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Fritz Knorr
University of Nebraska

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MANAGEMENT OF IRRIGATED LAND.

REPORT OF THE SCOTTSBLUFF EXPERIMENTAL SUBSTATION, MITCHELL, NEBRASKA.

BY FRITZ KNORR, Superintendent.

JUNE, 1915.

IRRIGATION CROP ROTATION PLATS. SCOTTSBLUFF EXPERIMENTAL FARM.

LINCOLN, NEBRASKA
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SUMMARY.

Seepage may be prevented to some extent by employing proper methods of irrigation. Overirrigation may have a tendency to water-log the soil.

A small head of water, properly used, will irrigate more land and do better work than a large head gone over the land hurriedly.

The distance of irrigation ditches should be such that the water may travel between the ditches in about two hours.

If land can be irrigated in the fall with the same care that crops are irrigated in the summer, there is an advantage to fall irrigation. If water cannot be properly cared for and this irrigation is uneven, it is a detriment rather than a benefit to the land.

It is a disadvantage to ditch the potatoes as deep on the lighter soils as on the heavier soils.

With the exception of the first crop it is best to irrigate alfalfa after the hay is cut. Irrigation of the stubble is more easily and more evenly done than the standing crop. The hay will cure more quickly on the dry soil than on previously irrigated soil.

There is no material difference in the yields in sugar beets where the soil is plowed from 4 to 20 inches deep. This may be due to the fact that the soil is of a sandier nature. The plowing under of a second and third crop of alfalfa has not produced as large tonnage of sugar beets as the second and third crops that were plowed under.

MANAGEMENT OF IRRIGATED LAND.

BY FRITZ KNORR, SUPERINTENDENT.*

INTRODUCTION.

It is the ambition of most farmers to produce the largest possible yields of which the land is capable, provided that the cost of production allows a sufficient income to warrant the extra labor required to produce the larger yield. In the humid areas the increased yield is accomplished to a large extent by the use of manure and such other methods as will encourage plant growth. On the irrigated lands, many are trying to force increased yields by the increased use of water, rather than by other means.

Water, however, can never be made to take the place of soil fertility or cultivation. It appears from observation that to a certain point fertility may replace water. In other words, the more fertile soils utilize moisture more efficiently, with the proper treatment.

The heavier soils likewise require less irrigation water than the sandy soil. The lighter soils lose a large amount of water thru seepage, whereas it may be retained in a heavier soil.

SEEPAGE.

Nearly all irrigated lands are subjected to damage thru seepage to a greater or lesser extent upon certain low points or areas. This seepage is brought about by a number of conditions, some of which may be prevented or modified, but many cannot be avoided.

The unavoidable conditions are due to the various strata of

* The Scottsbluff Experiment Farm is located on the North Platte Reclamation Project, six miles east of Mitchell and eight miles northwest of Scottsbluff, Nebraska. The tract consists of 160 acres of land, irrigated from the Government canal. About 30 acres are devoted to experiments in dry land agriculture, and the remainder is irrigated, a wide variety of experiments being conducted with irrigated crops. The work of the farm is maintained cooperatively by the University of Nebraska and the U. S. Department of Agriculture, and is under the direction of a Superintendent detailed by the Office of Western Irrigation Agriculture, U. S. Department of Agriculture.

the subsoil that prevent the water from passing farther down but carry the water to some outcropping of these impervious strata, thus forming a seepage area. It has been found that in many cases large basins are formed by this impervious subsoil, and this also has a tendency to hold the water as seepage.

Some seepage may be prevented by better means and methods of irrigation. In all crop work under irrigation the first consideration should be to secure the best possible results from the least amount of water applied.

IRRIGATION.

To irrigate properly requires time and is a costly operation. By using an excessive amount of water the cost of the extra water, together with the labor of irrigation, does not always increase the crop sufficiently to justify the expense.

Many irrigators are under the impression that, as the amount of water applied to the crop is increased, in a like proportion the crop yield is increased. In other words, if 1 acre-foot of water will produce 25 bushels of wheat, 2 acre-feet should be capable of producing approximately 50 bushels. No grain crop will produce in the same ratio as the water is applied; in fact, water applied beyond a certain limit has a tendency to decrease the yield rather than to increase it.

IRRIGATION HEAD.

It is not necessarily true that, because a large amount of water is applied to a crop in one or two irrigations, the crop gets the benefit from all of the water thus put on the land at the point of turnout.

Two large losses of irrigation water must be taken into consideration—run-off and underground seepage. The run-off is always apparent and may be reduced to a minimum by the careful irrigator by always catching the run-off from one ditch in the other, the only waste being in the end runs and on the last land. This run-off loss is well taken care of by most of our farmers, but the seepage loss has not been called to the attention of the irrigator as forcibly as it should be, for the reason that it is a condition that is not easily detected.

