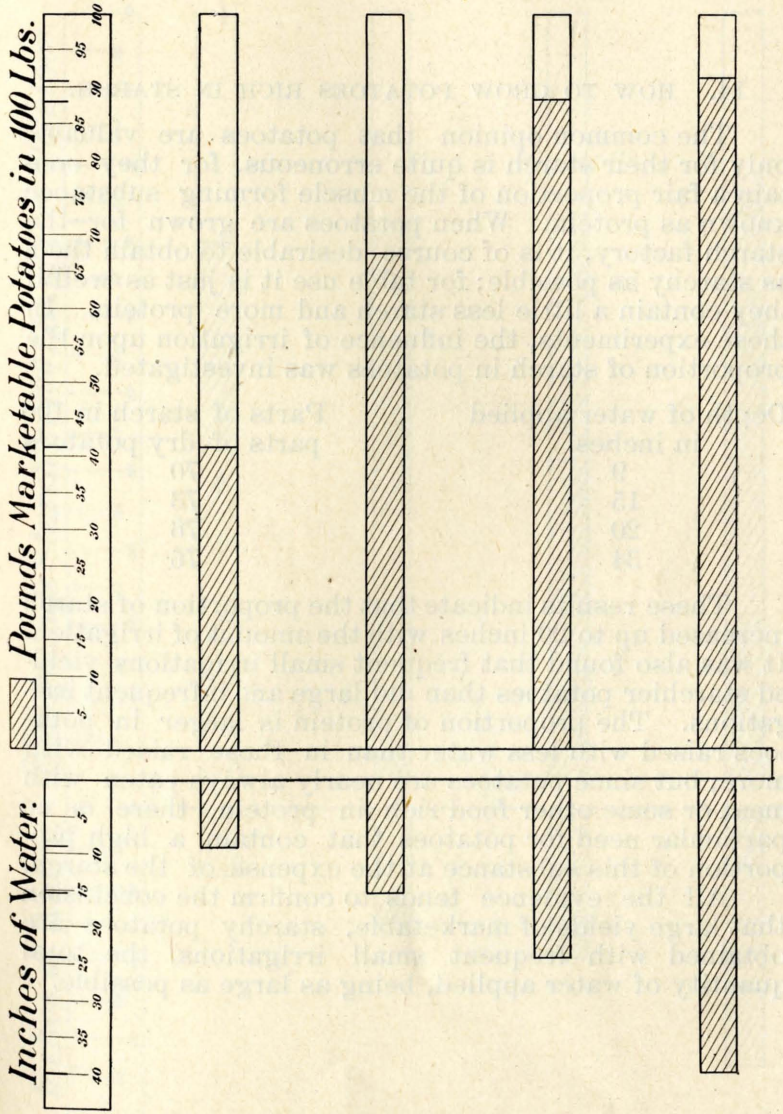
13. HOW TO GROW MARKETABLE POTATOES.

A large amount of water will produce a large crop of potatoes. Before deciding definitely upon the right amount of water to use, it is necessary to know under what conditions the greatest amount of marketable tubers can be obtained. Small and large potatoes do not differ much, pound for pound, in their feeding value; yet, the consumers demand a uniform grade of fair-sized potatoes, and small potatoes are practically unmarketable.

These investigations gave some striking results of irrigation upon the marketableness of potatoes.

Depth of water applied in inches.	Pounds of marketable tubers in 100 pounds of potatoes.
9	41
15	67
24	88
40	91

With 9 inches of water only 41 pounds in every 100 pounds of potatoes were marketable; with increasing applications of water, the proportion increased until, with 40 inches of water, 91 pounds in every 100 were marketable. This is a most emphatic argument in favor of liberal irrigations in potato farming.


Pounds Marketable Potatoes in 100 Lbs.
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Inches of Water.
5
10
15
20
25
30
35
40

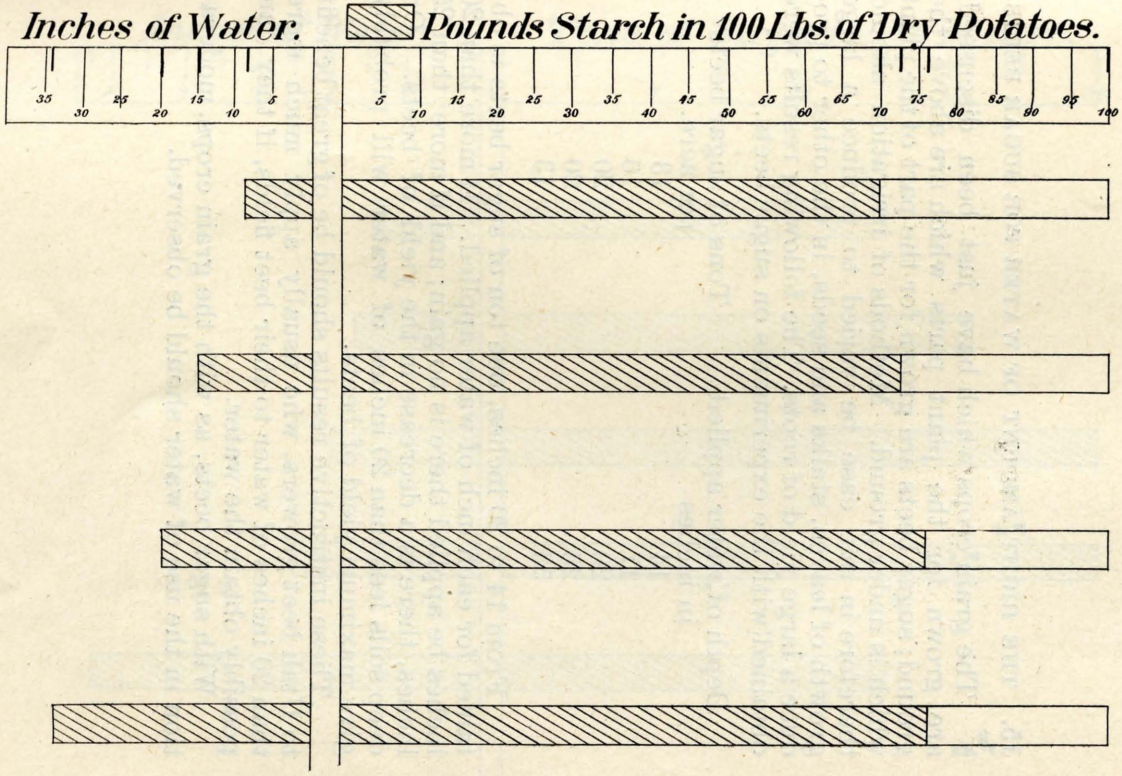
14. HOW TO GROW POTATOES RICH IN STARCH.

