5-1894

Bulletin No. 29 - Irrigation: Amount of Water to Use. Relative Feeding Values of Timothy, Lucerne and Wild Hay

J. W. Sanborn

Geo. F. Colby

THE UTAH AGRICULTURAL COLLEGE EXPERIMENT STATION.

BULLETIN No. 29.

Irrigation: Amount of Water to Use.
Relative Feeding Values of Timothy, Lucerne and Wild Hay

MAY, - - 1894.

PRESS OF THE SALT LAKE LITHOGRAPHING CO.

OFFICERS OF THE EXPERIMENT STATION:

STATION STAFF.

J. W. SANBORN.................................DIRECTOR
E. S. RICHMAN........HORTICULTURIST AND ENTOMOLOGIST
R. W. ERWIN..............................ASST. CHEMIST
A. A. MILLS............SUPT. OF FARM EXPERIMENT WORK
S. S. TWOMBLY...............CONSULTING VETERINARIAN
F. W. BREWER ....BIOLOGIST
S. FORTIER.........................HYDRAULIC ENGINEER
F. B. LINFIELD......................DAIRY INVESTIGATOR
JAMES DRYDEN................ CLERK AND STENOGRAPHER

POST OFFICE, - LOGAN, UTAH.

The Bulletins will be sent free to anyone requesting them.

BULLETIN No. 29.

Amount of Water to Be Used in Irrigation.

Relative Feeding Values of Timothy, Lucerne and Wild Hay.

J. W. SANBORN.

In Bulletin 24 are given results of the first three years of experimentation as to the relation between the amount of water used and crop yield, soil fertility, and the exit, through drains, of the matters held in solution in the water applied. In this report are included the results of the first three yeass, plus those of the past season. The experiment is regarded of the very highest importance in that it deals with the right amount of water essential to the growth of wheat and grass crops, but more especially as it approximately determines whether the materials of plant growth held in solution by irrigating waters are taken up by the soil, or whether the water, in passing through the soil, actually has added to it soluble matters already in the soil before the application of the water. A solution of this question would be of value mainly to those who, carelessly or otherwise, use an excess of water an excess that results in percolation. Such excess of water is used all over Utah. Those occupying lower lands are made cognizant of it by the increase in saturation of their soils due to the influence of water applied on high lands, so much so that drainage becomes a necessity. The trial has value to those in other sections of the country that may adopt irrigation for areas subject to drouth, yet have sufficient rain to induce percolation of water, as seen in springs and rivers.

Saturation 4 feet deep, 3¼ feet deep, etc., means that enough water was applied to furnish that amount which the soil will hold to the depths of 4 feet, 3¼ feet, etc. This amount was found by estimating the amount of water that a soil would hold. It is known from the experiments of Professor King that what has heretofore been known as water of saturation is much less than estimated, as when the soil is allowed to stand it is found that it will drip a long time after it is believed to contain only the water of saturation. Ordinary loams are believed to hold about 50 per cent of their weight, and soils of one foot deep weigh some 3,500,000 pounds.

The result of the application of water to the several plats will be seen in table No. 1:

TABLE I.

CROP, WHEAT—YIELD PER ACRE IN BUSHELS AND POUNDS.

Year	Saturated 4 Ft. Deep		3¼ Feet Deep		2½ Feet Deep		2 Feet Deep		1½ Feet Deep		¾ Feet Deep		Unwatered		Unwatered and Undrained	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1890	7.76	937	14.68	1417	12.00	879	8.28	1102	10.09	765	..	......	2.15	290	.81	177
1891	19.03	2171	9.47	1622	13.14	1496	11.75	1119	15.8	1039	......	......	18.28	1963	13.98	1742
1892	14.85	1051	12.56	1303	12.56	1874	24.00	3360	25.90	1988	.....	......	6.86	731	4.94	845
1893	5.71	457	6.09	320	13.33	800	14.85	1166	6.47	639	4.57	529.5	......	......	1.71	240
Average, 4 years	11.84	1154	10.7	1166	12.75	1262	14.72	2242	14.56	1108	4.57	529.5	9.09	994	5.36	751
Total pounds, grain and straw	1864.4		1807.5		2027.0		3125.0		1982.0		803.8		1374.0		972.0	

