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VARIABILITY AND TRAITS RELATIONSHIPS IN NINE SUGAR BEET VARIETIES UNDER THREE SOWING DATES

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ABSTRACT

Two field experiments were conducted in Fayoum Governorate (latitude 29° N, longitude 30° N and high tide 30 m) in 2003/2004 and 2004/2005 seasons to evaluate nine sugar beet genotypes (Beta vulgaris, L.) sown at three dates. The tested sugar beet genotypes were imported from Germany (Gazella, Del 937 and Carolla), France (LP12, LP11 and LP13), Netherlands (Farida and Samba) and Sweden (Baraca). Sowing dates were October,5, October,25 and November,14.

The obtained results indicated that sugar beet genotypes differed significantly in growth, yield and quality characteristics in both seasons except sodium and potassium percentages in the 1st and 2nd season, respectively. Farida and Gazella genotypes gave the highest values of the most studied characters, while Samba and LP11 contained the highest impurities and sugar loss in molasses.

Early sowing of sugar beet on the 5th of October surpassed significantly the other two dates (25th of October and 14th of November) in the values of most studied traits, while impurities in roots (α-amino-N, K and Na percentages) and sugar losses in molasses increased by delaying sowing date up to 14th of November. Top yield and leaf area index decreased as sowing date was delayed from 5 October up to 14 November in both seasons.

Sowing Gazella and/or Farida genotypes on the 5th of October gave the highest values of the most growth and yield characters. The highest root yield was achieved by sowing Farida genotype on the 25th of October. Most quality parameters were not affected by the interaction between genotypes and sowing dates.

Significant and positive correlation coefficient was found between sugar yield and each of root yield, root fresh weight, sucrose% and purity%. Linear regression analysis showed that root yield, root fresh weight/plant, purity % and sucrose% were the most effective traits affecting sugar yield.

Heritability was less than 50 % for the studied characters. So, all the response of genotypes may be due to the different environments.

Sowing Gazella and/or Farida genotypes early on 5th October is preferred and recommended for increasing yield and quality of sugar beet under Fayoum Governorate.

Key words: ***Sugar beet, Genotypes, Sowing dates, Correlation, Regression, Variability, Heritability***

INTRODUCTION

All sugar beet genotypes (*Beta vulgaris* L.) cultivated in Egypt are imported from foreign countries, so, it is preferable to evaluate them under Egyptian conditions especially under newly reclaimed soil and different sowing dates to select the best suited ones.

Nassar (1992) found from evaluation of eleven multigerm varieties that Supra Poly variety was superior in root length, diameter and fresh root weight) as well as purity %, sugar recovery % and root, sugar, top yields ton/fed followed by Maghribel. Supra Poly and Tribel recorded the highest sucrose percentage while the highest percentage of impurity components expressed as Na, K and amino-N resulted from the Maribo Maroc Poly variety. Schwarzbach *et al* (1996) classified some sugar beet varieties as high yielding sugar types, e.g. Adonis, Ibis and Reka, while others were normal or normal/high-yielding types, e.g. Oryx, Stella, Magnat and Matader. El-Taweel (1999) found that sugar beet varieties differed significantly in amino nitrogen content in the roots while the traits of top and sugar yields/fed, sucrose, purity, Sodium and Potassium percentages did not differe significantly. The variety Pleno was the highest one in this respect followed by Kawemira variety. Mahmoud *et al* (1999) evaluated five sugar beet varieties and they found that Maghribel and Zwaan poly varieties outyielded the other varieties in top, root and sugar yields/fed. Tribel variety gave the highest impurities in beet roots. The lowest percentage of Na resulted from KWS-695, while the lowest percentage of K and α-amino-N resulted from Zwaan poly. Ramadan and Hassanin (1999) tested sowing dates among 6 sugar beet varieties and found that the heaviest root fresh weight was obtained from Pamela variety. Desperiz poly-N variety gave the highest sucrose and purity percentages and sucrose loss to molasses. Marathon variety gave the highest percentages of impurities (Na, K and alpha amino acids), root yield ton/fed and recoverable sugar yield. Aly (2000) found that the variety Panther had almost the best individual root weight, root yield and recoverable sugar yield. On the other hand, Panther was the highest one in impurities (alpha amino-N, sodium and potassium contents). The variety Kawemira had the highest top yield/fed. Al-Labbody (2003) attained marked variation among sugar beet varieties in root length, diameter and fresh weight as well as sucrose%, top, root and sugar yields, while sugar extractability and juice impurities (K, Na and a-amino nitrogen did not significantly differ among varieties. Abo El-Ghait and Mohamed (2005) showed that the examined sugar beet varieties varied significantly for root fresh weight/plant, root and sugar, while root length and diameter as well as sucrose and purity percentages did not differ significantly. Sugar beet variety KWS-9422 gave the highest root and sugar yields/fed.

Many investigators showed the effect of sowing dates on growth, yields and quality characteristics of sugar beet varieties. Lauer (1997) found that 1-day delay in sowing reduced sugar yield by 0.45% while 46- day delay decreased sugar content by 4% and root yield by 38%. Ramadan and Hassanin (1999) reported that sugar beet sown on 10 Sep. significantly gave higher root length and diameter as well as root and recoverable sugar yields while delaying sowing date up to 10^{th} Nov., reduced sucrose, purity and recoverable sugar percentages. Abdou (2000) found that sowing sugar beet on the 1^{st} of October recorded marked increase in root length and diameter as well as fresh weight of root. Yield quality traits (sucrose, purity and recoverable sugar percentages) were higher when sugar beet was sown early. Abd El-Aal (2001) found that early sowing on September and October produced the highest leaf area, heavier top weight and sucrose percentage. On the contrary, delaying sowing date to mid November decreased root yield by 27.47% compared with early sowing. Fadel (2002) reported that the highest sugar yield was recorded by sowing sugar beet on 15^{th} October. He revealed that delaying sowing date gradually and significantly decreased top yield of sugar beet. Moreover, he explained that the relative advantage of early sowing on 15^{th} October could be due to the rapid growth and better maturity, consequently higher sugar content. Mohamed (2002) clarified that the decrease in root yield might be due to the increase in consumption of sucrose throughout or during respiration process. He declared that the loss in the weight of leaves at later stages of growth might be mainly attributed to the death of leaves. Moreover, he stated that recoverable sugar yield of sugar beet was affected by root yield, sucrose percentage and impurities content. Also, he revealed that superior values of sugar loss % was due to high K, Na or α-amino N contents of beet roots. Ramazan (2002) recorded that delaying sowing date decreased root and sugar yields, sugar content and extractable sugar content. Abou-El-Magd *et. al* (2003) disclosed that early planting of sugar beet on 1^{st} of October increased root and sugar yields and gave the best quality parameters.

