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SUGAR BEET

Faculty of Agricultural Sciences
AMERICAN UNIVERSITY OF BEIRUT
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INTRODUCTION

The Beka'a plain, because of its suitable soil and favorable climate, was considered a potential beet-growing area since 1947. During the early period the acreage of sugar beet production was limited somewhat by the excessive transportation costs involved in shipping the beet roots to a sugar factory in Homs, Syria. Since 1958, when a sugar beet factory was built in the Beka'a, beet production has increased gradually from 3000 tons grown on 1300 dunums to 24,500 tons produced on 7,800 dunums in 1961.

Unlike other important field crops, the sugar beet crop is grown under contract with a beet-sugar factory. The beet contract, entered into yearly by the grower, carries stipulations as to the acreage to be grown, the seed to be used, planting, culture, harvest and crop delivery. The factory makes available the seed and some cedit for other production costs and will accept the crop at a fixed price if it meets the minimum requirements when delivered.

The average yield of sugar beets obtained by growers in the Beka'a plain varies at present from 2.5 to 3 tons per dunum. These relative low yields are due to the fact that many farmers lack experience in growing this crop and that very little local research information is available on practices that could greatly increase the yields. The purpose of this study, therefore, was to determine the effect of various dates of planting and harvesting, different varieties and fertilizer treatments on the yield and sugar content in sugar beets. The study was conducted at the University Farm during the 5-year period 1957 to 1961.

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MATERIALS AND METHODS

The experiments on sugar beets were conducted at the University Farm located in the northern central Beka'a plain, Lebanon. The soil is high in clay content, low in organic matter and phosphorus, high in potassium content and is calcareous with a pH of about 8.0 A good seed bed was prepared after the land was leveled to facilitate more uniform irrigation of the plots.

Experimental plots not involving fertilizer studies received a uniform application of from 12 to 20 Kg. of P_2O_5 and 12 Kg. of nitrogen per dunum. The fertilizer was broadcasted and worked into the soil by disking. Also, the sugar beets received an additional one or two applications of 4 Kg. of nitrogen as a side dressing about a month after thinning and during the middle of the growth period. The beets were sprayed with fungicides and insecticides as needed and weeds were controlled by hoeing and cultivation. All plots were irrigated once a week throughout the growing season.

The field experiments were laid out on a latin square design for the cultural studies and a randomized block design for the variety trials. The fertilizer trials were planned on the basis of a central composite, rotatable, incomplete factorial design which has been described by Hader *et al* (3).

Three varieties, Kleinwanzleben, Hilleshog and Maribo P, were used in the experiments. Each plot was made of three rows, ten meters long and one-half meter apart. The center row was harvested for yield and sugar content. The beets were planted thick and at the 4 - to 6 - leaf stage thinned to a stand of 20-25 cm. between plants in the row. Each plot was replicated three or more times each year. At harvest the sugar beets were lifted, topped and each portion weighed immediately. Representative samples of the beets were stored in a cool room and all sugar analyses made the following day. The statistical analysis methods used were according to those described by Snedecor (4) and Cochran and Cox (2).

EXPERIMENTAL RESULTS

The data on the sugar beets are reported in percentage of sugar in the roots, weight of the tops and roots, and the gross yield of sugar in tons per dunum. The results of the various experiments will be discussed under three headings namely: cultural practices, varieties and fertilizer trials.

Cultural Practices

1. *Date of Planting Sugar Beets*

Sugar beets were planted the middle of March, April and May and harvested about the middle of October during 1959, 1960 and 1961. Three varieties, Kleinwanzleben, Hilleshog, and Maribo P, were used in all the trials. The average yield of roots of the three varieties planted on the three dates are reported in Table I.

It will be noted that the yields of roots decreased as the date of planting was delayed from March to May. The results are consistent for each of the three years of the study with the 3-years average yields of 8.10, 7.43 and 6.40 tons per

Table 1. Average yield of roots of sugar beets planted at different dates in the Beka'a, Lebanon, 1959-61.

