Effect of Nitrogen Supply on the Sucrose Percentage of Sugar Beets

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The primary objective in sugar beet culture is the production of a maximum quantity of sugar per acre. This necessitates abundant yields of roots with high sucrose content. A good supply of soil nitrogen is essential to high yields but excessive nitrogen may lower the percentage of sucrose. Thus, in order to give guidance to producers in the fertilization of commercial fields the agronomist must understand the relationship between nitrogen fertilization and the metabolism of the sugar beets, particularly in respect to sucrose formation.

In a rotation experiment in the sugar beet growing district of Southern Alberta, Canada, the sucrose content of sugar beets grown in a legume rotation has been consistently lower than that of sugar beets in a comparable non-legume rotation although the yields have been about equal. In the same area fall application of manure to sugar beet land has not depressed the sucrose content of the subsequent crop of beets nor have spring applications of nitrogenous chemical fertilizer.

This investigation was initiated to provide information on the relationship of the nitrogen in the soil to the sucrose content of beets grown thereon. The experiments were so planned as to provide a physiological explanation of the reduction in sucrose percentage due to the inclusion of alfalfa in a sugar beet rotation. A microbiological assay for glutamic acid was conducted on sugar beets grown under different nitrogen levels in the greenhouse since this amino acid has been shown to be useful as an index of nitrogen metabolism in the beet.

Several investigators (1) (2) (3) (5)[2] have reported results of studies on sucrose content of sugar beets as related to nitrogen content. However, no references were found to work wherein sugar beets showing a significant difference in sucrose percentage due to variation in nitrogen fertilization were analyzed for all fodder constituents (dry matter, protein, ash, fat, fibre, nitrogen free extract). Such analyses were made in this study on sugar beets from a legume and a comparable non-legume rotation and also on beets fertilized August 2, 1950, with 300 pounds of ammonium nitrate per acre as compared to unfertilized beets.

Experimental Procedure

These investigations were conducted under irrigation at the Dominion Experimental Station, Lethbridge, Alberta, Canada. The climate of the area may be compared roughly with that of northeastern Colorado and has a mean annual temperature of 41° F., annual precipitation of 16 inches, and an average growing season of 141 days. The soil is a chestnut loam of high natural fertility and excellent structure.

The two rotations studied were: 1—an eight-year cycle of beets, beets, wheat, wheat and alfalfa, alfalfa, alfalfa, alfalfa, wheat; and 2—a four-year sequence of beets, beets, wheat, barley. These two rotations were laid down in duplicate in 1929. The plots of the two rotations were contiguous and the individual plot size was 19.8 feet x 93.2 feet. Each plot was divided

[1] Agronomist, Dominion Experiment Station, Lethbridge, Alberta, Canada.
[2] Numbers in parentheses refer to literature cited.

into quarters by bisecting in two directions perpendicular to the borders and applications of manure[3] and phosphate fertilizer[4], singly and in combination, were assigned to three of the quarters. The fourth quarter was preserved as a check. These fertility treatments have been perpetuated on the original locations in each plot.

In addition to the usual yields and sucrose percentages of the beets produced, data have been obtained on the concentration of available nitrates in the soil of the various plots during the growing season of 1949. Petioles of the sugar beet plants were analyzed for nitrate nitrogen and total nitrogen in 1949 and 1950 respectively. In all cases duplicate determinations were made on duplicate plots.

The roots from the legume and non-legume rotations were analyzed for all fodder constituents as well as for sucrose. Similar determinations were made on roots from the manured and/or fertilized quarters of all plots in the two rotations to which had been applied the supplementary 300 pounds per acre of ammonium nitrate August 2, 1950. Correlation coefficients were calculated between sucrose percentage and the other plant constituents.