At the close of the season of 1892, it was found that saturation 1½ feet deep was substantially as valuable as a greater amount, leaving it doubtful whether a less amount might not be as valuable as a greater amount. Hence, a plat watered for saturation ¾ of a foot deep was added. The table for the year 1893, for ¾ of a foot saturation, shows adversely, but it will require other years to determine whether it is due to the plat or to deficiency in water, the plats being rotated year by year.

This table agrees with the result in former years in showing that 1½ feet of water, or rather water that will saturate soil 1½ feet deep, which is equal to 15.86 inches, is the equivalent of larger amounts for grain production, although it is probable that a lessened amount of straw will result.

The following table shows the amount of water applied per acre to the several plats each year:

TABLE II.

POUNDS OF WATER APPLIED PER ACRE, WITH SIZE OF HOLE AND TIME RUNNING.

SATURATION	1890				1891				1892				1893			
	Size of Hole In.	Time Running Hrs.	Time Running Min.	Pounds Water Per Acre	Size of Hole In.	Time Running Hrs.	Time Running Min.	Pounds Water Per Acre	Size of Hole In.	Time Running Hrs.	Time Running Min.	Pounds Water Per Acre	Size of Hole In.	Time Running Hrs.	Time Running Min.	Pounds Water Per Acre
Saturated ¾ ft.													3	2	51	1,784,260
" 3¼ ft.	1½	70		10,487,610	2	41	48	10,835,169	2	30	54	8,009,877	2	27	51	7,219,110
" 4 ft.	1½	88	45	13,890,871	2	51	24	13,323,628	2	38	1	9,905,902	2	34	15	8,878,100
" 1½ ft.	3	8	36	5,384,194	3	8	36	5,384,194	3	9	21	5,425,175	3	5	45	3,599,900
" 2 ft.	2½	16	30	7,173,709	2½	16	30	7,173,709	2½	15	13	6,615,897	2½	11		4,796,900
" 2½ ft.	2½	20	33	8,934,529	2½	20	33	8,934,529	2½	21	11	9,209,884	2½	13	42	5,956,350

As an inch of water weighs 226,000 pounds, it will be seen that the smallest amount applied in 1893 is between seven and eight inches, while the largest amount is, in round numbers, forty inches. In the year 1890 the largest amount applied, 1890 being the first year that water was used on the plat, was over fifty inches. It is specially worthy of notice that the amount of water used decreased annually for four years, notwithstanding the soil represents the extremes of gravelly soils as found in the Territory. This is somewhat remarkable as showing the capacity even of gravels to retain water at great depths, and afterwards to draw it to the surface by capillary action when required, and well illustrates why a reduced amount of water is required from year to year from that of the first years of irrigation.

Table No. 3 shows the amount of drainage water taken from the several plats. A review will not be given of all of them. The largest amount of drainage for the year 1893 was 61,554 pounds, on the plat saturated four feet deep, or where 8,878,100 pounds of water was applied.

This table is an exceedingly interesting one, as it shows that even where a large amount of water is applied but a small amount runs away in the drains of our hungry soils, when the drains are laid to the depth of 2½ feet.

TABLE III.

DRAINAGE WATER IN POUNDS PER ACRE.

	1890	1891	1892	1893
1½ feet saturation	....	....	....	48,364
2 " "	11,131	....	....	4,754
2½ " "	71,251	....	....	14,948
3¼ " "	91,394	49,394	17,737	2,240
4 " "	48,474	152,891	92,160	61,554

YIELD OF TIMOTHY PER ACRE.

It is well understood that grass requires more water for maximum growth than grain crops. For this reason, and for the purpose of duplicating the trial of the relation of the amount of moisture to crop yield, plats were laid out to timothy. The following table gives the yield from different amounts of water applied:

TABLE IV.