Date of planting	Yield of roots - tons per dunum*			Average
	1959	1960	1961	1959-61
March	7.0	8.9	8.4	8.10
April	6.6	7.9	7.8	7.43
May	5.8	6.9	6.5	6.40
**L.S.D. (5% level)	2.0	0.6	2.8	0.55

* Average yield of the three varieties, Kleinwanzleben, Hilleshog and Maribo P
** L.S.D. - Least significance difference.

dunum for March, April and May plantings, respectively. An average increase of 1.7 tons per dunum of roots was obtained by planting in March as compared to planting in May. Also, satisfactory stands were established easier during the cooler season of March and April as compared to the warmer period of May. The three varieties, Kleinwanzleben, Hilleshog and Maribo P, responded similarly to the three dates of planting.

The yield data for the sugar beet tops as influenced by various dates of planting, are shown in Table 2. The data shows that more beet-tops were produced with the March planting than with later plantings. The average increase of beet-tops for the March over the May planting date was .15 ton per dunum. All three varieties, Kleinwanzleben, Hilleshog, and Maribo P, reflected the same trend in yields of beet-tops as shown by the average data. However the yields of the beet-tops for Maribo P were consistently higher than that of the other two varieties with an average increase of .10 ton per dunum. The 1961 season resulted in considerably more top growth being produced than during the two preceding seasons.

Table 2. Average yield of tops of sugar beets planted at differnt dates in the Beka'a Lebanon, 1959-61.

Date of planting	Yield of beet-tops - tons per dunum*			Average 1959-1961
	1959	1960	1961	
March	.77	.70	1.35	.94
April	.69	.64	1.14	.82
May	.66	.59	1.12	.79

*Average yield of air-dry tops of three varieties, Kleinwanzleben, Hilleshog and Maribo P.

The effect of date of planting on the percentage of sugar in sugar beets is reported in Table 3.

Table 3. Average percentage of sugar in roots of sugar beets planted at different dates in the Beka'a, Lebanon, 1959-61.

Date of planting	Percent of sugar in roots *			Average
	1959	1960	1961	1959-61
March	16.7	18.7	17.3	17.6
April	16.9	18.0	16.9	17.3
May	17.5	18.9	17.1	17.8
L.S.D. (5% level)	2.0	2.1	3.0	0.8

* Average percent of sugar of the three varieties, Kleinwanzleben, Hilleshog and Maribo P.

The results show that the percentage of sugar in the roots of sugar beets was not affected by the three different dates of planting when harvested during the middle of October.

The 3-year average sugar content of the three varieties grown under these coditions was 18.2, 17.4 and 17.8 percent for Kleinwanzleben, Hilleshog and Maribo P, respectively.

The gross yield of sugar per dunum was determined on the average yields and sugar percentages data obtained from the date of planting studies. The results on the effect of date of planting on gross sugar yield in tons per dunum are illustrated in Fig. 1.

It will be noted from Fig. 1 that the earlier plantings resulted in the higher gross yield of sugar. The gross yields of sugar in tons per dunum were 1.43, 1.29 and 1.14 for the March, April and May plantings , respectively.

2. *Date of Harvesting Sugar Beets*

Sugar beets, planted the middle of April, were harvested near the middle of September, October and November of each of the three years, 1959-1961. Three varieties, Kleinwanzleben, Hilleshog, and Maribo P, were used in all the trials. Table 4 reports the average yield of roots of sugar beets harvested on the three dates.

Table 4. Average yield of roots of sugar beets harvested at different dates in the Beka'a, Lebanon, 1959-61.

Date of harvesting	Yield of roots - tons per dunum*			Average
	1959	1960	1961	1959-61
September	5.9	7.9	7.5	7.10
October	6.3	8.4	8.4	7.70
November	7.2	8.8	9.4	8.47
L.S.D. (5% level)	1.4	2.8	1.5	0.59

* Average yield of three varieties, Kleinwanzleben, Hilleshog and Maribo P.

