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GENOTYPE – ENVIRONMENT INTERACTION STUDY IN SUGAR BEET (*BETA VULGARIS* L.)

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Abstract

The research was carried out to study the response of 16 cultivars of sugar beet in 3 seasons at one major sugar beet producing location, Hama, in Syria in autumn time, and assess genotype by environment interaction, and to estimate the stability of the varieties performance, according to the yield stability statistics (Ysi), for the studied traits of these varieties. A randomized complete block design with four replications was used. Data collected from each experiment were subjected to simple analysis of variance and after homogenization of error variance, combined analysis for four traits including Sucrose content (SC %), Purity (P %), Root yield (RY $ton.ha^{-1}$), and Sugar yield (SY $ton.ha^{-1}$) were carried out. Combined analysis of variance over years, exhibited significant differences ($P \leq 0.05$) among the varieties. Results of yield stability statistics (Ysi) revealed that five of the monogerm sugar beet varieties (Vico, Dita, Al Ceste, Chimene, and SR305) were stable for all of the studied traits, during three seasons, which is recommended to be planted in autumn time.

Key words: Genotype-environment interaction (GEI), stability analysis, sugar beet, technological traits, yield traits.

Introduction

The second sugar crop over the world is sugar beet (*Beta vulgaris* L.) after sugar cane. It is generally better adapted to less favorable ecological conditions than sugar cane (El Refaey et al., 2012). The cultivation area of sugar beet in Syria was 6000 hectares in 2013, with an average yield of 49.5 ton ha^{-1} (Al Jbawi, 2015). Hama governorate ranks first in area (4000 ha), with average yield of 47 ton ha-1. Hama is considered one of the most important governorates in terms of sugar beet production (Ministry of Agriculture and Agrarian Reform, Syria, 2013). Genotype evaluation in plant breeding programs is usually done in different environments (locations and years) before the selection of genotypes. The different response of genotypes evaluated under different environments is called, genotype × environment interaction (GEI), and it advocates information about the performance of genotypes under different environments, to determine the existence of stability of the breeding materials (Moldovan et al. 2000). GEI complicates the assessment of superiority among the genotypes (Truberg and Hühn, 2000). Stable genotypes identified with relatively high yield across environments (Björnsson, 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, Ghareeb et al. (2014) used the phenotypic stability and additive main effect and multiplicative interaction AMMI model to study the stability of 7 sugar beet genotypes in two years. Various studies have been done in evaluating the stability of sugar beet varieties in different areas through using parametric univariate methods (Keshavarz et al. 2001 and Ebrahimian et al. 2008), regression analysis is certainly the most popular method, for stability analysis, due to its simplicity, and the fact that its information on adaptive response is easily applicable to locations. Also the assessment of GEI by AMMI model is currently defined for this situation (Ranji et al. 2005; Sabaghnia, 2008). Integrating stability of performance with yield is necessary for selecting high-yielding stable genotypes, and to make selection of genotype more precise and refined (Kang, 1998). Growers would have a greater risk of suffering a real yield loss when a cultivar is chosen only on the basis of mean yield than when cultivar is based on both yield and performance stability (Kang, 1993). A yield-stability statistic (Ysi) was proposed by Kang (1993) for simultaneous selection for yield and stability. (Ysi) is based on Shukla's (1972) stability variance statistic (σ2i).

The objective of this study is to:

Evaluate the magnitude of genotype X environment interaction of data set made up of 16 sugar beet genotypes evaluated at 3 environments (three seasons), using Kang's (1993) yield-stability (Ysi) measure.

Materials and Methods

This study was executed at Hama Agriculture Research Center (GCSAR), during 2010/2011-2012/2013 seasons. Hama is located in the middle region of Syria (latitude 35 º 9′ N and Longitude 36 º 52′ E) and is situated 270 meters above sea level. The genotypes were planted in a randomized completely block design (RCBD), with four replicates. A list of sugar beet genotypes used in this study and their countries of origin are presented in Table (1). Soil chemical and physical characteristics at site are presented in Table (2) Piper (1955).

Beet seed was planted on 16, 17, and 15th of Oct. during 3 seasons, respectively. Each plot had a size of 21 m^2, consisting 5 rows, 7 meters long and 50 cm apart, with 20 cm between the plants in each row.

