Middle East Journal of Agriculture Research, 3(4): 1145-1154, 2014
ISSN 2077-4605

Evaluation of Ten Exotic Sugar Beet Varieties under Different Locations in Egypt

[1]Hozayn M., [2]Korayem A. M., [3]El-Hashash, E. F., [4,5]Abd El-Monem A.A., [1]Abd El-Lateef E.M., [1]Hassanein M. S. and [1]Elwa, T.A

[1]Field Crops Research, [2]Plant Pathology and Nematology and [4]Botany Deprtments, Agriculture and Biology Division, National Research Centre, 33 El-Buhouth St., (former El-Tahrir), 12622 Dokki, Giza, Egypt.
[3]Agronomy Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.
[5]Biology Department, Faculty of Science, Tabuk University, Branch Tayma, Saudi Arabia.

ABSTRACT

Evaluation of crop varieties in different locations comes in the first order for our Department due to its importance in determining this adaptation, especially sugar beet where the Egyptian climatic conditions are unfavorable for its floral induction, which led to import its seeds annually from abroad especially from Europe. So, we need to optimize imported cultivars production by evaluation and adaptation under Egyptian conditions. A comparative study was conducted to assess the performance of ten exotic sugar beet varieties in three locations in Egypt. Soils of the experimental locations were clay, sandy clay and sandy texture. Results showed that, all sugar beet varieties showed different behavior with respect to sugar %, fresh root and gross sugar yield under three locations. Maximum fresh root beet yield was produced by Monte Rose (34.08 ton fed^{-1}) followed by Rosana (33.02 ton fed^{-1}) and DS-9007 (32.65 ton fed^{-1}), which were grown in clay soil, Swallow (35.20 ton fed^{-1}), Rosana (33.00 ton fed^{-1}) and Torro (33.21 ton fed^{-1}) in sandy clay soil and DS-9004 (31.20 ton fed^{-1}) and R-Hist (29.66 ton fed^{-1}) in sandy soil. Similar trends were recorded for gross sugar yield. In terms of sucrose %, varieties, Toro, DS-9007 and DS-9004 recorded the highest value (18.00, 19.00 and 17.65%) in clay, sandy clay and sandy soil respectively. Results also, indicated that, the estimated genetic parameters i.e., PCV, GCV,σ^2_P, σ^2_g, σ^2_e, H^2 and GA in clay soil location gave the highest values, followed by sandy clay soil and sandy soil locations of all studied traits, except sandy soil location which showed estimate of PCV and GCV than sandy clay soil location for sucrose % trait and of H^2 for the three studied traits. These results indicated the role of environmental influence across these locations. Also, cluster analysis showed that, the genotypes were grouped into three clusters. The minimum and maximum genetic distance was observed between LP-16 and Disk 01-99 as well as Rosana and Disk 01-99 genotypes, respectively. Based on the mean cluster distance, it was observed that the third group of cultivars (Rosana, Swallow, Monte Rosa and LP-15) and the second group of cultivars (DS 9007, DS-9004 and Toro) are highly dissimilar and genotypes from these two clusters could be evaluated for their combining ability and could be used as parents in heterosis breeding programs of sugar beet. Generally the results illustrated that all tested sugar beet cultivars can be successfully grown in clay, sandy clay and sandy soils in Egypt but we must take into consideration the suitable varieties for each location.

Key words: Sugar beet, Genotypes, Location. Genotype-Environment Interaction (GEI); Genetic parameters, Cluster analysis.

Introduction

Evaluation of crop varieties in different locations comes in the first order for our Department due to its importance in determining this adaptation, especially sugar beet where the Egyptian climatic conditions are unfavorable for its floral induction, which led to import its seeds annually from abroad especially from Europe.

Sugar beet is one of the most important crops, including spinach beet, swiss chard, garden beet (beetroot) and fodder beet, within *Beta vulgaris* species (Gill and Vear, 1980). It was selected from high sugar-content fodder beets at the end of the 18th century. Extraction of sugar from beet was one of the major agricultural developments in 19th century in Northern Europe (Ahmad *et al.*, 2012). Sugar beet is a cash crop with high value. Its planting area accounts for about 48% of that of the sugar-yielding crops in the world and it ranks second after sugarcane (Fangyan and Dongxing, 2012).

The genotype x environment interaction (GEI) is very important for plant breeding, mainly concerning the development of improved and superior genotypes (Allard and Bradshaw, 1964; Eberhart and Russel, 1966).When interaction between genotype and environment occurs, the relative ranking of cultivars for yield often differs when genotypes are compared across a series of environments and/or years. This poses a serious problem for selecting genotypes significantly superior in yield (Stafford, 1982). Increasing genetic gains in yield is possible in part from narrowing the adaptation of cultivars, thus maximizing yield in particular areas by

Corresponding Author: Hozayn M., Field Crops Research, National Research Centre, 33 El-Buhouth St.,(former El-Tahrir), 12622 Dokki, Giza, Egypt.
E-mail: m_hozien4@yahoo.com

exploiting GEI. The genotypes response to environment is multivariate, yet the parametric approach tries to transform it to univariate problem *via* stability characters.

The genetic improvement of plant population depends on the presence of magnitude of genetic variability and the extent to which the desirable traits are transmissible. Heritability plays a predictive role in breeding, expressing the reliability of phenotype as a guide to its breeding value. Quantitative characters present particular difficulty in selection programmes because heritable variations are often masked by non-heritable variations. In addition, availability of information on the extent to which variation in individual plant character is transmitted to the next generation is also important to speed-up the process of screening the breeding population in order to looking for a plant having greater yield potential. Johnson *et al. (*1955) indicated that the estimate of heritability and genetic advance should always be considered simultaneously as high heritability is not always associated with high genetic gain. The utility of heritability estimates increased when they are used in conjunction with genetic advance expressed as a percentage of mean (Johnson *et al*., 1955; Allard, 1960). Panes (1957) reported that association of high heritability with high genetic gain is due to additive gene effect.