The common opinion that potatoes are valuable only for their starch is quite erroneous, for they contain a fair proportion of the muscle forming substance known as protein. When potatoes are grown for the starch factory, it is of course desirable to obtain them as starchy as possible; for table use it is just as well if they contain a little less starch and more protein. In these experiments, the influence of irrigation upon the proportion of starch in potatoes was investigated.

Depth of water applied in inches.	Parts of starch in 100 parts of dry potatoes
9	70
15	73
20	76
34	76

These results indicate that the proportion of starch increased up to 20 inches with the amount of irrigation. It was also found that frequent small irrigations yielded starchier potatoes than did large and infrequent irrigations. The proportion of protein is larger in potatoes raised with less water than in those raised with more; but since potatoes are nearly always eaten with meat or some other food rich in protein, there is no particular need for potatoes that contain a high proportion of this substance at the expense of the starch.

All the evidence tends to confirm the conclusion that large yields of marketable, starchy potatoes are obtained with frequent small irrigations, the total quantity of water applied, being as large as possible.


Inches of Water.
Pounds Starch in 100 Lbs. of Dry Potatoes.
35 30 25 20 15 10 5
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

15. THE RIGHT AMOUNT OF WATER FOR SUGAR BEETS.

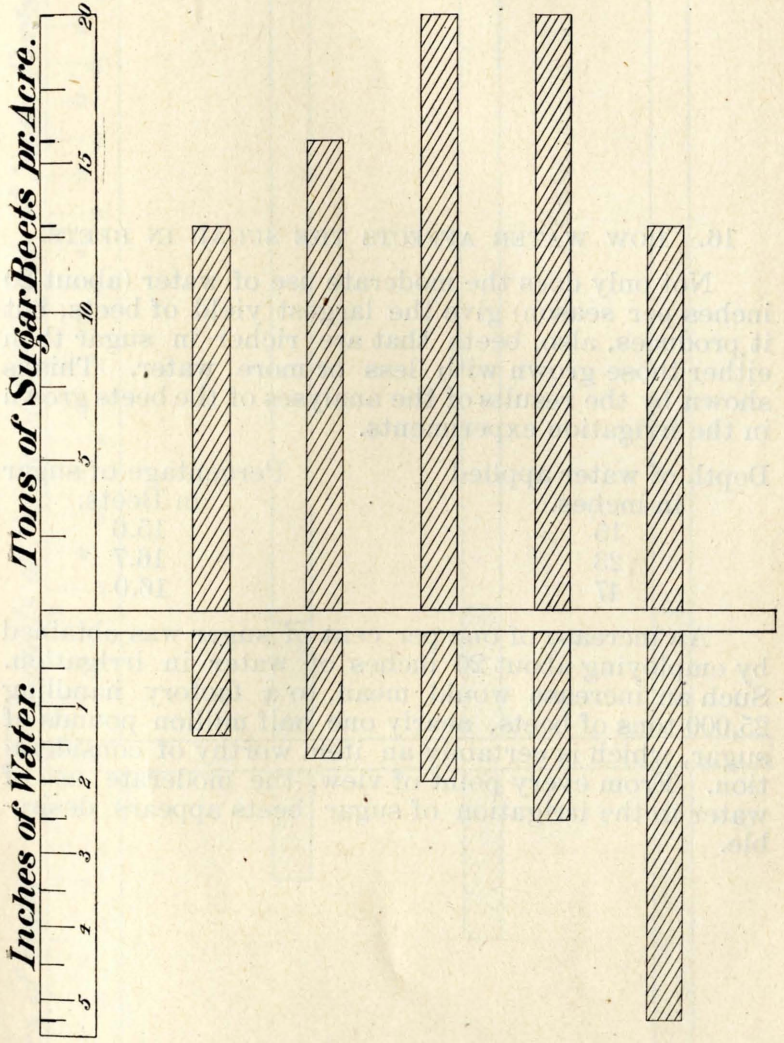
The grain crops which have just been discussed, are grown for the plant parts which are above the ground; sugar beets are grown for the part of the plant which is under ground. Methods of irrigation should therefore in one case be varied to produce a large growth of leaves, stalks and seeds, in the other to produce a large yield of roots. The following results were obtained with the experiments on sugar beets.

Depth of water applied in inches	Tons of sugar beets per acre.
14	13
17	16
20	20
25	20
53	13

From 14 to 20 inches, one ton of sugar beets is obtained for each inch of water applied. If more than 20 inches be applied there is no gain; and if more than 25 inches, there is a decrease in the yield of beets. On deep soils less than 20 inches of water will probably give maximum yield of beets.

These instructive results should be of great benefit to Utah beet growers, who usually apply much more than 20 inches of water to their beet fields, if they can possibly obtain the water.

With sugar beets, as with the grain crops, moderation in the use of water should be observed.