The objective of the present work was to find out the optimal sowing date and the best sugar beet genotype to obtain the maximum root and sugar yields/fed.

MATERIALS AND METHODS

This work was carried out in experimental field in Fayoum Governorate (latitude 29^{0}N, longitude 30^{0}N and high Tide 30m) during 2003/2004 and 2004/2005 seasons to investigate the effect of sowing dates on growth, yield, technological characteristics of some sugar beet genotypes to obtain the highest yield and quality traits. Sowing dates were 5th October, 25th October and 14th November. The tested sugar beet genotypes were imported from Germany (Gazella, Del 937 and Carolla), France (LP12, LP11 and LP13), Netherlands (Farida and Samba) and Sweden (Baraca). Split plot design with three replicates in both seasons was applied. Sowing dates were arranged in the main plots while the sub plots were assigned for the tested sugar beet cultivars. Plot area was 21 m^2 including five rows of 60 cm width and 7 m long. Nitrogen fertilizer was applied in the form of urea (46.5%) at the recommended rate (100 kg N/fed) in two equal doses, after thinning and 30 days later. Potassium fertilizer (in form of potassium sulfate, 48 % K_2O) at a rate of 24 kg K_2O/fed was added after thinning, while phosphorus fertilizer was added during land preparation at a rate of 30 kg P_2O_5/fed. Soil analyses showed that it was silt clay loam containing (0.24 and 0.15 % of total N), (15.8 and 10.4 ppm available P), and (0.68 and 0.47 meq/100 g soil K) with (pH of 8.10 and 7.3) and Ec ds/m (2.6 and 2.4) in the 1st and 2nd seasons, respectively. Mean of temperature and relative humidity percentage are presented in Table (1). Other agricultural practices required for growing sugar beet were carried out as usually practiced in the region.

Table 1. The temperature and relative humidity percentage during growth seasons.

Year	2003-2004 season						2004-2005 season					
Months	Temperature (C°)			Relative humidity %			Temperature (C°)			Relative humidity %		
	Max	Min	Aver	Max	Min	Aver	Max	Min	Aver	Max	Min	Aver
October	33.1	19.4	26.2	85	31	58.0	31.8	18.3	25.1	81	27	54.0
November	27.7	15.5	21.6	88	40	62.0	28.1	13.7	20.9	80	29	54.5
December	22.4	9.3	15.9	80	36	58.0	21.2	8.2	14.7	81	36	58.5
January	21.2	8.8	15	82	35	58.5	21.1	7.6	14.3	77	33	55.0
February	23.8	8.6	16.2	85	35	60.5	21	6.9	13.9	86	35	60.5
March	25.2	10.4	17.8	81	31	56.0	25.2	9.4	17.3	78	28	53.0
April	29.7	13.1	21.4	80	23	51.5	30.1	13	21.5	76	24	50.0

Source: Agro-meteorological station, Agric. Res. Center, Giza, Egypt.

Recorded data

Sugar beet plants of the three guarded rows were up-rooted, topped, weighed and a random sample of ten roots was taken from each sub- plot to determine:

Root length (cm), root diameter (cm), root fresh weight (kg/plant), leaf area index (LAI) was calculated using the formula outlined by Watson (1958), top yield (tons/fed), root yield (tons/fed), sugar yield (tons/fed).

Sugar quality was analyzed using an Automatic French System (HYCEL). Sucrose percentage was polarimetrically determined according to the methods of Le-Docte (1927).

Purity percentage was determined according to formula:

Purity % = (Sucrose% / total soluble solids %) x 100.

Sugar beet Impurities including K, Na and α- amino N. Potassium (K%) and Sodium (Na%) percentages were determined using Flame Photometer as described by Page (1982), while Alpha-amino nitrogen (α-amino N) was determined using Hydrogenation method according to the methods of Carruthers *et al* (1962).

Sugar loss percentage in molasses (SM%) was calculated according to formula Devillers (1988):

SM % = 0.14 (Na + K) + 0.25 (α amino N) + 0.50.

Extractable sugar and Extractability percentages were calculated as proposed by Dexter *et al* (1967):

Extractable sugar = sucrose % – (sugar loss in molasses % + 0.6).

Extractability % = (extractable sugar % / sucrose %) x100

Statistical analysis

Analysis of variance was made according to the method described by Snedecor and Cochrane (1980). Least significant difference test (LSD) at 5% level of significance was used to compare means. Also, simple correlation coefficients and linear regression were computed among studied traits.

The Data from each macro environment (combinations of years and sowing dates) were analyzed and Barteltt's test for heterogeneity of error variances across environments indicated that error terms were homogeneous.

Individual analysis of variance was computed for each experiment and combined analysis over seasons was done according to Gomez and Gomez (1984).

