ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor, Vol. 43(2): 527-544, (2005).

GENOTYPE X ENVIRONMENT INTERACTION AND STABILITY ANALYSIS FOR YIELD AND QUALITY OF SOME SUGAR BEET GENOTYPES

BY

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ABSTRACT

Ten polygerm sugar beet varieties (Gazelle. Oscar, Kawemera. Top, Lola, Carola, Gloria, Dema poly, Pleno and Farida) were evaluated in four field trials at two locations (Kafr El-Sheikh and El-Fayoum governorates) during the two successive growing seasons, 2002/03 and 2003/04 to study the effect of environmental conditions. i.e. seasons, locations and nitrogen fertilization (60, 80 and 100 kg N/ fed) on yield and quality of sugar beet genotypes, to determine the magnitude of genotype x environment interaction and to measure phenotypic stability for root, top and sugar yields of these genotypes. The combinations between three N-fertilization levels, two locations and two seasons were considered as 12 different environments. A split plot design with four replicates was used. Nitrogen fertilization levels were allocated in the main plots and the varieties were arranged in sub-plots.

The results of combined analysis of variance revealed that the main effects of growing seasons (Y), locations (L) and N-fertilization treatments (N) were significant for all studied characters. Moreover, the mean squares for genotypes were significant for all characters except purity percentage Furthermore, the first order interaction of G x Y was insignificant for all studied characters while, the interactions of (G x L) for root diameter, root weight per plant and root, top and sugar yields/fed as well as G x N interaction for all characters except purity percentage were significant. However, the second order interaction (G x L x N) was significant for root diameter, root weight/plant and root, top and sugar yields/fed while, other interactions (G x Y x N, G x Y x L) was not significant in all studied traits.

The results for stability analysis of variance showed that there were highly significant differences among either sugar beet genotypes (G) or environments (E), indicating substantial variability existed among both for all studied traits. Highly significant mean squares due to environments + (G x E) interaction indicated that such genotypes interacted considerably with environmental conditions for all studied traits. Both linear and non-linear components of G x E interactions were important in the expression of root, top and sugar yields/fed, but the linear component was larger in magnitude.

Considering the three stability parameters proposed by Eberhart and Russell (1966), i.e. x. b_i and S^2d_i, the two sugar beet varieties Carola and Top are the most stable genotypes for root, top and sugar yields/fed, since they exhibited relative high mean performance for these traits and had the smallest insignificant deviations, indicating the importance of these varieties in agricultural practice as commercial cultivars under such studied environmental conditions.

Key words: Sugar beet, Genotype x Environment Interaction, Phenotypic stability, Locations, N-fertilization, Sugar Yield and its contributing traits.

INTRODUCTION

Seeds of sugar beet (*Beta vulgaris*, L.) varieties, which are imported and evaluated annually, should indicate consistency and positive results across a range of locations and years for their productivity before being recommended for cultivation. However, if genotypes interact significantly with years or locations or both, selection of superior varieties will become more complex. At present, testing locations are situated in some of sugar beet growing regions. With the expansion of its cultivation in newly reclaimed areas which differ in soil types and climatic conditions, it is felt necessary to find out how sugar beet genotypes perform when grown under these different environmental conditions and to determine the importance of variety x environment interaction in variety evaluation programs in Egypt. Nitrogen fertilization is an important factor that affects the production and quality of sugar beet.

Variety performance depends on genetic and environmental factors, therefore, significant genotype x environment interaction (GEI) can be seriously limit efforts in selecting the superior genotypes and considered as barrier to the expanding of cultivating the genotypes across different environmental conditions. The cultivar must have the genetic potentially for superior performance under ideal growing condition and in meantime produce considerable yield under stress environments. Thus, it could be characterized as stable genotype. Some investigators studied genotype x environment interaction in sugar beet and indicated significant values for sugar yield and its contributing traits (El-Hinnawy *et al*., 2002 and Mahmoud *et al*., 2002). In addition, highly significant genotype x season, genotype x location and genotype x season x location interactions were also reported for sugar yield and its attributes (Rady *et al*. 2000). Moreover, El-Hinnawy *et al*. (2002) recorded adaptability and above average stability for some sugar beet varieties concerning root yield and juice quality.

The present study was performed to evaluate the effect of environmental conditions, i.e. seasons, locations and nitrogen fertilization on yield and quality of ten sugar beet genotypes, to determine the magnitude of genotype x environment interaction and to measure phenotypic stability for root, top and sugar yields of these genotypes.

MATERIALS AND METHODS

Four field experiments were conducted at Sakha Research Station, Kafr El-Sheikh Governorate (L_1) and Tamya, Fayoum Governorate (L_2) during the two successive growing seasons of 2002/2003 (Y_1) and 2003/2004 (Y_2). The soil analysis at (L_1) was 57 8 clay, silt 29.5, sand 14 6, pH 8.1, available nitrogen 35.7 ppm and $CaCO_3$ 3.02% in 2002/2003 season and clay 7.9, silt 6.4, sand 84.5, pH 8 3, available nitrogen 33.6 ppm and $CaCO_3$ 2.3% in 2003/2004 While, the soil test at (L_2) was: 7.6 clay, silt 4.9, sand 83.5, pH 7.8, available nitrogen 9.1 ppm and $CaCO_3$ 10.4% in 2002/2003 season and clay 8.5, silt 5.1, sand 86.2, pH 7.9, available nitrogen 10.4 ppm and $CaCO_3$ 9.3%. Ten multigerm sugar beet genotypes were used in this study namely; Gazelle and Oscar introduced from Denmark; Kawemera, Top, Lola, Carola and Gloria from Germany; Dema poly from France as well as Pleno and Farida from Netherland. In each experiment, a split plot design with four replicates was used. Nitrogen fertilization levels were allocated in the main plots and the varieties were arranged in sub-plots. The twelve environments represented the combinations between three levels of nitrogen fertilization of 60, 80 and 100 kg N/fed, two locations (L_1 and L_2) during two growing seasons. Nitrogen fertilizer was added in form of Urea (46.5% N) in two equal doses; the first one was applied after thinning and the second dose was added one month later. The plot area was 21 m^2 including six ridges of 7 m in length, 50 cm apart and 20 cm between hills. Seeds were sown on 15th and 17th of October in first season and on 18th and 19th of October in the second one at first and second locations, respectively. The seedlings were thinned to one plant per hill at true 4-leaf stage of growth. The other agricultural practices recommended for growing sugar beet were followed.