STORING WATER IN THE SOIL.

Soil is capable of storing and holding only a certain amount of water. Inasmuch as roots of plants penetrate and feed on the soil to only a limited depth, all water in the soil that is above the water holding capacity of that soil is waste. It percolates to soil areas below the reach of the roots and is carried off, usually cropping out at some place in the form of seepage. Furthermore, it is useless labor to saturate the soil to a greater depth than the plants are capable of feeding.

Knowledge of the subsoil is a great aid in a better understanding of the application of water. On the lighter soils where there is a sandy or gravelly subsoil, labor is wasted in trying to store very much moisture in such a soil; lighter and more frequent irrigation alone will solve that problem. On heavy soil, or a deep soil, water may be stored to advantage. If the lighter soil has a clay subsoil, water may also be stored, but a sandy subsoil cannot be used as a reservoir for storing soil water for future crop use.

DISTANCE APART OF IRRIGATION DITCHES.

Shorter runs of water, that is, placing the supply ditches closer together, will often overcome much of the trouble of underground loss. It is impossible to state a definite or even an approximate distance between field laterals, as it all depends upon the topography of the land and the nature of the soil.

This Substation has tried to establish a time factor to determine the distance between ditches. Here also difficulties are encountered that vary with the head of water used and upon the spread of the water at the turnout. Under ordinary conditions in western Nebraska a run from 1 hour and 30 minutes to 2 hours should constitute the distance between laterals.

Irrigators on sandy soil frequently try to force water thru rowed crops having runs from 40 to 60 rods long. Often it requires from 8 to 12 hours and sometimes much longer for water to go thru such rows. The waste of water thru underground seepage in such cases must be readily apparent even to the most unobserving irrigator. Even if the waste water factor be eliminated, the labor problem or waste of time in such cases is such as to make methods of this kind prohibitive.

DUTY OF WATER.

Much work has been done in determining the duty of water, that is, to determine how much water is required to grow a given crop and secure the best possible results. An irrigator cannot use this as a basis for growing and producing a crop, as the duty of water must vary with the climatic conditions. Determining the duty of water has been invaluable in proving that there is a decided limit to the amount of water which may profitably be applied to land, also in showing the bad effect of overirrigation on the crop. It would be folly for anyone to lay down a rule stating that a given amount of water should produce a certain crop yield, or that irrigations should be applied so far apart or a certain number of irrigations be applied during the growing period.

The amount of water to use or the number of irrigations depends upon climatic conditions, the slope of the land, nature or texture of the soil and subsoil, variety of the crop, and last upon the stage of growth of the crop.

It does not follow that because a grain crop has produced a heavy growth of straw it will produce grain in proportion to that growth. It is more often true that by forcing an undue amount of growth the grain may be small and shrunken, because the stems and leaves require a large amount of moisture that the irrigator cannot always apply at that stage of the growth. On land partially subjected to seepage the grain is usually plump because the moisture is constant.

It is not necessarily true, as many believe, that the greatest economy of water and labor is in the use of a large head of water forced over the greatest possible area that this water will cover. On very sandy soils a large head may be required, even tho considerable washing may take place unless great care is taken. Very level land bears a large head of water, in fact requires it. The more rolling lands should be handled under small heads, anything from 1 to 1½ second feet; more often 1 foot is found the best amount.

A large head of water rushing over the land has a tendency to "slick" the soil, where the water passes over readily, and thus prevents the proper irrigation. With small heads the run-off need not be very large and can be better regulated.

Rowed crops should be carefully planned on rolling land, giving the rows just enough fall that the water may be carried along without causing any washing. Where water is permitted to rush thru the rows, proper irrigation cannot take place; the washing of the soil and the waste water secured under such conditions are a loss. If the land permits, a fall of 3 inches to 100 feet is a good slope to give the run, altho on the average soil 6 inches to 100 feet will not cause much washing, if care is taken in irrigation.

The conservation of soil moisture is just as essential under irrigation as under any other method of farming, perhaps more so, as the water itself represents value and its application expense.

A good system of crop rotation is a means of saving irrigation water. It also brings about a more equitable distribution of the irrigation season.

Alfalfa, as is well known, requires more water than any other crop. It is extremely difficult to irrigate evenly a large acreage of alfalfa where the rotation delivery of water is practiced. Considering also that alfalfa, if sold off the farm at prevailing local prices, is a poor paying crop, it would be bad management to rely upon this one crop, if not used for feeding purposes on the farm where grown.

Seldom do sugar beets, potatoes, or corn require water early in the season when the small grain requires attention. About the time that the small grain is out of the way of irrigation the rowed crop will require water.

Where only alfalfa and small grain are grown the irrigation season is all crowded into one short period.

