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THE VALUE OF LEATHER REFUSE.

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I. RAW, ROASTED OR STEAMED LEATHER.

IN another publication[1] the writer reviewed the experiments made by various investigators concerning the agricultural value of different forms of leather refuse, and drew the following conclusions: "The results of both field and pot experiments, as well as artificial digestion experiments, indicate that leather, either raw, roasted or steamed, is a very inferior source of plant food. Carefully conducted experiments by Wagner give the nitrogen it contains a relative value of 20, the nitrogen in sodium nitrate being valued at 100. When nitrogen in organic matter is valued at from sixteen to eighteen cents per pound, nitrogen in raw, roasted or steamed leather should be worth but from three to six cents per pound.

II. DISSOLVED LEATHER.

Deherain and others have suggested that if leather be dissolved in sulphuric acid, its nitrogen will be made as available as that contained in the average animal matter. It is generally understood that many European manufacturers of fertilizers thus turn leather waste to account. No direct experiments are on record, so far as the writer is aware, to bear out the above claim.[2]

In order to study the value of dissolved leather, pot experi-

[1] Twelfth annual report of the Massachusetts Experiment Station, 1894. See also Agricultural Science, 8, Nos. 2 and 3.

[2] See however a single test reported in the Report of Connecticut Experiment Station for 1894, p. 101.

ments with oats were conducted during the years 1894 and 1895. The results obtained in 1894 have already been published.[1] The results for both years are presented below:

General Plan of the Experiment.—The experiments were conducted in galvanized iron pots. The soil, poor in all three ingredients of fertility, was supplied with an excess of potash and phosphoric acid. The nitrogen in sodium nitrate was taken as a standard, being rated at 100. The same quantity of nitrogen in sodium nitrate, Philadelphia tankage (roasted leather) and dissolved leather was applied to different sets of two or three pots each; one set of pots received no nitrogen. These latter pots measured the nitrogen capacity of the soil. The entire number of pots were treated as nearly alike as possible so far as sunlight, moisture, etc., were concerned. With similar conditions and plant food alike, excepting the nitrogen source, it is clear that the amount of nitrogen taken up by the plants in the different pots, would be a measure of the availability of the nitrogen in the several forms of nitrogen-containing material.

The Pots Used.—The pots, of thin galvanized iron, were seven and three-fourths inches in diameter and eight inches deep. A galvanized iron tube, half an inch in diameter, extended from the top to the bottom of the pot, connecting at the base with a second tube of the same material one inch in diameter. The latter tube extended along the bottom of the pot, and was perforated with small holes. The object of these tubes was to supply water partly from the bottom of the pot.

EXPERIMENTS A.

These experiments were begun in 1894 with eighteen pots, three parallel pots for each distinct test; they were continued in 1895 with twelve pots, two pots being employed for each test.

The Soil.—The soil was of a gravelly nature, and had not been cultivated for a long time. It was very poor in all three ingredients, as the following analysis will show:

	Per cent.
Water when tested	14.25
Phosphoric acid	0.13
Potassium oxide	0.08
Nitrogen	0.09

[1] *Loc. cit.*

Fertilizers Used.—The sources of nitrogen were sodium nitrate, Philadelphia tankage,[1] and dissolved leather. The dissolved leather was prepared in 1894 by heating 210 grams of C. P. sulphuric acid of 50° B. to 80° C. and slowly adding sixty-three grams of finely ground sole leather. The mixture was thoroughly stirred and allowed to stand one-half hour. A dark pasty mass resulted, to which were added forty-nine grams of water to thin somewhat, together with sufficient calcium carbonate to neutralize the excess of sulphuric acid, and to make the resulting mass suitable to handle. The calcium carbonate was used in preference to the phosphate, in our case, to avoid an excess of phosphoric acid. After standing twenty-four hours the mixture became dry and friable. The dissolved leather for 1895, was prepared in the same way, excepting that the water was omitted. Double superphosphate was used as a source of phosphoric acid, and potash was applied in the form of the double sulphate of magnesia and potash.

COMPOSITION OF FERTILIZERS USED.