WEIGHT OF HAY AND AMOUNT OF WATER APPLIED, 1893.

Plat No.	Inches applied	Weight of hay per plat	Weight of hay per acre	Size of hole	Time running, hours and minutes, inches. Hr.	Min.	Pounds water per acre
15a	8.01	100	2000	4	1	52	1,817,928
16a..........	16.02	65	1300	4	3	44	3,635,850
17a..........	24	200	4000	3	9	56	5,441,587
18a..........	31.96	125	2500	3	13	14	7,224,350
19a	39.96	125	2500	3	16	33	9,066,262
20a..........	17.23	....	....	2	17	14	4,467,131

HAY PER ACRE.

Saturation	1891	1892	1893	Total
Saturated 4 feet....................	1740	1800	2500	6040
" 3¼ "	....	1400	2500	3900
" 2½ "	1020	2000	4000	7020
" 2 "	1280	1000	1300	3580
" 1½ "	1550	1200	2000	4750

The following table shows the amount of elements of fertility found in the drainage water. The total amount of solid matter in the 61,554 pounds per acre of drainage water from the soil saturated 4 feet is 12.736 pounds per acre. The total amount of solids in the water applied to this plat was 1677.09 pounds per acre. Subtracting one from the other leaves 1664.35 pounds of soil fertility that was taken up for the use of vegetation.

If such wonderful results are secured on our gravelly soils, it is quite evident that on the ordinary clay loams, whose absorbing power is several fold that of our gravelly soils, the fertility that water brings to them is retained for the use of the plant.

TABLE V.

ANALYSIS OF DRAINAGE WATER, 1893.

PER ACRE IN POUNDS.

SATURATION	Total Solids	Lime	Potash	Phosphoric Acid.	Ammonia	Organic Matter	Nitrates
4 feet saturation	12.736	7.19	.210	Trace	.0131	.052	.254
2½ " "	4.425	2.044	.046	Trace	.0037	.017	.0581
2 " "	1.28	.503	.0236	Trace	.0015	.0035	.0203
1½ " "	11.80	4.600	.178	Trace	.0082	.0455	.178

TABLE VI.

CHEMICAL COMPOSITION OF WATER APPLIED—TOTAL PER ACRE, 1893, IN POUNDS.

SATURATION	Total Solids	Lime	Potash	Phosphoric Acid	Ammonia	Organic Matter	Nitrates
4 feet saturation..........	1677.09	635.76	7.102	Trace	.621	.364	1.86
3¼ " "	1363.69	516.96	5.77	"	.505	.296	1.52
2½ " "	1125.14	426.53	4.77	"	.417	.244	1.25
2 " "	906.13	343.50	3.84	"	.336	.197	1.007
1½ " "	680.02	257.79	2.88	"	.252	.148	.76
¾ " "	337.04	127.77	1.43	"	.125	.0732	.37

Moisture and temperature tests were made of the plats. These will be found in the two following tables:

TABLE VII.

AVERAGE TEMPERATURE, TAKEN SIXTEEN TIMES, FROM JUNE 16 TO AUGUST 14, 1893.

Depths Taken	17 Saturated 4 feet deep	16 3¼ ft. deep	20 2½ ft. deep	19 2 feet deep	18 1½ ft. deep	15 ¾ feet deep	14 Unwatered and undrained	Average
Depth of bulb......	102.4	103.3	102.0	101.0	104.4	108.8	115.4	105.3
1 inch deep.........	94.3	93.3	91.1	90.9	93.6	96.4	102.6	94.6
2 " "	86.7	87.6	83.7	83.5	86.5	89.2	92.6	87.1
3 " "	82.1	83.2	79.5	79.4	82.3	84.1	86.1	82.4
3 " above soil...	90.5	91.3	88.1	88.8	89.9	91.5	90.1	90.0
6 " " "	87.3	88.7	86.5	86.6	87.2	88.5	88.0	87.5
12 " " "	84.5	84.8	84.7	84.6	84.6	85.3	85.7	84.9
Average.........	89.7	90.3	87.9	87.8	89.8	91.9	94.3	90.2

TABLE VIII.

