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Original Research Article

Evaluation of Seven Fodder Beet Genotypes under Different Egyptian Ecological Conditions Using Regression, Cluster Models And Variance Measures Of Stability

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A B S T R A C T

A field experiment was conducted to evaluate seven fodder beet varieties under four different ecological locations, Sakha, Gemmiza, Serw and Esmaellia Farm Research Stations of the Agricultural Research Center during two successive growing winter seasons; 2010/11 and 2011/12. The experiment was carried out in a randomized complete block design (RCBD) with four replications. The present investigation focused on the yielding properties, quality, stability, cluster and correlation relationships. The maximum percentage of crude protein in seeds was noted in Rota, Beta Voroshanger and Monro (15.31, 14.51 and 14.5%); whereas, the minimum crude protein was observed in Jamon (13.32%). The highest percentage of seed carbohydrate was recorded in Rozsa Szinu Beta (74.01%) with mean value 72.72% across all genotypes. Total fresh Root yield and total dry yield of fodder beet genotypes ranged from 28.22 to 59.02 t fed^{-1} and 3.88 to 11.00 t fed^{1}, respectively. Sakha location had the highest total fresh yield t fed^{-1} across all growing locations. The total dry yield exhibited highly significant positive correlation coefficients with all studied characters except root length which reflected highly significant negative association. Hybrid Beta rose was shown to be the highest yielding, crude protein and most stable genotype across all locations. Cluster analysis based on squared Euclidean distance and ward's method, categorized the lines into three groups. Also, cluster analysis main components produced three clusters. The information on diversity and relationships among the agro-morphological traits will be helpful to fodder beet breeders in constructing their breeding populations or lines and implementing selection strategies.

Keywords

Fodder beet, Yield, Quality, Stability, Correlation and Cluster Analysis.

Introduction

Fodder beet (*Beta vulgaris*), a member of the *chenopodiaceae* family, is known as mangel (Martin, 1976). The fodder beet is grown as a root crop in Germany important for livestock production in Egypt, which contributes largely to the national income. Since fodder beet contains high water and sugar, it increases milk productivity and is suitable forage for dairy cows. The fodder beet is used by mixing it with straw in European countries. It is also reported that the plant is suitable for making silage (Aky ıld ız 1983, Özen *et al*. 1993).

Fodder beet offers a higher yield potential than any other arable fodder crop (Anonymous, 2006) and when grown under suitable conditions, it can produce almost 20 t/ha^{-1} dry matter yield (DAF, 1998) and also fresh yield more than 80 t/ha. (Shalaby *et al.*, 1989). The above and below growth parts (leaves and roots) are used to feed the animals but, the main fodder is tuberous roots (Ibrahim, 2005). Therefore, the optimum plant density which produces maximum leaves and roots yield must be carefully determined. Fodder beet is good forage especially during the critical period of forage shortage such as early summer season in Egypt.

One of the essential final stages in the most applied plant breeding programs was an evaluation of genotypes across diversified environments (years and locations). Shukla (1972) developed an unbiased estimate of stability variance termed as σ^2. The Shukla method can be extended to use a covariate to overcome the linear effect from GxE interaction. The famous parameters that fall into this aspect of stability include the ecovalence (W^2) proposed by Wricke (1962) and then developed to two stability variance statistics (σ^2 and S^2) by Shukla (1972). The yield stability (YS) was proposed by Kang and Magari (1995) for simultaneous selection of yield and yield stability.

Several stability models probably measure the same stability aspect due to the overlapping of computing their statistics. In Egypt, no references for stability of fodder beet are available. Therefore, the objectives of this study were to: 1) evaluate yield and quality of two varieties and five hybrid populations under different location and laboratory conditions and, 2) evaluate the fresh and dry yield stability under eight environmental conditions.

Materials and Methods

Locations

A field experiment was conducted in the four different ecological locations, Sakha, Al-Gemmiza, Al-Serw and Al-Esmaellia Research Stations of the Agricultural Research Center, Egypt during two consecutive winter seasons of October 2010/11 and November 2011/12. The study was designed to evaluate yield character and quality of seven fodder beet cultivars viz., Beta Voroshenger (Hungarian), Rota (German) and five France hybrids (Roszsa Szinu Beta, Jamon, Jary, Monro and starmon) under different soils and ecological conditions.

Field plot technique:

An experiment was conducted in a randomized complete block design (RCBD) with four replications. Cultivars were sown in plots 12 m^2 (4m x3m) in five rows, 50 cm row spacing, with 13 hills per row. Fodder-beet seeds of the seven studied genotypes were sown with 40000 to 45000 seeds (1 to 1.25 kg fed-1) on 10-15 October in the first season and 10-15 November in the second season, respectively. Fertilizers application at the rate of recommended doses, per location, of N, P_2O_5 and K_2O and hoeing twice were carried out. The crop was irrigated at 10-15 days intervals depending on the temperature, relative humidity and soil moisture conditions. Seeds were planted on top of the shoulder of the ridge (2 seeds per hole) at 30 cm apart. Hand thinning to one plant per hole and re-sowing by the removed seedlings were done simultaneously after 5-6 weeks from planting during both seasons. Soil features across locations were shown in Table (1).