	Nitrogen. Per cent.	Available phosphoric acid. Per cent.	Total phosphoric acid. Per cent.	Potassium oxide. Per cent.
Sodium nitrate for 1894 and 1895	14.28	....	....	....
Dissolved leather, I., 1894	0.97	....	....	....
" " I., 1895	0.97	....	....	....
Philadelphia tankage 1894 and 1895	7.80	....	....	....
Double superphosphate 1894 and 1895	....	47.42	47.80	
Double sulphate of magnesia and potash, 1894	....	....	....	24.32
Double sulphate of magnesia and potash, 1895	....	....	....	25.08

ARRANGEMENT OF THE EXPERIMENT.

1894.

	Source of nitrogen.	Amount of nitrogen applied per pot. Gram.	Amount of available phosphoric acid applied per pot. Grams.	Amount of potassium oxide applied per pot. Grams.
Pots	1, 2, 3, soil nitrogen	0.00	1.20	2.40
"	7, 8, 9, sodium nitrate	0.30	1.20	2.40
"	13, 14, 15, dissolved leather	0.30	1.20	2.40
"	10, 11, 12, sodium nitrate	0.60	1.20	2.40
"	16, 17, 18, dissolved leather	0.60	1.20	2.40
"	4, 5, 6, Phil. tankage	0.60	1.20	2.40

[1] Roasted leather.

Pots 1, 4, 7, 10, 13, 16, were infected with a small quantity of cultivated soil, to note if the infection facilitated to any marked degree the nitrification of the organic nitrogen in case of these particular experiments. To each of these pots was also added ten grams of air-slaked lime.

1895.

Source of nitrogen.	Amount of nitrogen applied per pot. Grams.	Amount of available phosphoric acid per pot. Grams.	Amount of potassium oxide per pot. Grams.
Pots 1, 2, soil nitrogen.....	0.00	2.40	4.80
" 7, 8, sodium nitrate	0.30	2.40	4.80
" 13, 14, dissolved leather ...	0.30	2.40	4.80
" 10, 11, sodium nitrate	0.60	2.40	4,80
" 16, 17, dissolved leather ...	0.60	2.40	4.80
" 4, 5, Phil. tankage.....	0.60	2.40	4.80

It will be noticed that double the quantity of phosphoric acid and potash was applied in 1895, to make sure of a sufficient amount to enable the nitrogen to do its best work. To each of the pots was added ten grams of air-slaked lime. The same soil was used in 1895 as in 1894.

Filling the Pots.—About an inch of good clean gravel was first placed in the pots. All of the fertilizer excepting the nitrate was then mixed with eleven and one-half pounds of soil, which was put in in layers and gently pressed down. One-half gram of selected oats was then scattered over the soil, and covered with one pound of earth. The pots were thus filled to within one centimeter of the rim. One-half of the nitrate was applied in solution at the time of seeding, and the other half five to six weeks later.

General Care of the Pots.—The pots were set into a wagon running on an iron track. The floor of the wagon was surrounded with sides six inches deep. The pots were carefully watched and kept sufficiently watered. A portion of this water was supplied from beneath, and the remainder was added to the surface by the aid of a sprinkling pot. Sometimes it was necessary to water twice daily. The pots were kept in the open whenever the weather permitted. During wet or windy weather, and at night, they were run under cover.

Harvesting, etc.—The plants in pots 1, 2, 3, 4, 5, 6, in 1894, and in 1, 2, 4, 5, in 1895, were very light green and spindling during the entire growing period. The plants in the different pots were harvested as they matured. They were cut close to the soil, put in paper bags and hung away to dry. After the product of each pot was thoroughly air-dry, the grain was carefully removed, weighed, coarsely ground, and dry matter determinations made. The straw was cut into short lengths, and also tested for dry matter. Finally both grain and straw were ground fine, and nitrogen determinations made.

The figures in Tables I and II show the results obtained in two years. The first column in Table I shows the amount of nitrogen applied to each pot. The next four columns show the average dry matter produced for both years. The four columns next following indicate the gain in dry matter over soil nitrogen pots. The last column shows the average gain in dry matter of straw and grain for two years, produced by the different fertilizers, the gain produced by sodium nitrate being reckoned at 100.