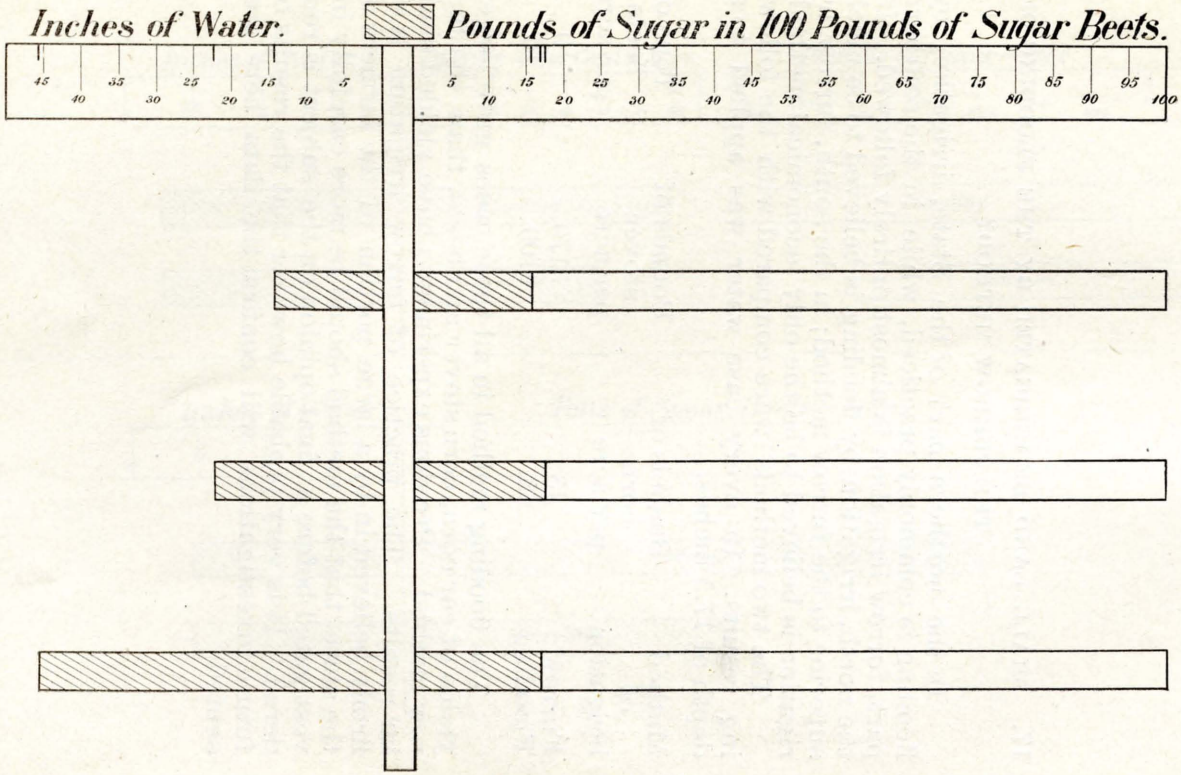

Tons of Sugar Beets pr. Acre.
5
10
15
20
Inches of Water.
1
2
3
4
5

16. HOW WATER AFFECTS THE SUGAR IN BEETS.

Not only does the moderate use of water (about 20 inches per season) give the largest yield of beets, but it produces, also, beets that are richer in sugar than either those grown with less or more water. This is shown by the results of the analyses of the beets grown in the irrigation experiments.

Depth of water applied in inches.	Percentage of sugar in Beets.
15	15.6
23	16.7
47	16.0

An increase of one per cent of sugar was obtained by employing about 20 inches of water in irrigation. Such an increase would mean, to a factory handling 25,000 tons of beets, nearly one half million pounds of sugar, which is certainly an item worthy of consideration. From every point of view, the moderate use of water in the irrigation of sugar beets appears desirable.


Inches of Water.
Pounds of Sugar in 100 Pounds of Sugar Beets.
45 40 35 30 25 20 15 10 5
5 10 15 20 25 30 35 40 45 53 60 65 70 75 80 85 90 95 100

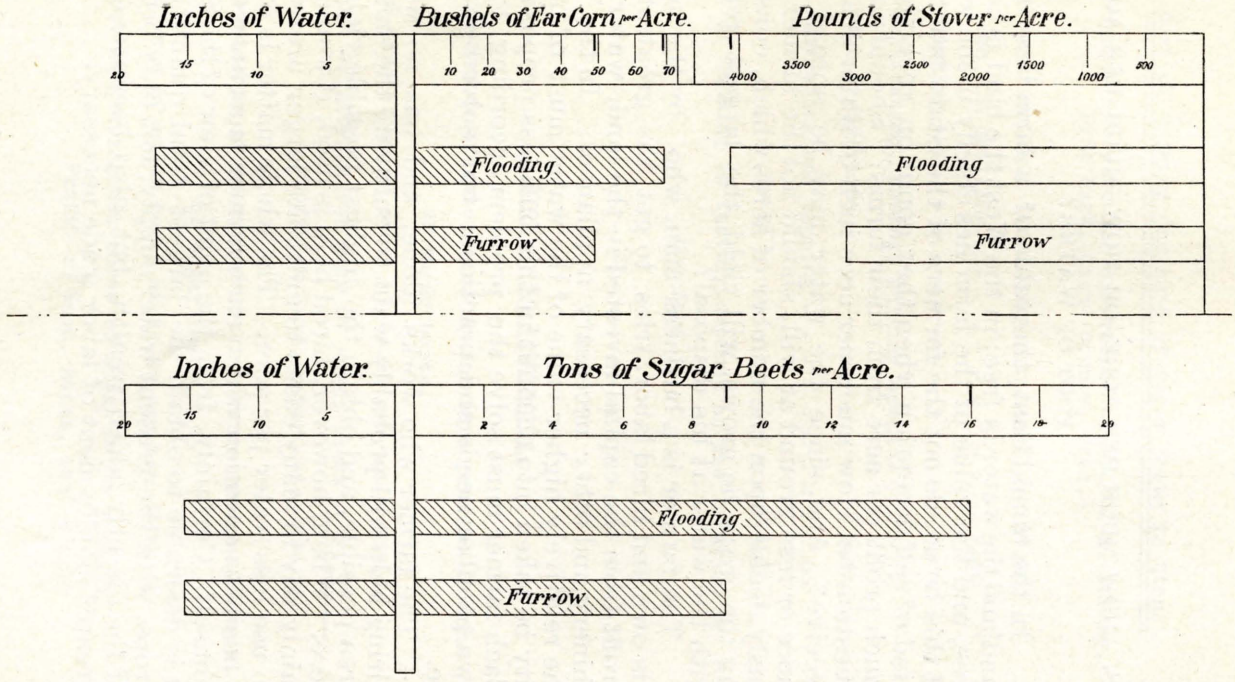
17. SHALL LAND BE IRRIGATED BY THE FLOODING OR THE FURROW METHOD?