Agronomical traits:

Plant samples

Individual and bulk samples of the fodder beet plot^{-1} were weighted for fresh leaves and root, measuring of root diameter and chopped into thin slices thoroughly mixed and dried at 105°C to constant weights for leaves or roots to obtain their dry matter percentages. Then the dried samples were ground by an electrical grinder to pass through a 1 mm diameter thieve and kept for analysis. Proximate analysis for nutritive value was carried following the conventional methods recommended by A.O.A.C (1984): 1- Crude protein percentage (CP %) was determined by micro-Kjeldahl method (N% x 6.25). 2- Crude fiber percentage (CF %). 3- Ash percentage (Ash%).

Seed quality

At seed Technology Research Department, Field Crops Research Institute, Agric., Research Center during 2010/2011 and 2011/12, laboratory experiments were carried out to assess seed quality from field, normal seedling at the end of testing period according to the International Seed Testing Association (I.S.T.A, 1985). Three replications of 50 seeds were planted in boxes of (40 X 20 X 20 cm) dimension containing sterilized sandy soil. The boxes were watered and incubated at 20°C in germination chamber for (14 day). Normal seedlings were counted and expressed as the germination percentage at the final count.

Chemical analysis for seeds and roots

The fine powder was wet digested according to Chapman and Pratt (1961). Nitrogen content% was determined in digestion by micro-keldahl method, total carbohydrate %, Fe, Zn, Mn and Cu were determined according to A.O. A. C. (1990).

Statistical analysis

Analysis of variances

Regular analysis of variance of RCBD as outlined by Gomez and Gomez (1984) was individually conducted for each environment. Bartlett test (1937) was performed prior to the combined analysis to test the homogeneity of individual error terms indicating the homogeneity of variances. Accordingly, the combined analysis of variance across eight environments was worked out. Overall the current study, the genotypes were regarded as fixed effects whereas environments (combinations of years x locations) were considered as random effects. The detection of significant interaction between genotypes and environments (GxE) enabled us to study the stability of yield performance for the tested genotypes.

Stability analyses

Some stability methods were placed into

variance measures (Table 2). The stability parameters, the high yielding ability of a genotype are a precondition for stability concept. The computations of the current procedures of stability were mentioned in details through many preceding papers.

Eco-valence stability index, W^2 or the contribution of a genotype to the G x E interaction sum of squares proposed by Wricke (1962) has been utilized in the present study. Because the value of W^2 is expressed as sum of squares, no means of testing the significance of W^2 for each genotype. In accordance, the genotype has minimum value of W^2 was considered as a stable one. Shukla (1972) developed an unbiased estimate of stability variance termed as σ^2. The Shukla method can be extended to use a covariate to overcome the linear effect from G x E interaction. The remainder of G x E interaction variance can be assigned to each genotype as second stability parameter S^2. The test of significance is available for the two stability variance parameters (σ^2 and S^2) against the error variance.

The current data were subjected to yield stability analysis as outlined by Kang (1993) which then developed by Kang and Magari (1995). In this method, the stability variance parameter σ^2 (Shukla, 1972) and high yielding performance Y were confounded into one measure called yield stability (YS). Genotypes had values of YS > the mean of YS characterized by stability proper.

The concepts of stability decision making according to the parameters of stability models (variance and yield) are presented in Table (2). Although, the use of stability parameters belonging to various concepts may lead to different rankings of genotypes in their stability, there is little attention and information available on the similarity among these stability parameters as well as on the consequences and effectiveness of the utilization of different parameters for an ordering genotypes.

Cluster analysis:

Squared Euclidian distance between genotypes and characters were calculated from the standardized data matrix by Un-weighted Pair Group Method using Arithmetic Averages (UPGMA) method and clustering was done by Sequential Agglomerative Hierarchical Non-overlapping (SAHN) clustering using NTSYS pc version 2.02 (Rohlf, 1998).