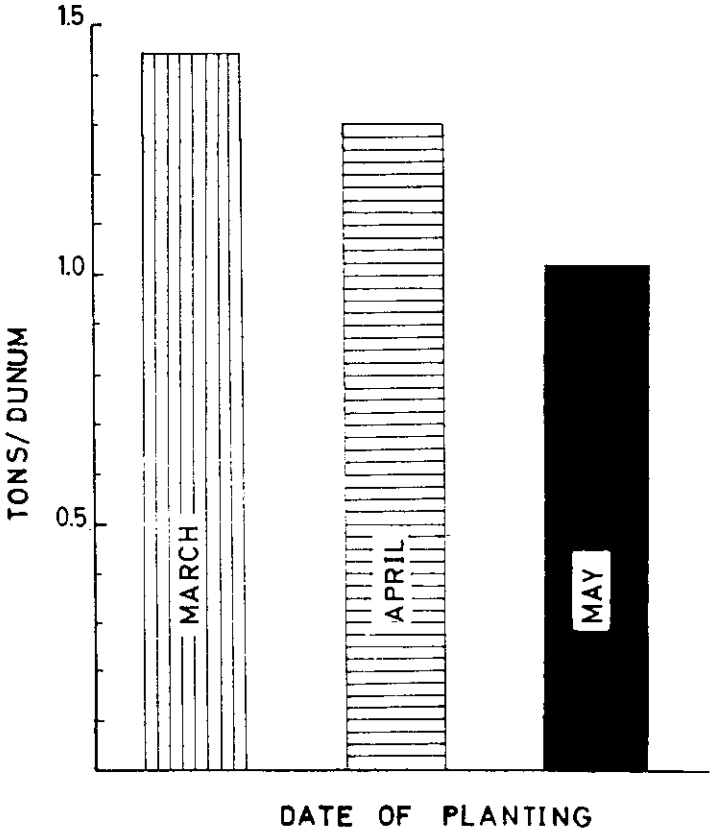

Fig. 1. Tons of sugar per dunum of beets planted on different dates.

The data show that the yield of roots of sugar beet increased as the harvest was delayed from the middle of September to the middle of November. The results are in agreement in each of the three years studied, with an average yield, of 7.10, 7.70 and 8.47 tons per dunum for the September. October and November harvests, respectively. An average increase of 1.37 tons of roots per dunum were obtained by harvesting sugar beets in November instead of in September. The data for each variety under test showed the same trend of increased yields associated with delayed harvests as reflected in the averages.

In this trial the varieties Kleinwanzleben and Hilleshog consistently produced a greater amount of roots than Maribo P at all dates of harvest, with an average yield of 7.97, 7.83 and 7.36 tons per dunum, respectively.

Table 5 shows the yield data for the beet-tops when the sugar beets were harvested at three different periods in the fall of each of the three years, 1959-61.

Table 5. Average yield of tops of sugar beets harvested at different dates in the Beka'a, Lebanon, 1959-61

Date of harvesting	Yield of beet-tops - tons per dunum*			Average
	1959	1960	1961	1959-61
September	.53	.65	.64	0.61
October	.61	.78	.90	0.76
November	.89	.71	.89	0.83

* Average yield of air-dry tops of 3 varieties, Kleinwanzleben, Hilleshog and Maribo P.

As shown in the Table the delayed harvest increased the yield of beet-tops, an average of 0.22 ton or from 0.61 ton in September to 0.83 ton per dunum in November. The variety Kleinwanzleben produced somewhat less beet-tops than the other two varieties in the trial.

The influence of date of harvest on the percentage sugar content in sugar beets is shown in Table 6.

Table 6. Average percentage of sugar in roots of sugar beets harvested at different dates in the Beka'a, Lebanon, 1959-61.

