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ABSTRACT

THE EFFECT OF TIME AND RATE OF APPLICATION OF NITROGEN, DATE OF HARVEST AND VARIOUS PRODUCTION PRACTICES ON THE YIELD AND SUCROSE CONTENT OF SUGAR BEETS

by Charles Stanley Baldwin

In a three-year experiment on Brookston clay loam, the effect of time and rate of application of nitrogen was studied on the yield and sucrose content of sugar beets. Maximum yield of sugar was obtained when nitrogen was applied as a preplant application at 90 or 120 pounds per acre or as a sidedressing in mid-June at 60 or 90 pounds per acre.

A harvest delay of 28 days resulted in an increase of 1017 pounds of sugar per acre, representing an average increase of 36 pounds per acre per day.

The date of harvest was the most important factor affecting the sucrose content of beets. The order of importance of the variables on differences in sucrose content was:

Date of harvest $\gg$ Time of nitrogen application $>$
Rate of nitrogen application $>$ Interactions.

The rate of nitrogen application and date of harvest were about equal in effect and accounted for the majority of the variation in root yield. The order of importance of the variables on differences in root yield was:

Rate of nitrogen application $\simeq$ Date of harvest $\gg$
Time of nitrogen application $>$ Interactions.

The date of harvest was the most important factor contributing to differences in sugar yield. The order of importance of the variables on the variation in sugar yield was:

Date of harvest $\gg$ Rate of nitrogen application $>$
Time of nitrogen application $>$ Interactions.

From a three-year survey of 2618 sugar beet farmers (representing 29457 acres of beets), various production practices were correlated with the yield and sucrose content. Regression and partial correlation coefficients were calculated for 11 production practices.

On coarse-textured soils the production practices accounted for approximately 36 percent of the total variation in yield and sucrose content of beets. The majority of the variability in sucrose content was accounted for by date of planting, date of harvest, and rate of nitrogen application. Variations in root and sugar yield were due primarily to the date of planting and rate of nitrogen application.

On fine-textured soils the production practices accounted for approximately 25 percent of the total variation in yield and sucrose content of beets. Variations in sucrose content were associated mainly with date of planting and date of harvest. The date of planting was the major factor causing variation in root and sugar yield each year. Nitrogen in 1961, tile drainage in 1962, and K_2O in 1963 made significant contributions to root and sugar yield differences.

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By

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TO MARLENE

This thesis is affectionately dedicated to
my wife for her unfailing encouragement
and willing assistance and sacrifices
during this investigation.

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INTRODUCTION

A marked increase in the rates of nitrogen applied to sugar beets in recent years has been accompanied by a decrease in the sucrose content of the roots. This apparent depression of sucrose content caused by nitrogen fertilization may be associated with both the rate and time of application.

The general trend of higher yield accompanied by a lowering of the sucrose content suggests that yield and sucrose content may be negatively correlated. When all other production practices are held constant, such as on one farm, nitrogen may decrease the sucrose content. However, when production practices are not held constant, such a correlation may not be evident. Stout (1961) observed that frequently farms having the highest yields produced sugar beets well above the average in sucrose content. High yields of roots and high sucrose content are evidently not incompatible, but the factors responsible for their concomitant occurrence may not be clearly recognized.

The objectives of this study are to evaluate: (1) the effect of time and rate of application of nitrogen, (2) the date of harvest, and (3) various field production practices on the yield and sucrose content of sugar beets.

EXPERIMENT I

THE EFFECT OF TIME AND RATE OF APPLICATION OF NITROGEN AND OF HARVEST DATE ON THE YIELD AND SUCROSE CONTENT OF SUGAR BEETS

Field experiments were conducted on a Brookston clay loam soil at the Western Ontario Agricultural School in 1961, 1962 and 1963. A different location was used each year to study the effect of time and rate of application of nitrogen and of harvest date on the yield and sucrose content of sugar beets.

LITERATURE REVIEW

The role of nitrogen fertilizer is closely associated with the efficient production of sugar beets. An adequate supply of nitrogen is essential for optimum yield, but excess may result in an increase in yield of roots with a lower sucrose content. Headden (1912) showed that beets required large quantities of nitrogen, but that the sucrose content was depressed when the available supply was excessive. Since then, many reports have shown that excessive nitrogen lowered the sucrose content of beet roots. (Gardener and Robertson, 1942; Hac et al., 1954; Ogden, 1958; Finkner et al., 1959; Schmehl, 1963). Hac et al. (1950) noted a reduction in sucrose content by applications as high as 240 pounds of nitrogen (N) per acre, but the yield of sugar per acre was not reduced. This inverse relationship between nitrogen and sucrose content was partially explained by Walker and Hac (1952) on the basis of growth and storage potential, and by Ulrich (1942) on the

basis of environmental factors such as intensity of sunlight, night and day temperatures and nitrogen supply. Doxtator and Bauserman (1952) suggested that sodium and potassium may also be melassigenic substances that could serve to modify the sucrose content of sugar beets. Finkner et al. (1959) reported that excessive phosphate fertilization failed to offset the reduction in sucrose content of roots caused by excess nitrogen.

Although many production practices affect the quality and quantity of sugar beets, nitrogen fertilization is particularly critical and every effort should be made to apply near optimum amounts of nitrogen to the crop. The "optimum" level of nitrogen as used in this manuscript may be defined as that level of nitrogen fertilization which produces the maximum yield per acre. Actual determinations of the optimum nitrogen level prior to planting is extremely difficult because of the many environmental factors that affect the availability of both soil and fertilizer nitrogen. Rounds et al. (1958) suggested that the nitrogen level could be determined by cropping and fertilizer histories and soil tests. This view was partially shared by Tolman and Johnson (1958).

Rate of nitrogen application

A wide range of optimum nitrogen levels for sugar beets is reported in the literature. Bland (1958) in a three-year experiment, found that the optimum rate of nitrogen was 90 pounds per acre where cereal straw was plowed under, and less than 90 pounds per acre when no straw was plowed under. Manure applications did not affect the optimum nitrogen rate. Applications of nitrogen greater than 90 pounds per acre increased yield of beet tops but not of roots and decreased the sucrose content of roots. Krantz and MacKenzie (1954), in studying the effect of nitrogen on yield and quality of sugar beets grown at three widely varying soil fertility

levels in a one-year experiment, reported yield increases of roots as high as 14 tons per acre. The yield of sugar per acre was increased from 1.72 to 3.73 tons per acre. Decoux et al. (1946) found that the sucrose content was increased by nitrogen rates up to 90 pounds per acre, but it was decreased when higher rates of nitrogen were applied. Primost (1958) obtained maximum root yields when 140 pounds of nitrogen were applied in conjunction with ample phosphorus and potassium without lowering the sucrose content. Hill and Dubetz (1952) found the optimum levels of sidedressed nitrogen to be between 40 and 60 pounds per acre. Tolman and Johnson (1958) found that 80 to 100 pounds of nitrogen per acre was usually sufficient for sugar beets grown in short-season areas, but in long-season areas and on new land, up to 200 pounds per acre were needed. Williams and Ririe (1957) reported optimum rates of nitrogen applications of 160 pounds per acre on fallowed land, 240 pounds per acre after barley, and 80 pounds per acre after a vetch crop. Hill (1952) observed that optimum levels of 40 to 60 pounds of nitrogen per acre had little or no effect on sucrose content. Carlson and Herring (1954) observed that nitrogen tended to reduce the sucrose content at each of five locations. On one soil the sucrose content of beets that received 60 pounds of nitrogen per acre was 2 percent lower than the sucrose content of beets grown on the phosphated check. Rounds et al. (1958) concluded that the effect of nitrogen fertilization was more pronounced than the effect of the varieties tested.

Time of nitrogen application

Adams (1960) found no yield differences between various sources of nitrogen, and 60 pounds per acre resulted in maximum sugar yield. Nitrogen plowed down was as effective in increasing sugar yield as sidedressing.

No reduction in sugar yield resulted from late applications of nitrogen if some had been applied as a preplant or at planting time. Davis et al. (1946) noted that one sidedressing of nitrogen approximately seven weeks after the beets were planted increased yields of roots to a greater extent than where the same amount of nitrogen was applied in two applications. Alexander and Cormany (1950), reporting on one-year data, found no significant yield increases in Colorado and Wyoming where rates of nitrogen were increased from 0 to 120 and 0 to 80 pounds of nitrogen per acre, respectively. Where the 120-pound rate was applied, the sucrose content of the roots was depressed slightly. In Montana, increases in yield of roots were obtained when increments of 40,60 and 80 pounds of nitrogen per acre were applied. High rates of nitrogen applied on or after August 10 resulted in low sugar yields and low sucrose content. In addition, these workers reported no increase in yield resulting from applying the same amount of nitrogen in 2 or 3 sidedress applications as compared to a single early application. Wauthy (1953) found that broadcasting nitrogen in the spring and discing-in was preferable to autumn plowdown in increasing sugar beet yields. Joret and Hiroux (1951) concluded that the root yield was affected little, if any, by variations in time of application of nitrogen. Hill (1952) in Alberta reported that 100 pounds of nitrogen per acre applied on June 28 did not affect the sucrose content but did increase the yield of roots. The same amount of nitrogen applied on August 2 did not affect root yield but did lower the sucrose content. Haddock (1949) noted no difference in yield of roots due to sidedressing nitrogen in mid-season as compared to sidedressing in early season. Beet root yields were not increased by applying the same amount of nitrogen in two applications rather than applying it in a one sidedressing application. Leavitt and

Stier (1954) working with anhydrous ammonia found that the optimum rate was 125 pounds of nitrogen per acre. When the rate was increased to 615 pounds of nitrogen sidedressed at thinning time no further reduction in sucrose content occurred, and no plant injury was noted. Applications of nitrogen sidedressed later than thinning time had been previously shown to be less effective in increasing yields than earlier applications.

Date of harvest

Hills et al. (1954) reported that root and sugar yields were increased 4.7 and 0.84 tons per acre, respectively, when harvest was delayed 34 days. The sucrose content was increased by 0.8 percent. Wolley and Bennett (1962) noted average daily gains of 0.12 tons of roots and 52 pounds of sugar per acre when harvest was delayed 34 days. Cook et al. (1962) found over a three-year period, that the date of harvest did not affect the yield of sugar beet roots.

Nitrate nitrogen content of petioles

Ulrich (1954) noted that beet plants that were continually supplied with all required nutrients failed to "sugar-up" or "ripen" in the greenhouse. Depriving the plants of nitrogen increased the sucrose content of roots to 12.1 percent while that of non-deficient beets fell to 7.1 percent. In 1950 Ulrich reported that the critical nitrate level of recently matured petioles was about 2,000 ppm in greenhouse experiments. The critical level was that level of nitrate in the petioles that resulted in a satisfactory growth and yield of sugar beets. In the field, recently matured petioles appeared to have a critical nitrate level of about 1,000 ppm. In both pot and field experiments, plants with a high nitrogen

content were lower in sucrose content than "low-nitrogen" plants. Afanasiev et al. (1954) concluded that the nitrate nitrogen content of beet petioles should be about 1,000 ppm in August for Montana conditions. The sucrose content before mid-August was negatively correlated with final yield. Ulrich in 1956 showed that the increase in sucrose content during ripening of sugar beets in the greenhouse was induced by low night temperatures (4°C to 17°C) and a deficiency of nitrogen. Krantz and MacKenzie (1954) reported the nitrate content of petioles should be maintained above the critical levels until 11 or 12 weeks before harvest. Haddock (1949) stated that establishing a critical nitrogen level in the plant was of doubtful value unless the season of the year was also specified.

EXPERIMENTAL PROCEDURE

Three similar experiments were conducted in 1961, 1962 and 1963. Each year, sugar beets were grown on a location that had been cropped without fertilizer for at least three years. Corn was grown for two years immediately preceding the experimental year, and soybeans preceded the first corn crop.

Soil description

The plot areas were located on Brookston clay loam, tiled at 40-foot intervals. This soil is similar in type and texture to the soils upon which the greater percentage of the commercial beets are grown in Ontario. These experiments were located on the Experimental Farm at Ridgetown, in the 11th and 12th Lots in the 9th Concession of Howard Township in the County of Kent, Province of Ontario. The surface soil contained 30 to 35 percent clay and 35 to 40 percent sand. Soil test results from samples obtained from 0-8 inches prior to treatment each year are given in Table 1. Phosphorus was determined by the modified PA_2 test of Smith and Sheard (1957). Potash was extracted by a solution 0.1 N with respect to ammonium acetate and 0.05 N with respect to sulfuric acid, as described by Heeg.[1] The pH determinations were made on a soil paste. Magnesium was determined by a revision of the Spurway and Lawton (1949) test.

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[1]Heeg, T. J. Unpublished methods used by the Department of Soil Science. Ontario Agricultural College, Guelph, Ontario Canada.

TABLE 1.--Soil tests results from the experimental locations

Year	pH	P_2O_5	K_2O	Mg
			Pounds per acre	
1961	7.0	187	127	156
1962	7.6	110	92	130
1963	7.4	195	117	69

Statistical design and treatments

The plots were laid out in a randomized split-plot design with three replications. Each plot contained four rows of beets and was 8 feet wide by 17 feet 9 inches long. The experimental area each year was 160 by 250 feet. The main plot treatments consisted of three dates of harvest (Table 5) and the sub-plot treatments were a 6x4 factorial arrangement of 6 rates of nitrogen (0,30,60,90,120 and 150 pounds of N per acre) and 4 times of applications (Table 2).

TABLE 2.--The time of preplant and sidedressed nitrogen applications

Year	Time of nitrogen application			
	Preplant	Mid-June	Mid-July	Mid-Aug.
			Sidedressing	
1961	April 19	June 14	July 14	Aug. 15
1962	April 20	June 18	July 16	Aug. 15
1963	April 22	June 21	July 17	Aug. 15

Preplant applications of nitrogen were broadcast by hand and disced into the surface soil. Sidedressed nitrogen was placed in bands to one side of the beet row and approximately $2\frac{1}{2}$ to 3 inches below the soil surface. The nitrogen was applied as ammonium nitrate. The sidedressings were applied at approximately one-month intervals.

Cultural practices

The experimental areas were fall-plowed at a depth of approximately 10 inches. Each year, an application of 800 pounds of 0-20-20 fertilizer per acre was drilled to a depth of 3 to 4 inches on all plots prior to planting.

Monogerm seed was spaced 2 or $2\frac{1}{2}$ inches apart in 24-inch rows, and were thinned to one beet per 12 inches in mid-June. The beets were planted on May 5, May 18 and May 3 in 1961, 1962 and 1963, respectively.

The monthly rainfall from April to the date of the last harvest was quite variable (Table 3).

TABLE 3.--The monthly rainfall during the growing season

Year	Month								Total
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.[a]	
	Inches per month								
1961	6.43	2.04	3.75	2.47	3.93	3.34	1.06	0.29	23.3
1962	1.75	1.12	4.06	3.61	5.65	2.97	0.91	0.94	21.0
1963	4.10	3.44	2.11	2.79	1.53	1.31	0.37	0.14	15.8

[a]Rainfall from November 1 to date of last harvest only.

Beets planted on April 21 in 1962 were replanted on May 18 because of the formation of a crust on the surface of the soil which resulted in a poor emergence of the plants.

Sampling and harvesting

Each year, petiole samples for nitrate analyses were taken at about 2-week intervals from mid-July to mid-September (Table 4). About 12 petioles were taken from plants in the center two rows of each plot. Nitrate was determined by the diphenylamine test described by Ulrich et al. (1959).

TABLE 4.--Date of petiole samplings

Year	Sampling number				
	1	2	3	4	5
	Date of sampling				
1961	July 14	July 28	Aug. 14	Sept. 1-2	Sept. 15
1962	July 13	July 31	Aug. 14	Sept. 29	Sept. 14
1963	July 17	July 31	Aug. 14	Sept. 29	Sept. 13

When a petiole sampling date coincided with a nitrogen application date, petiole samplings were taken before sidedressing with nitrogen.

Before the early harvest each year a visual cercospora blight rating was made on each plot according to the Kleinwanzlebener rating chart.[1]

[1]Kleinwanzlebener Cercospora-Tafel. Verlag Dr. Buhrbanck and Co. K.G. Berlin und Holzminden.

At the same time, a visual nitrogen rating was made. A rating of 1 to 5 was assigned depending on the decreasing intensity of the green color of the beet leaves.

The beets were hand harvested and hand topped. The dates of harvest are given in Table 5.

TABLE 5.--Dates of sugar beet harvest

Year	Date of harvest		
	Early	Medium	Late
1961	Oct. 10	Oct. 24	Nov. 7
1962	Oct. 9	Oct. 23	Nov. 6
1963	Oct. 8	Oct. 22	Nov. 5

Root and top weights were taken from 15 feet of each of the two center rows. From each plot, two lots of 5 beets each were scrubbed free of soil for sucrose determination. Within twenty-four hours of harvest the sucrose content of the fresh beet roots was determined at the Canada and Dominion Sugar Company Limited laboratories, Chatham Ontario, by the polarimetric procedure of Bates and associates (1942). The yield of sugar per acre was calculated from the sucrose content and the yield of roots per acre.

RESULTS AND DISCUSSION

The effect of date of harvest, and time and rate of application of nitrogen on the sucrose content of sugar beets

The sucrose content of beets generally increased as the date of harvest was delayed (Table 6). In 1962 and 1963, the sucrose content of beets harvested at the medium and late dates was higher than that of early-harvested beets. Delaying the harvest for 28 days (early to late harvest) increased the average sucrose content of beets harvested in 1961, 1962 and 1963 by 1.1 percent. The average sucrose content of beets harvested at the medium and late dates did not differ (Table 7). The statistical values (Table 8) indicate that date of harvest was the most important factor affecting sucrose content. This factor accounted for 43, 65 and 72 percent of the total variation in sucrose content in 1961, 1962 and 1963, respectively.

Beets to which nitrogen was applied as a preplant application or as a mid-June sidedressing had a higher sucrose content than beets to which nitrogen was applied as a mid-August sidedressing (Table 6). Beets to which nitrogen was sidedressed in mid-July tended to have a higher sucrose content than beets to which nitrogen was sidedressed in mid-August. In general, the lowest sucrose content was obtained in beets to which nitrogen was applied late and which were harvested early. The time of nitrogen application did not affect the average sucrose content of beets, except for a slight reduction where the nitrogen was applied in mid-August (Table 7). The statistical values (Table 8) indicate that the

TABLE 6.--The effect of time and rate of application of nitrogen, and of harvest date on the sucrose content of sugar beets, 1961, 1962 and 1963

Nitrogen application		Date of harvest								
Time	Pounds per acre	1961			1962			1963		
		Early	Medium	Late	Early	Medium	Late	Early	Medium	Late
		Percent sucrose								
	0	15.8	16.1	16.4	16.3	17.5	17.2	19.4	20.5	20.5
	30	15.8	16.3	16.4	16.7	17.7	17.0	19.5	20.6	20.9
	60	15.9	16.4	16.3	16.4	17.0	17.2	19.4	21.3	21.3
Preplant	90	15.5	15.6	16.0	16.0	17.5	17.5	19.6	21.6	20.6
	120	15.3	16.4	16.2	16.5	17.7	17.1	19.9	21.4	20.8
	150	14.4	16.2	16.2	16.0	17.1	17.5	19.9	21.0	21.1
	30	15.5	16.0	16.2	16.7	17.7	17.2	20.1	21.1	21.3
Mid-June	60	15.3	16.5	16.6	16.7	17.7	17.9	19.9	20.7	21.1
sidedressing	90	15.3	15.9	16.5	16.1	17.8	17.9	19.6	21.5	20.9
	120	15.6	16.3	16.5	16.0	17.5	17.2	19.9	21.3	21.0
	150	15.5	16.1	16.5	16.2	17.4	17.4	19.4	21.6	21.2
	30	16.3	16.6	16.0	16.3	17.7	17.0	19.6	21.1	21.1
Mid-July	60	15.8	16.1	16.5	16.0	17.5	17.6	19.9	21.9	20.7
sidedressing	90	15.4	16.3	16.5	15.9	17.4	17.4	19.7	22.0	21.2
	120	15.6	16.0	16.2	15.8	17.3	17.0	19.5	21.3	21.0
	150	15.1	15.8	15.9	15.5	17.4	16.3	19.3	20.9	21.0
	30	15.5	15.8	16.2	15.8	17.5	17.6	19.0	20.7	20.9
Mid-August	60	15.0	15.6	16.1	15.5	17.2	17.0	19.4	20.5	20.3
sidedressing	90	14.8	15.4	15.8	15.1	17.0	16.7	18.6	20.5	20.5
	120	14.0	16.3	15.7	15.0	16.4	16.3	17.8	20.7	20.2
	150	14.0	15.4	15.7	14.7	16.4	16.8	19.2	20.4	20.7
R^a	(.05)		1.10			1.00			1.01	
	(.01)		1.46			1.33			1.33	
LSD	(.05)		0.87			0.79			0.79	
	(.01)		1.15			1.04			1.05	

[a]R values calculated from Duncan's "New Multiple Range Tests", (LeClerg, et al., 1962) and allow for comparison of all means in any one year.

TABLE 7.--The effect of time and rate of application of nitrogen and of harvest date on the three-year average of yield and sucrose content of sugar beets

Treatment	Percent sucrose	Tons roots per acre	Pounds sugar per acre	Tons tops per acre
Harvest date				
Early	17.0	17.2	5719	11.4
Medium	18.1	17.9	6357	10.3
Late	18.1	18.9	6736	8.7
Time of application of nitrogen				
Preplant	17.8	18.4	6424	9.2
Mid-June	17.9	18.5	6506	10.6
Mid-July	17.8	17.7	6214	10.7
Mid-August	17.4	17.3	5921	10.0
Rate of nitrogen application (lbs. N per acre)				
0	17.7	16.2	5655	6.8
30	17.9	17.5	6062	8.4
60	17.8	18.3	6433	10.0
90	17.7	19.0	6594	11.3
120	17.6	18.5	6429	11.7
150	17.6	18.5	6359	12.5

TABLE 8.--The R^2 values for date of harvest, time and rate of application of nitrogen and their interactions on the sucrose content of sugar beets

Year	Harvest date	Time of N application	N rate	N rate x Time	N rate x Harvest date	Time x Harvest date	Total[a] R^2
1961	0.43	0.12	0.08	0.04[b]	0.04	0.01	0.72
1962	0.65	0.09	0.06	0.04	0.01	0.01	0.86
1963	0.72	0.09	0.02	0.02	0.01	0.00[b]	0.86

[a]Necessary total R^2 for significance = 0.47

[b]Denotes non-significance

time of nitrogen application accounted for 12, 9 and 9 percent of the total variation in sucrose content in 1961, 1962, and 1963, respectively. The interaction of harvest date and time of nitrogen application accounted for 1, 1 and 0 percent of the variation in sucrose content in 1961, 1962 and 1963, respectively.

