SUGAR BEET SEED PRODUCTION
IN BEQA'A - LEBANON

by

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ABSTRACT

The Beqa'a plain is an area of a high potential for growing sugar beet seed by the winter-annual method, since the climatic conditions are favourable for the photothermal induction required for seed stalk development. The winter-annual method was evaluated by studying the effect of three dates of plantings in September and three varieties (Pedigree E, Pedigree SSA and Polyrave) on seed yield, seed quality and other plant characteristics.

Maximum seed yields were obtained by planting sugar beets early in September in the Beqa'a, Lebanon. Pedigree E produced the highest average seed yields, followed by Pedigree SSA and Polyrave. However the three varieties yielded about the same when sown on September 1.

Pedigree E and Pedigree SSA produced a high percentage of viable seeds and a high number of seedlings per 100 seed balls. The immature harvesting of Polyrave resulted in its low quality seed. The seed size of the variety Pedigree E was larger than that of Polyrave and Pedigree SSA. Beets planted early in September produced larger seeds and a greater number of seedlings per 100 seed balls.

Early plantings resulted in early bolting and early plant maturity. Pedigree E and Polyrave bolted earlier than the variety Pedigree SSA, although Polyrave matured later than the other two varieties.

High seed shattering was encountered when beets were planted early in September. The amount of seeds shattered from the variety Polyrave was less than that of the other two varieties tested.

The plant height of the sugar beets was not affected by the different dates of planting and varieties used in the experiment.

Beet root weights and sizes decreased significantly as the date of planting was delayed from September 1 to 30. No significant differences were found in the root yields or sizes of the different varieties grown. The earlier plantings, that resulted in higher root reserves, produced the largest amount of seed.

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INTRODUCTION

The sugar beet industry in Lebanon made its first appearance in 1947 in the Beqa'a plain. The production at first was retarded due to the high costs of transporting beet roots to a Syrian sugar factory. The establishing of a sugar beet factory in the Beqa'a during 1958 has enhanced the production from 3000 tons grown on 1300 dunums of land to 32000 tons produced on 8600 dunums in 1963.

The sugar beet industry is flourishing also in other Middle Eastern countries like Syria, Iraq, Iran, Turkey and possibly Jordan in the near future. Syria produced 86900 tons grown on 45111 dunums during 1963.

All these countries depend heavily on the seed produced in North Europe for growing their beets each season. Lebanon imported 26 tons of sugar beet seed last year at a total price of 60,000 L.L. Syria's sugar beet seed needs are about four times that of Lebanon's. The seed is usually distributed by the factory to the "contracting" farmers who bear part or all of the seed cost.

Sugar beet seed is produced by two methods, namely (1) the biennial method and (2) the winter-annual method.

The biennial method is used extensively in Europe. In this method the beet seed is produced in two years. The first year, stecklings are established in the spring and summer, dug-up in the fall and stored in pits during the winter. In the next spring the stecklings are reset in the field for seed production. This method involves much labor and time and many stecklings are lost due to rotting, freezing and drying.

The winter-annual method was developed as a result of the cooperation of U.S. Department of Agriculture and the New Mexico Agricultural Experiment Station during the 10-year period, 1922 to 1931. This successful method has revolutionized the sugar beet industry because it required less time, less labor and eliminated the storage problems. Also, it permitted complete mechanization of the field operations and the production of locally grown seed of adapted and disease resistant varieties.

The new method is based on the principle that seeds planted in late summer are induced to bolt or initiate seed stalks in the next spring if subjected to optimum photothermal induction of 7 to 13 °C for 90 to 110 days so that enough hormones are produced in the roots for seed production.

The central Beqa'a plain has six months from November to April of average normal temperature equal to 8.6 °C. The coldest three months of winter from January to March have an average temperature of 6.4°C. These months are accompanied by plenty of sunshine and followed in the spring by long days essential for seed stalk development. So the climatic conditions in the Beqa'a plain appear to meet the required photothermal induction suitable for sugar beet seed production.

The purpose of this study therefore, was to evaluate the winter-annual method in the production of sugar beet seed in Lebanon. Sugar beet seeds were planted on three different dates in September using the three varieties: Polyrave, Pedigree E, and Pedigree SSA. Data involving bolting, maturity, plant height, root diameter and weight, seed yield and seed quality were recorded.

It may be possible that sugar beet seed can be produced efficiently in the Beqa'a plain by the winter-annual method. This would stabilize the sugar beet industry in the Middle East, and cut down the production costs.

REVIEW OF LITERATURE

Sugar beet seed production by the winter-annual method has a unique history in its development. The United States used to import more than 90 percent of its need of sugar beet seed from Europe prior to World War I. Europe produces seed by the biennial method where the stecklings produced from late spring planting are dug-up and stored in pits over fall and winter and reset in the field early in the spring for the seed production. To carry this method in the United States involves much labor and time, besides its storage problems. This obliged the United States to rely upon Europe for its seed supply. During World War I the seed supplies were cut off. A sugar beet seed production crisis soon developed and many sugar beet factories were closed down. Many seed companies tried to produce seed by the biennial method. It was not only costly but seed quality tended to deteriorate due to lack of pure stock seed and haste in pushing the seed program. After World War I the United States resumed again the importation of seed from Europe. Also, some American producers contracted to have their own strains produced in Europe (6, 8, 11, 16).

Between 1922 and 1933 a vigorous research program on sugar beet seed production by the winter-annual method was carried on through the cooperation of U.S.D.A. and New Mexico Agricultural Experiment Station. The spark that led to the initiation of the overwintering method, however, was accidental. During 1922 the cooperative research in New Mexico was directed towards finding out the best dates of sugar beet planting for sugar production. Sugar beet plantings were made at the beginning and fifteenth of every month. It was observed that plants seeded between September 1 and October 1 survived the winter and produced seed stalks in the early spring. Seeds were ready for harvest in July. Extensive experiments had since been conducted to determine the possibilities of the overwintering method. This revolutionary action allowed the United States during the Second World War, to produce enough sugar beet seed for its own need and for export to its allies in Europe. And other countries all over the world (6, 8, 11, 16).

The underlying principle of the winter-annual method of sugar beet seed production is photothermal induction. Photothermal induction is the process of flower initiation under the effect of prolonged low temperature and long photoperiod that cause the release of harmone-like substances in beet crowns necessary for bolting. Low temperatures affect the germinating seeds, beets stored in cold storage and growing plants (17). The interaction of light and heat factors are not well understood, but acting together the reproductive cycle develops. In nature, plantings made in the fall automatically brings the crop to fruiting period when day length is in the increasing phase (8). Stout (27) concluded that either photoperiodic induction or thermal induction, acting independently, can carry the reproductive process toward completion. The effect of light and temperature on reproduction in the sugar beets seems to be complementary.

In the greenhouse more than one generation of sugar beet seed can be produced by subjecting the sugar beet seedling to temperature of 50°F and continuous illumination (10). Steinberg and Garner (25) found that a selected strain of sugar beet could be induced to flower at 73°F by the use of continuous high intensity illumination. With continuous illumination, the period from germination to flowering decreased as the temperature was raised up to 73°F.