At harvest, a sample of four guarded plants were randomly taken from each plot to measure and determine the following characteristics: 1- Root length, 2- Root diameter (cm), 3- Root weight per plant (kg), 4- Sucrose percentage was determined using Saccharemeter method according to A.O.A.C. (1995), 5- Total soluble solids (TSS%) was determined using hand refractometer, 6- Purity percentage was calculated according to the following equation: Purity % = sucrose % x100 / TSS% percentages. In addition, sugar beet plants of four guarded ridges in each plot were uprooted and topped to determine the following characters: 7- top yield (tons/fed), Root yield (tons/fed) and sugar yield (tons/fed) was calculated according to the following equation: sugar yield = root yield x sucrose % x purity %.

The collected data were subjected to proper statistical analysis of split plot design according to Snedecor and Cochran (1981). The analysis of variance was carried out for each experiment separately. The combined analysis for the four experiments was carried out after making the homogeneity test of error variance. The treatment means were compared using L.S.D. test at 5 and 1% levels of significance.

The obtained data of ten sugar beet genotypes under the twelve different environments (2 seasons x 2 locations x 3 N-level) were statistically analyzed to estimate the genotype x environment interaction and phenotypic stability analysis for root, top and sugar yields using the method outlined by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

A- Analysis of variance and mean performance:

The combined analysis of variance for the studied characters of ten sugar beet varieties is presented in Table (1). Mean squares due to seasons, locations and nitrogen fertilization were highly significant for all studied characters. Meantime, the variances due to genotypes were highly significant for all studied characters except purity percentage. These results indicated the existence of wide genetic variability among these sugar beet genotypes for the studied characters. The interaction between genotypes and seasons was insignificant for all studied characters whereas, the genotype x location interaction was highly significant for all studied characters except root length, sucrose, TSS and purity percentages. In addition, the mean squares for genotype x nitrogen interaction was highly significant for all studied characters except purity (%), indicating that the ranking of studied genotypes is affected significantly by nitrogen fertilization levels Regarding the second order interaction of G x Y x L was highly significant for top yield/fed. On the other hand, G x Y x N mean squares were insignificant for all studied characters, while the mean squares for G x L x N interaction were highly significant for all studied characters except root length, sucrose, TSS and purity percentages. For the third order interaction, the mean squares due to G x Y x L x N interactions were insignificant for all studied characters, showing that sugar beet genotypes were not affected by the combination between these environmental factors under study.

Results of the mean performance of the ten sugar beet varieties presented in Table (2) showed that root length ranged from 28.77 to 39.70 cm with an average of 34.02 cm, from 10.68 to 18.66 cm with an average of 14.96 cm for root diameter, from 0.79 to 1.15 kg with an average of 1.01 kg for root weight per plant, from 26.93 to 35.30 ton with an average of 31.84 ton for root yield/fed, from 10.22 to 13.52 ton with an average of 12.17 ton for top yield/fed, from 4.66 to 5.41 ton with an average of 5.05 ton for sugar yield/fed, from 18.08 to 20.34% with an average of 18.84% for sucrose percentage, from 21.14 to 23.77% with an average of 22.03% for TSS percentage and from 85.28 to 85.44% with an average of 85.34% for purity percentage.

Data in Table (3) declare that increasing in nitrogen fertilization levels caused a significant increase in root length, root diameter, root yield/fed. and sugar yield/fed. The obtained results are in coincidence with those obtained by Azzazy (2000), Hassanin and Elaryan (2000), Ouda (2001), El-Geddawy *et al.* (2001), Kandil *et al.* (2002), Ismail (2002), Nawar and Saleh (2003), El-Sayed and Yousif (2003) and Nafei (2004). On the other hand, raising nitrogen fertilization rates caused decline in sucrose (%), TSS (%) and purity (%). These results are in agreement with findings of Azzazy (2000), Hassanin and Elaryan (2000), El-Geddawy *et al.* (2001) and Kandil *et al.* (2002).

Table (1): Mean squares for the studied characters of ten sugar beet genotypes over two years, two locations and three nitrogen levels.

S.O.V.	d.f.	Root length	Root diameter (cm)	Root weight/plant (kg)	(ton/fed)	Top yield (ton/fed)	Sugar yield (ton/fed)	Sucrose (%)	TSS (%)	Purity (%)
Years (Y)	1	2722.50**	223.26**	0.09**	390.15**	4.99**	33.98**	115.83**	186.05**	14.23**
Locations (L)	1	4632.54**	70.31**	6.04**	1396.45**	271.44**	41.89**	978.78**	340.67**	4992.60**
Rep./LY	8	1.20	4.46**	0.02**	12.21**	1.68**	0.19**	0.31*	0.49*	0.15
Nitrogen (N)	2	49.74**	417.07**	2.29**	2478.89**	359.59**	10.08**	229.32**	214.96**	174.58**
Y x L	1	93.23**	0.17		10.33*	440.90**	0.45**	1.71	1.156*	15.27**
Y x N	2	0.56	3.06*	0.03**	6.78*	3.09**	0.46**	0.22	0.27	6.26**
L x N	2	0.72	7.72**	0.07**	82.60**	12.30**	2.82**	1.81**	1.94**	16.56**
Y x L x N	2	0.01	0.73	0.01*	15.68**	5.48**	0.69**	0.02	0.27	6.20**
Error a	16	7.87	0.84		1.43	0.27	0.04	0.12	0.18	0.25
Genotypes (G)	9	376.37**	173.46**	0.36**	202.00**	30.89**	2.00**	14.91**	20.22**	0.12
G x Y	9	2.61	0.78	0.01	6.11	0.65	0.13	0.02	0.03	0.19
G x L	9	4.11	3.06**	0.02**	14.78**	2.12**	0.24**	0.13	0.07	0.31
G x N	18	10.36**	3.25**	0.02**	25.65**	3.38**	0.68**	2.1219**	2.8740**	0.16
G x Y x L	9	0.09	0.91	0.01	6.07	1.52**	0.17	0.01	0.01	0.16
G x Y x N	18	0.17	0.89	0.01	4.96	0.76	0.15	0.02	0.02	0.15
G x L x N	18	0.23	1.62**	0.01*	10.22**	1.74**	0.28**	0.04	0.05	0.16
G x Y x L x N	18	0.02	0.71	0.00	3.15	0.49	0.09	0.01	0.04	0.22
Error b	216	3.78	0.78	0.01	3.71	0.54	0.09	0.55	0.76	0.19

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

Table (2) Mean performance of ten sugar beet genotypes under 12 different environments.

