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STATISTICAL AND GENETICAL EVALUATION OF FIFTEEN SUGAR BEET GENOTYPES UNDER THREE SOWING DATES

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ABSTRACT

The present investigation was carried out during 2011/2012 and 2012/2013 at Snores region, El-Fayum Governorate, to evaluate fifteen sugar beet genotypes under different sowing dates. These genotypes were planted at three different dates for each year (at 15th September, 15th October and 15th November). The results showed significant differences between sowing dates for all traits under study, except root length and weight in the 1st season as well as, purity in both seasons. Sugar beet genotypes recorded the highest values at early sowing dates for yields of root and sugar in both seasons. Pleno, Samba, Sultan and Farida genotypes had the highest root and sugar yield values in both seasons. But in case delaying the sowing date, it could be used the Barca, Caple, Samba and Farida genotypes. Therefore, Samba and Farida genotypes had high root and sugar yield values in most cases. Differences between phenotypic and genotypic coefficient of variability were observed for all the descriptors for both years. Improvement in yields of foliage and root, as well as root weight and diameter traits can be achieved through mass selection. High values of heritability and genetic advance for these traits could be attributed to that such traits controlled by additive gene effects, indicating that selection for such traits might be effective for the improvement of root and sugar yield. Simple correlation, multiple linear regression and factor analysis were used to study the relationship between sugar beet yield and its components under three planting dates. The results revealed that root yield was positively and highly significant correlated with all traits under study, except root length and purity. These findings indicate that selection for root diameter, root weight, no. of root cycle, total soluble solids percentage, Sucrose percentage, sugar yield and foliage yield traits would be accompanied by high yielding ability under such conditions. Full model regression including all traits recorded R^2 = 96.6% of the total variation within the root yield components. Factor analysis showed that factor one had four variables (no. of root cycles and yields of foliage, root and sugar). Hence these traits could be used for the improvement of yield resulting in the evolution of high yielding sugar beet.

Key words***: Beta vulgaris, Sugar beet, Planting date, Multiple regression, Factor analysis, Simple correlation, Heritability and Genetic parameters*.**

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is the second important sugar crop after sugar cane; producing about 30 % sugar of total world production and have readily adaptation to different environmental factors including climate. Yield and quality of sugar beet are affected by many agronomic practices, among these planting dates are thought to have a great influence on yield and quality. Early sown sugar beet should be harvested early, while late sown sugar beet should be harvested later, after the field has undergone a more complete maturing process. Furthermore, early sown sugar beet has greater yield and quality potential (Ismail *et al* 2006, El-Gedawy *et al* 2007, Mosa 2009 and Refay 2010).

Early sowing provided better leaf growth per unit area throughout the growing season (Castillo Garcia and Lopez Bellido 1986 and Ramazan, 2002). While, late sowings decreased sugar content and sugar yield (Marlander 1992, Smit 1993 and Lauer 1997). In late sowings, the presence of gaps considerably reduced root yield and quality. The primary reason for planting early is to increase the length of the growing season and increase total production.

Sugar beet is considered a prospective sugar crop in Egypt. All sugar beet genotypes cultivated in Egypt are imported from foreign countries. So, it is preferable to evaluate them under Egyptian conditions, especially under different sowing dates to select the best ones characterized with high yield and quality traits to improve their productivity as an urgent demand to meet sugar consumption or at least to decrease the Egyptian gap from sugar (Al-Labbody 2012). Sugar beet varieties are considered the corner stone for production process; selecting the superior varieties from the imported one is the main purpose to the breeder, in addition to the recommended package of the agronomical practices.

El-Gedawy *et al* (2000) reported that full model regression is used to determine the best predictive equation for yield. Genetic parameters and correlation analysis help to facilitate the selection of genetically diverse parents in hybridization programs.

The objective of this work was to study the genetic parameters and correlation coefficients for ten characters of sugar beet and to assess the extent of available variability, which will be useful for selecting superior genotypes.

MATERIALS AND METHODS

Experimental material

This study was carried out during 2011/2012 and 2012/2013 growing seasons at Snorse, El-Fayum Governorate. Fifteen sugar beet genotypes were studied. Name, pedigree, maturity group and some features of the studied sugar beet genotypes are presented in Table (1).

Experimental layout

A split plot design in randomized complete blocks arrangement with three replicates was used in both seasons. Sowing dates were arranged in the main plots (15th September, 15th October and 15th November), while sugar beet genotypes were randomly allocated to the sub plots. Each plot consisted of 6 rows, seven meters long with 50 cm apart (plot size = 21.0 m^2); the distance between hills was 15-20 cm.. Cultural practices including irrigation were applied as recommended by Ministry of Agriculture.