In 1961 beets that had received 30 pounds of nitrogen per acre were higher in sucrose content than those that received 150 pounds of nitrogen. This was particularly evident when the nitrogen was applied in mid-July or mid-August to beets that were harvested early. The variability in sucrose content in 1962 and 1963 was largely accounted for by nitrogen rates applied in mid-August to beets that were harvested at the early or medium dates. In general, most of the significant variation in sucrose content attributed to rates of nitrogen resulted from differences between the sucrose content of beets that received 120 or more or 30 or less pounds per acre. Nitrogen rates greater than 30 pounds per acre reduced the sucrose content slightly (Table 7).

The interaction of rate of nitrogen application and date of harvest accounted for 4, 1 and 1 percent of the total variation in sucrose content in 1961, 1962 and 1963, respectively. The interaction of rate of nitrogen with time of application accounted for 4, 4 and 2 percent of the total variation in sucrose content in 1961, 1962 and 1963, respectively. The interaction of rate of nitrogen, time of application, and date of harvest, on the sucrose content was not significant.

The effect of date of harvest, and time and rate of application of nitrogen on root yield

In 1961 and 1962 the date of harvest did not affect root yield (Table 9). The root yield variation in 1963 was significant, possibly

TABLE

TABLE 9.--The effect of time and rate of application of nitrogen, and of harvest date on the tons of beet roots per acre, 1961, 1962 and 1963

Nitrogen application		Date of harvest								
Time	Pounds per acre	1961			1962			1963		
		Early	Medium	Late	Early	Medium	Late	Early	Medium	Late
		Tons of roots per acre								
	0	19.1	19.7	19.5	16.2	17.1	16.9	11.9	11.5	14.1
	30	16.9	18.6	18.8	17.5	17.3	18.8	12.8	13.9	16.0
	60	21.4	22.4	22.7	18.0	20.2	20.9	12.3	13.1	14.5
Preplant	90	21.4	23.7	24.9	19.8	22.0	23.0	13.2	13.7	14.5
	120	25.9	24.4	25.9	20.8	20.8	20.2	14.5	13.9	15.6
	150	20.9	25.3	24.9	20.7	22.4	20.2	15.0	13.4	16.1
	30	19.6	20.3	22.1	19.2	19.7	21.2	13.0	12.2	16.0
Mid-June	60	21.4	23.6	22.8	21.4	23.1	19.7	14.0	12.9	16.5
sidedressing	90	22.6	23.1	25.7	19.6	21.3	21.8	15.0	13.7	17.5
	120	19.4	20.9	21.8	20.1	20.5	20.0	13.6	12.3	17.1
	150	22.4	21.1	22.1	18.4	21.3	19.2	13.8	14.2	16.5
	30	20.3	20.0	21.2	18.3	20.4	19.0	13.3	13.4	16.1
Mid-July	60	21.1	20.1	20.7	19.1	21.1	21.3	13.1	12.3	15.7
sidedressing	90	19.8	20.6	21.5	19.6	20.7	18.9	14.0	13.6	16.9
	120	20.9	21.9	23.7	18.4	20.2	20.6	14.5	14.2	17.1
	150	18.0	19.2	19.8	19.0	18.8	17.8	12.7	13.3	18.6
	30	17.3	20.5	21.5	18.3	19.2	19.0	12.0	12.0	13.8
Mid-August	60	16.3	18.9	20.2	18.5	20.0	17.8	12.8	13.6	15.9
sidedressing	90	19.6	22.5	20.1	19.4	17.8	19.6	13.1	13.1	15.1
	120	16.8	18.4	17.4	17.3	19.1	17.3	13.1	13.8	16.9
	150	17.2	20.7	22.8	19.6	19.2	19.7	12.3	12.3	14.9
R[a]	(.05)		2.97			3.20			2.04	
	(.01)		3.91			4.22			2.69	
LSD	(.05)		2.33			2.51			1.60	
	(.01)		3.09			3.32			2.12	

[a]R values allow for comparison of all means in any one year.

due to the dry season. Precipitation after the medium harvest date increased the yield in the last harvest. Delaying harvest for 28 days increased the average root yield in 1961, 1962 and 1963 by 1.7 tons per acre (Table 7). The statistical values presented in Table 10 indicate that date of harvest accounted for 13, 6 and 58 percent of the total variation in root yield in 1961, 1962 and 1963, respectively.

Time of application of nitrogen affected the yield of roots in 1961. Beets that received nitrogen as a preplant or as a mid-June sidedressing in 1962 and 1963, had a higher root yield than beets that received nitrogen in mid-August (Table 9). There was a gradual decrease in root yield as nitrogen was applied later than the date of the mid-June sidedressing. The average root yield was the same when nitrogen was applied as a preplant or as a mid-June sidedressing. The statistical values (Table 10) indicate that time of nitrogen application accounted for 9, 4 and 3 percent of the total variation in root yield in 1961, 1962 and 1963, respectively. The interaction of harvest date with time of nitrogen application accounted for 1, 0 and 1 percent of the variation in root yield in 1961, 1962 and 1963, respectively.

In 1961 and 1962 higher yields of roots were obtained where nitrogen was applied at 60 or 90 pounds per acre to beets in mid-June than where 30 or less pounds per acre was used. When nitrogen was applied as a preplant, beets that received 90 or more pounds per acre had a higher root yield than beets that received nitrogen at 60 or less pounds per acre. Nitrogen applied in mid-July or in mid-August had little affect on root yield. In 1963 beets that received nitrogen at 30 or more pounds per acre as a preplant had a higher root yield than beets that did not receive nitrogen, especially when the beets were harvested at the medium

TABLE 10.--The R^2 values for date of harvest, time and rate of application of nitrogen and their interactions on the tons of roots per acre

Year	Harvest date	Time of N application	N rate	N rate x Time	N rate x Harvest date	Time x Harvest date	Total[a] R^2
1961	0.13[b]	0.09	0.14	0.03	0.01	0.01	0.41[b]
1962	0.06[b]	0.04[b]	0.40	0.03	0.01	0.00[b]	0.54
1963	0.58	0.03[b]	0.19	0.00[b]	0.00	0.01	0.81

[a]Necessary total R^2 for significance = 0.47

[b]Denotes non-significance

date. When nitrogen was applied in mid-June or in mid-July, beets that received nitrogen at 30 or more pounds per acre had higher root yields than beets that received no nitrogen, particularly when the beets were harvested late. On the average, root yield gradually increased as the rate of nitrogen increased from 0 to 90 pounds per acre. When beets received nitrogen at rates higher than 90 pounds per acre root yield decreased (Table 7). The statistical values given in Table 10 indicate that the total variation due to rate of nitrogen was 14, 40 and 19 percent; the interaction of rate of nitrogen with date of harvest 1, 1 and 0 percent; and the interaction of rate of nitrogen with time of application 3, 3 and 0 percent in root yield for 1961, 1962 and 1963, respectively. The interaction of rate of nitrogen, time of application, and date of harvest on root yield was not significant.

The effect of date of harvest, and time and rate of application of nitrogen on sugar yield

The sugar yield was calculated from the sucrose content and the tons of roots per acre.

Most of the differences in yield of sugar (1961 and 1962) due to the date of harvest were due to a higher yield in beets that were harvested at the medium or late dates over beets that were harvested early. In 1961 and 1962 (Table 11) sugar yields from beets harvested at the medium or late dates were not different. In 1963 sugar yields from beets harvested late were higher than those that were harvested at the early or medium dates. Delaying harvest for 28 days (Table 7) increased the average sugar yield in 1961, 1962 and 1963, 1017 pounds per acre. This represents an increase of 36 pounds of sugar per acre per day of delayed harvest beyond the early harvest date. The initial 14 days of

TABLE 11.--The effect of time and rate of application of nitrogen, and of harvest date on the pounds of sugar per acre, 1961, 1962 and 1963

Nitrogen application		Date of harvest								
Time	Pounds per acre	1961			1962			1963		
		Early	Medium	Late	Early	Medium	Late	Early	Medium	Late
		Pounds of sugar per acre								
	0	5999	6301	6386	5264	6052	5816	4612	4699	5765
	30	5257	6093	6205	5855	6121	6391	5010	5721	6682
	60	6837	7352	7412	5925	6871	7200	4804	5576	6192
Preplant	90	6637	7435	7998	6361	7711	8056	5179	5903	5988
	120	6982	8045	8415	6878	7398	6891	5788	5960	6489
	150	6028	8211	8032	6595	7654	7072	5971	5640	6799
	30	6085	6506	7136	6426	6980	7272	5195	5172	6809
Mid-June	60	6576	7786	7571	7149	8167	7048	5596	5363	6936
sidedressing	90	6929	7332	8482	6330	7582	7722	5892	5867	7341
	120	6032	6817	7186	6423	7165	6862	5394	5257	7156
	150	6926	6790	7314	5974	7395	6712	5338	6120	6973
	30	6593	6649	6769	5931	7254	6450	5209	5679	6802
Mid-July	60	6670	6456	6813	6134	7383	7483	5191	5406	6517
sidedressing	90	6108	6702	7087	6246	7215	6650	5539	5960	7165
	120	6527	6993	7676	5803	6990	7006	5753	6046	7160
	150	5443	6108	6300	5900	6542	5751	4912	5564	7839
	30	5404	6448	6961	5787	6755	6684	4552	4965	5772
Mid-August	60	5128	5931	6520	5736	6875	6030	4980	5547	6436
sidedressing	90	5842	6941	6344	5835	6052	6533	4876	5338	6214
	120	4733	5989	5447	5170	6260	5631	4642	5702	6833
	150	4865	6386	7137	5747	6323	6623	4731	5049	6154
R[a]	(.05)		1060			1056			748	
	(.01)		1397			1392			986	
LSD	(.05)		831			829			587	
	(.01)		1101			1097			777	

[a]R values allow for comparison of all means in any one year.

harvest delay resulted in an increase of 638 pounds of sugar, or a daily increase of 46 pounds per acre as compared to an increase of 379 pounds of sugar, or a daily increase of 27 pounds per acre for the last 14 days delay. The statistical values indicate that the date of harvest accounted for 24, 26 and 61 percent of the total variation in sugar yield in 1961, 1962 and 1963 respectively (Table 12).

In 1961 and 1962, beets that received nitrogen as a preplant or as a mid-June sidedressing had a higher sugar yield than beets that received nitrogen in mid-July or mid-August. Beets that were sidedressed with nitrogen in mid-July had a slightly higher yield of sugar than beets that were sidedressed in mid-August. The time of nitrogen application did not affect the yield of sugar in 1963. On the average, beets to which nitrogen was applied in mid-June had the highest yield of sugar (Table 7). A gradual reduction in sugar yield occurred when nitrogen was sidedressed to beets later than mid-June. Beets that received nitrogen as a preplant had a sugar yield slightly lower than beets that received nitrogen in mid-June. The statistical values indicate that the time of nitrogen application accounted for 11, 6 and 5 percent; and, the interaction of time of nitrogen application with date of harvest 1, 0 and 1 percent of the total variation in sugar yield in 1961, 1962 and 1963, respectively.

In 1961 and 1962, beets that received nitrogen at 90 or more pounds per acre as a preplant had a higher yield of sugar than beets that received 30 or less pounds per acre (Table 11). When nitrogen was applied as a mid-June sidedressing at 60 or 90 pounds per acre, beets had a higher sugar yield than those that received 30 or less pounds per acre. In 1962, beets that received 60 or 90 pounds of nitrogen per acre in mid-July had a greater yield of sugar than beets to which no nitrogen was applied, particularly when the beets were harvested at the medium date. Nitrogen

TABLE 12.--The R^2 values for date of harvest, time and rate of application of nitrogen and their interactions on the yield of sugar per acre

Year	Harvest date	Time of N application	N rate	N rate x Time	N rate x Harvest date	Time x Harvest date	Total[a] R^2
1961	0.24	0.11	0.08	0.05	0.02	0.01	0.51
1962	0.26	0.06	0.23	0.05	0.00[b]	0.00[b]	0.60
1963	0.61	0.05[b]	0.17	0.01[b]	0.01	0.01	0.86

[a]Necessary total R^2 for significance = 0.47

[b]Denotes non-significance

applied in mid-August did not affect the yield of sugar. In 1963, beets that received nitrogen as a preplant application at 120 or 150 pounds per acre had a higher yield of sugar than beets that received 30 or less pounds per acre, particularly when the beets were harvested early. Beets that received nitrogen at 60 or 90 pounds per acre in mid-June had a higher yield of sugar than beets that received 30 or less pounds per acre. Beets to which nitrogen was applied at 90 and 120 pounds per acre in mid-July had a higher sugar yield than those that received no nitrogen. Maximum yield of sugar was produced from beets that received 90 pounds of nitrogen per acre (Table 7). A gradual reduction in sugar yield resulted when beets received more, or less than 90 pounds of nitrogen per acre. The statistical values presented in Table 12 show that the rate of nitrogen application accounted for 8, 23 and 17 percent; the interaction of rate of nitrogen application with date of harvest 2, 0 and 1 percent; and the interaction of rate of nitrogen with time of application 5, 5 and 1 percent of the total variation in sugar yield in 1961, 1962 and 1963, respectively. In 1963 the interaction of rate of nitrogen, time of application, and date of harvest had a significant effect on the yield of sugar.

The effect of date of harvest, and time and rate of application of nitrogen on beet top yield

The yield of beet tops in 1963 was lower than in the previous two years possibly due to the shortage of rainfall during the 1963 season (Table 13). On the average, the yield of tops gradually decreased as the harvest date was delayed (Table 7). Early harvested beets yielded 11.4 tons of tops per acre compared to 8.7 tons from beets harvested late. Top yields were highest where nitrogen was sidedressed in mid-June or mid-July and lowest where applied as a preplant. There was a gradual increase in top yield as

TABLE 13.--The effect of time and rate of application of nitrogen and of harvest date on the tons of beet tops per acre, 1961, 1962 and 1963

Nitrogen application		Date of harvest								
Time	Pounds per acre	1961			1962			1963		
		Early	Medium	Late	Early	Medium	Late	Early	Medium	Late
		Tons of tops per acre								
	0	9.5	8.5	6.4	8.9	8.2	7.4	4.4	4.2	4.0
	30	8.5	8.1	6.2	8.5	8.0	7.7	5.1	5.2	4.5
	60	11.0	12.2	10.6	11.5	12.7	9.3	4.8	4.9	4.8
Preplant	90	12.0	11.6	11.5	16.1	12.3	12.9	6.0	5.0	4.1
	120	13.0	13.3	10.5	16.1	12.4	11.4	6.5	5.9	6.1
	150	12.8	15.1	10.5	19.2	16.3	12.2	7.1	6.3	6.3
	30	9.5	9.9	10.3	13.7	14.3	9.9	5.9	5.1	5.2
Mid-June	60	13.4	12.3	8.8	16.2	14.5	10.4	6.7	6.5	5.8
sidedressing	90	14.1	13.1	10.4	17.9	16.5	13.3	8.0	7.4	6.5
	120	16.2	13.0	10.4	20.1	17.1	12.8	8.2	6.9	7.3
	150	18.1	15.4	11.7	18.8	17.7	11.7	8.5	8.0	7.8
	30	12.0	10.9	8.9	12.7	11.4	9.2	5.8	5.9	5.8
Mid-July	60	13.2	14.2	9.0	17.0	14.3	13.6	6.6	6.3	5.4
Sidedressing	90	16.0	14.2	10.8	17.2	14.2	11.6	8.5	7.0	7.2
	120	15.1	14.2	10.9	21.3	16.1	14.9	8.5	7.3	6.9
	150	16.7	14.4	11.9	20.4	15.1	12.2	8.1	8.1	8.1
	30	9.7	10.4	7.3	13.7	10.5	10.3	5.3	4.7	4.3
Mid-August	60	12.2	10.7	8.1	13.3	12.7	9.7	6.3	6.3	5.0
sidedressing	90	13.8	13.2	9.9	17.8	14.0	14.4	6.7	6.5	5.7
	120	13.7	13.6	9.6	16.5	13.7	11.9	7.1	6.7	6.9
	150	13.8	12.7	11.0	22.1	19.0	14.6	5.8	6.3	6.3
R^a	(.05)		2.23			1.03			0.74	
	(.01)		2.94			1.35			0.97	
LSD	(.05)		1.75			0.80			0.58	
	(.01)		2.32			1.07			0.77	

[a]R values allow for comparison of all means in any one year.

the rate of nitrogen increased from 0 to 150 pounds per acre. Beets that did not receive nitrogen had a top yield of 6.8 tons per acre, whereas beets that received 150 pounds per acre had a yield of 12.5 tons per acre.

The effect of time and rate of application of nitrogen on the root to top ratios are presented in Table 14. Each year the root to top ratio gradually decreased as the rate of nitrogen increased. Beets that did not receive nitrogen had a root to top ratio between 2.1 and 3.0 as compared to a range of 1.0 to 2.2 when beets received 150 pounds of nitrogen per acre. These data indicate that a negative correlation exists between the rate of nitrogen applied and root to top ratios.

A visual rating of the intensity of cercospora leaf blight

The effect of time and rate of application of nitrogen on the incidence of cercospora leaf blight (Cercospora beticola) is presented in Table 15. There was considerable variation of blight incidence for the three years. The blight was severe on all plots in 1961, moderate in 1962, and not present in 1963. The disease was less severe in 1962 as time of nitrogen application was delayed. Beets that received nitrogen as a preplant showed the highest incidence of blight. Beets that received nitrogen in mid-August showed the least incidence of blight. The intensity of the blight decreased as the amount of nitrogen applied increased.

A visual rating of the intensity of nitrogen deficiency symptoms

Nitrogen was the only nutrient deficiency observed in any year. Color differences of foliage were observed for all rates of nitrogen at every application time except for the mid-July and mid-August applications during dry periods.

TABLE 14.--The effect of time and rate of application of nitrogen on root to top ratios of sugar beets

Nitrogen application				
Time	Pounds per acre	1961	1962	1963
		Root:top ratio		
	0	2.4	2.1	3.0
Preplant	30	2.4	2.2	2.9
	60	2.0	1.8	2.8
	90	2.0	1.6	2.8
	120	2.0	1.3	2.5
	150	1.9	1.3	2.2
Mid-June sidedressing	30	2.1	1.6	2.5
	60	2.0	1.6	2.3
	90	1.9	1.3	2.1
	120	1.6	1.2	1.9
	150	1.5	1.2	1.8
Mid-July sidedressing	30	1.9	1.7	2.4
	60	1.7	1.4	2.2
	90	1.5	1.4	1.9
	120	1.7	1.1	2.0
	150	1.3	1.2	1.8
Mid-August sidedressing	30	2.2	1.6	2.7
	60	1.8	1.6	2.4
	90	1.7	1.2	2.2
	120	1.4	1.3	2.1
	150	1.6	1.0	2.1

TABLE 15.--The effect of time and rate of application of nitrogen on the incidence of cercospora blight[a]

Nitrogen application					
Time	Pounds per acre	1961	1962	1963	Average
		Cercospora rating			
	0	4.0	3.6	1.1	2.9
Preplant	30	4.0	3.3	1.0	2.8
	60	4.0	3.7	1.0	2.9
	90	4.0	2.7	1.0	2.6
	120	4.0	3.3	1.0	2.8
	150	4.0	2.0	1.0	2.3
Mid-June sidedressing	30	4.0	3.0	1.0	2.7
	60	4.0	2.7	1.0	2.6
	90	4.0	2.3	1.0	2.4
	120	4.0	3.3	1.0	2.8
	150	4.0	3.3	1.0	2.8
Mid-July sidedressing	30	4.0	3.0	1.0	2.7
	60	4.0	2.7	1.0	2.6
	90	4.0	2.0	1.0	2.3
	120	4.0	2.0	1.0	2.3
	150	4.0	2.7	1.0	2.6
Mid-August sidedressing	30	4.0	2.3	1.0	2.4
	60	3.7	2.3	1.0	2.3
	90	4.0	2.0	1.0	2.3
	120	3.7	2.0	1.0	2.3
	150	3.3	2.0	1.0	2.1

[a]Cerospora rating

1 - Normal healthy leaves

2 - First spots (spore colonies) formed on outer leaves

3 - First appearance of spore colonies on inner leaves

4 - Spore colonies joined forming large areas of dead tissue

5 - Leaf and leaf stalks dead and drying up

Visual nitrogen ratings are given in Table 16. On the average when nitrogen was applied as a preplant or as a sidedressing in mid-June, beets at the time of early harvest showed a deficiency of nitrogen regardless of the rate of application. Beets that received nitrogen at 120 or 150 pounds per acre in mid-July or in mid-August did not show nitrogen deficiency at the time of early harvest. Beets that received adequate nitrogen for maximum sugar yield showed slight yellowing at the time of early harvest. When beet leaves did not show a deficiency of nitrogen at early harvest this tended to indicate that nitrogen had been applied late, and at 120 or 150 pounds per acre.

Petiole analyses for nitrate nitrogen

The effect of time and rate of application of nitrogen on the nitrate content of the petioles is shown in Table 17. Results between years were in good agreement for similar sampling dates and treatments except where nitrogen was applied in mid-August. Nitrate content of beet petioles that received nitrogen in mid-August was variable. This variability probably is associated with rainfall, as in 1963, nitrogen applied in mid-August was not detected in the petioles. The data indicate that when nitrogen was applied as a preplant or as a sidedressing in mid-June at 60 or 90 pounds per acre, the nitrate level of the petioles was very low or nil 6 to 8 weeks prior to the early harvest. This suggests that for maximum sugar production the level of nitrogen in the petiole should be low for approximately 8 to 12 weeks prior to harvest.