Env.	Gazelle	Kawemera	Dema poly	Top	Lola	Carola	Pleno	Oscar poly	Gloria	Farida	Average
					Root length (cm)						
Env. ($Y_1L_1N_1$)	27 03	28.97	32.90	29 40	26.03	23.27	24.13	26 63	28.87	30.97	27.82
Env. ($Y_1L_1N_2$)	28.00	28.40	33.33	28.57	25.90	23.33	24 50	28.27	29.10	30.67	28.01
Env. ($Y_1L_1N_3$)	28 80	29.53	32 37	30.53	27.00	24.87	25.90	29.13	29.77	29.67	28 76
Env. ($Y_1L_2N_1$)	32.97	35.23	40 17	35.87	31.73	28.40	29 40	31.23	35 30	37 77	33.81
Env. ($Y_1L_2N_2$)	34 13	34.67	40 67	34.83	31.67	28.43	29.87	34.47	35 50	37.43	34 17
Env. ($Y_1L_2N_3$)	35 17	36.03	39 43	37.27	33.00	30.37	31.60	35.53	36.23	36 17	36.08
Env. ($Y_2L_1N_1$)	31.50	33.53	38.23	34.13	30.17	27.03	27.80	29.73	33 57	35.93	32.16
Env. ($Y_2L_1N_2$)	32 47	33.00	38.67	33.17	29.80	27 00	28.37	32.77	33.80	35.67	32.47
Env. ($Y_2L_1N_3$)	33.53	34.27	37 57	35.43	31.43	28.90	30.10	33.87	34.50	34.37	33.40
Env. ($Y_2L_2N_1$)	39.23	41 93	47 80	42.67	37.77	33.77	35.00	37.17	42.00	44 93	40.23
Env. ($Y_2L_2N_2$)	40.60	41.23	48 33	41.43	37 70	33.80	35.50	41.00	42 27	44.53	40.64
Env. ($Y_2L_2N_3$)	41.83	42.83	46 93	44.33	39.30	36 13	37 63	42.30	43.10	43.00	41.74
Average	33.77	34.97	39 70	35.64	31.79	28.77	29.98	33.51	35.33	36.76	34.02

L.S.D. 5% for Env =0.95, G=0 87 and G x E interaction=n s.

Env.	Gazelle	Kawemera	Dema poly	Top	Lola	Carola	Pleno	Oscar poly	Gloria	Farida	Average
					Root diameter (cm)						
Env. ($Y_1L_1N_1$)	11.63	12 10	9.50	13.43	13.17	15.60	13.17	12 13	12.93	12.83	12.65
Env. ($Y_1L_1N_2$)	12.33	13 70	11.07	16.20	15.57	17 90	16 93	13.77	15.30	16.47	14.92
Env. ($Y_1L_1N_3$)	13 80	15 73	11 67	17 27	16 33	20.70	18 17	16 00	16.87	16 83	16.34
Env. ($Y_1L_2N_1$)	10 17	11 07	8 27	12 90	12 33	16.17	13.43	11.13	12.83	13.00	12 13
Env. ($Y_1L_2N_2$)	11.10	12.70	9 03	14 83	13.83	17.80	15 80	13 20	14 07	15 27	13 76
Env. ($Y_1L_2N_3$)	12 67	14 43	10 87	16.23	15.60	19.27	17.13	14.57	15 67	15.93	15.24
Env. ($Y_2L_1N_1$)	12.47	11.73	12.20	14 43	14.77	15.37	15 03	13.80	13.73	13.13	13 67
Env. ($Y_2L_1N_2$)	13.33	15 93	12 80	18.47	17.37	19.23	18.93	16 93	15.63	17.07	16.57
Env. ($Y_2L_1N_3$)	16 53	18.00	11 03	21.03	18.87	22 17	19 27	18.30	18 80	18.70	18 27
Env. ($Y_2L_2N_1$)	11.27	12.37	9 43	14 43	13 80	18.13	15 03	12.47	14 40	14.57	13.59
Env. ($Y_2L_2N_2$)	12.43	14.23	10 13	16.63	15.50	19.97	17 60	14 80	15.80	16 33	15.34
Env. ($Y_2L_2N_3$)	14.27	16 20	12 20	18 17	17.47	21 60	18 87	16.33	17.53	17.87	17 05
Average	12.67	14 02	10 68	16 17	15.38	18 66	16 61	14.45	15.30	15.67	14.96

L.S.D. 5% for Env =0 45, G=0 41 and G x E interaction=1 43

Table (2): Cont.

