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ASSESSMENT OF PERFORMANCE AND STABILITY FOR YIELD AND QUALITY OF SOME SUGAR BEET GENOTYPES UNDER TWO HARVESTING DATES

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ABSTRACT

Evaluation of sugar crops varieties at different environmental conditions comes in the first order in Egypt for, sugar beet genotypes where the Egyptian climatic conditions are unfavorable for its floral induction. A comparative study was conducted to assess the performance and stability of five exotic sugar beet varieties (Sarah, Glorius, Carnute, Gazelle and Dema poly) in three locations (Kafr Elsheikh, El-Giza and Elminia governorates) for two harvest age (180 and 210 days) during the two successive growing seasons 2016/17 and 2017/18.The combinations between three locations, two harvest age and two seasons were considered as 12 different environments. A split plot design in randomized complete blocks arrangement with three replications was used. The results of combined analysis of variance revealed that the main effects of growing seasons (Y), locations (L) and harvest age (H) were significant for all studied yield and technological characters except sodium and nitrogen percentages in roots. Meantime, the variances due to genotypes were significant for all studied characters. Moreover, Sarah and Glorious varieties had the highest mean values for root yield/fed. Besides, in Kafr El-Sheikh, harvesting after 210 days from sowing proved the superiority of those two varieties as commercial or suitable varieties for cultivation under desirable conditions. The results for stability analysis showed that the genotype Sarah had the most stable and highest yields of root and sugar as well as quality traits followed by Glorious. Since it exhibit relative high mean performance for these traits and had regression coefficient (b_i) approaching unity with insignificant deviations from regression (S^2_{di} =.0.0), indicating the importance of these varieties in agricultural practice as commercial varieties under such studied environmental conditions.

Key words: ***Sugar beet (Beta vulgaris L.), Genotype x environment interaction, Phenotypic stability, Locations, Harvest date, Sugar yield and contributing traits.***

INTRODUCTION

The second sugar crop across the world is sugar beet (Beta vulgaris L.). It is generally adapted to producing high yields under less favorable ecological conditions than that is required for sugar cane crop (El Kefaey *et al* 2012). In Egypt, the cultivation area of sugar beet was about 600 thousand feddan (one feddan = 4200 m^2) in 2019. Annually, seeds of sugar beet varieties which are imported and evaluated should indicate consistency and positive results across a range of locations and years for their productivity before being recommended for cultivation. (Al Jbawi, 2003). The different responses of genotypes which evaluated under different environments are due to genotype x environment interaction (GEI), and is of high magnitude because it advocates information about the performance of genotypes under different environments, to determine the existence of stability performance of the imported materials. If GEI is existed, this complicates the assessment of superiority among the genotypes (Truberg and Huhn 2000). Stable genotypes identified with the same performance with high yield even when circumstances was unfavorable (Bjornsson 2002). Since analysis of the ordinary methods such as using combined variance analysis gives just information about the presence or absence of interactions between genotype and environment, researchers have evaluated different methods of stability and each one has suggested a method (Rostayee *et al* 2003). Various studies have been done to evaluating the stability of various sugar beet varieties in different areas through using methods of parametric univariate (Keshavanz *et al* 2001 and Ebrahimian *et al* 2008). In that context, regression analysis is certainly the most popular method for stability analysis due to its simplicity and the feet that its information on adaptive response is easily applicable to locations. Al-Jbawi (2000), studied genotype x location interaction on yield (root and sugar yield) and quality traits (sucrose and purity). She found that genotype x location interaction exhibited significant effect on these traits.

The leaves of sugar beet are the main light receptor organ for crop. Leaf area development early during season causes more efficient use of sunlight, since it is important to the formation and expansion of canopy (Sarmadnia and Koocheki 1997). There is a close relationship between yield and production of leaf area. Fortune *et al* 1999 and Sarmadnia and Koocheki 1997 (Heidari *et al* 2008) emphasized that yield is affected by the amount of radiation received by the leaves. Sugar beet yield include biomass, root and sugar yield but economic characters are storable root and percentage of sugar (Koocheki 1996). In fact sugar yield is a part of root dry matter and higher yield of sugar is obtained when higher amount of dry matter is produced in root (Lauer 1995). Sugar yield comprises two aspects, total sugar yield that is obtained from root yield multiplied by total sugar content and white sugar yield that is obtained from root yield multiple by white sugar content. Sugar beet in primary growth stages needs warm and sunny climate and optimum warm supply for optimum photosynthesis and photo assimilate partitioning (Fortune *et al* 1999).

Time of harvest is one of the factors that affect yield and quality of sugar beet crop. The root dry matter percentage increases with passing growth period of plant and the amount of sugar reaches to 20-26% at the time of harvest. This dry matter contains sugar especially sucrose and several organic and mineral sources (Koocheki 1996). Jaggard and Scott 1999 and Burcky and Winner (1986) suggested that later harvest dates for sugar beet result in greater sugar yield under no rainfall and cold weather. Jozefyova *et al* 2004 reported the postponement of the time of harvest by 27 days increased average root yield by 11.35 t ha^{-1}. They also concluded that white sugar yield increased by delay in harvest by 1.69 t ha^{-1}. Kerr and Leaman 1997 in a two year experiment showed that the yield was increased under irrigation from the first till the last harvest. Evaluation on the yield and yield components during last stages of growth can determine the best time for the harvest of sugar beet. This may present the reduction of sugar and root yield at early or late harvesting.

The objective of this study is to

1- Evaluate the effect of environmental conditions, i,e. seasons, locations and harvest time on yield and quality of five sugar beet genotypes.
2- Determine the magnitude of genotype x environment interaction and to measure phenotypic stability for root and sugar yields of these genotypes.

MATERIALS AND MEHODS

Five sugar beet varieties (Table 1) were evaluated at three locations L1)Sakha Research Station, Kafr Elsheikh Governorate (latitude of 31^0 37 N and longitude of 30^0 20 E at an elevation of 15 m above the sea level), L2) El-Giza Research Station of sugar beet research institute, Agricultural Research Center, Giza governorate (latitude 28^0 76 N and longitude 29^0 23 E) 30m above sea level, and L3) Malawi Research Station, Elminia governorate (latitude 28^0 10 N and longitude 30^0 75 E) 55m above sea level in 15th Aug. 2016-2017 (Y1) and 2017-2018 (Y2) growing seasons. Climatic data for these two successive seasons at three locations are presented in Table (2).