Under field conditions the most inductive temperature is from 45 to 55°F for 90 to 110 days depending upon the genetic make-up of the variety. Temperatures more than 70°F increase vegetative development. Temperatures near freezing are not favourable to induction due to suppression of the metabotic activities of the plant (26). Poehlman (22) stated that some light freezing weather is needed to check plant vegetative growth. Pendelton (18) in overwintering studies found that sugar beet plants that appeared too badly frozen to recover made normal seedstalks and better than average seed yield. The improved seed yield was due to incomplete thermal induction caused by freezing. Under such conditions the plant is kept in a semi-vegetative state. The roots continue to develop while seed stalks are forming. Whereas, under conditions of complete thermal induction, no further root growth takes place after spring growth has resumed. Fife and Price (9) confirmed Pendelton's results and suggested that thermal induction, including the reactions it brings about, is related to continuance or discontinuance of vegetative development after bolting. They found that root weight increased from thinning time until bolting, then there was no significant increase until harvest time.

Warm temperature exposure following adequate thermal induction was found to reduce or neutralize the effect of cool temperature exposure and is referred to as the reversal of thermal induction. Rate of reversal was approximately twice as fast at 19.3°C as at 13.2°. This indicates a temperature coefficient of approximately 3.3°C for the rate of reversal between 13.2°C and 19.3° (27). The induction process exists in a state of complete reversibility until sufficient seedstalk development occurs. This explain the failure of nonbolting varieties to reproduce satisfactorily in some of the warm seed growing areas. Such warm temperature occurring before initiation of seedstalks may be detrimental to seedstalk development (27). Owen et al. (17) concluded that induction of flowering in mild climates was increased when the beets were kept cooler during the winter by means of artificial shades. They observed that the north sides of two-row beds running east and west had more bolters than the south sides.

Although photothermal induction is fixed by the climatic conditions prevailing in the seed-growing area and by the degree of bolting in the variety grown, there is much room for investigators to increase the efficiency of the induction process and thus the yield of the seed crop. This can be done by providing optimum dates of planting, plant populations, phosphate and nitrogen fertilization and efficient cultural practices. (7, 16, 28).

Research on date of planting was carried on by several workers (1, 6, 15, 28). They concluded that the main effects of dates of planting are as follows:

(i) Accumulation of enough carbohydrates reserve in the roots during the vegetative period for seed production in the spring.

(ii) Increasing the top size during the fall and this has an important effect on photothermal induction. Large top size increases the leaf area exposed to the sunlight and decreases the crown temperature by its shading effect.

(iii) Maintaining an optimum size of roots essential for winter hardiness. Roots must be large enough to withstand winter conditions, but not so large that freezing, which is known to kill plants standing far out of the ground, may destroy the stand.

Tolman (28) in his series of experiments from 1936 to 1940 concluded that bolting was not affected by date of planting but seed production was significantly lower from September 12 planting compared to August 24 planting. The depressive effect of late planting was especially noted on moderately non-bolting varieties coupled with late date of plowing and lack of phosphate and nitrogen fertilization. Planting later than September 20 was too late for sufficient fall growth, regardless of other optimum growing conditions. Planting earlier than August 25 increased the hazard of winter injury. The best planting dates in Hamet, California (7) ranged from August 20 to September 5. Planting prior to August 20 gave no more improvement in yield but entailed additional expenses of irrigation, cultivation and land preparation. In the Pacific northwest (21) planting earlier than June resulted in winter killing and leaf spot diseases. Planting later than August 15 plant growth was slow and weeds outgrew the beet seedlings. Mast (15) found that the best dates of planting in Arizona and New Mexico ranged from August 15 to September 10. Varieties of low bolting tendency or those requiring extensive photothermal induction needed to be planted as early as June.

Optimum time of harvest is important in sugar beet seed production. Early harvest results in poor seed quality, while delayed harvest results in excessive shattering. The criteria for optimum harvesting time is not well-defined. Generally it is best to harvest when the seeds in the middle portions of the branches are in the hard dough stage. At this stage seeds will reveal firm tissue with light brown seed coat. The immature seeds on tips of the branches are disregarded in favor of the higher quality basal seeds. To reduce shattering, cutting must be done early in the morning or late in the afternoon (8, 11).

Seed quality is especially important in any seed program because if it falls below the standards set by the seed laws it cannot be marketed. Purity, germination percentage and seed size are some of the important quality determiners. Tolman (28) found out that planting dates and phosphate or nitrogen fertilization have no consistent effect on germination percentage. Presence of injurious insects, high temperature or hot drying winds during the period of early seed set affects the seed germination drastically. Mast (15) suggested increasing the frequency of irrigation if the temperature is high or relative humidity is low during the seed set. Hawthorn and Pollard (11) reported that high moisture during seed set may delay seed maturity and decrease seed germination. Elcock (8) got better germination percentage and seed weights using 22-inch rows compared to thick planting. Pendelton (20) concluded that closer spacing resulted in slightly smaller seeds but it did not affect the germination.

Sugar beet size studies in the green house and field revealed that large seed balls had higher and faster germination and gave more vigorous seedlings and higher roots and gross sugar yields (24). Bush and Brewbaker (3) concluded that seed size has no significant effect on yield of roots or sugar. Large seeds are an important character in obtaining good stands in unfavourable conditions of soil or temperature. Tolman (28) reported that date of planting is an important factor in determining seed size. Late date of planting caused uneven ripening and resulted in higher percentage of small seeds.

MATERIALS AND METHODS

The experiment on sugar beet seed production was conducted at the Agricultural Research and Educational Center of the American University of Beirut located in the Northern Central Beqa'a plain, Lebanon. The soil is high in clay content, low in organic matter and phosphorous, high in potassium content and is calcareous with a pH of about 8. The climate of central Beqa'a plain consisting of the monthly average temperature, relative humidity, sunshine hours and rainfall is shown in Table 1. The dry period consists of about seven months with relatively hot temperature, and the humid period consists of five months with relatively cold temperature. The rainfall at the Center fluctuates from year to year with an average of 376.5 mm annually. The average temperature does not show much fluctuations from year to year. The light intensity is not a limiting factor in the Beqa'a plain.

A good seed bed was prepared after the land was levelled to facilitate more uniform irrigation of the plots. Then the experimental plots received a uniform application of 20 kg. of P_2O_5 as superphosphate and 12 kg. of nitrogen as ammonium sulfonitrate per dunum. The fertilizers were broadcasted and disked into the soil. Also, in January, one additional application of five kg. of nitrogen per dunum was side-dressed since the plants showed nitrogen deficiency symptoms.