The main aim of using a cluster technique in the analysis of data from plant breeding trials is to group the varieties into several homogeneous groups such that those varieties within a group have a similar response pattern across the locations. Cluster analysis can identify differences among genotypes for the breeder via classification of genotypes (Karimizadeh*et al*., 2006; Sabaghnia*et al*., 2012).Various algorithms have been used in studying of genetic diversity in cluster analysis of which, UPGMA and Ward's methods are the most popular approaches. Of the algorithms, UPGMA, Ward's, SLINK, and CLINK, applied for cluster analysis and exploring genetic diversity and grouping of plant materials in the past. The UPGMA is the most valid method in accordance with the relationship of family based on their genetic material (Mohammadi and Prasanna, 2003). Chaining effect in UPGMA model is considered as the major drawback on application of this approach in cluster analysis and results in confusions in interpretation of the results (Mohammadi and Prasanna, 2003). Ward's approach is similar to UPGMA method but it without having chain effect issues.

In Egypt, sugar beet is grown in the northern Delta and desert areas in the governorate of Kafr El-Sheikh and in Nubariya region. But in the recent years, it extended southwards to the governorates of Beni Suef and Fayoum as well as proliferation in the provinces of Lower Egypt, especially sub-Rashid neighborhood, Damietta particularly in the governorates of Kafr El-Sheikh, El-Gharbia and El- Dakahliya. Most beet production in the above mentioned regions, is under the control of private sector companies, except for about 15,000 ton produced by the Sugar and Integrated Industries Company (SIIC). Government of Egypt has taken steps to introduce sugar beet in the country by accustoming the cultivation of some exotic sugar beet cultivars initially at Agricultural Research Center, Giza, Egypt for testing their adaptability in the country. Therefore, this investigation was made to evaluate the performance of ten exotic sugar beet varieties under different conditions of Egypt.

Materials and Methods

Ten exotic sugar beet cultivars were evaluated at three locations 1) Research and Production Station, National Research Centre, Alemam Malek Village, Al Nubaria District, Al Behaira Governorate (Sandy soil), 2) a private farm at Ferrmon Village, Dessok Province, Kafer El-Sheikh Governorate (Clay sandy soil) and 3) Karadwa agriculture society, Dessok Province, Kafer El-Sheikh Governorate (heavy clay soil), Egypt during 2009/10 and 2010/11 winter successive season. The experimental area in the first location is located at the north of Cairo **(**30.8667 N latitude and 31.1667 E longitude) at an elevation of 21 m above the sea level. While the second and third locations are located at the west of Cairo (31^{o} 6' 42" N latitude and 30o 56' 45" E longitude).

Materials and cultivation methods: The cultivars under study were imported from Holland, Germany, Denmark and France (Table 1). The soil was ploughed triple, settled, ridged and divided into plots. During soil preparation, the recommended dose of phosphorus fertilizer was applied at a level of 200 kg calcium super phosphate fed^{-1} (15.5% P_2O_5) in the three locations. Then the experimental area was ridged and divided into plots (3.5 m width x 7m length). Two-three seeds of each variety were sown in each hill spaced 20 cm apart on one side of ridge. Each variety was replicated three times and arranged in a randomized complete block design (RCBD). The experiments were planted in the first week of October in the threelocations.The plots were sprinkler in the first location and flooded irrigated in the others both locations immediately after sowing. After 35 days from sowing, plants were thinned twice and later one was left to ensure one plant/hill. Other agricultural practices were kept the same as normally practiced in growing sugar beet fields.

Data recorded: At harvest, plants in the four inner ridges of each plot were collected and cleaned, therefore roots was separated and weighed in kilograms and converted to estimate root yield (ton fed^{-1}). A sample of 10 kg of roots were taken at random from each plot and sent to the Beet Laboratory at Nubaria Sugar Factory to determine root quality, i.e., sucrose percentage. Sugar yield (ton fed^{-1}) was calculated by multiplying root yield by root sucrose percentage.

Table 1. Origin and sources of sugar beet (*Beta vulgaris* L.) cultivars used in this study.

No.	Variety	Seeds	Origin	Source
1	DS–9007 (Lilly)	Multigerm	Denmark	*SCRI
2	DS–9004 (Mirador)	Multigerm	Denmark	*SCRI
3	Disk 01-99	Monogerm	Germany	*SCRI
4	LP-15 (L-12)	Multigerm	France	*SCRI
5	LP-16 (Percia)	Monogerm	France	*SCRI
6	Monte Rosa	Multigerm	Germany	*SCRI
7	Rosana	Multigerm	Germany	*SCRI
8	Rhist	Monogerm	Germany	*SCRI
9	Swallow	Multigerm	Germany	*SCRI
10	Toro	Multigerm	Germany	*SCRI

**Sugar Crops Research Institute, Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt.*

Statistical analysis and procedures: A combined analysis of variance was performed to determine the effect of genotype (G), environment (E) and G × E interaction on phenotypic data from trials in three environments was computed according to the method given by Comstock and Moll (1963). Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) were estimated (by dividing the square root of the genotypic and phenotypic variances by the population mean and multiplying by 100) using the formula suggested by Burton (1952) and Dudley and MolI (1969), while genetic advance (GA) as a percent of mean was estimated by the formula given by Lush (1949) and Johnson *et al*. (1955). The estimates of broad-sense heritability was computed as suggested by Allard (1960). Cluster analysis was performed and tree diagrams were developed by XLSTAT 2012.4.02 - Agglomerative Hierarchical Clustering (AHC) program based on linkage distances using Ward's method.