The recorded data

At harvest, sugar beet plants of three guarded rows were up – rooted and topped. Ten guarded roots were randomly taken from each plot to measure:

Root growth traits:

Table 1. Name, pedigree, maturity group and some features of the sugar beet studied genotypes.

	Genotype	Source	Type	Features
1	H. Poly I	Sweden	N	Moderate root yield and sugar%
2	Capel	France	E	High root yield and low sugar%
3	Des. Poly N	France	N	Moderate root yield and sugar%
4	Florima	Tunisia	EN	High or moderate root yield and low or moderate sugar%
5	Nejma	Sweden	N	Moderate root yield and sugar%
6	Cleopatra	France	NZ	Moderate or low root yield and moderate or high sugar%
7	Schems	Sweden	E	High root yield and low sugar%
8	Rita	Sweden	N	Moderate root yield and sugar%
9	Barca	Sweden	E	High root yield and low sugar%
10	Diamand	Sweden	N	Moderate root yield and sugar%
11	Pleno	Holland	E	High root yield and low sugar%
12	Samba	Holland	EN	High or moderate root yield and low or moderate sugar%
13	Sultan	Holland	NZ	Moderate or low root yield and moderate or high sugar%
14	Farida	Holland	N	Moderate root yield and sugar%
15	Dema poly	France	NZ	Moderate or low root yield and moderate or high sugar%

E: High root yield and low sugar%, N: Moderate root yield and sugar% and Z: Low root yield and high sugar%.
Data were obtained from Sugar Crops Res. Institute, ARC, Giza.

- Root length (cm).
- Root diameter (cm).
- Root weight (Kg).
- Number of root cycles.

Juice quality traits:

- Sucrose percentage (S %) was estimated in fresh samples of sugar beet roots, using saccharemeter according to the method described in A.O.A.C. (1995).
- Total soluble solids percentage (TSS %) was determined using hand refractometer.
- Purity percentage (P %) = S % ×100 / TSS%.

Yield traits (ton/fed):

- Root yield.
- Sugar yield = root yield × sucrose %.
- Foliage yield.

Statistical analysis

The recorded data were statistically analyzed according to Snedecor and Cochran (1981). Least significant difference test at 5% level of probability was used to compare means.

Simple correlation between the studied traits and multiple regression analysis according to Draper and Smith, (1966) were done to develop equations to predict yield.

The factor analysis was performed according to (Cattell, 1965), which consisted of the reduction of a large number of correlated variables to a much smaller number of clusters of variables called factors. After extraction, the matrix of factor loading was submitted to a varimax orthogonal rotation, as applied by Kaiser (1958). The array of communality, the amount of variance of a variable accounted by the common factors together, was estimated by the highest correlation coefficient in each array as suggested by Seiller and Stafford (1985).

In accordance to the methods used by Johnson et al (1955) and Kumar et al (1985), the phenotypic (PCV %) and genotypic (GCV %) coefficients of variation were estimated. Heritability and expected genetic advance (GA) as percent of the mean assuming selection of the superior 5% of the genotypes were estimated in accordance with the methods illustrated by Fehr (1987).

RESULTS AND DISCUSSION

Mean performance

Effect of sowing date

Data in Table (2) showed the effect of sowing dates on the studied traits of sugar beet across two seasons.

Table 2. Effect of sowing dates on root growth, quality and yield traits at harvest.

Trait type	Date / Trait	2012				2013			
		15th Sept.	15th Oct.	15th Nov.	LSD%	15th Sept.	15th Oct.	15th Nov.	LSD%
Root growth traits	Rl	29.4	29.68	30.2	NS	30.60	30.56	31.94	0.92
	Rd	9.61	7.53	8.5	0.86	10.94	7.80	8.58	0.68
	Rw	0.803	0.525	0.646	NS	1.076	0.674	0.768	0.041
	Cn	10.57	6.78	7.47	0.70	10.05	7.02	7.51	0.45
Quality traits	TSS%	23.6	21.27	22.73	0.09	24.00	22.10	23.10	0.50
	S%	17.81	15.86	16.4	0.96	17.65	16.42	16.83	0.52
	P%	75.74	74.68	72.18	NS	73.74	73.83	73.05	NS
Yield traits (ton/fed)	Ry	24.59	17.49	15.79	3.69	21.29	15.28	20.29	1.78
	Sy	4.41	2.76	2.59	0. 51	3.73	2.44	3.41	0. 39
	Fy	10.1	5.11	2.81	0.90	7.37	3.96	2.65	0.82

Rl: Root length (cm), Rd: Root diameter (cm), Rw: Root weight (g), Cn: No. of root cycle, TSS%: Total soluble solids percentage, S%: Sucrose percentage, P%: Purity percentage, Ry: root yield (ton/fed), Sy: Sugar yield (ton/fed), Fy: Foliage yield (ton/fed) and NS: Non-significant.

