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Fertilizer Experiments With Sugar Beets

By

A. H. DANIELSON

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Fertilizer Experiments With Sugar Beets

BY A. H. DANIELSON *

These experiments extended over three years, 1903, '04 and '05, and were to test the effect of fertilizers on the yield and quality of sugar beets and determine the effect from the different fertilizers used, under field conditions, and incidentally a number of other questions.

The tests of 1903-04 were on plats of one-tenth of an acre on the College farm, the plats used in the two years not being the same. The test of 1903 was of the nature of a preliminary test. A cooperative test with the Department of Agriculture formed one of the series of tests by the Bureau of Chemistry on the "Influence of Environment upon the Composition of the Sugar Beet." In 1905 corresponding tests were made with plats of six-tenths of an acre each in a field being raised under field conditions.

With the change in conditions brought by the cultivation of sugar beets the necessity which is being felt for artificial fertilizers, the exhaustion of the supply of sheep manure which has been the common source for a number of years, and the consequent realization of the future, if not the present, importance of fertilization, led to the tests here given.

Further and additional tests are desirable but it is believed the results are of value as they are.

Fertilizer Experiments in 1903.—The experiments conducted this season were in the nature of a preliminary test. The most complete series of plats was carried out on Field F, although there it is defective for an ideal series in that potash was left out except in the complete fertilizer as the experiment was planned too late to secure potash fertilizers.

The main object of this trial on Field F was to determine the effect of an excessive quantity of stable manure on beets, that of a fairly large application, and a small quantity with nitrate of soda, as compared with nitrate and phosphates alone and complete fertilizers. The result of the application of these materials in 1903 on this field is of more than ordinary interest because the after or residual effects of those applied in 1903 were tested for the two succeeding years. This data is given later.

*Assistant Agriculturist 1900-Jan. 1, 1903.

Crop History of Field F Used 1903.—The soil during 1901 1902 was very lumpy and especially in 1901 in poor physical co tion because being plowed when very wet in 1900. The crops b ning with 1900 have been as follows:

1900—Plats of grain, sugar beets and corn.

1901—Sugar beets, 10 tons per acre.

1902—Grains 1413 pounds per acre, as follows, wheat 756 pou oats 271, barley 256, rye 62 and emmer 68 pounds.

1903—Sugar beets, 23.5 tons per acre, with manure and fe zer.

1904—Sugar beets 17.6 tons per acre.

1905—Sugar beets 16.0 tons per acre.

The chemical analysis of the soil and subsoil from this fie 1903 and 1904, is given in Bulletins 95 and 96, U. S. Bureau Chemi The field was plowed the preceding fall (1902), disc harrowed next spring on April 17. The fertilizer was applied on April 18, c plats except 1, 2 and 3, by distribution with a drill on top of the and thorough harrowing with a drag harrow the long way of the p The cow manure on Plats 1, 2 and 3 was applied April 11-17, pl under, harrowed on the 18th; the nitrate applied to Plat 3, when manure had been plowed under, and harrowed into the soil toge with the balance of the fertilizers on April 18. The seed was plant rows twenty inches apart at the rate of fifteen pounds per ac April 21; Plats 9 and 10 on April 27. The seed used was the va known as Kleinwanzlebener grown in the State of Washington.

The cow manure used was without straw or litter, almost f being only three and a half months old. It was the intention t well rotted sheep manure, but none was available at the time. bone meal was odorless, probably from steamed bones, or "prairie bones." The two complete fertilizers consisting of nitr estimated as ammonia, 3.5—4.5%; available phosphoric acid 8-1 potash 6-8%, were made up especially for this experiment by a f izer firm.

The beets were hoed and thinned from May 30 to June 4. June 6-10 a heavy rain set in amounting to two inches in de Only two irrigations were given, on July 3 and 23. On Augus Plat 10, with the excessive quantity of manure had the rankest gr of leaves. The three manured plats were more thrifty than thos tilized. Plat 5, bone meal and nitrate, show better growth than 4, with nitrate alone. Plat 8, with Basic slag appears better the bone meal plat. Plat 10, complete fertilizer, looks better the adjacent plat with less nitrogen from nitrates.

On November 7th the samples for analyses were taken. The vesting and weighing began on November 14 with Plat No. 1, and not finished until November 25. Plats 1 to 6, inclusive, were harv November 14-16, although Plat 6 was not weighed until Nove 24. Plats 7-10, inclusive, were harvested and weighed Nove 23-25. Where the piles of beets could not be hauled and weigh once they were covered with a layer of beet leaves and soil in ord

nt freezing, and this also checked loss in weight from evapora-
r drying out.

n applying the fertilizer and manure a strip two feet wide was
etween each two plats to which nothing was applied. The rows
ts which grew on these strips were measured and harvested
ately, weighed and counted. It will be seen that the average
t per beet in these rows between the plats is 0.7 of a pound less
he average weight given in Table 11 of the samples taken for analy-
While the estimated average tonnage per acre of these rejected
s only 1.5 tons less than the actual average yields of all the plats.
no fertilizer was applied to the rows between the plats, practi-
a great deal would be worked within reach of the roots from that
d on both sides. From this data it is fair to assume, that in
of great care in selecting the samples the average weight of the
chosen for analysis to represent the sugar content and purity
h plat is about one-third larger than the average weight per beet
the beets harvested. Nearly the same proportion is found be-
the twelve beets analyzed from Plat 6 and 366 beets dug for
me plat to note changes in maturing, reported in Table 17.
ver, the samples for analysis were selected in exactly the same
o that the results were strictly comparable between themselves.
particular part of the data obtained shows that the 120 beets
lly selected to represent the whole field, were actually one
arger than 1,902 beets actually harvested.

TABLE 5.

FERTILIZERS ON FIELD F, 1903—ONE-TENTH ACRE PLATS

KIND OF FERTILIZER (Per Acre)	Cost of Fertilizer per acre	Yield of Clean Beets per acre	Sugar in Beets	Purity Coefficient	Amt. Rec'v'd pr. acre for Beets	Amt. Rec'd less cost of Fertilizer
		Tons	Per Ct.			
Cow Manure.....60 tons	$45.00	24.11	13.1	81.0	$120.55	$ 75.55
Cow Manure..... 30 tons	22.50	25.10	14.3	82.8	125.50	103.00
Cow Manure.....15 tons Nitrate of Soda.....150 pounds	15.75	25.25	14.4	84.2	126.25	110.50
Nitrate of Soda.....150 pounds	4.50	25.67	13.3	83.3	128.3	123.85
Nitrate of Soda.....150 pounds Raw Bone Meal.....200 pounds	7.10	25.61	14.9	83.8	128.0	120.95
No Fertilizer	.....	21.46	15.1	85.0	107.3	107.30
Raw Bone Meal.....200 pounds	2.60	21.72	15.1	87.3	108.6	106.00
Thomas Phosphate.....400 pounds (or Basic Slag)	6.00	22.60	15.1	84.4	113.0	107.00
Complete Fertilizer.....	10.00	20.63	16.1	87.9	103.1	93.15
Nitrate of Soda.....50 pounds Dried Blood .....75 pounds Acid Bone Meal.....250 pounds Sulphate of Potash.....50 pounds Carbonate of Potash.....75 pounds (from Tobacco Ashes)						
Complete Fertilizer.....	10.00	22.35	14.6	84.4	111.7	101.75
Nitrate of Soda.....100 pounds Dried Blood.....25 pounds Acid Bone Meal.....250 pounds Sulphate of Potash.....75 pounds Carbonate of Potash.....50 pounds (from Tobacco Ashes)						
Average.....	.....	23.45	14.6	84.4	117.2	.....