Results and Discussions

Sugar beet yield (fresh root and gross sugar yield

The analysis of variance for each location in Table 2 revealed that the differences in variety performance with respect to fresh and gross sugar yield (ton fed^{-1}) and sucrose percentage were highly significant ($P \leq 0.001$) at Karadwa agriculture society, Dessok Province, Kafer El-Sheikh Governorate (clay soil) (E1), Ferrmon Village, Dessok Province, Kafer El-Sheikh Governorate (clay sandy soil) (E2) and Al-Nubaria District, Al Behaira Governorate (Sandy soil) (E3). Means for tested parameters of all varieties at each location are shown in Table 3. The variation among tested varieties for fresh root yield ranged between (22.57 – 34.23), (22.50 – 35.20) and (21.13 – 29.60 ton fed^{-1}) in E1, E2 and E3, respectively. In clay soil (E1). The varieties Monte Rosa equaled significantly with Rosana and DS 9007 for producing maximum fresh yield (34.08, 33.02 and 32.65 ton fed^{-1}, respectively) while LP-6, Toro and DS-9004 gave the lowest value (20.15, 20.53 and 20.65 ton fed^{-1}, respectively at the same location. In sandy clay soil (E2), Swallow, Toro and Rosana yielded the highest fresh root (35.20, 33.21 and 33.00 ton fed^{-1}, respectively while Disk 01-99 yielded the lowest value (22.55 ton fed^{-1}). However, in sandy soil (E3) DS-9004 and RHist came in the first order by 31.20 and 29.60 ton fed^{-1}, respectively while Monte Rosa variety came in the last order by 21.13 ton. A similar trend was recorded for gross sugar yield. Several investigators indicated that sugar beet has a fairly wide adaptability and is relatively resistant to cold, withstand drought, and are not overly sensitive to salinity (Ahmed et al, 2012), however, productivity under unfavorable conditions is not high (Petkeviciene, 2009). Moreover, other investigators indicated that the beet yield differed with different cultivars but it was comparable to the average yield traits of previous studies conducted at different location in Egypt (Shalby *et al*., 2011 and Hussein *et al*., 2012). Finally, the obtained results of fresh root and gross sugar yield (ton fed^{-1}) possessed higher reasonable and promising values under the three locations in the present study.

Sucrose (%):

In case of sucrose percentage, the three varieties, i.e., Toro, Ds-2007 and DS-9004, gave the highest value (18.29, 17.95 and 17.60% respectively while RHist, Monte Rosa and Disk 01-99 varieties gave the lowest value (10.73, 13.01 and 13.40%, respectively in E1. In case of E2, four varieties, i.e., DS-9007, Disk 01-99, DS-9004 and Swallow gave the highest value of sucrose % (19.63, 18.80, 18.63 and 18.20%, respectively. However, the rest of the varieties exhibited satisfactory results at the same location (16.33- 17.81%). In Nubaria region, DS-9004, Swallow and Disk 01-99 came in the first order for producing maximum sucrose percentage (17.62, 17.43 and 17.23%, respectively). The rest of varieties gave satisfactory value of sucrose % and ranged from 15.43 to16.92% at the same location. Generally, the tested varieties gave satisfactory values of sucrose % i.e., (10.73 -18.29 in clay soil), (16.30- 19.63% in sandy clay soil) and (15.33 – 16.92% in sandy soil) (with an average 16.50% across three locations) comparable to that of beet producing countries which is in the range of

15-20% (Martin *et al*., 1967 and Ahmed *et al*., 2012). The differences among varieties used in this trait might be attributed to the differences in genetic constituents for each variety and their ability to benefit from the environmental factors which enabled they to adapt and achieve better yield and quality parameters. These results are in line with those obtained by Shehata et al (2000), Ismail (2002) and Gobarah and Mekki (2005). The overall chemical composition of sugar beet in Europe may vary considerably due to differences in cultivars and growing conditions (Burba, *et al*. 2001). Similar conclusion was obtained by Ebrahimian *et al*., (2009) and Ahmed *et al.*, (2012).

Mean performances across three locations

The analysis of variance for comparison of means with respect to tested varieties in all three locations (Table 2) revealed that the results were highly significant (P≤0.01) in sucrose % but not significant in fresh and gross sugar yield. Interaction of location and variety was significant (P≤0.01). Mean performance of the studied traits in the three environments are illustrated in Table (3). Differences in fresh root yield, gross sugar yield and sucrose % performances of the studied genotypes were detected among environments. Average fresh root yield, gross sugar yield and sucrose % traits ranged from 20.15 to 35.20 ton/fed. from 3.05 to 6.40 ton/fed and from 10.73 to 19.63 %, respectively. The environment E2 had the maximum mean values (29.13 ton/fed, 5.13 ton/fed. and 17.65 %) for the same previous traits, respectively, which has been the best environment for sugar beet production. The differences in studied traits are due to favorable and unfavorable environmental conditions. Since the interaction of genotype and environment had been signified, the application of combined variance analysis and attendances mean comparison based on calculated error was not sufficient. Therefore, in order to specify varieties adaptation degree and classifying them, different methods of stability analysis were used (Bahrami *et al*., 2008).

Genotype x environment interaction (GEI)

Genotype environment interaction (GEI) is of major importance to the plant breeder in developing stable varieties (Eberhart and Russell, 1966). GEI is of major importance, because they provide information about the effect of different environments on cultivar performance and have a key role for assessment of performance stability of the breeding materials (Moldovan *et al*., 2000). Analysis of variance for GEI for three traits of sugar beet is presented in Table (2). Analysis of variance of genotypes, environments and GEI was highly significant for the three studied traits. The mean squares due to replications in environment were significant for sucrose %, but, it showed insignificance for fresh root yield and gross sugar yield traits. Analysis of variance for GEI for traits showed significant variation across environments, indicating adequate heterogeneity in growing environment for evaluating the genotypes. Highly significant mean squares (MS) due to environment indicated that growing environments had profound influence on the expression of different characters of the sugar beet genotypes. Significant MS due to GEI indicated that the genotypes considerably interacted with the environmental conditions. In case the variance due to GEI is found significant the analysis may be further proceeded for estimating the stability parameters (Phundan and Narayanan, 2004). A genotype is therefore considered to be economically stable if its contribution to the GEI is low. The significance of genotype term suggested that genetic differences exist. This suggests that, genotypes need thorough and repeated testing before they can be recommended for particular environments or set of environments. MS due to environments was recorded the highest values for the three studied traits followed by MS due to GEI and genotypes for fresh root yield and gross sugar yield traits and followed by genotypes and GEI for sucrose % trait. The large environments mean squares showed that the influence of environmental effects on these studied traits are more important than the mean differences in genotypes one and by far greater is important than GEI. However, the significant environments mean squares provide a sufficient range of environments used, and hence validating the environmental requirements suggested by Eberhart and Russell (1966). Rao *et al*., (1986) stated that, the GEI was significant for root yield and gross sugar yield traits, indicating genetic differences. After analysis of variance, on the level of tested years and combined analysis of variance by localities, established differences among environments, genotypes and their interactions had a significant influence on the yield of investigated traits, and therefore a stability analysis was done by estimation of stability parameters (Ivica and Andrija, 2000). Reza *et al*., (2009) reported that, the results of sugar beet monogerm cultivars in different environments showed significant effect of genotypes and environments. EL-Refaey*et al.,* (2012) mentioned that, the environments were the most important source of variation, explaining (94.9%) of the variance in root yield, followed by the genotypes (3.58 %) and the GEI (1.52 %). They added that the combined analysis of variance showed that the mean squares of environments, genotypes and their interactions were highly significant.