The experiment was laid out on a split-plot design with the dates of planting as the major plots and varieties as sub-plots. The sugar beet seeds were planted on September 1, 15 and 30, and the

Table 1. Average temperature, rainfall, relative humidity and sunshine at the A.U.B. Agricultural Research and Educational Center in the Beqa'a, Lebanon.*

	Temperature (^{o}C)		Rainfall (mm)		Rel. Humidity	Sun (hrs)
	1962-63	1956-63	1962-63	1956-63	1962-63	1962-63
September	21.6	20.6	0.0	1.1	51.4	11:30
October	17.1	16.8	19.3	8.0	62.1	8:10
November	14.1	11.6	0.0	21.7	49.7	7:40
December	7.8	8.5	164.1	97.2	____	4:50
January	7.1	5.1	124.1	107.1	62.7	6:02
February	7.4	5.9	70.0	57.1	76.3	5:50
March	6.9	8.1	82.4	47.6	72.1	8:21
April	11.9	12.3	53.3	24.4	70.4	8:19
May	14.0	16.4	11.7	11.6	48.3	11:45
June	20.6	20.1	0.0	0.7	62.2	12:15
July	22.0	22.5	0.0	0.0	58.9	12:14
August	23.6	23.5	0.0	0.0	48.1	11:54
Total for the year			524.9	376.5		

* Amer. Univ. Farm meteorological data, Beqa'a Valley, Lebanon, by S. Abu-Shakra, F. Malouf and H. Nasr.

varieties used were Pedigree E, Pedigree SSA and Polyrave. There were four replications, each consists of three major plots assigned to dates of planting, and each major plot consists of three- sub-plots assigned to varieties. The sub-plots consisted of four rows each five meters long and 0.75 meters apart.

The seeds were planted thick by the Planet Junior garden drill at the rate of 1.87 kg. per dunum. The seedling emergence was 6 to 7 days for the first planting, 7 to 8 days for the second planting and 9 to 10 days for the third planting. Thinning was done at the 4 to 8 leaf stages to a stand of 20 to 25 cm. between plants in the row. The population came to an average of 5866 plants per dunum.

The beets were sprayed with Karathane five times during the season to control powdery mildew, Erysiphe betae, and three times with Metasystox for aphid control. The weeds were controlled by hoeing and by hand when necessary during the entire growing season. The experimental plots were irrigated weekly during the fall by the sprinkler method. Weekly irrigation using furrows was resumed on May 15, 1963 and continued until a week before harvesting the seed crop on July 15, 1963. Harvesting was done when most of the seeds were mature and noticeably brown or hard. Four meters from the two center rows only were harvested for yield to eliminate the border effect. The stalks bearing the seeds were cut off by sickles and put into sacs that were tied loosely and hung in the open air to permit curing. After the seeds were cured they were threshed by a nursery grain thresher. Chaff and other impurities were removed by using ordinary sieves. Representative samples were taken to evaluate the seed quality.

Data were obtained for the following characteristics: Percentage of bolting, percentage of maturity, root diameter at bolting date and at harvesting time, roots weights after harvesting, shattering, seed yield and seed quality. Statistical methods appropriate to the split-plot design were used according to Cochran and Cox (4).

RESULTS AND DISCUSSION

The effects of the three dates of planting, September 1, 15 and 30, and three varieties, Pedigree E, Pedigree SSA and Polyrave on sugar beet seed production are presented in Tables 2 to 13. The data are reported under the following headings: seed yield, 1000-seed weight, germination percentage, number of seedlings per 100 seedballs, seed purity, plant maturity, seed shattering, plant height, bolting, root diameter at bolting time, root diameter at seed harvest and beet root yield. Analyis of variance Tables are given in the appendix. The LSD figures are presented at the bottom of the Tables only for the treatments that were statistically significant.

Seed Yield.[1]

The date of planting greatly affected the yield of seed of sugar beets as shown in Table 2. Beets from September 1 plantings produced 101 kg. more seed per dunum than those sown on September 15 and 247 kg. over the September 30 plantings. The favourable effect of the early date of planting on seed yield may be attributed to the increased accumulation of root reserves and the extended period of photothermal induction.

The seed yields were affected significantly by the variety. Pedigree E produced the highest yield and the variety Polyrave gave the lowest yield. The variety Pedigree SSA was intermediate in seed production but not significantly better than Polyrave.

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[1] Seed yields include the shattered seed.

Table 2. Effect of date of planting and variety on the seed yield of sugar beet in kg. per dunum, when grown at the A.U.B. Agricultural Research and Education Center.

Date of Planting	Variety			Date mean
	Pedigree E (V_1)	Pedigree SSA (V_2)	Polyrave (V_3)	
Sept. 1 (D_1)	593	569	580	579
Sept.15 (D_2)	505	509	420	478
Sept.30 (D_3)	376	304	317	332
Variety mean	491	461	437	

	LSD (5%)	LSD (1%)
Between dates	69	105
Between varieties	26	36
Between varieties x dates	45	

Dates of planting	Sept. 1	Sept. 15	Sept. 30
Mean	579	478	332

Varieties	Ped. E	Ped. SSA	Polyrave
Mean	491	461	437 *

Varieties x dates:

V_1D_1	V_3D_1	V_2D_1	V_2D_2	V_1D_2	V_3D_2	V_1D_3	V_3D_3	V_2D_3
593	580	569	509	505	420	376	317	304

* Treatments underlined do not differ significantly at the 5 percent level.