Nitrogen fertilization was added in the form of urea (46 % N) at rate of 250 kg N ha^{-1}, in two equal doses; at sowing and after thinning (at 4-leaf stage). Phosphorous was added in the form of superphosphate (15.5 % P_2O_5) at 250 $kg.ha^{-1}$ at sowing, and potassium was applied also at sowing in the form of potassium sulphate (48% K_2O) at 250 $kg.ha^{-1}$ K_2O.

All cultural practices such as irrigation, weed control and insect control were applied in the same manner, as usually done in the ordinary sugar beet fields to obtain maximum yield (Al JBawi, 2009b).

Table 1. Sugar beet genotypes used in the study, their germity, and countries of origin.

No.	Monogerm	Source	No.	Multigerm	Source
1	Vico	Belgium	**1**	HM 10	Holland
2	Dita	Belgium	**2**	Heros	Holland
3	Semper	Belgium	**3**	Byblos	Holland
4	Rosella	Holland	**4**	Polydore	France
5	Al Ceste	France	**5**	Casapol	France
6	Chimene	France	**6**	Poly saphir	France
7	SR 305	Belgium	**7**	Poly jade	France
8	Humber	America	**8**	Nadir	Belgium

Table 2. Soil properties of the experimental location during 3 seasons.

Season	Particle size distribution			Texture Class	Available nitrogen $mg.Kg^{-1}$	Chemical analysis of soil paste extraction		
	Sand %	Silt %	Clay %			$CaCo_3$ %	E.C $mmhos.cm^{-1}$ $25C^0$	PH Soil paste

2010-2011	35	25	40	Clay	29.5	10.9	2.4	8.27
2011-2012	40	26	34	Clay	30.1	4.62	1.01	8.35
2012-2013	35	27	38	Clay	33.2	10.35	3.05	8.25

Table 3. Temperatures and rainfall distribution during 2011/2012-2012-2013 seasons.

Season	**2010/2011**			**2011/2012**			**2012/2013**		
Month	**Max. Temp. °C**	**Min. Temp. °C**	**Rainfall mm**	**Max. Temp. °C**	**Min. Tempe. °C**	**Rainfall mm**	**Max. Temp. °C**	**Min. Tempe. °C**	**Rainfall mm**
October	24	17	25.0	20	12	20	23	15	30.2
November	21	13	60	17	9	50	20	11	52.7
December	16	8	30	10	5	60	14	6	3.1
January	10	6	120	7	-1	180	10	4	113
February	17	7	100	12	5	150	15	8	88
March	21	11	120	15	6	130	18	9	100
April	24	14	40	18	10	100	22	13	36
May	30	19	-	25	14	-	27	17	-
June	32	22	-	27	18	-	30	20	-
July	34	24	-	32	22	-	32	21	-

Source: Meteorology Station in Hama governorate, Syria.

Data recorded:

At harvest (8 months from sowing), when plants showed signs of maturity which is indicated by leaf yellowing and partial drying of the lower leaves. Three inner rows were harvested and topped to determine root yield (ton.ha-1) on the whole plot basis. A sample of three plants of each variety were taken per plot from the inner ridges randomly hand-pulled and topped to determine sucrose content by Saccharometer on a lead acetate basis according to Le-Docte, (1927), and juice purity percentage was calculated according to Carruthers and Oldfield (1961), using digital refractometer, Model PRI (ATAGO). Then sugar yield (ton.ha^{-1}) was calculated as follow:

Sugar yield (ton.ha^{-1}) = Root yield (ton.ha^{-1}) X Purity%.

Quality traits:

Statistical manipulation of the data:

Separate analysis of variance for each season of each trait was conducted on plot mean basis and Barteletts's test for heterogeneity (Sokal and Rohlf, 1969) of error variances across environments indicated whether error terms were homogeneous.

Least significant difference LSD at 5% level of significance level was used to compare means of each treatment according to Waller and Duncan (1969).

Single selection criterion for integrating yield and stability:

Yield-stability (Ysi) statistic was used as a selection criterion. Whenever an interaction is significant, the use of means only is questionable. Ysi provides a measure of genotypes stability or consistency in performance across a range of environments, and it was calculated using STABLE program after Kang and Magari (1995).

Results and discussion

1- Genotypes performance and stability analysis of sucrose content:

The pooled statistical analysis over years is presented in Table 4. Highly significant variance due to genotype revealed the presence of genetic variability in the material under investigation for sucrose content. Environments differed highly significantly for this trait, indicating variation among the environments studied (Table 4). The genotype-environment interaction was significant for this character. A wide range in sucrose content was observed among genotypes (Table 5). Humber was superior in sucrose content compared to most other genotypes.