In the northern part of the State, irrigation by flooding is commonly practiced, while in the southern part, furrow irrigation is almost entirely followed. In the north, irrigation by flooding is believed to be much superior to the furrow method; in the south, furrow irrigation is believed to be the only economical method.

The two methods were compared with the following results. In every case water was applied to a depth of 17.5 inches.

Method of irrigation	Bushels of corn per acre	Pounds of stover per acre	Tons of beets per acre
Furrow	48	3170	9
Flooding	68	4100	16

The flooding method in all these cases gave larger yields of ear corn, corn stover and beets, than the furrow method. Previous experiments have yielded similar results. The practice of furrow irrigation is so firmly believed in by a large portion of the farmers of the state, that the method should be more carefully investigated before a final opinion on the subject is rendered. It is very probable however that the results of future investigations will confirm the data here presented.


Inches of Water.
Bushels of Ear Corn per Acre.
Pounds of Stover per Acre.
20
15
10
5
10
20
30
40
50
60
70
4000
3500
3000
2500
2000
1500
1000
500
Flooding
Flooding
Furrow
Furrow
Inches of Water.
Tons of Sugar Beets per Acre.
20
15
10
5
2
4
6
8
10
12
14
16
18
20
Flooding
Furrow

18. HOW MUCH PER ACRE, OR HOW MUCH PER ACRE—FOOT OF WATER?

In the humid East, the value of a farm lies in the land and the water is free; in the West the land is nearly free, and the value of the farm lies chiefly in the water. If this be so, do not the farmers of the State practice a kind of self deception when they count on receiving so much profit per acre from their farms? Should not the question be, How much per acre inch of water shall we receive? And, since the water may be spread over more or less ground at will, should not the farmer seriously decide upon the number of acres which, considering the crops he grows, will yield the largest returns with the water at his disposal?

The farmer is a business man, who, by the use of his own and hired labor, tries to get the greatest net profit from the capital invested in the land, water, machinery and other necessary appliances. In the West the relatively higher value of the water must of necessity be taken into account in this business proposition. Each farmer must solve the problem according to his own peculiar needs and practices; but solved it must be.

The farmer who works alone, and has no way of hiring help will probably want to cultivate the smallest area possible, and obtain the highest possible yield per acre. When, however, hired help is used, it would certainly pay in many cases to cultivate larger areas, and to use less water per acre. The whole matter is purely a business question which each farmer must answer for himself. Certainly, from the point of view of the State, it is desirable to obtain the largest total quantities of crops, with the present water supply, not only because of the directly added wealth, but also because of the greater employment of labor made necessary.

Cost of Growing One Acre of Sugar Beets in Utah.

(Based upon the personal experience of Mr. H. E. Hancey, Hyde Park, Cache County, Utah.)

Preparing land (including manuring)	$8.00
Seed and drilling	2.40
Thinning	4.00
Cultivating, hoeing, pulling weeds	5.75
Four irrigations	2.00
Harvesting and topping	9.00
Total	$31.15

(Cost of hauling to factory depends on the location of the farm.)

A Problem in Arithmetic.

30 acre-inches of water used on one acre produce 19 tons of sugar beets.

19 tons of sugar beets at $4.50 per ton - $85.50

Cost of growing one acre of sugar beets - 31.15

Profit on land, water, etc.-$54.35

30 acre-inches of water used on two acres produce 30 tons of sugar beets.

30 tons of sugar beets at $4.50 per ton -$135.00

Cost of growing two acres of sugar beets - 62.30

Profit on land, water, etc.-$72.70

19. THE BEST USE OF WATER FOR WHEAT.

If the value of an irrigated farm lies largely in its water right, the farmers should know how to make the best use of the water they own. To give the farmers this information has been the motive that led to the inauguration of these experiments, and which is directing them to-day.

Based on the facts already presented in this bulletin, a few calculations have been made, which show the economical use of water for various crops.