TEMPERATURE OF SOIL AND AIR, 1893.

Average at depth of bulb, 1, 2, 3 inches deep and 3, 6 and 12 inches above soil on the different dates.

Dates on Which Temperature was Taken	17 Saturated 4 feet deep	16 3¼ ft. deep	20 2½ ft. deep	19 2 ft. deep	18 1½ ft. deep	15 ¾ ft. deep	14 Unwatered and Undrained
June 16	78.6	78.6	79.	78.9	76.8	78.2	86.5
" 19	90.5	92.8	89.6	90.4	89.6	94.2	93.5
" 23	77.8	76.3	76.1	81.9	78.2	77.3	80.1
" 27	96.7	95.7	90.8	90.8	94.8	98.5	102.1
July 1	110.4	108.4	100.5	104.1	106.9	110.5	106.4
" 5	106.	106.5	99.3	101.	103.6	103.2	104.3
" 10	104.8	107.3	106.3	104.7	103.5	108.9	103.
" 13	75.8	74.1	67.1	73.3	75.5	80.8	86.4
" 17	88.9	86.9	92.8	84.5	87.3	92.9	98.
" 21	91.2	99.	94.8	92.5	94.3	96.6	97.4
" 25	92.8	93.1	91.8	91.7	93.8	96.1	96.7
" 28	77.5	77.5	78.	76.5	77.6	82.1	91.4
August 1	82.6	84.3	81.8	83.1	87.5	89.5	99.8
" 5	89.3	90.5	87.9	84.	91.7	91.3	90.4
" 9	91.3	91.8	88.7	87.8	92.5	91.1	92.8
" 14	80.2	82.5	83.1	80.4	83.8	81.1	79.5
Average	89.6	90.3	87.9	87.8	89.2	92.	94.2

TABLE IX.

MOISTURE IN SOIL, 1893.

Date	17 Saturated 4 Feet		16 Saturated 3¼ Feet		20 Saturated 2½ Feet		19 Saturated 2 Feet		18 Saturated 1½ Feet		15 Saturated ¾ Feet		14 Unwatered and Undrained		Average	
	Depth		Depth		Depth		Depth		Depth		Depth		Depth		Depth	
	2 in.	8 in.	2 in.	8 in.	2 in.	8 in.	2 in.	8 in.	2 in.	8 in.	2 in.	8 in.	2 in.	8 in.	2 in.	8 in.
July 16. 13 days after irrigation...	1.58	3.26	1.80	3.04	4.80	4.13	1.28	3.06	1.20	3.40	......	......	......	......	2.13	3.27
" 31. 4 " " " ..	7.42	9.46	5.36	2.62	7.76	9.52	7.10	9.00	7.38	8.48	5.18	8.24	4.00	4.18	6.31	7.37
August 8. 12 days after irrigation	2.74	3.46	2.72	5.04	2.68	4.48	1.80	4.40	2.68	4.16	1.94	4.72	6.39	2.68	3.00	4.13
" 12. 16 " " "	2.58	3.04	2.18	5.72	2.00	3.38	3.50	3.64	1.78	4.10	1.78	4.60	2.50	2.66	2.33	3.45
Average........................	3.58	4.81	3.01	4.10	4.31	5.37	3.42	5.02	3.26	5.03	2.96	5.85	4.29	3.17	3.44	4.55
Average of plat..................	4.19		3.55		4.84		4.22		4.14		4.40		3.73		4.15	

Table VII gives the average temperature of each plat from June 16 to August 14, 1893. In that period the temperature was taken on sixteen different days, and each figure given represents the average of the sixteen readings at the depth mentioned in the first column.

Table VIII gives the average daily temperature of the different plats at the different points at which the temperatures were taken. That is to say, each figure represents the average of the temperatures at depth of bulb, 1, 2, and 3 inches below the surface, and 3, 6, and 12 inches above the soil, these seven readings being averaged.