Table.1 Soil texture, pH, organic matter, EC, latitude and longitude of field stations

Governorate / Research Station		Soil texture	pH	Organic matter	EC (dSm^{-1})	latitude	longitude
Ismailia		**Sandy**	7.97	0.48	1.23	30-36 °	32 -14°
Kafer El-Sheikh	**Sakha**	**Clay**	8.60	1.90	3.03	07-31 °	75-30 °
Garbia	**Gemmiza**	**Clay**	8.20	1.90	2.80	47-30 °	00-30 °
Dumiat	**Serw**	**Clay**	8.21	0.87	8.60	25-31°	49-31 °

Table.2 The concepts of stability decision making according to the parameters of three models of stability

Stability models	Parameters	The concepts of stability decision making
Models based on variance approach		
Wricke (1962)	1 - W^2	Choose the minimum values
Shukla (1972)	2 – σ^2	Not significant
	3 – S^2	Not significant
Kang and Magari (1995)	4 – YS	More than its mean

Results and Discussion

Seed germination and contents

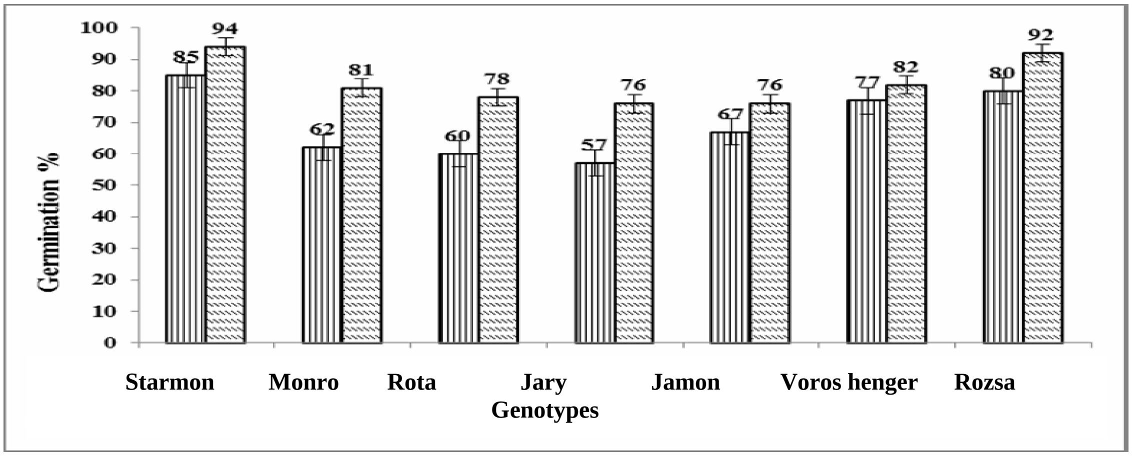
The results of germination percentage after four and ten days were are presented in Figure (1). It is evident from the results that Starmon and Betarose hybrids showed maximum germination percentages with values 88, 94% and 82, 92%; respectively, after four and ten days from sowing followed by Beta Voros henger variety (77, 82%) while minimum germination was recorded for cultivar Jary (57, 76%).Table (3) showed that the maximum percentage of crude protein in seeds was noted in Rota, Beta Voros henger and Monro (15.31, 14.51 and 14.5%), whereas, minimum crude protein was observed in Jamon 13.32%. The best percentage of seed carbohydrate was recorded in Beta rose (74.01%) with mean value 72.72% across all genotypes. Insignificant differences of Fe (ppm) seed contents across genotypes with mean of 118.9 (ppm). Seed contents of Zn, Mn and Cu (ppm) indicated significant differences ($p< 0.05$) across genotypes with means of 64.51, 72.32and 2.12 (ppm), respectively. The highest values of Zn noted for Monro 66.51 (ppm), of Mn content for Jamon 74.61(ppm) and of Cu content for Beta Voros henger and Jamon 2.61 and 2.53 (ppm), respectively.

Monro cultivar had the best percentage of crude protein plant sample^{-1} (6.42%) over all genotypes and locations followed by

Table.3 Chemical composition of seeds for combined analysis (2010/2011 and 2011/2012).

Genotypes	%		Macro-element (ppm)			
	Crude protein	Total carbohydrate	Fe	Zn	Mn	Cu
Monro	**14.50**	**72.62**	**121.34**	**66.51**	**70.31**	**1.60**
Jamon	**13.32**	**71.91**	**121.01**	**64.52**	**74.61**	**2.53**
Jary	**14.32**	**73.34**	**122.33**	**65.33**	**73.53**	**1.41**
Rozse Szinu Beta	**13.81**	**74.01**	**116.53**	**65.81**	**71.62**	**2.04**
Starmon	**13.41**	**70. 53**	**117.52**	**64.33**	**72.12**	**2.31**
Beta Voros henger	**14.51**	**72.63**	**118.70**	**63.70**	**72.54**	**2.61**
Rota	**15.63**	**71.90**	**114.81**	**61.70**	**71.71**	**2.04**
Mean	**14.21**	**72.72**	**118.9**	**64.51**	**72.32**	**2.12**
L.S.D. (0.05)	**0.92**	**1.30**	**n.s.**	**1.60**	**0.54**	**0.43**
C.V.	**4.45**	**3.72**	**2.12**	**3.80**	**4.87**	**1.32**

Figure.1 Germination percentage (± SE) after four and ten days from germination



Rozse Szinu Beta, Starmon and Voros henger varieties (5.98, 5.90 and 5.87%, respectively). Crude fiber % had insignificant interaction effects with mean value of 7.63% across genotypes X locations. The highest percentage of carbohydrate was recorded for Rozse Szinu Beta cultivar with 74.01% had insignificant effect across the interaction between genotypes and locations. Also, Rota variety recorded the higher percentage of Ash followed by Voros henger and Jamon cultivars (11.87, 10.66 and 10.63%, respectively). Cultivar Monro may be considered that had the best quality content across genotype location interaction.