Some interesting results are shown from the expertments on Field F, in 1903, which can be a little better understood on account of the data obtained from the same plats for the next two years.

The difference in effect of the fertilizers and manures is greater than could reasonably be expected, when it is seen that this soil without manure or fertilizer was able to produce about 21.5 tons per acre.

TABLE 6.

DATA IN REGARD TO NEGLECTED ROWS BETWEEN FERTILIZED PLATS—FIELD F, 1903, FROM A MEAN OF 154 BEETS PER ROW

Row Between Plats Number	Estimated Yield Per Acre Tons	Average Weight Per Beets Pounds	Average Space Between Beets in Row Inches
0–1	24.14	1.67	11.3
1–2	25.85	1.51	9.6
2–3	20.50	1.16	9.0
3–4	27.01	1.59	9.6
4–5	22.58	1.32	9.6
5–6	19.16	1.20	10.3
6–7	19.24	1.30	11.0
7–8	20.52	1.13	8.9
8–9	20.06	1.37	10.4
9–10	20.06	1.39	10.6
Averages	21.91	1.36	10.0

The effect of the excessive quantity of manure, Plat 1, was not as injurious to the quality of the beet as might be expected, only about two per cent less sugar and four points less in purity than the plats yielding less. The yield was also about a ton less than the other manured plats, while the beets although larger were of poorer shape.

The phosphoric acid used alone from bone meal and Basic slag, Plats 7 and 8, had very little if any effect on increasing the yield, although the Basic slag produced a ton more beets than the bone meal, which alone had practically no effect on the yield of beets. Used with nitrate of soda on Plat 5, we may presume it would be equally ineffective. The highest yields of any of the fertilizers was from the Plats 4 and 5 where nitrate of soda was used at the rate of 150 pounds per acre. This is a little more than the result from the plat of thirty tons manure or 4.1 tons more than the unfertilized plat. The nitrate of soda and fifteen tons of manure together, could not evidently increase the yield as 25.6 tons per acre was the limit of which this soil seemed capable.

Although the highest yield was from Plat 4, with nitrate alone, this is probably a trifle more than should be due to the nitrate, as a study of residual effects during the next two years seems to show that the soil conditions of this plat were slightly more favorable than those adjacent.

The results from the two complete fertilizers, Plats 9 and 10, are disappointing in yield. The highest yield was obtained from the one containing the larger quantity of nitrate of soda, 100 pounds, produ

cing 1.7 tons more than the other with fifty pounds. It is very likely that the increase in Plat 10 was not entirely due to the larger quantity of nitrate in the complete fertilizer, as the yields from these plats during the next two years seem to show that the soil on Plat 10 had greater producing capacity than the adjacent No. 9. When it is considered that the two complete fertilizers contained nearly the same amount of nitrogen, the less nitrate in one being balanced by more dry blood in the other, and that the average yield of the two plats is the same as the unfertilized plat, it is hard to ascribe any effect at all upon the yield due to the nitrogen in the complete fertilizers. The curious fact appears here in the complete fertilizers, as well as during the tests of the next two years, that phosphoric acid and potach in the presence of nitrogen on our soils seems to neutralize to a great extent the beneficial effect of the nitrogen upon the yield when compared with the results from nitrogen used alone.

In the results from this experiment the highest sugar content and purity are associated with the lowest yields, the highest being found in the lowest yielding plat, No. 9, with the complete fertilizer, and the lowest sugar content in the highest yielding plat, No. 4, with nitrate of soda, with the exception of the one with excessive quantity of manure.

In this test also the phosphate form the bone meal, although ineffective upon the yield when used alone, with nitrate it seemed to a great extent to prevent the lowering of sugar content and purity, the nitrate and bone meal plat giving the highest yield of sugar per acre of any plat in the series, while the one with the excessive quantity of manure produced the least, the unfertilized plat giving the next lowest amount of sugar per acre.

FERTILIZER EXPERIMENTS IN 1904

On Field C3.—The fertilizer experiment for this season was planned to include a series of all three elements, used in about the proportion which experiments elsewhere had proven to be fair average quantities. As nitrate bone meal had shown only negative results the previous year, acid treated phosphate rock or superphosphate as the source of the phosphoric acid was used, and this season it was planned to give a more thorough test with nitrate of soda which had given the best results in 1903. The same, as well as twice the amounts used in 1903 were given in one application at the time of planting, and also in three applications. High grade sulphate of potash was employed as a source of the potash. Refuse lime cake from the sugar factory was also used on one plat. This is the refuse lime which has been used in refining and purifying the juices in sugar making, and contains a small proportion of phosphoric acid and nitrogen, large quantities of which are used as a fertilizer on the sugar beet soils of Germany and it was thought it might have some effect upon our soils. Such, however, proved not to be the case. The thoroughly air dried lime cake was

scattered over the land at the rate of 4.7 tons per acre and thoroughly harrowed into the soil three times before seeding.

The following analysis of lime cake is given in the Beet Sugar Gazette of July 20, 1903:

	Per Cent
Potash	.05
Phosphoric Acid	2.08
Nitrogen	.26
Lime Carbonate	54.61
Oxide of Lime	13.32

The fertilizers were applied at the time of seeding with the seed, by the use of an attachment to the regular seed drill. The fertilizer falls in such a way that a slight layer of soil falls over the seed and the fertilizer over this layer and a thicker layer of soil covers fertilizer and all. It will be seen that in this way a large amount of concentrated chemicals is applied directly with the seed. The beet seed has germinated quicker and stronger when applied with the fertilizer in this way than when no fertilizer was used. As all the materials were easily soluble examination showed that it had been practically absorbed by the moist soil in a few days before germination of the seed was fairly in progress. The method of applying fertilizers with a drill was changed also because it was realized that should fertilizers be found desirable to use to any extent on sugar beets, the cheapest method of practice would be the most desirable.