The results show that, especially on the surface of the ground, that which was least watered had, as might be expected, the highest temperature, showing that the less the evaporation of water from the surface the higher the temperature of the soil.

The moisture tests of the soils at the different depths of irrigation are not conclusive. It is, perhaps, a logical deduction that after the expiration of twelve to sixteen days from irrigation evaporation has been so rapid that the water applied has nearly been exhausted, for were this not so the irrigated plats must show a large amount of water. It cannot be that the lateral flow of water, as has been heretofore shown, equalized the amount between the two plats, for that unwatered gave a very small crop indeed.

SUMMARY.

1. The plats saturated to the depth of 1½ feet gave a better crop of grain than a greater or less amount.

2. For timothy, the plats saturated 2½ feet deep gave the best results.

3. Soils remove most of the solids from water applied beyond soil saturation.

4. The water that does escape from soils by leaching is richer in the elements of fertility than before it entered, the amount so escaping, however, being so small that the total contains but a fraction of the solids applied.

5. Where water applied is small in amount, the temperature grows higher and higher on decreasing amounts.

6. Water applied to our gravelly soils appears to evaporate inside of twelve days.

RELATIVE FEEDING VALUES OF TIMOTHY, LUCERNE AND WILD HAY.

J. W. Sanborn.

The following experiment with steers was written up some months ago and laid aside as unworthy of publication. The cattle, it seems, did not consume enough at the time experiments were carried on to more than maintain existence. This time of the year growth is less than at any other, and being confined upon a single food, the appetites of the steers were so impaired that they would eat only enough to maintain existence. In the spring months when warm weather is coming on and when general lassitude takes possession of all animal life, particularly animals that are shedding their coats, consumption of food is usually small.

During the winter, subsequent to the writing of the following experiment with steers, a new one was made with sheep, but with sheep confined in too small pens where exercise and appetite are reduced to their minimum. This error will have to be corrected in future experiments. Although there is little value in the experiment I will give the results, as they bring out one fact prominently.

The trial with steers commenced April 20, 1893, the steers having been weighed three days in succession, the average of the three weighings being given. There were three steers in each set, and previous to this trial they had been fed mixed hay, corn fodder, roots and grain. In this trial only hay and grain were fed, the grain consisting of one-half wheat and one-half bran by weight. One steer of each set was put in a box-stall, the other two steers of each set being tied up.

Set 11 was fed timothy at the rate of 45 pounds per day.

Set 12 was fed native hay at the rate of 45 pounds per day.

Set 13 was fed lucerne at the rate of 45 pounds per day.

Table 1 gives the weekly weighings of each set and the gain or loss at the end of the period. Table 2 gives the weight of food eaten by each set.

TABLE I.

WEIGHTS OF STEERS, APRIL 20 TO MAY 31, 1893.

Set No.	Feed	Weight April 18, 19, 20	Weight April 24	May 1	May 8	May 15	May 22	Average May 29, 30, 31	Gain or Loss.
11....	Timothy	3296	3124	3176	3174	3186	3130	3171	—125
12....	Native hay	3320	3054	3222	3212	3280	3242	3271	—49
13....	Lucerne	3203	3026	3144	3152	3166	3142	3230	27

TABLE II.

WEIGHTS OF FEED, APRIL 20 TO MAY 31, 1893.

Set No.	Timothy	Native Hay	Lucerne	Grain	Waste	Total Eaten
11	1873	....	....	360	224.75	1972.25
12............	....	1837	....	360	108.75	2088.25
13............	....	....	1837	360	116.25	2080.75

It will be seen by the table that the lot on timothy hay did poorest and the lot on the lucerne hay best. The great disparity in gain is not explained by the different amounts of food eaten. Those receiving timothy hay wasted 116 pounds more than the others and consumed over 100 pounds less of food, but this 100 pounds of food would account for less than twenty pounds difference in gain and does very little to relieve the disparity in the gain of the different lots.