In Table (3) all presented characters were significantly different at ($p<0.05$) level in each location and across the four locations. In Gemmiza location Rozse Szinu Beta and Rota varieties recorded the best root length plant^{-1} with means values 45.81 and 44.88 cm, respectively. Starmon and Jamon cultivars had the highest root weight plant^{-1} 1.99 and 1.74 kg, respectively. Beta rose cultivar had the highest weight of leaves plant^{-1} and leaves root ratio (0. 34 kg and 20.95%)). Starmon and Rozse Szinu Beta cultivars produced the highest total fresh yield (51.34 and 50.33 t fed^{-1}, respectively). The best results of total dry yield produced by Starmon and Jamon hybrids (11.0 and 10.43 t fed^{-1}, respectively). Cultivar Starmon had the best performance yield at Gemmiza location.

Our data are in agreement with those stated by (Antonov and Zakhariev, 1994 and G. Kikindonov, 2012) who noted that beet hybrids have higher productive potential (Table 3).

Total yield across locations

Total fresh and dry yield (t fed^{-1}) across all sowing locations is presented (Table 4). Beta rose, hybrid, recorded the highest fresh yield t fed^{-1} 59.02, 56.47 and 50.33 across Sakha, Serw and Gemmiza locations, respectively. While Starmon hybrid produced the highest total fresh and dry yield (51.34 and 11.00 t fed^{-1}) in Gemmiza site. The results of blend dry root yield ranged between genotypes from 9.59 to 5.04 t fed^{-1} with

Table.4 Total yield (t fed^{-1}) of seven fodder beet genotypes planted in different locations during two growing seasons

Locations	Gemmiza		Sakha		Serw		Ismaelia		Mean	
Genotypes	**Fresh**	**Dry**	**Fresh**	**Dry**	**Fresh**	**Dry**	**Fresh**	**Dry**	**Fresh**	**Dry**
Monro	**42.21**	**9.60**	**56.43**	**8.42**	**36.21**	**5.41**	**31.40**	**4.62**	**41.56**	**7.01**
Jamon	**49.94**	**10.41**	**57.05**	**8.68**	**28.39**	**3.88**	**29.02**	**4.84**	**41.10**	**6.95**
Jary	**47.65**	**9.98**	**52.07**	**7.72**	**28.22**	**4.04**	**31.29**	**4.70**	**39.81**	**6.61**
Rozse Szinu Beta	**50.33**	**9.75**	**59.02**	**8.86**	**56.47**	**7.50**	**30.43**	**4.63**	**49.06**	**7.64**
Starmon	**51.34**	**11.00**	**54.17**	**8.21**	**42.41**	**6.35**	**32.03**	**5.37**	**44.99**	**7.73**
Beta Voros henger	**38.59**	**8.43**	**49.03**	**6.77**	**37.72**	**5.25**	**33.76**	**4.83**	**39.78**	**6.82**
Rota	**47.41**	**8.41**	**53.76**	**7.95**	**43.13**	**6.30**	**39.22**	**6.28**	**45.88**	**7.24**
Mean	**46.60**	**9.59**	**54.50**	**8.06**	**38.94**	**5.53**	**32.45**	**5.04**	**43.09**	**7.00**
L.S.D. (0.05)	**8.69**	**2.51**	**6.37**	**1.22**	**16.98**	**2.16**	**5.77**	**1.13**	**3.64**	**0.68**