TABLE 16.--The effect of time and rate of application of nitrogen on nitrogen deficiency symptoms of the sugar beets at the time of early harvest[a]

Nitrogen application					
Time	Pounds per acre	1961	1962	1963	Average
		N deficiency ratings			
	0	5.0	4.7	5.0	4.9
Preplant	30	5.0	3.7	5.0	4.6
	60	3.7	3.3	4.7	3.9
	90	3.7	2.7	4.7	3.7
	120	3.0	2.3	3.6	3.0
	150	3.0	2.0	4.0	3.0
Mid-June sidedressing	30	4.0	3.3	4.3	3.9
	60	3.7	2.7	4.0	3.5
	90	3.0	2.0	3.0	2.7
	120	2.7	2.0	2.7	2.5
	150	2.7	2.0	2.3	2.3
Mid-July sidedressing	30	3.7	3.0	4.3	3.7
	60	3.0	2.7	3.3	3.0
	90	2.7	2.0	2.3	2.3
	120	2.3	1.3	2.0	1.9
	150	1.7	2.0	1.7	1.8
Mid-August sidedressing	30	4.0	3.0	4.0	3.7
	60	3.0	1.7	2.7	2.5
	90	2.0	1.0	2.0	1.7
	120	1.7	1.0	2.0	1.6
	150	1.0	1.0	1.7	1.2

[a]Nitrogen rating

1 - Dark abnormally green leaves

2 - Normal green leaf color

3 - Slight yellowing of the leaves

4 - Moderate yellowing of the leaves

5 - Severe yellowing of the leaves

TABLE 17.--The effect of time and rate of application of nitrogen on the nitrate nitrogen content of sugar beet petioles in 1961, 1962 and 1963

Nitrogen application		Date of sampling														
		1961					1962					1963				
Time	Pounds per acre	July 14	July 28	Aug. 14	Sept. 1-2	Sept. 15	July 13	July 31	Aug. 14	Aug. 29	Sept. 14	July 17	July 31	Aug. 14	Aug. 29	Sept. 13
		ppm of nitrate														
	0	14	8	0	0	0	22	8	1	2	0	55	0	0	2	0
	30	40	1	0	0	0	35	2	0	0	0	63	1	0	0	0
	60	76	39	8	3	3	82	48	4	0	0	82	23	1	0	0
Preplant	90	77	23	22	2	1	100+	100+	18	1	0	56	28	4	3	0
	120	100	71	13	2	1	100+	100+	50	1	0	63	75	10	4	0
	150	80	75	18	15	1	100+	100+	82	10	0	100	100	45	4	1
	30	58	40	13	5	2	43	73	3	0	0	100	40	0	0	0
Mid-June	60	55	8	9	2	0	43	3	8	0	0	100	63	15	3	0
sidedressing	90	100	47	82	23	6	77	100	53	2	0	100+	100	29	12	1
	120	100+	50	62	10	6	82	100+	80	13	0	100+	82	57	6	3
	150	100	63	82	30	20	73	100+	100+	22	2	100+	100	63	4	8
	30	23	20	20	2	0	18	82	16	2	0	37	23	1	0	0
Mid-July	60	22	22	82	24	5	22	100+	42	3	0	60	40	18	1	1
sidedressing	90	17	12	100+	63	17	7	100+	82	8	0	45	82	27	10	11
	120	22	90	100	100	72	10	100+	100+	58	4	60	63	25	12	41
	150	23	12	100	82	43	0	100+	100+	97	7	37	100	53	32	23
	30	7	0	0	10	5	2	0	15	0	0	40	0	0	0	0
Mid-August	60	20	0	0	13	63	4	2	0	0	2	40	0	3	0	0
sidedressing	90	55	9	0	20	100	33	33	3	0	50	18	1	0	4	5
	120	8	0	1	28	82	0	2	0	0	75	28	0	0	4	3
	150	17	2	0	37	100	45	23	1	2	43	43	1	3	1	4

General discussion

The data in Table 18 illustrate three combinations of treatments calculated from the three year averages. The "normal" combination was selected to correspond to the most common practice of the commercial sugar beet growers. The "best" combination was selected to give the maximum yield of sugar per acre. The "poorest" combination was selected to obtain the lowest yield of sugar per acre.

TABLE 18.--A comparison of three combination of treatments selected from the three-year averages

Treatment	Treatment combination		
	Best	Normal	Poorest
Rate of application (pounds N per acre)	90	60	0
Time of application of N	Mid-June	Mid-June	———
Date of harvest	Late	Medium	Early

The best combination of treatments occurred where 90 pounds of nitrogen per acre were sidedressed in mid-June to beets harvested late. The poorest combination of treatments was obtained where beets did not receive nitrogen and harvested early. The normal practice of the commercial beet growers was to apply 60 pounds of nitrogen per acre in mid-June and harvest at the medium date.

The yield data corresponding to the treatment combination are shown in Table 19. The best treatment combination selected resulted in 742 and

2167 pounds of sugar per acre higher than the normal and poorest combination, respectively. The best combination of treatments had a root yield advantage over the normal and poorest combinations of 1.8 and 4.8 tons per acre respectively.

TABLE 19.--The effect of three treatment combinations on the yield and sucrose content of sugar beets

Combination	Percent sucrose	Tons roots per acre	Pounds sugar per acre
Best	18.4	21.7	7848
Normal	18.3	19.9	7106
Poorest	17.2	16.9	5681

A summary of the probability levels for significant differences of treatments is given in Table 20. Yield of roots was affected by date of harvest in 1963. This possibly was due to a very dry season followed by rain between the medium and the late harvest dates. This resulted in an increased root yield at the last harvest. The sucrose content and sugar yield were significantly affected by the date of harvest each year. Time of application of nitrogen affected root yields in 1961 and the sucrose content of beets each year. Date of harvest and rate of nitrogen affected sugar yield each year. Time of application of nitrogen affected sugar yield in 1961 and 1962. Yield and sucrose content were affected each year by the rate of application of nitrogen. Differences in beet top yield were obtained each year for each treatment except for the date of harvest in 1963.

A summary of the probability levels for significant differences of

TABLE 20.--Probability levels for significant differences between treatments for 1961, 1962 and 1963[a]

Treatments	1961	1962	1963
	Probability levels		
Date of harvest			
Percent sucrose	.01	.01	.01
Tons of roots per acre	NS	NS	.01
Pounds of sugar per acre	.05	.05	.01
Tons of tops per acre	.05	.01	NS
Time of application of nitrogen			
Percent sucrose	.01	.01	.01
Tons of roots per acre	.01	NS	NS
Pounds of sugar per acre	.01	.05	NS
Tons of tops per acre	.01	.05	.01
Rate of application of nitrogen			
Percent sucrose	.05	.01	.05
Tons of roots per acre	.05	.01	.01
Pounds of sugar per acre	.05	.01	.01
Tons of tops per acre	.01	.01	.01

[a]Taken from appendix tables 61 to 72 inclusive.

interactions is given in Table 21. Although considerable significant differences were noted for the interactions, they contributed a relatively small amount to the observed variability.

The preplant and mid-June sidedressing of nitrogen were approximately equal and both superior to the last two sidedressing times when root and sugar yield are considered. The highest yield of roots and sugar was obtained when beets were harvested late. However, most of the significant differences attributed to date of harvest resulted from higher yield and sucrose content of beets harvested at the medium or late date over beets that were harvested early. There were few instances where beets that were harvested late had higher yields and sucrose content than beets that were harvested at the medium date.

The greatest decrease in sugar yield resulted from nitrogen applications made in mid-July or mid-August to beets harvested early. Nitrogen applied late to beets harvested early resulted in roots of low sucrose content rather than a low root yield. Therefore if nitrogen is not applied till late in the growing season beet harvest should be delayed as long as possible.

Maximum sugar yield was obtained where nitrogen was applied at 90 to 120 pounds per acre as a preplant application, or 60 to 90 pounds per acre as a sidedressing in mid-June.

TABLE 21.--Probability levels for significant differences between interactions for 1961, 1962 and 1963[a]

Interaction	1961	1962	1963
	Probability levels		
Harvest date x Treatments			
Percent sucrose	NS	NS	NS
Tons of roots per acre	NS	NS	NS
Pounds of sugar per acre	.05	NS	.01
Harvest date x Rate of nitrogen			
Percent sucrose	.01	.05	.05
Tons of roots per acre	.05	.05	NS
Pounds of sugar per acre	.01	NS	.05
Time of N application x Rate of N			
Percent sucrose	NS	.05	.05
Tons of roots per acre	.01	.01	NS
Pounds of sugar per acre	.01	.01	NS
Harvest date x Sidedressing of N			
Percent sucrose	.05	.05	NS
Tons of roots per acre	.05	NS	.05
Pounds of sugar per acre	.05	NS	.05
Rate of N x Sidedressing of N			
Percent sucrose	.05	.01	.01
Tons of roots per acre	.05	.01	NS
Pounds of sugar per acre	.05	.01	NS

[a]Taken from appendix tables 61 to 72 inclusive.

EXPERIMENT II

A SURVEY OF THE PRODUCTION PRACTICES AFFECTING YIELD AND SUCROSE CONTENT OF SUGAR BEETS IN ONTARIO, CANADA

LITERATURE REVIEW

The majority of the investigations concerning production practices of sugar beets have dealt mainly with yield of beet roots, with less emphasis on sugar production. Cook et al. (1962) reported that root yields on tile-drained soil were 3.4 tons higher than those on non-tiled soil. Nickol in 1962 stated that "no matter what kind of year -- wet or dry, cold or not, -- the evidence is always the same. Tile drainage is a must for sugar beet production".

Research results on the relationship of tillage practices and sugar beet yields are somewhat controversial. Research on the advantages of fall plowing over spring plowing are not in complete agreement, (Miller, 1943; Lill and Rather, 1943; and Morris and Afanasiev, 1946). Wofford and Dexter (1955) reported that seedbed preparation without tillage produced better and more vigorous stands, and higher yields of beets than where the soil was spring plowed. Cook et al. (1962) reported that beets grown on fall-plowed land out-yielded those on spring-plowed land by 2.4 tons per acre. Morris and Afanasiev (1947) suggested that time of plowing was dependent upon the previous crop.

Deep plowing of soil for sugar beets is generally considered better than shallow plowing (Cook et al., 1962; Morris and Afanasiev, 1946).

However, Doneen (1947) reported that deep plowing had little or no effect on growth, yield and sucrose content of beets. Good stands and yields of sugar beets were obtained by Cook (1950) on plots where the soil had been plowed and fitted in one operation. Similar results were reported by Cook, Davis and Frakes (1962).

In a rotation experiment in Southern Alberta, the sucrose content of sugar beets grown in a legume rotation was consistently lower than that of sugar beets grown in a comparable non-legume rotation. No yield differences were noted. Hill and Dubetz (1952) noted that fall-applied manure or spring-applied commercial nitrogen did not affect the sucrose content of sugar beets. Grimes (1959) reported that legumes in the rotation increased the beet root yield but not the yield of sugar per acre. Nuckols and Harris (1948), however, reported that legumes grown in rotation with sugar beets increased the yield of roots but depressed the sucrose content slightly. Rhoades and Harris (1954) found marked differences in both yield and sucrose content of beets due to cropping practices and manure application over a 37-year period. Robertson et al. in 1952 reported poor yields of beets grown in 1946 to 1950 following alfalfa, although higher yields were previously reported from 1941 to 1945 in the same rotation experiment (Cook et al., 1946). This difference was attributed to moisture fluctuation during the initial five years. Guttay et al. in 1958 observed that lower beet yields were produced where alfalfa preceded the beet crop. Lill and Rather (1943) reported that the number of organisms causing black root of beets was high where the crop followed alfalfa. Corn and soybeans grown preceding the beet crop resulted in a more favourable soil condition than when oats or sugar beets were the preceding crop (Deming, 1948; Lill, 1946; Cook et al., 1962). Stockinger et al. (1963) reported that the effect of cropping sequence was due to the

differences in the soil nitrogen supplying power. This could be offset by nitrogen fertilization. Gregg and Harrison (1950) observed marked differences in beet yields depending upon the type of grass sod in the preceding crop.

The value of livestock manure for beets is dependent upon factors, such as the existing fertility conditions and nitrogen applications. Nuckols (1942) reported that greater returns were obtained with manure on low-yielding fields than on highly productive fields. Moderate applications of manure, approximately 10-12 tons per acre, have given best results where manure has been used in the rotation (Grimes, 1959; Nuckols and Harris, 1948).

Root and sugar yield is markedly influenced by the date of planting of the sugar beet crop. A reduction in root yield of 2 to 4 tons per acre has been reported, due to delayed plantings (Harris et al., 1956; Nuckols, 1946). Many investigations have indicated that the sucrose content of beets was unaffected by the beet planting date (Skuderna, 1942; Harris, et al., 1950; Harris, et al., 1956; Cook et al., 1962). Harris et al. (1950) reported that variations in yield due to the date of planting was associated with the occurrence of early frosts. Nuckols (1946) however, concluded that "any frost damage to early-planted beets was less hazardous than insufficient moisture for the germination of late-planted beets".

Murphy and Carsner (1946) found a progressive decrease in root yield and sucrose content as the row widths increased from 22" to 44". Similar findings have been reported by other workers (Tolman, 1946; Doxtator, 1948; Haddock, 1949). Deming 1948 noted that sugar yield was reduced as row widths increased beyond 20 inches.

The amount of fertilizer to apply to a sugar beet crop depends on many factors. The existing nutrient level and organic matter content is of prime importance (Cook and Turk, 1958). Generally, mineral soils have given best response to sugar beet yields when 600 - 1000 pounds per acre of fertilizer have been applied (Guttay, et al., 1958; Cook and Millar, 1946; Berger, 1950; Cook et al., 1962). The optimum level of nutrients to apply tend to fluctuate with current fertilizer and sugar prices. Davis et al. (1959) in a study of phosphorus and potassium levels reported that potassium slightly increased the sucrose content of the beets.

Several fertilizer placement practices are in use by the beet growers. Research data concerning method of fertilizer application for beets have met with varying results (Cooke, 1949; Cooke, 1951; Davis, et al., 1961). Broadcasting the fertilizer and plowing or discing-in has given as good as, or higher yield of beets than where the fertilizer has been applied as a band application at planting, or by applying the same amount of fertilizer in several applications (Cooke, 1949; Nelson, 1950). Davis et al. (1962) found that planting time fertilizer placed in a band three inches directly below the seed stimulated early growth and increased root and sugar yields over fertilizer that was placed in a band $1\frac{1}{2}$ inches to the side and 3 inches below the seed. Planting-time rates of 6-24-12 at 150 and 300 pounds per acre placed directly below the seed increased root and sugar yield even where 400 and 800 pounds per acre of P_2O_5 had been plowed under.

Production practices concerning the time and rate of nitrogen application and date of harvest on the yield and sucrose content of beets were discussed in Experiment I.

EXPERIMENTAL PROCEDURE

The survey of production practices of sugar beet growers in Southern Ontario was conducted in 1961, 1962 and 1963, with the co-operation of the Canada and Dominion Sugar Company, Chatham Ontario. Each load of beets delivered by the farmers was sampled for sucrose content.

With the assistance of Company fieldmen data were collected from 2618 farmers, representing 29,457 acres of sugar beets. This acreage represents approximately 80 percent of the acreage of the beets grown in Ontario in 1961, 1962 and 1963.

The data were coded and punched on IBM cards for analysis:

List of data collected

1. **District.** Three districts.
2. **Year.** 1961 to 1963.
3. **Fieldmen.** Nine in total.
4. **Soil texture.** Clay and clay loams, sand and sandy loams, combinations.
5. **Tile drained.** Yes, no, partly.
6. **Pounds seed per acre.** (monogerm): 0-0.5, 0.6-0.9, 1.0-1.4, 1.5-1.9, 2.0-2.4, 2.5-2.9, 3.0-3.4, 3.5-3.9, over 3.9.
7. **Pounds seed per acre (processed).** Same breakdown as monogerm classification.
8. **Pounds seed per acre (whole).** 0-0.9, 1.0-1.9, 2.0-2.9, 3.0-3.9, 4.0-4.9, 5.0-5.9, 6.0-6.9, 7.0-7.9, over 7.9.
9. **Pounds seed per acre. Combination (Whole-Processed-Monogerm).** 0-0.5, 0.6-0.9, 1.0-1.4, 1.5-1.9, 2.0-2.4, 2.5-2.9, 3.0-3.4, 3.5-3.9, 4.0-4.5, over 4.5.

10. Previous crop (1st year). Corn, vegetables, beans, wheat, spring grain, clover, alfalfa, sweet clover, grass sod, tobacco, beets, potatoes, others.

11. Legumes preceding years. 1st year, 2nd year, 3rd year, none.

12. Manure application (Tons per acre). 1-4, 5-9, 10-14, 15-19, over 19, none.

13. Manure and year of application. 1963, 1962, 1961, 1960, 1959, 1958, 1957, none.

14. Plowing practice. Fall, spring, none.

15. Depth of plowing (inches). Less than 3.9, 4.0-5.9, 6.0-7.9, 8.0-9.9, 10.0-11.9, over 12.0, not plowed.

16. Soil test. Yes, no.

17. Soil test recommendation followed. Yes, no, partly.

18. Times worked between plowing and planting. 1, 2, 3, 4, 5, 6, 7, 8, 9, over 9.

19. Fertilizer application method. Plowdown, broadcast, drill, combination.

20. Pounds fertilizer with drill (pounds per acre) None, 1-99, 100-199, 200-299, 300-399, 400-499, 500-599, 600-699, 700 and over.

21. Total pounds fertilizer used (pounds per acre) None, 1-199, 200-399, 400-599, 600-799, 800-999, 1000-1199, 1200-1399, 1400 and over.

22. Fertilizer ratio used with drill. 0-x-x, 1-1-1, 1-2-3, 1-3-1, 1-4-2, 1-4-4, 1-6-5, 1-6-3, others.

23. Nitrogen material used. Ammonium nitrate, urea, anhydrous ammonia, nitrate-urea, aqua ammonia, cyanamid, others, none, combination.

24. Nitrogen application method. Pre-plant, sidedress, combination, none.

25. Time of sidedressing nitrogen. Before June 1, June 1-14, June 15-30, July 1-14, July 15-31, August 1-14, August 15 and later, no sidedressing.

26. Total pounds per acre nitrogen used. 0-19, 20-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90-99, 100-119, 120 or more.

27. Total pounds per acre phosphate (P_2O_5) used. 0-49, 50-74, 75-99, 100-124, 125-149, 150-174, 175-199, 200-224, 225-249, 250 or more.

28. Total pounds per acre potash (K_2O) used. 0-24, 25-49, 50-74, 75-99, 100-124, 125-149, 150-174, 175-199, 200-224, 225 or more.

29. Date of planting, actual planting date or average planting date, e.g. Mar. 1-31, Apr. 1-30, May 1-31, June 1-30.

30. Row width (inches). Less than 22, 22, 24, 26, 28, 30, 32, 34, 36, 38 and over.

31. Date of harvest. Before Oct. 1, Oct. 1-7, Oct. 8-14, Oct. 15-21, Oct. 22-28, Oct. 29-Nov. 4, Nov. 5-11, Nov. 12-18, after Nov. 18.

32. Minor elements. No minor elements, boron, manganese, sodium, magnesium, zinc, others, combination.

33. Acres harvested.

34. Total tons beets.

35. Percent sugar.

36. Total tons sugar.

37. County. Eight counties.

38. Townships. Eighty townships.

39. Tons per acre beets.

40. Date planted. Before Mar. 21, Mar. 21-30, Apr. 1-10, Apr. 11-20, Apr. 21-30, May 1-10, May 11-20, May 21-30, May 31-June 9, after June 9.

From these analyses the following list of comparisons were made:

1. Districts.

2. Coarse-textured versus fine-textured soils.

3. Tile drainage.

4. The effect of legumes in preceding years.

5. The effect of previous crops.

6. Manure application - amount.

7. Manure - year of application.

8. Fall plowing versus spring plowing.

9. Depth of plowing.

10. Number of times worked prior to planting.

11. Soil test.

12. Date of planting.

13. Row width.

14. Time of sidedressing nitrogen.

15. Nitrogen application method.

16. Total pounds of nitrogen per acre.

17. Total pounds of phosphate per acre.

18. Total pounds of potash per acre.

19. Fertilizer application method.

20. Date of harvest.

21. Total pounds of fertilizer applied.

22. Relationship of nitrogen material and application method.

23. Relationship of nitrogen material and time of sidedressing nitrogen.

24. Relationship of planting date and date of harvest.

Eleven production practices were selected and used in computing correlation and regression analyses. The computer program CORE 2 ROUTINE was used in these calculations on the CDC 3600 (AES Program Description 4).[a]

The independent variables were:

-- tile drainage
-- date of planting
-- rate of nitrogen
-- row spacing
-- pounds of K_2O per acre
-- pounds of P_2O_5 per acre
-- date of harvest
-- depth of plowing
-- time of plowing
-- legumes grown in preceding years
-- number of times worked

The three dependent variables were: (1) sucrose content (%), (2) tons of roots per acre and (3) pounds of sugar per acre. The regression

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[a]This description was written by D. F. Kiel and W. L. Ruble, Agricultural Experiment Station, Michigan State University, Computer Laboratory, 1963.

coefficients of the production practices represent the actual deviations from the yield and sucrose content ($\hat{Y}_c$). The regression constant ($\hat{Y}_c$) was calculated for sugar beets that were grown the second year after a legume crop, on tiled-drained soil that was spring-plowed at 8-10 inches and then worked 7 times before planting (April 11 to 20) in 26 -inch rows. The partial correlation coefficients indicate the correlation coefficient of a variable when the others are constant.

RESULTS AND DISCUSSION

Data for the individual years are presented with the weighted averages for the three years. The weighted average takes into consideration the number of acres each year for each factor. Unless otherwise stated, the discussion pertains to the weighted averages. Approximately 80 percent of the acreage of beets is grown on fine-textured soils. Where results from coarse-textured soils are discussed, sufficient acreage exists so that reasonable confidence is assured. Any yields represented by less than 500 acres should be interpreted with caution.

The average yield and sucrose content data show considerable variation between the three areas (Table 22). Beets grown on the fine-textured soils in the Wallaceburg area had 2 tons of roots and 1004 pounds of sugar per acre more than beets grown in the Chatham area and 4.3 tons of roots and 1545 pounds of sugar higher than those produced in the Weigh Station areas. The beets grown in the Wallaceburg and Weigh Station areas were approximately 0.6 percent higher in sucrose content than beets grown in the Chatham area. A similar trend in results was obtained from beets grown on the coarse-textured soils.

On the average, beets grown on coarse-textured soils had a root yield 0.6 tons per acre higher than beets grown on fine-textured soils. However, since the sucrose content of beets grown on fine-textured soils was 0.3 percent higher than that of beets grown on coarse-textured soils the yield of sugar was similar (Table 23).