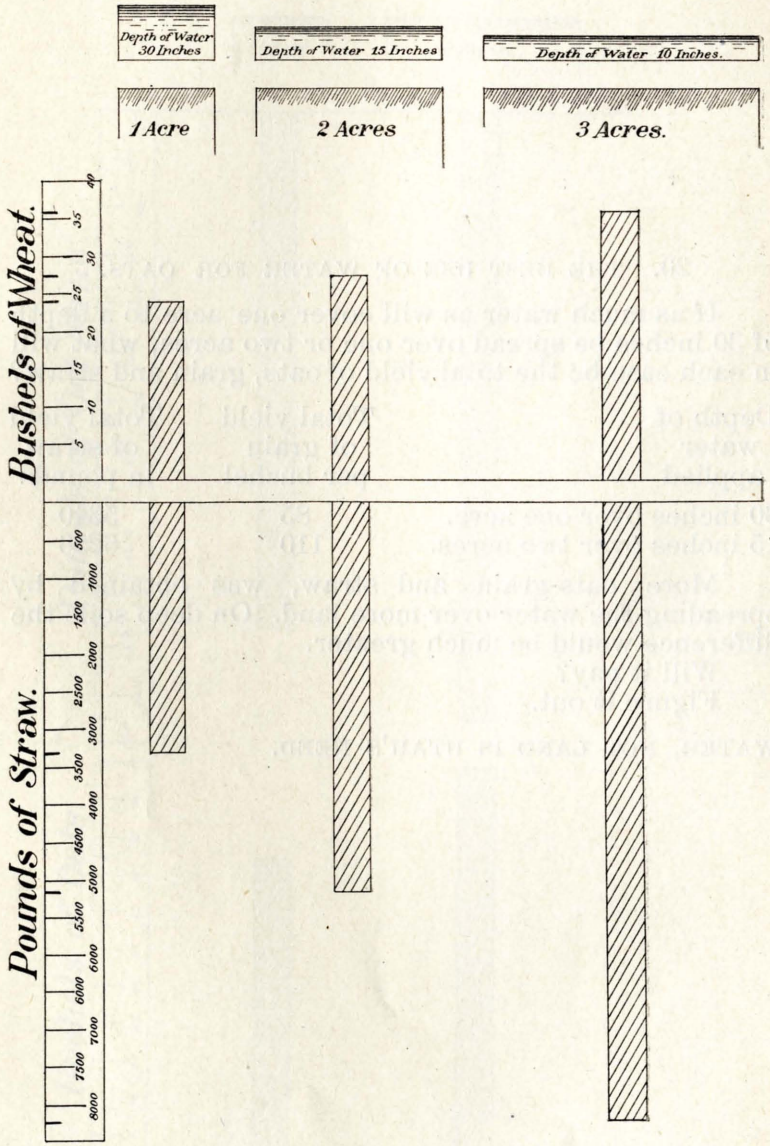
If as much water as will cover one acre to a depth of 30 inches be spread over one, two or three acres, what will be in each case the total yield of wheat-grain and straw?

Depth of water applied.	Total yield of bushels of grain	Total yield of pounds of straw.
30 inches over one acre.	24	3380
15 inches over two acres.	27	5172
10 inches over three acres.	36	8268

These results teach that when the same amount of water is spread over more ground, within certain limits, there was a decided increase in the total yield of grain and straw. One and one-half as much grain and two and one-half as much straw was obtained when three acres instead of one acre were covered with 30 inches. These results were obtained on shallow, gravelly soil; on the deep soils of the State the differences would be much greater.

The straw obtained with little water is much more nutritious than that obtained with much water.

Will the increased amounts of grain and straw compensate the farmer for the extra work of caring for these extra acres of land? In all probability they will, but that is a problem the farmer must finally solve for himself.


Depth of Water 30 Inches
Depth of Water 15 Inches
Depth of Water 10 Inches.
1 Acre
2 Acres
3 Acres.
Bushels of Wheat.
5 10 15 20 25 30 35 40
Pounds of Straw.
500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000

20. THE BEST USE OF WATER FOR OATS.

If as much water as will cover one acre to a depth of 30 inches be spread over one or two acres, what will in each case be the total yield of oats, grain and straw?

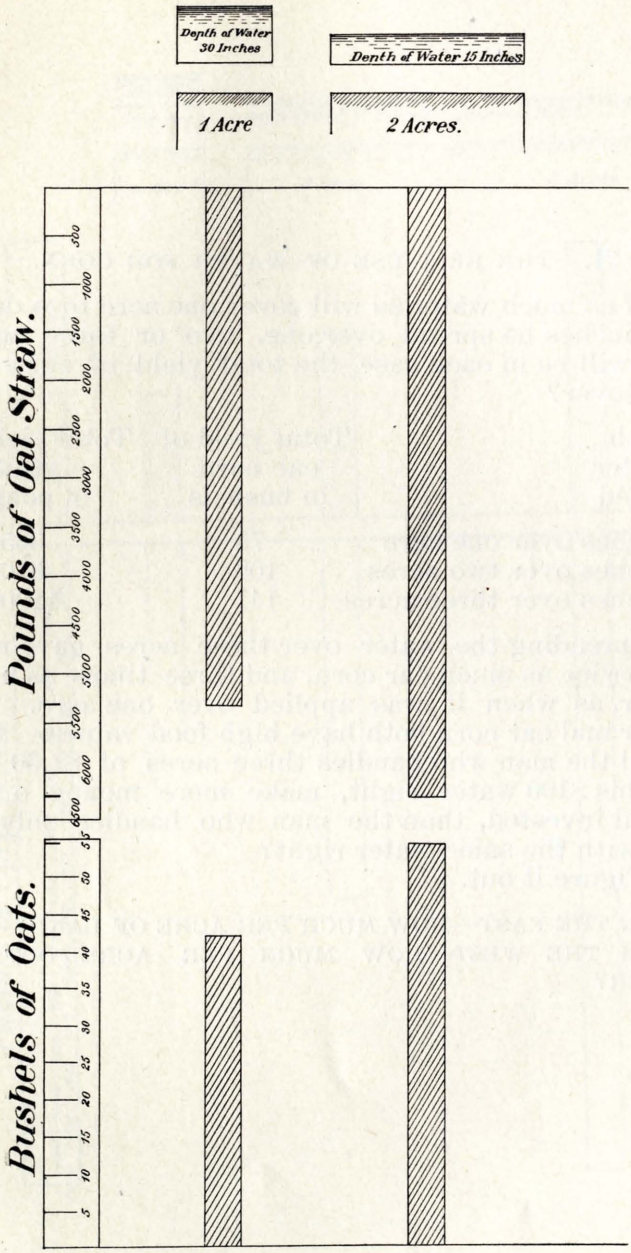
Depth of water applied	Total yield of grain per bushel	Total yield of straw in pounds
30 inches over one acre.	85	5340
15 inches over two acres.	110	6256

More oats-grain and straw, was obtained by spreading the water over more land. On deep soils the difference would be much greater.