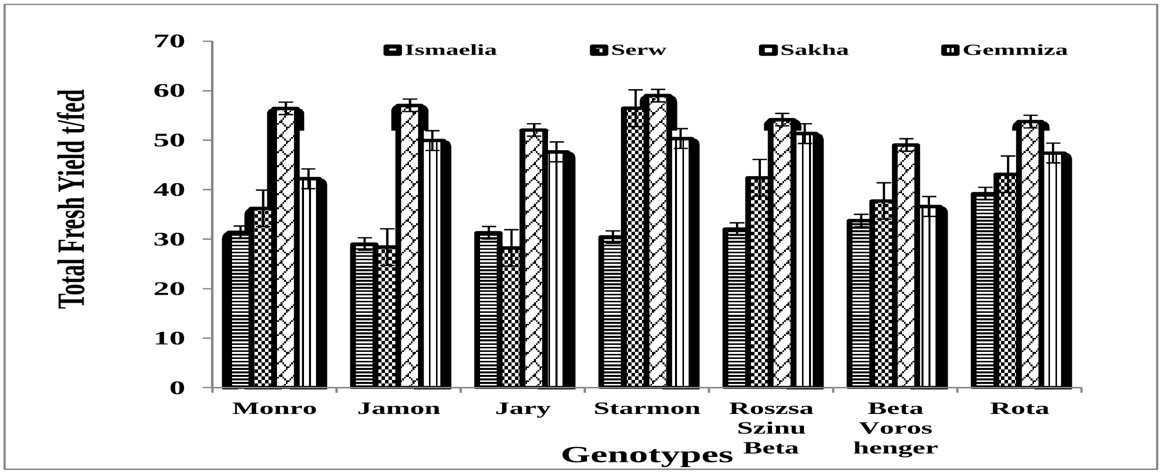
average mean 7.00 t fed^{-1} over locations. Beta rose and Jamon hybrids had the highest total of root fresh yield (59.02 and 57.05 t fed^{-1}) and highest dry yield (8.86 and 8.68 t fed^{-1}), respectively, in Sakha location. With respect to growth attributes the highest total fresh and dry yield was recorded by Beta rose (hybrid), Rota (variety) and Staromon (hybrid) with 56.47, 43.13 and 42.41 t fed^{-1}, respectively, of fresh yield and 7.50, 6.30 and 6.35 t fed^{-1}, respectively, of dry yield (Table 4).

Hybrid Jamon had the lowest total fresh and dry yield (28.39 and 3.88 kg $plant^{-1}$) in Serw and (29.02 and 4.88 kg $plant^{-1}$) in Ismaelia locations and Beta Voros henger (variety) had the lower yield in Gemmiza and Sakha locations. Sakha location indicated the higher percentage of dry matter across all locations. Hybrids indicated high performance comparing with fodder beet varieties under study. Our data are in agreement with those obtained by Antonov and Zakhariev, 1994 and Kikindonov, 2012, who noted that beet hybrids have higher productive potential.

The total fresh yield t fed^{-1} of the seven genotypes across the four locations are shown in Figure (3). Sakha location had the highest total fresh yield t fed^{-1} across all growing locations. Hybrid Beta rose had the best records in Sakha, Serw and Gemmiza locations. This may be due to suitable environmental conditions to healthy growth and development. Ismaelia location produced the lowest fresh yield of all genotypes except for Rota variety. Jamon and Jery hybrids recorded the lowest mean of total fresh yield in Serw location may be related to soil EC=8.60 dSm^{-1} of soil in Serw station. The averages of monthly temperature over two growing seasons were varied from 14.8 °C to 27.2 °C and the averages of relative humidity varied between 54.3 % and 74.2 % across growing locations, whereas considered as best conditions to fodder beet production.

Burney and Mahmood (2002) reported that temperature above 30 °C and humidity (more than 75 %) enhance reduction in fodder beet yield. Sakha location had the highest % of dry matter across all locations.

Figure.2 Total fresh yield of seven fodder beet genotypes ±SE across four locations.



Chemical Composition of Roots

Results of crud protein (CP), crude fiber (CF) and ash contents in seven fodder beet genotypes are presented in Table (5). Among the tested genotypes the statistical analysis indicated the presence of significant differences regarding the crude protein and ash % ($p<0.05$) with insignificant effect of crude fiber% of fodder beet roots. Concerning the comparison of different genotypes, hybrid Monro reported the best crude protein % followed by hybrid Beta rose (6.42 and 5.95%, respectively). Rota variety had the lowest CP% over all genotypes (5.07%). Crude fiber% was ranged from 8.09 to 7.11% with mean of 7.63% across all genotypes. Beta Voros henger variety was superior in CF% (8.09%), whereas, hybrid Monro had the lowest one (7.11%). With regarded to ash percentage in Table (5) revealed that the highest content of ash% recorded for Rota (variety), Beta Voros henger (variety) and Jamon (hybrid) with (11.87, 19.66 and 10.60%, respectively). Jary cultivar had the lowest content of (7.31%). Fodder beet roots had lower contents of crude protein and crude fibers comparing with the forage legumes. These data indicate two potential problems with fodder beet as a ruminant feed: low CP, and low fibre percentages, our data agreed with Matthew *et al*. (2011). Perhaps because of the possibility of acidosis from rapid volatile fatty acid production in ruminants on high carbohy-drate diets or other digestive issues with low fiber feeds (Chalupa and Sniffen, 2000) most reported trials of fodder beet feeding involve a diet of fodder beet mixed with other legume forages.

Table.5 Chemical composition performance of seven fodder beet genotypes.