A supplementary test on nitrogen nutrition of beet roots and its effect on sucrose content was conducted in the greenhouse during the winter of 1950-51. In order to provide identical material for each of four nitrogen levels, 20 large roots from a commercial field were lifted on October 15, trimmed of all green material and quartered. Previous success in sectioning beet roots to provide additional units in a breeding program prompted this procedure. One quarter of each beet was assigned to each of four nitrogen series; thus the experiment constituted 20 replications (provided by the 20 original roots) of four treatments (the nitrogen levels). Each root section was planted in sterile sand contained in a one-gallon stone crock.

A balanced nutrient solution described by Weidemann and Cook, 1947, was used as a basic solution. The amount of nitrogen in this solution was designated as "normal" and this "normal" concentration was doubled, halved and omitted entirely to provide three additional nitrogen levels. The pots in all series received exactly the same amount of nutrient during the experimental period with the exception of the variation in nitrogen. The root sections in the "normal" nitrogen series each received 250 milligrams of nitrogen and those in the other series received 500, 125 and 0 milligrams respectively. After 14 weeks of growth the root sections were harvested and analyzed for sucrose, total nitrogen, dry matter, ash, fat and fibre. In addition a microbiological assay for glutamic acid was conducted on each root section. This assay procedure included extraction of the glutamic acid from the root with 99 percent isopropanol followed by addition of the extract to tubes containing a suitable basal medium inoculated with *Lactobacillus Arabinosus* 17-5. After incubation, the growth of the organisms were measured by titration of the acid produced. All determinations were made in triplicate.

[3] Thirty tons of manure per acre were applied in the fall previous to the first beet crop to the appropriate plots in legume rotation and 20 tons to those in the non-legume rotation.
[4] One hundred pounds of triplesuperphosphate were applied in both rotations at the time of seeding the beets.

Root Yields

The 10-year averages (1941-50) for yields and sucrose percentages are reported since the length of the record smooths out annual variations and provides a better sampling of the different growing seasons than would a two-year average covering the experimental years, 1949 and 1950. Under similar fertilizer treatments the yields were nearly equal in the two rotations. Acre yields on plots treated with manure and phosphate fertilizer or manure only were about 20 tons, whereas plots which received only phosphate fertilizer produced approximately 13 tons. The check plots yielded seven and three tons per acre respectively on the non-legume and legume rotations.

Sucrose Percentages

The sucrose percentages of beets grown under the three fertilizer treatments (manure and phosphate fertilizer, singly and in combination) were very similar within each rotation. Thus no deleterious effect on sucrose percentage could be ascribed to the manure application. However, the 10-year mean sucrose content of beets on all plots, excepting the checks, in the legume rotation was 16.2 percent as compared to a mean of 17.4 percent in the non-legume rotation. The difference was statistically significant at the one percent point.

Nitrogen Content of Soils and Petioles

Available soil nitrates were higher in the plots of the legume rotation than in those of the non-legume and a similar relationship occurred in the manured plots compared with the unmanured within either rotation. The superiority of the plots in the legume rotation in this respect was particularly marked in the latter part of the growing season.

The content of nitrate nitrogen and total nitrogen of sugar beet petioles from the legume rotation was generally higher than the comparable values from petioles grown in the rotation which did not include alfalfa.

Analyses of Roots

The analyses for the various fodder constituents supplied information on the relative composition of beets of equal size which showed significant differences in sucrose percentage. The roots from the two rotations provided ideal analytical material for this study since their yields and field populations were about equal and the beets from the legume rotation were consistently inferior in sucrose percentage. Where 300 pounds of ammonium nitrate were added to a section of some of the plots in both rotations the yield was not affected but the sucrose percentage was reduced significantly. The analyses of these roots contrasted to analyses of comparable roots which did not receive any additional fertilizer indicated the same trends of differences as noted in comparison of the legume and non-legume rotations. These data are summarized in Table 1.

In a supplementary test 300 pounds of ammonium nitrate were added to sugar beets June 28. An increase of 25 percent in yield over unfertilized beets was recorded but the sucrose percentage was not affected. These results do not agree with those set forth in Table 1 and it is proposed that the

difference is due to the time of application of the fertilizer. Nitrogen fertilizer added June 28 brought about increased leaf growth and yield, whereas the same amount of fertilizer applied August 2 was too late to affect the yield, but apparently some of the nitrogen was taken up by the roots and its effect was expressed in a lower sucrose percentage.