It was planned to apply the materials used singly or in mixture in the following quantities:

Nitrate of soda 150 pounds, and the same quantity in three applications of fifty pounds each, one portion applied at time of seeding, and the other two portions at different periods later in the season.

Nitrate of soda 300 pounds, and in the same quantity in portions of 100 pounds each in three applications, as before.

Acid phosphate rock, 300 pounds.

Sulphate of potash, 100 pounds.

However, it was found that the three materials differed in texture and consistency, no two mixtures being alike, it was impossible to regulate the drill attachment to sow the exact quantity intended.

Soil History of Field C3, 1904.—The most practical benefit from the results of an experiment of this kind would doubtless be derived if carried out on soil which had been more or less exhausted by previous beet crops, but none such was available.

The land finally chosen was some which had borne alternate crops of grain and corn for the previous five years without manure, and had not been in alfalfa for at least ten years, as far as known. On such a soil it would be natural to expect that the nitrogen would be nearly exhausted, and the high return from the nitrogen in the fertilizer is not surprising.

The previous crops on Field C3 for ten years, as far as known, have been as follows: 1893 red clover; 1894 barley, rye and oats; 1895 corn; 1899 grain; 1900 corn; 1901 emmer; 1902 Kaffir corn; 1903 wheat; 1904 beets, fertilizer experiment.

The land was plowed in the spring and prepared for planting in the usual way. The seed used was Kleinwanzlebener grown in the State of Washington, planted at the rate of thirty pounds per acre, with the fertilizer applied April 27. A heavy rain occurred from April 30 to May 3, amounting to four inches, and had the result of forming a thick crust on the surface, making it very difficult for the germinating seed to break through. This was assisted somewhat by the use of a roller, but the final result was that although uniform the stand of beets was rather thin, with a distance of 12 to 15 inches between beets after thinning.

On Plats 8 and 9 the first top dressing of nitrate of soda was applied June 11, and the second July 29. All the plats which had received nitrate of soda alone or in combination were in better growing condition, July 15, with greener, larger leaves than those without it, except Plat 11, where the action of nitrate was only slightly apparent. This thrifty appearance was in about the proportion in which the nitrate had been used. This difference in appearance continued until harvest.

The beets were weeded by hand and cultivated and irrigated three times, samples for analysis taken on October 15, and plats harvested October 15, 16 and 17.

TABLE 9.

FERTILIZERS ON FIELD C3, 1904—ONE-TENTH ACRE PLATS—PLANTED APRIL 27

Plat Number	Total Am't of Fertilizer used per acre	KIND OF FERTILIZER Per Acre	Cost of Fertilizer per acre	Yield of Clean Beets per acre	Sugar in Beets	Purity Coefficient	Am't Received per acre for Beets	Am't Received Less Cost of Fertilizer
	Pounds	Pounds		Tons	per ct.			
1	240	Nitrate of Soda....144 Sulphate of Potash.... 96	$ 7.34	14.75	16.8	89.1	$73.75	$66.41
2	128	Sulphate of Potash....128	4.03	12.60	15.3	86.6	63.00	58.97
3	435	Sulphate of Potash....109 Acid Phosphate Rock....326	6.69	12.77	15.3	88.8	63.85	57.16
4	330	Acid Phosphate Rock....330	3.30	11.53	14.6	86.2	57.65	54.35
5	495	Acid Phosphate Rock....330 Nitrate of Soda....165	8.25	14.94	14.3	89.0	74.70	66.45
6	.....	No Fertilizer.....	.....	10.98	15.6	87.9	54.90	54.90
7	140	Nitrate of Soda....140	4.20	13.16	15.2	88.0	65 80	61.60
8	187	Nitrate of Soda....97 June 11....45 June 29....45	5.60	13.92	15.3	86.1	69.60	64.00
9	431	Nitrate of Soda....111 June 11....160 July 29....160	12.93	15.30	15.4	88.8	76.50	63.57
10	480	Nitrate of Soda....4 0 (a) June 11....160	17.40	15.30	14.8	85.5	76.90	59.50
11	578	Complete Fertilizer.... Nitrate of Soda....158 Acid Phosphate Rock....315 Sulphate of Potash....195	11.20	11.72	16.4	89.0	58.60	47.40
12	9360	Lime Cake....4.68 tons (air dried)	.....	9.73	15.8	88.1	48.65	.....
		Average.....	.....	13 06	15.4	87.8	65.30	.....

(a) Applied by mistake.

Comments on Results of Fertilizer Experiment 1904.—The most important points as indicated by the results of this experiment are the higher yields wherever nitrate was used either alone or in combination except where used in the "complete" fertilizer. There is nothing to indicate that there was any benefit from applying the same amount of nitrate in several doses. In the case of Plat 8 the higher yield over Plat 7 is undoubtedly due to the larger amount used in the three applications. In the case of Plat 10 which accidentally received a top dressing where it was not intended, the larger total quantity used did not increase the yield, although it lowered the sugar content and purity slightly. There is also a little evidence that sulphate of potash had some effect and that it at least did a little more than pay for itself, while the acid phosphate had very little if any effect upon the yield. It is also seen that the effect of nitrate was not influenced by potash or the acid rock when used separately with nitrate, but when all three were used together in the complete fertilizer, the result is negative, as was found in the experiment of the previous year. Looking at this result in one way there seems to be a neutralization of the action of nitrate in presence of potash and phosphate together.

The limit of the most profitable application of nitrate of soda with the soil and conditions of this experiment appears to be about 175 pounds. Taking into consideration all the plats where the increased yield seems due to a reasonable quantity of nitrate a moderate estimate would be that on land capable of producing 11 to 15 tons without fertilizers, the profit can be increased from $9 to $10 per acre by the use of said amount of nitrate of soda. The larger quantities, even the extreme amount of 580 pounds, although giving a profit above the cost of application, did not give returns in proportion to the amounts used, after deducting the cost.

The results of the lime cake applied was ineffective if it did not actually decrease the yield. In this experiment there is no indication to show that phosphoric acid used with nitrate of soda, increased the sugar content of the beet over nitrate alone, as in the experiment of the previous year. If anything, this effect, is due to potash with nitrate, in this experiment.

The sugar content and purity is generally uniform and satisfactory, being the highest on Plat 1 with nitrate of soda and potash, and Plat 11 with all the elements. In this experiment, perhaps for the reason that the average yield, thirteen tons, of all the plats is below the average of this district, there is no connection between higher yields and high sugar content and purity, or vice versa.