It will be seen that the Philadelphia tankage has been but slightly available as a nitrogen source. Its effect the second year was rather better than during the first season. The combined results for the two years show it to be very inferior to the sodium nitrate, yielding practically one-tenth as much dry matter. These results simply confirm the investigations made by others with different forms of untreated leather.

The results with dissolved leather are very different. One could easily observe that during the entire growing season the plants treated with this substance were uniformly green, healthy, and grew continuously, being but little if any inferior in color to the sodium nitrate pots. The amount of dry matter obtained for two years with the aid of this source of nitrogen when compared with sodium nitrate, has been as 78 to 100.

The three-tenths gram of nitrogen from sodium nitrate the second year produced a poor yield of grain. This can only be accounted for from the fact that the second half of the nitrate was not applied until shortly before the grain began to head,

TABLE I.

	Nitrogen applied to each pot yearly.	Average dry matter produced.				Gain in dry matter over soil nitrogen pots, on basis of 0.3 gram of nitrogen applied.				If gain in dry matter with sodium nitrate = 100, then other sources of nitrogen would be equal to:				Average gain in straw and grain 1894 and 1895.
	Grams.	Straw. 1894 Grams.	Straw. 1895 Grams.	Grain. 1894 Grams.	Grain. 1895 Grams.	Straw. 1894 Grams.	Straw. 1895 Grams.	Grain. 1894 Grams.	Grain. 1895 Grams.	Straw. 1894	Straw. 1895	Grain. 1894	Grain. 1895	
Soil nitrogen.....	0.000	7.82	8.64	1.69	1.32	....	....	....	....	....	....	....	....	....
Philadelphia tankage	0.600	8.88	11.10	1.66	2.66	0.53	1.23	±	0.67	5.40	13.75	±	31.45	7.5
Sodium nitrate.....	0.300	17.59	17.59	6.37	3.45	9.77	8.95	4.68	2.13	100.00	100.00	100.00	100.00	100.00
Dissolved leather....	0.300	14.35	14.79	4.25	6.00	6.53	6.15	2.56	4.69	66.8	68.7	54.7	220.3	78.1
Sodium nitrate.....	0.600	19.54	17.28	1.85	2.50	5.86	4.32	0.08	1.19	....	....	....	....	....
Dissolved leather....	0.600	19.76	19.76	4.92	5.15	5.97	5.56	1.61	1.91	....	....	....	....	....

TABLE II.

	Quantity nitrogen to each pot.	Nitrogen in total dry matter produced. Grams.			Average nitrogen in 100 grams dry matter. 1894 and 1895.		For 100 parts of nitrogen applied there has been returned in straw and grain:		When sodium nitrate = 100 other sources of nitrogen equal to:	Every gram of nitrogen applied has produced in dry matter. Average 1894 and 1895.			For every 100 parts of straw, there has been produced in grain:
	Grams.	1894	1895	1894 and 1895	Straw. Grams.	Grain. Grams.	1894.	1895.	1894 and 1895.	Straw. Grams.	Grain. Grams.	Straw and Grain. Grams.	Grams.
Soil nitrogen.....	0.000	0.094	0.105	0.100	0.76	2.50	....	....	....	....	....	....	18.2
Phila. tankage.....	0.600	0.126	0.163	0.144	0.94	2.39	5.3	9.67	11.00	2.49	1.12	3.61	38.1
Sodium nitrate.....	0.300	0.305	0.305	0.305	0.97	2.84	70.0	66.70	100.00	31.20	11.34	42.54	36.3
Dissolved leather...	0.300	0 210	0.273	0.241	0.71	2.70	39.0	56.00	70.00	21.13	12.07	33.20	57.2
Sodium nitrate.....	0.600	0.425	0.436	0.430	1.98	3.04	55.0	55.17	80.00	....	....	....	12.5
Dissolved leather...	0.600	0.325	0.374	0.349	1.00	2.99	39.0	44.83	62.00	....	....	....	31.7

and that this was not early enough for the plant to work it over into organic combination.