Mean performance revealed significant differences between sowing dates for all studied traits in both seasons, except for root length and weight in the 1st season as well as, purity in both seasons. The 1st sowing date recorded the highest values for all traits in both seasons, except root length in the third sowing date across two seasons and purity in the second season. These results agree with those obtained by Ramazan (2002), Mosa (2009) and Refay (2010).

Differences among the evaluated sugar beet genotypes

Data in Table (3) showed the effect of genotypes on the studied traits

Table 3. Differences among fifteen sugar beet genotypes for root growth, quality and yield traits at harvest.

Genotypes	Root growth traits				Quality traits			Yield traits (ton/fed)		
	Rl	**Rd**	**Rw**	**Cn**	**TSS**	**S**	**P**	**Ry**	**Sy**	**Fy**
					2011/2012					
H. Poly I	**31.55**	**8.83**	**0.640**	**7.68**	**22.5**	**17**	**75.62**	**18.57**	**3.18**	**4.81**
Capel	**30.98**	**8.33**	**0.573**	**8.35**	**23**	**16.33**	**70.95**	**20.31**	**3.36**	**6.55**
Des. Poly N	**27.31**	**7.77**	**0.504**	**7.65**	**22.83**	**16.2**	**70.88**	**19.11**	**3.13**	**5.07**
Florima	**29.42**	**8.33**	**0.618**	**8.1**	**23**	**16.63**	**73.41**	**19.23**	**3.26**	**4.11**
Nejma	**27.45**	**8.53**	**0.600**	**8.48**	**22.67**	**16.02**	**71.25**	**20.04**	**3.18**	**5.519**
Cleopatra	**31.07**	**7.78**	**0.505**	**8.2**	**22.17**	**15.95**	**72**	**21.79**	**3.43**	**6.46**
Schems	**29.43**	**7.63**	**0.517**	**7.85**	**23**	**17.17**	**74.84**	**16.42**	**2.82**	**7.66**
Rita	**31.07**	**8.53**	**0.756**	**8.75**	**22.67**	**16.33**	**71.53**	**16.38**	**2.91**	**7.08**
Barca	**31.23**	**7.42**	**0.598**	**7.6**	**23.33**	**17.2**	**74.26**	**18.18**	**3.13**	**8.54**
Diamand	**33.83**	**7.49**	**0.734**	**8.15**	**22.83**	**17.03**	**74.83**	**21.11**	**3.59**	**9.03**
Pleno	**26.55**	**9.23**	**0.659**	**9**	**22**	**16.53**	**75.42**	**19.91**	**3.33**	**5.12**
Samba	**30.47**	**9.92**	**0.742**	**9.2**	**22.17**	**17.2**	**77.8**	**20.74**	**3.62**	**5.36**
Sultan	**27.22**	**9.37**	**0.814**	**8.34**	**22**	**17.03**	**78.78**	**20.57**	**3.52**	**4.71**
Farida	**28.52**	**9.33**	**0.729**	**8.37**	**22.83**	**17.37**	**76.21**	**18.87**	**3.35**	**4.72**
Dema poly	**30.28**	**9.65**	**0.885**	**8.33**	**21.67**	**16.3**	**75.24**	**18.1**	**3.01**	**5.37**
LSD 5%	**2.18**	**0.66**	**0.10**	**0.67**	**0.71**	**0.73**	**3.64**	**3.17**	**NS**	**1.56**
					2012/2013					
H. Poly I	**32.55**	**9.05**	**0.789**	**8.12**	**23**	**17.2**	**74.78**	**16.36**	**2.80**	**3.91**
Capel	**32.72**	**9.83**	**0.792**	**8.4**	**24**	**16.62**	**72.55**	**16.29**	**2.71**	**3.13**
Des. Poly N	**29.67**	**8.25**	**0.641**	**7.78**	**23**	**16.78**	**71.61**	**15.45**	**2.62**	**5.43**
Florima	**30.43**	**8.98**	**0.891**	**8.2**	**23**	**17.13**	**72.9**	**19**	**3.12**	**6.33**
Nejma	**30.78**	**9.3**	**0.870**	**8.3**	**23.33**	**15.87**	**66.98**	**19.62**	**3.05**	**5.9**
Cleopatra	**31.73**	**8.3**	**0.716**	**8.1**	**23**	**16.08**	**68.98**	**16.71**	**2.67**	**4.86**
Schems	**30.43**	**8.18**	**0.750**	**8.3**	**23**	**17.38**	**74.76**	**17.97**	**3.14**	**6.17**
Rita	**34.08**	**9.13**	**0.901**	**8.35**	**23.17**	**16.53**	**71.44**	**17.72**	**2.91**	**5.49**
Barca	**28.72**	**8.01**	**0.721**	**7.4**	**24.17**	**17.4**	**72.28**	**17.19**	**2.99**	**4.98**
Diamand	**34.58**	**7.95**	**0.858**	**8.08**	**23**	**17.3**	**74.83**	**18.21**	**3.14**	**6.11**
Pleno	**29.88**	**9.48**	**0.900**	**8.32**	**22.5**	**16.52**	**72.54**	**23.21**	**3.82**	**3.92**
Samba	**31.48**	**10.05**	**0.925**	**8.78**	**22.5**	**17.63**	**78.31**	**22.09**	**3.93**	**3.34**
Sultan	**27.95**	**10.36**	**0.961**	**8.17**	**22**	**17.63**	**79.85**	**19.71**	**3.49**	**3.17**
Farida	**28.55**	**9.74**	**0.934**	**8.35**	**22.83**	**17.55**	**77.73**	**25.26**	**4.46**	**3.81**
Dema poly	**31.97**	**9.96**	**0.943**	**8.27**	**22.83**	**16.9**	**73.52**	**19.48**	**3.15**	**3.31**
LSD 5%	**1.87**	**0.54**	**0.071**	**0.41**	**0.53**	**0.42**	**2.13**	**0.39**	**0.14**	**0.22**