Env.	Gazelle	Kawemera	Dema poly	Top	Lola	Carola	Pleno	Oscar poly	Gloria	Farida	Average
					Root weight per plant (kg)						
Env. ($Y_1L_1N_1$)	0.99	0.93	0.87	1.02	1.06	1.13	1.03	0.98	1.00	1.04	1.00
Env. ($Y_1L_1N_2$)	1.11	1.11	0.86	1.21	1.26	1.31	1.25	1.11	1.17	1.21	1.16
Env. ($Y_1L_1N_3$)	1.21	1.21	0.98	1.35	1.35	1.50	1.41	1.27	1.37	1.34	1.30
Env. ($Y_1L_2N_1$)	0.70	0.72	0.63	0.76	0.79	0.86	0.77	0.71	0.78	0.80	0.75
Env. ($Y_1L_2N_2$)	0.81	0.80	0.63	0.88	0.94	0.97	0.90	0.93	0.88	0.91	0.86
Env. ($Y_1L_2N_3$)	1.03	0.96	0.87	1.13	1.05	1.21	1.13	1.03	1.09	1.14	1.07
Env. ($Y_2L_1N_1$)	0.95	0.86	0.83	1.03	1.10	1.04	1.02	0.98	0.99	0.97	0.98
Env. ($Y_2L_1N_2$)	1.08	1.09	0.89	1.24	1.29	1.31	1.28	1.12	1.07	1.12	1.15
Env. ($Y_2L_1N_3$)	1.14	1.19	0.74	1.38	1.34	1.44	1.33	1.22	1.30	1.27	1.24
Env. ($Y_2L_2N_1$)	0.68	0.71	0.71	0.79	0.80	0.88	0.71	0.74	0.85	0.83	0.77
Env. ($Y_2L_2N_2$)	0.80	0.73	0.65	0.78	0.97	1.01	0.82	0.85	0.82	0.72	0.82
Env. ($Y_2L_2N_3$)	0.97	0.85	0.82	1.06	1.04	1.14	1.11	0.99	0.99	1.08	1.00
Average	0.96	0.93	0.79	1.05	1.08	1.15	1.06	0.99	1.03	1.04	1.01
L.S.D. 5% for Env.=0.04, G=0.03 and G x E interaction=0.12.											
					Root yield (ton/fed)						
Env. ($Y_1L_1N_1$)	27.41	27.10	25.87	29.50	29.80	31.17	28.73	27.23	27.57	28.13	28.25
Env. ($Y_1L_1N_2$)	31.20	32.70	27.60	35.37	34.27	35.27	35.20	31.77	31.83	32.00	32.72
Env. ($Y_1L_1N_3$)	34.07	35.87	29.47	38.37	37.23	41.57	39.77	35.90	38.57	37.43	36.82
Env. ($Y_1L_2N_1$)	22.30	24.07	21.50	25.07	25.37	27.07	24.47	22.80	24.97	24.93	24.25
Env. ($Y_1L_2N_2$)	26.10	26.90	23.10	29.53	29.43	30.03	29.23	30.37	27.50	27.83	28.00
Env. ($Y_1L_2N_3$)	33.37	32.43	30.07	36.80	33.03	38.77	36.83	33.70	35.37	37.00	34.74
Env. ($Y_2L_1N_1$)	29.23	27.93	27.27	32.53	34.47	31.67	31.57	30.30	30.07	29.17	30.42
Env. ($Y_2L_1N_2$)	33.33	35.37	30.50	40.10	38.37	38.83	40.23	35.67	32.40	33.00	35.78
Env. ($Y_2L_1N_3$)	35.67	38.90	24.77	43.43	40.77	44.30	41.70	38.37	40.77	39.90	38.86
Env. ($Y_2L_2N_1$)	23.77	26.03	26.60	28.33	28.47	30.57	25.03	26.07	29.33	28.27	27.25
Env. ($Y_2L_2N_2$)	28.53	27.07	25.50	28.83	33.07	34.57	29.30	30.87	28.00	24.30	29.00
Env. ($Y_2L_2N_3$)	34.33	31.83	30.93	38.23	35.87	39.83	39.63	35.40	35.10	38.57	35.97
Average	29.94	30.52	26.93	33.84	33.34	35.30	33.47	31.54	31.79	31.71	31.84

L.S.D. 5% for Env.=0.98, G=0.89 and G x E interaction=3.10.

Table (2): Cont

Env.	Gazelle	Kawemera	Dema poly	Top	Lola	Carola	Pleno	Oscar poly	Gloria	Farida	Average
					Top yield (ton/fed)						
Env. ($Y_1L_1N_1$)	10.13	10 00	9.57	10.90	10.97	11.53	10.63	10.10	10.20	10.40	10.44
Env. ($Y_1L_1N_2$)	11.53	12.03	10.20	13.10	12.50	13.00	13.00	11.73	11.77	11.87	12.07
Env. ($Y_1L_1N_3$)	12.63	13.27	10.83	14.20	13.80	15.40	14.70	13.30	14.20	13.87	13.62
Env. ($Y_1L_2N_1$)	9.70	10.57	9.13	10.93	10.73	12.37	11.20	9.83	10.87	10.57	10.59
Env. ($Y_1L_2N_2$)	11.30	11.40	9.97	12.70	12.53	12.93	12.47	13.27	11.83	12.00	12.04
Env. ($Y_1L_2N_3$)	14.33	13.97	12.90	15.83	14.23	16.70	15.80	14.47	15.20	15.93	14.94
Env. ($Y_2L_1N_1$)	11.70	11.17	10.90	13.03	13.77	12.77	12.63	12.13	12.03	12.00	12.21
Env. ($Y_2L_1N_2$)	13.33	14.13	12.20	16.03	15.37	15.53	16.13	14.27	12.93	13.20	14.31
Env. ($Y_2L_1N_3$)	14.27	15.57	9.90	17.40	16.30	17.70	16.67	15.33	16.33	15.97	15.54
Env. ($Y_2L_2N_1$)	7.67	8.70	8.50	9.13	9.00	10.27	8.27	8.43	9.93	9.23	8.91
Env. ($Y_2L_2N_2$)	9.30	8.90	8.37	9.53	10.60	11.10	9.53	10.23	9.23	7.83	9.46
Env. ($Y_2L_2N_3$)	11.17	10.53	10.17	12.57	11.87	12.93	13.20	11.67	11 63	12.70	11.84
Average	11.42	11.69	10.22	12.95	12.64	13.52	12.85	12.06	12.18	12.13	12.17

L.S.D. 5% for Env.=0.38, G=0.35 and G x E interaction=1 20.