The form of the variance analysis and the mean square expectations from which estimate of variance components obtained is presented in Table (2). Separate estimates of the components of variation in each mean square expectation were calculated to evaluate the magnitude of the different effects. The estimates of these variance components and the expected composition of the mean squares were determined by the procedures described by Miller *et al* (1959) where g is number of genotypes, y is number of years, P is sowing date, σ^2e is error of variance, σ^2g, σ^2gy, σ^2gp, $r\sigma^2gyp$ are the variance attributed to genotypes, genotypes x years, genotypes x sowing dates and genotypes x years x sowing dates respectively. Such estimates of variance components were obtained from the mean squares of the analysis of variance by using the following formula:

Genotypes $(\sigma^2g) = [(M5 + M2) - (M3 + M4)] / rpy$

Genotypes x years $(\sigma^2gy) = M4 - M2 / rp$

Genotypes x sowing dates $(\sigma^2gp) = M3 - M2 / ry$

Genotypes x years x sowing dates $(\sigma^2gyp) = M2 - M1 / r$

Plot error $(\sigma^2e) = M1$

Heritability in broad sense $h_b^2 = (\sigma^2g/\sigma^2p) \times 100$.

Where: M1, M2, M3, M4 and M5 are the values of the appropriate mean squares as indicated in Table (2), and (r and p) are the number of replicates and planting dates respectively.

Table 2. Form of variance analysis and mean square expectations over two years.

Source of variation		d.f	Expected mean squares
Years	(y)	(y-1) = 1	
Reps in years	(r)	y(r-1)= 4	
sowing date	(p)	(p- 1) = 2	
Y x p		(y-1) (p-1) = 2	
Error	(a)	Y(p-1) (r-1)= 8	
Genotypes	(g)	(g-1) = 8	M5: $\sigma^2e + r\varsigma^2_{ypg} + ry\ \sigma^2_{pg} + rp\sigma^2_{yg} + rg\varsigma^2_{yp}$
Y x g		(y-1) (g-1) = 8	M4: $\sigma^2e + r\sigma^2_{ypg} + rp\sigma^2_{yg}$.
P x g		(p-1) (g-1) = 16	M3: $\sigma^2e + r\sigma^2_{ypg} + ry\varsigma^2_{pg}$.
Y x p x g		(y-1) (p-1) (g-1) =16	M2: $\sigma^2e + r\sigma^2_{ypg}$.
Error	(b)	Yp (g-1) (r-1) = 96	M1: σ^2e.

RESULTS AND DISCUSSION

Effect of sugar beet genotypes

Root characters (length, diameter and fresh weight)

Results in Table (3) indicated that the tested genotypes differed significantly in root length, diameter and fresh weight in both seasons. Gazella genotype gave high values of root length, diameter and fresh weight (32.6 cm, 14.5 cm and 1.24 kg) followed by Farida and LP12 genotypes in the 1st season. Also, Farida followed by Baraca genotypes were superior in the 2nd season followed by Samba and Lp12 genotypes. On the other hand, Dell 937 genotype recorded the lowest values of root length, diameter and root fresh weight (25.9 cm, 11.8 cm and 0.98 kg) and (26.9 cm, 12.3 cm and 1.01 kg) in the 1st and 2nd seasons, respectively. The differences among the tested sugar beet varieties might be principally due to the genetic variation. These findings are agreement with those obtained by Nassar (1992), Ramadan and Hussein (1999), Al-Labbody (2003) and Abo El-Ghait and Mohamed (2005).

Leaf area index (LAI)

Data confirmed in Table (3) showed that differences among genotypes in leaf area index were variable and significant in both seasons. Baraca and LP13 attained the highest values of LAI compared with the other genotypes which recorded insignificant values among them for this trait in the 1st season. Also, Farida, Lp12 and Gazella recorded high values of LAI while Carolla and Dell 937 genotypes attained the lowest value of this trait. Similar results were obtained by Nassar (1992).

Top, root and sugar yields (tons/fed)

Results presented in Table (3) illustrated that genotypes differed significantly in top, root and sugar yields in both seasons. Farida genotype was superior in these traits where it recorded (13.47, 33.3 and 5.04 tons/fed), respectively in 1st season, corresponding to, (12.87, 26.5 and 4.47 tons/fed.), respectively, in the 2nd season, followed by Lp12 and Baraca genotypes. Otherwise, Dell 937 genotype recorded the lowest values of top, root and sugar yields (10.67, 25.8 and 3.53 tons/fed) and (10.60, 22.5 and 3.03 tons/fed) in 1st and 2nd seasons, respectively. Some differences were insignificant among genotypes for these traits. These results may be due to the increase in yield components which attribute to the genetic variation. These results coincide with those reported by Aly (2000), Al-Labbody (2003) and Abo El-Ghait and Mohamed (2005).

Table 3. Average values of root performance, LAI and yields as affected by some sugar beet genotypes in 2003/2004 and 2004/2005 seasons.

Genotypes	Root length (cm)	Root diameter (cm)	Root fresh weight (kg)	Leaf area index	Top yield (tons/fed)	Root yield (tons/fed)	Sugar yield (tons/fed)
2003-2004 season							
Gazella	32.63	14.56	1.24	6.12	12.03	29.8	4.78
LP12	31.86	14.11	1.20	6.24	12.85	31.7	4.81
Farida	30.97	14.28	1.21	6.31	13.47	33.3	5.04
Baraca	27.52	13.20	1.18	6.58	12.69	30.7	4.62
Dell 937	25.99	11.87	0.98	6.21	10.67	25.8	3.53
LP 11	25.80	12.29	1.01	6.42	11.99	28.8	3.86
Samba	26.98	12.40	0.98	6.25	12.78	30.7	4.06
Carolla	27.63	13.09	1.06	6.35	11.03	26.5	3.99
LP13	27.58	13.23	1.07	6.50	12.05	28.8	4.17
LSD at 5% level	1.90	0.93	0.07	0.26	0.50	1.69	0.31
2004/2005 season							
Gazella	27.90	14.55	1..02	5.94	11.68	24.8	4.17
LP12	31.78	14.21	1.14	6.01	12.17	26.1	4.24
Farida	35.36	14.84	1.26	6.10	12.87	26.5	4.47
Baraca	33.63	14.56	1.24	5.78	12.43	26.4	4.08
Dell 937	26.96	12.31	1.01	5.61	10.60	22.5	3.03
LP 11	30.30	12.77	1.13	5.68	11.40	25.6	3.48
Samba	33.04	12.79	1.24	5.71	11.44	23.2	3.16
Carolla	28.20	13.36	1.07	5.58	11.48	23.6	3.51
LP13	31.12	14.32	1.12	5.69	11.73	24.8	3.99
LSD at 5% level	1.19	0.76	0.05	0.28	0.67	1.29	0.34