On the lighter soils with a sandy subsoil, it is impossible to irrigate in the hope of storing sufficient water to grow and mature a crop of any kind. Such a procedure, however, may be possible where there is a clay subsoil and the water may be held as in a basin. A sandy subsoil gives up its water and but a small amount is held in reserve for the plants.

Many of the crops, such as potatoes, sugar beets, and small grains, do not feed very deep. Even tho there may be enough moisture in the lower strata of the soil, it is of no value to the plants. Many irrigators consider a soil well irrigated if the full blade of the shovel may be pushed into the soil easily. Others dig a hole about a foot or more deep, and if the soil is thoroly saturated at that depth, the water is discontinued.

The latter method is more satisfactory; it will be found that where the shovel blade is used as a tester the soil is often wet much deeper than necessary. Tho the shovel may be pushed thru the very soft soil, just beneath this the soil may be almost saturated.

Several canvas dams are now on the market that by means of clocks and other devices can be set so as to collapse the dam at a certain time, permitting the water to go on down to a second dam, and so on. By the use of these dams much time as well as labor may be saved, especially during the night runs. Perfect irrigation cannot be expected from these dams, but with a very little trouble the uncovered spots may be gone over the following day. As a rule, 75 per cent of the irrigation water is lost during the night runs. This is a large item during the hot, dry weather, when the water is scarce. All end runs should be avoided during the night. It is best to start on a new land for a night run, thus making sure that the waste will not damage adjoining land.

FALL IRRIGATION OF CROPS.

Work has been conducted for three years to determine the value of fall irrigation. The object was to store water in the soil and have the soil in better condition for field operations in the spring. As a rule the precipitation during the winter is very light, making it necessary at times to irrigate in the spring before some of the crops can be put into the soil to advantage.

Many are under the impression that the fall irrigation does not require the attention of general crop irrigation, that it is unnecessary to cover the ground as thoroly, and that to let it run as it will is sufficient. If one has not the time, however, to watch the water and irrigate thoroly, the work had better be left undone. If the ground is carelessly covered, some areas may be moist enough to germinate the grain quickly; on others it will have to lie in the soil until moisture comes to bring it up. This uneven growth will bring about an uneven maturity, hence a poor quality of grain. Some of the grain also may shatter long before a portion is ready to be cut.

One advantage of fall irrigation is that the soil has an opportunity to freeze and thaw during the winter, thus aiding in putting it in better tilth in the spring.

An objection to fall irrigation is the lack of time at that season of the year, and hence the careless manner in which the water is likely to be handled. The irrigation at this time of the year should receive just as much attention as tho a growing crop were on the ground.

Uneven application in the fall will make an uneven crop growth the following year. By allowing water to run where it will without any attention, or change, for a great length of time, is a waste of water. Such water is very likely to develop into seepage, either on that farm or lower down.

As previously stated, when the subsoil has been moistened to a certain depth, anything beyond that depth is waste, for grain crops. This depth is usually from 5 to 6 feet.

The first year's work in fall irrigation at this Substation did not include corn; this was added the second year. The crops were grown on one-tenth acre plats, either in duplicate or triplicate, depending upon the availability of the land. Table 1 shows the crops grown each year and the rotation that they followed, also the repetition of the crop each year.

TABLE 1.—*Sequence of crops in the plats in Series VI and VII, used for the fall-irrigation experiments in 1911, 1912, and 1913.*

Plat No.	Year and crop 1911	1912	1913	Plat No.	Year and crop 1911	1912	1913
1	....	Potatoes	Barley.	9	Oats	Barley	Beets
2	Wheat	Corn	Oats.	10	Potatoes	Oats	Potatoes.
3	Barley	Beets	Wheat.	11	Beets	Wheat	Corn.
4	Oats	Barley	Beets.*	12	Wheat	Potatoes	Oats.*
5	Potatoes	Wheat	Potatoes.	13	Oats	Beets	Wheat.*
6	Beets	Oats	Corn.	14	Potatoes	Barley	Beets.
7	Wheat	Corn	Oats.	15	Barley	Oats	Corn.*
8	Barley	Beets	Wheat.	16	Beets	Wheat	Barley.

*These plats were used for a special experiment in 1913, and the yields of the crops are not considered in this report.

The land was broken out of the virgin sod during the fall of 1910 and irrigated after plowing. It was necessary to work down the land previous to irrigation. This required considerable useless labor. In succeeding years the land was irrigated before plowing.

The field designated as Series VI was irrigated in the fall. Series VII was not fall irrigated. During the growing seasons each field was irrigated in order as the various crops required it.

It was found without exception that the land that was irrigated in the fall did not require as early irrigation in the summer and thereby saved considerable labor at that time of the year. Thus, the expense of the late summer or fall irrigation was paid for.