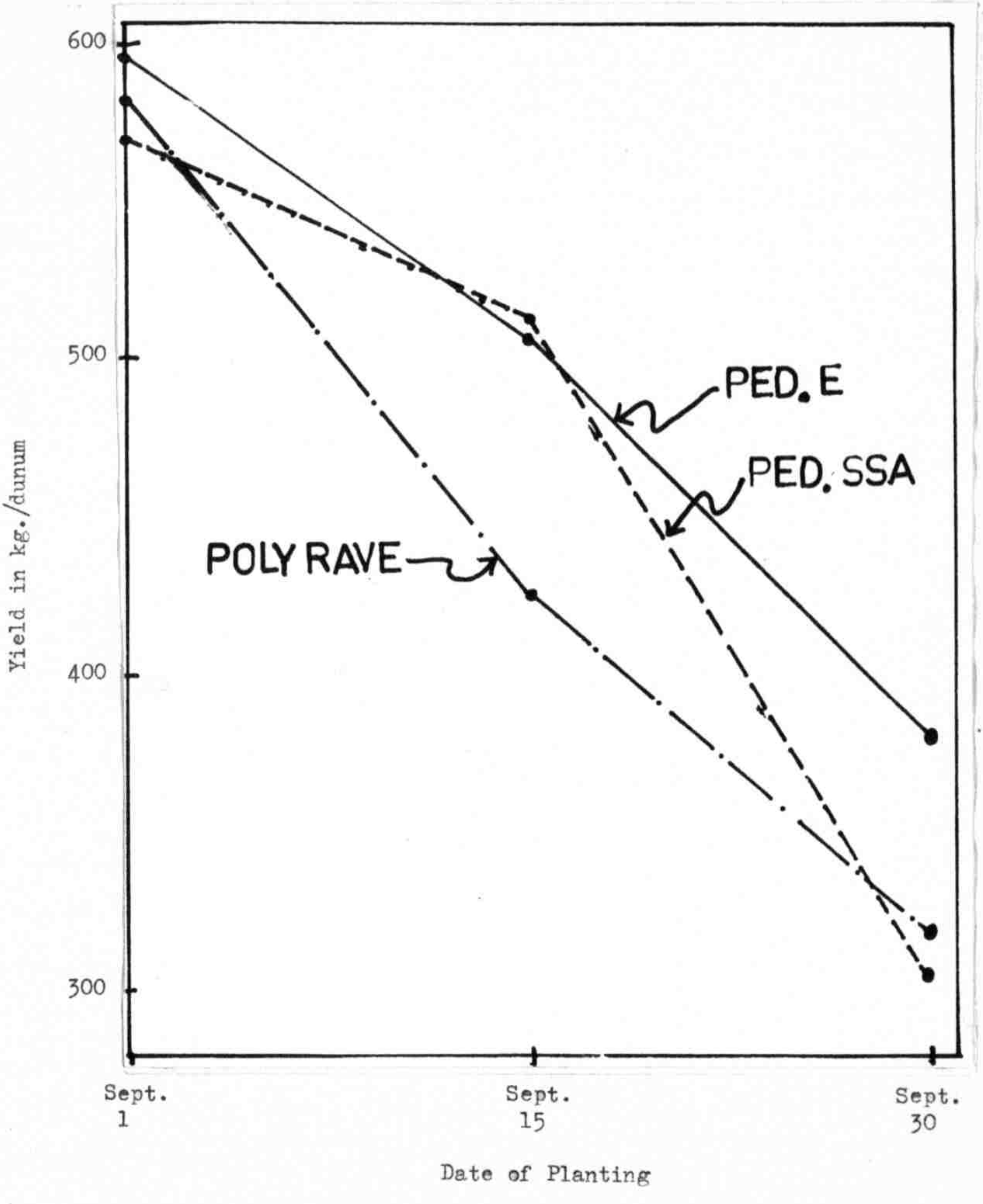

Fig. 1: Effect of date of planting and variety on yield of sugar beet seed.

The data on seed yield indicate a significant interaction between variety and date of planting. A close study of Fig. 1 reveals that the three varieties yielded about the same when sown at the earliest date of planting. On September 15 Pedigree E and Pedigree SSA produced the same amount of seed while variety Polyrave yielded significantly less than the other two tested. The adverse effects of the September 30 plantings on the seed yield were the least for the variety Pedigree E compared with the other two varieties.

Weight of 1000-seeds

The seed weight of sugar beets was affected significantly by the different varieties used in the experiment (Table 3). Pedigree E produced heavier seeds than those obtained from the variety Polyrave. The seed of both of these varieties was significantly heavier than that of Pedigree SSA. The three dates of planting studied had little, if any, influence on the seed weights of sugar beets.

The data in Table 3 indicate a significant interaction between variety and date of planting. The first and second date of planting resulted in heavy seed weight in Pedigree E and Polyrave, but in light seed weight in Pedigree SSA. On the third date of planting the varieties did not differ significantly among themselves with respect to seed weight.

Germination percentage

The effect of date of planting and variety on the percentage of viable seeds is shown in Table 4. The varieties Pedigree E and Pedigree SSA produced seed of higher viability than that obtained from Polyrave with average germination percentages of 90, 93 and 55, respectively.

Table 3. Effect of date of planting and variety on the 1000 - seed weight of sugar beet in grams, when grown at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety			Date mean
	Pedigree E (V_1)	Pedigree SSA (V_2)	Polyrave (V_3)	
Sept. 1 (D_1)	20.2	15.9	19.1	18.4
Sept.15 (D_2)	19.6	16.2	18.5	18.1
Sept.30 (D_3)	18.3	17.6	18.4	18.1
Variety mean	19.4	16.5	18.7	

	LSD (5%)	LSD (1%)
Between varieties	1.5	2.1
Between varieties x dates	2.1	2.9

Variety	Ped. E	Polyrave	Ped. SSA
	19.4	18.7 *	16.5

Variety x date:

V_1D_1	V_1D_2	V_3D_1	V_3D_2	V_3D_3	V_1D_3	V_2D_3	V_2D_2	V_2D_1
20.2	19.6	19.1	18.5	18.4	18.3	17.6	16.2	15.9

* Treatments underlined do not differ significantly at the 5 percent level.

Table 4. Effect of date of planting and variety on germination percentage of sugar beet seed grown at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety: Pedigree E	Pedigree SSA	Polyrave	Date mean
Sept. 1	93	97	56	82
Sept. 15	91	92	55	79
Sept. 30	87	91	54	77
Variety mean	90	93	55	

	LSD (5%)	LSD (1%)
Between varieties	5.0	6.9

Variety	Ped. SSA	Ped. E	Polyrave
Mean	<u>93</u>	<u>90</u> *	55

* Treatments underlined do not differ significantly at the 5 percent level.

The low viability of the seed produced by the variety Polyrave may be attributed to the immaturity of the seed at harvest time as will be shown later. A laboratory examination of the ungerminated seed balls revealed that the seeds were either empty or filled partially as compared with viable seeds.

The effect of date of planting on the germination percentage of sugar beet seeds was not significant, however, beets that were planted at the earlier dates tended to produce seeds that germinated higher than those obtained from the later plantings.

Number of seedlings per 100 seed balls

Sugar beet seed is the commercial name for the botanical fruit structure that consists of one or more seeds. Monogerm fruit contains only one seed, whereas the multigerm contains from 2 to 5 seeds. The multigerm character of sugar beet seed increases the labor for thinning. On the other hand, multiple seed balls improve the stand of low quality seed.

Date of planting affected the multigerm character of sugar beet seed significantly (Table 5). Beet seed obtained from the September 1 planted crop produced higher number of seedlings per 100 seed balls than those obtained from the September 15 and 30 plantings.

The varieties Pedigree E and Pedigree SSA produced seed balls of higher number of seedlings than those obtained from Polyrave. One hundred seed balls gave 165 seedlings in Pedigree E and Pedigree SSA, but only 87 seedlings in the variety Polyrave. The low number of seedlings obtained from the variety Polyrave might be attributed to its low germination percentage.

Table 5. Effect of date of planting and variety on number of seedlings per 100 seed balls at the A. U. B. Agricultural Research and Educational Center.

Date of Planting	Variety			Date mean
	Pedigree E (V_1)	Pedigree SSA (V_2)	Polyrave (V_3)	
Sept. 1 (D_1)	180	175	90	148.3
Sept. 15 (D_2)	163	164	86	137.5
Sept. 30 (D_3)	153	158	81	131.7
Variety mean	165.4	165.4	86.7	

	LSD (5%)	LSD (1%)
Between dates	11.3	—
Between varieties	9.2	12.7

Dates of planting	Sept. 1	Sept. 15	Sept. 30
Mean	148.3	137.5	131.7*

Variety	Ped. E	Ped. SSA	Polyrave
Mean	165.4	165.4	86.7

* Treatments underlined do not differ significantly at the 5 percent level.