Sucrose (S %)and purity (Pur%)

Data illustrated in Table (4) revealed that varieties significantly differed in sucrose % in the 1st and 2nd seasons. Gazella genotype produced the maximum values of sucrose % followed by Baraca Farida, LP13 and LP12 genotypes in 1st season, respectively, while in the 2nd season, the same trend was recorded by Farida genotype followed by Gazella, LP12 and LP13 genotypes. Also, the highest values of purity % were obtained in Carolla, Gazella, Farida genotypes in the 1st season while the same superiority was attained by Gazella, LP12, farida and LP13 genotypes compared with the other genotypes in the 2nd season. Conversely, Samba genotype followed by LP11 and Dell 937 genotypes achieved the lowest values of sucrose and purity percentages. This result may due to the genetic of genotypes. These results are in agreement with those obtained by Nassar (1992), Ramadan and Hussein (1999) and Al-Labbody (2003).

Impurities (K%, Na% and α- amino nitrogen %)

Results demonstrated in Table (4) revealed that impurities content, except Na% in the 1st season and K% in the 2nd season, were significantly affected by the tested genotypes in both seasons. LP11 genotype recorded the highest values of K and Na percentages while Samba genotype attained the same trend in α- amino acids compared with the others varieties. In contrast, Gazella, Farida and Carolla achieved the minimum values of impurities. This result may be due to the genetic variation of different varieties. Similar results are obtained by El-Taweel (1999), Nassar (1992), Mahmoud *et al* (1999), Ramadan and Hussein (1999) and Aly (2000).

Table 4. Average values of quality characters as affected by some sugar beet genotypes in 2003/2004 and 2004/2005 seasons.

Genotypes	Sucrose %	Purity %	Impurities content K %	Na %	α-amino N%	Sugar loss in molasses %	Extractable sugar %	Extractability %
2003/2004 Season								
Gazella	18.53	84.69	2.12	1.22	1.61	1.37	16.56	89.16
LP12	17.86	83.75	2.23	1.36	1.79	1.45	15.81	88.40
Farida	17.88	84.10	2.19	1.18	1.63	1.30	16.51	89.48
Baraca	18.15	82.38	2.45	1.35	1.67	1.44	16.10	88.59
Dell 937	16.81	80.87	2.40	1.46	2.23	1.59	14.61	86.80
LP 11	16.67	79.77	2.82	1.55	2.16	1.65	14.42	86.40
Samba	16.53	79.53	2.52	1.34	2.23	1.59	14.34	86.63
Carolla	17.66	84.90	2.39	1.51	1.67	1.46	15.60	88.22
LP13	17.87	80.55	2.23	1.22	1.73	1.41	15.85	88.68
LSD at 5% level	0.35	2.71	0.31	N.S	0.16	0.07	0.47	0.56
2004/2005 Season								
Gazella	19.46	83.85	2.16	1.29	1.68	1.40	17.46	89.44
LP12	19.26	83.60	2.05	1.29	1.64	1.37	17.28	89.62
Farida	19.74	83.44	2.02	1.31	1.70	1.39	17.75	89.70
Baraca	18.91	80.91	2.10	1.32	1.78	1.42	16.88	89.11
Dell 937	16.64	79.51	2.06	1.78	1.85	1.50	14.54	87.16
LP 11	17.11	79.00	2.09	1.86	1.84	1.51	15.00	87.51
Samba	17.10	78.81	2.09	1.70	1.95	1.51	14.98	87.44
Carolla	18.24	80.04	2.10	1.31	1.46	1.34	16.30	89.07
LP13	19.16	83.22	2.16	1.42	1.56	1.39	17.17	89.47
LSD at 5% level	0.74	3.09	N.S	0.25	0.23	0.06	0.75	0.61

Sugar loss in molasses percentage (SM%)

Data in Table (4) showed that genotypes differed significantly in sugar loss in molasses in both seasons. LP11 and Samba genotypes were superior in sugar loss in molasses percentage in the 1st and 2nd seasons alternative, followed by Dell 937 genotype. Conversely, Farida, Gazella, LP13 and Carolla recorded low values of sugar loss in molasses compared with the other genotypes. This result may be due to increasing of impurities in roots which caused an increase in sugar loss in molasses (Table 4), In addition, the genetic variation. These findings are in line with those reported by Nassar (1992) and Ramadan and Hussein (1999).

Extractable sugar (Ex%) and extractability (Exb%)

Results revealed in Table (4) proved that extractable sugar and extractability percentages were significantly differed among the tested genotypes in both seasons. Farida and Gazella genotypes attained the highest values of these traits in the 1st and 2nd seasons followed by LP13 and LP12 genotypes. On the other hand, Dell 937, LP11 and Samba genotypes recorded the lowest values of extractable sugar percentage compared with the other genotypes. This result may be due to the genetic variation. Similar results were obtained by Nassar (1992), Ramadan and Hussein (1999).

Effect of sowing date

Root characters (length, diameter and weight)

Data presented in Table (5) showed that the sowing sugar beet on October, 5 exhibited a significant increase in root length, diameter and fresh weight of the individual roots compared with the other two dates (October, 25 and Nov., 14) in both seasons. On the other hand, late sugar beet sowing up to October, 25 and November, 14 caused decreasing by 10.67 and 22.5% for length, 0.0 and 8.73% for diameter and 4.72 and 8.37% for fresh weight in the 1st season, respectively. The same trend was achieved for those traits in the 2nd season. These results may be attributed to favorable condition which encountered within the early growth stage of seedlings that could boost their growth, and/or the relatively cooler weather in the late sowing on 14th November. Similar results were recorded by Ramadan and Hussein (1999) and Abdou (2000).