Table 1. Origin of the examined sugar beet varieties.

No.	Sugar beet varieties	Type of seeds	Origin	
			Company	Country
1	Carnute	Multigerm	Desprez	France
2	Glorius	Multigerm	Strube	Germany
3	Gazelle	Multigerm	Maribo	Germany
4	Sarah	Multigerm	Kuhn	Netherlands
5	Dema poly	Multigerm	Desprez	France

Table 2. Monthly temperature and relative humidity* of locations.

Month	Temperature °C						Relative Humidity%		
	Maximum			Minimum					
	Sakha	Giza	Menia	Sakha	Giza	Menia	Sakha	Giza	Menia
2016-2017									
Aug.	32.20	34.67	37.10	24.30	21.26	22.20	63.50	49.10	34.10
Sep.	31.20	31.50	32.89	23.70	20.44	18.58	59.90	48.63	42.33
Oct.	28.70	25.70	29.02	21.50	17.90	16.74	64.40	56.40	54.14
Nov.	24.90	19.10	24.38	18.50	14.14	12.87	62.70	57.58	46.79
Dec.	19.00	34.67	18.80	13.70	8.70	6.60	65.50	61.60	57.70
Jan.	17.30	19.90	18.10	10.90	7.10	4.93	66.40	60.30	52.17
Feb.	18.70	21.40	20.60	11.20	8.20	5.70	66.70	54.00	47.70
Mar.	21.10	25.40	24.30	13.20	12.10	14.70	64.80	43.30	36.90
2017-2018									
Aug.	32.60	37.10	38.50	24.90	22.20	23.50	62.20	34.10	32.90
Sep.	31.10	32.90	35.50	22.90	18.60	19.80	62.50	42.30	37.40
Oct.	27.60	29.60	30.00	20.40	16.40	15.90	60.80	51.20	41.00
Nov.	23.30	25.08	24.60	16.80	13.19	10.90	63.50	59.67	48.40
Dec.	20.90	23.09	21.40	14.90	12.40	9.00	68.00	63.70	52.50
Jan.	18.38	19.30	18.35	12.51	7.65	7.60	67.33	61.74	63.73
Feb.	20.32	23.39	21.63	12.67	10.11	9.27	66.80	49.74	53.71
Mar.	22.63	23.87	21.97	14.13	15.90	8.13	54.57	56.73	38.40

***Monthly report, Agro meteorological data ARC, Egypt.**

The soil analysis at the three locations is presented in Table (3). The analysis of variance was carried out for each experiment separately. Collected data from three replications were subjected to combined analysis of variance for a split plot design in randomized complete block arrangement over locations and years, where harvest time occupied the main plots and varieties distributed in the sub plots.

The twelve environments represented the combinations between three locations (L_1, L_2, and L3), two harvest time (H1 and H2) and two growing seasons (Y1 and Y2).The plot area was 15.4 m^2 consisted of 4 rows, 7 meter long and 55 cm apart, spaced 20 cm between the hills in each row.The experiments were planted in the first week of August in the three locations. All culture practices such as irrigation, weed and insect control etc, were applied in the same manner as usually done in the ordinary sugar beet field to obtain maximum yield.

Table 3. Chemical and physical properties of the experimental soils

Location	Sakha		EL- Giza		EL- Menia	
Seasons	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Physical analysis	Partial soil distribution					
Sand %	16.65	18.85	22.30	20.00	8.65	9.35
Silt%	33.15	32.73	27.10	26.50	54.45	53.52
Clay%	50.20	48.42	50.60	53.50	36.90	37.13
Soil texture	Clay		Clay		Silt Clay Loam	
Chemical analysis	Soluble cations and ions (mq r^1)					
E.C.(m. mhos/cm)	3.35	3.40	5.20	5.40	1.80	1.60
Ph(1:2.5)	8.10	8.20	7.70	7.81	8.10	8.00
Organic matter%	1.89	1.93	-	-	1.22	1.18
Cations (meq/L)						
Ca^{**}	2.45	2.50	-	-	9.78	8.45
Mg^{**}	280	2.85	19.15	18.90	2.72	2.75
Na^+	6.70	6.75	11.49	10.75	4.95	4.45
K^+	0.45	0.35	0.59	0.63	0.24	0.23
Anions(meq / L)						
HCO_3^-	6.20	6.22	3.77	3.66	3.68	3.25
Cl^-	6.00	6.00	12.50	12.30	5.80	4.90
SO_4^-	0.20	0.23	-	-	8.36	7.78
Available N (ppm)	18.20	18.31	73.0	74.0	21.10	19.35
Available P (ppm)	6.90	6.50	1.50	1.60	8.50	7.85
Available k (ppm)	289.6	270.2	221.2	223.4	175	180

Data recorded

At each harvest date, plants in the four inner ridges of each plot were collected and cleaned. Thereafter, roots were separated to measure and estimate root diameter (cm), root weight/plant (kg) and root yield ton/fed.A sample of 10 kg of roots were taken at random from each plot and sent to the Beet Laboratory at Delta Sugar Factory to determine root quality, sucrose percentage (Pol. %) was determined according to the method of Le-Docte (1927).

Alfa amino nitrogen was determined using hydrogenation method. according to Carruthers *et al* (1962). Sodium and potassium (Na & K) were determined in the digested solution using flame photometry- according to the method described by Brown and Lilliand (1964).

Purity% = corrected sugar x 100/polarity (Devillers 1988).

Correct sugar = Sucrose% - 0.029- 0.343 (K + Na) – 0.0939 (alfa amino – N).

Sugar yield = root yield x sucrose %.

The collected data were subjected to proper statistical analysis of split plot design according to Snedecor and Cochran (1994).

The analysis of variance was carried out for each experiment separately and the combined analysis was carried out after making the homogeneity test for error variance.

The treatment means and mean performance in seasons, locations and harvest dates of the studied characters were compared using LSD at 1 and 5% level probability and Dunkin,s test, respectively.