Table 2. Analysis of variance (ANOVA) for fresh and gross sugar yield (ton fed^{-1}) and sucrose (%) of ten genotypes under three locations in Egypt.

Source of variation	Degree of freedom	Yield (ton fed^{-1})		Sucrose %
		Fresh root	Gross sugar	
		Clay soil		
Replicates	2	0.74^{ns}	0.18^{ns}	1.32^{ns}
Variety	9	85.51^{***}	2.58^{***}	17.92^{***}
Error	18	4.13	0.15	0.24
		Sandy clay soil		
Replicates	2	7.08^{ns}	0.13^{ns}	0.13^{ns}
Variety	9	47.37^{***}	1.27^{***}	3.98^{***}
Error	18	2.86	0.14	0.27
		Sandy soil		
Replicates	2	11.28^{ns}	0.32^{ns}	0.05^{ns}
Variety	9	25.43^{***}	0.92^{***}	1.97^{***}
Error	18	3.36	0.09	0.05
		Combined analysis		
Location	2	8.20^{ns}	0.46^{ns}	14.61^{**}
Error (Rep x Location)	6	4.25	0.22	0.89
Variety	9	95.53^{***}	3.09^{***}	25.74^{***}
Location x variety	18	50.46^{***}	1.50^{***}	6.04^{***}
Error	54	3.88	0.13	0.18

***, ***, = significant at P < 0.01 and P < 0.001, respectively, ns = not significant.*

Table 3: Mean performance of fresh and gross sugar yield (ton fed^{-1}) and sucrose (%) of ten sugar beet genotypes under three locations in Egypt.

Character	Clay soil			Sandy clay soil			Sandy soil		
	Yield (ton fed^{-1})		Sucrose %	Yield (ton fed^{-1})		Sucrose %	Yield (ton fed^{-1})		Sucrose %
Variety	Fresh root	Gross sugar		Fresh root	Gross sugar		Fresh root	Gross sugar	
Lp-16	20.15	3.16	15.70	30.17	5.27	17.43	25.73	4.25	16.50
DS-9004	20.65	3.63	17.60	26.83	5.00	18.63	31.20	5.49	17.62
Monte Rosa	34.08	4.44	13.01	29.66	5.29	17.81	21.13	3.54	16.77
RHist	28.38	3.05	10.73	25.71	4.20	16.33	29.60	4.57	15.43
DS 9007	32.65	5.87	17.95	25.67	5.05	19.63	26.40	4.47	16.92
LP-15	29.28	4.88	16.63	29.28	4.78	16.30	23.47	3.60	15.33
Rosana	33.02	5.11	15.44	33.00	5.48	16.61	27.20	4.32	15.90
Swallow	26.80	3.86	14.40	35.20	6.40	18.20	24.00	4.13	17.23
Disk 01-99	25.52	3.42	13.40	22.55	4.24	18.80	26.87	4.68	17.43
Toro	20.53	3.75	18.29	33.21	5.59	16.81	26.40	4.25	16.10
Grand Mean	27.11	4.12	15.32	29.13	5.13	17.65	26.20	4.33	16.52
F significant	***	***	***	***	***	***	***	***	***
$LSD_{5\%}$	3.49	0.67	0.84	2.90	0.64	0.88	3.15	0.52	0.37
CV (%)	7.50	9.25	3.21	5.80	7.31	2.92	7.00	6.87	1.30

****= significant at P < 0.001*

Genetic parameters

Estimates of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), phenotypic variance (σ^2_P), genotypic variance (σ^2_g), environmental variance (σ^2_e) components, broad-sense heritability (H^2) and genetic advance (GA) from selection are shown in Table (4). The PCV was greater than GCV for all the traits studied of the three locations. These results indicated that, the environment had an important role in the expression of these traits.The estimates of PCV and GCV for clay soil location gave the highest values, followed by sandy clay soil and sandy soil locations of all studied traits, except sandy soil location which had higher estimates than sandy clay soil location for sucrose % trait. Bozokalfa *et al*., (2014) stated that the results displayed higher phenotypic coefficient variation than genotypic coefficient variation for traits in sugar beet. These results indicated the role of environmental influence across these locations. There is enough scope for selection based on these traits during these locations, and the diverse genotypes can provide materials for a sound breeding programme. The higher value of genotypic coefficient of variability (>10%) were obtained for all studied traits in the three locations, except fresh root yield in sandy clay soil and sandy soil locations, indicating that these traits were least affected by the environment. Genetic coefficient of variation indicates the genetic variability present in various quantitative traits without the level of heritability. Genetic coefficient of variation together with heritability estimates would give the best indication of the amount of gain due to selection (Mengesha and Alemaw , 2010).

The estimates σ^2_P and σ^2_g of clay soil location were higher than these of other locations, and sandy clay soil location had greater estimates than sandy soil location for the three studied traits. For the studied traits, the

σ^2_P and σ^2_g estimates for gross sugar yield recorded were highest followed by fresh root yield and sucrose % traits, indicating significant environmental role expressing for gross sugar yield trait. The σ^2_g estimates were found greater than the σ^2_e estimates for all location and all traits in this study. The higher proportion of σ^2_P observed on these traits was due to the larger proportion of σ^2_P.