Beets that were grown on tile-drained soil yielded about 4.0 tons of roots and 1200 pounds of sugar per acre higher than beets grown on

TABLE 22.--The effect of districts on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Districts	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Suc. rose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
Chatham	2189	17.2	14.3	4919	2257	17.1	15.8	5404	2618	14.7	17.6	5174	7064	16.2	16.0	5184
Wallaceburg	2261	18.4	15.1	5557	3263	19.3	15.7	6060	3323	16.9	17.7	5983	8847	18.2	17.0	6188
Weigh Stations	1918	15.2	15.4	4682	2342	17.4	16.3	5672	3155	10.4	17.8	3702	7415	13.9	16.7	4643
Coarse-textured soils																
Chatham	1041	18.1	14.0	5068	940	15.8	15.5	4898	667	16.5	17.8	5874	2648	16.9	15.5	5239
Wallaceburg	459	17.1	15.0	5130	1051	19.9	15.2	6050	1211	16.2	17.7	5735	2721	17.8	16.3	5803
Weigh Stations	195	14.0	15.6	4368	312	14.9	16.1	4798	255	11.7	17.8	4165	762	13.6	16.5	4488

TABLE 23.--The effect of soil texture on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Soil texture	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils	6368	17.0	14.9	5066	7862	18.1	15.9	5756	9096	14.0	17.7	4956	23326	16.2	16.3	5281
Coarse-textured soils	1695	17.4	14.4	5011	2303	17.5	15.4	5390	2133	15.7	17.8	5589	6131	16.8	16.0	5376

non-tiled soil (Table 24). Most of the observed differences in sugar production was due to differences in root yield rather than in sucrose content. Statistically,[a] beets grown on non-tiled, coarse-textured soils had a higher sucrose content than beets on tiled soils in 1961 (Table 25). The reverse was true in 1963. In 1963, on fine-textured, tiled-drained soils beets had higher root and sugar yields than beets grown on non-tiled soils (Tables 26 and 27).

The influence of elapsed time between growing an alfalfa or clover crop and growing a sugar beet crop on fine-textured soils is illustrated in Table 28. The lowest root and sugar yield was obtained where legumes had been grown the preceding year. On fine-textured soils this yield was lower than where legumes were not grown in the rotation. Where the legume was grown the second or third year preceding the beet crop sugar yield was approximately 425 pounds per acre higher than that of beets grown immediately after the legume. The sucrose content of beets was higher when legumes were in the rotation than where they were not. The sucrose content of beets increased with increasing proximity of the legumes to the beet crop in the rotation.

The preceding crop had a marked influence on the root and sugar yield of beets grown on fine-textured soils (Table 29). Yield of roots and sugar were 17.0 and 5508, 16.3 and 5314, 15.2 and 5077, 15.6 and 5086 tons and pounds per acre, respectively, where the preceding crop was corn, vegetables, beans, and wheat.

Fifteen percent of the beet acreage received manure in the rotation on fine-textured soils (Table 30). The highest yield of roots and sugar was obtained when 10 to 14 tons per acre of manure were applied. This yield was 2.3 tons of roots and 786 pounds of sugar per acre increase over beets that received 1 to 9 tons of manure per acre. Manure applications

[a]When statistical significance is discussed, reference is made to the 0.05 probability level.

TABLE 24.--The effect of tile drainage on yield and sucrose content of sugar beets in 1961, 1962 and 1963

Tile drainage	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
Yes	5893	17.2	14.9	5122	7561	18.2	15.9	5786	8236	14.4	17.7	5100	21690	16.5	16.3	5345
No	475	14.9	14.8	4491	301	15.2	15.8	4875	860	10.5	17.7	3700	1636	12.6	16.5	4146
Coarse-textured soils																
Yes	1420	17.9	14.3	5111	2256	17.6	15.4	5422	2028	16.1	17.8	5732	5704	17.1	16.0	5445
No	275	14.7	14.7	4350	38	14.4	16.1	4621	105	10.4	17.6	3680	418	13.6	15.6	4206

TABLE 25.--Regression coefficients and partial correlation coefficients of the sucrose content due to various production practices of beets grown on coarse-textured soils

Deviation from:	Variable	1961 Reg'n coeff.	1961 Partial corr. coeff.	1962 Reg'n coeff.	1962 Partial corr. coeff.	1963 Reg'n coeff.	1963 Partial corr. coeff.	Average Reg'n coeff.	Average Partial corr. coeff.
	$\hat{Y}_c$[a]	15.00		16.08		17.78		16.26	
	Non-tiling	1.01	.359**	.22	.024	-.54	-.242*	.20	.026
Planting April 11-20	Apr. 1-10	-.30	-.051	-.29	-.062	-.17	-.073	-.94	-.117*
	Apr.21-30	.56	.078	.14	.078	-.08	-.086	-.32	-.107*
	May 1-10	-.47	-.089	-.25	-.106	-.10	-.132	-.22	-.054
	May 11-20	.18	.036	-.20	-.072	-.13	-.150	-.51	-.123**
	> May 20	-.31	-.059	-.15	-.055	-.20	-.134	-.97	-.177**
26 inch rows	< 26"	.64	.248*	.21	.107	.03	.041	.37	.091
	> 26"	.63	.210*	.41	-.173	.15	.131	.26	.054
Harvest Oct.22-28	< Oct. 15	-.90	-.276**	-.34	-.107	-.92	-.421**	-1.01	-.156**
	Oct.15-21	-.06	-.032	.20	.089	-.19	-.161	-.88	-.213**
	Oct.29-Nov.4	-.21	-.099	.38	-.168	.06	.083	.24	.063
	> Nov. 4	-.12	-.055	-.27	-.138	.06	.080	.36	.100*
Plowed 8-10"	< 8" Plowed	-.41	-.255**	.09	.059	-.00	-.001	.11	.041
	> 10" Plowed	.54	.201*	.16	.018	-.09	-.092	.60	.109*
	Fall plowed	.12	.078	.08	.053	-.09	-.138	.25	.085
Legume 2nd yr. prec.	1st year	--	--	.13	.069	.06	.076	.23	.052
	3rd year	-.44	-.102	.10	.049	.00	.010	-.18	-.039
	none	-.19	-.056	.00	.001	.07	.100	-.76	-.220**
7 times worked	< 4	.32	.117	-.23	-.075	.30	.147	-.34	-.057
	4	.16	.073	-.26	-.111	.15	.168	-.18	-.043
	5	.16	.083	-.13	-.067	.20	.242*	-.16	-.045
	6	.73	.270	-.28	-.108	.07	.076	.27	.059
	> 7	.17	.057	-.07	-.029	.09	.089	.25	.052
	N[b]	-.06	-.219*	-.03	-.127	-.00	-.028	-.01	-.021
	P_2O_5[c]	-.08	-.204*	.04	-.094	.00	.001	.07	.089*
	K_2O[c]	-.06	-.142	-.07	-.163	-.01	-.055	-.08	-.095

[a] $\hat{Y}_c$ = Percent sucrose of beets grown the 2nd year after a legume crop, on tiled-drained soil that was spring-plowed at 8-10", worked 7 times then planted in 26" rows on April 11-20.

[b] Deviations due to 10-pound increments of nitrogen (1st two and 9th increments were 20 pounds).

[c] Deviations due to 25-pound increments of P_2O_5 and K_2O (1st increment of P_2O_5 was 0-49 pounds).

*Denotes significance at 0.05 level.

**Denotes significance at 0.01 level.

TABLE 26.--Regression coefficients and partial correlation coefficients of the root yield due to various production practices of beets grown on fine-textured soils

Deviation from:	Variable	1961 Reg'n coeff.	1961 Partial corr. coeff.	1962 Reg'n coeff.	1962 Partial corr. coeff.	1963 Reg'n coeff.	1963 Partial corr. coeff.	Average Reg'n coeff.	Average Partial corr. coeff.
	$\hat{Y}_c$[a]	15.25		19.93		13.17		17.12	
	Non-tiling	-.52	-.020	-4.60	-.100*	-1.53	-.086*	-3.54	-.116**
	Mar.21-30	.81	.026	--	--	--	--	.30	.003
Plant-	Apr. 1-10	1.99	.108*	.21	.008	-.08	-.005	.65	.032
ing	Apr.21-30	1.18	.043	-.84	-.054	-1.55	-.135**	-.48	-.030
April	May 1-10	-.24	-.014	-2.88	-.120**	-1.57	-.164**	-1.89	-.120**
11-20	May 11-20	-1.04	-.064	-3.00	-.106*	-3.40	-.296**	-2.15	-.140**
	>May 20	-1.52	-.089*	2.82	.077	-3.98	-.204**	-1.20	-.058
26 inch	<26"	-1.38	-.130**	-1.86	-.093*	.28	.026	-.68	-.042
rows	>26"	-1.95	-.147**	-2.60	-.099*	-2.10	-.152**	-2.50	-.122**
	<Oct. 15	-.52	-.052	-.40	-.017	-1.06	-.077	-.58	-.032
Har-	Oct.15-21	-.64	-.065	.89	.045	-1.45	-.122**	.61	.039
vest	Oct.29-Nov.4	.90	.088*	-.69	-.034	.45	.045	-.45	-.029
Oct.22-28	>Nov. 4	.57	.052	.04	.002	1.03	.099*	-.06	-.003
Plowed	<8" Plowed	.29	.043	-.78	-.056	-.95	-.122**	-1.05	-.096**
8-10"	>10" Plowed	.63	.046	-.30	-.009	2.56	.170**	1.05	.046
	Fall plowed	1.09	.061	-.54	.014	-.18	-.011	.49	.019
Legume	1st year	-.83	-.056	-.77	-.042	-.22	-.022	-.70	-.044
2nd year	3rd year	.07	.005	-.56	-.030	-.63	-.053	-.14	-.008
prec.	none	-.52	-.044	.27	.016	-.10	-.011	.40	.030
	<4	-.70	-.055	.42	.017	-.49	-.030	-.02	-.001
7	4	-.42	-.047	-.42	-.023	-.33	-.028	-.17	-.011
times	5	-.56	-.066*	.39	.022	-.47	-.046	-.23	-.016
worked	6	-1.06	-.101*	-.94	-.043	.62	.054	-.50	-.029
	>7	-.90	-.075	-1.81	-.062	.50	.040	-.89	-.046
	N[b]	.31	.234**	.07	.031	.07	.051	-.02	-.010
	P_2O_5[c]	.19	.092*	.02	.003	-.14	-.050	.01	.004
	K_2O[c]	.29	.128**	.15	.032	.71	.289**	.36	.103**

[a] $\hat{Y}_c$ = Tons of root per acre of beets grown the 2nd year after a legume crop, on tiled-drained soil that was spring-plowed at 8-10", worked 7 times then planted in 26" rows on April 11-20.

[b] Deviations due to 10-pound increments of nitrogen (1st two and 9th increments were 20 pounds).

[c] Deviations due to 25-pound increments of P_2O_5 and K_2O (1st increment of P_2O_5 was 0-49 pounds).

*Denotes significance at 0.05 level.

**Denotes significance at 0.01 level.

TABLE 27.--Regression coefficients and partial correlation coefficients of the sugar yield due to various production practices of beets grown on fine-textured soils

Deviation from:	Variable	1961 Reg'n coeff.	1961 Partial corr. coeff.	1962 Reg'n coeff.	1962 Partial corr. coeff.	1963 Reg'n coeff.	1963 Partial corr. coeff.	Average Reg'n coeff.	Average Partial corr. coeff.
	$\hat{Y}_c$[a]	4653		6423		4739		5660	
	Non-tiling	-232	-.031	-1599	-.103*	-558	-.088*	-994	-.101**
	Mar.21-30	703	.075	--	--	--	--	-51	-.001
Plant-	Apr. 1-10	673	.124**	-8	-.000	-37	.006	22	.003
ing	Apr.21-30	499	.061	-254	-.049	-558	-.137**	-243	-.047
April	May 1-10	75	.014	-858	-.106*	-560	-.165**	-627	-.123**
11-20	May 11-20	-208	-.043	-1019	-.106*	-1207	-.296**	-973	-.195**
	>May 20	-241	-.048	963	.077	-1398	-.202**	-641	-.096**
26 inch	<26"	-452	-.144**	-560	-.082	97	.024	-225	-.043
rows	>26"	-513	-.131**	-807	-.091*	-750	-.153**	-740	-.112**
Har-	<Oct. 15	-398	-.133**	-196	-.025	-553	-.113**	-359	-.061
vest	Oct.15-21	-215	-.073	344	.051	-637	-.150**	-15	-.003
Oct.	Oct.29-Nov.4	316	.105**	-286	-.041	193	.053	-11	-.002
22-28	>Nov. 4	163	.050	-45	-.006	393	.106**	82	.016
Plowed	< 8" Plowed	103	.052	-166	-.035	-345	-.124**	-260	-.073*
8-10"	>10" Plowed	239	.059	-179	-.016	873	.163**	383	.052
	Fall plowed	329	-.063	194	.014	-59	-.010	102	.012
Legume	1st year	-217	-.050	-231	-.037	-94	-.026	-215	-.042
2nd year	3rd year	12	.002	-192	-.031	-236	-.056	-136	-.024
prec.	none	-208	-.059	86	.015	-34	-.010	-50	-.011
	< 4	-335	-.089*	185	.022	-172	-.029	-74	-.011
7	4	-161	-.061	-56	-.009	-108	-.026	-53	-.010
times	5	-286	-.112**	134	.022	-154	-.042	-105	-.022
worked	6	-354	-.114**	-283	-.038	227	-.056	-136	-.025
	>7	-286	-.081	-530	-.054	185	-.042	-173	-.027
	N[b]	83	.210**	6	.007	23	.046	4	.006
	P_2O_5[c]	60	.097*	19	.010	-55	-.052	8	.006
	K_2O[c]	61	.091*	23	.015	245	.281**	124	.108**

[a] $\hat{Y}_c$ = Pounds sugar per acre of beets grown the 2nd year after a legume crop, on tiled-drained soil that was spring-plowed at 8-10", worked 7 times then planted in 26" rows on April 11-20.

[b] Deviations due to 10-pound increments of nitrogen (1st two and 9th increments were 20 pounds).

[c] Deviations due to 25-pound increments of P_2O_5 and K_2O (1st increment of P_2O_5 was 0-49 pounds).

*Denotes significance at 0.05 level.

**Denotes significance at 0.01 level.

TABLE 28.--The effect of legumes the preceding years on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Legumes preceding year	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
							Fine-textured soils									
1st year	661	15.7	15.2	4773	1614	17.4	15.9	5533	2336	13.4	17.7	4744	4611	15.1	16.7	5043
2nd year	483	17.9	15.0	5370	2538	17.7	15.8	5593	2433	14.3	17.7	5062	5454	16.6	16.6	5511
3rd year	457	17.4	14.8	5150	1506	18.9	16.0	6048	1133	13.6	17.7	4814	3096	16.7	16.4	5478
None	4767	17.1	14.9	5096	2204	18.6	15.9	5915	3194	14.5	17.7	5133	10165	16.6	16.0	5312
							Coarse-textured soils									
1st year	—	—	—	—	401	15.0	15.7	4710	412	15.9	17.8	5660	813	15.5	16.8	5191
2nd year	83	17.3	14.6	5052	820	17.6	15.7	5526	645	16.4	17.7	5806	1548	17.1	16.5	5617
3rd year	149	18.4	14.4	5299	372	19.0	14.4	5472	340	16.4	17.7	5806	861	17.9	15.7	5574
None	1463	17.3	14.4	4982	710	18.1	15.5	5611	736	14.7	17.8	5233	2909	16.8	15.5	5199

TABLE 29.--The effect of the previous crop on the yield and sucrose content of sugar beets grown on fall-plowed, fine-textured soils in 1961, 1962 and 1963

Previous crop	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Corn	2304	17.7	14.7	5204	3100	18.4	15.8	5814	3327	15.1	17.7	5345	8731	17.0	16.2	5508
Vegetables	749	18.0	14.8	5328	11	15.7	15.9	4993	849	14.9	17.7	5275	1609	16.3	16.3	5314
Beans	561	16.4	15.3	5018	1049	17.8	15.8	5625	1650	13.2	17.7	4673	3260	15.2	16.7	5077
Wheat	1189	16.9	14.9	5036	1315	17.4	16.0	5568	1423	12.9	17.7	4567	3927	15.6	16.3	5086
Small grains	282	17.7	15.0	5310	—	—	—	—	590	12.9	17.8	4592	872	14.5	16.9	4901
Clover	429	14.9	15.4	4589	370	16.4	15.9	5215	289	13.3	17.7	4708	1088	15.0	16.2	4860
Grass sod	101	14.5	15.5	4495	31	13.9	16.7	4643	62	13.5	17.6	4752	194	14.1	16.4	4625
Beets	41	14.4	14.7	4234	11	14.2	15.1	4288	41	11.7	17.6	4118	93	13.2	16.0	4224
Alfalfa	144	17.4	15.0	5220	128	19.0	16.2	6156	116	13.3	17.7	4708	388	16.7	16.2	5411

TABLE 30.--The effect of the amount of manure applied on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Manure application tons per A.	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
1-9	486	16.0	15.3	4896	558	16.7	15.7	5244	596	13.8	17.7	4885	1640	15.4	16.3	5020
10-14	477	18.4	14.9	5483	488	18.5	15.8	5846	725	16.7	17.7	5912	1690	17.7	16.4	5806
15-19	255	18.9	14.7	5557	427	19.1	15.9	6074	281	17.2	17.7	6089	963	17.2	16.1	5506
19 or more	141	18.2	14.4	5242	194	19.2	15.6	5990	209	18.6	17.8	6622	544	18.7	16.1	6021
None	5009	16.9	14.9	5036	6205	18.1	15.9	5756	7285	13.5	17.7	4779	18499	16.0	16.3	5216

did not affect the sucrose content of beets. The highest root and sugar yield of beets grown on fine-textured soils was obtained where manure was applied during the preceding year (Table 31). Beets grown on soil that received manure in the rotation had a higher sugar yield than beets on unmanured soil. The farther the manure application was from the beet crop year the lower the root yield, but the higher the sucrose content of the beets.

Beets grown on fall-plowed soil produced approximately 1 ton of roots and 300 pounds of sugar per acre more than beets grown on spring-plowed soil (Table 32). In 1962 and 1963, beets on tiled-drained, fine-textured soils had a significantly higher yield of sugar than beets on untiled soil (Table 31). Time of plowing did not affect the sucrose content of beets (Table 33). Approximately 90 percent of the fine-textured soils and about 70 percent of the coarse-textured soils were fall-plowed for the beets. In Ontario fall plowing is recommended for fine-textured soils but not for coarse-textured soils. The lowest yield was obtained where soil was plowed less than 8 inches deep (Table 34). Root and sugar yields gradually increased as the depth of plowing increased on the fine-textured soils. Beets grown on fine-textured soils that had been plowed deeper than 10 inches had a 2.3 tons of roots and a 654 pounds of sugar per acre increase over beets grown on soil that had been plowed less than 8 inches. The statistical values (Tables 26 and 27) indicate that root and sugar yield in 1963 of beets on soil plowed less than 8 inches was negatively correlated with beets on soil plowed 8 to 10 inches, and positively correlated with beets on soil plowed more than 10 inches. Beets grown on fine-textured soils that were plowed more than 10 inches produced 873 pounds of sugar per acre more than beets on soil plowed at 8 to 10 inches deep. Maximum yield of roots and sugar of beets grown on

TABLE 31.--The effect of the year of application of manure on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Year of application of manure	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
1st year preceding	588	19.0	14.7	5586	727	18.3	15.5	5673	614	17.3	17.7	6124	1929	18.2	16.0	5824
2nd year preceding	477	17.2	15.1	5194	685	18.2	16.0	5824	729	15.6	17.7	5522	1891	16.9	16.4	5543
3rd year preceding	225	15.6	15.4	4805	185	17.9	15.8	5656	413	15.0	17.7	5310	823	16.7	16.6	5544

TABLE 32.--The effect of time of plowing on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Plowing practice	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
Fall	5881	17.1	14.9	5096	7507	18.2	15.9	5788	8471	14.0	17.7	4956	21859	16.3	16.3	5314
Spring	182	15.1	15.0	4530	272	17.2	15.7	5401	488	14.3	17.6	5034	942	15.3	16.5	5049
Not plowed	305	16.3	15.3	4988	83	16.1	16.3	5249	126	11.5	18.0	4140	514	15.1	16.1	4862
Coarse-textured soils																
Fall	1148	17.5	14.4	5040	1584	18.3	15.4	5636	1566	15.7	17.7	3558	4298	17.1	16.0	5472
Spring	531	17.1	14.5	4959	701	15.8	15.5	4898	550	15.8	17.8	5625	1782	16.2	15.9	5152
Not plowed	16	12.9	15.5	3999	18	16.8	15.5	5208	17	13.2	18.0	4752	51	14.4	16.3	4694

TABLE 33.--Regression coefficients and partial correlation coefficients of the sucrose content due to various production practices of beets grown on fine-textured soils

Deviation from:	Variable	1961 Reg'n coeff.	1961 Partial corr. coeff.	1962 Reg'n coeff.	1962 Partial corr. coeff.	1963 Reg'n coeff.	1963 Partial corr. coeff.	Average Reg'n coeff.	Average Partial corr. coeff.
	$\hat{Y}_c$[a]	15.35		16.09		17.98		16.58	
	Non-tiling	-.21	-.031	-.31	-.062	-.02	-.015	.70	.098**
	Mar. 21-30	1.11	.131**	--	--	--	--	-.34	-.016
Planting	Apr. 1-10	.17	.034	-.14	-.056	-.03	-.022	-.45	-.096*
April	Apr. 21-30	.31	.043	.09	.056	-.03	-.028	-.20	-.056
11-20	May 1-10	.35	.076	.23	.092*	-.00	-.001	.05	.016
	May 11-20	.17	.040	-.13	-.045	-.01	-.017	-.74	-.205**
	>May 20	.50	.109**	.05	.015	.06	.031	-.78	-.160**
26 inch	<26"	-.06	-.022	.12	.056	-.02	-.024	.04	-.012
rows	>26"	.27	.077	.10	.038	-.01	-.009	.27	.058
Har-	<Oct. 15	-.80	-.285**	-.29	-.118**	-.67	-.441**	-.60	-.140**
vest	Oct. 15-21	-.04	-.017	.16	.076	-.46	-.363**	-.65	-.179**
Oct.	Oct. 29-Nov. 4	.09	.036	-.21	-.097*	.10	.100*	.40	.111**
22-28	>Nov. 4	-.02	-.007	-.19	-.093*	.06	.064	.30	.085**
Plowed	<8" Plowed	.04	.025	.24	.160**	-.00	-.002	.30	.120**
8-10"	>10" Plowed	.17	.047	-.24	-.069	-.11	-.077	.02	.004
	Fall plowed	.01	-.003	.04	.011	-.00	-.001	-.16	-.027
Legume	1st year	.16	.041	.03	.017	-.06	-.066	.03	.008
2nd yr.	3rd year	-.02	-.006	-.05	-.026	-.05	-.043	-.28	-.071*
prec.	none	-.15	-.047	-.02	-.014	.01	.012	-.58	-.188**
	<4	-.34	-.101*	.12	.048	-.00	-.004	-.21	-.044
7	4	-.07	-.031	.23	.116**	.04	.041	.00	.000
times	5	-.28	-.123**	-.01	-.005	.05	.050	-.07	-.021
worked	6	-.09	-.035	.01	.005	.03	.027	.05	.013
	>7	-.08	-.026	.15	.049	.01	.015	.31	.068*
	N[b]	-.03	-.102*	-.04	-.160**	-.01	-.072	.04	.101**
	P_2O_5[c]	.01	.023	-.04	-.133**	-.00	-.016	.02	-.011
	K_2O[c]	.07	-.128**	-.06	.069	-.02	-.105*	-.00	.026

[a]$\hat{Y}_c$ = Percent sucrose of beets grown the 2nd year after a legume crop, on tiled-drained soil that was spring-plowed at 8-10", worked 7 times then planted in 26" rows on April 11-20.