Date of harvest	Percent of sugar in roots*			Average
	1959	1960	1961	1959-61
September	15.7	17.4	16.1	16.4
October	17.7	18.3	18.0	18.0
November	18.2	18.8	20.8	19.3
L.S.D. (5% level)	3.0	3.4	2.2	2.1

* Average percent of sugar in three varities, Kleinwanzleben, Hilleshog and Maribo P.

The date of harvest was found to have a marked effect on the percentage of sugar in the roots of sugar beets. In each of the three years under study sugar beets harvested in September contained the lowest percentage of sugar while those harvested in November possessed the highest sugar content. On the basis of the 3-year average the sugar analyses were 16.4 percent for the September, 18.0 percent for the October and 19.3 for the November harvest dates.

Each of the three varieties showed the same trend each year with the 3-year average sugar content of 18.2, 17.4 and 17.8 percent for Kleinwanzleben, Hilleshog and Maribo P, respectively.

The gross yield of sugar was calculated from the average yields and average sugar percentages obtained from the three dates of harvests. The results on the effect of dates of harvest on gross sugar yield in tons per dunum are illustrated in Fig. 2.

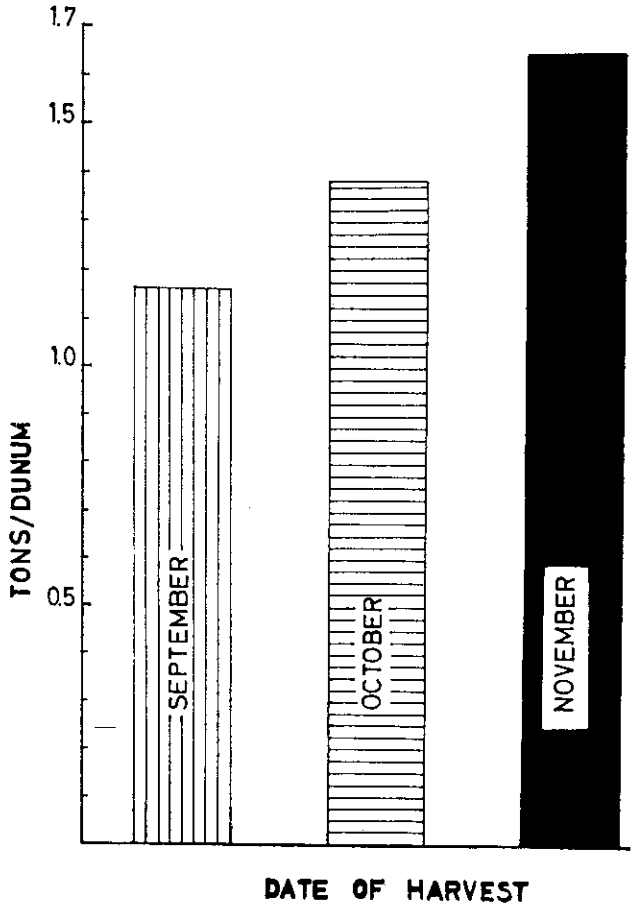

Fig. 2 Tons of sugar per dunum of beets harvested on different months

Large increases in gross sugar yields resulted from delayed harvests as shown in Fig. 2. The gross yield of sugar in tons per dunum were 1.16, 1.38 and 1.64 for the September, October and November harvests, respectively. The November harvest date resulted in an increase of 0.48 ton of sugar per dunum over that of September.

Variety Tests

From seven to twelve varieties of sugar beets were appraised each year for their relative yield of roots, beet-tops and percentage of sugar. Only four varieties, which are grown extensively in the area, were grown each year, while the others represent experimental strains that have been introduced.

The average yield of roots obtained for the various sugar beet varieties during the 3-year period are shown in Table 7. The varieties Kleinwanzleben, Hilleshog and Khun R have yielded best during the 3-year period. Some of the newer varieties appear promising but more years of testing are necessary to establish their adaptability in the Beka'a. The yield of beet tops for the four varieties grown during the three years were not consistent and showed little if any differences among them.