Env.	Gazelle	Kawemera	Dema poly	Top	Lola	Carola	Pleno	Oscar poly	Gloria	Farida	Average
					Sugar yield (ton/fed)						
Env. ($Y_1L_1N_1$)	4.16	4.09	4.00	4.43	4 36	4.29	4.08	4.03	3.97	4.08	4.15
Env. ($Y_1L_1N_2$)	4.26	4.50	4.10	4 87	4.40	4.51	4.59	4.22	4.18	4.16	4.38
Env. ($Y_1L_1N_3$)	4.23	4.43	3.97	4.61	4.51	5.20	4.78	4.59	4.82	4.56	4.57
Env. ($Y_1L_2N_1$)	4.44	4.76	4.38	4.96	4.89	4.90	4.58	4.42	4.70	4.70	4.67
Env. ($Y_1L_2N_2$)	4.83	4.93	4.59	5.48	5 09	5.13	5.16	5.42	4.89	4 82	5.03
Env. ($Y_1L_2N_3$)	5.42	5.26	5.32	5.80	5.27	6 28	5.84	5.60	5.79	5.93	5.65
Env. ($Y_2L_1N_1$)	4.77	4.53	4.52	5.28	5.43	4.68	4.88	4.84	4 66	4.56	4 81
Env. ($Y_2L_1N_2$)	4.99	5.28	4.92	6.00	5.36	5.43	5.69	5.20	4.66	4.67	5.22
Env. ($Y_2L_1N_3$)	4.66	5.13	3.55	5.58	5.26	5 83	5.31	5.23	5.45	5.21	5.12
Env. ($Y_2L_2N_1$)	4.92	5.36	5 64	5.84	5.70	5 75	4.94	5.28	5.83	5.62	5.49
Env. ($Y_2L_2N_2$)	5 50	5.25	5.27	5.56	5 86	6 15	5.29	5.73	5.14	4.40	5.42
Env. ($Y_2L_2N_3$)	5.76	5.36	5.68	6 27	5.92	6.72	6 54	6.10	5 96	6.52	6 08
Average	4 83	4.91	4.66	5 39	5.17	5.41	5.14	5.05	5.00	4.94	5.05

L.S.D. 5% for Env.=0.15, G=0.14 and G x E interaction=0.48.

Table (2): Cont.

Env.	Gazelle	Kawemera	Dema poly	Top	Lola	Carola	Pleno	Oscar poly	Gloria	Farida	Average
					Sucrose (%)						
Env. ($Y_1L_1N_1$)	18.33	18.23	18.73	18.23	17.70	16.63	17.20	17.87	17.40	17.50	17.78
Env. ($Y_1L_1N_2$)	16.80	16.93	18.27	16.93	15.83	15.77	16.03	16.33	16.20	16.00	16.51
Env. ($Y_1L_1N_3$)	15.27	15.30	16.70	14.87	15.03	15.37	14.90	15.77	15.47	15.10	15.38
Env. ($Y_1L_2N_1$)	22.10	21.97	22.57	22.00	21.37	20.07	21.00	21.70	21.00	21.17	21.49
Env. ($Y_1L_2N_2$)	20.47	20.40	22.03	20.47	19.07	19.00	19.30	19.80	19.60	19.27	19.94
Env. ($Y_1L_2N_3$)	18.40	18.47	20.13	17.93	18.10	18.47	18.03	18.97	18.70	18.23	18.54
Env. ($Y_2L_1N_1$)	19.70	19.57	20.10	19.63	19.07	17.90	18.73	19.37	18.70	18.87	19.16
Env. ($Y_2L_1N_2$)	18.23	18.17	19.67	18.23	17.03	16.97	17.23	17.63	17.53	17.20	17.79
Env. ($Y_2L_1N_3$)	16.37	16.50	17.90	16.03	16.17	16.43	15.93	17.00	16.67	16.33	16.53
Env. ($Y_2L_2N_1$)	23.17	23.03	23.67	23.07	22.43	21.07	22.03	22.73	22.20	22.17	22.56
Env. ($Y_2L_2N_2$)	21.53	21.63	23.10	21.40	19.83	19.93	20.07	20.90	20.57	20.23	20.92
Env. ($Y_2L_2N_3$)	19.30	19.40	21.17	18.83	19.00	19.37	18.97	19.80	19.63	19.43	19.49
Average	19.14	19.13	20.34	18.97	18.39	18.08	18.29	18.99	18.64	18.46	18.84

L.S.D. 5% for Env.=0.38, G=0.35 and G x E interaction=n.s.

Env.	Gazelle	Kawemera	Dema poly	Top	Lola	Carola	Pleno	Oscar poly	Gloria	Farida	Average
					TSS (%)						
Env. ($Y_1L_1N_1$)	22.13	22.03	22.67	22.10	21.43	20.10	20.80	21.57	21.03	21.13	21.50
Env. ($Y_1L_1N_2$)	20.63	20.83	22.47	20.83	19.53	19.40	19.70	20.10	20.00	19.67	20.32
Env. ($Y_1L_1N_3$)	18.80	18.97	20.70	18.40	18.63	18.87	18.47	19.47	19.17	18.70	19.02
Env. ($Y_1L_2N_1$)	24.50	24.37	24.97	24.40	23.67	22.23	23.47	24.20	23.37	23.77	23.89
Env. ($Y_1L_2N_2$)	22.63	22.67	24.40	22.57	21.03	21.10	21.10	21.90	21.60	21.37	22.04
Env. ($Y_1L_2N_3$)	20.80	21.03	22.83	20.40	20.50	21.07	20.50	21.63	21.30	20.73	21.08
Env. ($Y_2L_1N_1$)	23.80	23.63	24.33	23.73	23.07	21.70	22.67	23.43	22.60	22.80	23.18
Env. ($Y_2L_1N_2$)	22.20	22.13	23.97	22.20	20.77	20.60	20.97	21.37	21.37	20.93	21.65
Env. ($Y_2L_1N_3$)	20.47	20.63	22.37	20.00	20.27	20.53	19.90	21.23	20.80	20.40	20.66
Env. ($Y_2L_2N_1$)	25.93	25.77	26.43	25.80	25.10	23.57	24.63	25.43	24.83	24.70	25.22
Env. ($Y_2L_2N_2$)	24.03	24.10	25.77	23.77	22.20	22.30	22.33	23.47	23.03	22.60	23.36
Env. ($Y_2L_2N_3$)	22.20	22.30	24.37	21.63	21.83	22.23	21.80	22.77	22.57	22.33	22.40
Average	22.34	22.37	23.77	22.15	21.50	21.14	21.36	22.21	21.81	21.59	22.03

L.S.D. 5% for Env.=0.44, G=0.40 and G x E interaction=n.s.