[b]Deviations due to 10-pound increments of nitrogen (1st two and 9th increments were 20 pounds).

[c]Deviations due to 25-pound increments of P_2O_5 and K_2O (1st increment of P_2O_5 was 0-49 pounds).

*Denotes significance at 0.05 level.

**Denotes significance at 0.01 level.

TABLE 34.--The effect of depth of plowing on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Depth of plowing	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
8.0"	2365	16.4	15.0	4920	2840	17.1	16.1	5506	3759	12.9	17.7	4567	8964	15.2	16.5	5016
8.0-9.9"	3251	17.4	14.8	5150	4575	18.7	15.8	5909	4538	14.6	17.7	5168	12364	16.9	16.2	5476
10.0-11.9"	447	18.3	15.1	5527	346	17.7	15.6	5522	574	16.8	17.5	5880	1367	17.5	16.2	5670
Coarse-textured soils																
8.0"	777	17.2	14.3	4919	883	15.7	15.7	4930	976	15.4	17.7	5452	2636	16.0	16.0	5120
8.0-9.9"	709	17.6	14.4	5069	1388	18.8	15.2	5715	893	16.0	17.8	5696	2990	17.7	15.8	5593
10.0-11.9"	156	17.5	14.9	5215	14	15.0	16.0	4800	166	15.5	17.7	5487	336	16.4	16.3	5346

coarse-textured soils was obtained where soil was plowed between 8 and 10 inches deep.

The times worked refers to the number of times a field was worked after plowing and prior to planting. The number of times worked did not materially affect root and sugar yield of beets grown on fine-textured soils (Table 35). The advantage in minimum tillage is due to the reduced labor and power requirements. On coarse-textured soils (Table 36) root and sugar yield decreased slightly when soil was worked more than four times. Statistically, the number of times a field was worked had no affect on the yield and sucrose content of beets.

There was practically no differences in root or sugar yield where beets were grown on fields that had been tested as compared to those grown on areas not tested. (Table 37).

Beet planting in Ontario usually occurs during the months of April and May. Ten-day planting intervals were recorded in this survey. On fine-textured soils (Table 38) beet root and sugar yields gradually decreased when planting was delayed beyond April 1 to 10. A marked decline in yield occurred when beets were planted later than the month of April. The sucrose content appeared to decrease when beets were planted later than May 10. Beets that were planted between April 11 and May 10 had the highest sucrose content. Statistically the date of planting was a principle cause of variation in root and sugar yield of beets in 1962 and 1963 (Tables 26 and 27). The yield of beets planted later than April 30 in 1962 and later than April 20 in 1963 were negatively correlated with the yield of beets planted April 11 to 20. In 1963 the average sugar yield was reduced about 900 pounds per acre for each 10-day delay of planting later than April 20.

TABLE 35.--The effect of the number of times worked prior to planting on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Times worked	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
2	154	19.4	14.4	5587	89	19.2	16.2	6221	84	14.3	17.8	5091	327	18.0	15.8	5688
3	368	16.6	14.6	4847	732	18.7	16.0	5984	434	12.5	17.4	4350	1534	16.4	16.1	5281
4	1498	16.7	15.0	5010	1472	17.4	16.1	5603	1241	13.9	17.7	4921	4211	16.1	16.5	5313
5	1534	16.8	14.8	4973	1734	18.0	15.8	5688	1842	14.1	17.7	4991	5110	16.2	16.2	5249
6	1329	17.5	15.0	5250	2255	18.3	15.8	5783	2315	14.3	17.7	5062	5899	16.6	16.4	5445
7	864	17.2	14.9	5126	1106	18.6	15.8	5878	1629	13.9	17.7	4921	3599	16.1	16.4	5281
8	366	16.3	14.7	4792	265	17.4	15.7	5464	509	13.7	17.8	4877	1140	15.4	16.3	5020

TABLE 36.--The effect of the number of times worked prior to planting on the yield and sucrose content of sugar beets grown on coarse-textured soils in 1961, 1962 and 1963

Times worked	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
2	46	19.5	14.5	5655	27	19.6	15.0	5880	15	17.4	17.9	6229	88	19.2	15.2	5837
3	120	20.0	14.4	5760	207	18.6	13.1	4873	39	15.6	17.8	5554	366	18.7	14.0	5236
4	337	17.7	14.1	4991	388	18.7	15.6	5834	397	17.7	17.8	6301	1122	18.0	15.9	5724
5	519	17.3	14.4	4982	733	18.1	15.7	5683	585	15.7	17.8	5589	1837	17.1	16.0	5472
6	379	16.7	14.4	4810	376	17.6	15.9	5597	508	14.1	17.6	4963	1263	15.9	16.1	5120
7	181	16.0	14.8	4736	259	17.0	15.3	5202	300	15.4	17.7	5452	740	16.1	16.2	5216
8	79	16.9	14.5	4901	129	9.8	15.7	3077	138	16.1	17.7	5699	346	13.9	16.2	4504

TABLE 37.--The effect of soil test on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Soil test	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
Yes	1277	17.9	14.8	5298	856	18.5	16.1	5957	978	13.1	17.7	4637	3111	16.6	16.1	5345
No	5091	16.8	14.9	5006	7006	18.1	15.9	5756	8118	14.1	17.7	4991	20215	16.2	16.4	5314
Coarse-textured soils																
Yes	624	18.7	13.9	5199	501	14.5	15.4	4466	185	17.4	17.9	6229	1310	16.9	15.0	5070
No	1071	16.6	14.7	4880	1802	18.4	15.4	5667	1948	15.6	17.7	5522	4821	16.9	16.2	5476

TABLE 38.--The effect of date of planting on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Date of planting	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Apr. 1-10	641	20.0	14.7	5880	666	19.5	15.7	6123	789	15.6	17.6	5491	2096	18.2	16.1	5860
Apr. 11-20	218	19.7	13.7	5398	3343	18.6	15.8	5878	3248	15.2	17.7	5381	6809	17.0	16.6	5644
Apr. 21-30	151	19.1	14.8	5654	2289	18.0	16.0	5760	1113	13.6	17.7	4814	3553	16.7	16.5	5511
May 1-10	1068	17.5	14.9	5215	769	16.1	16.1	5184	2267	14.3	17.7	5062	4104	15.5	16.7	5177
May 11-20	2801	16.4	14.9	4887	344	15.9	15.9	5056	1314	11.1	17.7	3929	4459	14.8	15.8	4677
May 21-30	1076	15.3	15.3	4682	62	13.4	16.3	4368	328	9.8	17.8	3489	1466	14.0	15.9	4452

The effect of planting date on the yield of beets grown on coarse-textured soils was similar to that obtained on the fine-textured soils, (Tables 39, 40 and 41).

Approximately 66 percent of the beets were planted in 24-inch rows. The root and sugar yield was reduced where beets were planted in rows wider than 26 inches (Table 42). Beets planted in 26-inch rows on fine-textured soils had a root and sugar yield increase of 3.8 tons and 1091 pounds per acre, respectively, over beets planted in 28-inch rows. On coarse-textured soils beets planted in 26-inch rows had a root and sugar increase of 2.9 tons and 887 pounds per acre, respectively, over beets planted in 28-inch rows. Row spacing did not affect the sucrose content of beets. The statistical values indicate that each year for beets planted on fine-textured soils in rows wider than 26 inches the root and sugar yield was significantly lower than that from beets planted in 26-inch rows. In 1961, 1962 and 1963 this reduction was 513, 807 and 750 pounds of sugar per acre, respectively (Table 27).

The highest root and sugar yield on fine-textured soils was obtained when fertilizer was applied as a combination of the drill and broadcast methods (Table 43). The drill method of fertilizer application refers to fertilizer that was applied at planting in a band to one side and below, or directly below the seed. Beets grown on soils to which fertilizer was broadcast had a higher root and sugar yield than beets to which fertilizer was applied at planting time. The method of fertilizer application did not affect the sucrose content of beets.

The maximum root and sugar yield of beets on coarse-textured soils was obtained where the fertilizer was broadcast. Beets with which fertilizer was drilled at planting time produced the lowest yield of sugar and

TABLE 39.--The effect of date of planting on the yield and sucrose content of sugar beets grown on coarse-textured soils in 1961, 1962 and 1963

Date of planting	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Apr. 1-10	133	20.2	13.8	5575	52	19.8	16.6	6574	64	17.6	17.8	6266	249	19.4	15.4	5975
Apr. 11-20	56	20.4	14.2	5794	702	18.8	15.7	5903	442	15.6	17.8	5554	1200	17.7	16.4	5806
Apr. 21-30	56	18.9	15.1	5708	791	19.6	15.0	5880	263	16.0	17.7	5664	1110	18.7	15.6	5834
May 1-10	361	17.9	14.2	5084	320	13.3	15.6	4150	673	16.6	17.8	5910	1354	16.2	16.3	5281
May 11-20	758	16.6	14.7	4880	110	15.8	15.8	4993	568	14.7	17.7	5204	1436	15.8	16.0	5056
May 21-30	174	16.7	14.2	4743	68	12.4	15.9	3943	123	14.9	17.7	5275	365	15.3	15.7	4804

TABLE 40.--Regression coefficients and partial correlation coefficients of the root yield due to various production practices of beets grown on coarse-textured soils

Deviation from:	Variable	1961 Reg'n coeff.	1961 Partial corr. coeff.	1962 Reg'n coeff.	1962 Partial corr. coeff.	1963 Reg'n coeff.	1963 Partial corr. coeff.	Average Reg'n coeff.	Average Partial corr. coeff.
	$\hat{Y}_c$[a]	17.03		15.98		11.38		14.69	
	Non-tiling	-1.96	-.177	-.38	-.008	-1.98	-.085	-1.45	-.073
	Apr. 1-10	-1.36	-.056	-.29	-.012	-2.47	-.097	.66	.032
Plant-	Apr.21-30	-1.99	-.067	-.78	-.091	.00	.000	-.05	-.005
ing	May 1-10	-4.03	-.181	-3.19	-.268**	.09	.010	-1.28	-.120*
April	May 11-20	-4.13	-.192*	-2.46	-.177	-1.38	-.144	-1.45	-.133**
11-20	> May 20	-4.54	-.205*	-3.70	-.268**	-.86	-.053	-2.00	-.141**
26 inch	<26"	-.47	-.046	-.88	-.091	.72	.070	-.49	-.046
rows	>26"	.88	.072	-.18	-.016	-1.07	-.084	-.26	-.021
	<Oct. 15	-.27	-.021	1.4	.097	1.52	.069	1.02	.061
Har-	Oct.15-21	-1.54	-.178	-2.0	-.188	.59	.044	-.10	-.010
vest	Oct.29-Nov.4	1.77	.198*	1.69	.154	.43	.049	.52	.052
Oct.22-28	> Nov. 4	1.32	.143	.99	.107	.90	.105	.55	.058
Plowed	<8" Plowed	-.36	-.056	-2.18	-.276**	-.98	-.134	-1.28	-.172**
8-10"	>10" Plowed	-1.39	-.127	-4.87	-.113	.31	.027	-.92	-.064
	Fall plowed	1.10	.161	- .46	-.059	-.15	-.020	-.11	-.015
Legume	1st year	--	--	-1.74	-.185	-.84	-.092	-1.43	-.124**
2nd year	3rd year	1.80	.101	-1.01	-.097	.25	.024	.11	.009
prec.	none	.35	.025	-1.25	-.154	-.82	-.104	-.27	-.031
	<4	1.71	.148	2.69	.181	2.40	.105	2.89	.182**
7	4	-.76	-.080	-.41	-.037	1.37	.135	.70	.063
times	5	-.53	-.067	1.04	.114	.21	.023	.68	.072
worked	6	-.87	-.080	-.74	-.059	.03	.002	-.37	-.030
	>7	.03	-.002	-.82	-.067	.48	.043	-.23	-.018
	N[b]	.30	.267**	.36	.280**	.24	.183	.29	.222**
	P_2O_5[c]	.15	.095	.51	.224*	.07	.029	.23	.107*
	K_2O[c]	.28	.139	.27	.134	.56	.266**	.30	.143**

[a] $\hat{Y}_c$ = Tons of roots per acre of beets grown the 2nd year after a legume crop, on tiled-drained soil that was spring-plowed at 8-10", worked 7 times then planted in 26" rows on April 11-20.

[b] Deviations due to 10-pound increments of nitrogen (1st two and 9th increments were 20 pounds).

[c] Deviations due to 25-pound increments of P_2O_5 and K_2O (1st increment of P_2O_5 was 0-49 pounds).

* Denotes significance at 0.05 level.

** Denotes significance at 0.01 level.

TABLE 41.--Regression coefficients and partial correlation coefficients of the sugar yield due to various production practices of beets grown on coarse-textured soils

Deviation from:	Variable	1961 Reg'n coeff.	1961 Partial corr. coeff.	1962 Reg'n coeff.	1962 Partial corr. coeff.	1963 Reg'n coeff.	1963 Partial corr. coeff.	Average Reg'n coeff.	Average Partial corr. coeff.
	$\hat{Y}_c$[a]	5026		5119		4048		4732	
	Non-tiling	-215	-.065	-52	-.003	-870	-.103	-357	-.059
	Apr. 1-10	-477	-.065	-174	-.025	-933	-.104	-128	-.020
Plant-	Apr. 21-30	-294	-.033	-188	-.072	-24	-.006	-102	-.030
ing	May 1-10	-1278	-.190*	-1053	-.289**	-1	-.000	-452	-.137**
April	May 11-20	-1095	-.169	-823	-.195*	-534	-.158	-613	-.182**
11-20	> May 20	-1393	-.208*	-1198	-.285**	-358	-.063	-928	-.211**
26 inch	< 26"	92	.029	-187	-.064	270	.073	- 6	-.002
rows	> 26"	485	.131	94	.027	-330	-.073	4	-.001
Har-	< Oct. 15	-369	-.093	393	.084	279	.036	18	.003
vest	Oct. 15-21	-452	-.173	-560	-.169	152	.032	-289	.089
Oct.	Oct. 29-Nov. 4	442	.164	376	.113	180	.057	237	.076
22-28	> Nov. 4	375	.134	228	.081	353	.116	309	.106*
Plowed	< 8" Plowed	-243	-.123	-667	-.278**	-352	-.136	-380	-.166**
8-10"	> 10" Plowed	-183	-.055	-1557	-.120	84	.020	-82	.018
	Fall plowed	352	.170	-124	-.053	-81	-.030	35	.014
Legume	1st year	--	--	-513	-.179	-282	-.087	-393	-.111*
2nd year	3rd year	378	.071	-274	-.087	92	.026	-20	-.005
prec.	none	66	.015	-410	-.165	-273	-.097	-359	-.132**
	< 4	602	.173	741	.165	933	.116	783	.161**
7	4	-179	-.062	-280	-.083	525	.146	170	.050
times	5	-96	-.040	253	.091	126	.039	159	.055
worked	6	1	.000	-345	-.091	22	.005	-30	-.008
	> 7	77	.021	-305	-.083	189	.048	25	.006
	N[b]	66	.196*	106	.270**	87	.184	87	.219**
	P_2O_5[c]	12	.024	181	.260**	22	.023	44	.066
	K_2O[c]	60	.100	62	.100	201	.270**	127	.196**

[a] $\hat{Y}_c$ = Pounds sugar per acre of beets grown the 2nd year after a legume crop, on tiled-drained soil that was spring-plowed at 8-10", worked 7 times then planted in 26" rows on April 11-20.

[b] Deviations due to 10-pound increments of nitrogen (1st two and 9th increments were 20 pounds).

[c] Deviations due to 25-pound increments of P_2O_5 and K_2O (1st increment of P_2O_5 was 0-49 pounds).

*Denotes significance at 0.05 level.

**Denotes significance at 0.01 level.

TABLE 42.--The effect of row width on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Row width (inches)	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
24	4512	17.1	14.8	5062	5374	18.1	15.9	5756	6023	14.6	17.7	5168	15909	16.5	16.3	5379
26	731	18.9	14.9	5632	1168	19.2	15.7	6029	1114	16.0	17.7	5664	3013	17.9	16.2	5800
28	951	15.6	15.4	4805	1204	17.1	16.1	5506	1803	11.2	17.7	3965	3958	14.1	16.7	4709
30 or more	129	16.1	14.4	4637	86	16.4	16.2	5314	128	9.6	17.6	3379	343	13.7	16.0	4384
Coarse-textured soils																
24	1111	17.7	14.4	5098	1280	18.9	15.3	5783	1533	16.0	17.7	5664	3924	17.4	16.0	5568
26	230	17.8	14.1	5020	300	18.7	15.2	5685	274	16.3	17.9	5835	804	17.6	15.8	5562
28	349	16.1	14.8	4766	712	14.5	15.7	4553	310	13.5	17.8	4806	1371	14.7	15.9	4675

TABLE 43.--The effect of method of application of fertilizer on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Fertilizer application method	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
Broadcast	923	17.4	15.0	5220	1144	17.8	15.7	5589	1328	14.5	17.6	5104	3395	16.4	16.3	5346
Drill	2486	15.7	15.0	4710	2234	17.7	16.1	5699	2687	12.5	17.7	4425	7407	15.1	16.3	4923
Combination	2920	18.0	14.8	5328	4451	18.4	15.8	5814	5080	14.7	17.7	5204	12451	16.8	16.3	5477
Coarse-textured soils																
Broadcast	187	16.7	14.8	4943	407	18.3	15.7	5746	402	16.2	17.8	5767	996	17.2	16.4	5642
Drill	338	15.7	14.6	4584	356	16.1	15.9	5120	396	15.7	17.6	5526	1090	15.8	16.1	5088
Combination	1163	17.9	14.3	5119	1540	17.6	15.3	5386	1330	15.6	17.8	5554	4033	17.0	15.8	5372

roots. Beets grown on soil where fertilizer was broadcast had a 0.6 higher sucrose content than beets that were grown on soil that received fertilizer in a combination of methods.

Beets grown on soils to which nitrogen was applied as a preplant had higher root and sugar yields than beets that received nitrogen as a sidedressing (Table 44). On fine-textured soils, beets that had nitrogen as a preplant application resulted in an increase of 1.3 tons of roots and 459 pounds of sugar per acre more than beets to which nitrogen was applied as a sidedressing. The method of nitrogen application did not affect the sucrose content of the beets. Approximately 60 percent of the beets received nitrogen as a sidedressing; whereas, about 20 percent of the beets received nitrogen as a preplant application. The remaining 20 percent of the beets received no additional nitrogen other than that applied with the mixed fertilizer.

The percent sucrose was not affected by the time of sidedressing nitrogen (Table 45). When beets received nitrogen later than a mid-June sidedressing marked reductions in root and sugar yield resulted.

The root and sugar yield of beets that received nitrogen as a preplant application (Table 44) was similar to the yield when beets received nitrogen as an early sidedressing (June 1 to 14, Table 45). Therefore, the yield advantage of beets that received nitrogen as a preplant application over beets that received nitrogen as a sidedressing (Table 44) was possibly due to nitrogen sidedressings that were made later than mid-June.