Table 7. Average yield of roots of sugar beet varieties grown in the Beka'a, Lebanon, 1959-61.

Variety	Yield of roots - tons per dunum*			Average
	1959	1960	1961	1959-61
Kleinwanzleben	6.2	7.6	10.0	7.93
Hilleshog	5.7	8.1	9.8	7.87
Maribo P	5.9	7.9	8.5	7.43
Khun R	6.3	8.0	9.9	8.07
Khun P	5.4	—	8.9	—
Kleinwanzleben P (Polybeta)	5.6	8.1	—	—
Hilleshog P	6.3	8.8	—	—
Lepeuple H	—	7.0	9.4	—
Polyrave	—	—	10.2	—
Trirave	—	—	9.7	—
Pedigree E	—	—	10.0	—
Pedigree SSA	—	—	10.4	—
Debrovicka A	—	—	8.4	—
Debrovicka V	—	—	10.5	—

* The varities were planted the middle of April and harvested the middle of October.

The data for the percentage of sugar in the roots of the several varieties of sugar beets tested are reported in Table 8. From the standpoint of sugar content, the varieties Kleinwanzleben and Maribo P are higher in percentage of sugar than that found in Hilleshog. This is in agreement with the data reported for the sugar percentage of these varieties under the date of planting and date of harvest studies. Considering both yield and sugar or gross sugar yield the variety Kleinwanzleben appears best.

Table 8. Average percent of sugar in roots of sugar beet varieties grown in the Beka'a, 1959-61.

Variety	Percent sugar in roots			Average
	1959	1960	1961	1959-61
Kleinwanzleben	17.8	19.1	19.6	18.83
Hilleshog	18.0	18.6	17.3	18.00
Maribo P	19.2	18.1	18.3	18.53
Khun R	16.4	18.1	16.7	17.07
Khun P	17.6	—	19.2	—
Kleinwanzleben (Polybeta)	17.4	20.9	—	—
Hilleshog P	17.2	18.0	—	—
Lepeuple H	—	20.9	17.4	—
Polyrave	—	—	17.9	—
Trirave	—	—	17.9	—
Pedigree E	—	—	17.7	—
Pedigree SSA	—	—	18.2	—
Debrovicka A	—	—	17.7	—
Debrovicka V	—	—	16.5	—

Fertilizer Trials

1. Effect of Nitrogen Application

The yield of sugar beets was considerably increased by application of nitrogen fertilizers (Fig. 3) in tests carried out over a five-year period, 1957 to 1961. The yield of beet-tops was also increased considerably by application of nitrogen fertilizer. The tests for the years 1957 (Allos and Macksoud) (1) and 1961, indicate that the response to nitrogen is greater where there is adequate available phosphorus present in the soil. In both years, yields dropped off at high rates of nitrogen when the phosphorus supply was low. The rate of nitrogen application for maximum profit at present prices (Fig. 4) is in the range between 20 and 30 Kg./dunum when phosphorus and water supplies are adequate and the other conditions of growth are not limiting. It should be noted that profit did not change greatly over a considerable range of nitrogen application levels.

2. Effect of Phosphorus Application

In 1960, a decrease in yield resulted from an application of phosphorus (Table 9) with a low rate of nitrogen application probably because the soil already had an adequate supply of available phosphorus. However, at the 22.8 Kg./dunum level of nitrogen there was considerable response to phosphorus. The 1960 soil test for available phosphorus was "medium" while the soil of the 1961 tests was "low". In 1957 and 1961, there was considerable response to application of phosphorus fertilizer at the higher rates of nitrogen application (Table 10.) The response to phosphorus was greater at the higher levels of nitrogen levels while at a low level of applied nitrogen, 3.2. Kg./dunum, there was a slight decrease in yield. In 1958 and 1959, phosphorus was not varied in the experiments. Most of the soils of the Beka'a are naturally low in available phosphorus. Therefore, it is recom-