Table (2): Cont.

Env.	Gazelle	Kawemere	Dema poly	Top	Lola	Carola	Pleno	Oscar poly	Gloria	Farida	Average
					Purity (%)						
Env. ($Y_1L_1N_1$)	82.83	82.75	82.65	82.50	82.58	82.75	82.69	82.85	82.73	82.81	82.71
Env. ($Y_1L_1N_2$)	81.42	81.28	81.30	81.28	81.06	81.27	81.39	81.26	81.02	81.36	81.26
Env. ($Y_1L_1N_3$)	81.23	80.67	80.67	80.80	80.67	81.46	80.69	80.99	80.69	80.75	80.86
Env. ($Y_1L_2N_1$)	90.21	90.15	90.38	90.17	90.28	90.26	89.47	89.67	89.88	89.06	89.95
Env. ($Y_1L_2N_2$)	90.42	89.99	90.30	90.69	90.65	90 05	91.55	90 41	90.74	90.16	90.50
Env. ($Y_1L_2N_3$)	88.49	87.80	88.16	87.91	88.30	87.66	87.97	87.68	87.80	87.94	87.97
Env. ($Y_2L_1N_1$)	82.77	82.79	82.60	82.72	82.66	82.49	82.64	82.64	82.74	82.75	82.68
Env. ($Y_2L_1N_2$)	82.13	82.08	82 06	82.13	82.02	82.37	82.20	82.53	82.06	82.16	82.17
Env. ($Y_2L_1N_3$)	79.97	79.97	80.03	80.17	79.79	80.03	80.07	80.06	80.12	80.06	80 03
Env. ($Y_2L_2N_1$)	89.33	89.39	89.55	89.40	89.37	89.39	89.44	89 39	89.39	89.74	89.44
Env. ($Y_2L_2N_2$)	89.59	89.77	89.66	90.04	89.34	89.39	89.84	89.08	89.29	89.54	89.55
Env. ($Y_2L_2N_3$)	86.93	87.00	86.87	87.06	87.03	87.11	87 00	86 97	87.01	87.01	87.00
Average	85.44	85.30	85.35	85 41	85.31	85 35	85 41	85.29	85.29	85.28	85.34

L.S.D. 5% for Env.=0.22, G=n.s. and G x E interaction=n.s.

Table (3): Mean performance of the studied characters under two seasons, two locations and three nitrogen fertilization levels.

Character	Years		Locations		N-fertilization levels (Kg N/fed)		
	2002/03	2003/04	Kafr El-Sheikh	El-Fayoum	60	80	100
3- Root length (cm)	31.27 b	36.77 a	30.44 b	37.61 a	33.50 b	33.82 b	34.74 a
2- Root diameter (cm)	14.17 b	15.75 a	15.40 a	14.52 b	13.01 c	15.15 b	16.72 a
8- Root weight/plant (kg)	1.03 a	0.99 b	1.14 a	0.88 b	0.88 c	1.00 b	1.15 a
1- Root yield (ton/fed)	30.80 b	32.88 a	33.81 a	29.87 b	27.54 c	31.38 b	36.60 a
4- Top yield (ton/fed)	12.28 a	12.05 b	13.03 a	11.30 b	10.54 c	11.97 b	13.99 a
10- Sugar yield (ton/fed)	4.74 b	5.36 a	4.71 b	5.39 a	4.78 c	5.01 b	5.36 a
6- Surcose (%)	18.27 b	19.41 a	17.19 b	20.49 a	20.25 a	18.79 b	17.49 c
7- TSS (%)	21.31 b	22.75 a	21.05 b	23.00 a	23.45 a	21.84 b	20.79 c
9- Purity (%)	85.54 a	85.15 b	81.62 b	89.07 a	86.20 a	85.87 b	83.96 c

As shown in Table (3), the locations had significant effects on the studied characters. For Kafr El-Sheikh location (L_1), the mean values for root diameter, root length and root and top yields/fed were higher than those at El-Fayoum (L_2). The reverse was true for sugar yield/fed, sucrose, TSS and purity percentages. In this connection, some investigators (Campbell and Kern, 1982; Goto *et al.*, 1992; Azzazy, 2000 and El-Hinnawy *et al.*, 2002) emphasized that locations had great effect on sugar beet genotypes.

Data presented in Table (2) show that the environments used in this study provided a wide range of variation in environmental conditions, the means for the studied characters of sugar beet genotypes were significantly differed from one environment to another. They ranged from 27.82 cm for Env. 1 ($Y_1L_1N_1$) to 41.74 cm for Env. 12 ($Y_2L_2N_3$), from 12.13 cm for Env. 4 ($Y_1L_2N_1$) to 18.27 cm for Env. 9 ($Y_2L_1N_3$), from 0.75 kg for Env. 4 ($Y_1L_2N_1$) to 1.30 kg for Env. 3 ($Y_1L_1N_3$), from 24.25 ton for Env. 4 ($Y_1L_2N_1$) to 38.86 ton for Env. 9 ($Y_2L_1N_3$), from 8.91 to for Env. 10 ($Y_2L_2N_1$) to 15.54 ton for Env. 9 ($Y_2L_1N_3$) and from 4.15 ton for Env. 1 ($Y_1L_1N_1$) to 6.08 ton for Env. 12 ($Y_2L_2L_3$), from 15.38% for Env. 3 ($Y_1L_1N_3$) to 22.55% for Env. 10 ($Y_2L_2N_1$), from 19.02% for Env. 3 ($Y_1L_1N_3$) to 25.22% for Env. 10 ($Y_2L_2N_1$) and from 80.03% for Env. 9 ($Y_2L_1N_3$) to 90.50% for Env. 5 ($Y_1L_2N_2$), for root length, root diameter, root weight/plant, root, top and sugar yields/fed, sucrose, TSS and purity percentages, respectively.