The best results were obtained during the cropping season of 1911. This is attributed to the fact that there was a small amount of precipitation during the winter and spring. All soil was very dry at the time of seeding; in many cases irrigation was necessary before seeding could be done. That year the wheat was seeded April 4; the barley and oats were seeded April 20. It may be well perhaps to state here that untimely rains often interfere with irrigation experiments.

Series VI, which was fall irrigated, contained enough moisture to bring up all of the small grain, whereas the grain seeded on Series VII did not come thru the ground until after the rains of May 15.

The first irrigations applied to the small grain were June 12.

Series VI, which was fall irrigated, absorbed the water more readily, took up more water, and had less run-off than Series VII, which was not fall irrigated.

On June 27 the second irrigation was applied. At this time Series VI could have matured a good crop without any further irrigation, but for uniformity both fields were irrigated.

The yields of 1911 are given in Table 2.

TABLE 2.—*Comparison of yields, fall-irrigated land (Series VI) and nonfall-irrigated land (Series VII). 1911.*

Crop	Height, inches		Yield per acre				Pounds of straw per bushel of grain	
			Straw, pounds		Grain, bushels			
	Series VI	*Series VII*	*Series VI*	*Series VII*	*Series VI*	*Series VII*	*Series VI*	*Series VII*
Wheat....	30	28	3,253	2,916	31.5	22.4	103.3	130.2
Barley....	30	25	2,573	2,936	37.6	28.0	68 4	104.9
Oats	39	38	3,506	3,178	68.5	49.6	51.2	64.1

In every case there was more straw on the fall-irrigated land as a whole, but it required more straw growth to produce 1 bushel of grain on the land not fall irrigated.

WORK IN 1912.

On September 29 and 30, 1911, the land was irrigated preparatory for work in 1912. As soon as the soil was dry enough it was plowed about 7 inches deep and left in the rough until the following spring. In the fall of 1911 and the spring of 1912 the precipitation was 7.31 inches, as compared with 3.5 inches during the same period of the preceding year. This put all of the soil in splendid condition for spring seeding.

The wheat was seeded April 10, the barley and oats were seeded April 24, corn was planted May 8, sugar beets were seeded April 27, and Early Ohio potatoes were planted the second week in May. All of the crops came up nicely. Two irrigations were required to produce a crop of small grain, the corn received one irrigation, and the beets and potatoes three irrigations each.

The yields of the various crops are given in Table 3.

TABLE 3.—*Yields of various crops on fall-irrigated land (Series VI) and on land not fall-irrigated (Series VII). 1912.*

Crop	Height, inches		Yield per acre				Pounds of straw per bushel of grain	
			Straw, pounds		Grain, bushels			
	Series VI	*Series VII*	*Series VI*	*Series VII*	*Series VI*	*Series VII*	*Series VI*	*Series VII*
Wheat....	40	37	3,236	3,140	41.6	38.4	77.8	81.8
Barley....	37	36	1,586	1,020	42.8	35.0	37.1	29.1
Oats.....	42	42	4,170	3,216	94.6	81.8	44.1	39.3
Corn.....	......	......	4,050*	3,875*	52.2	48.8	77.5	79.4
Beets....	......	......	......	......	12.2†	11.4†	......	......
Potatoes..	......	......	......	......	121.0	119.5	......	......

*Stover. †Tons.

In 1912 there was not as much difference in the yield as in the previous year. It will also be noted that the relation of grain to straw is much smaller, and both the oats and barley showed more pounds of straw per bushel of grain on fall irrigation.

WORK IN 1913.

In the fall of 1912 the land was irrigated September 29-30, plowed as soon as the land was dry enough, and left rough during the winter to check blowing. In the spring of 1913 the soil was in fair shape for seeding. The precipitation during the fall and winter was such as to give sufficient moisture for spring seeding.

The soil preparation was the same as in previous years. Wheat was seeded April 4. Barley and oats were seeded April 24. The barley and wheat germinated much more quickly than the oats. The germination of the oats on the land that was not fall irrigated was very slow and the field was spotted until after a rain in early May.

Corn was planted May 19. Hot winds from July 7 to 12 slightly damaged the corn.

The yields of the various crops are given in Table 4.

TABLE 4.—*Yields of seven crops on fall-irrigated land (Series VI) and on land not fall-irrigated (Series VII). 1913.*

Crop	Height, inches		Yield per acre				Pounds of straw per bushel of grain	
			Straw, pounds		Grain, bushels			
	Series VI	*Series VII*	*Series VI*	*Series VII*	*Series VI*	*Series VII*	*Series VI*	*Series VII*
Wheat....	37	37	1,695	1,630	26.9	22.8	63.0	·71.5
Barley ...	31	32	1,530	1,405	30.4	26.9	50.3	52.2
Oats......	44	42	3,310	2,005	92.7	87.0	35.7	23.0
Corn....	......	......	4,425*	3,570*	66.0	48.2	67.0*	74.1*
Potatoes..	......	......	......	......	124.5	122 2	......	......
Sugarbeets	......	......	......	......	11.4†	8.9†	......	......