I must frankly state that I do not regard the result as representing the relative values of the foods, and only put the experiments on record because it is only one of a series of trials of the same character, this being the second, the first being with the same foods for sheep. In that trial the difference in value of these three foods was very little, wild hay being the best for sheep, tame hay being the next best, and lucerne hay being the poorest.

Very likely the marked difference noted is to be explained by the fact that the steers in this trial had been fed in other experiments during the winter and came to this experiment in an unlike condition, although we endeavored to so select the steers, as far as possible, as to overcome the likelihood of differences at the start. We had both the time and the hay and made the trial to fill the blank spaces. This is not the true scientific way. Perhaps it should not be put on record, and yet when taken in connection with other trials to come it may prove to have some value in connection with the whole series of trials, and I, therefore, make this record. Indeed, one fact seems to stand out fairly that lucerne hay, in all probability, will stand a fair comparison in value with the other foods when fed to steers.

EXPERIMENT WITH SHEEP.

Our experiment with the sheep was, as with the cattle mentioned in the opening of this article, in pens so small that appetite was reduced beyond point of maintenance. The results are similar to those in the preceding trial. With the steers the timothy did poorer than the native hay and the native hay was less valuable than the lucerne. With the steers the amount eaten was substantially equal, and yet some of the steers gained where others lost. With sheep the amount of timothy and wild hay eaten was substantially equal, while the sheep did poorer on the timothy hay. Unlike the steer experiment the sheep ate more of lucerne than of the other varieties of hay and made a positive gain.

Both experiments concur, then, in showing that lucerne in the barn is a more valuable food than either timothy or wild hay. This does not agree with our pasture experiments. Invariably in the pasture green lucerne has been found less valuable than the other grasses for grazing purposes.

The sheep fed upon lucerne consumed only 1.7 per cent of their live weight per day, and yet made a gain of fourteen pounds. This 1.7 per cent of live weight daily is a little less than is regarded as a maintenance ration. Those that were fed on timothy and wild hay ate considerably less than a recognized ration, which accounts entirely for the failure to grow, and rests not in the kind of food, nor in any other factor but that of appetite.

The moral of this experiment is that one of the first factors in successful feeding is the maintenance of appetite adequate for the consumption of sufficient food above maintenance. Experiments that have been from time to time reported in the Bulletins of this Station have shown that the amount of food consumed, palatableness remaining the same, by stock is almost in direct ratio to the amount of exercise taken. In both instances with sheep it was wholly a question of quarters ample enough for sufficient exercise and pure air to excite a good appetite.

TABLE I.

WEIGHTS OF SHEEP, DECEMBER 6 TO FEBRUARY 19, 1894.

Sets	When Weighed												Gain or loss	Feed		
	Dec. 4, 5, 6	Dec. 11	Dec. 18	Dec. 25	Jan. 1	Jan. 8	Jan. 15	Jan 22	Jan. 29	Feb. 5	Feb. 12	Feb. 19		Weight of feed fed	Waste	Weight of feed eaten.
Set 1—Fed Timothy..................	394	388	380	378	372	368	364	362	362	350	354	346	—48	429	137.5	415.25
Set 2—Fed wild hay..................	388	388	382	372	370	368	364	366	368	362	360	356	—32	429	101.75	418.82
Set 3—Fed lucerne	388	382	380	272	384	384	388	388	392	398	408	402	14	502	44.25	497.57

SUMMARY.

1. The experiment with cattle appears to show that lucerne is a more valuable food, pound for pound for growth, than timothy hay or wild hay.

2. The above reported experiment with steers appears to show that a pound of wild hay is more valuable, pound for pound, than a pound of timothy.

3. The above experiment with sheep appears to show that a pound of lucerne hay is much more valuable than a pound of timothy or wild hay.

4. The experiment also appears to show that a pound of wild hay is more valuable for sheep than timothy hay.

5. It adds another proof to those secured at this Station, that exercise is indispensable to appetite and growth.