The obtained data of five sugar beet varieties under the twelve different environments (2 seasons x 3 locations x 2 harvest age) were statistically analyzed to estimate the genotype x environment interaction and phenotypic stability analysis for root and sugar yields using the method outlined by Eberhart and Russell 1966 (Okasha and Mubarak 2018). The studied traits were root and corrected sugar yields ton/fed.

RESULTS AND DISCUSSION

Analysis of variance

The combined analysis of variance for the studied characters of five sugar beet varieties is presented in Table (4). Mean squares due to seasons, locations and harvest time were significant for all yield components and technological traits except sodium and nitrogen percentages in roots. Meantime, the variances due to genotypes were significant for all studied characters. These results indicated the existence of wide genetic variability among these sugar beet genotypes for all studied characters.

The interaction between genotypes and seasons was significant for root diameter (cm), sucrose and corrected sugar% in contrast, the genotype x location interaction was insignificant for all studied characters, indicating that the ranking of studied genotypes is affected significantly by transforming from one location to another.

Table 4. Mean squares for the studied characters of five sugar beet varieties across two years and three locations under two harvest dates.

SOV	df	Root diameter (cm)	Root weight/ plant (kg)	Root yield (ton/fed)	Sodium%	Potassium%
Year	1	2.001**	0.33**	27.269**	0.005	0.350**
Location	2	2.236**	0.101**	18.527**	19.537**	76.468**
YL	2	0.156**	0.002**	0.680*	0.002	0.086
R (LY)	12	0.028	0.003**	0.358	0.023	0.039
Harvest date (H)	1	9.122**	0.339**	424.243**	0.090	0.061
Y x H	1	0.538**	0.004**	9.458**	0.008	0.238**
L x H	2	0.292**	0.006**	1.249**	0.355**	0.007
Y x L x H	2	0.098**	0.002	0.294	0.224**	0.005
Error	12	0.011**	0.000	0.114	0.028	0.025
Variety (V)	4	2.007**	0.155**	63.035**	0.329**	0.750**
Y x V	4	0.332**	0.001	0.794	0.001	0.024
L x V	8	0.054	0.004	0.318	0.042	0.057
Y x L X V	8	0.036	0.001	0.082	0.018	0.058
H x V	4	0.015	0.007	6.064**	0.022	0.076*
Y x H x V	4	0.110	0.003	0.284	0.058	0.035
L x H x V	8	0.089	0.002	0.346	0.025	0.020
Y x L x H x V	8	0.140	0.001	0.553	0.042	0.020
Error	96	0.043	0.002	0.515	0.016	0.015

Table 4. Cont.

SOV	df	Nitrogen%	Sucrose%	Corrected sugar%	Sugar yield (ton/fed)	Purity%
Year	1	0.008	1.834**	2.312**	1.452**	5.506**
Location	2	2.550**	42.27**	19.769**	5.088**	49.871**
YL	2	0.212*	0.518	0.492	0.045	0.901
R (LY)	12	0.009	0.241	0.264	0.028	0.734
Harvest date (H)	1	0.021	72.415**	72.403**	29.640**	30.267**
Y x H	1	0.006	1.330*	0.910*	0.036	0.000
L x H	2	0.143*	0.515	0.750*	0.199**	3.728**
Y x L x H	2	0.029	5.740**	5.346**	0.241**	5.038**
Error	12	0.037	0.193	0.188	0.019	0.382
Variety (V)	4	0.268**	10.167**	13.915**	4.227**	43.973**
Y x V	4	0.025	0.584*	0.579*	0.045	0.880
L x V	8	0.025	0.292	0.278	0.028	0.406
Y x L X V	8	0.036	0.264	0.278	0.021	0.412
H x V	4	0.019	0.625*	0.602*	0.162**	1.026*
Y x H x V	4	0.009	0.285	0.336	0.031	1.202*
L x H x V	8	0.019	0.333	0.341	0.038	0.467
Y x L x H x V	8	0.018	0.619*	0.626*	0.051	0.983*
Error	96	0.024	0.137	0.133	0.020	0.246

*** and ** denote significant differences at 0.05 and 0.01 levels of probability, respectively.**

In addition, the mean squares for genotype x harvest date interaction was significant for all studied characters except root diameter (cm), root weight/plant (kg), sodium and nitrogen%. Regarding the second order interaction from V x Y x L it was insignificant for all studied characters. On the other hand V x Y x H mean squares were significant for quality%, while the mean squares for V x L x H were insignificant for all studied characters. For the third order interaction, the mean square due to V x Y x L x H interactions were significant for sucrose, corrected sugar and quality%, showing that sugar beet genotypes were affected by the combination between these environmental factors under study.

results of the mean performance of the five sugar beet varieties presented in Table (5, 6, 7, 8 and 9) showed that root diameter ranged from 12.39 to 12.92 cm with an average of 12.62 cm, from 1.057 to 1.201 kg with an average of 1.121 kg for root weight/plant, from 4.77 to 5.03 with an average of 4.91% for potassium, from 1.96 to 2.20% with an average of 2.07% for sodium, from 1.48 to 1.65% with an average of 1.57% for nitrogen, from 16.01 to 17.08% with an average of 16.52% for sucrose%, from 22.95 to 26.00 ton/fed with an average of 24.16 ton/fed for root yield, from3.68 to 4.45 ton/fed with an average of 4.01 ton/fed for sugar yield, from 13.09 to 14.39% with an average of 13.69% for corrected sugar% and from81.94 to 84.13% with an average of 82.90% for quality. Data presented in the same tables revealed also that the environments used in this study provided a wide range of variation in environmental conditions, the means of the studied characters of sugar beet genotypes were significantly differed from one environment to another.