Table 1.—Chemical Constituents of Sugar Beet Roots Grown in a Legume and a Non-legume Rotation and Also With and Without a Late Application of Ammonium Nitrate at Lethbridge, Alberta. 1950.

Treatment	Plant constituents in percent of green weight						
	Water	Sucrose	Total N.	Ash	Fat	Fibre	N-free extract[1]
Legume vs. non-legume rotation							
Legume	78.93[2]	16.12	.158	.660	.097	1.13	2.07
Non-legume	77.54	17.36	.137	.624	.082	1.24	2.30
Min. sig. difference	0.95	0.58	.016	.078	. .	.....	. .
Fertilized on August 2 vs. no fertilizer							
300 lb. NH_4NO_3 per acre	79.38	15.64	.167	.717	.080	1.233	1.91
No fertilizer	78.10	16.42	.147	.693	.092	1.188	2.59
Min. sig. difference	0.67	0.60	.016	.020	.....	.....	.....

[1] The nitrogen free extracts were derived by subtraction after having converted the total nitrogen to protein by the factor 6.25.
[2] Each statistic is the mean of at least 50 individual determinations.

It has been mentioned previously that an application of manure did not decrease the percentage of sucrose. Since it was possible to apply nitrogen in the form of chemical fertilizer early in the season and not affect the sucrose content of beets (thus paralleling the experience with manure), and furthermore since the same amount of chemical fertilizer applied late in the season reduced the sucrose content (thus paralleling the experience with nitrogen supplied by the legume), circumstantial evidence would indicate that the legume provides an excess of nitrogen late in the growing season.

Relationships Between Various Plant Constituents

Sucrose percentage showed a highly significant positive correlation with percentage of dry matter. This is understandable since sucrose makes up a major portion of the dry matter. No significant correlations were apparent between sucrose and ash, fat or fibre.

A highly significant, negative correlation was evident between the percentages of sucrose and total nitrogen. In addition, a partial correlation coefficient was calculated between sucrose percentage and total nitrogen percentage holding dry matter percentage constant. This rvalue amounted to —0.505, which proved to be highly significant. This significant correlation between sucrose and nitrogen percentages independent of the moisture content of the roots is an important relationship.

It is interpreted to mean that the deleterious influence of nitrogen on sucrose percentage does not occur merely as a result of a "high-nitrogen" plant being more succulent, thus containing less sucrose and other dry matter. It seems more probable that a plant which is high in nitrogen may

be relatively low in sucrose content because more than a usual amount of the stored carbohydrates in the plant was used to provide energy for the reduction of the excessive nitrates which were taken up.

Greenhouse Experiment

The sections of the quartered roots survived well and produced new leaf growth although some individuals were damaged by disease and others by insects. The mean sucrose percentages (from 14 replications) of the roots in the four nitrogen series were as follows: 1. no nitrogen—10.94; 2. half-normal nitrogen—11.46; 3. normal nitrogen 10.81; and 4. twice-normal nitrogen—8.86; the mean dry matter percentage of the same four series were 15.41, 15.11, 14.37, and 13.02 respectively.

In sucrose percentage the twice-normal series was significantly lower than all others, thus these data leave little doubt as to the deleterious effect of the high nitrogen level on the sucrose content of these roots. There were only very small differences among the percentages of total nitrogen in the root sections of the four series. The values for total nitrogen in all series were considerably lower than the comparable values in the field roots discussed previously. Statistical analyses of the analytical data failed to show any significant differences among the four nitrogen series in respect to ash, fat or fibre.

The microbiological assay for glutamic acid proceeded very successfully in the laboratory. A standard growth curve for *L. Arabinosus* 17-5 was prepared by adding 0.015 milligram increments of standard L-glutamic acid to inoculated tubes containing a basal medium which included all the necessary nutrients (except glutamic acid) for the growth of the organism. The amount of growth in each tube was determined by titration of the acid produced. In assaying the root sections the amount of acid produced by organisms growing on the extract from the root section was referred to the standard curve and from this the glutamic acid concentration was read.