Rl: Root length (cm), Rd: Root diameter (cm), Rw: Root weight (g), Cn: No. of root cycle, Tss%: Total soluble solids percentage, S%: Sucrose percentage, P%: Purity percentage, Ry: root yield (ton/fed), Sy: Sugar yield (ton/fed), Fy: Foliar yield (ton/fed) and NS: Non-significant.

of sugar beet across two seasons. Highly significant differences among the studied genotypes were detected for all studied traits in both seasons except for sugar yield in the 1st season only. The differences between genotypes may be due to their genetic makeup (El-Sheikh *et al* 2009).

Root growth traits

Data showed that Diamand, Dema poly and Samba genotypes had the highest values for root length, root weight and root cycles, respectively in both seasons. Meanwhile, Samba and Sultan genotypes had the highest values for root diameter in both seasons. Similar results were reported by El-Sheikh (2007), El-Sheikh *et al* (2009) and Aly *et al* (2012).

Juice quality

Barca and Sultan genotypes had the highest values for total soluble solids percentage and purity percentage, respectively in both seasons. Meanwhile, Farida and Samba also Sultan genotypes had the highest values for sucrose percentage in the 1st and 2nd season, respectively (El-Sheikh 2007).

Yields (ton/fed)

Cleopatra, Samba and Diamand genotypes had the highest values for yields of root, sugar and foliage in the 1st season, respectively. Farida variety had the highest values for root yield and sugar yield; meanwhile Florima variety had the highest value for yields of foliage in the 2nd season. Similar results were reported by Aly *et al* (2012).

Interaction effects

Data in Table (4) showed that interaction between sowing dates and sugar beet genotypes had highly significant effects on all studied traits in both seasons. Pleno, Samba, Sultan and Farida genotypes had the highest root and sugar yield values in both seasons under the 1st sowing date. Whereas, these genotypes recorded 28.51, 31.04, 29.56 and 26.83 tons, respectively in the 1st season and 31.7, 26.45, 22.99 and 29.78 tons, respectively in the 2nd season under the early sowing date for root yield. Sugar yield values were 4.99, 5.64, 5.11 and 5.18 tons, respectively in the 1st season and 5.28, 4.90, 4.19 and 5.54 tons, respectively in the 2nd season under the early sowing date.