The root and sugar yield of beets grown on fine-textured soils gradually increased with increasing rates of nitrogen up to 70 to 90 pounds per acre (Table 46). Beyond this rate of nitrogen yields appeared to level off. The sucrose content of beets was not affected by nitrogen applications

TABLE 44.--The effect of method of application of nitrogen on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Nitrogen application method	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
Preplant	980	19.1	14.8	5654	1168	19.3	15.7	6060	2167	15.8	17.6	5562	4315	17.5	16.4	5740
Sidedress	3820	16.8	15.0	5040	5199	18.4	15.9	5851	5256	13.7	17.7	4850	14275	16.2	16.3	5281
Combination	85	17.0	15.3	5202	8	16.1	16.1	5184	230	15.6	17.9	5585	323	16.0	17.2	5504
Coarse-textured soils																
Preplant	365	18.4	14.4	5299	589	18.5	14.7	5439	668	16.9	17.8	6016	1622	17.8	15.9	5660
Sidedress	902	17.4	14.3	4976	1333	17.5	15.6	5460	1139	15.7	17.7	5558	3374	16.9	16.0	5408
Combination	62	16.0	14.6	4672	365	16.0	15.8	5056	40	18.0	18.0	6480	467	16.2	15.8	5119

TABLE 45.--The effect of time of sidedressing nitrogen on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Time of sidedressing nitrogen	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
<June 1	11	19.1	14.9	5692	304	17.7	15.6	5522	119	12.4	17.8	4414	434	16.3	16.2	5281
June 1-14	735	18.4	14.8	5446	2101	18.9	16.0	6048	2471	15.2	17.6	5350	5307	17.1	16.6	5677
June 15-30	2315	16.8	14.9	5006	2745	18.1	15.9	5756	2361	13.3	17.7	4708	7421	16.2	16.2	5249
July 1-14	802	15.6	15.3	4774	106	16.4	15.9	5215	468	9.9	17.3	3425	1376	13.7	16.0	4384
Coarse-textured soils																
<June 1	43	19.9	13.4	5333	152	19.9	15.4	6129	—	—	—	—	195	19.9	15.0	5970
June 1-14	272	19.1	14.0	5348	395	18.6	15.9	5915	420	16.0	17.7	5664	1087	17.7	16.1	5699
June 15-30	588	16.5	14.5	4785	745	16.2	15.6	5054	683	16.0	17.8	5696	2016	16.2	16.0	5184
July 1-14	51	14.7	14.4	4234	10	16.3	16.4	5346	76	12.8	17.9	4582	137	13.8	16.5	4554

TABLE 46.--The effect of total pounds of nitrogen per acre on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Total pounds nitrogen per A.	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
0-19	346	14.0	15.3	4284	307	14.9	16.0	4768	244	11.0	17.8	3916	897	13.5	16.2	4374
20-39	820	15.5	15.0	4650	1026	15.9	16.0	5088	798	12.7	17.7	4496	2644	14.8	16.2	4795
40-49	687	15.9	15.2	4834	554	17.4	16.1	5603	471	12.4	17.6	4365	1712	15.4	16.2	4990
50-59	1230	17.2	15.1	5194	865	17.7	16.1	5699	558	13.3	17.7	4708	2653	16.5	16.0	5280
60-69	668	17.1	14.9	5096	853	18.7	16.0	5984	613	15.1	17.7	5345	2134	17.2	16.1	5538
70-79	814	17.6	15.1	5315	1286	18.8	15.9	5978	1365	14.2	17.7	5027	3465	16.7	16.4	5478
80-89	768	18.5	14.4	5328	809	18.2	15.7	5715	927	14.1	17.6	4963	2504	16.8	16.0	5376
90-99	357	17.4	14.7	5116	670	20.6	15.7	6468	1003	14.0	17.7	4956	2030	16.8	16.5	5544
100-119	365	18.0	14.7	5292	812	19.1	15.8	6036	1712	14.2	17.9	5084	2889	16.1	16.9	5442
>119	313	19.4	14.4	5587	680	18.3	15.7	5746	1405	15.3	17.7	5416	2398	16.7	16.7	5578

from 0 to 90 pounds per acre. Beets that received more than 90 pounds of nitrogen per acre had higher sucrose contents than beets that received less than 90 pounds. This was possibly associated with the high sucrose content of beets in 1963 regardless of the amount of nitrogen applied and the relatively large acreages of beets that received more than 90 pounds of nitrogen per acre. In 1961 and 1962 the sucrose content of beets decreased when more than 70 to 80 pounds of nitrogen was applied. The statistical values (Table 33) indicate that nitrogen applications were negatively correlated with sucrose content in 1961 and 1962. In 1961, nitrogen was positively correlated with root and sugar yield.

The effect of nitrogen on the yield of beets grown on coarse-textured soils (Table 47) was similar to that obtained on the fine-textured soils. Nitrogen applications were negatively correlated with sucrose content in 1961 only (Table 25). Nitrogen was positively correlated with root and sugar yields in 1961 and 1962 (Tables 40 and 41).

The root and sugar yield of beets grown on fine-textured soils gradually increased as the amount of P_2O_5 applied increased from 0 to 175 pounds per acre (Table 48). Beets grown on soil to which 125 to 149 pounds of P_2O_5 was applied had the highest sucrose content. Statistically P_2O_5 was found to be negatively correlated with the sucrose content in 1962 (Table 33). Root and sugar yields were positively correlated with P_2O_5 applications in 1961.

Maximum sugar yield was produced from beets grown on coarse-textured soils where 100 to 175 pounds of P_2O_5 per acre was applied (Table 49). Phosphorus (as P_2O_5) was negatively correlated with sucrose content in 1961 (Table 25). Root and sugar yields were positively correlated with P_2O_5 applications in 1962 (Tables 40 and 41).

Potash had no effect on the sucrose content of beets grown on

TABLE 47.--The effect of total pounds of nitrogen per acre on the yield and sucrose content of sugar beets grown on coarse-textured soils in 1961, 1962 and 1963

Total pounds nitrogen per A.	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
0-19	186	15.3	15.1	4621	140	15.0	15.9	4770	35	12.9	17.8	4592	361	15.0	15.7	4710
20-39	127	17.0	14.6	4964	215	16.2	16.0	5184	203	12.3	17.7	4354	545	14.9	16.3	4857
40-49	222	15.6	14.5	4524	138	16.7	15.7	5244	50	13.1	17.7	4637	410	15.7	15.3	4804
50-59	137	16.9	14.6	4935	79	16.6	15.6	5179	85	15.7	17.9	5621	301	16.5	15.8	5214
60-69	126	18.2	14.7	5351	314	13.7	16.1	4411	207	15.9	17.6	5597	647	15.3	16.3	4988
70-79	223	17.6	14.2	4998	304	21.6	14.0	6048	287	15.1	17.8	5376	814	18.2	15.4	5606
80-89	152	18.9	14.3	5405	404	17.0	15.6	5304	276	16.5	17.8	5874	832	17.2	16.1	5538
90-99	159	17.1	14.3	4891	165	19.5	15.8	6162	398	16.2	17.8	5767	722	17.2	16.6	5710
100-119	251	18.6	14.3	5320	300	19.4	15.4	5975	364	17.1	17.7	6053	915	18.3	16.0	5856
>119	112	19.5	13.4	5226	244	18.0	15.5	5580	228	16.6	17.7	5876	584	17.7	16.0	5664

TABLE 48.--The effect of total pounds of P_2O_5 per acre on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Total pounds P_2O_5 per A.	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
0-49	1249	15.1	15.0	4530	1039	17.8	15.8	5625	724	13.3	17.8	4735	3012	15.6	15.9	4961
50-74	1715	17.1	15.0	5130	1786	17.8	16.0	5696	1941	13.3	17.7	4708	5442	16.0	16.3	5216
75-99	1204	17.9	14.8	5298	1863	18.8	15.9	5978	2189	13.5	17.7	4779	5256	16.4	16.4	5379
100-124	1192	17.6	14.8	5210	2040	17.5	15.8	5530	2598	14.2	17.7	5027	5830	16.0	16.4	5248
125-149	458	17.2	15.2	5229	637	19.1	16.0	6112	1060	14.9	17.7	5275	2155	16.6	16.7	5544
150-174	207	16.1	14.9	4798	375	18.8	16.1	6054	350	16.9	17.6	5949	932	17.5	16.4	5740
>174	343	19.2	14.4	5530	47	18.0	16.1	5796	234	16.4	17.6	5773	624	18.1	15.7	5683

TABLE 49.--The effect of total pounds of P_2O_5 per acre on the yield and sucrose content of sugar beets grown on coarse-textured soils in 1961, 1962 and 1963

Total pounds P_2O_5 per A.	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
0-49	322	16.9	14.7	4969	312	17.5	15.6	5460	165	14.7	17.8	5233	799	16.7	15.7	5244
50-74	365	17.1	14.6	4993	512	17.4	15.7	5464	544	16.1	17.8	5732	1421	16.8	16.2	5443
75-99	279	17.5	14.4	5040	535	16.1	15.7	5055	470	15.7	17.8	5589	1284	16.3	16.2	5281
100-124	256	17.0	14.7	4998	401	20.4	14.5	5916	615	15.4	17.7	5452	1272	17.3	16.1	5571
125-149	173	18.3	14.0	5124	340	16.2	15.2	4925	226	15.9	17.7	5629	739	16.6	15.7	5212
150-174	133	17.3	14.2	4913	116	20.1	16.1	6472	77	16.3	17.9	5835	326	18.1	15.6	5647
>174	136	17.4	13.4	4663	87	16.3	16.2	5281	34	19.9	17.6	7005	257	17.4	14.9	5185

fine-textured soils (Table 50). The root and sugar yield gradually increased as the amount of K_2O applied increased over the entire range of application (0 to 175 or more pounds per acre). Potassium applications were negatively correlated with sucrose content in 1961 and 1963 (Table 33). Root and sugar yields were positively correlated with K_2O applications in 1961 and 1963 (Tables 26 and 27).

The effect of K_2O on the yield of beets on coarse-textured soils was similar to that obtained on the fine-textured soils (Table 51). The statistical values (Tables 26 and 27) indicate that in 1963, root and sugar yield was positively correlated with K_2O applications.

The effect of harvest date on the yield and sucrose content of beets was recorded at 7-day intervals. Maximum sugar yield was produced from beets on fine-textured soils when harvested between October 15 and November 4 (Table 52). The sucrose content of beets gradually increased as the harvest date was delayed. Root yield gradually decreased when beets were harvested later than October 28. Statistical values (Table 33) show that the date of harvest had considerable effect on the sucrose content, particularly in 1962 and 1963. Beets harvested before October 22 had a significantly lower yield of sugar, and beets harvested after October 28 had a higher yield of sugar than beets harvested between October 22 and 28 in 1961 and 1963.

Maximum root and sugar yield was obtained on coarse-textured soils when beets were harvested from October 29 to November 4 (Table 52). The sucrose content increased over the entire range of harvest intervals. Beets that were harvested prior to October 15 in 1961 and 1963 had a significantly lower sucrose content than beets harvested October 22 to 28 (Table 25). The date of harvest showed few significant differences in the root and sugar yields.

TABLE 50.--The effect of total pounds of K_2O per acre on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Total pounds K_2O per A.	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
0-24	545	15.5	14.8	4588	486	18.6	16.3	6064	467	11.0	17.8	3916	1498	15.1	16.2	4892
25-49	1657	15.7	15.1	4741	1571	17.0	16.0	5440	1551	11.4	17.8	4058	4779	14.7	16.3	4792
50-74	1432	16.8	15.0	5040	1900	18.1	15.9	5756	1828	12.9	17.7	4567	5160	15.9	16.3	5183
75-99	1238	18.0	14.9	5364	1375	18.1	15.8	5720	1620	14.5	17.7	5133	4233	16.7	16.3	5444
100-124	955	18.3	14.8	5417	1769	17.8	15.8	5625	2011	14.8	17.7	5239	4735	16.6	16.4	5445
125-149	221	17.6	15.0	5280	357	19.9	15.6	6209	766	17.1	17.6	6019	1344	17.9	16.6	5943
150-174	147	17.6	15.1	5315	162	20.0	15.8	6320	388	16.9	17.5	5915	697	17.8	16.6	5910
> 174	173	21.2	13.8	5851	242	19.4	15.7	6092	464	17.8	17.6	6266	879	18.9	16.3	6161

TABLE 51.--The effect of total pounds of K_2O per acre on the yield and sucrose content of sugar beets grown on coarse-textured soils in 1961, 1962 and 1963

Total pounds K_2O per A.	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
0-24	73	14.9	14.4	4291	30	18.0	15.8	5688	69	13.2	18.1	4788	172	14.8	16.1	4766
25-49	357	16.2	14.7	4763	247	18.5	13.6	5032	127	13.1	17.8	4664	731	16.4	14.9	4887
50-74	583	17.0	14.6	4964	299	16.9	15.8	5340	353	13.4	17.7	4744	1235	15.9	15.8	5024
75-99	139	17.9	14.6	5227	409	17.6	16.0	5632	404	15.5	17.7	5487	952	16.8	16.5	5544
100-124	315	18.6	13.8	5134	567	17.2	15.6	5366	510	16.6	17.7	5876	1392	17.3	16.0	5536
125-149	136	20.0	14.5	5800	395	16.5	15.4	5082	224	16.0	17.7	5664	755	17.0	15.9	5406
150-174	31	18.1	13.8	4996	188	18.3	15.7	5746	180	17.2	17.8	6123	399	17.8	16.5	5874
174	61	16.3	13.6	4434	95	19.8	15.3	6059	266	18.3	17.9	6551	422	18.3	16.7	6112

TABLE 52.--The effect of date of harvest on the yield and sucrose content of sugar beets in 1961, 1962 and 1963

Date of harvest	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
<Oct. 15	78	16.1	14.4	4637	775	18.0	15.7	5652	795	13.3	17.1	4549	1648	15.6	16.3	5086
Oct. 15-21	2139	17.1	15.0	5130	2151	18.8	15.9	5978	1376	12.6	17.4	4385	5666	16.7	15.9	5311
Oct. 22-28	1822	17.1	14.9	5096	2025	19.0	16.0	6080	2144	14.1	17.7	4991	5991	16.6	16.3	5391
Oct. 29-Nov.4	1026	17.3	15.2	5259	1317	17.8	15.8	5625	2564	14.8	17.8	5269	4907	16.1	16.7	5377
Nov. 5-11	572	17.0	14.7	4998	788	17.4	15.9	5533	1512	14.6	17.9	5227	2872	15.8	16.7	5277
Nov. 12-18	13	21.7	15.9	6901	326	13.8	15.7	4333	612	13.9	17.8	4948	951	14.0	17.1	4788
Coarse-textured soils																
Oct. 15	131	17.7	13.6	4814	112	18.7	15.6	5834	43	14.8	16.7	4943	286	17.7	14.8	5239
Oct. 15-21	463	16.3	14.8	4825	564	18.3	15.6	5710	130	13.6	17.6	4787	1157	17.0	15.5	5270
Oct. 22-28	401	17.0	14.3	4862	510	17.8	16.0	5696	410	15.8	17.7	5593	1321	16.9	16.0	5408
Oct. 29-Nov.4	375	18.3	14.4	5270	425	19.6	14.4	5645	671	16.2	17.7	5735	1471	17.7	15.9	5629
Nov. 5-11	270	18.1	14.4	5213	411	16.6	15.5	5146	614	16.2	17.8	5767	1295	16.7	16.4	5478
>Nov. 12	55	17.3	14.6	5052	281	13.2	15.8	4171	265	14.7	17.9	5263	601	14.2	16.6	4714

Maximum yield of roots and sugar from beets grown on fine-textured soils was produced where 800 to 1200 total pounds of fertilizer was applied (Table 53). The sucrose content of beets increased as the total pounds of fertilizer applied increased from 200 to 1200 pounds per acre. Approximately 30 percent of the beets received 400 to 600 pounds of fertilizer per acre that gave a beet sugar yield of 4990 pounds; whereas, about 5 percent of the beets received 1000 to 1200 pounds of fertilizer per acre which resulted in a sugar yield of 6016 pounds per acre. The highest sugar yield of beets grown on coarse-textured soils was obtained where 600 to 800 pounds of fertilizer was applied (Table 53).

Maximum root and sugar yield was produced when ammonium nitrate or anhydrous ammonia were applied as a preplant application (Table 54). The interaction of nitrogen materials with time of sidedressing (Table 55) indicates that beet root and sugar yield was highest when nitrogen was sidedressed early (before June 15). Root and sugar yield was very similar when ammonium nitrate or anhydrous ammonia were applied as a preplant (Table 54) or as an early sidedressing (Table 55). The sucrose content of beets was reduced when ammonium nitrate or anhydrous ammonia were applied later than mid-June. Approximately 54 and 62 percent of the beets that were sidedressed with anhydrous ammonia and ammonium nitrate, respectively, received the application later than June 15.

Beets planted on fine-textured soils between April 11 and 20 (Table 56) or between May 1 and 10 (Table 57) produced maximum sugar yield when the beets were harvested between October 15 and November 11. The root yield gradually decreased when beets were harvested later than the October 15 to 21. The highest yield of sugar from beets planted late (May 11-20) on fine-textured soils was obtained when beets were harvested

TABLE 53.--The effect of the total pounds of fertilizer applied on the yield and sucrose content of sugar beets grown on tiled-drained, fine-textured soils in 1961, 1962 and 1963

Total pounds fertilizer applied	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Fine-textured soils																
200-399	635	14.4	15.1	4349	531	16.9	16.2	5476	137	11.6	17.9	4153	1303	15.1	15.8	4772
400-599	2227	16.7	15.0	5010	2251	16.9	16.0	5408	2039	12.4	17.7	4390	6517	15.4	16.2	4990
600-799	1963	17.7	14.9	5275	3343	18.6	15.8	5878	3566	14.2	17.7	5027	8872	16.6	16.4	5445
800-999	685	18.9	14.8	5594	1275	20.1	15.8	6352	1764	16.2	17.7	5735	3724	18.0	16.5	5940
1000-1199	188	19.3	14.7	5674	134	18.2	16.3	5933	630	17.3	17.7	6124	952	17.8	16.9	6016
1200-1399	55	21.0	14.4	6048	27	19.4	16.7	6480	63	16.7	17.5	5845	145	18.8	16.2	6091
Coarse-textured soils																
200-399	129	16.5	14.9	4917	47	13.9	16.1	4476	6	5.8	18.0	2088	182	15.5	15.3	4743
400-599	341	16.3	14.5	4785	578	16.9	15.9	5374	388	15.4	17.8	5482	1307	15.8	16.1	5088
600-799	481	18.3	14.5	5307	977	17.8	15.6	5554	1068	16.3	17.7	5770	2526	17.3	16.3	5640
800-999	405	19.4	13.7	5316	505	18.1	14.6	5285	400	15.6	17.8	5554	1310	17.7	15.3	5416
1000-1199	39	17.6	13.8	4858	105	18.0	15.3	5508	105	17.9	17.9	6408	249	17.9	16.2	5800

TABLE 54.--The effect of the interaction of nitrogen material with the method of application, on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Method of application of nitrogen	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Ammonium nitrate																
Preplant	809	19.3	14.8	5713	795	19.2	15.6	5990	1366	16.6	17.6	5843	2970	18.0	16.3	5868
Sidedress	2735	16.7	15.1	5043	3467	18.3	15.9	5819	2835	14.0	17.7	4956	9037	16.5	16.2	5346
Urea																
Preplant	28	14.5	14.0	4060	79	21.2	15.8	6699	117	11.9	17.5	4165	224	15.5	16.5	5115
Sidedress	88	17.1	15.0	5130	648	20.1	16.2	6512	395	13.1	17.7	4637	1131	17.4	16.6	5777
Anhydrous ammonia																
Preplant	105	17.9	14.2	5084	224	18.7	15.8	5909	495	14.1	17.8	5020	824	15.8	16.8	5309
Sidedress	529	17.1	14.7	5027	882	17.9	15.8	5656	1219	13.5	17.6	4752	2630	15.7	16.4	5150

TABLE 55.--The effect of the interaction of nitrogen material with time of sidedressing, on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Time of sidedressing nitrogen	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Ammonium nitrate																
< June 1	11	19.1	14.9	5692	198	17.5	15.6	5460	55	13.4	17.9	4797	264	16.7	16.1	5377
June 1-14	542	18.3	15.0	5490	1397	18.9	16.0	6048	1300	15.3	17.6	5386	3239	17.4	16.5	5742
June 15-30	1675	16.6	15.1	5013	1823	18.0	15.8	5688	1261	13.6	17.7	4814	4759	16.3	16.1	5249
July 1-14	550	15.5	15.3	4743	60	17.8	15.6	5554	279	10.7	17.8	3809	889	14.1	16.1	4540
Anhydrous ammonia																
June 1-14	77	19.0	14.6	5548	434	17.9	15.9	5692	655	15.1	17.6	5315	1166	16.4	16.8	5510
June 15-30	337	17.1	14.6	4993	362	18.0	15.8	5688	484	11.5	17.7	4071	1183	15.1	16.2	4892
July 1-14	106	15.9	15.4	4897	18	11.3	16.6	3752	48	9.5	17.8	3382	172	13.6	16.2	4406
Urea																
June 1-14	—	—	—	—	200	21.9	16.2	7096	207	13.4	17.6	4717	407	17.6	16.9	5949
June 15-30	66	16.8	15.0	5040	448	19.3	16.3	6292	116	14.0	17.9	5012	630	18.1	16.5	5973

TABLE 56.--The effect of the interaction of planting date (April 11-20) with the date of harvest, on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Date of harvest	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Oct. 1-7	—	—	—	—	22	17.6	15.5	5456	—	—	—	—	22	17.6	15.5	5456
Oct. 8-14	43	17.2	14.1	4850	309	18.0	15.6	5616	348	14.4	17.0	4896	700	16.2	16.2	5249
Oct. 15-21	28	19.7	14.4	5674	1113	19.8	15.8	6257	522	14.1	17.4	4907	1663	18.0	16.3	5868
Oct. 22-28	63	23.1	13.0	6006	925	19.1	16.0	6112	950	14.9	17.7	5275	1938	17.2	16.7	5745
Oct. 29-Nov.4	41	17.3	14.1	4879	405	17.8	15.6	5554	762	16.5	17.8	5874	1208	17.0	16.9	5746
Nov. 5-11	43	19.6	14.0	5488	317	18.2	15.9	5788	513	15.2	17.9	5442	873	16.5	17.0	5610
Nov. 12-18	—	—	—	—	152	10.2	15.7	3203	153	16.5	17.9	5907	305	13.4	16.8	4502
> Nov. 18	—	—	—	—	100	19.3	15.5	5983	—	—	—	—	100	19.3	15.5	5983

TABLE 57.--The effect of the interaction of planting date (May 1-10) with the date of harvest, on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Date of harvest	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Oct. 1-7	—	—	—	—	16	15.2	15.5	4712	—	—	—	—	16	15.2	15.5	4712
Oct. 8-14	111	16.4	14.2	4658	26	13.8	15.9	4388	167	12.3	17.1	4207	304	13.9	15.9	4420
Oct. 15-21	392	18.2	15.0	5460	194	16.4	16.1	5281	242	13.8	17.4	4802	828	16.5	16.0	5280
Oct. 22-28	235	17.0	14.7	4998	111	17.0	16.1	5474	450	15.1	17.7	5345	796	15.9	16.6	5279
Oct. 29-Nov.4	247	17.0	15.4	5236	141	17.6	16.1	5667	827	14.9	17.8	5304	1215	15.6	17.1	5335
Nov. 5-11	70	17.2	14.8	5091	161	15.3	15.9	4865	403	15.0	17.9	5370	634	15.3	17.0	5202
Nov. 12-18	13	21.7	15.9	6901	79	15.1	16.1	4862	109	10.4	17.6	3661	201	13.0	16.9	4394
Nov. 18	—	—	—	—	41	14.4	16.4	4723	69	11.3	17.7	4000	110	12.5	17.2	4300

between October 15 and November 4 (Table 58). In general, the interaction of planting with harvest date indicates that regardless of planting time maximum sugar yield was produced when beets were harvested between October 15 and November 11.