The concentration of glutamic acid in the root sections was generally less than 100 milligrams per 1,000 grams of root weight. This is somewhat lower than usual. Apparently the conditions of this experiment were not conducive to glutamic acid elaboration.

Although this microbiological assay added limited information concerning the nitrogen nutrition of sugar beets, it did advance knowledge of the experimental technique and this can now be extended with confidence to field material in southern Alberta.

Summary

1. A legume rotation has consistently produced beets of equal yield but lower sucrose percentage than a comparable non-legume rotation, and this investigation has sought to learn the reasons for this. Analyses have been made to determine the difference in chemical composition of sugar beets of the same weight which display significant differences in sucrose percentage.

2. **Soil analyses** have shown the legume rotation to be higher than the non-legume in soil nitrates particularly in the latter part of the growing season.

3. Accordingly the beets of the legume rotation have both a higher nitrate and a higher total nitrogen content as indicated by petiole tests.

4. Three hundred pounds of ammonium nitrate applied to beets on August 2 reduced the average sucrose percentage from 16.42 to 15.64, but the same amount of fertilizer applied on June 28 did not affect the sucrose content. The yields were increased in the latter case but not in the former.

5. Beets from the legume rotation were higher in nitrogen, water and ash but of equal size to beets from the non-legume rotation. A similar relationship occurred between the beets which received 300 pounds of ammonium nitrate August 2, and those which were unfertilized. This indicates that the time of the season at which the nitrogen is available has a very important bearing on the sucrose percentage.

6. There are complex relationships among nitrogen supply, vegetative growth, photosynthetic capacity and sucrose percentage. If supplementary nitrogen is applied early in the season it may stimulate vegetative growth and leaf area, thus increasing the capacity to manufacture carbohydrates and even though more sugar is used for energy to reduce the excess nitrates the net percentage of sucrose may not be lowered.

7. A significant partial correlation coefficient of $r = -0.505$ between sucrose percentage and nitrogen content with dry matter percentage held constant indicates that there is an inverse relationship between sucrose and nitrogen content independent of moisture relationships.

8. In a supplementary test in the greenhouse beet roots were quartered to provide identical genetic material and the respective quarters, which were grown in sterile sand for 14 weeks under four series, ascending in amount of nitrogen applied, displayed mean sucrose percentages of 15.41, 15.11, 14.37 and 13.02.

9. A microbiological assay for glutamic acid was conducted on the roots grown in the greenhouse. The procedure, as outlined in the text, worked very satisfactorily and excellent agreement was obtained among the triplicate standard tubes and also the triplicate assay tubes. The values for glutamic acid were low in all cases and it appears that environmental or cultural effects made conditions unfavorable for glutamic acid elaboration.

10. The expected relationship of low nitrogen content accompanied by low glutamic acid content was confirmed.

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Fertilizer Side-Dressing Studies on Sugar Beets in Southern Alberta

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Introduction

Sugar beets have been grown in southern Alberta for twenty-six years. Since the early 1930's growers have been applying 100 pounds of 11-48-0 fertilizer per acre, at the time of seeding. This has become a common practice and is virtually a requirement of the grower's contract. For this reason it is expected that sugar beet farms are quite well supplied with phosphorus. Some barnyard manure has been applied to beet fields since the inception of the industry, but of recent years growers have become more aware of its benefits to the extent that at the present time about twenty percent of the beet land receives manure during the rotation cycle.

Table 1.—Mean Yields in Tons per Acre of Sugar Beets Grown Under Different Fertilizer Side-Dressing Experiments in Southern Alberta in Three Successive Tests During 1948, 1949, and 1950.