*Stover. †Tons.

In 1913 it required more straw or stover for each bushel of grain produced with all crops except oats, but as in previous years all crops produced higher yields under fall irrigation.

Table 5 gives a summary for the three years of all crops grown.

TABLE 5.—*Average and relative yields of six crops on fall-irrigated land (Series VI) and on land not fall-irrigated (Series VII).*

Crop	No. of yrs.	Number of plats		Unit of yield	Average yield per acre			Relative yield per acre (per cent)		
		VI	VII		VI	VII	Gain by fall irrigation	VI	VII	Gain by fall irrigation
Wheat....	3	8	8	Bushel	33.3	27.8	5.5	119	100	19
Barley...	3	8	8	Bushel	36.9	29.9	7.0	123	100	23
Oats	3	8	8	Bushel	83.8	72.8	11.0	115	100	15
Corn.....	2	4	4	Bushel	59.1	48.5	10.6	122	100	22
Sugarbeets	2	5	5	Ton	12.3	10.7	1.6	115	100	15
Potatoes..	2	4	4	Bushel	124.5	122.2	2.3	102	100	2
All crops	....	....	....	......	......	......	.....	116	100	16

The average increase of all crops was 16 per cent in favor of fall irrigation. Where the soil is very light it would not be advisable to do fall plowing, as too much blowing and drifting would occur.

IRRIGATING AND CULTIVATING POTATOES.

In 1912 an experiment was begun to determine if possible the best method of irrigating potatoes, taking also into consideration methods of cultivation, labor, and water requirement.

The usual practice has been deep cultivation and ditching; the cultivation is often from 5 to 8 inches deep, and when the potatoes are properly ditched the ridges are over 1 foot high. In common practice every row is irrigated thruout the season after irrigation once becomes necessary.

The method of applying water in the experiment has been:

First, to irrigate every row, keeping the soil moist and the plants in a growing condition.

Second, not to irrigate until the plants require water, then irrigate every row and irrigate according to common farm practice.

Third, irrigate every row, but permitting the plants to suffer between irrigations.

Fourth, to irrigate alternate rows at such times as the crop requires water. At the first irrigation every other row was skipped; at the second irrigation the skipped rows were irrigated and the previously irrigated rows omitted. This switching back and forth was continued thruout the irrigation season.

Fifth, to irrigate every other row thruout the season, that is, one set of alternate rows did not receive any irrigation whatever.

One of the objects sought in this work was to reduce the labor of irrigation and the use of water to the minimum. No definite results can be given from the three years' work, but some valuable data have been collected with special reference to irrigation.

In the three years' work it was found that it is unnecessary to cultivate and ditch as deep on light soil as on the heavy soil. The yield of marketable tubers has been in favor of the more shallow culture.

By shallow cultivation is meant the working of the soil from 3 to 4 inches; the ditching is about 8 inches deep. The depth of the ditching must vary with the fall of the land to a large extent. On the land where there is but little fall and the water moves slowly the ditches must be deeper; otherwise the water in the furrow may get too high on the ridge and submerge the tubers in water, a condition that is detrimental to the crop. Where the fall is such that the water moves freely, the shallow ditching will give the best results.

Untimely rains interfered with the methods of irrigation during 1912 and 1913. In 1914, however, the conditions for irrigation experiments were most excellent, and the water movement in the soil could be observed to good advantage.

In the case of alternate and every-other-row irrigation it was thought enough water could be stored in the soil to carry the crop a longer time than where water was applied in every row. On alternate and every-other-row irrigation, only one-half as much irrigated surface was exposed for evaporation, but the amount of water required was not affected by this; on the contrary more water was required.

The water for irrigation was run thru 1-inch iron pipes sunk into the soil at the head of each row. By this means the water could be well regulated, and the approximate time of running with an equal head gave the comparative amounts of water used.

Under the usual method it required approximately 2 hours and 30 minutes for the water to run thru rows 264 feet long and thoroly irrigate them; where water was run in alternate rows it required 5 hours running, and then the soil was not in as good condition as where every row was irrigated.

Considering the time of running, approximately the same amount of water was used in every instance, but in the alternate and the every-other-row irrigations the run-off was very large, causing much waste of water. The lateral or side movement of the water being very small, a deeper saturation was secured and a large amount of this no doubt was lost as underground seepage, and was too deep to be of any value to the potato crop.

On plats where the soil was kept moist thruout the season and the plants in a growing condition it required only about one hour for the water to run thru the rows. It is unnecessary to wet the soil more than three feet deep for potatoes. By keeping the soil moist is not meant keeping it saturated; a continuously wet, soggy soil saturated to its greatest possible depth is perhaps the worst condition that can be created for this crop. A mass of unprolific vines is usually the result from too much water.