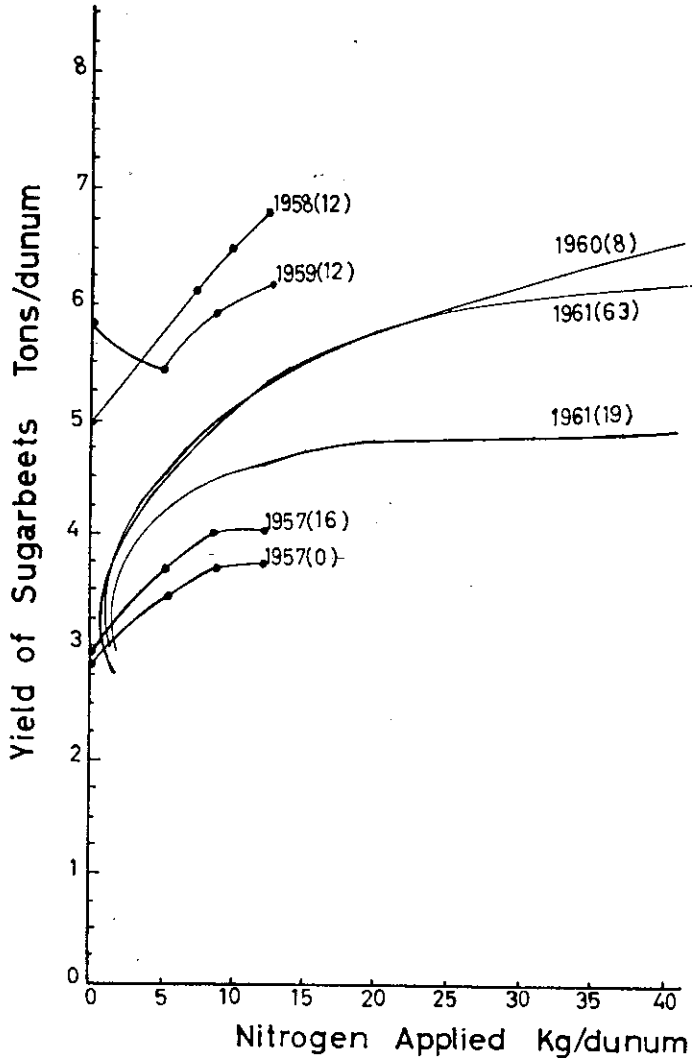

Fig. 3. Effect of nitrogen in combination with phosphorus on yield of sugar beets. (Number in parenthesis refers to Kg. of P_2O_5 /dunum).