Caple, Nejma, H. Poly I and Des. Poly N genotypes recorded 18.11, 17.6, 17.51 and 17.4 tons, respectively in the 1st season and Samba, Farida, Nejma and Rita genotypes exhibited 25.55, 24.04, 23.78 and 22.86 tons, respectively in the 2nd season under the early sowing date for root yield.

Meanwhile, Samba, Farida, Schems and Rita genotypes recorded 4.48, 4.22, 3.91 and 3.78 tons, respectively in the 2nd season under the late sowing date for sugar yield. Therefore, Samba genotype had high root and sugar yield values under the most cases.

In general, and regardless the significance, it could be noticed that sucrose percentage, sugar yield and root yield showed better performance under early sowing with previously recommended genotypes according to

Table 4. Interaction between the studied sugar beet varieties and sowing dates at harvest.

Genotypes	Sowing dates					
	Root yield(tons)			**Sugar yield** (tons)		
	15th Sept.	**15th Oct.**	**15th Nov.**	**15th Sept.**	**15th Oct.**	**15th Nov.**
2011/2012						

H. Poly I	22.49	15.700	17.51	4.02	2.51	3.01
Capel	27.59	15.23	18.11	4.87	2.16	3.04
Des. Poly N	23.46	16.46	17.40	4.19	2.57	2.64
Florima	23.95	16.88	16.88	4.45	2.74	2.59
Nejma	24.21	18.29	17.60	3.88	2.91	2.73
Cleopatra	27.03	22.38	15.98	4.46	3.22	2.58
Schems	17.88	18.33	13.04	3.19	2.94	2.32
Rita	19.18	15.00	14.95	3.96	2.33	2.42
Barca	18.54	18.75	17.24	3.29	3.03	3.06
Diamand	23.45	26.25	13.63	4.37	4.21	2.19
Pleno	28.51	17.78	13.44	4.99	2.90	2.09
Samba	31.04	14.86	16.33	5.64	2.42	2.80
Sultan	29.56	16.03	16.13	5.11	2.66	2.78
Farida	26.83	15.59	14.19	5.18	2.48	2.40
Dema poly	25.10	14.75	14.44	4.53	2.31	2.19
LSD 5%		5.49			0. 92	
			2012/2013			
H. Poly I	21.81	12.56	14.71	3.75	2.12	2.52
Capel	16.65	13.44	18.77	2.95	2.04	3.15
Des. Poly N	20.15	12.28	13.93	3.70	1.96	2.19
Florima	18.63	17.57	20.81	3.53	2.55	3.28
Nejma	21.15	13.92	23.78	3.43	2.22	3.51
Cleopatra	19.35	12.17	18.60	3.10	1.84	3.07
Schems	15.84	16.69	21.38	2.92	2.60	3.91
Rita	14.28	16.01	22.86	2.47	2.48	3.78
Barca	20.50	13.79	17.28	3.38	2.30	3.28
Diamand	17.24	17.65	19.75	3.19	2.85	3.36
Pleno	31.70	16.18	21.75	5.28	2.62	3.56
Samba	26.45	14.27	25.55	4.90	2.39	4.49
Sultan	22.99	15.35	20.78	4.19	2.63	3.64
Farida	29.78	21.97	24.04	5.54	3.62	4.22
Dema poly	22.77	15.3	20.38	3.70	2.45	3.29
LSD 5%		0.67			025	

Ramazan (2002) Mosa (2009) Refay (2010) and Aly *et al* (2012). But in case of delaying the sowing date, the previously alternative recommended genotypes could be used.

*** Correlation**

Simple correlation coefficients between pairs of studied characters, in both seasons, are presented in Table (5). The results revealed that root yield was positively and highly significant correlated with root diameter, root weight, no. of root cycles, total soluble solids, sucrose percentage, sugar yield and foliage yield. But, sugar yield was positively and highly significant correlated with root diameter, root weight, no. of root cycles, total soluble solids, sucrose percentage, purity, root yield and foliage yield in the two seasons.

Table 5: A matrix of simple correlation coefficients (r) for the estimated ten variables of sugar beet (n=270).