In the irrigation no allowance was made for the deep and shallow cultivation, but in every instance it was found that those rows which were ditched deep were not as well watered as the shallow ditched rows. This was due to the fact that the downward movement of the water is much greater than the lateral movement. Hence, the roots did not benefit so much from the water; only a small portion of the main root system came in contact with the water.

TABLE 6.—*Yields of potatoes under the various methods of irrigation.*

Method	Bushels per acre	Rank of marketable tubers	Rank per cent culls
Irrigated every other row	215	5	5
Irrigated usual method	270	2	2
Irrigated alternate rows	239	4	4
Plants allowed to suffer between irrigations	234	3	3
Soil kept moist and plants growing	296	1	1

It will be noticed that the rank of marketable tubers and culls is the same thruout. It was found that whenever the growth of the potatoes was checked, second growth began on the tubers, making them very uneven and "knobby," many of them having to be thrown out with the culls.

ALFALFA.

Alfalfa is one of the leading crops, tho it is far from being a profitable crop, if only the hay is sold as such upon the market. Where the hay is fed to live stock and the alfalfa stubble is turned under every four or five years, then alfalfa becomes a profitable crop. One of the greatest values of alfalfa is the effect it has on other crops after it is plowed under; the fertilizing value of it is greater than manure when the latter is applied at the rate of 12 tons per acre.

The United States Reclamation Service has collected some very valuable data on the North Platte Project relative to the value of alfalfa stubble when turned under.

TABLE 7.—*Shows a comparison of yields on alfalfa ground and ground that has not been in alfalfa.*

Crops	Area acres	Unit yield	Yield per acre	Value per acre	Increased value of crop
Barley*	808	Bushels	36	$21.72	$12.02
Barley†	1,454	Bushels	16	9.70	
Corn*	510	Bushels	31	23.60	13.10
Corn†	5,514	Bushels	14	10.50	
Oats*	425	Bushels	39	15.75	7.90
Oats†	6,592	Bushels	19	7.85	
Potatoes*	525	Bushels	220	77.25	50.84
Potatoes†	570	Bushels	75	26.41	
Rye*	15	Bushels	6	4.67	.82
Rye†	230	Bushels	5	3.85	
Stock beets*	206	Tons	16	63.36	31.81
Stock beets†	9	Tons	8	31.55	
Sugar beets*	4,014	Tons	11	60.80	14.93
Sugar beets†	1,069	Tons	8	45.87	
Wheat*	55	Bushels	34	28.60	16.10
Wheat†	433	Bushels	16	12.50	

*Alfalfa stubble plowed under.
†Land that has not been in alfalfa.

The foregoing data were collected by the United States Reclamation Service on the North Platte Project in 1914. The figures were taken from a compilation made by Mr. Paul Rothi from the annual census taken on Reclamation Projects.

In many cases the crop yields were increased over 100 per cent by plowing under alfalfa stubble.

SEEDING ALFALFA.

Many farmers dislike to break up alfalfa, as some have experienced a little difficulty in securing a good stand. Some time has been devoted to methods of seeding alfalfa. As with other crops, no hard and fast rules can be laid down for this; much depends upon the soil conditions. Three methods have been followed, all of them more or less successful.

Spring seeding without a nurse crop has some years given excellent results, and has produced one and sometimes two good cuttings the same season. The objection to such seeding is that some years the weeds will get started at about the same time as the alfalfa, and it is necessary to clip these, thus entailing extra labor at a time of the year when it is not readily available.

The second method is the seeding of alfalfa with a nurse crop. In common practice this is the most popular method. The disadvantage of this is the failure of securing a good stand; uneven stands are very common. It often happens when the grain is almost ripe that the alfalfa should have water. The question then is whether one should take the chances of the grain lodging by an untimely irrigation or let the alfalfa take the chances of drouth. Another hardship on the young alfalfa comes after the nurse crop is cut. The young plants that have been growing in the shade of the grain are suddenly exposed to the hot sun; if the soil is moist there is no danger of the plants suffering very much. However, should the soil be very dry, then there is a great loss thru drying up of the small plants.

The third method that has been practiced very successfully for the past three years is stubble seeding. After the grain crop has been removed, the alfalfa is seeded into the stubble. This method of seeding permits the seeding of a full crop of grain instead of a lighter seeding, as required by a nurse crop. The soil, if too dry, should be irrigated previous to seeding, or, as on the sandier soils, it may be "irrigated up." The earlier this stubble seeding is done the better it is. The seeding may be done as late as August 25, and a good stand has been secured with a seeding as late as September 1, but such late seeding is not recommended.