Leaf area index

The results exposed in Table (5) proved that leaf area index was markedly increased when sugar beet was sown early in the 2nd season. The increase was 35.36 and 17.68 % at sowing on October, 5 and October, 25 respectively, compared with the late sowing on November, 14.

Table 5. Root characters, LAI and yield of sugar beet as affected by sowing date in 2003-2004 and 2004-2005 seasons.

Sowing date	2003-2004 season						
	Root length (cm)	Root diameter (cm)	Root fresh weight (kg)	Leaf area index	Top yield (t/fed)	Root yield (t/fed)	Sugar yield (t/fed)
5 October (S1)	32.1	13.6	1.15	6.54	12.63	31.6	5.12
25 October (S2)	28.6	13.6	1.10	6.30	12.37	29.5	4.42
14 November (S3)	24.9	12.4	1.06	6.15	11.53	27.7	3.41
LSD at 5% level	2.3	0.8	0.03	N.S	NS	2.31	0.29
Sowing date	2004-2005 season						
5 October (S1)	35.2	16.1	1.33	6.66	12.85	27.2	4.79
25 October (S2)	30.5	14.1	1.13	5.79	11.46	25.5	3.74
14 November (S3)	26.9	11.1	0.93	4.92	10.95	21.8	2.84
LSD at 5% level	1.9	0.4	0.05	0.31	0.94	1.86	0.37

Top, root and sugar yields (t/fed)

Data presented in Table (5) revealed that early sowing date increased significantly root and sugar yields in both seasons. Sowing beet on October,5 gave the maximum value of these traits where it surpassed the other two dates (October,25 and November,14) by 7.11 and 14.08% for root yield and 15.87 and 50.14% for sugar yield in the 1st season, respectively, corresponding to 4.65 and 17.35% for top yield, 6.66 and 24.77 % for root yield and 28.07 and 68.66 % for sugar yield in the 2nd season, respectively. This result could be attributed to increase yield components as a result of early sowing and hence root and sugar yields increased in the end. Conversely, the exposure of plant tops to hot weather and high temperature degrees by the end of the growing season, led to increasing transpiration rate and dehydration of leaves and in turn decreasing their yield. However, the latest sowing date, the lowest yields of top, root and sugar. This result is in line with those reported by Fadel (2002) who explained that the relative advantage of early sowing could be due to the rapid growth and improved maturity, consequently higher sugar content.

Sucrose and purity percentages

Data illustrated in Table (6) indicated that sucrose and purity percentages were significantly decreased by delaying sowing date up to Oct.,25 and Nov.,14 in both seasons. The percentages of loss for sucrose were 0.92 and 2.68% when sowing sugar beet was delayed from Oct.,5 up to Oct.,25 and Nov.,14 respectively, in the 1st season, corresponding to 2.58 and 4.28 % in the 2nd season, respectively. The same trend was achieved for purity % where the percentages of loss for purity were 2.22 and 9.42% when

Table 6. Average values of quality characters of sugar beet as affected by sowing date in 2003-04 and 2004-05 seasons.

Sowing date	2003-2004 Season							
	S %	Pur %	K %	Na%	α-amino N %	SM%	Ex%	Exb%
5 October (S1)	18.75	86.16	1.95	0.99	1.45	1.27	16.88	89.95
5 October (S2)	17.83	83.94	2.47	1.43	1.91	1.49	15.91	88.27
4 November (S3)	16.07	76.74	2.70	1.65	2.21	1.66	13.81	85.90
LSD at 5% level	0.53	1.19	0.34	0.32	0.19	0.05	0.58	0.54
Sowing date	2004-2005 Season							
5 October (S1)	20.69	84.49	1.82	1.06	1.36	1.24	18.84	91.01
5 October (S2)	18.11	80.56	2.08	1.61	1.76	1.45	16.05	88.58
14 November (S3)	16.41	79.07	2.38	1.76	2.03	1.58	14.23	86.58
LSD at 5% level	0.48	2.38	0.27	0.15	0.13	0.06	0.41	0.42

S: sucrose Pur: purity k: potassium Na: sodium
MS: sugar loss in molasses Ex: extractable sugar Exb: extractability

sowing sugar beet was delayed up to 25th of Oct. and 14th of Nov., respectively, in the 1st season, corresponding to 3.93 and 5.42% in the 2nd season, respectively. This result may be attributed to the unsuitable conditions at harvest as a result to late sowing where high temperature on April did not encourage accumulation of sucrose well in root and so purity % was decreased. Otherwise, the earlier sowing date, the highest sucrose and purity percentages. Similar results were evidenced by Ramadan and Hussein (1999) and Abou El-Magd *e. al* (2003) who disclosed that early planting of sugar beet gave the best quality parameters.

Impurities content (K%, Na% and α- amino nitrogen)

Results in Table (6) exposed that delaying sowing date significantly increased impurities content in both seasons. The last sowing date (November,14) recorded the highest impurities percentage where it gave 2.70, 1.65 and 2.21 for K%, Na% and alpha amino nitrogen, respectively, in the 1st season, corresponding to 2.38, 1.76 and 2.03%, respectively in the 2nd season. Otherwise, the 1st sowing date (October,5) attained the best results (the lowest impurities percentages) where it attained 1.95, 0.99 and 1.45% for K, Na and α- amino N %, respectively, in the 1st season, corresponding to, 1.82, 1.06 and 1.36% for the same impurities in the 2nd season. These results may be attributed to the late sowing which led to harvest at unsuitable conditions, consequently, impurities percentages increase in juice as compared with the earlier sowing. Theses results coincide with this reported by Ramazan (2002).