B- Analysis of phenotypic stability:

According to the model outlined by Eberhart and Russell (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 for root, top and sugar yields/fed. are presented in Table (4). The data indicated that the mean squares due to genotypes were highly significant for all the studied traits, indicating the presence of variability among entries under study in all traits. Environments mean squares were also highly significant, revealing a wide range of environmental effects. Furthermore, the highly significant mean squares associated with environments + genotype x environment interactions indicated that the genotypes interacted considerably with environmental conditions. The linear components of G x E interactions were large in magnitude for all the studied traits. On the other hand, the non-linear portion of interaction due to deviation from regression was significant and/or highly significant for the studied traits, suggesting the relative importanee of S^2_{di} parameter in determining the degrees of stability for different sugar beet genotypes. In this respect, Eberhart and Russell (1969) 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.

D- Estimates of stability parameters for sugar yield and its attributes:

The three stability parameters, i.e. mean (x), regression coefficient (b_i) and deviation from regression (S^2_{di}) estimated for the studied traits are given in Table (5) and well be discussed as follows:

1- Root yield (ton/fed):

Root yield/fed. for the ten sugar beet genotypes ranged from 26.93 to 35.30 tons with an overall mean of 31.84 tons. Carola variety had the highest root yield followed by Top, Pleno and Lola varieties. These four varieties yielded above the grand mean and considered as high yielding group. The other 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 (5), the b_i values varied from 0.44 for Dema poly variety to 1.32 for Pleno variety. Furthermore, the regression coefficients deviated significantly from unity ($b_i > 1$) in sugar beet genotypes Top and Pleno, indicating higher production potential in favorable environments. Otherwise, the b_i value was deviated significantly from unity ($b_i < 1$) in genotype Dema poly, 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. In case of the insignificant b_i 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 in genotypes Gazelle, Kawemera, Top, Carola, Pleno and Oscar poly, showing their stability for root yield/fed. In this connection, El-Hinnawy *et al.* (2002) mentioned that the deviation from regression seemed to be very important for estimating phenotypic stability. Whereas, genotypes Dema poly, Lola, Gloria and Farida appeared to be more sensitive to the fluctuating environmental conditions.

A simultaneous consideration of the three stability parameters (x, b_i and S^2_{di}) evidenced that the most high yielding and stable genotype was genotype Carola followed by genotypes Top and Pleno. In this respect, Eberhart and Russell (1966) described the stable genotype which had high mean performance over environments with b_i value approaching near unity and the deviation from regression as minimum as possible (S^2_{di}=0.0). Also, the two high yielding genotypes Top and Pleno are being stable on the basis of their low S^2_{di} values with bi > 1, showing that these two genotypes would be more responsive and yielded relatively better in more favorable growing conditions.

Results of root yield/fed (Table, 2) emphasize this conclusion, where genotypes Top and Pleno had the highest mean values at Kafr El-Sheikh location with applying 100 kg N/fed during the two growing seasons proved to be distinguished commercial varieties under that condition or considering suitable for growing under good conditions.

Table (4): Stability analysis of variance for sugar yield and its attributes in ten sugar beet genotypes.

Sources of variance	d.f.	Root length (cm)	Root diameter (cm)	Root weight/plant (kg)	Root yield (ton/fed)	Top yield (ton/fed)	Sugar yield (ton/fed)	Sucrose (%)	TSS (%)	Purity (%)
Environments (E)	11	686.39**	104.63**	0.9936**	633.17**	134.39**	9.49**	141.73**	0.87.52**	493.56**
Genotypes (G)	9	376.37**	173.46**	0.3554**	202.00**	30.89**	2.00**	14.91**	20.22**	0.12
G x E	99	2.58	1.61**	0.0101**	10.45**	1.55**	0.27**	0.41	0.55	0.18
Environments (E) + (GxE)	110	70.96**	11.91**	0.1084**	72.72**	14.83**	1.19**	14.54**	9.25**	49.52**
Environments (linear)	1	7550.32**	1150.89**	10.93**	6964.82**	1478.24**	104.36**	1559.06**	962.75**	5429.15**
G x E (linear)	9	5.18	4 56**	0.0461**	39.07**	6.05**	0.27**	1.01	1.62*	0.35
Pooled deviation	100	2.09	1.18*	0.0058	6.83**	0.99**	0.24**	0.32	0.40	0.15
Genotypes:	10									
Gazelle	10	0.61	1.24	0.0023	2.57	0.35	0.10	0.25	0.32	0.13
Kawemera	10	0.52	0.45	0.0038	4 92	0.64	0.10	0.18	0.23	0.12
Dema poly	10	3 92	3.46**	0.0163**	15.73**	2 23**	0 57**	0 62	0.75	0.09
Top	10	1 58	0.48	0 0032	2.85	0.29	0.13	0.69	0.88	0.08
Lola	10	0.22	0.34	0.0084	8.05*	1.18*	0.20*	0.37	0.44	0 08
Carola	10	0.88	2.66**	0.0044	4.48	0.67	0.21*	0.56	0.64	0.21
Pleno	10	0.88	0.87	0.003	3.64	0.58	0.25**	0 04	0.10	0.40*
Oscar poly	10	6 40	0.63	0.0031	4.68	1.01	0.12	0.17	0.27	0.08
Gloria	10	0.08	0 62	0.0062	8.02*	1.30*	0.24**	0.16	0.20	0 07
Farida	10	5.76	1 05	0.0074	13.33**	1.64**	0.47**	0.12	0.17	0 25
Pooled error	216	3 48	0.78	0.0055	3.71	0 58	0.09	0.55	0.76	0.19

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

Table (5): Stability parameters of sugar beet genotypes for root, top and sugar yield/fed.