Genotypes	%		
	Crude protein	Crude fiber	Ash
Monro	**6.42[a]**	**7.11**	**9.09[abc]**
Jamon	**5.44[b]**	**7.38**	**10.60[ab]**
Jary	**5.55[ab]**	**7.62**	**7.31[c]**
Rozse Szinu Beta	**5.98[ab]**	**7.72**	**8.33[bc]**
Starmon	**5.90[ab]**	**7.63**	**9.92[abc]**
Beta Voros henger	**5.87[ab]**	**8.09**	**10.66[ab]**
Rota	**5.07[b]**	**7.88**	**11.87[a]**
Mean	**5.74**	**7.63**	**9.68**

Means in each column followed by similar letters are not significantly different at 5% level.

Stability analysis

Stability analysis of fresh and dry yield was suggested by Kang and Magari (1995), who upgraded the procedure of Shukla (1972). The results are presented in Table (6). Examining this table, it was found that all variance sources are highly significant. It implies that genotype, the model partitioned the environment + (genotype x environment) terms into three parts; included environment, genotype x environment (GxE) interaction and the part of pooled deviation are highly significant.

It means that genotypes are genetically different with variable performance from environment to another. Pooled deviation and pooled error were significantly different. So, conclusions will be made using both sources. The previous results appeared the magnitude of both predictable and unpredictable interaction components in explaining the stability phenomenon of the used breeding materials. The obtained results are partly in agreement with those reported by Al-Assily *et al* (2002).

The results of mean stability statistics based variance models for seven fodder beet genotypes in addition to their fresh and dry yields are shown in Tables (7 and 8). Significant differences among genotypes in terms of fresh and dry yield were deteced. The highest fresh yield was obtained by genotype Jary, Rozse Szinu Beta and Jamon that surpassed all genotypes (49.06, 45.88 and 44.99 t fed^{-1}), but the highest dry yield was obtained by genotype Jamon, Jary, Rozse Szinu Beta and Starmon surpassed the overall genotypes (7.73, 7.64, 7.24 and 7.01 t fed^{-1}, respectively).

The lowest fresh and dry yield of genotype Beta Voros henger may diminish the magnitude of its stability value. The rest of genotypes were unstable since they had high values of W^2 and highly significant values of σ^2. Even after the linear component of the environmental effect (as a covariate) was removed, the examined S^2 values were proved that the above mentioned genotypes continued to be unstable.

The results of stability case were observed using the stability models of Wricke (1962) and Shukla (1972). It was clear from the results that only Rozse Szinu Beta genotype could be judged as the most stable where it had the minimum value of covalence statistic W^2 and also insignificant values of σ^2 and S^2. Piepho and Lotito (1992) pointed out that most stability statistics that based on variance components models have good properties under certain statistical assumptions, such as normal distribution of errors and interaction effects, while they may perform badly if these assumptions were violated; *e.g.*, in the presence of extreme values. Three and four genotypes out of seven were characterized by stability in addition to high performance of green and dry yield according to Kang and Magari (1995) method as shown in Tables (7 and 8). These genotypes were Jary, Jamon and Rozse Szinu Beta for fresh yield, Jamon, Jary and Rozse Szinu Beta for dry yield. They had greater value of YS than the mean of YS; so, they are judged to be stable.

It is evident that greatest number of stable genotypes (Jary, Rozsa Szinu Beta out of Rota variety) was proved only by Kang and Magari (1995) model compared with the other studied stability models. One of the reasons is the non-parametric concept of YS measure. Also, the complementary relationship between the two components

Table.6 Stability analysis of total fresh and dry yield (t fed^{-1}) for seven fodder beet genotypes tested across eight environments

Source of variation	Total fresh yield			Total dry yield	
	df	Sum of squares	Mean square	Sum of square	Mean square
Genotypes (G)	6	629.3359	104.88**	20.39	3.40**
Env. + (G x Env.)	49	5973.43	121.91**	278.52	5.68**
Env.	1	4325.50	4325.50**	216.54	216.54**
G x Env.	6	417.93	69.66**	36.62	6.10**
Pooled	42	1230.02	29.29**	25.36	0.60**
deviation	168	19.34	0.12	19.34	0.12

** Significant at 0.01 probability level.

Table.7 Mean performance of total green yield (ton/fed) and stability statistics, based on variance components models, for seven fodder beet genotypes grown under eight environments**.**

Genotypes	Mean	Stability parameters (variance components models)			
		Shukla (1972)		Wricke (1962)	Kang & Magari
		σ^2	S^2	W^2	YS
Monro	**41.10**	**174.23****	**109.88****	**1028.09**	**-8**
Jamon	**44.99#**	**72.98****	**91.04****	**<u>521.85</u>**	**<u>0+</u>**
Jary	**49.60#**	**339.68****	**404.42****	**1855.33**	**<u>2+</u>**
Rozse Szinu Beta	**45.88#**	**<u>82.83</u>**	**<u>0.71</u>**	**<u>571.11</u>**	**<u>1+</u>**
Starmon	**41.56**	**138.58****	**137.81****	**849.86**	**-6**
Beta Voros	**39.27**	**146.44****	**57.53****	**889.13**	**-10**
Rota	**39.81**	**143.90****	**155.32****	**876.45**	**-9**
Mean	**43.10**	**156.95**	**136.67**		**-4.29**

***, **: Significant at 0.05 and 0.01 probability levels, respectively.**
 # Denote the genotype that means exceed the overall mean.
Note: Bold and underline cells indicate the stable genotypes according to different models of stability.