Will it pay?

Figure it out.

WATER, NOT LAND IS UTAH'S NEED.


Depth of Water 30 Inches
Depth of Water 15 Inches
1 Acre
2 Acres.
Pounds of Oat Straw.
300
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
Bushels of Oats.
5
10
15
20
25
30
35
40
45
50
55

21. THE BEST USE OF WATER FOR CORN.

If as much water as will cover one acre to a depth of 30 inches be spread over one, two or three acres, what will be in each case the total yield of corn-ears and stover?

Depth of water applied	Total yield of ear corn in bushels	Total yield of stover in pounds
30 inches over one acre	73	3658
15 inches over two acres	106	6700
10 inches over three acres	141	12000

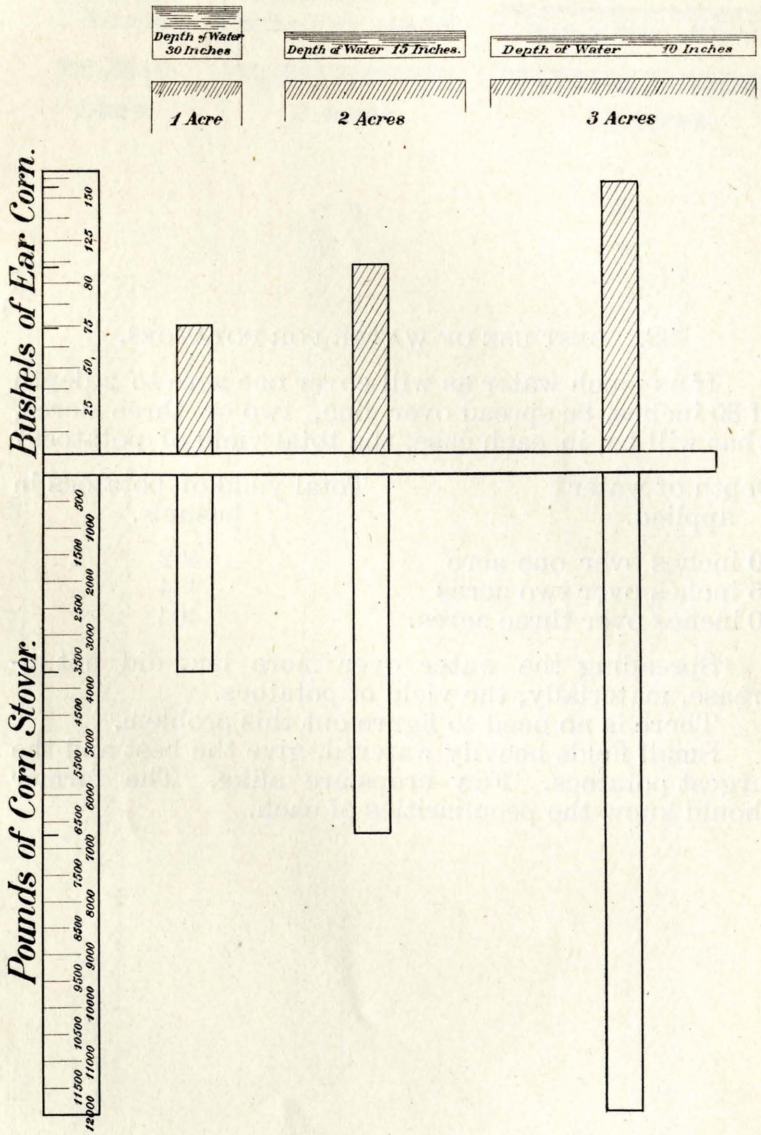
Spreading the water over three acres gave more than twice as much ear corn, and three times as much stover, as when it was applied over one acre. The stover and ear corn both have high food values.

Will the man who handles three acres of $1.50 land with his $100 water right, make more money on the capital invested, than the man who handles only one acre with the same water right?

Figure it out.

IN THE EAST—HOW MUCH PER ACRE OF LAND?

IN THE WEST—HOW MUCH PER ACRE-FOOT OF WATER?


Depth of Water 30 Inches
Depth of Water 15 Inches.
Depth of Water 10 Inches
1 Acre
2 Acres
3 Acres
Bushels of Ear Corn.
25 50 75 80 125 150
Pounds of Corn Stover.
500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500 10000 10500 11000 11500 12000