Trait	Rl	Rd	Rw	Cn	TSS	S%	P	Ry	Sy
Rd	**- 0.078**								
Rw	**0.138***	**0.797****							
Cn	**- 0.051**	**0.636****	**0.480****						
TSS	**0.133***	**0.208****	**0.303****	**0.422****					
S%	**0.059**	**0.384****	**0.415****	**0.481****	**0.463****				
P	**- 0.056**	**0.233****	**0.156***	**0.146***	**- 0.370****	**0.599****			
Ry	**- 0.001**	**0.365****	**0.383****	**0.552****	**0.236****	**0.283****	**0.104**		
Sy	**0.009**	**0.430****	**0.441****	**0.619****	**0.338****	**0.504****	**0.242****	**0.955****	
Fy	**- 0.029**	**0.168****	**0.147***	**0.565****	**0.276****	**0.298****	**0.061**	**0.384****	**0.431****

***, ** and ns indicates significant at the 0.05 and 0.01 level of probability and insignificant, respectively.**

Rl: root length (cm), Rd: root diameter (cm), Rw: root weight (g), Cn: No. of root cycle, TSS%: total soluble solids percentage, S%: Sucrose percentage, P%: Purity percentage, Ry: root yield (ton/fed), Sy: Sugar yield (ton/fed) and Fy: foliar yield (ton/fed).

Multiple linear regression analysis

Data presented in Table (6) showed regression coefficients and the probability of the estimated variables in predicting root and sugar yield. The obtained results showed that the prediction equation for sugar yield ($\hat{Y}$) is formulated using the sugar beet variables as follows:

- Root yield ton/fed:

$\hat{Y} = 26.449 - 0.001\mathbf{Rl} - 0.169\mathbf{Rd}^{*} + 0.977\mathbf{Rw}^{*} + 0.138\mathbf{Cn}^{*} - 0.304\mathbf{Tss}^{**} - 0.811\mathbf{S\%}^{**} - 0.071\mathbf{P}^{*} + 56.669\mathbf{Sy}^{**} - 0.030\mathbf{Fy}$.

- Sugar yield ton/fed:

$\hat{Y} = -0.466 - 0.00003\mathbf{Rl} + 0.002\mathbf{Rd} - 0.011\mathbf{Rw} - 0.001\mathbf{Cn} + 0.006\mathbf{Tss}^{**} + 0.014\mathbf{S\%}^{**} + 0.001\mathbf{P}^{*} + 0.017\mathbf{Ry}^{**} + 0.0007\mathbf{Fy}$.

The root yield formula explains 96.6% of the total variation within the yield components, while the remaining 3.4% may be due to residual effects, but sugar yield formula explains 97.2% of the total variation within the yield components, while the remaining 2.8% may be due to residual effects. The t-test showed that Sy, S%, TSS, Rd, Rw, Cn and P have contributed significantly towards root yield. Meanwhile, Ry, S%, TSS and P have contributed significantly towards sugar yield, while the other five variables did not. The overall results reflect the importance of the mentioned

Table 6. The regression coefficient (b), standard error (SE) and T-value in predicting sugar beet root and sugar % yield by the multiple linear regression analysis.

Variables	Root yield			Variables	Sugar yield		
	Regression coefficient (b)	Standard error	T		Regression coefficient (b)	Standard error	T

Rl	**– 0.0005**	**0.170**	**-0.03**	**Rl**	**– 0.00002**	**0.0003**	**-0.09**
Rd	**– 0.1685***	**0.076**	**-2.21**	**Rd**	**0.00232**	**0.0013**	**1.77**
Rw	**0.9770***	**0.441**	**2.22**	**Rw**	**– 0.01094**	**0.008**	**-1.44**
Cn	**0.1377***	**0.064**	**2.15**	**Cn**	**– 0.00104**	**0.0011**	**-0.94**
TSS	**– 0.3044****	**0.118**	**-2.59**	**TSS**	**0.00566****	**0.0020**	**2.81**
S%	**– 0.8111****	**0.156**	**-5.19**	**S%**	**0.01364****	**0.0027**	**5.07**
P	**– 0.0712***	**0.035**	**-2.03**	**P**	**0.00140***	**0.0006**	**2.33**
Sy	**56.669****	**0.827**	**68.53**	**Ry**	**0.01672****	**0.0002**	**68.53**
Fy	**– 0.0297**	**0.022**	**-1.34**	**Fy**	**0.00068**	**0.0004**	**1.79**
Intercept=26.486,Standard error of estimation = 0.967, R^2 = 96.6%, Adjusted R^2 =96.5%				Intercept=–0. 466,Standard error of estimation = 0.0166, R^2 = 97.2%, Adjusted R^2 =97.1%			

***, ** and ns indicates significant at the 0.05 and 0.01 level of probability and insignificant, respectively.**

Rl: root length (cm), Rd: root diameter (cm), Rw: root weight (g), Cn: No. of root cycle, Tss%: total soluble solids percentage, S%: Sucrose percentage, P%: Purity percentage, Ry: root yield (ton/fed), Sy: Sugar yield (ton/fed) and Fy: foliar yield (ton/fed).

commensurate four variables in sugar beet selection for breeding programs. These findings are in accordance with the results obtained by El-Gedawy *et al* (2000) and Abo El-Ghait and Mahmoud (2005).