Data in this study indicated that, the H^2 and GA estimates obtained of clay soil location were higher than these the other of studied locations. The H^2 and GA estimates were the largest for gross sugar yield followed by fresh root yield and sucrose % traits. Estimates of heritability and genetic advance in combination are more important for selection than heritability alone. High heritability combined with high genetic advance observed for studied traits in the three locations showed that these traits were controlled by additive gene effects and phenotypic selection for these traits would likely to be effective. Falconer and Mackey (1996) suggested that estimates of heritability are subject to environmental conditions, and therefore may be used with great care and caution in plant improvement programme. The genetic advance is the magnitude of improvement that can be made in a particular character by selecting a certain proportion of population in a definite direction. Heritability of metric characters is of great significance to the breeders as its magnitude indicates the accuracy with which a genotype can be recognized by its phenotypic expression and determines the generation in which selection can be profitable. On the other hand, genetic advance under selection is a function of genetic variability of the base population, G x E interaction and selection intensity.

Table 4: Genetic parameters of fresh root yield, gross sugar yield and sucrose %traits at three locations in sugar beet.

Traits	Fresh root yield			Gross sugar yield			Sucrose %		
Parameters	Clay soil	Sandy clay soil	Sandy soil	Clay soil	Sandy clay soil	Sandy soil	Clay soil	Sandy clay soil	Sandy soil
σ^2_g	5.89	1.24	0.64	27.13	14.84	7.36	0.81	0.38	0.28
σ^2_P	5.97	1.33	0.66	28.50	15.79	8.48	0.86	0.42	0.31
σ^2_e	0.08	0.09	0.02	1.38	0.95	1.12	0.05	0.05	0.03
H^2%	98.65	93.34	97.66	95.17	93.97	86.78	94.19	88.86	90.39
GCV%	15.85	6.31	4.85	19.22	13.22	10.35	21.87	11.95	12.16
PCV%	15.96	6.53	4.91	19.70	13.64	11.11	22.54	12.68	12.79
GA %	4.22	1.88	1.39	8.89	6.53	4.42	1.53	1.01	0.88

Cluster analysis

Cluster analysis was used as a tool to classify sugar beet growing environments. The cluster analysis technique differentiate the high yielding and low yielding environments into groups and sub-groups based on genotypic mean yield performance across environments. A dendrogram was constructed using the WARD clustering method. This approach successfully discriminated all the ten genotypes at the three environments. Cluster analysis based on fresh root yield (ton/fed), gross sugar yield (ton/fed) and sucrose % traits resulted in three cluster classes (Figure 1).First and second clusters comprised of three genotypes (RHist, LP-16 and Disk 01-99) and (DS 9007, DS-9004 and Toro), respectively. While, second cluster consisted of Rosana, Swallow, Monte Rosa and LP-15. The distribution of genotypes in the study indicated that the geographical origin has bearing on clustering pattern.The distribution of genotypes in the study indicated that the geographical origin has bearing on clustering pattern.

Mean and morphological differences among the three cluster groups of the three studied traits are illustrated in Table (4). First cluster comprised of three genotypes, i.e., RHist, LP-16 and Disk 01-99 with mean fresh rootyield, gross sugar yield and sucrose % traits of 26.08 (ton/fed), 4.09 (ton/fed) and 15.75 %, respectively. The second cluster consisted of DS 9007, DS-9004 and Toro genotypes with means of the same previous traits of (27.06 ton/fed), (4.79 ton/fed) and 17.72 %, respectively. This cluster included medium fresh root yield and highest gross sugar yield and sucrose % traits. While, cluster three included the four genotypes viz., Rosana, Swallow, Monte Rosa and LP-15 with average of same traits of (28.84 ton/fed), (4.65ton/fed) and 16.14 %, respectively. This cluster included the highest fresh root yield and medium for the other studied traits. These results indicated that, fresh root yield gave the highest values in the third cluster; however, gross sugar yield and sucrose % traits recorded the greatest values in the second cluster. So, it is apparent that through cluster analysis it is possible to differentiate high, medium and low yielding locations and/ or genotypes.

The central object (genotype) in cluster analysis is illustrated in Table (5). LP-16, Toro and Swallow genotypes were found in the center of the first, second and third cluster, respectively. The third cluster recorded the highest values of fresh root yield and gross sugar yield traits, which were 28.67 and 4.80 ton/fed, respectively. However, the second cluster had given the greatest value for sucrose % trait, which was 17.07%.

Profile plots

Profile plots display the value of each profiling variable on a series of parallel vertical lines, with one vertical line for each variable. For each cluster, the values plotted on each vertical line are connected with a line.