Sugar loss in molasses (MS %)

Data presented in Table (6) revealed that earlier sowing date significantly decreased sugar loss in molasses in both seasons. The reduction percentage was accounted by 0.22 and 0.38%, respectively, compared with the other two sowing dates (Oct.,25 and Nov.,14) in the 1st season, corresponding to, 0.21 and 0.34 %, respectively, in the 2nd season. This result may be due to earlier sowing date led to earlier harvest date in which low temperature encourages sugar accumulation in roots, so, sugar loss in molasses decreased. Conversely, the increase in sugar loss in molasses might be attributed to an increase in impurities especially, alpha amino nitrogen, potassium and sodium contents in roots. These findings agree with those obtained by Mohamed (2002).

Extractable sugar (Ex%) and extractability (Exb%)

Data exhibited in Table (6) disclosed that extractable sugar and extractability percentages were significantly decreased by delaying sowing date in both seasons. In opposition, sowing sugar beet early on Oct.,5 gave an increase accounted by 0.97 and 3.07% for extractable sugar % compared with sowing on Oct.,25 and Nov.,14 in the 1st season, respectively, corresponding to 2.79 and 4.61% in the 2nd season, respectively. The same trend was obtained for extractability % where the increase was 1.68 and 4.05% compared with the 2nd and 3rd sowing dates in the 1st season, respectively, corresponding to, 2.43 and 4.43 in the 2nd season, respectively. This result may be due to earlier sowing date increased accumulation of sugar in root where low temperature at this time was available. This finding is in line with those obtained by Ramazan (2002) who recorded that delaying sowing date decreased sugar content and extractable sugar content.

Interaction between genotypes and sowing dates

Interaction effect was insignificant in respect to the studied traits except there were in Table (7).

The results showed that interaction between genotypes and sowing date significantly affected root length, top yield, sugar yield and sugar loss in molasses% in both season. Also, leaf area index, root yield, sucrose%, extractable sugar% and extractability% were markedly affected in the 1st season while root fresh weight was significantly influenced in the 2nd season. Sowing Gazella genotype on 5th Oct. produced the highest values of root length, leaf area index, sugar yield, sucrose%, extractable sugar and

Table 7. Average values of sugar beet significant characters as affected by interaction between sowing date and sugar beet genotype in 2003/2004 and 2004/2005 seasons.

Sowing date X Genotypes	2003/2004 season											
	Root length (cm)			Root yield (tons/fed)			Top yield (tons/fed)			Sugar yield (tons/fed)		
	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14
Gazella	38.7	32.6	26.5	32.8	32.8	23.6	13.12	13.12	9.85	5.98	5.31	3.04
LP12	37.2	31.2	27.1	33.8	34.1	27.3	13.51	13.65	11.39	5.73	5.19	3.51
Farida	35.0	29.9	28.0	33.8	35.4	30.6	13.51	14.16	12.74	5.69	5.46	3.97
Baraca	26.2	27.8	23.9	28.7	23.9	24.9	11.46	10.18	10.38	4.24	3.35	3.00
Dell 937	28.0	26.5	22.8	29.9	28.2	28.3	11.97	12.22	11.77	4.50	3.89	3.17
LP 11	29.3	27.7	23.8	30.9	30.6	30.6	12.37	13.22	12.74	4.60	4.20	3.38
Samba	30.5	27.4	24.9	30.4	24.2	24.9	12.16	10.57	10.37	4.81	3.80	3.36
Carolla	32.1	26.6	24.0	31.4	27.2	27.9	12.56	11.96	11.62	4.94	4.17	3.41
LP13	31.4	27.5	23.5	32.5	28.9	30.9	12.99	12.21	12.87	5.59	4.47	3.81
LSD at 5%	3.3			2.93			0.12			0.55		
	2004/2005 season											
	Root length (cm)			Root fresh weight (kg)			Top yield (tons/fed)			Sugar yield (tons/fed)		
	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14
Gazella	32.3	26.8	24.5	1.20	0.97	0.88	14.40	10.48	10.15	5.88	3.88	2.77
LP12	36.7	30.7	27.8	1.34	1.11	0.97	13.50	11.47	11.54	5.22	4.23	3.27
Farida	41.1	34.7	30.2	1.48	1.26	1.05	13.95	12.96	11.71	5.94	4.37	3.08
Baraca	30.6	26.8	23.4	1.21	0.99	0.81	12.07	10.01	9.72	3.85	3.02	2.21
Dell 937	33.4	29.7	27.7	1.34	1.08	0.96	11.98	11.11	11.10	4.04	3.51	2.90
LP 11	36.3	32.7	30.1	1.47	1.22	0.90	11.21	12.21	10.91	3.84	3.20	2.42
Samba	32.7	28.1	23.7	1.20	1.09	0.92	13.48	10.49	10.47	4.46	3.61	2.45
Carolla	35.6	31.1	26.5	1.31	1.13	0.92	12.31	11.64	11.24	4.91	3.69	3.36
LP13	38.3	34.3	28.2	1.41	1.32	0.93	12.78	12.82	11.69	4.99	4.12	3.14
LSD at 5%	2.1			0.08			1.16			0.60		

Sowing date X Genotypes	2003/2004 season											
	Sucrose %			Sugar loss in molasses %			Extractable sugar %			Extractability %		
	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14
Gazella	20.43	18.89	16.28	1.120	1.393	1.600	18.71	16.89	14.08	91.58	89.45	86.46
LP12	19.22	18.00	16.37	1.153	1.523	1.673	17.47	15.88	14.09	90.89	88.19	86.12
Farida	19.21	18.06	16.38	1.130	1.167	1.610	17.48	17.89	14.17	90.99	90.94	86.51
Baraca	17.90	17.17	15.36	1.417	1.597	1.780	15.88	14.98	12.98	88.72	87.17	84.52
Dell 937	17.57	16.99	15.45	1.423	1.720	1.810	15.55	14.67	13.04	88.47	86.35	84.39
LP 11	17.64	16.52	15.45	1.500	1.577	1.717	15.54	14.34	13.13	88.08	86.81	85.01
Samba	18.49	18.28	16.22	1.213	1.523	1.653	16.68	16.16	13.96	90.18	88.37	86.10
Carolla	18.56	18.36	16.68	1.227	1.483	1.530	16.73	16.28	14.55	90.15	88.65	87.23
LP13	19.77	18.18	16.49	1.273	1.490	1.583	17.90	16.09	14.31	90.51	88.51	86.75
LSD at 5%	0.61			0.135			0.81			0.97		