FERTILIZER EXPERIMENTS IN 1905

The experiment this season with fertilizers of sugar beets was conducted on a large area, and in cooperation with a farmer growing beets exclusively and under his control as regards cultural methods. The experiment can therefore be considered as under the conditions of ordinary farm work, and none of the refinements possible in small plat work was attempted, with the exception of the accurate appli-

cation of the fertilizers and weighing the beets from each plat separately. The weights and tare were taken at the factory in exactly the same manner and in the regular way all beets are received.

A sufficient number of average beets were taken from each load as delivered, or about six per load, to make a total sample of eighteen beets per plat for analysis as to sugar content and purity. The only reason for the analysis and taking samples in this manner was to determine whether any of the beets as delivered would be unsatisfactory. No other comparisons can be made as to the analysis, as there was several weeks difference in the time of harvesting the various plats and also in exposure to the drying influences of the air, the beets having been dug and placed in piles.

The difference between results from the various fertilizers, when the experiment is conducted in this manner must be rather great to be of value, but when large should be convincing. The results, however, only corroborate those trials made in previous years on smaller areas.

The location of this tract is about one quarter of a mile from the grounds where the previous tests reported were made, and apparently of the same character, if anything more productive. The field where the experiment was conducted was ideal in location and slope being very uniform of surface, smooth, with just sufficient grade to facilitate uniform flow of water in irrigation. The plats were made long in proportion to width, a point of great value in comparative tests, each plat occupying twelve rows, twenty inches apart, or nearly twenty feet wide to 1240 feet or nearly a quarter of a mile long, and therefore nearly sixty-three times as long as wide. The average area of the plats was six-tenths acre to each plat.

The experiment is of considerable value for the reason that this soil had already previously produced three successive crops of sugar beets, the experimental crop being the fourth, and without manure on the portion where the plats were located, except on a small strip running across all the plats at one end, where manure had been used for two years. This test is of particular value because fertilizers, if effective, are needed when the soil is becoming exhausted by successive crops of sugar beets. The returns from unfertilized and unmanured plats are disappointing for the purpose of the experiment by too high yields, for the various elements in the fertilizers do not have an opportunity to demonstrate what each element can really do on exhausted beet soil. That the soil was not exhausted is well seen. It also shows the staying qualities of our Colorado soil with a presumably exhausing crop.

The land had previously been in alfalfa for a number of years, with a crop of wheat succeeding the alfalfa, and before the first crop of beets as follows: 1900 alfalfa, of several years standing; 1901 wheat; 1902 sugar beets, 1903 sugar beets; 1904 sugar beets, 17.5 tons per acre; 1905 sugar beets, as reported in this experiment. The average yield on twenty five acres, including the fertilizer experiment, and balance of manured land in 1905, was nearly 16.5 tons per acre.

The fertilizer used and the quantities of each intended for application, alone and in combination are as follows:

Nitrate of soda, 200 pounds and 400 pounds.

Sulfate of potash (high grade) 100 pounds.

Acid bone meal, 200 pounds.

Acid bone meal was stated to have been made up in proportions as follows:

1800 pounds steamed bone meal.

750 pounds 50 Beaume sulphuric acid.

All the fertilizers were passed through a one-fourth inch sieve and well mixed in the proportion desired. The land was plowed in the spring and prepared for planting in the usual way, which was done on May 1-2, sowing the fertilizer along with the seed by an attachment to the beet drill, approximating very closely the total amount desired per acre of each ingredient. The seed used at the rate is sixteen pounds per acre was the German imported Kleinwanzlebener supplied by the sugar factory. As before noted the seed germiniated quicker and stronger on the fertilized than the unfertilized plats. Even the large quantity of 426 pounds per acre sodium nitrate with the seed had no injurious effect upon the germination. The beets were hoed and thinned once, and cultivated and irrigated three times each. The two plats of nitrate of soda alone, especially the larger quantity, were distinguished by thrifty growth throughout the season, the larger quantity having apparently twice as large tops and much larger sized beets than any other plat.

The harvest began October 24 and was finished November 29. Two-thirds of Plat 11 was weighed October 26, and the balance November 13, for the reason that a snowstorm set in just as harvesting began, followed by a freeze, the temperature falling to eight below zero. The fields were protected by the fallen snow and no injury resulted only that harvesting was delayed ten days. When digging could be resumed, another freeze being feared, all the beets were plowed out as fast as possible, progressing from Plat 11 towards Plat 1. They were placed in piles and covered with tops. It thus occurred that Plats 4 to 1 inclusive were weighed without much loss or shrinkage, and Plats 5 to 10 inclusive, probably suffered considerable loss through shrinkage, some of the beets being exposed over three weeks before being weighed. These facts must be considered in comparing results.

Comments on Result of Fertilizer Experiment in 1905.—The most striking items of consideration in the experiment of 1905 are that the unfertilized plats gave the lowest yields in the series, and on an average those containing nitrogen the highest. Some allowance must be made for the fact that Plats 1 to 3 gave nearly as high yields as those containing nitrate, as all the conditions were in favor of Plats 1 to 3 showing greater weights, being harvested and weighed from two to three weeks later than the balance of the plats which were being exposed to shrinkage during that time.

There are also two discrepancies in the fact that while phosphate

and potash, all conditions being considered, gave very small increase when used singly, the two used together produced higher yield than either alone; the other being the small yield of Plat 7 where the smaller quantity of nitrate was used alone, when compared with other plats containing nitrate.

TABLE 10

FERTILIZERS ON THE ANDREWS FARM SOUTH OF LAKE PARK, 1905—SIX-TENTH ACRE PLAT

Plat Number	KIND OF FERTILIZER Per Acre	Cost of Fertilizer per acre	Yield of Clean Beets per acre	Sugar in Beets	Purity Coefficient	Amount Received per acre for Beets	Amount Received Less Cost of Fertilizer	Factory Tare was	Av. Wt. of 18 Sample Beets per Beet
	Pounds		Tons	perct				perct	ozs.
1	Acid Bone Meal....193	$ 1.93	15.61	15.2	87.8	$78.05	$76.12	10.	31
2	Acid Bone Meal....192 Sulphate of Potash....96	5.58	16.81	15.4	88.0	84.05	78.47	10.	28
3	Sulphate of Potash....142	4.47	15.14	15.0	86.2	75.70	71.23	10.8	29
4	Sulphate of Potash....100 Nitrate of Soda....199	9.12	17.89	14.2	85.8	89.45	80.33	12.0	34
5	Nitrate of Soda....426	12.78	18.60	14.6	85.7	93.00	80.22	9.	26
6	No Fertilizer....	.....	14.76	14.0	87.2	73.80	73.80	14.	24
7	Nitrate of Soda....212	6.36	16.16	15.0	85.3	80.80	74.44	10.	29
8	Nitrate of Soda....214 Acid Bone Meal....215	9.28	15.93	15.2	85.3	79.65	70.37	15.	24
9	Complete Fertilizer.... Acid Bone Meal....187 Nitrate of Soda....187 Sulphate of Potash....94	11.06	14.71	15.0	86.3	73.55	62.49	15.	26
10	No Fertilizer....	.....	12.18	15.2	84.9	60.90	60.90	13.2	18
11	No Fertilizer....	.....	13.63	15.2	88.7	68.15	68.15	8.6	30
	Average....	.....	15.58	14.9	86.5	$77.90	.....	.....	27

The effect of complete fertilizer although more favorable than in the previous two years, indicates the same general tendency, in the apparent neutralization of the action of nitrate of soda in the presence of potash and phosphoric acid together, as derived from the fertilizer; the yield being about the same as the unfertilized plat, two plats removed, less than the nitrate and acid bone meal plat adjoining, but much more than the unfertilized plats adjoining on the other side.