The variance due to G X E (linear), i.e. heterogeneity was statistically significant for sucrose suggesting that linear components of genotype-environment interaction were presented, indicated that genotypes differed with respect to their stability, suggesting that the prediction would be difficult, which means that selection of genotype on the basis of mean performance alone (mean yield) would not be appropriate.

In such situations, methods that combine yield and stability of performance are useful (El Hinnawy et al. 2003; Al Jbawi, 2009a). Values stability-variance statistic ($\delta^2 i$) according to Shukla's (1972) were generated from GE means with a computer program developed by Kang (1993). This program partitions GE interaction into variance components corresponding to each cultivar. A cultivar is classified as stable if its stability variance is not significant ($P \geq 0.05$). The linear effect of the environment caused the instability of genotype performance; so the removal of this effect by covariate adjustment can give more accurate information of cultivar stability (Kang and Miller 1984). Significant genotype-environment interaction (GEI) requires that either the linear effect or the non-linear effect or both are significant when tested against the experimental error.

Examination of (δ^2i) values (Table 5), revealed that out of the 16 sugar beet genotypes Humber was judged to be stable.

Data presented in Table 5 showed that the Ysi identified that seven genotypes (Vico, Dita, Semper, Al Ceste, Chimene, SR305, and Humber) were stable among the genotypes in sucrose.

A significant δ^2i indicates the instability of genotype performance across environments (Table 5).

Table 4. Analysis of variance (ANOVA) of quality traits

Trait / Source of variance	DF	Sucrose% MS	Sucrose% Variance %	Purity% MS	Purity% Variance %
Replications	**3**	0.91	1.25	2.51	0.24
Environment (Year) En	**2**	144.77**	198.39	270.80**	26.21
Genotypes (G)	**15**	19.40**	26.59	53.08**	53.08
G * E	**30**	3.92**	5.37	13.70^{ns}	1.33

DF: Degree of Freedom, MS: Mean, SS: Sum of Squares.

(ns), *, **, denote not significant, significant differences at 0.05 and 0.01 level of probability respectively.

Table 5. Sucrose (%) for 16 sugar beet genotypes as affected by environments (3 seasons) and yield stability statistics (Ysi).

no	Genotypes	Seasons (Environments) 2010/2011	2011/2012	2012/2013	Mean	O^2	Ysi
1	**Vico**	16.73^{a}	16.27^{b}	18.16^{bc}	17.05^{bc}	0.003^{ns}	15#
2	**Dita**	16.62^{ab}	15.75^{bc}	18.28^{bc}	16.88^{c}	-0.056 ^{ns}	13#
3	**Semper**	15.35^{cdef}	15.37^{bc}	20.30^{a}	17.01^{bc}	0.513 ^{ns}	14#
4	**Rosella**	15.92^{abc}	13.70^{e}	17.50^{cd}	15.71^{de}	0.055 ^{ns}	8
5	**Al Ceste**	15.56^{abcd}	15.00^{cd}	17.10^{cde}	15.89^{d}	-0.023 ^{ns}	12#
6	**Chimene**	15.95^{abc}	15.07^{cd}	16.62^{cdef}	15.88^{d}	0.101 ^{ns}	11#
7	**SR 305**	15.36^{cde}	18.00^{a}	19.55^{ab}	17.64^{b}	0.763 ^{ns}	16#
8	**Humber**	16.72^{a}	17.97^{a}	20.66^{a}	18.45^{a}	0.288 ^{ns}	17#
9	**HM 10**	15.80^{abcd}	12.07^{f}	15.28^{f}	14.38^{fg}	0.594 ^{ns}	1
10	**Heros**	15.35^{cde}	13.55^{e}	16.33^{def}	15.08^{ef}	0.022 ^{ns}	6
11	**Byblos**	15.45^{bcd}	13.62^{e}	15.75^{ef}	14.94^{ef}	0.138 ^{ns}	4
12	**Polydore**	13.91^{h}	12.10^{f}	15.78^{ef}	13.93^{g}	-0.004 ^{ns}	0
13	**Casapol**	14.15^{egh}	13.42^{e}	17.20^{cde}	14.93^{ef}	0.006 ^{ns}	3