Percentage of plant maturity:

The effect of date of planting and variety on the percentage of plants with mature brown seedstalks at the time of harvest is shown on Table 6.

A significant difference in maturity percentage of plants was found between the three varieties studied. The maturity percentage of Pedigree E, Pedigree SSA and Polyrave was 85.1, 75.9 and 55.2 respectively. Variety Polyrave seems to be a late maturing variety and this might be a cause for its lower seed yield (Table 2) and lower seed viability (Table 4). A general look, at time of harvest, at the sugar beet plots showed that variety Polyrave was somewhat greenish against the brownish background of the other two varieties.

The September 1 plantings gave the highest percentage of mature plants at the time of harvest when compared with those planted later. The September 30 plantings had lower percentage of mature plants than those from the September 15 planted crop, but not significantly.

Seed shattering

Sugar beet seed mature unevenly on each plant. The seedballs at the bases of the stalks mature first, while those at the tip of the stalks mature last. This uneven maturity results in a seed shattering problem. Shattering is enhanced by low relative humidity and excessive handling of the crop.

The results in Table 7 show that the effect of date of planting on seed shattering was significant, with the early date of planting resulting in more shattered seed than the later plantings. Beets planted

Table 6. Effect of date of planting and variety on the percentage of plants with mature, brown seed stalks at the time of harvest at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety			Date mean
	Pedigree E (V_1)	Pedigree SSA (V_2)	Polyrave (V_3)	
Sept. 1 (D_1)	92.4	87.6	86.6	82.9
Sept. 15 (D_2)	86.2	72.8	49.0	69.5
Sept. 30 (D_3)	75.6	67.2	47.6	63.8
Variety mean	85.1	75.9	55.2	

	LSD (5%)	LSD (1%)
Between dates	14.6	——
Between varieties	8.7	11.8

Date of planting	Sept. 1	Sept. 15	Sept. 30
Mean	82.9	69.5	63.8*

Variety	Ped. E	Ped. SSA	Polyrave
	85.1	75.9	55.2

* Treatments underlined do not differ significantly at the 5 percent level.

Table 7. Effect of date of planting and variety on seed shattering in kg. per dunum at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety: Pedigree E (V_1)	Variety: Pedigree SSA (V_2)	Variety: Polyrave (V_3)	Date mean
Sept. 1 (D_1)	29.8	29.3	14.5	24.5
Sept. 15 (D_2)	19.5	18.5	13.3	17.1
Sept. 30 (D_3)	11.0	11.3	8.8	10.3
Variety mean	20.1	19.6	12.2	

	LSD (5%)	LSD (1%)
Between dates	10.7	
Between varieties	3.5	4.9
Between varieties x dates	6.1	

Date of planting	Sept. 1	Sept. 15	Sept. 30
Mean	24.5	17.1	10.3*

Variety	Ped. E	Ped. SSA	Polyrave
Mean	20.1	19.6	12.2

Variety x date

V_1D_1	V_2D_1	V_1D_2	V_2D_2	V_3D_1	V_3D_2	V_2D_3	V_1D_3	V_3D_3
29.8	29.3	19.5	18.5	14.5	13.3	11.3	11.0	8.8

* Treatments underlined do not differ significantly at the 5 percent level.

on September 1 shattered 24.5 kg. seed per dunum, while those planted on September 15 and 30 shattered 17.1 and 10.3 kg., respectively.

The varieties used in this experiment behaved differently with respect to seed shattering. Variety Polyrave shattered significantly less seeds than either of the two varieties, Pedigree E and Pedigree SSA. Of the latter two varieties, Pedigree E shattered more seed than Pedigree SSA, but the difference was not statistically different.

The interaction between varieties and dates of planting was found to be significant. When the varieties are planted on September 1 Pedigree E and Pedigree SSA shattered significantly more seed than variety Polyrave. On subsequent dates of planting, the differences in shattered seeds, between Pedigree E and Pedigree SSA on one hand and variety Polyrave on the other hand became smaller and smaller.

<u>Seed purity</u>

Under this trial weeds were controlled, therefore, sugar beet seed samples tested did not contain weed seeds but only inert matter. Inert matter, here, refers to chaff and very small immature seeds.

The data presented in Tables 20 and 8 shows that the percentage of inert matter in sugar beet seeds was not significantly affected either by date of planting or variety. Beets planted on September 1 appeared to be clearer of inert matter than those planted later. Variety Polyrave had larger inert matter content compared to the other two varieties.

<u>Plant height</u>

No statistical difference in sugar beet plant heights due to

Table 8. Effect of date of planting and variety on the percentage of inert matter in sugar beet seed grown at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety			Date mean
	Pedigree E	Pedigree SSA	Polyrave	
Sept. 1	5.27	4.10	8.62	6.00
Sept. 15	6.73	5.68	8.04	6.80
Sept. 30	6.83	5.89	6.74	6.50
Variety mean	6.27	5.22	7.81	

Table 9. Effect of date of planting and variety on the average plant height of sugar beet in cm. at time of harvest, at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety			Date mean
	Pedigree E	Pedigree SSA	Polyrave	
Sept. 1	170	160	169	166
Sept.15	155	151	155	154
Sept.30	141	144	145	143
Variety mean	155	152	156	

either date of planting or variety were found as shown in Tables 9 & 21. A trend towards higher plants is obtained with the early planting. Beets planted on September 1 were taller than those planted later. Variety Pedigree SSA seemed to be shorter than the other two varieties especially when grown at the first date of planting.

Percentage of bolting

Sugar beet plants after being exposed to photothermal induction in the fall, winter and early spring bolt or develop seed stalks. It was noted that the overwintered sugar beets, in this study, showed bolting over a period extending throughout April. The effect of date of planting and variety on the percentage of bolted plants on April 10 is shown at Table 10.

The date of planting greatly affected the percentage of bolting in sugar beets. The percentage of bolted plants is about doubled as the planting is made earlier from September 30 to 1 as shown in Table 10.

Variety Pedigree SSA gave a lower percentage of bolters than Pedigree E and Polyrave. The difference in bolting percentage between Pedigree E and Polyrave was not significant. Variety Polyrave showed the highest bolting percentage when planted on September first, while on the other dates of planting Pedigree E gave the highest percentage of bolters.

Root diameter at bolting time

Accumulation of enough carbohydrate reserves in the roots is essential for bolting and seed production.