Various methods have been tried for preparing the soil previous to seeding into the stubble. In the fall of 1913 one field was divided into three equal plats; No. 1 was double disked and harrowed before seeding; No. 2 was single disked and harrowed; No. 3 was seeded without any preparation whatever. All of the alfalfa was seeded with a disk drill, the seed running into the shoe and at the rate of 12 pounds per acre. There was no difference in the stand secured nor in the yield of hay cut during the following year.

In 1914 a good stand was again secured by seeding into the stubble without any preparation. This method, especially on the lighter soil, is to be recommended, as it will prevent blowing and drifting during the windy season, and the stubble will also have a tendency to hold the snow during the winter. The drill will do much better work in standing stubble than where it is worked down. The disk, unless very sharp, will not cut thru the straw if worked down.

IRRIGATING ALFALFA.

Experiments with (*a*) late summer and fall irrigation and (*b*) with early spring and late spring irrigations of alfalfa have resulted in no gain for one or the other. It is a common practice to irrigate alfalfa in the spring as soon as water is available. This is usually at the beginning of the growing season, when the alfalfa requires a good irrigation.

Should the soil be very dry in the spring when growth begins it is well to irrigate. Alfalfa uses considerable water and suffers when irrigation is neglected. Many irrigators prefer to irrigate the crop just before cutting, believing that the water will injure the young growth and the crown if water is applied after the crop is removed. This, however, is not the case unless water is allowed to stand stagnant on the alfalfa.

The disadvantages of irrigating previous to cutting are: (1) The labor of walking thru the crop and tramping it down; (2) uneven spreading of water. Skips cannot be detected, the operation requires more labor, and after the crop is cut the hay will not cure as rapidly on the moist soil as where the land is dry. One of the advantages often mentioned for irrigating previous to cutting is more often a detriment. The contention is that the stubble will start the new growth more quickly if there is an abundance of moisture in the soil. If such a growth is too rapid it often seriously interferes with the hay on the ground; the new shoots growing under the haycocks even to the extent of growing into the hay.

CUTTING ALFALFA.

The time of cutting alfalfa makes no material difference as to the total yield obtained during the year, provided the irrigation has been normal. Tests have shown that three cuttings will produce just as much hay as four cuttings, provided the last cutting is made at the same time in both cases.

Cuttings made at different times to determine if the yield may be increased gave the following results:

TABLE 8.—*Results of alfalfa cuttings made at different times to determine if the yield may be increased.*

Yield	Date cut		
	June 23 July 26 Aug. 29 Sept. 18	July 2 Aug. 7 Sept. 18	July 12 Aug. 20 Sept. 18
1st cutting	1.22	1.89	2.70
2d cutting	1.74	1.94	2.05
3d cutting	1.85	1.45	.45
4th cutting	.53		
Total yield for season	5 34	5.28	5.20

The disadvantage of allowing the alfalfa to go too long before cutting is that it becomes very coarse; a better quality of hay is secured by the more frequent cutting. The difference in the food value of the hay cut at different times has not been determined, but experience has taught all feeders that the finer hay causes less waste in feeding, and more of it is consumed by the animals. This is sufficient cause for cutting it early and often. The quality of the hay should receive the first consideration.

SUGAR BEETS.

DEPTH OF PLOWING.

In 1912 work was started in an effort to determine the best depth of plowing for sugar beets. The depths plowed were 4, 8, 12, 16, and 20 inches. The first three depths were turned with a common sulky plow; the 16 and 20 inches were plowed 12 inches deep, and a subsoil plow was used to obtain the balance of the depth required.

The average yield for the three years is shown in Table 9.

TABLE 9.—*Average yield of sugar beets for three years.*

Year	Depth of plowing in inches				
	4	8	12	16	20
1912	20.5	15.4	17.1	18.7	16.4
1913	21.7	21.2	20.5	21.3	21.6
1914	14.6	14.0	14.8	14.7	14.4
Average	18.9	16.8	17.4	18.2	17.4

The three years' results do not show any material difference for the various depths of plowing. It would, therefore, not be advisable under average farm conditions to turn alfalfa under as shallow as 4 inches, as the crowns cause too much trouble. Cultivation under such conditions is too slow and tedious, and good work cannot be done.

Results show, however, that plowing from 7 to 9 inches is all that is necessary for our soils, and if stubble ground is used for beets, even a shallower plowing on the lighter soils will produce equally good results.

PLOWING UNDER ALFALFA FOR SUGAR BEETS.

In the fall of 1913 and spring of 1914, work was carried on in connection with spring and fall plowing of alfalfa, also the turning under of the second and third crop of alfalfa in comparison with alfalfa stubble. One year's results would indicate that there is but little difference when the plowing is done except in so far as the horse labor is concerned, and this must be taken into consideration. It was found that when the plants were in a growing condition and the roots full of sap the draft was much lighter than at that period when the roots were dormant.