14	**Poly saphir**	13.83^{h}	13.55^{e}	17.83^{cd}	15.07^{ef}	0.193^{ns}	5
15	**Poly jade**	15.25^{cdefg}	13.07^{ef}	15.40^{f}	14.58^{fg}	0.185^{ns}	2
16	**Nadir**	14.65^{defgh}	14.20^{de}	17.88^{cd}	15.57^{de}	0.023^{ns}	7
	Mean	**15.41**	**14.55**	**17.47**	**15.81**	**-**	**8.38**
	CV%	**4.9**	**5.0**	**5.9**	**5.4**		
	$LSD_{0.05}$						
	Genotypes G	**1.08**	**1.03**	**1.46**	**0.69**		
	En				**0.30**		
	G*En				**1.19**		

\# Stable genotypes.
Ó2: Stability variance according to Shukla's (1972). When σ2i is not significant indicated that the genotype performance across environments was stable.
Ysi: Yield-stability statistic according to Kang (1993).
CV: Coefficient of variation.
LSD: Least Significant Difference.
G*En: Genotype x environment interaction.
Means with the same letters have no significant differences at 0.05 levels of probability.

2- Genotypes performance and stability analysis of Purity (%):

Table (4) shows a significant effect for genotypes and environment, this confirm the variability among genotypes, and environments for this trait. The results also revealed a non significant genotype-environment interaction, so it is reliable to relay on the means of genotypes for selection. The genotypes differed significantly in purity (Table 5). SR305, and Humber gave the highest purity compared to all other genotypes, and could be selected, because they have the same performance over the studied environments.

Table 5. Purity (%) for 16 sugar beet genotypes as affected by environments (3 seasons) and yield stability statistics (Ysi).

no	Genotypes	Seasons (Environments)			Mean
		2010/2011	2011/2012	2012/2013	
1	**Vico**	84.80^{a}	84.01^{ab}	83.76^{cde}	84.19^{abcde}
2	**Dita**	83.31^{ab}	82.42^{abc}	87.64^{abc}	84.45^{ab}
3	**Semper**	80.64^{ab}	82.55^{abc}	89.74^{a}	84.31^{abcd}
4	**Rosella**	81.87^{ab}	81.86^{abc}	89.28^{ab}	84.34^{abc}
5	**Al Ceste**	80.91^{ab}	81.24^{abc}	87.12^{abcd}	83.09^{bcdef}
6	**Chimene**	80.82^{ab}	81.50^{abc}	84.85^{abcde}	82.39^{bcdefg}
7	**SR 305**	85.49^{a}	85.83^{a}	89.58^{a}	86.97^{a}
8	**Humber**	85.20^{a}	86.39^{a}	87.05^{abcd}	86.21^{a}

9	**HM 10**	80.71 ab	74.90 d	83.76 bcde	79.79 g
10	**Heros**	81.52 ab	77.34 cd	80.89 e	79.92 g
11	**Byblos**	81.39 ab	79.45 bcd	82.95 cde	81.26 cefg
12	**Polydore**	83.49 ab	79.22 bcd	82.40 cde	81.70 bcdefg
13	**Casapol**	79.10 b	78.62 bcd	83.72 bcde	80.48 fg
14	**Poly saphir**	81.43 ab	80.95 abc	84.52 abcde	82.30 bcdefg
15	**Poly jade**	81.32 ab	82.05 abc	81.76 de	81.71 bcdefg
16	**Nadir**	81.48 ab	82.26 abc	83.90 bcde	82.55 bcdefg
	Mean	**82.09**	**81.29**	**85.18**	**82.85**
	CV%	**3.5**	**4.73**	**4.76**	**3.9**
	$LSD_{0.05}$				
	Genotypes G	**4.09**	**4.1**	**3.9**	**2.59**
	En				**1.12**
	G*En				**4.49**

CV: Coefficient of variation.

LSD: Least Significant Difference.

G*En: Genotype x environment interaction.

Means with the same letters have no significant differences at 0.05 levels of probability.

3- Genotypes performance and stability analysis of Root and sugar yields (ton.ha^{-1}):

Significant mean square values of variance over environments are clarified in Table (6). Although the variance due to genotype revealed significant effect for root and sugar yields. The significance of environments for both traits, indicating variation among the environments studied (Table 6). The interaction of genotype by environment was significant for both characters. Wide ranges in root and sugar yield.ha^{-1} were observed among genotypes (Tables 7and 8). Dita was the highest in root and sugar yields compared to all other genotypes.