They ranged from 13.34 cm for Env. 8 ($Y_2L_1H_2$) to 12.13 cm for Env. 5 ($Y_1L_3H_1$), from 1.013 kg for Env. 3 ($Y_1L_2H_1$) to 1.251 kg for Env. 7 ($Y_2L_1H_1$), from 3.5% for Env. 11 ($Y_2L_3H_1$) to 5.8% for Env. 8 ($Y_2L_1H_2$), from 1.24% for Env.4 ($Y_1L_2H_2$) to 2.58% for Env. 6 ($Y_1L_3H_2$), from 1.17% for Env. 2 ($Y_1L_1H_2$) to 2.27 for Env.5 ($Y_1L_3H_1$), from 15.13% for Env. 11($Y_2L_3H_1$) to 18.21% for Env. 2 ($Y_1L_1H_2$), from 21.55 ton/fed for Env. 5 ($Y_1L_3H_1$) to 26.37 ton/fed for Env. 8 ($Y_2L_1H_2$), from 3.33 ton/fed for Env. 5 ($Y_1L_3H_1$) to 4.77 ton/fed for Env. 8 ($Y_2L_1H_2$), from 12.56% for Env. 9 ($Y_2L_2H_1$) to 15.11% for Env. 2 ($Y_1L_1H_2$), from 80.98% for Env. 1 ($Y_1L_1H_1$) to 84.55% for Env. 12 ($Y_2L_3H_2$), for root diameter, root weight/plant, potassium, sodium, nitrogen, sucrose, root yield, sugar yield, corrected sugar and quality percentage, respectively.

In brief, the two varieties (Sarah and Glorious) had the highest mean values of root yield/fed at Kafr El-Sheikh location when harvested after 210 days after sowing during the two growing seasons proved to be distinguished commercial varieties under that condition or considering suitable for growing under good conditions.

The present environmental index represented all differences among environments, which could include differential in fertility, cultural practices, insect or disease, humidity, sunshine, etc.

Table 5. Mean performance of sugar beet varieties under the twelve environments for root diameter and weight.

Env.	Root diameter (cm)					Average	Root weight/plant (kg)					Average
	Carnute	Glorious	Gazelle	Sarah	Dema poly		Carnute	Glorious	Gazelle	Sarah	Dema poly	
Env. ($Y_1L_1H_1$)	12.28	12.92	11.75	13.00	12.33	12.46	0.983	1.138	1.018	1.152	1.067	1.072
Env. ($Y_1L_1H_2$)	12.57	12.96	12.74	13.23	12.81	12.86	1.083	1.240	1.116	1.250	1.165	1.171
Env. ($Y_1L_2H_1$)	12.25	12.58	12.27	12.85	12.10	12.41	0.950	1.063	0.947	1.100	1.007	1.013
Env. ($Y_1L_2H_2$)	12.42	13.01	12.22	13.39	12.57	12.72	1.097	1.215	1.085	1.190	1.100	1.137
Env. ($Y_1L_3H_1$)	11.81	12.39	11.79	12.68	11.97	12.13	1.063	1.250	1.100	1.267	1.227	1.181
Env. ($Y_1L_3H_2$)	12.40	12.47	12.35	12.54	12.39	12.43	1.087	1.118	0.998	1.157	1.033	1.078
Env. ($Y_2L_1H_1$)	12.29	12.57	12.44	12.55	12.79	12.53	1.167	1.322	1.227	1.360	1.177	1.251
Env. ($Y_2L_1H_2$)	13.22	13.51	13.29	13.43	13.26	13.34	1.153	1.192	1.157	1.260	1.210	1.194
Env. ($Y_2L_2H_1$)	12.16	12.54	12.32	12.71	12.47	12.44	0.992	1.152	0.983	1.152	1.092	1.074
Env. ($Y_2L_2H_2$)	12.65	13.09	12.80	13.17	12.68	12.88	1.095	1.180	1.127	1.222	1.137	1.152
Env. ($Y_2L_3H_1$)	12.23	12.46	12.33	12.48	12.16	12.33	0.950	1.148	0.928	1.135	0.985	1.029
Env. ($Y_2L_3H_2$)	12.40	12.96	12.61	13.01	13.26	12.85	1.087	1.137	0.998	1.165	1.078	1.093
Average	12.39	12.79	12.41	12.92	12.57	12.62	1.059	1.180	1.057	1.201	1.107	1.121
L.S.D at 5%												
Environment						0.083						0.012
Variety						0.094						0.021
Variety x Environment						0.321						0.075

Y_1 = 2016/2017 L_1 = Kafr Elsheikh H_1 = Feb.
Y_2 = 2017/2018 L_2 = El-Giza H_2 = March

Table 6. Mean performance of sugar beet varieties under the twelve environments for impurities content.

Env.	Potassium%					Average	Sodium%					Average
	Carnute	Glorious	Gazelle	Sarah	Dema poly		Carnute	Glorious	Gazelle	Sarah	Dema poly	
Env. ($Y_1L_1H_1$)	5.92	5.43	5.62	5.41	5.60	5.60	2.20	2.12	2.34	2.21	2.40	2.25
Env. ($Y_1L_1H_2$)	5.67	5.57	5.90	5.42	5.96	5.70	2.08	1.92	2.01	2.03	2.33	2.07
Env. ($Y_1L_2H_1$)	5.61	5.52	5.74	5.50	5.72	5.62	1.65	1.51	1.68	1.54	1.71	1.62
Env. ($Y_1L_2H_2$)	5.64	5.35	5.77	5.33	5.82	5.58	1.28	1.18	1.29	1.14	1.31	1.24
Env. ($Y_1L_3H_1$)	3.79	3.62	3.51	3.65	3.50	3.61	2.58	2.75	2.27	2.24	2.69	2.51
Env. ($Y_1L_3H_2$)	3.63	3.45	3.71	3.53	3.64	3.59	2.69	2.50	2.67	2.37	2.68	2.58
Env. ($Y_2L_1H_1$)	5.57	5.27	5.53	5.40	5.50	5.45	2.47	2.27	2.53	2.43	2.40	2.42
Env. ($Y_2L_1H_2$)	5.83	5.66	5.70	5.98	5.85	5.80	2.18	2.24	2.41	2.21	2.40	2.29
Env. ($Y_2L_2H_1$)	5.52	5.21	5.33	5.27	5.66	5.40	1.60	1.27	1.56	1.30	1.58	1.46
Env. ($Y_2L_2H_2$)	5.53	5.31	5.51	5.42	5.54	5.46	1.52	1.25	1.54	1.20	1.55	1.41
Env. ($Y_2L_3H_1$)	3.73	3.40	3.71	3.30	3.34	3.50	2.69	2.29	2.60	2.29	2.75	2.52
Env. ($Y_2L_3H_2$)	3.88	3.46	3.83	3.41	3.66	3.65	2.49	2.70	2.25	2.55	2.58	2.51
Average	5.03	4.77	4.99	4.80	4.98	4.91	2.12	2.00	2.10	1.96	2.20	2.07
L.S.D at 5%												
Environment						0.0126						0.132
Variety						0.053						0.056
Variety x Environment						0.190						0.195

Y_1 = 2016/2017 **L_1 = Kafr Elsheikh** **H_1 = Feb.**
Y_2 = 2017/2018 **L_2 = El-Giza** **H_2 = March**

Table 7. Mean performance of sugar beet varieties under the twelve environments for N% and sucrose%.