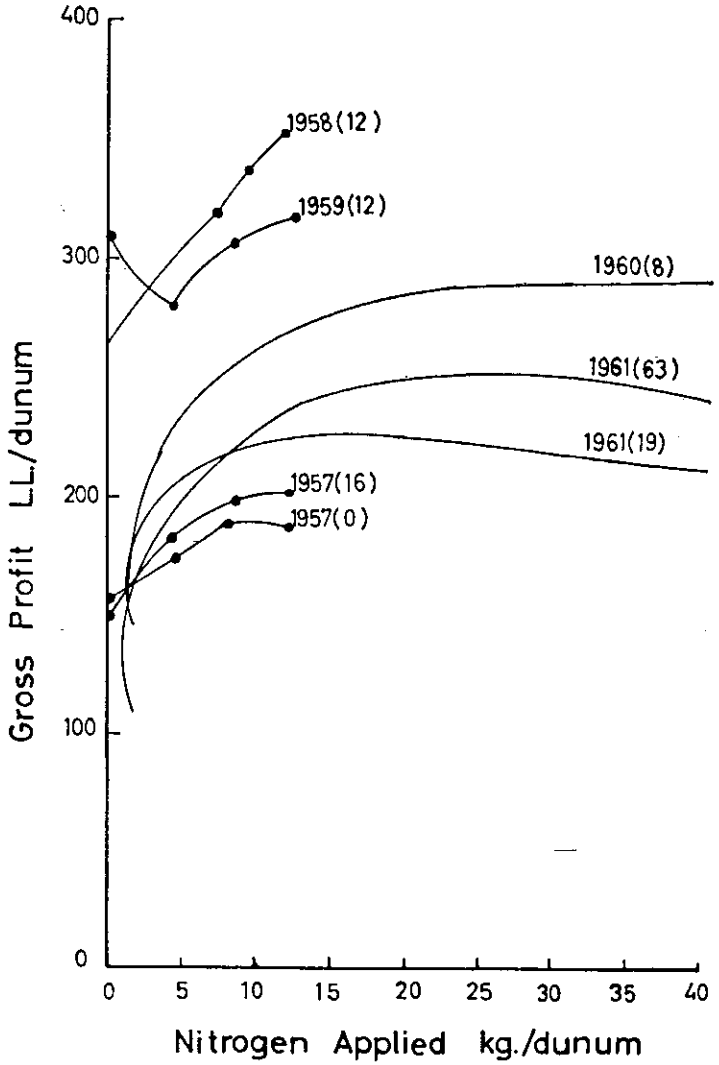

Fig. 4 Gross profit (Beets at 55 LL./ton minus cost of fertilizer at 1.36 L.L./Kg. of N and O.625 L.L./Kg. of P_2O_5) of sugar beets as affected by applied nitrogen and phosphorus. (number in parenthesis refers to Kg. of P_2O_5 / dunum).

mended that phosphorus fertilizer be applied to sugar beets at the rate of 12 to 20 Kg. of P_2O_5/dunum annually unless large amounts of animal manure or phosphorus fertilizer have been applied in the past. In case of doubt, the soil should be tested for available phosphorus. To be effective, the phosphorus fertilizer should be applied either broadcast and worked into the soil before planting time, or, more efficiently, placed in a band in the soil along side the row at planting time. Phosphorus applied after planting time will probably have little effect on yield.

Table 9. Response of sugar beets (tons/dunum) to applications of phosphorus and nitrogen. 1960.*

Phosphorus applied	Nitrogen applied, Kg. N/dunum				
Kg. P_2O_5/du.	1.1	3.1	8.4	22.8	61.8
1.1			5.1		
3.1		4.9	5.1	5.3	
8.4	3.8	4.6	5.0	5.7	7.1
22.8		4.3	5.2	6.0	
61.8			5.0		

*From M.S. thesis of Karim K. Husseini, American University of Beirut, 1961.

Table 10. Response of sugar beets (tons/dunum) to applications of phosphorus and nitrogen. 1961.

Phosphorus applied	Nitrogen applied, Kg. N/dunum				
Kg. P_2O_5/du.	1.5	3.2	10.9	35.7	80.0
2.6			4.2		
5.9		4.0	4.7	5.1	
19.0	2.8	3.9	4.0	5.6	4.3
63.0		3.8	4.9	6.0	
143 0			5.6		

3. *Time of Nitrogen Application*

In 1958 and 1959, application of all the nitrogen at planting time was compared to a split application with one third at planting time and two thirds after thinning (Table 11). No difference in yield was found from these practices.

Table 11. Effect of time of application of nitrogen fertilizer on yield of sugar beets, tons/dunum.

Rate of application of nitrogen Kg./du.	Nitrogen applied	
	All at planting	1/3 at planting 2/3 after thinning
1958		
7.2	6.3	6.0
9.6	6.4	6.5
12.0	6.9	6.7
1959		
4.0	5.0	5.7
8.0	5.7	6.1
12.0	6.4	5.8

4. *Effect of Nitrogen Application on Percentage Sugar*

The percentage of sugar in sugar beets was not significantly affected by either rate or time of nitrogen application in any of the five years. (Tables 12, 13). There was a tendency for decreased sugar percentage at extremely high rates of nitrogen application.