The R^2 values for the production practices on the yield and sucrose content of beets grown on coarse-textured soils are shown in Table 59. In general, date of planting, date of harvest and rate of nitrogen application accounted for most of the variation in sucrose content of beets. Most of the variation in root and sugar yield was accounted for by date of planting and rate of nitrogen application. Potassium applications accounted for a major share of the variation in root and sugar yield in 1963.

The R^2 values for the production practices on the yield and sucrose content of beets grown on fine-textured soils are given in Table 60. The date of planting and date of harvest were the main factors contributing to the variation in sucrose content. In 1963 the date of harvest accounted for approximately 90 percent of the observed variation in sucrose content. The date of planting had the most effect on the root and sugar yield variation. Nitrogen applications in 1961, tile-drainage in 1962, and plowing depth and K_2O applications in 1963 accounted for considerable variation in root and sugar yield.

Generally more variation in yield and sucrose content was accounted for in beets grown on coarse-textured soils than on the fine-textured soils. The production practices accounted for 36 percent of the total variation on coarse-textured soils and 25 percent on fine-textured soils.

TABLE 58.--The effect of the interaction of planting date (May 11-20) with the date of harvest, on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Date of harvest	1961				1962				1963				Weighted average			
	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Acres	Tons roots per A.	% Sucrose	Pounds sugar per A.	Total acres	Tons roots per A.	% Sucrose	Pounds sugar per A.
Oct. 1-7	7	12.9	15.6	4025	—	—	—	—	—	—	—	—	7	12.9	15.6	4025
Oct. 8-14	283	14.6	14.2	4146	29	13.8	15.9	4388	111	10.2	17.3	3529	423	13.4	15.1	4047
Oct. 15-21	1017	16.7	14.9	4977	148	16.2	15.7	5087	231	9.4	17.4	3271	1396	15.4	15.4	4743
Oct. 22-28	885	16.7	14.9	4977	75	16.9	16.0	5408	225	11.6	17.7	4106	1185	15.7	15.5	4867
Oct. 29-Nov.4	396	17.2	15.1	5194	52	15.1	15.7	4741	390	11.8	17.9	4224	838	14.6	16.4	4789
Nov. 5-11	190	15.3	14.9	4559	12	14.2	16.2	4601	263	11.8	17.9	4224	465	13.3	16.6	4416
> Nov. 11	23	13.4	16.2	4342	28	16.0	16.3	5216	94	10.7	17.9	3831	145	12.2	17.3	4221

TABLE 59.--The R^2 values for the various production practices on the yield and sucrose content of sugar beets grown on coarse-textured soils in 1961, 1962 and 1963

Variable	Percent sucrose				Root yield				Sugar yield			
	1961	1962	1963	Ave.	1961	1962	1963	Ave.	1961	1962	1963	Ave.
	R^2											
Tile-drainage	.06	.00	.05	.00	.03	.00	.01	.00	.01	.00	.02	.01
Planting date	.11	.04	.03	.07	.09	.13	.02	.05	.08	.15	.02	.08
Nitrogen	.05	.05	.00	.00	.07	.11	.07	.08	.03	.09	.07	.08
Row width	.01	.03	.01	.00	.02	.00	.04	.00	.01	.00	.04	.00
K_2O	.03	.03	.00	.01	.03	.04	.10	.03	.01	.03	.11	.05
P_2O_5	.04	.01	.00	.01	.01	.03	.00	.01	.00	.04	.00	.00
Harvest date	.06	.03	.19	.09	.04	.03	.02	.01	.05	.02	.01	.02
Depth of plowing	.10	.00	.01	.01	.00	.05	.01	.02	.02	.06	.01	.02
Time of plowing	.00	.00	.02	.01	.02	.00	.00	.00	.02	.00	.00	.00
Legumes preceding years	.00	.01	.01	.06	.01	.02	.02	.02	.01	.02	.01	.02
Times worked	.04	.02	.05	.02	.04	.05	.02	.04	.04	.05	.02	.02
Total	.50	.22	.37	.28	.36	.46	.31	.26	.28	.46	.31	.30

TABLE 60.--The R^2 values for the various production practices on the yield and sucrose content of sugar beets grown on fine-textured soils in 1961, 1962 and 1963

Variable	Percent sucrose				Root yield				Sugar yield			
	1961	1962	1963	Ave.	1961	1962	1963	Ave.	1961	1962	1963	Ave.
	R^2											
Tile-drainage	.00	.00	.00	.01	.00	.02	.01	.02.	.00	.02	.01	.01
Planting date	.06	.02	.01	.09	.13	.04	.12	.05	.11	.04	.11	.07
Nitrogen	.02	.04	.00	.01	.06	.00	.01	.00	.05	.00	.01	.00
Row width	.01	.01	.00	.01	.02	.01	.06	.02	.02	.01	.06	.02
K_2O	.01	.03	.02	.00	.03	.00	.11	.02	.02	.00	.10	.02
P_2O_5	.00	.01	.00	.00	.01	.00	.00	.00	.01	.00	.00	.00
Harvest date	.10	.02	.31	.07	.01	.00	.03	.00	.03	.00	.04	.01
Depth of plowing	.00	.04	.01	.01	.00	.00	.04	.01	.00	.00	.04	.01
Time of plowing	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Legumes preceding years	.01	.00	.01	.04	.00	.00	.00	.01	.01	.00	.00	.00
Times worked	.02	.02	.00	.01	.01	.01	.01	.00	.02	.01	.01	.00
Total	.23	.19	.36	.25	.27	.08	.39	.13	.27	.08	.38	.14

SUMMARY AND CONCLUSIONS

EXPERIMENT I: THE EFFECT OF TIME AND RATE OF NITROGEN APPLICATION AND DATE OF HARVEST ON THE YIELD AND SUCROSE CONTENT OF SUGAR BEETS

The effect of time and rate of application of nitrogen and date of harvest was studied on the yield and sucrose content of sugar beets grown on Brookston clay loam soil.

The maximum production of sugar per acre was obtained when nitrogen was applied as a preplant application at 90 or 120 pounds per acre or as a mid-June sidedressing at 60 or 90 pounds per acre.

Delayed harvest usually resulted in an increase of root yield and sucrose content, consequently an increase in sugar yield per acre. On the average when harvest was delayed 28 days an increase of 1017 pounds of sugar was obtained, representing a daily increase of approximately 36 pounds per acre per day. The first 14 days of delayed harvest increased sugar yield more than the last 14-day delay.

The rate of nitrogen application had relatively small effects on the sucrose content of beets. However, slight reductions in sucrose content were obtained where nitrogen was applied at rates higher than 30 pounds per acre. High rates of nitrogen applied in mid-July or mid-August resulted in low sugar and root yields. Nitrogen applied as a mid-August sidedressing resulted in a reduction in the sucrose content of beets.

On the average date of harvest accounted for most of the variation in the sucrose content of the sugar beets and accounted for considerably more variation (>>) than the time of nitrogen application. The decreasing

order of importance of the treatments on the differences in sucrose content was as follows:

Date of harvest $\gg$ Time of nitrogen application $>$
Rate of nitrogen application $>$ Interactions.

The rate of nitrogen application and date of harvest were about equal ($\simeq$) in accounting for the variability in root yield. The time of application of nitrogen had a very slight effect on root yield differences. The decreasing order of importance of the treatments on the variation in root yields was as follows:

Rate of nitrogen application $\simeq$ Date of harvest $\gg$
Time of nitrogen application $>$ Interactions.

The date of harvest was the most important variable accounting for differences in sugar production. The decreasing order of importance of the treatments on the variation in sugar yield was as follows:

Date of harvest $\gg$ Rate of nitrogen application $>$
Time of nitrogen application $>$ Interactions.

Although several of the treatment interaction effects on the yield and sucrose content of beets were statistically significant their contribution to the total observed variability was of minor importance. In general, the interactions accounted for from 0 to 14 percent of the observed variation in yield and sucrose content.

EXPERIMENT II: A SURVEY OF THE PRODUCTION PRACTICES AFFECTING YIELD AND SUCROSE CONTENT OF SUGAR BEETS IN ONTARIO, CANADA

Several production practices were correlated with the yield and sucrose content of sugar beets grown in Southern Ontario in 1961, 1962 and 1963.

On the average, sugar production from beets grown on fine-textured soils was similar to the yields obtained from beets on coarse-textured soils. There was a marked yield advantage of beets grown on tile-drained soil over beets grown on non-tiled soil.

Alfalfa or clover grown the year preceding the beet crop had a detrimental effect on root and sugar yield but no significant effect on the sucrose content. Maximum sugar yield was obtained when legumes were grown one year removed from the beet crop. The previous crop had considerable effects on the root and sugar yield. When corn was the preceding crop maximum root and sugar yield was obtained.

When farmyard manure was applied at 10 to 14 tons per acre the year preceding the beet crop root and sugar yield increased.

Beets grown on fine-textured soils that had been fall-plowed to a depth of 10 to 12 inches and on coarse-textured soil to a depth of 8 to 10 inches gave the highest sugar yield. The advantage derived from minimum tillage operations on fine-textured soils would result from a reduction in labor and expense for seed-bed preparation rather than from increased yields.

Beets planted early (before May 1) and in rows less than 28 inches wide resulted in maximum sugar production. Nitrogen applied at 70 to 90 pounds per acre as a preplant application or as a sidedressing before mid-June gave the highest sugar yield. Root yields were usually reduced by

late sidedressings of nitrogen but there was no effect on the sucrose content of beets.

Maximum sugar production was obtained on fine-textured soils where 150 to 175 pounds per acre of P_2O_5 was applied, and where 100 to 175 pounds was applied on coarse-textured soils. Sugar yield gradually increased with increasing K_2O applications over the entire range of application (0 to 175 or more pounds per acre). Applications of K_2O did not affect sucrose content of beets. The sucrose content seemed to decline when P_2O_5 was applied at rates higher than 125 pounds per acre.

The sucrose content gradually increased with increasing delay of beet harvest. On fine-textured soils the highest root and sugar yield was obtained when beets were harvested October 15 to November 4. Maximum yield on coarse-textured soils was obtained when beets were harvested October 22 to November 11.

Maximum sugar yield and the highest sucrose content occurred when 1000 to 1200 total pounds of fertilizer was applied on fine-textured soils, and 600 to 800 pounds per acre on coarse-textured soils.

On the average, regardless of the date of planting beets maximum sugar production was obtained when beets were harvested between October 15 and November 11.

Eleven production practices were selected and analysed statistically by the computer program CORE 2 routine for regression and partial correlation coefficients. On coarse-textured soils the production practices accounted for approximately 36 percent of the total variation in yield and sucrose content of beets. Most of the differences in sucrose content were accounted for by date of planting, date of harvest, and nitrogen applications. The date of planting and rate of nitrogen application had the most effect on root and sugar yields.

On fine-textured soils the production practices accounted for about 25 percent of the total variation in yield and sucrose content of beets. Date of planting, date of harvest, and rate of nitrogen application had the most effect on the sucrose content. On the average, the date of planting was the most important factor affecting the root and sugar yield of beets. Nitrogen in 1961, tile-drainage in 1962, and K_2O applications in 1963 accounted for considerable variation in root and sugar yield differences.

Significant differences in root and sugar yield and sucrose content are discussed when results are presented for each production practice.

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APPENDIX

TABLE 61.--Analysis of variance of sucrose content data, 1961

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	4.02		
Treatments		23	22.27	0.97	1.83*
Application time		3	8.16	2.72	5.13**
Prepl. vs Other 3	(A)	1	0.22	0.22	0.42
Sidedressings (S.D.)		2	7.94	3.97	7.49**
S.D. (Lin.)	(B)	1	7.05	7.05	13.30**
S.D. (Quad.)	(C)	1	0.89	0.89	1.68
Rate of nitrogen		5	6.60	1.32	2.49*
Rate of N. (Lin.)	(D)	1	5.17	5.17	9.76**
Rate of N. (Quad.)	(E)	1	0.53	0.53	1.00
Remainder	(F)	3	0.90	0.30	0.57
A x D		1	0.06	0.06	0.11
A x E		1	0.27	0.27	0.51
A x F		3	0.66	0.22	0.42
B x D		1	3.13	3.13	5.91*
B x E		1	0.00	0.00	0.00
B x F		3	0.22	0.07	0.13
C x D		1	0.32	0.32	0.60
C x E		1	2.02	2.02	3.81
C x F		3	0.84	0.28	0.53
ERROR (a) (Reps. x Treat.)		46	24.28	0.53	
TOTAL		71	50.57		
HARVEST DATES (H.D.)		2	29.64	14.82	24.30**
H.D. (Lin.)	(G)	1	26.86	26.86	44.03**
H.D. (Quad.)	(H)	1	2.78	2.78	4.54
ERROR (b) (Reps. x H.D.)		4	2.43	0.61	
TOTAL		8	36.09		

Continued

"TABLE 61--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	16.69	0.36	1.25
H.D. (Lin.) x A	1	0.00	0.00	0.00
H.D. (Quad.) x A	1	0.03	0.03	0.10
H.D. (L) x B	1	0.02	0.02	0.07
H.D. (Q) x B	1	0.30	0.30	1.04
H.D. (L) x C	1	1.72	1.72	5.93*
H.D. (Q) x C	1	0.14	0.14	0.48
H.D. (L) x D	1	2.75	2.75	9.48**
H.D. (Q) x D	1	1.89	1.89	6.52*
H.D. (L) x E	1	0.07	0.07	0.24
H.D. (Q) x E	1	0.00	0.00	0.00
H.D. x F	6	1.27	0.21	0.72
H.D. (L) x A x D	1	0.00	0.00	0.00
H.D. (Q) x A x D	1	1.23	1.23	4.24*
H.D. (L) x A x E	1	1.23	1.23	4.24*
H.D. (Q) x A x E	1	0.04	0.04	0.14
H.D. x A x F	6	1.13	0.19	0.66
H.D. (L) x B x D	1	0.76	0.76	2.62
H.D. (Q) x B x D	1	0.29	0.29	1.00
H.D. (L) x B x E	1	0.03	0.03	0.10
H.D. (Q) x B x E	1	0.30	0.30	1.04
H.D. x B x F	6	1.49	0.25	0.86
H.D. (L) x C x D	1	0.00	0.00	0.00
H.D. (Q) x C x D	1	0.00	0.00	0.00
H.D. (L) x C x E	1	0.00	0.00	0.00
H.D. (Q) x C x E	1	0.06	0.06	0.21
H.D. x C x F	6	1.88	0.31	1.07
ERROR (c)(Reps. x H.D. x Treat.)	92	26.66	0.29	
GRAND TOTAL	215	125.99		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 62.--Analysis of variance of root yield data, 1961

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	108.64		
Treatments		23	794.51	34.54	2.97**
Application time		3	197.85	65.95	5.67**
Prepl. vs Other 3	(A)	1	97.93	97.93	8.42**
Sidedressings (S.D.)		2	99.92	49.96	4.29*
S.D. (Lin.)	(B)	1	90.60	90.60	7.79**
S.D. (Quad.)	(C)	1	9.32	9.32	0.80
Rate of nitrogen		5	184.01	36.80	3.16*
Rate of N. (Lin.)	(D)	1	107.28	107.28	9.22**
Rate of N. (Quad.)	(E)	1	45.13	45.13	3.88
Remainder	(F)	3	31.60	10.53	0.91
A x D		1	104.00	104.00	8.94**
A x E		1	1.83	1.83	0.16
A x F		3	64.31	21.44	1.84
B x D		1	35.60	35.60	3.06
B x E		1	63.02	63.02	5.42*
B x F		3	6.95	2.32	0.20
C x D		1	10.43	10.43	0.90
C x E		1	33.13	33.13	2.85
C x F		3	92.66	30.89	2.66
ERROR (a) (Reps. x Treat.)		46	534.806	11.63	
TOTAL		71	1437.960		
HARVEST DATES (H.D.)		2	140.80	70.40	3.49
H.D. (Lin.)	(G)	1	133.93	133.93	6.64
H.D. (Quad.)	(H)	1	6.87	6.87	0.34
ERROR (b) (Reps. x H.D.)		4	80.653	20.16	
TOTAL		8	330.092		

Continued

"TABLE 62--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	142.494	3.10	1.48
H.D. (Lin.) x A	1	3.65	3.65	1.75
H.D. (Quad.) x A	1	0.07	0.07	0.03
H.D. (L) x B	1	7.87	7.87	3.77
H.D. (Q) x B	1	0.20	0.20	0.10
H.D. (L) x C	1	3.87	3.87	1.85
H.D. (Q) x C	1	11.76	11.76	5.63*
H.D. (L) x D	1	11.79	11.79	5.64*
H.D. (Q) x D	1	0.28	0.28	0.13
H.D. (L) x E	1	0.82	0.82	0.39
H.D. (Q) x E	1	0.20	0.20	0.10
H.D. x F	6	8.492	1.42	0.68
H.D. (L) x A x D	1	0.02	0.02	0.01
H.D. (Q) x A x D	1	4.27	4.27	2.04
H.D. (L) x A x E	1	0.05	0.05	0.02
H.D. (Q) x A x E	1	2.68	2.68	1.28
H.D. x A x F	6	8.96	1.49	0.71
H.D. (L) x B x D	1	0.06	0.06	0.29
H.D. (Q) x B x D	1	2.15	2.15	1.03
H.D. (L) x B x E	1	14.15	14.15	6.77*
H.D. (Q) x B x E	1	0.20	0.20	0.10
H.D. x B x F	6	39.36	6.56	3.14**
H.D. (L) x C x D	1	0.10	0.10	0.05
H.D. (Q) x C x D	1	4.37	4.37	2.09
H.D. (L) x C x E	1	1.46	1.46	0.70
H.D. (Q) x C x E	1	0.03	0.03	0.14
H.D. x C x F	6	17.85	2.98	1.43
ERROR (c)(Reps.x H.D. x Treat.)	92	192.26	2.09	
GRAND TOTAL	215	1,994,163		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 63.--Analysis of variance of sugar yield data, 1961

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	7,772,450		
Treatments		23	88,553,022	3,850,131	2.83**
Application time		3	26,482,390	8,827,463	6.48**
Prepl. vs Other 3	(A)	1	10,712,535	10,712,535	7.86**
Sidedressings (S.D.)		2	15,769,855	7,884,927	5.79**
S.D. (Lin.)	(B)	1	15,292,681	15,292,681	11.23**
S.D. (Quad.)	(C)	1	477,174	477,174	0.35
Rate of nitrogen		5	14,259,117	2,851,823	2.10
Rate of N. (Lin.)	(D)	1	5,995,667	5,995,667	4.40*
Rate of N. (Quad.)	(E)	1	6,050,649	6,050,649	4.44*
Remainder	(F)	3	2,212,801	737,600	0.54
A x D		1	11,031,320	11,031,320	8.10**
A x E		1	70,796	70,796	0.05
A x F		3	6,781,387	2,260,462	1.66
B x D		1	6,674,596	6,674,596	4.90*
B x E		1	6,360,799	6,360,799	4.67*
B x F		3	781,950	260,650	0.19
C x D		1	1,492,464	1,492,464	1.10
C x E		1	5,231,451	5,231,451	3.84
C x F		3	9,388,206	3,129,402	2.30
ERROR (a) (Reps. x Treat.)		46	62,640,039	1,361,740	
TOTAL		71	158,965,511		
HARVEST DATES (H.D.)		2	34,596,332	17,298,166	8.22*
H.D. (Lin.)	(G)	1	32,343,865	32,343,865	15.37*
H.D. (Quad.)	(H)	1	2,252,467	2,252,467	1.07
ERROR (b) (Reps. x H.D.)		4	8,419,085	2,104,771	
TOTAL		8	50,787,867		

Continued

"TABLE 63--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	20,416,468	443,836	1.68*
H.D. (Lin.) x A	1	598,384	598,384	2.27
H.D. (Quad.) x A	1	117,002	117,002	0.44
H.D. (L) x B	1	386,760	386,760	1.47
H.D. (Q) x B	1	1,120,464	1,120,464	4.25*
H.D. (L) x C	1	1,021,625	1,021,625	3.87
H.D. (Q) x C	1	1,242,500	1,242,500	4.71*
H.D. (L) x D	1	2,910,004	2,910,004	11.03**
H.D. (Q) x D	1	423,720	423,720	1.61
H.D. (L) x E	1	35,645	35,645	0.14
H.D. (Q) x E	1	20,848	20,848	0.08
H.D. x F	6	577,612	96,269	0.37
H.D. (L) x A x D	1	240,010	240,010	0.91
H.D. (Q) x A x D	1	1,337,658	1,337,658	5.07*
H.D. (L) x A x E	1	408,168	408,168	1.55
H.D. (Q) x A x E	1	49,666	49,666	0.19
H.D. x A x F	6	1,328,008	221,335	0.84
H.D. (L) x B x D	1	84,340	84,340	0.32
H.D. (Q) x B x D	1	409,836	409,836	1.55
H.D. (L) x B x E	1	1,824,017	1,824,017	6.92*
H.D. (Q) x B x E	1	13,634	13,634	0.05
H.D. x B x F	6	3,294,589	549,098	2.08
H.D. (L) x C x D	1	96,881	96,881	0.37
H.D. (Q) x C x D	1	441,803	441,803	1.68
H.D. (L) x C x E	1	106,988	106,988	0.41
H.D. (Q) x C x E	1	1,219	1,219	0.00
H.D. x C x F	6	2,325,080	387,513	1.47
ERROR (c)(Reps. x H.D. x Treat.)	92	24,268,862	263,792	
GRAND TOTAL	215	246,666,258		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 64.--Analysis of variance of top yield data, 1961

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications	2	82.8		
Treatments	23	1001.1	43.52	10.41**
Application time	3	65.2	21.73	5.19**
Prepl. vs Other 3	1	27.7	27.70	6.62*
Sidedressings	2	37.5	18.75	4.48*
Rate of nitrogen	5	868.1	173.62	41.53**
ERROR (a) (Reps. x Treat.)	46	192.1	4.18	
TOTAL	71	1276.5		
HARVEST DATES (H.D.)	2	428.4	214.20	7.19*
ERROR (b) (Reps. x H.D.)	4	119.1	29.77	
TOTAL	8	630.3		
Harvest Dates x Treatments	46	136.3	2.96	0.23
ERROR (c)(Reps. x H.D. x Treat.)	92	1152.0	12.52	
GRAND TOTAL	215	3112.3		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 65.--Analysis of variance of sucrose content data, 1962