All the results seem to indicate that the increase in yields was chiefly due to nitrate of soda used alone or with the other elements, and that there was no additional net profit from the application of over double the quantity of the smaller amounts.

Taking all the factors into consideration a careful comparison of Plats 5 and 6 and conservative estimates seem to indicate that on soil capable of producing from 13.5 to 14.5 tons per acre without fertilization, about 200 pounds of nitrate of soda caused a gross increase of $20 per acre with beets at $5 per ton, or a net increase over the cost of fertilizer of about $6 to $7 per acre.

In appearance the size and shape of the beets grown in this ex-

periment were excellent, the average weight per beet of the 200 samples being twenty-seven ounces, or 1.7 pounds.

The sugar content and purity of the beets analyzed were in general satisfactory, and about as high as the average of the district this season (1905). Both the sugar content and yield of sugar beets were somewhat below the average of previous seasons in Northern Colorado and elsewhere, largely due to the late spring and copious rains in the earlier part of the growing season, which caused a more luxuriant growth of tops or leaves than usual, but which proved rather unfavorable to the production of a proportionate increase in weight of the sugar beet crop.

RESIDUAL OR AFTER EFFECTS OF MANURES AND FERTILIZERS

Experiments on Field F, 1903-4-5.—From the plats on Field F, to which manures and fertilizers were applied in 1903, the data of which is given in Table 5, the beets were harvested separately and other data secured in the following two years in order to determine the residual or after effects of the manures and fertilizers used. Some very interesting facts were disclosed, that data being given in Table 11.

TABLE 11.

RESIDUAL ON AFTER EFFECTS OF MANURE AND FERTILIZERS APPLIED ONE YEAR ONLY ON FIELD F, 1903

Plat Number	KIND OF FERTILIZER Applied in 1903 only	Yield in Tons per acre				Quality of Beets								
						1903				1904				1905
		1903	1904	1905	Average 3 Years	Sugar in Beet	Purity Coeff.	Av. Weight per Beet	Per Cent Tops	Sugar in Beet	Purity Coeff.	Av. Weight per Beet	Per Cent Tops	Not Determined
	Amt. per acre—Tons					per ct.		lbs		p. c.		lbs		
1	Cow Manure.....60	24.11	19.68	15.82	19.87	13.1	81.0	2.44	72	15.2	84.3	2.13	41.4	....
2	Cow Manure.....30	25.10	20.31	14.57	19.99	14.3	82.8	2.00	47	15.8	86.0	1.18	42.3	....
3	Cow Manure.....15 Pounds Nitrate of Soda.....150	25.25	19.13	16.94	20.44	14.4	84.2	1.51	51	15 9	86.3	1.33	28.1	....
4	Nitrate of Soda.....1.0	25.67	19.28	17.78	20.91	13.3	83.3	2.56	46	14.9	87.4	1 18	37.1	....
5	Nitrate of Soda.....150 Raw Bone Meal.....200	25.61	17.98	16.10	19.89	14.9	83.8	2.03	47	15.2	86.5	1.13	39.7	....
6	No Fertilizer.....	21.46	16.94	17.07	18.49	15.1	85.0	2.04	33	15.8	87.6	1.04	40.8	....
7	Raw Bone Meal.....200	21.72	16.17	16.14	18.01	15.1	87.3	2 23	31	16.0	87.5	1.22	38.1	....
8	Thomas Phosphate....400 (or Basic Slag)	22.60	15.55	14.61	17.59	15.1	84.4	2.13	37	14.4	87.3	1.32	39.6	....
9	Complete Fertilizer..... Nitrate of Soda.....50 Dried Blood.....75 Acid Bone Meal.....250 Sulphate of Potash..50 Carbonate of Potash.75 (from Tobacco Ashes)	20.63	14.57	15.18	16.79	16.1	87.9	1.59	42	15.2	87.1	1.23	42.6	....
10	Complete Fertilizer..... Nitrate of Soda.....100 Dried Blood.....25 Acid Bone Meal.....250 Sulphate of Potash..50 Carbonate of Potash.75 (from Tobacco Ashes)	22.3.	16.49	15.99	18.28	14.6	84.4	2 12	45	15.0	84.3	1.08	40.8	....
	Averages.....	23.4.	17.59	16.02	19.01	14.6	84.4	2.06	45.3	15.4	86.3	1.23	39.0	....

Some facts as to the effects of cow manure will be especially interesting. A positive residual effect is noted the second year. The difference between the manured plats and the other plats which had received more of less ineffective fertilizers was even more largely in favor of the manure the second year, than the year of its application. For instance the difference between the averages of the three manured Plats 1, 2 and 3, and the unfertilized or ineffectively fertilized Plats 6, 7 and 8 in 1903, the year of application, was 3.2 tons and the second year 3.5 tons, in favor of the manure.

In the third year after application the residual effects entirely disappeared in the case of the cow manure, the difference in fact between the plats just given, being a small fraction or 0.16 tons against the manure.

While there are interesting after effects the second year of the application of manure, the yields are not proportionate to the amounts used in the previous year, being only slightly more with sixty and thirty tons than with fifteen tons.

Thus if the cost and the expense of the application are deducted, there is little if any net profit from the increased yield of sugar beets in the year of the application, of a moderate or large amount of manures, but that the returns are found in the succeeding year therefore clear profit except for the expense of topping and delivery of the extra quantity.

It is also seen that large to excessive quantities of manure used are sheer waste, and that returns as good if not better are obtained with medium amounts.

In the case of any residual effect from nitrate of soda where it was used in any quantity alone or with potash or phosphoric acid, leaving out its use in Plat 3, with manure, which obscures its effects, in Plats 4, 5 and 10, on the face of the returns, there actually appears to be beneficial after effects, although this is probably a coincidence due to some inherent difference in the quality of soil on these plats for it would be almost absurd to suppose that an easily soluable, and in the soil, unstable compound like nitrate, would remain until a second season.