Env.	Nitrogen%					Average	Sucrose%					Average
	Carnute	Glorious	Gazelle	Sarah	Dema poly		Carnute	Glorious	Gazelle	Sarah	Dema poly	
Env. ($Y_1L_1H_1$)	1.24	1.14	1.31	1.29	1.25	1.25	15.90	16.53	16.53	16.30	15.83	16.11
Env. ($Y_1L_1H_2$)	1.20	1.20	1.21	1.10	1.12	1.17	17.01	18.65	18.65	18.79	18.39	18.21
Env. ($Y_1L_2H_1$)	1.61	1.35	1.64	1.37	1.64	1.52	15.57	16.53	16.53	16.17	15.17	15.77
Env. ($Y_1L_2H_2$)	1.75	1.55	1.71	1.63	1.82	1.69	15.98	17.37	17.37	17.16	15.76	16.50
Env. ($Y_1L_3H_1$)	2.07	2.18	2.54	2.18	2.38	2.27	15.57	16.53	16.53	16.00	15.17	15.73
Env. ($Y_1L_3H_2$)	1.89	1.57	1.84	1.56	1.77	1.73	15.44	16.39	16.39	16.60	16.12	16.15
Env. ($Y_2L_1H_1$)	1.47	1.53	1.47	1.57	1.60	1.53	17.35	18.24	18.24	17.69	17.26	17.56
Env. ($Y_2L_1H_2$)	1.37	1.21	1.43	1.21	1.44	1.33	16.40	18.38	18.38	19.62	17.17	17.84
Env. ($Y_2L_2H_1$)	1.45	1.41	1.60	1.34	1.54	1.47	14.70	15.90	15.90	16.37	15.63	15.28
Env. ($Y_2L_2H_2$)	1.63	1.65	1.64	1.53	1.36	1.56	17.12	17.58	17.58	17.62	17.48	17.42
Env. ($Y_2L_3H_1$)	1.88	1.63	1.76	1.35	1.66	1.66	15.08	15.66	15.66	15.54	14.99	15.13
Env. ($Y_2L_3H_2$)	1.83	1.67	1.64	1.61	1.71	1.69	16.04	17.07	17.07	17.05	16.53	16.57
Average	1.62	1.51	1.65	1.48	1.61	1.57	16.01	17.07	17.07	17.08	16.29	16.52
L.S.D at 5%												
Environment						0.0151						0.348
Variety						0.069						0.166
Variety x Environment						0.238						0.569

Y_1 = 2016/2017 **L_1 = Kafr Elsheikh** **H_1 = Feb.**
Y_2 = 2017/2018 **L_2 = El-Giza** **H_2 = March**

Table 8. Mean performance of sugar beet varieties under the twelve environments for yields of root and sugar (ton/fed).

Env.	Root yield (ton/fed)					Average	Sugar yield (ton/fed)					Average
	Carnute	Glorious	Gazelle	Sarah	Dema poly		Carnute	Glorious	Gazelle	Sarah	Dema poly	
Env. ($Y_1L_1H_1$)	21.38	23.65	21.24	24.97	21.74	22.60	3.40	4.15	3.39	4.10	3.42	3.69
Env. ($Y_1L_1H_2$)	25.44	26.13	25.48	27.53	25.75	26.07	4.33	4.87	4.64	5.16	4.74	4.75
Env. ($Y_1L_2H_1$)	20.49	22.71	20.51	24.15	21.44	21.86	3.19	3.76	3.16	3.91	3.32	3.47
Env. ($Y_1L_2H_2$)	24.91	26.06	25.02	27.40	25.11	25.70	3.98	4.53	4.06	4.70	3.96	4.24
Env. ($Y_1L_3H_1$)	20.31	22.39	20.02	23.76	21.28	21.55	3.06	3.64	3.03	3.73	3.20	3.33
Env. ($Y_1L_3H_2$)	23.99	25.84	24.51	25.91	23.86	24.82	3.73	4.23	3.96	4.32	3.85	4.02
Env. ($Y_2L_1H_1$)	21.88	24.92	22.02	25.74	22.93	23.50	3.59	4.39	3.76	4.55	3.94	4.05
Env. ($Y_2L_1H_2$)	25.52	27.06	25.69	27.74	25.84	26.37	4.43	4.97	4.52	5.44	4.50	4.77
Env. ($Y_2L_2H_1$)	21.17	24.77	21.71	25.63	23.82	23.42	3.11	4.02	3.06	4.20	3.65	3.61
Env. ($Y_2L_2H_2$)	25.39	26.75	25.47	27.70	25.52	26.17	4.35	4.70	4.38	4.90	4.46	4.56
Env. ($Y_2L_3H_1$)	20.88	24.66	21.51	25.41	21.53	22.80	3.12	3.87	3.10	3.99	3.23	3.46
Env. ($Y_2L_3H_2$)	24.05	25.84	24.37	26.02	24.78	25.01	3.86	4.41	3.94	4.35	4.10	4.13
Average	22.95	25.07	23.13	26.00	23.63	24.16	3.68	4.30	3.75	4.45	3.86	4.01
L.S.D at 5%												
Environment						0.0268						0.110
Variety						0.321						0.064
Variety x Environment						1.106						0.220

Y_1 = 2016/2017 L_1 = Kafr Elsheikh H_1 = Feb.
Y_2 = 2017/2018 L_2 = El-Giza H_2 = March

Table 9. Mean performance of sugar beet varieties under the twelve environments for recoverable or white sugar% and quality%.