22. BEST USE OF WATER FOR POTATOES.

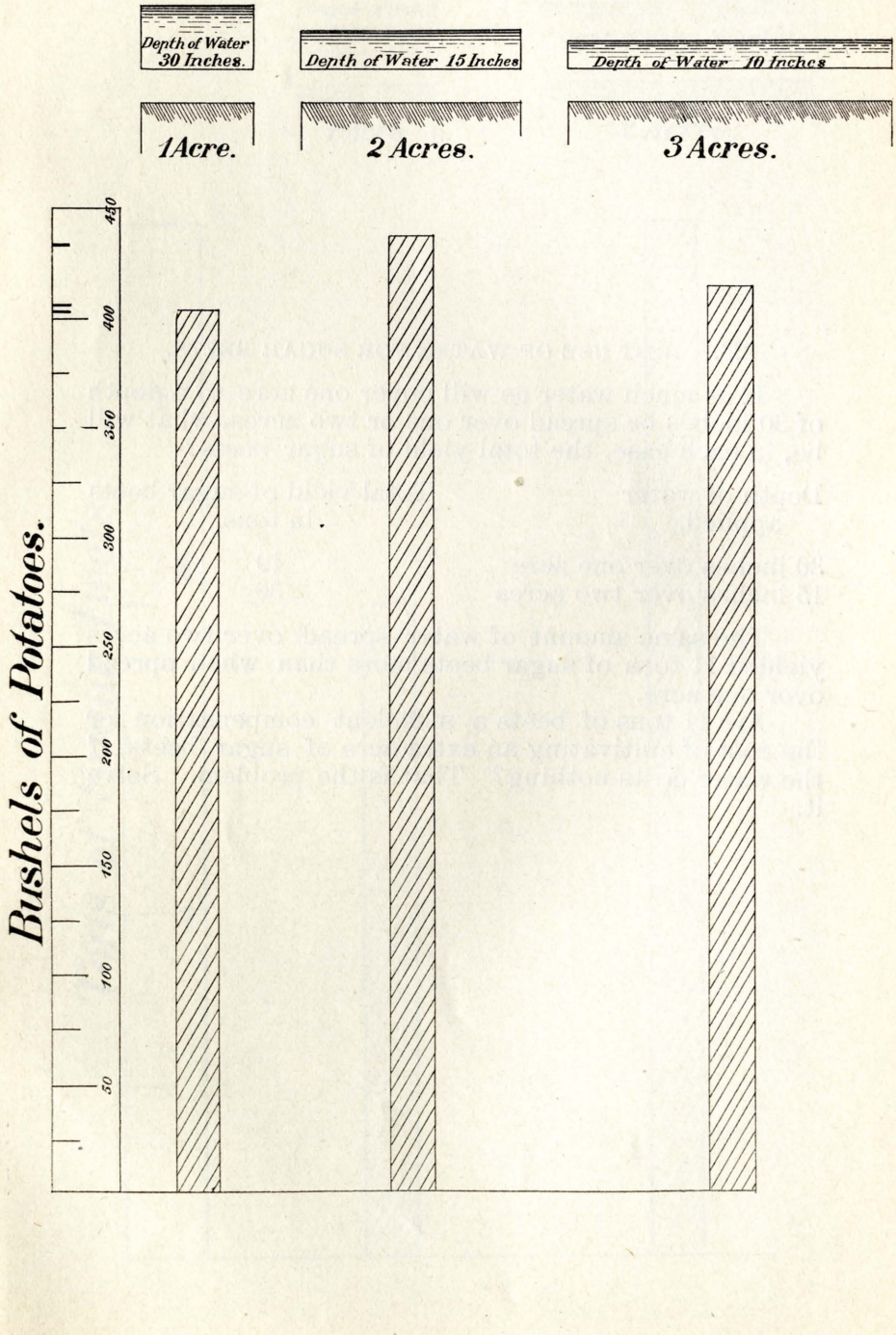
If as much water as will cover one acre to a depth of 30 inches, be spread over one, two or three acres, what will be, in each case, the total yield of potatoes?

Depth of water applied.	Total yield of potatoes in bushels.
30 inches over one acre	402
15 inches over two acres	434
10 inches over three acres.	404

Spreading the water over more land did not increase, materially, the yield of potatoes.

There is no need to figure out this problem.

Small fields heavily watered, give the best and the largest potatoes. Few crops are alike. The farmer should know the peculiarities of each.


Depth of Water 30 Inches.
Depth of Water 15 Inches
Depth of Water 10 Inches
1 Acre.
2 Acres.
3 Acres.
Bushels of Potatoes.
450
400
350
300
250
200
150
100
50

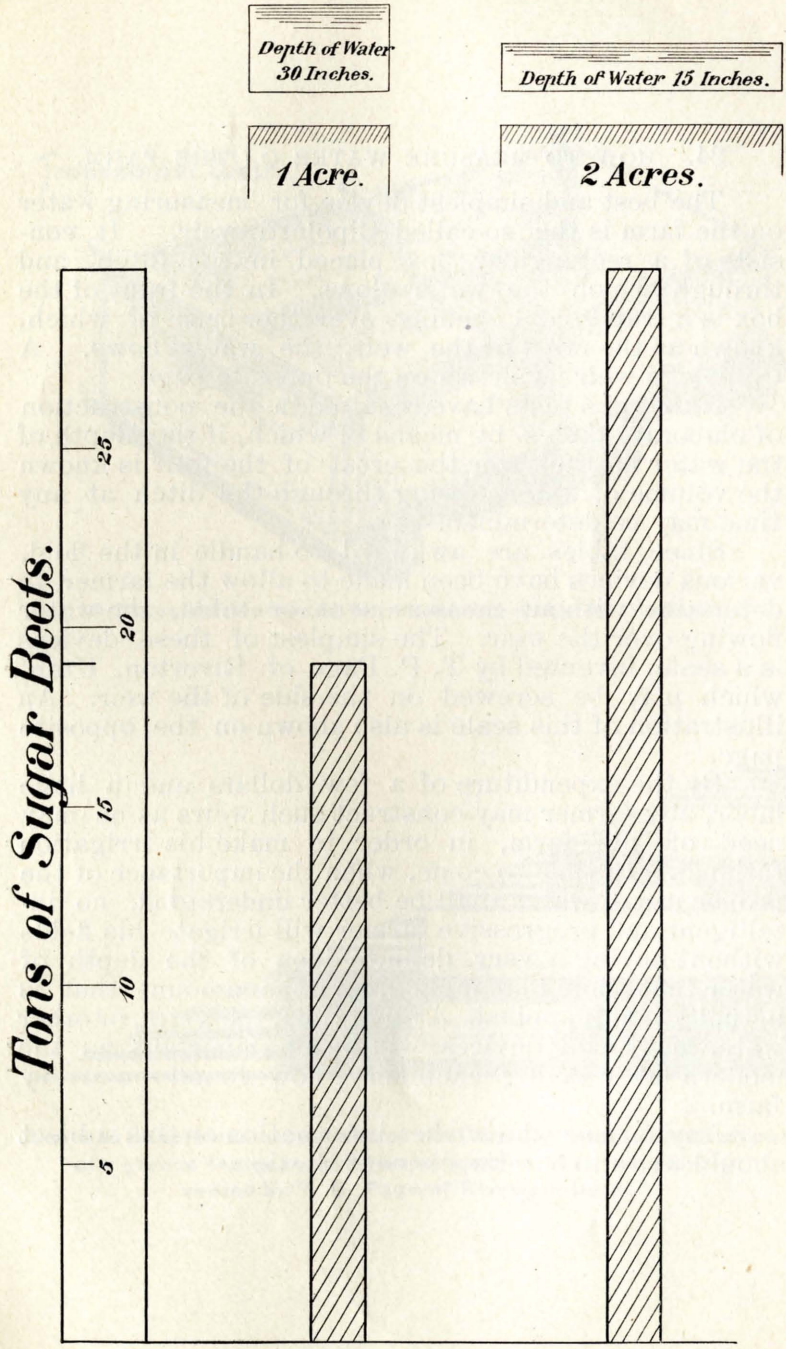
23. BEST USE OF WATER FOR SUGAR BEETS.