The significance of G X E for root and sugar yields suggests that heterogeneity in genotypes for both traits relative to the environmental index is significant (Table 6). This environmental index represents all differences between environments, which could include differential in fertility, cultural practices, insect or disease incidence, humidity and sunshine. The presence of GEI indicated that conclusion based solely on genotype means was not reliable. Genotypes responded differently to changes in environments; therefore measures of stability (δ^2i, and Ysi) were deemed appropriate (Tables 7and 8).

Value of δ^2i for root yield revealed that the genotype HM10 was stable (Table 7). Examination of δ^2i for sugar yield revealed that two sugar beet genotypes were labeled unstable (Table 8). On the other hand Ysi-based selection identified eight genotypes (Vico, Dita, Rosella, Al Ceste, Chimene, SR305, and Nadir) that could be selected as superior among the genotypes in root yield, and identified six genotypes (Vico, Dita, Semper, Rosella, Al Ceste, and Chimene) that could be selected as superior among the genotypes in sugar yield, because Ysi value is bigger than the mean Ysi.

Table 6. Analysis of variance (ANOVA) of yield traits

Trait		Root yield (ton.ha^{-1})		Sugar yield (ton.ha^{-1})	
Source of variance	DF	MS	Variance %	MS	Variance %
Replications	**3**	175.6	1.25	2.21	0.80
Environment (season) En	**2**	11702.5**	83.13	377.76**	136.36
Genotypes (G)	**15**	1640.4**	11.65	62.08**	22.41
G * E	**30**	732.3**	5.20	17.99**	6.49

DF: Degree of Freedom, MS: Mean, SS: Sum of Squares.
(ns), *, **, denote not significant, significant differences at 0.05 and 0.01 level of probability respectively.

Table 7. Root yield (ton/ha) for 16 sugar beet genotypes as affected by environments (3 seasons) and yield stability statistics (Ysi).

no	Genotypes	Seasons (Environments)			Mean	O^2	Ysi
		2010/2011	2011/2012	2012/2013			
1	**Vico**	93.73^{b}	64.97^{cd}	94.64^{abc}	84.45^{bc}	-8.22**	6
2	**Dita**	107.33^{a}	69.56^{c}	109.25^{a}	95.38^{a}	10.79**	9
3	**Semper**	93.53^{b}	49.98^{def}	84.91^{abcd}	76.14^{cde}	11.32**	2
4	**Rosella**	92.71^{bc}	66.02^{c}	88.35^{abc}	82.36^{bcd}	-12.91**	5
5	**Al Ceste**	87.94^{bcd}	59.77^{cde}	97.35^{ab}	81.69^{bcde}	7.28**	4
6	**Chimene**	90.17^{bcd}	70.39^{c}	97.31^{ab}	85.96^{abc}	-4.81**	7
7	**SR 305**	108.33^{a}	105.61^{a}	60.81^{de}	91.58^{ab}	286.91**	8
8	**Humber**	90.05^{bcd}	85.61^{b}	53.31^{e}	76.32^{cde}	180.71**	3
9	**HM 10**	80.41^{bcde}	63.52^{cde}	70.34^{cde}	71.42^{def}	0.75^{ns}	5#
10	**Heros**	79.35^{cde}	59.35^{cde}	74.85^{bcde}	71.18^{efg}	-10.46**	-4
11	**Byblos**	82.44^{bcde}	48.73^{ef}	87.67^{abc}	72.94^{de}	7.99**	-1
12	**Polydore**	72.16^{ef}	31.03^{g}	76.55^{bcde}	59.91^{h}	27.74**	-6
13	**Casapol**	61.46^{f}	$39.78f^{g}$	71.32^{cde}	57.52^{h}	0.77^{ns}	0
14	**Poly saphir**	62.77^{f}	32.49^{g}	78.22^{bcde}	57.82^{h}	31.71**	-7
15	**Poly jade**	73.82^{ef}	39.98^{fg}	70.78^{cde}	61.53^{fh}	-5.56**	-5
16	**Nadir**	77.71^{de}	64.56^{cd}	74.35^{bcde}	72.21^{de}	-0.90**	6

Mean	**84.6**	**59.5**	**80.6**	**74.90**	**-**	**2.00**
CV%	**9.9**	**13.99**	**11.65**			
$LSD_{0.05}$						
Genotypes G	**11.94**	**16.5**	**18.9**	**9.58**		
En				**4.15**		
G*En				**16.59**		

\# Stable genotypes.