Factor analysis

Data in Table (7) showed that four main factors (groups) accounted for 78.898% of the total variability in the dependent structure. The first factor (group) included sugar yield, root yield, foliar yield and No. of root cycles, which accounted for 28.796% of the total variability in the dependent structure. The second factor included root diameter and root weight which accounted for 22.286% of the total variability in the dependent structure. The third factor included sucrose percentage and purity percentage which accounted for 15.455% of the total variability in the dependence structure. The fourth factor included root length and total soluble solids percentage which accounted for 12.36% of the total variability in the dependent structure.

Table 7. Rotated (Varimax rotation) factor loadings and communalities for the estimated variables of sugar beet.

Variable	Loading	Communality	Latent roots	Factor variance (%)
Factor1:			**2.880**	**28.796**
Cn	0.694	0.736		
Fy	0.760	0.586		

Ry	0.814	0.732		
Sy	0.842	0.832		
Factor2:			**2.229**	**22.286**
Rw	0.895	0.864		
Rd	0.924	0.917		
Factor3:			**1.546**	**15.455**
S%	0.615	0.807		
P	0.980	0.986		
Factor4:			**1.236**	**12.36**
Tss	0.593	0.753		
Rl	0.811	0.676		
Cumulative variance				**78.898**

Rl: root length (cm), Rd: root diameter (cm), Rw: root weight (g), Cn: No. of root cycle, Tss%: total soluble solids percentage, S%: Sucrose percentage, P%: Purity percentage, Ry: root yield (ton/fed), Sy: Sugar yield (ton/fed) and Fy: foliar yield (ton/fed).

Genetic parameters

Mean squares due to genotypes were highly significant for all studied characters indicating that the variation was genetic. The genotypic coefficient of variability (GCV %) and phenotypic coefficient of variability (PCV %), heritability and expected genetic advance (as percentage of mean) for various characters studied are presented in Table (8). The estimates of heritability (h^2) in broad sense and expected genetic advance for various characters studied are calculated. Broad sense heritability based on both additive as well as non-additive gene effects gives only a rough estimate. Phenotypic coefficient of variability (PCV %) was higher than corresponding genotypic coefficient of variability (GCV %) for all studied traits which demonstrated the effect of environment upon the traits. The highest estimates of genotypic coefficient of variability were observed for foliar yield (39.36%), root weight (29.44%), root diameter (16.24%), root yield (11.53%) and root length (10.24%) in 1st season, and foliar yield (39.14%), sugar yield (26.13%), root yield (22.74%), root weight (18.24%) and root diameter (14.49%) in 2nd season. That indicates the presence of exploitable genetic variability for foliar yield, root weight, root diameter and root yield traits across two seasons. All studied traits except root yield and sugar yield had higher heritable variation. Hence it can be assumed that

Table 8. Variability, heritability and expected genetic advance for studied traits in 2012, 2013 in sugar beet Traits.

Trait	2012					2013				
	mean	GCV %	PCV %	h^2%	G.A%	mean	GCV %	PCV %	h^2 %	G.A%
Rl	29.76	10.24	10.57	93.86	20.43	31.03	9.31	9.55	94.93	18.69
Rd	8.54	16.24	16.47	97.25	32.99	9.105	14.49	14.64	97.91	29.54

Rw	0.658	29.44	29.93	96.72	59.64	0.839	18.24	18.66	95.47	36.70
Cn	8.27	9.32	9.75	91.3	18.35	8.194	5.32	5.61	90	10.40
Tss	22.53	3.14	3.34	88.62	6.10	23.07	2.10	2.26	86.42	4.02
S%	16.69	4.53	4.8	89.26	8.82	16.97	4.68	4.76	96.43	9.46
P	74.2	5.01	5.31	89.08	9.74	73.54	7.21	7.28	97.98	14.69
Ry	19.29	11.53	12.94	79.45	21.18	18.95	22.74	22.75	99.89	46.81
Sy	0.325	8.58	10.26	70	14.79	0.319	26.13	26.24	99.68	53.89
Fy	6.01	39.36	40.44	94.73	78.92	4.658	39.14	39.18	99.83	80.57

$\bar{x}$ = Mean, PCV% = Phenotypic coefficient of variability, GCV% = Genotypic coefficient of variability, h^2 = heritability, GA% = Expected genetic advance as percent of the mean.