If as much water as will cover one acre to a depth of 30 inches be spread over one or two acres, what will be, in each case, the total yield of sugar beets?

Depth of water applied.	Total yield of sugar beets in tons.
30 inches over one acre	19
15 inches over two acres	30

The same amount of water spread over two acres yielded 11 tons of sugar beets more than when spread over one acre.

Are 11 tons of beets a sufficient compensation for the cost of cultivating an extra acre of sugar beets, if the water costs nothing? That is the problem. Solve it.


Depth of Water 30 Inches.
Depth of Water 15 Inches.
1 Acre.
2 Acres.
Tons of Sugar Beets.
25
20
15
10
5

24. HOW TO MEASURE WATER ON THE FARM.

The best and simplest device for measuring water on the farm is the so-called Cipoletti weir. It consists of a rectangular box placed in the ditch, and through which the water flows. In the front of the box is a trapezoidal opening, over the base of which, known as the crest of the weir, the water flows. A Cippoletti weir is shown on the opposite page.

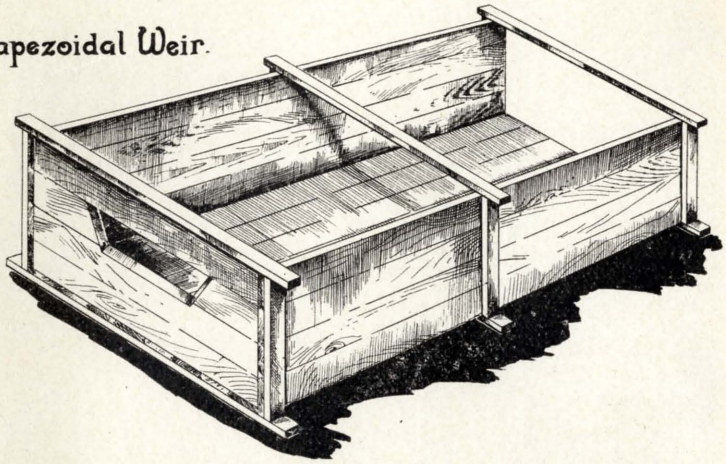
Numerous tests have resulted in the construction of elaborate tables, by means of which, if the depth of the water flowing over the crest of the weir is known the volume of water flowing through the ditch at any time may be determined.

Since tables are awkward to handle in the field, various devices have been made to allow the farmer to determine without measurement or table, the water flowing over the weir. The simplest of these devices is a scale, invented by T. P. Page of Riverton, Utah, which may be screwed on the side of the weir. An illustration of this scale is also shown on the opposite page.

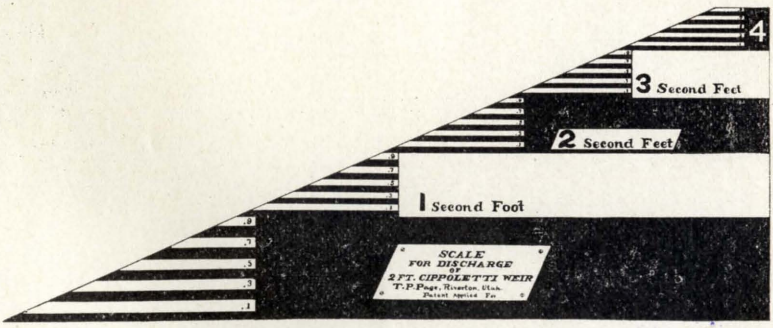
By the expenditure of a few dollars and a little labor, any farmer may construct such weirs as he may need on his farm, in order to make his irrigation rational. In time to come, when the importance of the proper use of water shall be better understood, no intelligent and progressive farmer will irrigate his fields without having a very definite idea of the depth of water that should be applied, and the amount that is actually being applied. At that time, the weirs, or other water measuring devices, will be as important as the modern labor-saving machinery, now found on every farm.

Any farmer who wishes information on this subject should write to the Experiment Station.

Trapezoidal Weir.



A Cippoletti weir used for measuring water on the farm.



Scale to be screwed on the side of the Cippoletti weir, which shows at a glance the quantity of water passing over the weir; invented by T. E. Page of Riverton, Utah.