Comparison of the sugar content of the beets of the three manured plats and the unmanured Plats 6, 7 and 8, previously mentioned, shows a difference between the averages the first year of 1.7 per cent, and the second year only 0.3 per cent. The difference in yields between the two was greater the second year than the first, but of course with a lower average yield all around. The purity coefficient shows a difference of 2.5 and 1.9 when compared in the same way. The point of the whole matter is that in the second year the sugar content and purity of the beets from the manured plats, with higher yield, was just about as good as that of the unmanured plats with lower yield, which was not the case the first year the manure was applied.

Acknowledgements for furnishing the raw materials for these experiments are due Mr. Wm. S. Myers, of the Nitrate of Soda Propo-

ganda; Armour Fertilizer Works, Omaha; German Kali Works, New York; and Colorado Packing and Provision Company, Denver.

Relation of Size and Amount of Fresh Beet Tops to Quality of Sugar Beets.—In the samples taken for analysis in all the fertilizer experiments of 1903 and 1904, the beets were carefully cleaned, weighed and the tops consisting of crown and leaves, removed in the approved manner, and beets weighed again. Considerable data was then secured of value, especially as regards the amount of beet tops, in relation to the size of the beet, quality and yield and fertilizers used. The detailed data is given in Tables 12 and 13, and the summary in Table 14.

TABLE 12.

DATA AS TO THE RELATION OF SIZE AND AMOUNT OF FRESH TOPS TO QUALITY OF SUGAR BEETS, 1903

	Plat Number	Number of Beets in Sample	Average Weight Per Beet in Pounds	Per Cent Tops	Sugar in Beet	Purity Co-efficient
	2	12	2.17	40	15.6	85.6
	3	12	3.13	55	15.0	83.6
FIELD C	4	12	2.25	43	15.1	84.4
Total Area Sampled	5	12	2.46	58	14.8	83.2
0.6 Acres	6	12	2.33	52	15.5	85.4
	7	12	2.33	46	15.7	86.4
Averages		72	2.45	49.2	15.3	84.7
Field F.—1 Acre	1	12	2.44	72	13.1	81.0
	2	12	2.00	47	14.3	82.8
	3	12	1.51	51	14.4	84.2
	4	12	2.56	46	13.3	83.3
	5	12	2.03	47	14.9	83.8
	6	12	2.04	33	15.1	85.0
	7	12	2.23	31	15.1	87.3
	8	12	2.13	37	15.1	84.4
	9	12	1.59	42	16.1	87.9
	10	12	2.12	45	14.6	84.4
Averages		120	2.06	45.3	14.6	84.4
Field E.—0.2 Acres	1	12	1.67	41	15.1	87.3
	2	12	1.88	44	15.3	85.9
Averages		24	1.78	42.5	15.2	86.6

There does not appear to be any definite relation between these various factors, although there are some indications that the larger beets with large percentage of tops have somewhat lower sugar content and purity. The opposite is true in a few cases.

Beet tops have come to be of considerable value, being pastured by cattle and sheep with success. The value of the beet tops thus pastured has a market price at present of from $1.00 to $3.00 an acre and sometimes more. As to palatibility it has been found that sheep

ill readily leave alfalfa hay for beet tops, but that the crowns are ot readily eaten. Cattle, however, will eat the crowns clean.

TABLE 13.

ATA AS TO THE RELATION OF SIZE AND AMOUNT OF FRESH BEET TOPS TO QUALITY OF SUGAR BEETS, 1904

	Plat Number	Number of Beets in Sample	Average Weight Per Beet Pounds	Per Cent Tops	Sugar in Beet	Purity Co-efficient
eld C.3-Area 1.2 Acres	1	12	1.28	39.0	16.8	89.1
	2	12	1.12	42.5	15.3	86.6
	3	12	1.29	41.3	15.3	88.8
	4	12	1.42	41.8	14.6	86.2
	5	12	1.70	41.1	14.3	89.0
	6	12	1.44	43.4	15.6	87.9
	7	12	1.58	37.0	15.2	88.0
	8	12	2.24	46.9	15.3	86.1
	9	12	1.93	51.9	15.4	88.8
	10	12	2.66	51.1	14.8	85.5
	11	12	1.28	36.6	16.4	89.0
	12	12	1.23	41.5	15.8	88.1
Averages		144	1.60	43.8	15.4	87.8
eld F.—Area 1 Acre	1	12	2.13	41.4	15.2	84.3
	2	12	1.18	42.3	15.8	85.0
	3	12	1.33	28.1	15.9	86.3
	4	12	1.18	37.1	14.9	87.4
	5	12	1.13	39.7	16.2	86.5
	6	12	1.04	40.8	15.8	87.6
	7	12	1.22	38.1	16.0	87.5
	8	12	1.32	39.6	14.4	87.3
	9	12	1.23	42.6	15.2	87.1
	10	12	1.08	40.8	15.0	84.3
Averages		120	1.23	39.0	15.4	86.3
eld B.—Area 1 Acre	W	12	1.92	54.0	14.6	89.0
	N	13	1.57	53.2	13.9	86.8
Averages		26	1.75	53.6	14.3	87.9

TABLE 14.

SUMMARY OF AMOUNTS OF BEET TOPS AND QUALITY OF SUGAR BEETS

	FIELD	Area Acres	Number of Determinations	Total Number of Beets Analyzed	Average Weight Per Beet Pounds	Yield of Beets Per Acre Tons	Green, Fresh Tops			Sugar in Beet	Purity Coefficient
							Per Acre Tons	Pounds Per Ton of Beets	Per Cent of Tops		
03	C1	0.6	6	73	2.45	27	13.28	984	49.2	15.3	84.9
03	F	1.0	10	120	2.06	23	9.96	906	45.3	14.6	84.6
03	E	0.2	2	24	1.78	20	8.50	850	42.5	15.2	86.6
04	C3	1.2	12	144	1.60	13	5.70	876	43.8	15.4	87.8
04	F	1.0	10	120	1.23	18	7.02	780	39.0	15.4	86.3
04	B	1.0	2	25	1.75	22	11.80	1073	53.6	14.3	87.9

The average weight per beet of all samples analyzed is found to be 1.76 pounds, and the average fresh green tops 44.2, from 42 determinations of 12 samples each. The average yield of 19.8 tons will thus produce 8.75 tons of fresh green tops.

The loss of weight in thorough air drying or curing has not been determined, but it is believed that one-eighth of the green weight would be a reasonable estimate. Calculating the green tops at 44.2 per cent of the net weight of beets the relation of tons per acre and tops would be as follows:

Beets per acre tons	Fresh green tops per acre tons	Estimated Tons air dry weight per acre
20	8.84	1.10
15	6.63	.83
10	4.41	.55

TABLE 15.