Sowing date X Genotypes	2003/2004 season			2004/2005 season		
	Leaf area index			Sugar loss in molasses %		
	Oct,5	Oct,25	Nov,14	Oct,5	Oct,25	Nov,14
Gazella	7.01	6.27	5.93	1.18	1.49	1.52
LP12	6.62	6.73	6.14	1.23	1.44	1.46
Farida	6.62	6.89	6.25	1.19	1.43	1.54
Baraca	6.61	6.15	5.86	1.35	1.46	1.68
Dell 937	6.28	5.82	6.28	1.34	1.47	1.73
LP 11	6.37	6.28	6.09	1.38	1.46	1.71
Samba	6.37	6.65	6.04	1.12	1.42	1.48
Carolla	6.41	5.93	6.38	1.16	1.45	1.56
LP13	6.54	6.02	6.38	1.22	1.47	1.57
LSD at 5%	0.45			0.11		

extractability % in the 1st season while the highest top yield (14.4 tons/fed) was obtained at the same interaction in the 2nd season. Sowing Farida genotype on 25th Oct. attained the highest values of top and root yields (14.16 and 35.4 tons/fed) in the 1st season, respectively, while sowing the same genotype on 5th Oct. recorded the maximum values of root length and sugar yield (41.09 cm and 5.94 tons/fed) in the 2nd season, respectively. Sowing Dell 937 genotype on 14th Nov. produced the highest sugar loss in molasses (1.81 and 1.73%) in both seasons, respectively, compared with the other genotypes. This result proved the evidence of the importance and the need to find out the appropriate sowing date as well as selecting the best sugar beet genotypes which benefit well from the conditions prevailing under a given region. These findings are in line with those obtained by Ramadan and Hussein (1999).

Relationships among traits

Simple correlation coefficients

Simple correlation coefficients between root and sugar yields of sugar beet and its attributes for 2003/2004 and 2004/2005 seasons are shown in Table (8). Data revealed that there was a highly positive correlation between sugar yield and each of root yield (r =0.72 and 0.76), root fresh weight (r=0.59 and 0.55), sucrose% (r =0.59 and 0.82) and purity (r=0.76 and 0.78) in 1st season and 2nd seasons, respectively. Also, the correlation was highly positive between root yield and each of root fresh weight (r =0.86 and 0.88), sucrose% (r= 0.53 and 0.85) and purity% (r= 0.89 and 0.97 in the 1st and 2nd seasons, respectively. As well as, a highly positive correlation occurred between purity% and each of sucrose% (r= 0.84 and 0.92) and root fresh weight (r= 0.79 and 0.86) in the 1st and 2nd seasons, respectively. Positive correlation between root fresh weight and sucrose% (r= 0.38) in the 1st season and highly significant correlation (r= 0.67) in the 2nd season. Similar results were obtained by Dewy and Lu (1959) and Draper and Smith (1966) and Abo El-Ghait and Mohamed (2005).

Table 8. Simple correlation matrix between some traits (sugar yield, root yield, root weight, sucrose % and Purity %).

Traits	Sugar yield (tons/fed)	Root yield (tons/fed)	Root fresh weight (kg)	Sucrose %	Purity %
	2003/2004 season				
Sugar yield (tons/fed)	-	-	-	-	-
Root yield (tons/fed)	0.7245 **	-	-	-	-
Root fresh weight (kg)	0.5913 **	0.8604**	-	-	-
Sucrose %	0.5950 **	0.5378**	0.3878 *	-	-
Purity %	0.7615 **	0.8920**	0.7962 **	0.8405**	-
	2004/2005 season				
Sugar yield (tons/fed)	-	-	-	-	-
Root yield (tons/fed)	0.7673 **	-	-	-	-
Root fresh weight (kg)	0.5585 **	0.8856 **	-	-	-
Sucrose %	0.8253 **	0.8552 **	0.6784 **	-	-
Purity %	0.7873 **	0.9767 **	0.8696 **	0.9271**	-

Correlation coefficients at 5% and 1% levels of significance.

Regression

Data presented in Table (9) indicated that there was a significant regression coefficient (liner) for root yield, root fresh weight kg/plant, sucrose, purity % and sugar yield tons/fed in both seasons. Regression coefficient (R^2) was 72% in sugar content such that increasing 1.05 tons/fed from root yield leads to increasing 0.18 ton/fed from sugar yield while (R^2 = 61 %) from root fresh weight kg/plant in sugar content such that increase 1.12 kg from individual root leads to increasing 0.45 ton/fed from sugar yield. Moreover, R^2 = 0.57 and 40 % for sucrose and purity % from sugar content and also increasing 5.28 and 8.02 % from sucrose and purity % cause an increase by 54 and 15 % from sugar yield (ton/fed). Also, in the 2nd season, it was observed that a significant regression coefficient (linear) for root yield (ton/fed), root fresh weight (kg/plant), sucrose %, purity % and sugar yield (ton/fed) was (R^2 =71 %) in sugar content such that increasing of 3.55 tons/fed from root yield leads to increasing 0.29 ton/fed from sugar yield while (R^2 =77%) from root fresh weight in sugar content such that increase of 4.14 kg from individual root cause an increasing 0.67 ton/fed from sugar yield. Moreover, (R^2 = 0.91 and 76 %) for sucrose and purity % from sugar content and also increasing 3.92 and 13.45 % from sucrose and purity % caused an increase by 42 and 21 % from sugar yield ton/fed, respectively. These results agreed with those obtained by Dewy and Lu (1959) and Draper and Smith (1966) and Abo El-Ghait and Mohamed (2005).

Table 9. Effect of sugar yield (tons/fed) as dependent variable with root fresh weight (kg), root yield (tons/fed), sucrose% and purity% as independent variables.