Ơ2: Stability variance according to Shukla's (1972). When σ^2i is significant indicated that the genotype performance across environments was un stable.

Ysi: Yield-stability statistic according to Kang (1993).

CV: Coefficient of variation.

LSD: Least significant difference.

G*En: Genotype x environment interaction.

Means with the same letters have no significant differences at 0.05 levels of probability.

Table 8. Sugar yield (ton/ha) for 16 sugar beet genotypes as affected by environments (3 seasons) and yield stability statistics (Ysi).

no	Genotypes	Seasons (Environments)			Mean	O^2	Ysi
		2010/2011	2011/2012	2012/2013			
1	**Vico**	13.27^{ab}	8.90^{c}	14.36^{abc}	12.18^{b}	-0.260^{ns}	14#
2	**Dita**	14.85^{a}	8.89^{c}	17.47^{a}	13.74^{a}	0.721^{ns}	15#
3	**Semper**	11.59^{bcde}	6.32^{de}	15.44^{ab}	11.12^{b}	1.019^{ns}	10#
4	**Rosella**	12.10^{bcd}	7.46^{cd}	13.85^{bcd}	11.14^{b}	-0.117^{ns}	11#
5	**Al Ceste**	11.08^{cdef}	7.29^{cd}	14.45^{abc}	10.94^{b}	0.175^{ns}	9#
6	**Chimene**	11.68^{bcde}	8.66^{c}	13.73^{bcd}	11.36^{b}	-0.269^{ns}	12#
7	**SR 305**	14.26^{a}	16.36^{a}	10.63^{de}	13.75^{a}	6.902**	8
8	**Humber**	12.85^{abc}	13.27^{b}	9.61^{e}	11.91^{b}	4.309*	9
9	**HM 10**	10.27^{defg}	5.75^{def}	9.06^{e}	8.36^{cde}	0.058^{ns}	3
10	**Heros**	9.93^{efg}	6.20^{de}	9.84^{e}	8.66^{cd}	-0.202^{ns}	6
11	**Byblos**	10.35^{defg}	5.25^{efg}	11.35^{cde}	8.98^{c}	-0.116^{ns}	5
12	**Polydore**	8.32^{gh}	2.97^{h}	9.98^{e}	7.09^{e}	0.085^{ns}	0
13	**Casapol**	6.93^{h}	4.23^{fgh}	10.12^{e}	7.09^{e}	-0.044^{ns}	0
14	**Poly saphir**	7.08^{h}	3.56^{gh}	11.82^{cde}	7.48^{de}	0.820^{ns}	2
15	**Poly jade**	$9.16f^{g}$	4.27^{fgh}	8.85^{e}	7.43^{de}	-0.139^{ns}	3
16	**Nadir**	$9.26f^{g}$	7.54^{cd}	11.06^{cde}	9.29^{c}	-0.103^{ns}	6
	Mean	**10.81**	**7.31**	**11.98**	**10.03**	**-**	**7.06**
	CV%	**12.1**	**17.1**	**3.07**	**2.33**		

$LSD_{0.05}$				
Genotypes G	**1.86**	**1.78**	**18.0**	**1.34**
En				**0.58**
G*En				**2.33**

Stable genotypes.
Ơ2: Stability variance according to Shukla's (1972). When $\sigma^2 i$ is significant indicated that the genotype performance across environments was un stable.
Ysi: Yield-stability statistic according to Kang (1993).
CV: Coefficient of variation.
LSD: Least significant difference.
G*En: Genotype x environment interaction.
Means with the same letters have no significant differences at 0.05 levels of probability.

Conclusion

For sucrose content the genotype Humber gave significantly the highest value over all other genotypes (18.45%). The genotypes SR305, and Humber gave significantly the highest purity (86.21 and 86.97%), respectively, while the genotype Dita had the highest root and sugar yields (95.38, 13.74 $ton.ha^{-1}$), respectively over all other genotypes.
Data showed that the Ysi-based selection identified seven genotypes (Vico, Dita, Semper, Al Ceste, Chimene, SR305, and Humber) as superior among genotypes in sucrose content, and identified eight genotypes (Vico, Dita, Rosella, Al Ceste, Chimene, SR305, and Nadir) in root yield, and six genotypes (Vico, Dita, Semper, Rosella, Al Ceste, and Chimene) in sugar yield.
Five sugar beet genotypes (Vico, Dita, Al Ceste, Chimene, and SR305) could be considered stable genotypes in terms of all studied traits.

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