YIELD OF FRESH BEET TOPS BY GATHERING AND WEIGHING ALL THE TOPS AFTER HARVESTING BEETS

FIELD F. 1904—ONE TENTH ACRE PLATS,

Plat No.	Yield of Beets Per Acre Tons	Tops Per Acre Tons	Tops Per Ton of Beets Pounds	Per Cent Tops
1	19.57	10.65	1088	54.4
2	20.23	5.85	578	28.9
3	19.03	5.88	618	30.9
4	19.20	4.64	484	24.2
5	17.90	5.11	571	28.5

NOTE—Tops on Plats 2 to 5 were allowed to remain on the ground from three to five days after topping.

The data given in Table 15 was obtained by gathering and weighing all the tops of a known area, with yield of beets, from one to five days after topping. A considerable per cent was lost in this way, being impossible to gather. There was also considerable loss in weight from evaporation in those last gathered. It will be seen that the percent of tops from Plat 1 with an excessive amount of leaves by actually gathering all the tops, is greater than the figure obtained from the sample beets, the sample showing forty-one per cent and the gathered leaves fifty-one per cent of the beets harvested.

Data in Regard to Maturing Period of Sugar Beets.—The data given in Tables 16, 17 and 18 was obtained in cooperative work with the Bureau of Chemistry, Department of Agriculture, Washington, D. C. All the analyses of 1902 were made by the Bureau, and that of other years in the laboratory of the local sugar factory by the courtesy of Mr. Booraem.

The samples were taken every week beginning with the last week in September and continuing until the beets were all harvested or until prevented by freezing of the ground. The manner of taking the samples consisted of digging all the beets from a fifty foot row, each successive digging adjoining the other, counting, cleaning, par-

tially topping, weighing the beets and analyzing twenty-five average specimens. In the samples shipped to Washington the sugar content and purity is based on the first weight of the beets, thus allowing for evaporation and shrinkage. The weight per beet and estimated yield per acre is a little higher than the actual for the reason that all the crowns were not removed in trimming. The difference is also seen in the actual yield of each plat when harvested, being somewhat less than the tonnage from the samples.

TABLE 16.

SAMPLES FROM FIELD D, 1902

Date of Sampling	Mean Weight of Topped Beets in		Estim'd Yield Per Acre Tons	Sugar in Beet Per Cent	Purity Co-efficient
	Ounces	Pounds			
September 17	19.6	1.23	20.2	12.9	80.5
September 26	24.5	1.53	26.0	12.1	78.3
October 3	25.0	1.56	25.7	10.5	74.0
October 10	27.0	1.69	27.3	9.8	66.6
October 17	27.4	1.71	24.2	13.2	81.4
October 24	22.9	1.43	25.5	14.3	83.8
October 31	27.0	1.69	31.8	13.9	80.4
November 7	22.0	1.38	24.4	14.7	87.0
November 14	23.4	1.46	26.6	14.4	84.3
November 21	26.9	1.68	28.6	13.7	78.0
November 28	26.1	1.63	26.7	13.6	79.1
December 5	27.2	1.70	25.7	13.0	79.7
Average	24.9	1.56	26.0	13.0	79.4

Sept. 12, killing frost. Sept. 20-21, 6 inches rain.
Yield of whole Plat when harvested was 25.4 tons.
Average space between beets 9.3 inches but with 9% of the beets missing the majority were 8.56 inches apart.

TABLE 17.

SAMPLES FROM FIELDS F AND E, 1903

Field F. Plat 6

Date of Sampling	Mean Weight of Topped Beets		Est. Yield Per Acre Tons	Sugar in Beet Per Cent	Purity Coeffi.
	Ounces	Pound			
September 26	19.8	1.24	20.4	14.8	82.0
October 6	22.9	1.43	19.7	16.7	83.6
October 10	23.5	1.47	24.2	15.7	81.1
October 17	17.4	1.09	21.8	18.5	81.6
October 26	25.1	1.57	22.2	16.2	85.3
November 3	25.9	1.62	23.8	15.9	81.7
Average	22.4	1.40	22.0	16.3	82.5

Yield of whole plat when harvested 21.5 tons. Spacing 8.2 inches.
Nov. 7. Sugar in beet 15.1. Purity 85.0.

(TABLE 17, CONTINUED.)

On Field E					
September 26	1.47	23.5	20.7	13.8	79.1
October 6	1.40	22.4	21.2	15.3	81.5
October 10	1.53	24.5	19.6	15.6	79.7
October 17	1.45	23.2	22.8	14.4	80.4
October 26	1.25	20.0	21.7	16.2	87.3
November 3	1.67	26.7	25.3	15.1	77.6
Average	1.46	23.4	21.9	15.1	80.9

Yield of whole plat when harvested 19.8 tons. Spacing 10.5 inches. Nov. 7. Sugar 15.1% Purity 87.3.

TABLE 18.

SAMPLES FROM FIELD F, PLAT 6, 1904

Date of Sampling	Mean Weight of Topped Beets in		Est. Yield Per Acre Tons	Sugar in Beet Per Cent	Purity Coeffi.
	Ounces	Pounds			
September 22	16.2	1.01	17.6	15.4	83.5
October 12	18.1	1.13	18.8	16.2	88.4
October 15	16.0	1.00	16.7	16.7	87.9
October 20*	16.6	1.04	.....	15.8	87.6
October 22	16.8	1.05	18.2	16.4	89.1
Average	16.7	1.05	17.8	16.1	87.3

* Average of 12 samples.
Yield of whole plot when harvested 16.9 tons.
Average space between beets 8.9 inches.

The data secured offers some interesting evidence as to the progress of ripening in the sugar beet, the most striking being the comparatively slight increase in sugar content and purity, or yield, after the last week in September.

The data for 1902 is especially interesting, showing the effects of the early freeze of September 12 of that year, which destroyed the leaves. This was followed in a week by a heavy rain amounting to six inches, causing the beets to put forth an entirely new set of leaves. The effect of the renewed growth is plainly seen in the great decrease of sugar content and purity reaching the minimum twenty days after the rain on October 10.

PRACTICAL SUGGESTIONS AS TO THE USE OF FERTILIZERS ON SUGAR BEETS IN COLORADO

The Kind to Use.—Nitrogen is the only element which has proven of practical value giving decided profit over the cost of application. Its use in the form of nitrate of soda with potash and phosphoric acid together in "complete" fertilizers, has not been as effective in increasing the yield, as nitrate used alone. On the contrary there are decided indications that the effect of the nitrate has been largely neutralized when so used, although the quality of the beet has been good.