Entry	Root yield (ton/fed)			Top yield (ton/fed)			Sugar yield (ton/fed)		
	$\overline{X}$	b_i	S^2_{di}	$\overline{X}$	b_i	S^2_{di}	$\overline{X}$	b_i	S^2_{di}
Gazelle	29.94	0.94	-0.38	11.42	0.94	-0.07	4.83	0.88	0.004
Kawemera	30.52	0.98	0 40	11.69	1.00	0.03	4.91	0.71**	0.002
Dema poly	26.93	0.44**	4.01**	10.22	0.51**	0.56**	4.66	1.01	0.1598**
Top	33.84	1.22**	-0.29	12.95	1.22**	-0.09	5.39	0.95	0.014
Lola	33.34	0.91	1.45*	12.64	0.97	0.21*	5.17	0.85	0.0372*
Carola	35.30	1.14	0.26	13.52	1.07	0.04	5.41	1.27**	0.0394*
Pleno	33.48	1.32**	-0.02	12.85	1.24**	0.01	5.14	1.07	0.0530**
Oscar poly	31.54	0.96	0 32	12.06	0.97	0.15	5.05	1.09	0.008
Gloria	31.79	1.00	1.44*	12.18	0.97	0.25*	5.00	1.04	0.0503**
Farida	31.71	1.10	3.21**	12.13	1.11	0.36**	4.94	1.14	0.1269**
Average	31.84			12.17			5.05		
L.S.D. 5%	0.89			0.35			0.14		

2- Top yield (ton/fed):

As shown in Table (5), it is clear that top yield/fed. of the ten sugar beet genotypes ranged from 10.22 ton for Dema poly variety to 13.52 tons for Carola variety with an average of 12.17 ton. According to Eberhart and Russell's model, the genotypes Top and Pleno appeared to be more responsive to favorable environments as indicated by higher mean values than the grand mean and/or other genotypes as significant higher regression coefficient than unity. Therefore, these two varieties were adapted to high yielding environments. On the contrary, Dema poly variety appeared to be less responsive to environmental change, as indicated by lower mean value than the grand mean and significant low regression coefficient than unity and considered as adapted to low yielding environments. On the other hand, the varieties Carola and Lola, were adapted to all environments due to their higher mean yield and insignificant b_i values. However, Gazelle. Kawemera, Oscar poly, Gloria and Farida varieties were poorly adapted to all environments due to lower mean yield and insignificant b_i values. Considering the two stability parameters together with the mean performance of genotypes over environments, it would be detectable trend for top yield stability among genotypes. Out of ten genotypes studied, only the variety Carola met the three criteria of ideal stable genotype that suggested by Eberhart and Russell (1966). This genotype exhibited significant higher mean performance than the grand mean, its regression coefficient (b_i) did not differ significantly from unity and deviation from regression (S^2_{di}) did not differ significantly from zero (Table, 5). Therefore, it was identified as more stable sugar beet genotype than others.

3- Sugar yield (ton/fed):

Results in Table (5) show that considerable variations among genotypes for sugar yield mean yield and for estimated stability parameters (b_i and S^2_{di}). Sugar yield/fed for the ten genotypes ranged from 4.66 to 5.41 tons with an overall mean of 5.05 tons. The genotype Carola had the highest sugar yield followed by genotype Top with insignificant difference between them. These two genotypes yielded above the grand mean and considered as high sugar yielding genotypes.

Concerning stability parameters, b_i values were not significant for genotypes, except for genotypes Kawemera and Carola which were significantly less or larger than unity showing that these two genotypes gives higher sugar yield under poor and better conditions, respectively.

Significant deviation from zero was observed for all genotypes except for Gazelle, Kawemera, Top and Oscar poly, indicating significant departure from linearity.

From the above mentioned results (Table, 5), it could be concluded that the two varieties Carola and Top are the most stable genotypes for root, top and sugar yields/fed., since they exhibited relative high mean performance for these traits and had the smallest insignificant deviations, indicating the importance of these varieties in agricultural practice as commercial cultivars under such studied environmental conditions.

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التفاعل بين التركيب الوراثى والبيئه وتحليل الثبات للمحصول والجودة لبعض اصناف بنجر السكر

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تم تقييم ١٠ أصناف من بنجر السكر متعددة الأجنة هى جازيل ، أوسكار بولى ، كاوميرا ، توب ، لولا ، كارولا ، جلوريا ، ديما بولى ، بلينو و فريدا من حيث السلوك والثبات المظهرى بالنسبة لصفات محصول السكر ومحصول الجذر وجودة العصير (نسبة السكر ، نسبة المواد الصلبة الذائبة الكلية ، نسبة النقاوة) فى اربعة تجارب حقليه خلال موسمين زراعيين ٢٠٠٣/٢٠٠٢ ، ٢٠٠٤/٢٠٠٣ بمحطة بحوث سخا بمحافظة كفر الشيخ و مركز طميا بمحافظة الفيوم واشتملت كل تجربه منها على ثلاثه مستويات من التسميد النتروجينى هى ٦٠ ، ٨٠ ، ١٠٠ كجم ن/ فدان. وكان التصميم التجريبى المستخدم هو القطع المنشقه مره واحده فى اربعه مكررات حيث وزعت معدلات التسميد بالقطع الرئيسيه والتراكيب الوراثيه بالقطع الفرعيه. واعتبر التوافق بين كل مستوى نتروجينى وموسم زراعى ومنطقة بمثابه بيئه مستقله فى تحليل التفاعل بين التركيب الوراثى والبيئه وكذلك فى تحليل ثبات اداء الاصناف باستخدام طريقة Eberhart و Russell (١٩٦٦).

ولقد أظهرت النتائج ان التباين الراجع الى كل من السنوات و المواقع والتسميد النتروجينى كان عالى المعنوية لكل الصفات المدروسة. كما كان التباين الوراثى الراجع الى التراكيب الوراثية معنويا لكل الصفات تحت الدراسه ماعدا نسبه النقاوه. كان التباين الراجع للتفاعل بين التراكيب الوراثية والسنوات غير معنوى لكل الصفات المدروسه بينما كان تباين التفاعل بين التراكيب الوراثيـة والمواقع عالى المعنويه لكل الصفات ماعدا طول الجذر و نسبه السكروز ونسبة النقاوه و نسبه المواد الصلبه الكليه الذائبة. كان التباين الراجع لتفاعل التراكيب الوراثيه مع موسمى الزراعه والمواقع عالى المعنويه لمحصول العرش للفدان.

واظهرت مقاييس الثبات المظهرى (المتوسط الحسابى ، معامل الانحدار ، الانحراف عن خط الانحدار) لمحصول كل من الجذور و العرش و السكر ان الصنفين كارولا وتوب عاليان فى المحصول وثابتان بالمقارنه بالاصناف الاخرى تحت الدراسه مشيرا الى إمكانية التوصيه بزراعه هذين الصنفين فى هاتين المنطقتين.