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	0.21		
Treatments		23	30.60	1.33	5.32**
Application time		3	13.25	4.42	17.68**
Prepl. vs Other 3	(A)	1	1.67	1.67	6.68*
Sidedressings (S.D.)		2	11.58	5.79	23.16**
S.D. (Lin.)	(B)	1	11.28	11.28	45.12**
S.D. (Quad.)	(C)	1	0.28	0.28	1.12
Rate of nitrogen		5	7.65	1.53	6.12**
Rate of N. (Lin.)	(D)	1	6.40	6.40	25.60**
Rate of N. (Quad.)	(E)	1	0.78	0.78	3.12
Remainder	(F)	3	0.47	0.16	0.64
A x D		1	1.39	1.39	5.56*
A x E		1	0.02	0.02	0.08
A x F		3	0.66	0.22	0.88
B x D		1	5.07	5.07	20.28**
B x E		1	1.06	1.06	4.24*
B x F		3	0.11	0.03	0.12
C x D		1	0.00	0.00	0.01
C x E		1	0.09	0.09	0.36
C x F		3	0.69	0.23	0.92
ERROR (a) (Reps. x Treat.)		46	11.56	0.25	
TOTAL		71	42.38		
HARVEST DATES (H.D.)		2	79.45	39.73	50.94**
H.D. (Lin.)	(G)	1	49.47	49.47	63.42**
H.D. (Quad.)	(H)	1	29.98	29.98	38.44**
ERROR (b) (Reps. x H.D.)		4	3.11	0.78	
TOTAL		8	82.78		

Continued

"TABLE 65--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	11.31	0.245	1.03
H.D. (Lin.) x A	1	1.25	1.25	5.25*
H.D. (Quad.) x A	1	0.19	0.19	0.80
H.D. (L) x B	1	0.96	0.96	4.03*
H.D. (Q) x B	1	0.34	0.34	1.43
H.D. (L) x C	1	0.38	0.38	1.60
H.D. (Q) x C	1	0.35	0.35	1.47
H.D. (L) x D	1	1.02	1.02	4.29*
H.D. (Q) x D	1	0.44	0.44	1.81
H.D. (L) x E	1	0.11	0.11	0.46
H.D. (Q) x E	1	0.01	0.01	0.04
H.D. x F	6	1.70	0.28	1.18
H.D. (L) x A x D	1	0.28	0.28	1.18
H.D. (Q) x A x D	1	0.26	0.26	1.09
H.D. (L) x A x E	1	0.06	0.06	0.25
H.D. (Q) x A x E	1	0.05	0.05	0.21
H.D. x A x F	6	1.13	0.18	0.76
H.D. (L) x B x D	1	0.00	0.00	0.00
H.D. (Q) x B x D	1	0.16	0.16	0.67
H.D. (L) x B x E	1	0.08	0.08	0.34
H.D. (Q) x B x E	1	0.01	0.01	0.04
H.D. x B x F	6	1.28	0.21	0.88
H.D. (L) x C x D	1	0.03	0.03	0.13
H.D. (Q) x C x D	1	0.16	0.16	0.67
H.D. (L) x C x E	1	0.48	0.48	2.02
H.D. (Q) x C x E	1	0.56	0.56	2.35
H.D. x C x F	6	0.59	0.09	0.38
ERROR (c)(Reps.x H.D. x Treat.)	92	21.91	0.238	
GRAND TOTAL	215	158.16		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 66.--Analysis of variance of root yield data, 1962

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	31.73		
Treatments		23	560.01	24.35	3.27**
Application time		3	24.49	8.16	1.10
Prepl. vs Other 3	(A)	1	1.12	1.12	0.15
Sidedressings (S.D.)		2	23.37	11.69	1.57
S.D. (Lin.)	(B)	1	19.08	19.08	2.56
S.D. (Quad.)	(C)	1	4.29	4.29	0.58
Rate of nitrogen		5	305.47	61.09	8.20**
Rate of N. (Lin.)	(D)	1	144.72	144.72	19.43**
Rate of N. (Quad.)	(E)	1	138.63	138.63	18.61**
Remainder	(F)	3	22.12	7.37	0.99
A x D		1	87.61	87.61	11.76**
A x E		1	2.49	2.49	0.33
A x F		3	9.74	3.25	0.44
B x D		1	23.22	23.22	3.12
B x E		1	74.71	74.71	10.03**
B x F		3	7.78	2.59	0.35
C x D		1	2.42	2.42	0.32
C x E		1	16.76	16.76	2.25
C x F		3	5.31	1.77	0.24
ERROR (a) (Reps. x Treat.)		46	342.58	7.45	
TOTAL		71	934.32		
HARVEST DATES (H.D.)		2	42.15	21.07	5.82
H.D. (Lin.)	(G)	1	15.47	15.47	4.27
H.D. (Quad.)	(H)	1	26.68	26.68	7.37
ERROR (b) (Reps. x H.D.)		4	14.48	3.62	
TOTAL		8	88.36		

Continued

"TABLE 66--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	114.78	2.50	1.04
H.D. (Lin.) x A	1	2.05	2.05	0.85
H.D. (Quad.) x A	1	0.04	0.04	0.01
H.D. (L) x B	1	0.81	0.81	0.33
H.D. (Q) x B	1	0.11	0.11	0.04
H.D. (L) x C	1	0.00	0.00	0.00
H.D. (Q) x C	1	0.48	0.48	0.17
H.D. (L) x D	1	3.44	3.44	1.43
H.D. (Q) x D	1	1.01	1.01	0.42
H.D. (L) x E	1	2.85	2.85	1.19
H.D. (Q) x E	1	0.01	0.01	0.00
H.D. x F	6	10.13	1.69	0.70
H.D. (L) x A x D	1	0.18	0.18	0.07
H.D. (Q) x A x D	1	0.30	0.30	0.12
H.D. (L) x A x E	1	9.25	9.25	3.85
H.D. (Q) x A x E	1	4.46	4.46	1.86
H.D. x A x F	6	13.68	2.28	0.95
H.D. (L) x B x D	1	0.15	0.15	0.06
H.D. (Q) x B x D	1	11.58	11.58	4.82*
H.D. (L) x B x E	1	0.06	0.06	0.02
H.D. (Q) x B x E	1	0.85	0.85	0.35
H.D. x B x F	6	13.77	2.29	0.95
H.D. (L) x C x D	1	0.03	0.03	0.01
H.D. (Q) x C x D	1	0.94	0.94	0.39
H.D. (L) x C x E	1	6.07	6.07	2.53
H.D. (Q) x C x E	1	0.72	0.72	0.30
H.D. x C x F	6	30.336	5.06	2.10
ERROR (c)(Reps. x H.D. x Treat.)	92	220.57	2.40	
GRAND TOTAL	215	1326.30		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 67.--Analysis of variance of sugar yield data, 1962

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	2,983,848		
Treatments		23	75,314,288	3,274,534	3.90**
Application time		3	8,967,870	2,989,290	3.56*
Prepl. vs Other 3	(A)	1	853,544	853,544	1.02
Sidedressings (S.D.)		2	8,114,326	4,057,163	4.84*
S.D. (Lin.)	(B)	1	7,853,772	7,853,772	9.36**
S.D. (Quad.)	(C)	1	260,554	260.554	0.31
Rate of nitrogen		5	31,112,673	6,222,534	7.42**
Rate of N. (Lin.)	(D)	1	9,218,991	9,218,991	10.98**
Rate of N. (Quad.)	(E)	1	18,803,013	18,803,013	22.41**
Remainder	(F)	3	3,090,669	1,030,223	1.23
A x D		1	12,058,269	12,058,269	14.37**
A x E		1	82,575	82,575	0.10
A x F		3	1,656,080	552,027	0.66
B x D		1	6,227,315	6,227,315	7.42**
B x E		1	10,977,304	10,977,304	13.08**
B x F		3	774,911	258,304	0.31
C x D		1	333,249	333.249	0.40
C x E		1	2,361,653	2,361,653	2.81
C x F		3	761,911	253,970	0.30
ERROR (a) (Reps. x Treat.)		46	38,597,251	839,071	
TOTAL		71	116,895,387		
HARVEST DATES (H.D.)		2	31,563,702	15,781,851	17.16*
H.D. (Lin.)	(G)	1	16,144,324	16,144,324	17.55*
H.D. (Quad.)	(H)	1	15,419,378	15,419,378	16.77*
ERROR (b) (Reps. x H.D.)		4	3,678,714	919,679	
TOTAL		8	38,226,264		

Continued

"TABLE 67--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	14,994,539	325,968	1.25
H.D. (Lin.) x A	1	13,422	13,422	0.05
H.D. (Quad.) x A	1	16,498	16,498	0.06
H.D. (L) x B	1	572	572	0.00
H.D. (Q) x B	1	7,597	7,597	0.03
H.D. (L) x C	1	45,269	45,269	0.17
H.D. (Q) x C	1	195,070	195,070	0.75
H.D. (L) x D	1	21,300	21,300	0.08
H.D. (Q) x D	1	141,807	141,807	0.54
H.D. (L) x E	1	664,573	664,573	2.54
H.D. (Q) x E	1	7,625	7,625	0.03
H.D. x F	6	1,140,360	190,060	0.73
H.D. (L) x A x D	1	11,214	11,214	0.04
H.D. (Q) x A x D	1	13,559	13,559	0.05
H.D. (L) x A x E	1	823,877	823,877	3.15
H.D. (Q) x A x E	1	922,988	922,988	3.53
H.D. x A x F	6	2,387,478	397,913	1.52
H.D. (L) x B x D	1	17,600	17,600	0.07
H.D. (Q) x B x D	1	1,781,509	1,781,509	6.82*
H.D. (L) x B x E	1	14,261	14,261	0.05
H.D. (Q) x B x E	1	154,371	154,371	0.59
H.D. x B x F	6	1,431,573	238,595	0.91
H.D. (L) x C x D	1	3,136	3,136	0.01
H.D. (Q) x C x D	1	34,019	34,019	0.13
H.D. (L) x C x E	1	1,317,755	1,317,755	5.04*
H.D. (Q) x C x E	1	0	0	0.0
H.D. x C x F	6	3,780,986	630,164	2.41
ERROR (c)(Reps. x H.D. x Treat.)	92	24,039,690	261,300	
GRAND TOTAL	215	191,172,032		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 68.--Analysis of variance of top yield data, 1962

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications	2	20.5		
Treatments	23	2216.1	96.35	5.59**
Application time	3	160.0	53.33	3.09*
Prepl. vs Other 3	1	159.7	159.70	9.26**
Sidedressings	2	0.3	0.15	0.87
Rate of nitrogen	5	1809.4	361.88	21.00**
ERROR (a) (Reps. x Treat.)	46	792.7	17.23	
TOTAL	71	3029.3		
HARVEST DATES (H.D.)	2	656.7	328.35	52.11**
ERROR (b) (Reps. x H.D.)	4	25.2	6.30	
TOTAL	8	702.4		
Harvest Dates x Treatments	46	255.0	5.54	22.16**
ERROR (c)(Reps. x H.D. x Treat.)	92	23.7	0.25	
GRAND TOTAL	215	3989.9		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 69.--Analysis of variance of sucrose content data, 1963

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	1.66		
Treatments		23	27.16	1.18	5.46**
Application time		3	13.16	4.39	20.32**
Prepl. vs Other 3	(A)	1	0.63	0.63	2.96
Sidedressings (S.D.)		2	12.53	6.27	29.03**
S.D. (Lin.)	(B)	1	9.66	9.66	44.72**
S.D. (Quad.)	(C)	1	2.87	2.87	13.28**
Rate of nitrogen		5	2.86	0.57	2.64*
Rate of N. (Lin.)	(D)	1	1.34	1.34	6.20*
Rate of N. (Quad.)	(E)	1	0.18	0.18	0.83
Remainder	(F)	3	1.34	0.45	2.08
A x D		1	1.00	1.00	4.63*
A x E		1	0.01	0.01	0.04
A x F		3	2.95	0.98	4.58**
B x D		1	2.27	2.27	10.51**
B x E		1	1.21	1.21	5.60*
B x F		3	0.98	0.33	1.53
C x D		1	0.25	0.25	1.20
C x E		1	2.44	2.44	11.30**
C x F		3	0.31	0.10	0.46
ERROR (a) (Reps. x Treat.)		46	9.97	0.21	
TOTAL		71	38.80		
HARVEST DATES (H.D.)		2	103.79	51.90	76.66**
H.D. (Lin.)	(G)	1	67.10	67.10	99.11**
H.D. (Quad.)	(H)	1	36.69	36.69	54.19**
ERROR (b) (Reps. x H.D.)		4	2.70	0.67	
TOTAL		8	108.171		

Continued

"TABLE 69--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	14.03	0.31	1.29
H.D. (Lin.) x A	1	0.23	0.23	0.95
H.D. (Quad.) x A	1	0.16	0.16	0.67
H.D. (L) x B	1	0.50	0.50	2.08
H.D. (Q) x B	1	0.00	0.00	0.00
H.D. (L) x C	1	0.04	0.04	0.17
H.D. (Q) x C	1	0.71	0.71	2.96
H.D. (L) x D	1	0.48	0.48	2.00
H.D. (Q) x D	1	1.01	1.01	4.21*
H.D. (L) x E	1	0.01	0.01	0.04
H.D. (Q) x E	1	1.06	1.06	4.42*
H.D. x F	6	1.82	0.30	1.25
H.D. (L) x A x D	1	0.46	0.46	1.92
H.D. (Q) x A x D	1	0.01	0.01	0.04
H.D. (L) x A x E	1	0.12	0.12	0.50
H.D. (Q) x A x E	1	0.40	0.40	1.67
H.D. x A x F	6	1.51	0.25	1.04
H.D. (L) x B x D	1	0.02	0.02	0.08
H.D. (Q) x B x D	1	0.07	0.07	0.29
H.D. (L) x B x E	1	0.25	0.25	1.04
H.D. (Q) x B x E	1	0.63	0.63	2.63
H.D. x B x F	6	2.40	0.40	10.04**
H.D. (L) x C x D	1	0.01	0.01	0.04
H.D. (Q) x C x D	1	0.57	0.57	2.38
H.D. (L) x C x E	1	0.05	0.05	0.21
H.D. (Q) x C x E	1	0.55	0.55	2.29
H.D. x C x F	6	0.86	0.14	0.58
ERROR (c)(Reps. x H.D. x Treat.)	92	22.29	0.24	
GRAND TOTAL	215	181.63		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 70.--Analysis of variance of root yield data, 1963

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	17.56		
Treatments		23	186.24	8.10	1.44
Application time		3	17.44	5.82	1.04
Prepl. vs Other 3	(A)	1	0.08	0.08	0.01
Sidedressings (S.D.)		2	17.36	8.68	1.54
S.D. (Lin.)	(B)	1	14.24	14.24	2.52
S.D. (Quad.)	(C)	1	3.13	3.13	0.56
Rate of nitrogen		5	117.89	23.57	4.19**
Rate of N. (Lin.)	(D)	1	91.13	91.13	16.22**
Rate of N. (Quad.)	(E)	1	22.39	22.39	3.98
Remainder	(F)	3	4.37	1.46	0.26
A x D		1	0.25	0.25	0.04
A x E		1	9.22	9.22	1.64
A x F		3	6.36	2.12	0.38
B x D		1	2.22	2.22	0.40
B x E		1	0.18	0.18	0.03
B x F		3	14.34	4.78	0.85
C x D		1	5.28	5.28	0.94
C x E		1	0.00	0.00	0.00
C x F		3	13.12	4.38	0.78
ERROR (a) (Reps. x Treat.)		46	258.52	5.62	
TOTAL		71	462.33		
HARVEST DATES (H.D.)		2	347.34	173.67	27.52**
H.D. (Lin.)	(G)	1	239.76	239.76	38.00**
H.D. (Quad.)	(H)	1	107.59	107.59	17.05*
ERROR (b) (Reps. x H.D.)		4	25.22	6.31	
TOTAL		8	390.13		

Continued

"TABLE 70--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	65.50	1.42	1.45
H.D. (Lin.) x A	1	6.32	6.32	6.45*
H.D. (Quad.) x A	1	2.93	2.93	2.99
H.D. (L) x B	1	0.27	0.27	0.28
H.D. (Q) x B	1	4.33	4.33	4.42*
H.D. (L) x C	1	3.16	3.16	3.22
H.D. (Q) x C	1	2.01	2.01	2.05
H.D. (L) x D	1	1.41	1.41	1.44
H.D. (Q) x D	1	0.64	0.64	0.65
H.D. (L) x E	1	0.22	0.22	0.22
H.D. (Q) x E	1	0.32	0.32	0.33
H.D. x F	6	2.25	0.38	0.39
H.D. (L) x A x D	1	8.40	8.40	8.57**
H.D. (Q) x A x D	1	0.01	0.01	0.01
H.D. (L) x A x E	1	0.22	0.22	0.22
H.D. (Q) x A x E	1	7.69	7.69	7.85**
H.D. x A x F	6	0.76	0.13	0.13
H.D. (L) x B x D	1	0.39	0.39	0.40
H.D. (Q) x B x D	1	0.20	0.20	0.20
H.D. (L) x B x E	1	0.10	0.10	0.10
H.D. (Q) x B x E	1	5.19	5.19	5.30*
H.D. x B x F	6	1.80	0.30	0.31
H.D. (L) x C x D	1	0.59	0.59	0.60
H.D. (Q) x C x D	1	0.33	0.33	0.34
H.D. (L) x C x E	1	5.58	5.58	5.69*
H.D. (Q) x C x E	1	3.09	3.09	3.15
H.D. x C x F	6	7.41	1.24	1.27
ERROR (c)(Reps. x H.D. x Treat.)	92	90.45	0.98	
GRAND TOTAL	215	990.86		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 71.--Analysis of variance of sugar yield data, 1963

Source of Variation		Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications		2	3,879,113		
Treatments		23	39,994,344	17,388,845	18.19**
Application time		3	7,255,860	2,418,620	2.53
Prepl. vs Other 3	(A)	1	36,932	36,932	0.04
Sidedressings (S.D.)		2	7,218,928	3,609,464	3.78*
S.D. (Lin.)	(B)	1	5,747,290	5,747,290	6.01*
S.D. (Quad.)	(C)	1	1,471,638	1,471,638	1.54
Rate of nitrogen		5	23,836,450	4,767,290	4.99**
Rate of N. (Lin.)	(D)	1	17,613,851	17,613,851	18.42**
Rate of N. (Quad.)	(E)	1	5,230,434	5,230,434	5.47*
Remainder	(F)	3	992,165	330,721	0.35
A x D		1	2,261	2,261	0.00
A x E		1	1,407,642	1,407,642	1.47
A x F		3	839,126	279,708	0.29
B x D		1	1,030,744	1,030,744	1.08
B x E		1	215,836	215,836	0.23
B x F		3	2,153,959	717,986	0.75
C x D		1	1,216,095	1,216,095	1.27
C x E		1	136,676	136,676	0.14
C x F		3	1,910,426	636,808	0.67
ERROR (a) (Reps. x Treat.)		46	43,977,760	956,038	
TOTAL		71	87,851,217		
HARVEST DATES (H.D.)		2	81,445,816	40,722,908	30.16**
H.D. (Lin.)	(G)	1	73,944,234	73,944,234	54.76**
H.D. (Quad.)	(H)	1	7,501,582	7,501,582	5.56
ERROR (b) (Reps. x H.D.)		4	5,401,474	1,350,368	
TOTAL		8	90,726,403		

Continued

"TABLE 71--Continued."

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Harvest Dates x Treatments	46	13,625,120	296,198	2.26**
H.D. (Lin.) x A	1	1,344,133	1,344,133	10.26**
H.D. (Quad.) x A	1	384,228	384,228	2.93
H.D. (L) x B	1	22,969	22,969	0.17
H.D. (Q) x B	1	789,405	789,405	6.03*
H.D. (L) x C	1	502,476	502,476	3.84
H.D. (Q) x C	1	141,571	141,571	1.08
H.D. (L) x D	1	628,836	628,836	4.80*
H.D. (Q) x D	1	75	75	0.00
H.D. (L) x E	1	16,918	16,918	0.13
H.D. (Q) x E	1	274,160	274,160	2.09
H.D. x F	6	540,269	90,044	0.69
H.D. (L) x A x D	1	1,839,674	1,839,674	14.05**
H.D. (Q) x A x D	1	4,440	4,440	0.03
H.D. (L) x A x E	1	57,178	57,178	0.44
H.D. (Q) x A x E	1	1,677,947	1,677,947	12.81**
H.D. x A x F	6	247,889	41,314	0.32
H.D. (L) x B x D	1	65,085	65,085	0.50
H.D. (Q) x B x D	1	11,324	11,324	0.09
H.D. (L) x B x E	1	50,930	50,930	0.39
H.D. (Q) x B x E	1	1,280,407	1,280,407	9.78**
H.D. x B x F	6	609,783	101,630	0.78
H.D. (L) x C x D	1	114,494	114,494	0.87
H.D. (Q) x C x D	1	4,490	4,490	0.03
H.D. (L) x C x E	1	992,380	992,380	7.58**
H.D. (Q) x C x E	1	907,820	907,820	6.93**
H.D. x C x F	6	1,116,242	186,040	1.42
ERROR (c)(Reps. x H.D. x Treat.)	92	12,049,551	130,973	
GRAND TOTAL	215	200,373,178		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level

TABLE 72.--Analysis of variance of top yield data, 1963

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	"F"
Replications	2	19.2		
Treatments	23	341.1	14.83	16.66**
Application time	3	55.0	18.33	20.59**
Prepl. vs Other 3	1	32.3	32.30	36.29**
Sidedressings	2	22.7	11.35	12.75**
Rate of nitrogen	5	246.8	49.36	55.46**
ERROR (a) (Reps. x Treat.)	46	41.3	0.89	
TOTAL	71	401.6		
HARVEST DATES (H.D.)	2	17.7	8.85	1.03
ERROR (b) (Reps. x H.D.)	4	34.1	8.52	
TOTAL	8	51.8		
Harvest Dates x Treatments	46	18.6	0.40	3.07**
ERROR (c)(Reps. x H.D. x Treat.)	92	12.4	0.13	
GRAND TOTAL	215	484.4		

* - denotes significance at the 0.05 level

** - denotes significance at the 0.01 level