Although nitrogen from nitrate of soda has been effective in increasing the yield, no sufficient comparaive tests have been made as to the effect of nitrogen from the less soluble organic fertilizers such as dried blood, tankage, or cottonseed meal. It is probable that the same amount of nitrogen from those sources would be less effective although this is offset to some extent by the fact that their cost is less and more could be used.

WHERE AND HOW TO USE NITRATE OF SODA

The Soil.—It is probable that nitrate of soda could not be used profitably on soil which is in condition to produce close to the maximum yields of the particular locality without manures or fertilizers. It also must be understood that fertilizers, no matter how effective, will never take the place of proper preparation of the soil and care of the crop. It is absolutely necessary that the soil be in good physical condition in order to enable plants to use the plant food therein, or added to it.

For our conditions the most satisfactory practice would probably be to use nitrate of soda along with a light coating of manure. The maximum effect of both would be secured in this way.

Depending upon conditions it will require a yield of sugar beets of from six to ten tons or more to cover cost of production. No land is likely to be planted to sugar beets which will not produce that much. The high average yields are in the neighborhood of twenty tons per acre. The profitable application of nitrogenous fertilizers then will probably be on soils which, without manure or fertilizers, will range in yield from ten to fifteen tons per acre.

ANY INJURIOUS EFFECTS OF NITRATE

The Beet.—Our Colorado soils and climate have shown an ability to produce a high quality of beet under good average conditions. The quality of the beet is also largely controlled by the proper irrigation. Manures are chiefly valuable for the large amount of nitrogen they contain, besides the humus, and it has been shown that even excessive quantities of manure will lower the sugar content only from one to two per cent, and purity two to four per cent. Excessive quantities of nitrate of soda will do the same, but neither is recommended. The presence of more active nitrogen than the plants can use lessens the yield.

It might be reasonable that as active nitrogen acts as a stimulant it will induce the plants to absorb so much of the other available elements in the increased crop, that there would be none left over for the next crop. Our soils contain ample supplies of both potash and phosphoric acid held in reserve, which are constantly being liberated or made available in the soil, and of lime we have something to spare.

It is claimed that nitrate of soda has a tendency to make the soil more compact or less easily workable. Even if such is the case, and it has not been observed in our experiments, it is difficult to see how

this could take place with the frequent cultivation and hoeings sugar beets are bound to receive. Granting that there is some truth in both claims advanced, the soil would have ample time to recover during the rotation with other crops, which is imperative for best all round results. It is well known that crops do not use the same amounts of food elements, and while growing they give an opportunity for those elements to accumulate which are best used by a succeeding different crop.

How Much to Use.—The limit of profitable application of nitrate of soda on land which is naturally capable of producing from ten to eighteen tons per acre is probably from 150 to 300 pounds per acre. The larger quantity gives more profit on less productive land than on more highly productive soil. This is largely due to the fact that there seems to be a certain limit to the productiveness of a soil, due more or less to its present physical state of condition, no matter how much available plant food is present.

In one case 580 pounds per acre applied to land which produced 11.5 tons without fertilization, gave a small profit, but not nearly as much in proportion as was derived from smaller amounts applied on the same land. In another case 300 pounds applied to a soil which produced twenty-eight tons per acre without fertilization increased the yield, while 100 pounds applied to the same soil, was without effect.

Larger quantities can sometime be applied, depending on the soil, with an increase in yield it is true, but the margin between the returns from the increased yield and the cost of the fertilizer, will not be as great as when smaller quantities are used on the same soil. A point will be reached where cost of the fertilizer applied will equal the increase in yield. And in the case of nitrate of soda an amount much beyond that point, will decrease the yield even below the normal productiveness of the soil.

WHEN AND HOW USED

Details of Application.—Cost.—No matter in what manner the nitrate is applied it must be prepared by breaking up the lumps and coarse particles and passed through a one-fourth or one-third inch sieve or screen. It can then be broadcasted before the last harrowing before seeding, which is probably the best method, or sown with the combined seeder and fertilizer drill with the seed. The broadcasting can be done with an endgate seeder or fertilizer sower, or with drills made for the purpose. When sowing the nitrate at the same time as the seed by the use of a fertilizer attachment to an ordinary beet seed drill, the writer has found that unless the material is kept agitated it is likely to "bridge" similar to beet seed, and stop feeding.

As to the cost of application it has been found that by the use of an endgate sower, two men with a team and wagon are able to cover from forty to fifty acres per day at an expense of $6.00 per day, or at forty acres per day, fifteen cents per acre. The screening of the nitrate and resacking should not exceed five cents per hundred.

With a fertilizer drill distributor with one man and a team, half that number of acres could probably be covered. When drilled with the seed the only duty would be to keep the hoppers or cans full and prevent 'bridging.'

SUMMARY AND CONCLUSIONS

(1) Our Colorado soils generally contain ample supplies of potash and phosphoric acid, and an excess of lime.

(2) The native soil is generally somewhat deficient in nitrogen and humus, both are supplied by growing leguminous plants like alfalfa, peas, vetches, or beans, or from sheep and stable manures. Nitrogen, but not humus, can be supplied by commercial fertilizers.

(3) Nitrogen in the form of nitrate of soda is the only element which has had any decided effect in increasing the yield of sugar beets over the cost of application.

(4) Potash and phosphoric acid, from sulphate of potash, raw bone meal, Basic slag, dissolved or acid bone, and phosfate rock, used alone or together, have very little or no effect upon the yield.

(5) There are strong indications that potash and phosphoric acid from fertilizers, largely, if not entirely, neutralize the effect of nitrate of soda upon the yield of sugar beets, although the quality of the beet is good.

(6) No difference in results were obtained between applying the nitrate of soda at the time of planting, or in part at the time of planting, and in two applications during the growing season.

(7) The net profit from reasonable quantities of manure, if cost of manure and its application is considerable, is mainly obtained in the after effects in the succeeding year, while there appears to be no residual effect the third year after application.

(8) An excess of nitrogen from manures or fertilizers over what the plant needs lowers the yield and the quality of the sugar beet some though not much.

(9) Reasonable quantities of manure were fully as effective as large or excessive quantities.

(10) Refuse lime cake from the sugar factories as a fertilizer on sugar beets was of no benefit.

11() Soluble fertilizers applied to the seed favored strong germination.

(12) Very high sugar content and purity seem to go with low yields, although there are exceptions.

(13) Fertilizers will not take the place of good preparation or cultivation of the soil, or good care of the crop. The soil must be in good physical condition to make the best use of fertilizers applied.

(14) The tops were about forty-four per cent of the weight of the clean beets. A fifteen ton crop of sugar beets will produce 6.6 tons fresh, green tops. It is estimated that this will air-dry to one-eighth the original weight or 0.8 of a ton.