Rl: root length (cm), Rd: Root diameter (cm), Rw: Root weight (g), Cn: No. of root cycles, TSS%: total soluble solids percentage, S%: Sucrose percentage, P%: Purity percentage, Ry: Root yield (ton/fed), Sy: Sugar yield (ton/fed) and Fy: Foliar yield (ton/fed).

phenotypes of almost all the traits except root yield and sugar yield are mainly determined by their genotypes. Higher estimates of genetic advance were observed for foliar yield (78.92%), root weight (59.64%), root diameter (32.99%), root yield (21.18%) and root length (20.43%) in the 1st season, and foliar yield (80.57%), sugar yield (53.89%), root yield (46.81%), root weight (36.70%) and root diameter (29.54%) in the 2nd season. That indicates the presence of exploitable genetic variability for foliar yield, root weight, root diameter and root yield traits across two seasons and can be improved through selections effectively.

High heritability values coupled with high genetic advance were observed for foliar yield, root weight, root diameter and root length in 1st season, and foliar yield, sugar yield, root yield, root weight and root diameter in the 2nd season. From the results of two seasons, it can be concluded that foliar yield, root weight and root diameter traits are controlled by additive type of gene action and could be improved through selection.

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التقييم الإحصائى والوراثي لخمسة عشرصنفاً من بنجر السكر تحت ثلاثة مواعيد زراعة

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أجريت هذه التجربة بمنطقة سنورس بمحافظة الفيوم خلال موسمى الزراعة 2012/2011 و 2013/2012 لتقييم تباين المحصول تحت مواعيد الزراعة المختلفة. تم زراعة خمسة عشر صنفاً من بنجر السكر تحت ثلاثة مواعيد زراعة مختلفة هى منتصف شهر سبتمبر و منتصف أكتوبر و منتصف نوفمبر. وقد أوضحت النتائج أن وجود اختلافات معنوية بين مواعيد الزراعة في كل الصفات المدروسة عدا طول ووزن الجذر خلال الموسم الأول بالاضافة لصفة النقاوة خلال موسمى الزراعة. وقد سجلت أصناف بنجر السكر المدروسة أعلى قيم بالنسبة محصول الجذور والسكر تحت مواعيد الزراعة المبكرة (منتصف شهر سبتمبر) خلال موسمى الزراعة. وكانت الأصناف بلينو وسامبا وسلطان وفريدة ذات أعلى قيم بالنسبة لصفتي محصول الجذر والسكر. ولكن عند تأخير الزراعة إلى منتصف نوفمبر يوصى بزراعة أصناف (بركة وكابل وسامبا وفريدة). لذا يوصى بزراعة الصنف سامبا وفريدة تحت مختلف الظروف لارتفاع محصولى الجذر والسكر. كما أعطى معامل الاختلاف المظهرى والوراثى تبايناً لكل الصفات فى كلا الموسمين.وعليه فيمكن تحسين صفات المحصول الورقى ووزن وسمك الجذر عن طريق الانتخاب. كما أن قيم كفاءة التوريث العالية المصاحبة للتحسين الوراثى المتوقع بالانتخاب لنفس الصفات تؤكد طبيعة الفعل الجينى المضيف وفاعلية الانتخاب لتحسين صفتى محصول الجذر والسكر.

وقد اوضحت نتائج تحليل الارتباط البسيط والانحدار وتحليل العامل وجود ارتباط عالى موجب بين صفتى محصول الجذر وكل الصفات تحت الدراسة عدا صفتى طول الجذر والنقاوة مما يؤكد أن الانتخاب خلال هذه الصفات أو بعضا منها يكون مصحوباً بزيادة المحصول تحت كل الظروف. أما نتائج تحليل الانحدار الكلى أوضحت أن معامل التحديد R^2 سجل 96.6% من التباين الكلى. وقد حدد التحليل العاملي أكثر الصفات أهمية وتأثيرا فى المحصول فكان لعدد الحلقات الجذرية والمحصول الورقى والجذرى والسكر/النبات هى الاكثر أهمية حيث تقع جميعا فى العامل الأول. وعليه يتم أخذ هذه الصفات فى الاعتبار عند تنفيذ برامج التربية لتحسين انتاجية بنجر السكر بالانتخاب لهذه الصفات.

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