1948					
Amount and kind of fertilizer used for side-dressing	Check No side-dressing		100 lb. 11-48-0	250 lb. 16-20-0	200 lb. 21-0-0
Mean Yield	13.86		13.59	13.97	14.04
1949					
Amount and kind of fertilizer used for side-dressing	Check No side-dressing		140 lb. 21-0-0	270 lb. 21-0-0	540 lb. 21-0-0
Mean Yield	11.96		11.80	12.19	12.70
M. S. D. = 0.41					
1950					
Amount and kind of fertilizer used for side-dressing	Check No side-dressing	230 lb. 21-0-0	460 lb. 21-0-0	150 lb. 33-0-0	300 lb. 33-0-0
Mean Yield	12.32	13.57	14.00	13.66	14.34
M. S. D. = 0.92					

Outline of Experiments

In 1948, 1949 and 1950, in cooperation with the Canadian Sugar Factories Ltd., and the Consolidated Mining and Smelting Co. Ltd., experiments were undertaken by the Dominion Experimental Station, Lethbridge, to study the effect o£ applying additional fertilizer as a side-dressing to sugar beets. The effect on the percentage of sucrose as well as the yield of beets has been considered. Suitable fields of sugar beets were selected on different farms, widely scattered throughout the beet growing districts of southern Alberta. Tests were conducted on a total of *S3* farms during the three years.

The side-dressing machine provided for four rows of beets to be side-dressed at one time with both sides of each row receiving fertilizer at a depth of three inches. The side-dressing was done soon after thinning and before the first irrigation.

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The 1948 experiment was designed to compare the response o£ sugar beets to nitrogen and phosphorus fertilizers, and consisted of four treatments. The side-dressing fertilizer applications were:

1. 100 pounds of 11-48-0 per acre
2. 250 pounds of 16-20-0 per acre
3. 200 pounds of 21-0-0 per acre
4. Check (no fertilizer used for side-dressing, but all check plots received the usual 100 pounds of 11-48-0 at the time of seeding)

As in the two following years the treatments were in duplicate on each farm. A treatment plot consisted of eight, twelve or sixteen rows throughout the full length of the farmer's field. During all seasons the plots were sampled, usually during the first week of October, to provide material for sucrose and purity determinations, and all plots were harvested during the

Table 2.—Variance Table Showing Analysis of Yields of Sugar Beets Grown Under Different Fertilizer Side-Dressing Treatments in Southern Alberta in Three Successive Tests during 1948, 1949, and 1950.

	1948		1949		1950	
Variance due to	D.F.	Mean Square	D.F.	Mean Square	D.F.	Mean Square
Treatments	3	1.64	3	4.10**	4	14.07**
Reps. in General	8	0.93	13	1.38*	12	10.44**
Farms	7	59.59**	12	24.04**	11	111.84**
Treatments x farms	21	0.90	36	0.61	44	1.11
Error	24	0.64	39	0.55	48	2.51
Total	63		103		119	

first two weeks of October. The yields were calculated from the total weight of beets grown on the plots, since the production from each plot was delivered separately to the sugar company's receiving station.

The data for the three years are summarized in Tables 1, 2 and 3. The 1950 results from individual farms are shown in Tables 4 and 5.

In 1949, phosphorus fertilizer was not used for side-dressing and the primary objective of the experiment was to determine the most practical amount of nitrogen fertilizer to be used as a side-dressing. The treatments were as follows:

1. 140 pounds of 21-0-0 per acre
2. 270 pounds of 21-0-0 per acre
3. 540 pounds of 21-0-0 per acre
4. Check (no fertilizer used for side-dressing)

An additional purpose of the 1950 experiment was to compare the effectiveness of the two common nitrogenous fertilizers, ammonium sulphate (21-0-0) and ammonium nitrate (33-0-0). The following treatments were used:

1. 230 pounds of 21-0-0 per acre
2. 460 pounds of 21-0-0 per acre
3. 150 pounds of 33-0-0 per acre
4. 300 pounds of 33-0-0 per acre
5. Check (no fertilizer used for side-dressing)

Discussion

Tons of Beets per **Acre**

The yield results of the 1948 experiment did not show wide differences and statistical analysis did not reveal significant differences between the treatments. However, a careful study during the growing season and of the resulting data indicated that, on some farms where response was most pronounced, the yield increases and improvement in growth due to nitrogen application were too large and too consistent to be ignored. Several farms showed no response, and there was no suggestion of an increase in yield due to phosphorus application on any farm, but two-thirds of the farms

Table 3.—Mean Percentages of Sucrose of Sugar Beets Grown Under Different Fertilizer Side-Dressing Treatments in Southern Alberta in Three Successive Tests During 1948, 1949, and 1950.