Table 12. Percentage sugar of sugar beets as affected by application of nitrogen and phosphorus fertilizers. 1960.

Phosphorus applied	Nitrogen applied, Kg. N/dunum				
Kg. P_2O_5 /du.	1.1	3.1	8.4	22.8	61.8
1.1			20.6		
3.1		19.2	20.3	21.3	
8.4	20.0	20.2	20.5	20.5	16.3
22.8		21.2	20.4	19.6	
61.8			21.0		

Table 13. Percentage sugar of sugar beets as affected by application of nitrogen and phosphorus fertilizers. 1961.

Phosphorus applied	Nitrogen applied, Kg./Ndunum				
Kg. P_2O_5/du.	1.5	3.2	10.9	35.7	80.0
2.6			16.8		
5.9		20.6	19.7	18.8	
19.0	19.5	19.7	20.7	18.9	17.1
63.0		18.9	19.0	19.0	
143.0			20.0		

5. *Effect of Application of Various Nutrients on Yield of Sugar Beets*

The response of sugar beets in the trials to sodium has been variable (Table 14). In 1960, application of sodium resulted in a significantly higher yield of beets while in the 1961 trial no increase in yield resulted. More work on sodium application for sugar beets in Lebanon is needed before a recommendation can be made

Trials with potassium, sulfur, zinc, boron, iron, manganese, magnesium and copper have resulted in either no response or very slight response in 1960 and 1961 (Tables 14, 15). Additional work is needed before definite conclusions can be made.

Table 14. Effect of various macronutrients on the yield of sugar beets, tons/dunum.

Rate of application, Kg./du.	1961 Potassium	1961 Sodium	1961 Magnesium	1961 Sulfur	Rate of application Kg./du.	1960 Potassium	1960 Sodium	1960 Magnesium
1.1	8.41	8.41	6.36	4.03	1.1	3.98	3.86	4.86
2.6	6.93	7.12	6.80	4.50	3.1	4.92	4.78	4.84
8.4	6.95	6.95	6.95	4.01	8.4	5.05	5.05	5.05
27.6	6.90	6.73	7.04	5.07	22.7	5.33	5.46	5.42
61.8	6.40	7.08	6.75	2.66	61.8	3.89	5.06	5.06

Table 15. Effects of Various Micronutrients on the yield of sugar beets, tons/dunum.

Rate of application Kg./du.	1961 Zinc	1961 Boron	1961 Manganese	1961 Copper	Rate of application Kg./du.	1961 Iron
.20	7.56	7.73	7.28	7.51	.57	7.58
.57	7.68	7.39	7.70	7.49	1.54	7.67
1.54	7.52	7.52	7.52	7.52	4.20	7.52
4.20	7.50	7.78	7.50	7.70	11.37	7.51
11.37	8.02	6.56	8.25	7.41	30.90	7.93

SUMMARY

Sugar beet trials, involving cultural practices, varieties and fertilizer studies were conducted in the Beka'a, Lebanon, during the 5-year period 1957-61.

Yield and sugar content were affected greatly by the time of planting and date of harvest. The yield of roots of sugar beets decreased as the date of planting was delayed from March to May. The yield of beet roots as well as the sugar percentage increased as the harvest was delayed from September to November.

Varieties of sugar beets varied in yield and sugar content. Under the conditions of these trials the variety Kleinwanzleben appeared best.

Yield of sugar beets and sugar beet tops was considerably increased by application of nitrogen fertilizer. Where the supplies of water and phosphorus are adequate, it appears that nitrogen should be applied for sugar beets at the rate of 20 to 30 Kg. of actual nitrogen per dunum for yields on the order of 6 to 10 tons per dunum.

Unless phosphorus is shown to be adequate by soil tests, phosphorus should be applied for sugar beets at the rate of 12 to 20 Kg. of P_2O_5 per dunum.

Trials with potassium, sodium, magnesium, sulfur, zinc, boron, iron, manganese, and copper have resulted in variable or only slight response of sugar beet yields.

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