Table.8 Mean performance of total dry yield (ton/fed) and stability statistics, based on variance components models, for seven fodder beet genotypes grown under eight environments**.**

Genotypes	Mean	Stability parameters (variance components models)			
		Shukla (1972)		Wricke (1962)	Kang & Magari (1995)
		σ^2	S^2	W^2	YS
Monro	**6.95**	**6.08****	**2.77****	**36.32**	**-6**
Jamon	**7.73#**	**4.82****	**4.20****	**30.04**	**2+**
Jary	**7.64#**	**4.16****	**5.57****	**26.74**	**1+**
Rozse Szinu Beta	**7.24#**	**7.80**	**0.78**	**24.59**	**-1+**
Starmon	**7.01#**	**3.73**	**3.28****	**44.92**	**-3+**
Beta Voros henger	**5.82**	**10.89****	**0.91**	**60.35**	**-10**
Rota	**6.61**	**3.80****	**2.17****	**24.90**	**-9**
Mean	**7.00**	**5.90**	**2.81**		**-3.71**

***, **: Significant at 0.05 and 0.01 probability levels, respectively.**
 # Denote the genotype that means exceed the overall mean.
Note: Bold and underline cells indicate the stable genotypes according to different models of stability.

of YS (Yield and Shukla stability statistic σ^2) may be considered as another cause, like genotypes Jary and Jamon in fresh root yield. Also, genotypes Starmon, Jary and Jamon in dry yield were highly significant values of σ^2 and they were stable considering YS statistic due to their high yields. In contrast, the stability of Rozsa Szinu Beta using YS statistic may be returned to the insignificant value of σ^2 irrespective of its highly yield. So, the stability model of Kang and Magari (1995) may be less effective compared to the other studied parametric models. Piepho and Lotito (1992) reported that the non-parametric models of stability would be used when the necessary assumptions for the parametric stability models are violated.

In summary, it is evident that genotype Rozse Szinu Beta, in addition to its high yield, was the most stable because it met the assumptions of stable genotype as described by three estimated stability used (Tables 7 and 8). Therefore, this genotype could be considered as breeding material stock in any future breeding program of fodder beet (Al-Assily *et al.* 2002).

Correlation analysis

Table (9) and Fig. (3) present proximity matrix of relation coefficients for all studied traits. Positive significant relations were found between total dry yield t fed^{-1} and all studied traits except root length (cm) (x1) had negative relation. The highest positive significant relation scored by total dry yield t fed^{-1} and root dry yield t fed^{-1} (0.991), total fresh yield t fed^{-1} (0.802), root fresh yield t fed^{-1} (0.768) , leaves dry yield t fed^{-1} (0.713) and leaves fresh yield t fed^{-1} (0.521) while the highest negative significant relation scored by root length (cm) (-0.525), these results indicate that these characters might be linked to each other.

Table.9 Proximity matrix coefficients of hierarchical cluster analysis for studied variables similar over all the two seasons in fodder beet

Characters	RL	LR%	RD	RFY	LFY	TFY	RDY	LDY	TDY
X1	1.000								
X2	-0.432**	1.000							
X3	-0.223**	-0.068	1.000						
X4	-0.487**	0.262**	0.578**	1.000					
X5	0.079	0.270**	0.258**	0.339**	1.000				
X6	-0.436**	0.279**	0.581**	0.981**	0.489**	1.000			
X7	-0.575**	0.340**	0.376**	0.798**	0.428**	0.813**	1.000		
X8	-0.087	0.290**	0.208**	0.353**	0.833**	0.478**	0.613**	1.000	
X9	-0.525**	0.350**	0.369**	0.768**	0.521**	0.802**	0.991**	0.713**	1.000

X1=Root length (RL), X2=leaves root ratio % (LR%), X3=root diameter (RD), X4=root fresh yield (RFY), X5=leaves fresh yield (LFY), X6=total fresh yield (TFY), X7=root dry yield (RDY), X8=leaves dry yield (LDY) and X9= total dry yield (TDY).