In cases where six-tenths of a gram of nitrogen was applied in the form of sodium nitrate but little grain was produced. This might be the result of two causes. First, because an excess of soluble nitrogen interfered with its natural transformation into organic combination, and in the next place it is possible, as already stated, that the second application was made too late. It is believed that the amount of phosphoric acid and potash applied especially the second year was in all cases sufficient. The six-tenths gram of nitrogen from the dissolved leather did rather better work than that from sodium nitrate, but it was still much inferior to that performed by three-tenths gram.

The amount of nitrogen obtained by the plant is a better measure of the availability of the nitrogen than the dry matter produced. This will be found in Table II. The first portion of the table shows the nitrogen in the total dry matter produced, and the average per cent. of nitrogen in 100 grams of dry matter. Next to be noted is the amount of nitrogen returned in the straw and grain, for every 100 parts of nitrogen applied. The results obtained from the several sources of nitrogen are then compared with the nitrogen obtained by the straw and grain of the sodium nitrate pots reckoned at 100. This comparison shows that the plants were able to take only about one-tenth as much nitrogen from Philadelphia tankage as from sodium nitrate, while they secured seven-tenths as much nitrogen from the dissolved leather as from the nitrate. When six-tenths gram of nitrogen was applied in the form of sodium nitrate and in dissolved leather, both the straw and grain contain a higher percentage of nitrogen than when but three-tenths gram was applied; the yield of straw and especially of grain was proportionately less, however, when the larger quantity was added. It is evident that a portion at least of the nitrogen taken up had not been turned to account in the production of organic substance.

EXPERIMENT B.

In this experiment, made in 1895, a soil was selected even poorer in nitrogen than the one used in Experiment A. The

object of this experiment was to see if more leather—than the amount used in the previous experiment—could not be added to the same quantity of stronger sulphuric acid, and thus secure a fertilizer testing higher in nitrogen. Dissolved leather II was therefore prepared by adding sixty grams of fine ground sole leather to 120 grams of 60° B. sulphuric acid heated to 200° F. The black pasty mass was allowed to stand for one-half hour, and was then dried off with calcium carbonate.

Dissolved leather III was prepared by adding 100 grams fine sole leather to 120 grams of 60° B. sulphuric acid. This amount of leather and acid—nearly one to one—furnished a very thick paste. It was dried off with calcium carbonate. The two dissolved leathers contained the following percentages of nitrogen:

	Per cent.
Dissolved leather II	1.13
" " III	1.75

The composition of the sulphate of potash and magnesia and of the double superphosphate, as well as the quantity applied, was the same as in Experiment A for 1895. The method of filling the pots, planting, and harvesting, was also similar.

Tables III and IV express the results in a similar way as Tables I and II. The sodium nitrate pots produced rather less grain than those to which the dissolved leather was applied. This tendency was noted in Experiment A. The three-tenths gram of nitrogen in the form of dissolved leather II produced about nine-tenths as much dry matter as did a like quantity of nitrogen in the form of sodium nitrate. The percentage of nitrogen in the dissolved leather plants is noticeably less however. The six-tenths gram of nitrogen from both the sodium nitrate and dissolved leather did not produce proportionately as much dry matter as did three-tenths gram, thus indicating that the plant was not able to work it all over into organic matter.

The three-tenths gram of nitrogen from dissolved leather III produced rather more dry matter than did the same quantity of nitrogen from sodium nitrate. The percentage of nitrogen in the straw and grain was decidedly less however.

Table IV shows that the oat plants were able to get but sixty-five per cent. as much nitrogen from dissolved leather II and III

TABLE III.