Env.	Corrected sugar%					Average	Quality%					Average
	Carnute	Glorious	Gazelle	Sarah	Dema poly		Carnute	Glorious	Gazelle	Sarah	Dema poly	
Env. ($Y_1L_1H_1$)	12.74	14.55	12.82	13.37	12.58	13.21	80.15	82.95	80.30	81.55	79.97	80.98
Env. ($Y_1L_1H_2$)	13.91	15.66	15.00	15.75	15.21	15.11	81.77	84.01	82.36	84.11	82.73	83.00
Env. ($Y_1L_2H_1$)	12.64	13.71	12.41	13.33	12.50	12.92	81.17	82.89	80.57	82.46	80.62	81.54
Env. ($Y_1L_2H_2$)	13.16	14.70	13.35	14.50	12.85	13.71	82.29	84.60	82.30	84.49	81.53	83.04
Env. ($Y_1L_3H_1$)	12.48	13.82	12.62	13.27	12.41	12.92	82.78	84.89	83.42	84.58	82.49	83.63
Env. ($Y_1L_3H_2$)	12.94	13.92	13.51	14.21	13.50	13.62	83.15	84.92	83.64	85.26	83.71	84.14
Env. ($Y_2L_1H_1$)	13.25	14.66	13.93	14.72	14.02	14.12	80.76	83.09	81.56	83.18	81.68	82.05
Env. ($Y_2L_1H_2$)	14.19	15.36	14.45	16.61	14.19	14.96	81.80	83.56	82.05	84.67	81.54	82.72
Env. ($Y_2L_2H_1$)	11.83	13.59	11.31	13.70	12.38	12.56	80.49	83.68	80.09	83.66	80.94	81.77
Env. ($Y_2L_2H_2$)	14.25	14.88	14.34	14.98	14.63	14.62	83.27	84.67	83.36	84.70	83.70	83.94
Env. ($Y_2L_3H_1$)	12.25	13.29	11.77	13.37	12.46	12.63	82.10	84.84	81.76	85.13	83.10	83.39
Env. ($Y_2L_3H_2$)	13.39	14.58	13.65	14.23	13.94	13.96	83.50	85.41	84.37	85.13	84.33	84.55
Average	13.09	14.39	13.26	14.34	13.39	13.69	81.94	84.13	82.15	84.08	82.20	82.90
L.S.D at 5%												
Environment						0.0345						0.493
Variety						0.163						0.222
Variety x Environment						0.561						0.767

Y_1 = 2016/2017 L_1 = Kafr Elsheikh H_1 = Feb.
Y_2 = 2017/2018 L_2 = El-Giza H_2 = March

The presence of GEI indicated that conclusion based solely on genotype means was not reliable. Genotypes responded differently to changes in environments.

Data in Table (10) declare that the effect of harvest time was significant on root diameter, root weight/plant and root yield.

Table 10. Mean performance of the studied characters in the two seasons, the three locations and the two harvest dates.

Character	Years		Locations			Harvest dates	
	2016/2017	2017/2018	Sakha	Giza	Malawi	Feb. 15th	Mar. 15th
Root diameter	12.50 b	12.73 a	12.80 a	12.61 b	12.44 c	12.38 b	12.85 a
Root weight	1.109 b	1.132 a	1.172 a	1.094 c	1.095 b	1.103 b	1.138 a
Potassium	4.95 a	4.88 b	5.64 a	5.52 b	3.59 c	4.86 b	4.96 a
Sodium	2.05 a	2.10 a	2.26 b	1.43 c	2.53 a	2.13 a	2.02 b
Nitrogen	1.61 a	1.54 a	1.32 c	1.56 b	1.84 a	1.62 a	1.53 b
Sucrose	16.41 b	16.63 a	17.43 a	16.24 b	15.90 c	15.93 b	17.12 a
Root yield	23.77 b	24.55 a	24.64 a	24.29 b	23.55 c	22.62 b	25.69 a
Sugar yield	3.92 b	4.10 a	4.32 a	3.97 b	3.74 c	3.60 b	4.41 a
Corrected sugar	13.58 b	13.81 a	14.35 a	13.45 b	13.28 b	13.06 b	14.33 a
Purity	82.72 b	83.07 a	82.19 c	82.57 b	83.93 a	82.23 b	83.57 a

The lowest amounts for these traits were obtained in the first harvest date (180 days after sowing date), which in order obviously increased at the last harvest (210 days). This increase occurred due to increased plant growth as a result of increasing the accumulated temperature and increases in light absorption during the whole growth stages. Plants harvested at 210 days had significantly increased root diameter, root weight and root yield by 0.47 cm, 35 g. and 3.07 ton/fed, respectively, as compared to those harvested at thirty days earlier. The obtained results are in coincidence with those obtained by Heidari *et al* (2008). Also, the later harvesting date produces sugar beet plants with more sucrose percentage. This enhancement can be related to extended growth period under favorable climatic conditions especially light was represented in sunny days and cool nights of late winter which are the best for sugar production and reserving in sugar beet. Sucrose% increased significantly by 1.19% as harvest delayed from 180 to 210 days (one month).

Sugar yield, which is the most important economic indicator in sugar beet production, was increased during growth season from the first up to the second harvest. This increase was due to increase in root yield, sucrose and corrected sugar%. Sugar beet plants of seven months old (210 days) exhibited greater sugar yield than those of six months with difference of 0.81 ton/fed between them. Which was in agreement with the findings that the postponement of the time of harvest by 27 days increased root yield and white sugar yield on average 11.35 and 1.69 t ha-1, respectively (Jozefyova *et al* 2004). There was logically apparent distinction in corrected sugar and quality% due to postponed harvest which logically resulted from diminishing the factors on which it depends.

In addition, the locations had significant effects on the studied characters. For Kafr El-Sheikh location (L1), the mean values for root diameter, root weight/plant, root yield, sucrose, sugar yield and corrected sugar were higher than those at either Giza or Malawi location (L2 and L3, respectively). The reverse was true for N and quality%. In this connection, some investigators (Campbell and Kern 1981, Goto *et al* 1992, Azzazy 2000 and El-Hinawy *et al* (2002) emphasized the great effect on sugar beet genotypes as moved from one location to others.

According to Alberts 2004 and *Solomon et al* 2008 (Anley 2013), the regression coefficient should be better considered as an indicator for genotypic to varying environments. Hence, genotype Wanchi which had a regression coefficient close to unity, minimum deviation from regression and the highest yield can be considered as the most stable genotype.

The results of this research confirmed the presence of significant statistical difference among genotypes, environments and G x E interactions, suggesting the need to assess the stability of genotypes across environments.