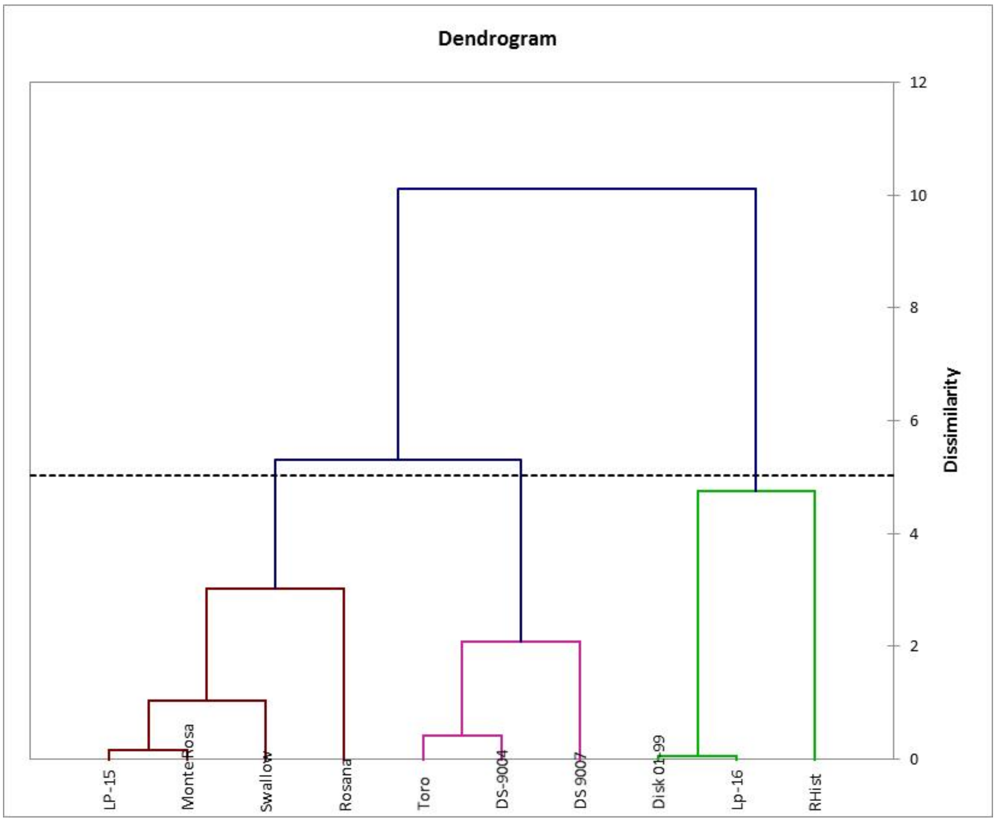

Fig. 1. Tree diagram of ten sugar beet genotypes for the three studied traits using hierarchical cluster analysis (ward's method and squared Euclidean distance).

Table 4. Mean of the studied traits of each cluster formed by Ward´s clustering analyses.

clusters	Traits / Genotypes	Yield fresh root (ton/fed)	Yield gross sugar (ton/fed)	Sucrose %
1	RHist, LP-16 and Disk 01-99	26.08	4.09	15.75
2	DS 9007, DS-9004 and Toro	27.06	4.79	17.72
3	Rosana, Swallow, Monte Rosa and LP-15	28.84	4.65	16.14

Table 5. The central genotypes for the studied traits during each cluster.

clusters	Genotypes	Yield (ton/fed)		Sucrose %
		Fresh root	Gross sugar	
1	LP-16	25.35	4.22	16.54
2	Toro	26.72	4.53	17.07
3	Swallow	28.67	4.8	16.61

The result is a series of colored lines with each colored line representing a cluster. Profile plots are sometimes called parallel axis plots (Robert *et al*., 2001). Since three profiling variables were used, the profile plot will have three parallel lines each representing one of the three variables being used to profile the clusters (Figure 2). The profile plot in cluster analysis for the three studied traits indicated that, the third cluster had the highest values for fresh root yield trait, followed by the second and first clusters. As for gross sugar yield and sucrose % traits, the second cluster recorded the greatest values followed by the third and first clusters.The yields of these lines were significantly affected by varying environmental conditions and yields increased when the conditions were adequate and decreased to below average when the conditions were inadequate. These results may indicate similar segments that might be combined. Lines that are close to each other indicate clusters that are similar (with respect to the mean values of the standardized profiling variables), and lines that are far apart indicate clusters that are not similar (Robert *et al*., 2001).

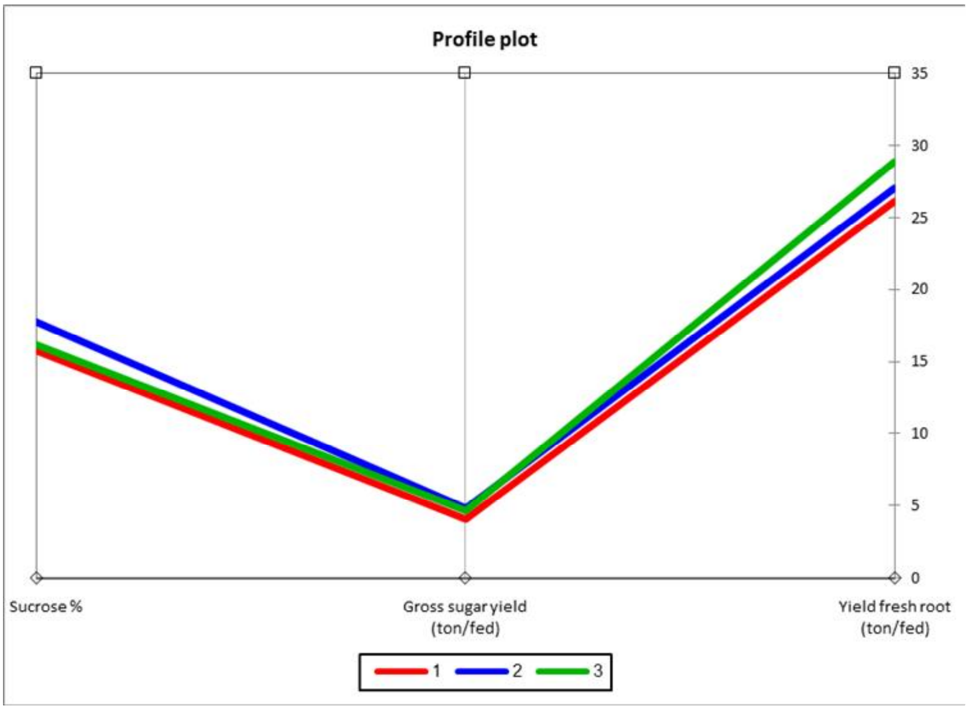

Fig. 2. Profile plot for the three cluster segmentation for studied traits.

Euclidean distance

Most datasets contain variables measured on different scale levels. This creates the problem of how to simultaneously incorporate these variables into one cluster analysis. One way is to compute distinct distance matrices for each group of variables; that is, distance matrix.The variations in the studied traits were analyzed through estimation of Euclidean distance between and among the genotypes. The Proximity Matrix Table (6) shows the squared Euclidean distance of each pair of cases. You will noticethat values on the diagonal are 0, since a case does not differ from itself. The smallest difference between the genotypes is 0.36, the distance between the Disk 01-99 and LP-16 genotypes. The largest differencebetween the genotypes is 4.12, the distance between the Disk 01-99 and Rosana genotypes. Overall low Euclidean distances were found among most genotypes, indicating apparent strong genetic relationship among these genotypes. Euclidean distance can theoretically estimated the genetic distance between parents to maximize the trangressive segregation (Hoque and Rahman, 2006).According to Rahim *et al*. (2010) who showed that the hybrids of genotypes with maximum distance resulted in high yield; the cross between these genotypes can be used in breeding programs to achieve maximum heterosis. Minimum distance was between the genotypes, which can be used for backcross breeding programs.