	1948				
Amount and kind of fertilizer used for side-dressing	Check No side-dressing		100 lb. 11-48-0	250 lb. 16-20-0	200 lb. 21-0-0
Mean sucrose percentage	17.6[1]		17.1	17.2	17.1
	1949				
Amount and kind of fertilizer used for side-dressing	Check No side-dressing		140 lb. 21-0-0	270 lb. 21-0-0	540 lb. 21-0-0
Mean sucrose percentage	15.8		15.7	15.7	15.7
	1950				
Amount and kind of fertilizer used for side-dressing	Check No side-dressing	230 lb. 21-0-0	160 lb. 21-0-0	150 lb. 33-0-0	300 lb. 33-0-0
Mean sucrose percentage	17.6	17.3	17.0	17.2	17.3

[1] There were no significant differences between the percentages of sucrose resulting from the various treatments in any of the three years.

showed decided increases from the nitrogen fertilizer. For these reasons it was decided the following year that different rates of nitrogen fertilizer alone be used for side-dressing.

The 1949 results established that nitrogen fertilizer can be side-dressed to sugar beets profitably. However, the 540-pound application was the only rate which produced significantly higher yields. Because eight of the thirteen fields were either in fallow or grew a legume the preceding year, it was felt that the lower applications of nitrogen did not have a chance to express themselves. Therefore, the sugar company fieldmen were requested to select fields for the 1950 experiment, which, on the basis of the results of 1948 and 1949, would be expected to respond to additional nitrogen. The selected fields were of relatively lower fertility than in the two former years, the previous crop being sugar beets or cereal grains in all cases. Two different nitrogen fertilizers were used to compare their relative effectiveness.

The results from this experiment showed highly significant yield increases of all treatments over the check plots. The source of nitrogen had no effect on yields; plots treated with ammonium sulphate (21-0-0) or ammonium nitrate (33-0-0) gave essentially the same yields at comparable levels of nitrogen application.

Table 4.—Individual Farm Yields in Tons per Acre of Sugar Beets Grown Under Different Fertilizer Side-Dressing Treatments in Southern Alberta in 1950.

		Amount and kind of fertilizer used for side-dressing				
Grower	Reps	460 lb. 21 0-0	Check No Side-dressing	300lb. 33-0 0	150lb. 33-0-0	230lb. 21-0-0
Schmidt	1	17.23	17.10	17.55	17.37	17.43
	2	17.40	16.51	17.55	17.66	16.88
Barton	1	16.40	12.59	21.33	22.10	18.30
	2	19.07	13.90	17.93	13.40	16.59
Zink	1	19.50	15.77	18.47	17.22	17.28
	2	17.67	13.58	17.12	15.09	15.63
Dueck	1	16.14	9.99	14.98	14.52	13.82
	2	11.62	10.15	12.99	12.55	11.69
Boras	1	14.81	12.14	12.38	12.33	13.98
	2	16.43	16.11	16.11	13.28	16.45
Johnson	1	12.12	10.04	11.53	12.10	14.33
	2	12.04	10.92	15.07	12.86	10.68
Jensen	1	14.19	13.42	15.62	15.20	14.14
	2	17.15	15.81	17.39	16.57	16.34
Thomas	1	18.97	16.53	17.80	20.95	18.00
	2	15.24	12.78	15.58	12.23	12.36
Knoch	1	9.50	9.82	11.94	11.27	10.82
	2	10.36	10.41	11.02	6.70	7.86
Bartz	1	14.37	11.31	13.94	13.39	13.94
	2	14.02	13.71	14.70	15.04	15.45
Dahl	1	10.85	10.88	10.51	10.38	9.65
	2	9.38	9.87	9.46	11.54	9.84
Toth	1	5.45	5.44	6.38	6.74	6.99
	2	6.21	7.02	6.85	7.43	7.29
Mean yield		14.00	12.32	14.34	13.66	13.57