The presence of significant G x E interaction indicated the inconsistency in performance of genotypes across environments. Therefore, developing genotypes that would have low G x E interaction could result in improving sugar beet productivity to the target area. The relatively large portion of genotype x environment variance, more than double when compared to that of genotypes as main effect is very important consequence.

Similar results were found by *Kaya et al.* (2002). Alberts (2004) and Solomon *et al* (2008).

The significant effects of environments indicated that the testing environments were statistically different in yield potential that is the genotypes performed differently across locations. In other words, the mean yield of genotypes differed from location to location.

The significant difference among the genotypes showed variations in their response (yield potential) to different locations. The significance of G x E indicates not only the mean yield difference of genotypes but also the presence of fluctuations of genotypes performance across environments or testing sites. Similar results recorded by other authors (Akcura et al 2005) Akcura and *Kaya* 2008 Asfaw 2008, *Dagne* 2008, Soloman et al 2008 Abdurrahman 2009 and Muluken 2009.

Regardless the level of significance, an over view on this interaction show that the duration of the crop stay in the land was prolonged accompanied with a distinguished enhancement in all studied traits of the evaluated beet varieties. These results indicate that harvest time was the principal effective factor on sugar beet growth as well as manufacturing features.

Analysis of phenotypic stability

According to the model outlined by Eberhart and Russel (1966), the stable and desirable variety would have a high mean yield, regression coefficient (bi) = 1 and deviation from regression (S^2_{di}) = 0. however, the regression coefficient measures the response of genotype to a given environment and the deviation from regression measures the stability of performance.

The results of stability analysis are presented in Table (11). The data indicated that the mean squares due to genotypes were significant for all the studied traits, indicating the presence of variability among entries under study in all traits. Environments mean squares were also significant, revealing a wide range of environmental effects. Furthermore, the significant mean squares associated with environments + genotype x environment interactions indicated that the genotypes interacted considerably with environmental conditions.

Table 11. Stability analysis of variance for sugar yield and its attributes in five sugar beet genotypes.

SOV	df	Root diameter (cm)	Root weight/ plant (kg)	Potassium %	Sodium %	Nitrogen %	Sucrose %	Root yield (ton/ fed)	Sugar yield (ton/ fed)	Corrected sugar%	Purity %
Varieties	4	2.01^{**}	0.16^{**}	0.50^{**}	0.33^{**}	0.20^{**}	9.45^{**}	62.95^{**}	4.49^{*}	13.95^{**}	43.91^{**}
Env, Env.V	55	0.39^{**}	0.02^{**}	2.96^{**}	0.79^{**}	0.27^{**}	3.56^{**}	9.83^{**}	0.79^{*}	2.67^{**}	4.28^{*}
Env (linear)	1	17.20^{**}	0.85^{**}	160.51^{**}	41.32^{**}	13.36^{**}	171.38^{**}	501.83^{**}	38.17^{**}	128.28^{**}	204.91^{*}
V.Env (linear)	4	0.04	0.00	0.09^{**}	0.04^{*}	0.03	1.15^{**}	4.29^{**}	0.18	0.93^{**}	1.36^{*}
Pooled Deviation	50	0.08^{**}	0.00	0.04^{**}	0.04^{**}	0.03	0.40^{**}	0.44	0.09^{*}	0.29^{**}	0.50^{*}
Carnute	10	0.03	0.00^{*}	0.03^{*}	0.02	0.04	0.38^{**}	0.48	0.03	0.14	0.27
Glorious	10	0.05	0.00	0.01	0.06^{**}	0.02	0.14	0.51	0.03	0.21	0.31
Gazelle	10	0.14^{**}	0.00	0.04^{**}	0.05^{**}	0.02	0.36^{**}	0.24	0.03	0.23	0.62^{*}
Sarah	10	0.13^{**}	0.00	0.06^{**}	0.03^{*}	0.03	0.69^{**}	0.37	0.09^{**}	0.54^{**}	0.75^{**}
Demapoly	10	0.07	0.00	0.03^{*}	0.02	0.03	0.41^{**}	0.58	0.026^{**}	0.34^{*}	0.56^{*}
Average Error	96	0.043	0.002	0.015	0.016	0.024	0.137	0.515	0.02	0.133	0.246

The linear components of G x E interactions were large in magnitude for all the studied traits except for root diameter (cm), root weight/plant (kg) and nitrogen%. On the other hand, the non-linear portion of interaction due to deviation from regression was significant for the studied traits, suggesting the relative importance of S^2_{di} parameter in determining the degrees of stability for different sugar beet genotypes. In this respect, Eberhart and Russell (1966) reported that the most important stability parameter appeared to be the deviation mean squares, where all types of gene action are to be involved in this parameter. Also, Becker *et al*, (1982) mentioned that mean squares due to deviation from regression was to be the most appropriate criterion for measuring phenotypic stability in an agronomic sense, because this parameter gave the predictability of genotypic reaction to environments.

Stability parameters for sugar yield and its attributes

The three stability parameters, i.e. mean (x^-), regression coefficient (bi) and deviation from regression (S2di) estimated for the studied traits are given in Table (12) and will be discussed as follows:

Table 12. Stability parameters of sugar beet varieties for root and sugar yields /fed.

Entry	Root yield (ton/fed)			Sugar yield (ton/fed)		
	X^-	b_i	S^2_{di}	X^-	b_i	S^2_{di}
Carnute	**22.95**	**1.190****	**0.48**	**3.68**	**1.049**	**0.03**
Glorious	**25.07**	**0.837***	**0.51**	**4.30**	**0.873**	**0.03**
Gazelle	**23.13**	**1.219****	**0.24**	**3.75**	**1.214***	**0.03**
Sarah	**26.00**	**0.755****	**0.37**	**4.45**	**1.030**	**0.09****
Dema poly	**23.63**	**0.999**	**0.58**	**3.86**	**0.834**	**0.26****
Average	**24.16**			**4.01**		
L.S.D. 5%	**0.321**			**0.064**		

Root yield (ton/fed)

Root yield/fed. for the five sugar beet genotypes ranged from 26.00 to 22.95 tons with an overall mean of 24.16 tons. Sarah variety had the highest root yield followed by Glorius variety. These two varieties yielded above the grand mean and considered as high yielding group. The other three genotypes yielded below the grand mean and classified as medium yielding group.