Table 6. Proximity Matrix (Euclidean distance) for genotypes in studied traits and environments.

Genotypes	LP-16	DS-9004	Monte Rosa	RHist	DS 9007	LP-15	Rosana	Swallow	Disk 01-99	Toro
LP-16	0.00	1.84	1.83	2.65	3.23	1.30	3.80	2.41	0.36	1.21
DS-9004		0.00	2.29	4.00	1.59	1.89	3.28	1.81	2.11	0.93
Monte Rosa			0.00	1.97	2.77	0.57	2.13	1.22	2.11	1.42
RHist				0.00	4.74	2.15	3.62	3.16	2.70	3.08
DS 9007					0.00	2.67	2.55	1.65	3.55	2.04
LP-15						0.00	2.54	1.33	1.60	0.98
Rosana							0.00	1.52	4.12	2.87
Swallow								0.00	2.75	1.37
Disk 01-99									0.00	1.55
Toro										0.00

Among the clusters, based on the mean cluster distance, it was observed that third and second clusters are highly dissimilar and genotypes from these two clusters could be evaluated for their combining ability and could be used as parents in heterosis breeding programmes in sugar beet. Most of the suitable genotypes were clustered in major groups, indicating their specific adaptation to favorable conditions. Genotypes Rosana, Swallow, DS- 9007 and Lp-16were the most adapted genotypes; they had specific adaptation to poor and rich environments. Clustering genotypes based on similarity of linear regression model parameters (intercept and slope) indicated considerable variation among genotypes. This may be due to the different origins, pedigrees and breeding procedures of these improved genotypes. Brandle and Brule-Bable (1991) mentioned that this clustering method may be a suitable tool for selecting the most stable as well as the highest yielding genotypes. Acikgoz*et al*., (2009) reported that cluster analysis could be a powerful tool to examine GEI and suggested that the use of both stability and cluster analysis might give better results and if the number of environments was sufficient, a separate stability analysis could be run in each cluster. Nagl *et al*., (2011) stated that, the cluster analysis among sugar beet genotypes showed that samples were divided into two clusters with relatively high coefficient of similarity. Cluster analysis showed clear genetic relationships among the 10 sugar beet cultivars. The results indicated that the cluster tree was in accordance with the character of the populations and ISSR markers could be used to estimate genetic distance between populations (Qiaohong *et al*., 2012).

References

Acikgoz, E., A. Ustun, I. Gul, E. Anlarsal, A.S. Tekeli, I. Nizam, R. Avcioglu, H. Geren, S. Cakmakci, B. Aydinoglu, C. Yucel, M. Avci, Z. Acar, I. Ayan, A. Uzun, U. Bilgili, M. Sincik, M. Yavuz, 2009. Genotype x environment interaction and stability analysis for dry matter and seed yield in field pea (*Pisumsativum* L.). Spanish J. Afric. Res. 7(1): 96-106.

Ahmad, S., M. Zubair, N. Iqbal, N.M. Cheema and K. Mahmood, 2012. Evaluation of sugar beet hybrid varieties under Thal-Kumbi in Pakistan. J. Agric. Biol., 14(4):605-608.

Allard, R.W., 1960. Principles of Plant Breeding. New York: John Willy and sons, Inc.

Allard, R.W. and A.D. Bradshaw, 1964. Implications of genotype environmental interactions in applied plant breeding. Crop Sci., 4: 503 – 507.

Bahrami, S., M.R. Bihamta;, M. Salari, M. Soluki, A. Ghanbari, A.A.V. Sadehi and A. Kazemipout, 2008. Yield stability analysis in hulless barley (*Hordeum vulgare* L.). Asian J. of Plant Sci., 7(6): 589 – 593.

Bozokalfa, M.K., B. Yağmur,D. Eşiyok and T.K. Aşçioğul, 2014. Genetic variability and association pattern among quantitative nutritional traits in swiss chard (beta vulgaris subsp. l. var. cicla) accessions and its implication for breeding. Genetika, 46(2): 505-514.

Brandle, J. E. and A. L. Brule-Bable,1991. An integrated approach to oilseed rape cultivar selection using phenotypic stability. Theor. Appl. Genet. 81: 679-684.

Burba, M., T. Huijbregts and E. Hilscher, 2001. Zur bestimmung des lbslichen gesamt-stickstoffs in zuckerruben mit nah-lnfrarot- spektrometrie. Zuckerind, 126, 367-375

Burton, G.M., 1952. Quantitative inheritance in grasses. Proc. 6th Int. Grassland Cong., 1: 277-283.

Comstock, R.E. and R.H. Moll, 1963.Genotype-environment interactions. In: Statistical Genetics and Plant Breeding, (Ed: W.D. Hanson and H.F. Robinson). Proc. Natl. Acad. Sci.-NRC Pub.no.982, pp. 164 – 196.

Dudley, J.W. and R. H. Moll, 1969.Interpretation and use of estimates of heritability and genetic variances in plant breeding. Crop Sci. 9(3):257-262.

Eberhart, S.A. and W. A. Russel, 1966. Stability parameters for comparing varieties. Crop Sci., 6: 36–40.

Ebrahimian, H.R., S.Y. Sadegheian, M.R. Jahadakbar and Z. Abbasi, 2009. Study of adaptability and stability of sugar beet monogerm cultivars in different locations of Iran. J. Sugar Beet, 24: 1–13

EL-Refaey, R.A., E.H. El-Seidy; I.H.EL-Geddawy and H.M.EL-Sayed, 2012. Phenotypic and genotypic stability for some sugar beet genotypes. Proc. 13th international Conf. Agron., Fac.of Agric., Benha Univ., Egypt, 9 – 10, September, 317 – 331.

Falconer, D.S. and T.F.C. Mackey, 1996.Introduction to Quantitative Genetics. 3rd Ed. Longman, London.