Percent of **Sucrose**

The mean percentages of sucrose for the different treatments within each experiment were very similar in amount as is indicated in Table 3. A study of the data for the individual farms revealed no tendency for the superiority of any one treatment. The mean percentages of sucrose for the check plots which received no additional fertilizer as a side-dressing were slightly higher for each of the three years. However, this increase seemed to be due to chance variability since it is accounted for almost wholly by two rather high-testing plots for each year, which gave readings up to 19.8 percent sucrose. The duplicates of these plots showed much lower percentages. The contention that this slight superiority in percentage sucrose is not real was borne out also by the statistical analysis. In spite of the large number of replications of these treatments over a wide variety of farms, the statistical reduction of the data showed no tendency for the fertilizers applied shortly after thinning to significantly influence the percentage of sucrose.

Conclusions

The results from these tests indicate that fields which have been intensively cropped without any organic manurial additions may be expected to be low in nitrogen and probably will react favorably to side-dressed applications of chemical nitrogen fertilizer, in addition to 100 pounds of 11-48-0 at seeding time. Such side-dressed applications are not so likely to produce increased yields on fields which have been summer-fallowed or

Table 5.—Individual Farm Percentages of Sucrose of Sugar Beets Grown Under Different Fertilizer Side-Dressing Treatments in Southern Alberta in 1950.

		Amount and kind of fertilizer used for side-dressing				
Grower	**Reps**	**460 1b. 21-0-0**	**Check No Side-dressing**	**3001b. 33 0-0**	**1501b. 33-0-0**	**2301b. 21-0-0**
Schmidt	1	18.4	17.8	17.6	17.8	18.0
	2	16.8	18.0	18.0	15.4	17.8
Barton	1	17.7	17.4	18.0	17.6	17.3
	2	17.8	18.0	17.6	18.4	17.5
Zink	1	16.8	17.4	16.2	16.2	16.6
	2	17.2	17.0	16.6	17.4	16.4
Dueck	1	18.2	18.6	17.6	18.0	17.8
	2	15.0	17.4	17.2	17.2	18.0
Johnson	1	17.0	16.8	17.4	17.0	17.2
	2	17.0	16.2	17.0	17.2	17.6
Jensen	1	16.0	18.0	18.6	17.8	18.4
	2	18.2	18.8	18.2	20.2	18.0
Thomas	1	16.0	18.0	16.6	17.4	16.6
	2	17.4	18.8	17.8	17.8	18.0
Knoch	1	16.2	17.2	16.2	17.2	16.8
	2	16.4	17.2	16.6	14.8	16.4
Bartz	1	17.0	18.4	18.0	18.2	17.8
	2	18.0	17.8	17.2	18.2	17.4
Dahl	1	16.4	17.4	15.2	16.0	14.8
	2	14.4	16.2	15.0	14.6	15.4
Toth	1	17.4	18.2	19.4	18.8	18.4
	2	18.8	16.4	19.4	16.0	18.4
Mean percentage of sucrose		17.0	17.6	17.3	17.2	17.3

manured recently. The most efficient and profitable rate of application seems to be between 200 and 300 pounds of ammonium sulphate or ammonium nitrate at a comparable rate of nitrogen. As was shown in the choice of fields for the 1950 experiment, the sugar company fieldmen appear to be able to select fields, on the basis of crop history, which will respond favorably to side-dressing with nitrogen fertilizer.

There was no evidence to indicate that the amounts of fertilizer, as they were applied early in the season under the conditions of these experiments, affected the sucrose content of the beets.