The regression coefficient is a measure of the linear response or the adaptability of a genotype to be grown at different environments. As shown in Table (12), the bi values varied from 0.755 for Sarah variety to 1.190 for Carnute variety. Otherwise, the bi value significantly deviated from unity (bi<1) in genotypes Sarah and Glorius, which appeared to be more adapted to less favorable environments. The response to environments as measured by the regression technique was found to be highly heritable and controlled by genes with additive action (Abe El-Aal and Mohammed 2005). In case of the insignificant bi values, the deviation from regression (S^2_{di}) is considered most appropriate for measuring phenotypic stability, because it measures the predictability of genotypes reaction to various environments (Becker *et al* 1982). Moreover, it can be seen that the deviation from regression was very small and did not deviate significantly from zero for all of the five tested genotypes showing their stability for root yield/fed. Consequently, neither of them appeared to be sensitive to the fluctuating environmental conditions. In this connection, El-Hinnawy *et al* 2002 (Sanghera *et al* 2017) mentioned that the deviation from regression seemed to be very important for estimating phenotypic stability.

A simultaneous consideration of the three stability parameters (x, bi and (S^2_{di}) evidenced that the most high yielding and stable genotype was genotype Sarah followed by Glorius. In this respect Eberhart and Russell (1966) described the stable genotype which had high mean performance over environments with bi value approaching near unity and the deviation from regression as minimum as possible (($S^2_{di} = 0.0$).

Sugar yield (ton/fed)

Results in Table (8) show that considerable variations among genotypes for sugar mean yield and for estimated stability parameter (bi). Sugars yield/fed for the five genotypes ranged from3.68 and 4.45 tons with an overall mean of 4.01 tons.

The genotype Sarah had the highest sugar yield followed by genotype Glorious with significant difference between them. These two genotypes yielded above the grand mean and considered as high sugar yielding genotypes.

From the above mentioned results (Table 8), it could be concluded that the variety Sarah followed by Glorius are the most stable genotypes for sugar yield. Since it exhibit relative high mean performance for this trait with insignificant regression coefficient approaching near unity and small insignificant and significant deviations from regression (S2di = 0.0) for Glorius and Sarah variety, respectively, indicating the importance of those varieties in agricultural practice as commercial cultivar under such studied environmental conditions.

In this study, the mean performance (x-) and deviation from regression (S2di) of each genotype were considered for stability and bi was used for testing the varietals response. Genotypes with lowest or insignificant S^2di depicted stability in traits and vice-versa. The three parameters, x^- , bi and S^2di together provided an idea of adaptability of genotypes across the environments. Genotypes with higher bi value (bi>1) indicate highest response to improving environments. Such genotypes would perform better in favorable environments but its performance will be lower in stress environments as compared to its genetic potential. Reverse is true when bi value is significantly below 1 (bi<1). It means these genotypes perform better in unfavorable or stress environments.

Hence, the genotype that was found stable for root yield and sugar yield may be used in future breeding program by crossing between stable lines and selecting among their progenies.

According to Ghaderi *et al* (1980) standard analysis of variance procedure is useful for estimating the magnitude of genotype x environment interaction but fails to provide more information on the contribution of individual genotypes to genotype x environment interaction.

To tackle the problem, different statistical procedures have been developed. Therefore, the different stability parametric procedures were used to evaluate and describe sugar beet genotype performance.

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تقييم الآداء وثبات المحصول والجوده لبعض أصناف بنجر السكر خلال ميعادين للحصاد

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يأتي تقييم أصناف محاصيل السكر في البيئات المختلفه في المرتبه الأولي من الاهتمام المصري وذلك يعود إلي أهميه ذلك في تقدير تكيفها خاصه بنجر السكر حيث أن الظروف المصريه تعتبر غير مواتيه لدفعه للتزهير مما يؤدي إلي استيراد بذوره سنوياً من الخارج وبالأخص من أوربا. وبالتالي فأن هناك حاجه ملحه لتعظيم إنتاجيه الأصناف المستورده عن طريق التقييم والتأقلم تحت الظروف المصريه. وتهدف الدراسه المقارنه الحاليه إلي تقييم آداء وإنتاجيه خمسه أصناف من بنجر السكر وهي Sarah, Glorius, Carnute, Gazelle and Dema poly في ثلاث مواقع هم كفر الشيخ , الجيزه والمنيا عند عمري حصاد ١٨٠ و ٢١٠ يوم وذلك خلال موسمي زراعه متتاليين ٢٠١٧/٢٠١٦ و ٢٠١٨/٢٠١٧. بما يمثل ١٢ بيئه مختلفه. تم استخدام تصميم القطاعات المنشقه مره واحده في وجود ثلاث مكررات. أوضحت نتائج تحليل التباين أن التأثيرات الأساسيه لمواسم الزراعه' المواقع وعمر الحصاد كانت معنويه بالنسبه لكل الصفات الإنتاجيه والتكنولوجيه فيما عدا النسبه المئويه لكل من الصوديوم والنيتروجين في الجذور. في نفس الوقت كانت التباينات الممثله في الأصناف معنويه بالنسبه لكل الصفات المدروسه. علاوه علي أن الأصناف Sarah, Glorius كان لهما أعلي قيم متوسطه من حيث محصول الجذور للفدان وذلك في محافظه كفر الشيخ عند حصادهما بعد ٢١٠ يوم من الزراعه خلال موسمي الزراعه مما يثبت تميزهما كأصناف تجاريه تحت تلك الظروف أو بمعني آخر كأصناف مواتيه للزراعه تحت الظروف المواتيه. علي الجانب الآخرأوضحت نتائج تحليل التباين أن الصنف Sarah قد حقق أفضل ثبات وأعلي متوسط لمحصول الجذور والسكر وأيضاً صفات الجوده يليه الصنف Glorious. حيث أظهر متوسط أداء عالي بالنسبه لتلك الصفات بالإضافه لمعامل انحدار يقترب من الوحده وانحراف عن الانحدار أقرب ما يمكن إلي الصفر مع عدم وجود فرق معنوي بينهما ، مما يشير إلي أهميه الصنفين في الزراعه كأصناف تجاريه في ظل الظروف البيئيه موضع الدراسه.

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