TABLE 10.—*Results of plowing under alfalfa for sugar beets.*

Plat	Alfalfa plowed under	Yield per acre	Sugar	Purity
Number	*Crop*	*Tons*	*Per cent*	*Per cent*
3	Second	19.9	16.1	82.6
5	Third	17.2	17.3	87.1
7	Third	15.5	17.4	87.0
	Average	17.5	16.9	85.5

In this instance it would indicate that the second crop of alfalfa turned under produced 3.6 tons more sugar beets per acre than the average of Plats 5 and 7. This is offset by about 2 tons of alfalfa hay that the land would have produced in the second cutting, or 3.5 tons for both second and third cuttings. Where the third cutting was turned under, an average of 16.3 tons of beets was produced at the cost of the third cutting of hay, or 1.5 tons of hay.

At the same time this alfalfa was plowed under, adjoining plats were cut and the stubble plowed under, with the following results:

TABLE 11.—*Results of plowing under alfalfa stubble for sugar beets.*

Plat	Alfalfa cut before plowing compared with Table No. 9	Yield per acre	Sugar	Purity
Number	*Crop*	*Tons*	*Per cent*	*Per cent*
2	Second—stubble	20.6	14.3	82.6
4	Second—stubble	19.1	17.0	87.1
6	Third—stubble	18.5	17.0	87.2
8	Third—stubble	14.6	18.2	86.8
	Average	18.2	16.6	85.9

Comparing the two instances where the second crop was turned under and where only the second crop stubble was plowed under, there is only 0.1 of a ton of beets in favor of turning the alfalfa under, and this is at the expense of 2 tons of hay.

Between the third crop of alfalfa turned under and the stubble there is a difference of 0.3 of a ton of beets, at the expense of 1.5 tons of hay.

Taking the average of all plats, the yield is in favor of the stubble plowing, as the difference in all cases is very small.

Under fall plowing the land was crowned in the fall and also backset in the fall. Under fall crowning the crowning was done in the fall and the backsetting in the spring.

TABLE 12.—*Results of fall plowing land for sugar beets.*

Fall plowing Plat No.	Yield per acre
	Tons
2	20.6
3	19.9
4	19.1
5	17.2
6	18.5
7	15.5
8	14.6
9	17.3
10	16.7
Average	17.7

TABLE 13.—*Yield of sugar beets on land fall crowned but spring plowed.*

Plat No.	Yield per acre
	Tons
11	16.2
12	16.2
13	16.8
14	18.1
15	16.8
16	17.5
17	13.8
18	14.5
Average	16.2

TABLE 14.—*Yield of sugar beets on land spring crowned and plowed.*

Plat No.	Yield per acre	Plat No	Yield per acre
	Tons		*Tons*
19	16.6	22	17.6
20	17.0		
21	18.5	Average	17.4

In all of the instances of plowing and of whatever method followed, the yield is not affected so long as the work is done well and the alfalfa crowns destroyed so as to prevent any volunteer growth as much as possible.

Where the planting of the beets followed the backsetting, as soon as it could possibly be done, the volunteer growth of the alfalfa could be kept down much better. Where the land was allowed to lie any great length of time before planting, the alfalfa came thru and made considerable growth before the beets were out of the ground. This causes considerable trouble in the cultivation.

DISTANCE OF SPACING SUGAR BEETS.

The distance of spacing beets has but little influence upon the yield until distances of rows 28 inches apart and beets 12 inches apart in the row are attained.

This work was conducted for two years, but as the stand of beets in 1912 was not perfect, due to climatic conditions, the results are not comparable, and only the 1913 results are given in Table 15.

TABLE 15.—*Yield of sugar beets with various distances of spacing.*

Distance of rows	Distance plants apart in the row	Yield per acre
Inches	*Inches*	*Tons*
18	6	17.9
18	9	17.0
18	12	16.8
18	15	13.6
20	6	19.3
20	9	17.1
20	12	18.1
20	15	18.4
20	18	17.8
24	6	16.1
24	9	16.0
24	12	16.3
24	15	16.6
24	18	15 6
28	6	17.5
28	9	15.4
28	12	16.7
28	15	14.6
28	18	14.8

There was considerable difficulty in irrigating the beets that were 24 and 28 inches apart. As previously stated, the soil has but little capacity for carrying the water laterally. As the feeder roots of the beets are along the sides of the beet and do not seem to extend laterally very much, it was necessary to run the water too long to irrigate the crop properly. This was especially true where the rows had too much fall.

Several plats were planted with rows alternately 18 and 24 inches apart; this would make the rows 21 inches apart on the average. The object was to give more space to the horses in the rows and perhaps work the beets to better advantage.

Only the wide rows were to be ditched, but the same difficulty was encountered as in the wide planting, and in order to irrigate properly the narrow rows had to be ditched.

(6-7-'15—10M.)