Table 10. Effect of date of planting and variety on the percentage of bolting in sugar beet on April 10, at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety			Date mean
	Pedigree E (V_1)	Pedigree SSA (V_2)	Polyrave (V_3)	
Sept. 1 (D_1)	57.8	57.0	68.8	61.2
Sept. 15 (D_2)	41.3	27.8	37.3	35.4
Sept. 30 (D_3)	16.3	10.8	15.5	14.2
Variety mean	38.4	31.8	40.5	

	LSD (5%)	LSD (1%)
Between dates	12.2	18.5
Between varieties	5.8	

Dates of planting	Sept. 1	Sept. 15	Sept. 30
Mean	61.2	35.4	14.2

Variety	Polyrave	Ped. E	Ped. SSA
	<u>40.5</u>	<u>38.4</u>*	31.8

* Treatment underlined do not differ significantly at the 5 percent level.

Table 11. Effect of date of planting and variety on beet root diameter in cm. on April 23, at the A.U.B. Agricultural Research and Educational Center.

Date of Planting (D)	Variety (V) Pedigree E	Pedigree SSA	Polyrave	Date mean
Sept. 1	8.21	8.17	8.36	8.19
Sept. 15	7.18	7.62	6.83	7.22
Sept. 30	5.76	5.51	6.06	5.78
Variety mean	7.00	7.10	7.09	

	LSD (5%)	LSD (1%)
Dates of planting	1.02	1.52

Dates of planting	Sept. 1	Sept. 15	Sept. 30
Mean	<u>8.19</u>	<u>7.22*</u>	5.78

* Treatments underlined do not differ significantly at the 5 percent level.

Table 11 shows the effect of date of planting and variety on root diameter at bolting time (April 23). Root diameter was found to be affected significantly by date of planting. Beets planted on September 1 gave the largest root diameter, while those planted on September 30 showed the smallest root diameter at bolting time. Root diameters of beets planted on September 15 were intermediate compared to the other two dates of planting. The early plantings resulted in larger roots at bolting time due to the vigorous vegetative growth obtained during the fall.

The results reported in Table 11 indicate that the three varieties studied in this experiment had about the same root sizes at the time of bolting.

Root diameter at seed harvest

The effect of date of planting and variety on the root diameter at the time of harvesting the sugar beet seed crop is shown in Table 12.

The root diameter was affected greatly by the date of planting. Beets planted on September 1 had root diameters larger than those planted on September 15 and 30 by 20 percent and 42 percent, respectively. The date of planting had less influence on the root diameter of the sugar beets at the time of bolting (Table 11) than at the time of seed harvest (Table 12). The range in the diameter of the roots of September 1 and 15 plantings was greater at the time of seed harvest as compared to that during bolting.

The variety effect is very slight on the root diameter. Similar observations on root size were obtained at the bolting time.

An analysis of the data in Table 12 shows a significant interaction

Table 12. Effect of date of planting and variety on root diameter of sugar beet in cm. at harvesting time, at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety			Date mean
	Pedigree E (V_1)	Pedigree SSA (V_2)	Polyrave (V_3)	
Sept. 1 (D_1)	8.3	6.7	8.5	7.8
Sept. 15 (D_2)	6.2	6.5	6.7	6.5
Sept. 30 (D_3)	5.5	5.5	5.5	5.5
Variety mean	6.7	6.3	6.9	

	LSD (5%)	LSD (1%)
Between dates	1.0	1.5
Between dates x varieties	1.0	

Dates of planting	Sept. 1	Sept. 15	Sept. 30
Mean	7.8	6.5	5.5

Variety x date:

V_3D_1	V_1D_1	V_2D_1	V_3D_2	V_2D_2	V_1D_2	V_1D_3	V_2D_3	V_3D_3
8.5	8.3	6.7	6.7	6.5	6.2	5.5	5.5	5.5*

* Treatments underlined do not differ significantly at the 5 percent level.

between date of planting and variety. The highest root diameters were obtained when the varieties Pedigree E and Polyrave were planted on September 1. All of the varieties planted on September 30 produced relatively smaller roots than when planted earlier.

Comparing the data of Table 11 and 12 the decreases in root diameter from bolting to harvesting time are as follows: 4.8 percent for the first date of planting, 10 percent for the second date and 5 percent for the third date of planting. These slight decreases seem to be in accordance with the findings of Fife and Price (9).

Beet root yields

The yield of sugar beet roots made at the time of the seed harvest indicates the amount of food reserves accumulated during the previous growing season of beets. Also, these harvested roots are a potential livestock feed since they are rich in carbohydrates. The analysis for sugar percentage was not carried on in this study.

The effect of date of planting and variety on the yield of beet roots is presented on Table 13. The roots yield decreases significantly as the date of planting is delayed from September 1 to 30. The yields of roots obtained from beets planted on September 1, 15 and 30 were 4.87, 3.41, 2.37 tons per dunum, respectively. This suggests that the early date of planting resulted in more accumulation of food reserves in the roots and thus a higher seed crop (Table 2).

The variety effect on root yield was found to be significant. Pedigree E and Polyrave produced about the same amount of roots, while Pedigree SSA was the least in yield of beet roots.

Table 13. Effect of date of planting and variety on the yield of beet roots in tons per dunum made at time of seed harvest at the A.U.B. Agricultural Research and Educational Center.

Date of Planting	Variety			Date mean
	Pedigree E (V_1)	Pedigree SSA (V_2)	Polyrave (V_3)	
Sept. 1 (D_1)	5.52	3.48	5.68	4.87
Sept. 15 (D_2)	3.65	3.13	3.45	3.41
Sept. 30 (D_3)	2.24	2.30	2.57	2.37
Variety mean	3.80	2.97	3.88	

	LSD (5%)	LSD (1%)
Between dates	1.04	2.20
Between varieties	0.61	0.82
Between varieties x dates	1.05	

Dates of plantings	Sept. 1	Sept. 15	Sept. 30
Mean	4.87	3.41	2.37

Variety	Polyrave	Ped. E	Ped. SSA
Mean	3.88	3.80*	2.97

Varieties x dates

V_3D_1	V_1D_1	V_1D_2	V_3D_2	V_2D_1	V_2D_2	V_3D_3	V_2D_3	V_1D_3
5.68	5.52	3.65	3.48	3.45	3.13	2.57	2.30	2.24

* Treatments underlined do not differ significantly at the 5 percent level.

The data in Table 13 indicates a significant interaction between date of planting and variety. The best root yields are obtained with Pedigree E and Polyrave when planted on September 1. All varieties, when grown on the second or third date of planting, showed slight differences among themselves with respect to root yields.

A comparison of sugar beet seed yield and root yield as affected by date of planting and variety is illustrated in Fig. 2 and Fig. 3. Fig. 2 shows that by planting sugar beets early (September 1) the root yield as well as seed yield were increased significantly, whereas, both seed and root yields were decreased with delayed plantings. It seems evident that the high food reserves accumulated in the roots by the early date of planting resulted in proportionally high seed yields. Fig. 3 indicates that the varieties did not react uniformly as to the relative root and seed yields. Pedigree E produced high root yield and high seed yield, and variety Polyrave produced high root yield but low seed yield. The low seed yield of Polyrave may be attributed to its low maturity at harvesting. The amount of photothermal induction in the Beqa'a area may have a variable influence on each variety.