Fangyan, W. and Z. Dongxing, 2012.Experimental analysis on physical characteristics of sugar beet. Transactions of the Chinese Society of Agricultural Engineering. 28(2): 297 – 303.

Gill, N.T. and K.C. Vear, 1980.Agricultural Botany, Dictoyledonous Crops, 3rd edition. Duckworth, London.

Gobarah M.E. and B.B. Mekki, 2005. Influence of boron application on yield and juice quality of some sugar beet cultivars grown under saline soil conditions. Journal of Applied Sciences Research 1(5): 373-379.

Hoque M. and L.Rahman, 2006.Estimation of Euclidian distance for different morpho-physilogical characters in some wild and cultivated rice genotypes (*Oryza sativa* L.). Pak Sci 1:77-79.

Hussein M., U. Al-Sayed, A.M. Abd El-Razek, M. Hazem and H.S. Fateh, 2012. Effect of harvest dates on yield and quality of sugar beet varieties. Australian Journal of Basic and Applied Sciences, 6(9): 525-529, 2012

Ismail, A.M.A., 2002. Evaluation of some sugar beet varieties under different nitrogen levels in El-Fayium Egypt. J. Appl. Sci. 17: 75-85.

Ivica, L. and K. Andrija, 2000.Stability of agronomic traits in sugar beet hybrids.Rostlinnavyrobam, 4:169-175.

Johnson, W.H., H.E. Robinson and R.E. Comstok, 1955.Estimation of genetic and environmental variability in soybean.Agron.1. 47:314-318.

Karimizadeh, R., H. Dehghani and Z. Dehghanpour, 2006. Using cluster analysis for stability of maize hybrids. J. Sci. Tech. Agric. Nat. Res. 10: 337-348.

Langer, S.; K.J. Frey and T. Bailey,1979. Associations among productivity, production response, and stability indexes in oat varieties. Euphytica, 28: 17-24.

Liovic, I. and A. Kristek, 2000.Stability of agronomic traits in sugar beet hybrids .Rostlinna-Vyroba. 2000; 46(4): 169-175.

Lush, J.N., 1949. Animal breeding plans. The collegiate Press. Amer. Iowa Ed. 3.

Mengesha, B. and G. Alemaw, 2010.Variability in Ethiopian coriander accessions for agronomic and quality traits. African Crop Sci. J., Vol. 18, No. 2, pp. 43-49.

Mohammadi S.A. and B.M. Prasanna, 2003. Analysis of geneticsdiversity in crop plants: salient statical tools and considerations. Crop Sci 43: 1235-1248.

Moldovan V., M. Moldovan and R. Kadar, 2000.Item from Romania.S.C.A.Agricultural Research Station.Turda, 3350, str. Agriculturii 27 Jud Chuj, Romania.

Nagl, N., K. Taški-Ajdukovic, A. Popovic, Ž. Curcic, D. Danojevic and L. Kovacev, 201).Estimation of genetic variation among related sugar beet genotypes by using RAPD.Genetika, 43(3): 575-582

Panes, V.G., 1957.Genetics of quantitative characters in relation to plant breeding. Indian J. of Genetics, 17:318-328.

Peterson, C.J., R.A. Graybosch, P.S. Baenziger and A.W. Grombacher, 1992. Genotype and environment effects on quality characteristics of hard red winter wheat. Crop Science, 32: 98- 103.

Petkeviciene, B., 2009. The effects of climate factors on sugar beet early sow timing. Agron. Res. 7(Special issue I), 436–443.

Pfahler, P.L. and H.F. Linskens, 1979. Yield stability and population diversity in oats (Avenasp). Theor.and Appl. Genet., 54: 1-5.

Phundan S. and S.S. Narayanan, 2004.Biometrical techniques in plant breeding.Kalyani Publishers, Ludhiana, New Delhi, India.

Qiaohong, L., C. Dayou, Y. Lin, L. Chengfei, K. Fanjiang and W.Yumei, 2012.Construction of digital fingerprinting and cluster analysis using ISSR markers for sugar beet cultivars (lines).Transactions of the Chinese Soc. of Agric. Eng., 22(2): 280 – 284.

Rahim M.A., A.A. Mia, F. Mahmud, N. Zebaand K. Afrin, 2010.Genetic variability, character association and geneticdivergence in Mungbean (*Vigna radiate*L. Wilczek). Plant Omic., 3: 1-6.

Rao, C.P., P.S. Bhatnagar, B. Raj, D.P. Pant,1986.Phenotypic stability analysis of yield and quality characters in sugarbeet. Indian Journal of Agricultural Sciences. 56(6): 409 – 412.

Raturi, A., S.K. Singh, V. Sharma and R. Pathak, 2012.Stability and Environmental Indices Analyses for Yield Attributing Traits in Indian Vignaradiata Genotypes under Arid Conditions. Asian J. of Agric. Sci., 4(2): 126 – 133.

Reza, E.H., S.Y. Sadeghian, M.R. Jahadakbarand A. Zahra, 2009. Study of adaptability and stability of sugar beet monogerm cultivars in different locations of Iran. Journal of Sugar Beet, 24(2):1-13.

Robert M., F. Ameripriseand M.N. Minneapolis, 2011.Multivariate Data Displays for Evaluating Clusters. Reporting and Information Visualization, SAS Global Forum, Paper 283.

Sabaghnia, N., M.Mohammadi and R. Karimizadeh,2012. Grouping lentil genotypes by cluster methods related to linear regression model and genotype × environment interaction variance. Yyu. J. Agric. Sci. 22: 134-145.

Shalaby, N.M.E., A.M.H. Osman and A.H.S.A El-Labbody, 2011. Evaluation of some sugar beet varieties as affected by harvesting dates under newly reclaimed soil. Egyptian Journal of Agricultural Research, p. 605-614

Shehata, M.M., S.A. Azer and S.N. Mostafa, 2000. The effect of soil moisture stress on some sugar beet cultivars. Egypt. J. Agric. Res. 78: 1141-1160.

Stafford, R.E. (1982). Yield stability of guar breeding lines and cultivars. Crop. Sci., 2(5): 1009 –1011.