	Quantity of nitrogen to each pot.	Dry matter yielded by single pots.		Average dry matter from two pots.		Gain in dry matter over soil nitrogen pots on basis of 0.3 grams nitrogen applied.		If gain in dry matter with sodium nitrate = 100, then other sources of nitrogen equal to:		Average Straw and Grain.
	Grams.	Straw. Grams.	Grain. Grams.	Straw. Grams.	Grain. Grams.	Straw. Grams.	Grain. Grams.	Straw. Grams.	Grain. Grams.	Grams.
Soil nitrogen	0.000	3.146	0.296	3.706	0.426	....	....	....	....	....
	0.000	4.266	0.557							
Sodium nitrate	0.300	12.104	3.057	12.695	3.807	8.989	3.381	100.00	100.00	100.00
	0.300	13.286	4.557							
Dissolved leather II...	0.300	11.122	4.417	11.122	4.117	7.416	3.691	82.5	109.00	89.8
	0.300									
Sodium nitrate	0.600	15.628	3.014	16.836	3.742	6.565	1.658	73.00	49.00	60.5
	0.600	18.044	4.470							
Dissolved leather II...	0.600	18.582	6.646	17.344	6.612	6.819	3.093	75.9	91.5	80.1
	0.600	16.107	6.578							
Dissolved leather III..	0.300	12.976	4.879	12.664	4.880	8.958	4.454	99.6	131.8	108.4
	0.300	12.352	4.882							

TABLE IV.

	Quantity of nitrogen to each pot.	Nitrogen yielded in total dry matter.	Nitrogen in 100 grams of dry matter.		For every 100 parts of nitrogen applied, there has been returned in straw as grain:	When sodium nitrate=100 other sources of nitrogen equal to:	For every gram of nitrogen applied there has been produced in dry matter:			For every 100 parts straw there has been produced in grain:
	Grams.	Grams.	Straw. Grams.	Grain. Grams.			Straw. Grams.	Grain. Grams.	Straw and Grain. Grams.	
Soil nitrogen	0.000	0.041	0.82	2.52	.....	....	....	....	....	11.5
Sodium nitrate	0.300	0.235	0.96	2.98	65.00	100.00	29.96	11.27	41.23	37.6
Dissolved leather II...	0.300	0.165	0.66	2.06	41.00	63.1	24.72	13.30	38.02	49.8
Sodium nitrate	0.600	0.412	1.78	3.01	62.00	95.4	21.90	5.53	27.43	25.3
Dissolved leather II ..	0.600	0.305	0.83	2.43	42.00	65.0	22.73	10.31	33.04	45.4
Dissolved leather III..	0.300	0.170	0.60	1.92	43.00	66.0	29.86	14.85	44.71	49.7

as from sodium nitrate. This confirms the results obtained in Experiment A for 1894. The oat plants secured twice as much nitrogen from the six-tenths gram as from the three-tenth gram in case of the sodium nitrate and both dissolved leathers, showing that the nitrogen was fully utilized.

GENERAL CONCLUSIONS.

The above experiments, part of which cover two years, make clear that dissolved leather, when properly prepared, yields as available a source of nitrogen as the average animal matter used for fertilizing purposes.

The quantity of nitrogen obtained by the plants from sodium nitrate being represented as equal to 100, the quantity obtained from dissolved leather during two years has been shown to be equal to 70.[1]

In this connection I beg leave to add the results of the availability of the various sources of nitrogen as determined by P. Wagner. Sodium nitrate is taken as 100 in value, and the value of other sources are compared with it.

Sodium nitrate	100
Ammonium sulphate	90
Dried blood, ground horn, and green plants	70
Ground bone, ground fish, and flesh	60
Stable manure	45
Ground wool	30
Ground leather	20

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THE PROTEIDS OF THE POTATO.[2]

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SO far as we can ascertain, the only investigations of the proteids obtained from the tubers of the potato have been made by Rüling,[3] Ritthausen,[4] Zöller,[5] and Vines.[6]

[1] The Connecticut Experiment Station, in its recently issued report for 1895, confirmed these results.

[2] From the report of the Connecticut Agricultural Experiment Station for 1895. Communicated by the authors.

[3] *Ann. Chem.* (Liebig), 58, 306.

[4] Pflüger's Archiv, 21, 101.

[5] *Ber. d. chem. Ges.*, 13, 1064.

[6] *Journal of Physiology*, 3, 93.