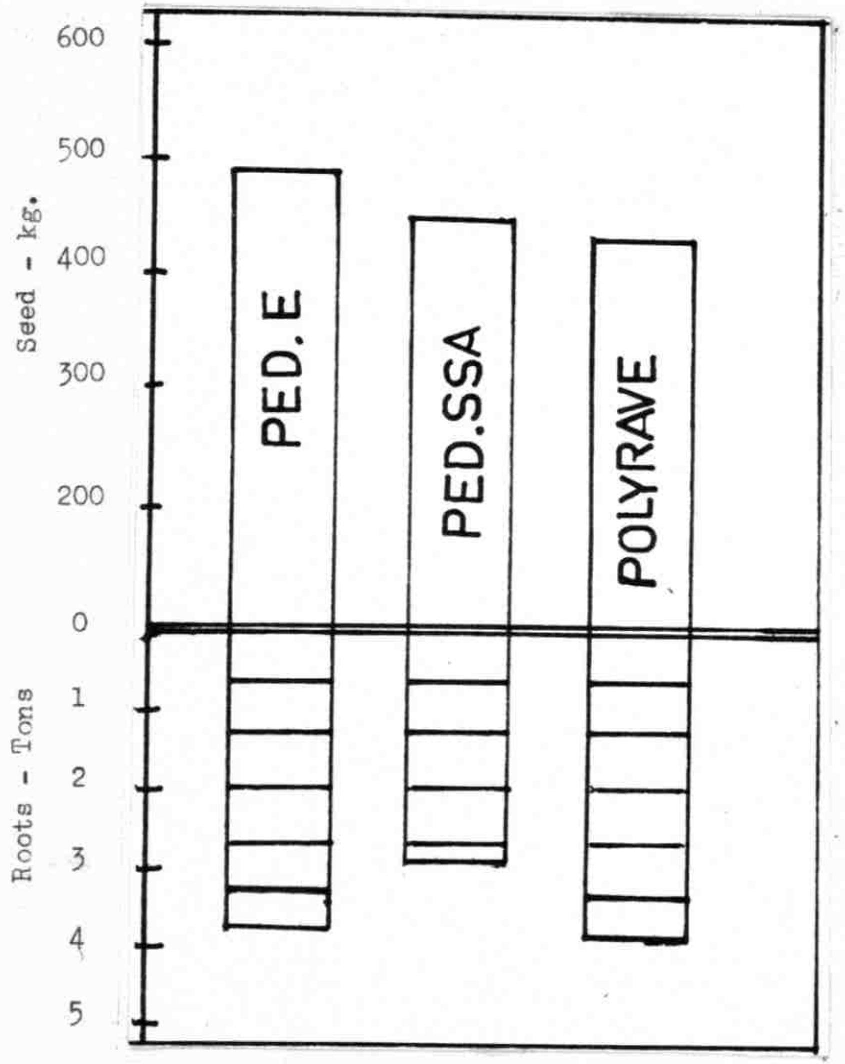

Fig. 3 : Sugar beet seed yield in kg. and root yields in tons/dunum as affected by variety.

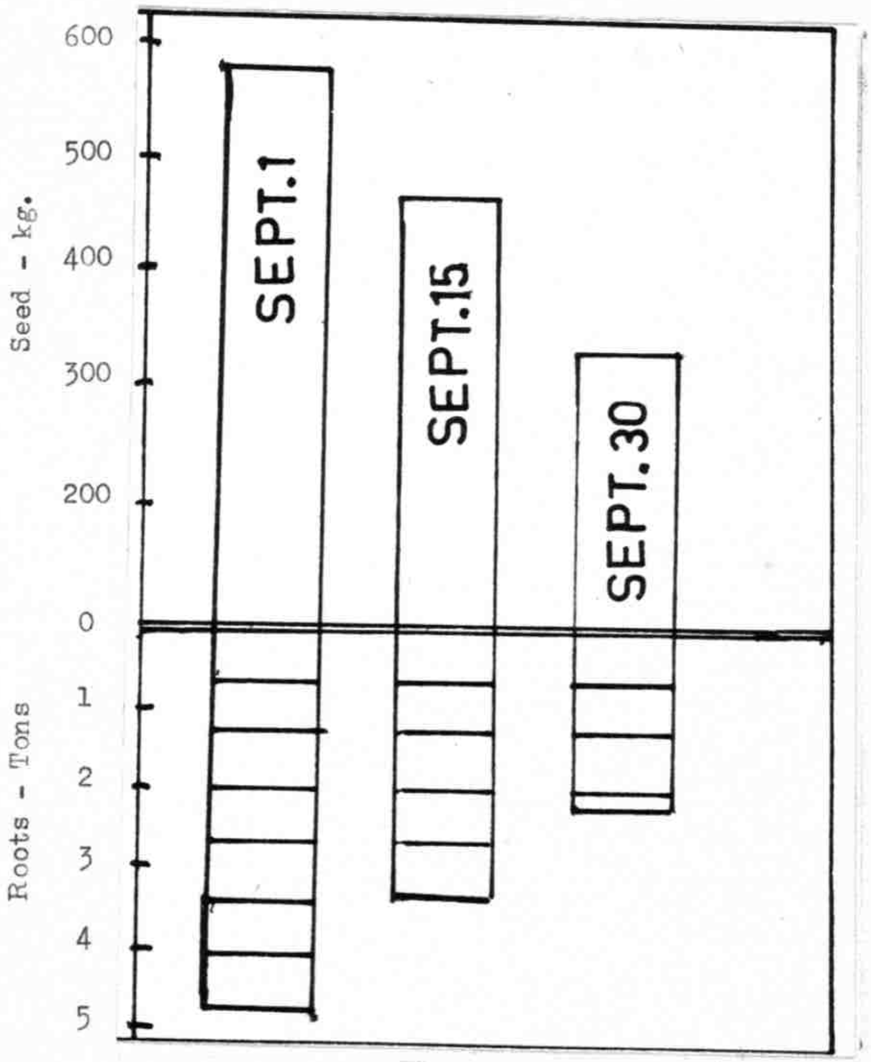

Fig. 2: Sugar beet seed yield in kg. and root yields in tons/dunum as affected by date of planting.

SUMMARY AND CONCLUSIONS

This study deals with evaluating the winter-annual method of sugar beet seed production in Beqa'a, Lebanon. Plantings were made on September 1, 15 and 30 using three varieties Pedigree E, Pedigree SSA and Polyrave. Data were obtained on seed yield, seed size, seed viability, multigermness character, seed purity, seed shattering, plant maturity, plant height, bolting, root diameter at bolting time, root diameter at seed harvest and beet root yields at seed maturity.

Sugar beet seed yields were influenced greatly by different dates of planting. Beets planted on September 1 gave the highest seed yield, while those planted on September 30 produced the lowest seed yield. The large seed yields obtained with the early planting can be attributed to the high food reserves accumulated in the roots and to the extended period of photothermal induction during the fall.