Independent	Intercept α Coefficients	X Variable b Coefficients	F	R^2
	2003-2004 season			
Root yield (tons/fed)	-1.058	0.182	18.359*	0.724
Root fresh weight (kg)	-1.121	0.446	10.990*	0.610
Sucrose %	-5.288	0.547	9.370*	0.572
Purity %	-8.020	0.150	9.610*	0.397
	2004-2005 season			
Root yield (tons /fed).	-3.556	0.295	17.77*	0.717
Root weight (kg)	-4.142	0.674	23.21*	0.768
Sucrose %	-3.925	0.419	88.10*	0.916
Purity %	-13.45	0.212	25.72*	0.755

$Y = \alpha + bx$

Y= Sugar yield α = Intercept   bx = x Variable

Variance components

Estimates of the pertinent variance components for root weight, sucrose, purity %, root and sugar yield ton/fed are presented in Table (10). The relative magnitude of these components indicates the relative importance of the corresponding source of variation. The plot error variance σ^2e and the components of σ^2g were higher in importance than the σ^2gyp component and to the σ^2gy and σ^2gp. The second order interaction σ^2gyp for these traits indicated that those evaluated genotypes responded differently when they were grown under those environments. Concerning of phenotypic, the values were higher and indicated to variance of root weight, sucrose, purity %, root and sugar yield ton/fed. Regarding heritability, the reduction was about 50 % such as these results may be due to responses indicated differential environments.

Table (10): Variance component estimates from combined ANOVA for root traits of nine genotypes grown in six environments.

Variance components	Expected mean square				
	Root fresh weight (kg)	Sucrose %	Purity %	Root yield (tons/fed)	Sugar yield (tons/fed)
σ^2g	9.55	0.963	4.026	4.063	0.280
σ^2gy	7.23	0.239	0.720	1.597	0.054
σ^2gp	10.85	0.359	1.080	2.400	0.081
σ^2gyp	0.28	0.037	2.794	1.669	0.094
σ^2e	4.22	0.389	9.460	2.882	0.130
σ^2_{Ph}	32.16	1.987	18.08	12.611	0.639
H_b^2	29.70	48.47	22.27	32.22	43.82

σ^2g, σ^2gy, σ^2gp and σ^2gyp are the variance attributed to genotypes, genotype x year, genotype x planting date and genotype x year x planting date, respectively.

H_b^2: Heritability in broad sense. σ^2_{Ph}: Phenotypic variance

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التباين والارتباط بين الصفات فى تسعة اصناف من بنجر السكر تحت ثلاثة مواعيد زراعة

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أقيمت تجربتـــان حقليتـــان بمحافظـــة الفيـــوم خـــلال موســـمى الزراعـــة ٢٠٠٣ /٢٠٠٤، ٢٠٠٤/ ٢٠٠٥ لتقييم تسعة طرز من بنجر السكر مستوردة من المانيا(جازيللا- ديل٩٣٧- كـــارولا) وفرنسا (LP12, LP11, LP13) وهولندا (فريدة- سامبا) والسويد (بركة) تحت ثلاثة مواعيد زراعة

هي ٥ أكتوبر ، ٢٥ أكتوبر و ١٤ نوفمبر. استخدم تصميم القطع المنشقة حيث شغلت مواعيد الزراعة القطع الرئيسية ووزعت أصناف بنجر السكر عشوائيا في القطع الشقية.

١. أوضحت النتائج تفوق ميعاد الزراعة الاول (٥ اكتوبر) في قيم جميع الصفات تحت الدراسة في حين زادت النسبة المئوية للشوائب (أمينو نتروجين والبوتاسيوم والصوديوم) والسكر المفقود في المولاس بتأخير ميعاد الزراعة. انخفضت قيم محصول العرش و دليل مساحة الأوراق بتأخير ميعاد الزراعة.

٢. تباينت الأصناف المختبرة معنويا في صفات النمو والمحصول والجودة في كلا الموسمين ماعدا النسبة المئوية للصوديوم والبوتاسيوم في الموسم الاول والثاني على التوالي. أعطى الطرزين فريدة وجازيللا أعلى قيم لمعظم الصفات المدروسة – بينما احتوت جذور الطرزين سامبا و LP11 على أعلى نسبة مئوية للشوائب والنسبة المئوية للسكر المفقود في المولاس.

٣. أدت زراعة أى من الطرزين فريدة وجازيللا في ميعاد الزراعة الأول (٥ اكتوبر) للحصول على أعلى قيم لمعظم صفات النمو والمحصول، وأعطى الطرز فريدة أعلى محصول جذور بزراعته في ٢٥ أكتوبر – ولم تتأثر معظم صفات الجودة بالتفاعل بين طرز بنجر السكر ومواعيد الزراعة.

٤. دلت نتائج تحليل الارتباط البسيط على وجود ارتباط معنوى وموجب بين محصول السكر وكل من محصول الجذور، وزن الجذر الطازج للنبات ، النسبة المئوية للسكروز والنسبة المئوية للنقاوة. أيضا وجد ارتباط معنوى بين محصولي الجذور والوزن الطازج للجذر.

٥. أوضحت نتائج تحليل الانحدار أن الوزن الطازج للجذر، محصول الجذور، النسبة المئوية للسكروز النسبة المئوية للنقاوة كانت أكثر الصفات مساهمة في محصول السكرالنهائي.

٦. أوضحت نتائج البحث أن درجة التوريث كانت أقل من ٥٠% في الصفات تحت الدراسة وعلى ذلك فإن استجابة طرز بنجر السكر قد ترجع للتأثير البيئي.

٧. يوصى هذا البحث بزراعة طرز بنجر السكر في محافظة الفيوم في أى من مواعيد الزراعة تحت الدراسة برغم تفوق الطرز (فريدة – جازيللا) في ميعاد الزراعة الأول على الطرز الأخرى للحصول على أعلى محصول جذر وسكر (طن/فدان).

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