The variety Pedigree E produced the maximum average seed yields, followed by Pedigree SSA and Polyrave. However, on the first date of planting, when the seed yields were high, the three varieties produced about the same amount of seed. On the second date of planting Polyrave produced relatively less seed than the other two varieties, while on the third date of planting both Polyrave and Pedigree SSA yielded less than Pedigree E.

The seed size of the variety Pedigree E was found to be larger than that of Polyrave and Pedigree SSA. The date of planting did not influence the seed size in sugar beets.

Seed viability, expressed in percentage of germinating seeds, was very high in Pedigree E and Pedigree SSA in comparison with variety Polyrave. The low germination percentage of Polyrave could be attributed to its delayed maturity in comparison with the other two varieties. The date of planting had no effect on the beet seed viability.

The number of seedlings germinating from 100 seed balls was increased from the beet plants grown early in September. The seedballs of Pedigree E and Pedigree SSA give high number of seedlings in comparison with Polyrave. The low number of seedlings germinating from Polyrave's seed balls could be ascribed to the low germination percentage of its seeds.

The percentage of inert matter resulting from threshing the seed stalks was found to be independent of either date of planting or variety. Late plantings in September and variety Polyrave gave relatively larger clean-out of small seeds.

High seed shattering was encountered when beets were planted early in September. The amount of seeds shattered from the variety Polyrave was much less than that of the other two varieties.

The data taken on plant maturity indicated that both Pedigree E and Pedigree SSA were earlier in maturity than Polyrave. The percentage of plants with brown seedstalks was found to increase as beet planting was made earlier in September.

No significant effect was observed on the plant height of the sugar beets due to different dates of planting or varieties. A trend towards higher plant heights was obtained as the dates of sowing were made early in September. Variety Pedigree SSA seemed to be shorter than the other two varieties.

The plants resulting from sowing sugar beet seeds on September first bolted earlier than those sown later. Pedigree E and Polyrave bolted earlier than the variety Pedigree SSA.

The beet root yields obtained at seed harvest time were found to be maximum when beet planting are made on September first. Sharp decreases in root yields resulted as the planting dates were delayed. No significant differences were found in the root yields of the different varieties grown. However, Pedigree E and Polyrave planted on September first produced high root yields.

Evaluation of root diameters at bolting and harvesting time revealed no significant differences among the varieties. Beets planted earlier in September were found to have larger root diameters.

Beet root weights and sizes reflect the food reserves accumulated by the sugar beet plants during the growing season. It was found that the relationship between root yields and seed yields was consistent for the dates of planting, but inconsistent in the case of varieties. Other environmental factors seem to affect the efficiency of utilization of root reserves in the different varieties.

From the results of this experimental work, it seems evident that commercial sugar beet seed production by the winter annual method is practical in the Beqa'a plain. The high root yields obtained as a by-product of sugar beet seed production may add to the potential of sugar production in this area.

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APPENDIX

Table 14. Analysis of variance for yield of seed in sugar beets

Source	D.F.	M.S.	F
Blocks	3	2409	0.52
Planting date	2	184847	38.70**
Error "a"	6	4774	
Varieties	2	8716	9.41**
Varieties x dates	4	3907	4.23*
Error "b"	18	926	

* Significant at the 5 percent level.

** Significant at the 1 percent level.

Table 15: Analysis of variance for the weight of 1000-seeds in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	16.0	0.83
Planting dates	2	4.0	0.21
Error "a"	6	19.3	
Varieties	2	25.7	12.85**
Varieties x dates	4	36.0	18.00**
Error "b"	18	2.0	

** Significant at the 1 percent level.

Table 16: Analysis of variance for seed germination percentage in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	41.18	1.01
Planting dates	2	58.58	1.44
Error "a"	6	40.67	
Varieties	2	5467.58	157.93**
Varieties x dates	4	10.92	0.32
Error "b"	18	34.62	

** Significant at the 1 percent level.

Table 17: **Analysis of variance for the number of seedlings per 100 seed balls in sugar beets.**

Source	D.F.	M.S.	F
Blocks	3	270	2.10
Planting dates	2	848	6.63*
Error "a"	6	128	
Varieties	2	24806	215.70**
Varieties x dates	4	236	2.10
Error "b"	18	115	

* Significant at the 5 percent level.

** Significant at the 1 percent level.

Table 18: Analysis of variance for the percentage of plants with brown seedstalks in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	70.98	0.34
Planting dates	2	1131.00	5.41*
Error "a"	6	209.04	
Varieties	2	3053.4	27.9**
Varieties x dates	4	46.8	0.44
Error "b"	18	109.2	

* Significant at the 5 percent level.

** Significant at the 1 percent level.

Table 19: Analysis of variance for the weight of shattered seeds in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	16.3	0.15
Planting dates	2	602.5	5.24*
Error "a"	6	115.0	
Varieties	2	238.5	13.95**
Varieties x dates	4	57.3	3.35*
Error "b"	18	17.1	

* Significant at the 5 percent level.

** Significant at the 1 percent level.

Table 20: Analysis of variance for the percentage of inert matter in the threshed seeds of sugar beets.

Source	D.F.	M.S.	F
Blocks	3	4.32	0.47
Planting dates	2	2.03	0.22
Error "a"	6	9.28	
Varieties	2	20.34	3.18
Varieties x dates	4	4.24	0.67
Error "b"	18	6.40	

Table 21: Analysis of variance for plant height in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	260.0	0.53
Planting dates	2	1471.5	2.97
Error "a"	6	495.2	
Varieties	2	46.5	0.51
Varieties x dates	4	59.0	0.64
Error "b"	18	91.9	

Table 22: Analysis of variance for the bolting percentage in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	71.10	0.48
Planting dates	2	6647.30	44.50**
Error "a"	6	149.07	
Varieties	2	245.59	5.28*
Varieties x dates	4	77.71	1.67
Error "b"	18	46.48	

* Significant at the 5 percent level.

** Significant at the 1 percent level.

Table 23: Analysis of variance for the root diameter at bolting in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	1.47	1.43
Planting dates	2	17.60	17.10**
Error "a"	6	1.03	
Varieties	2	0.04	0.05
Varieties x dates	4	0.50	0.57
Error "b"	18	0.88	

** Significant at the 1 percent level.

Table 24: Analysis of variance for the root diameter at seed harvesting in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	0.28	0.29
Planting dates	2	16.39	17.25**
Error "a"	6	0.95	
Varieties	2	1.30	3.25
Varieties x dates	4	1.43	3.58*
Error "b"	18	0.40	

* Significant at the 5 percent level.

** Significant at the 1 percent level.

Table 25: Analysis of variance for the root yield in sugar beets.

Source	D.F.	M.S.	F
Blocks	3	0.68	0.64
Planting dates	2	19.00	17.97**
Error "a"	6	1.06	
Varieties	2	3.08	6.18**
Varieties x dates	4	1.56	3.13*
Error "b"	18	0.50	

* Significant at the 5 percent level.

** Significant at the 1 percent level.