Figure.3 Relation coefficients of some agronomical characters across seven fodder beet genotypes

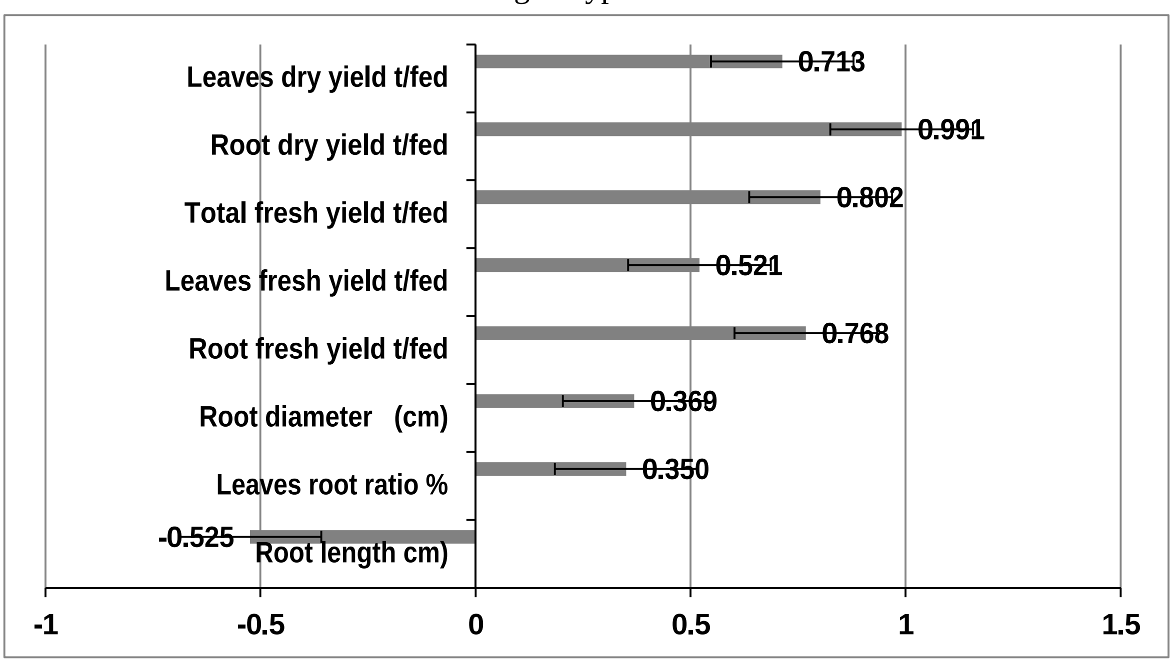


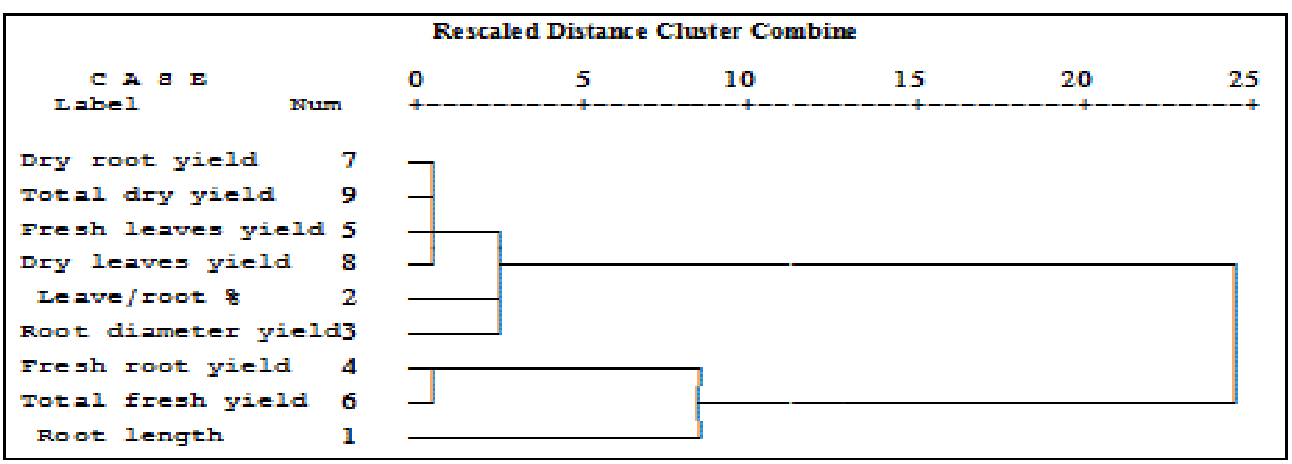
Table.10 Proximity matrix coefficients of hierarchical cluster analysis for studied fodder beat genotypes according to hierarchical cluster analysis

Steps	Number of cluster	Similarity Level%	Distance Level %	Clusters Joined	Cluster 1 content	Cluster 2 content	Cluster 3 content
1	8	99.55	0.009	X7,x9	Dry root x Total dry root		
2	7	99.07	0.018	X4,x6	Fresh root x Total fresh root yield		
3	6	91.66	0.167	X5,x8		Fresh Leaves x Dry leaves	
4	5	90.65	0.1879	X5,x7		Fresh Leaves x Dry root	
5	4	85.64	0.287	X2,x5			Leave/root % x Fresh Leaves
6	3	79.05	0.419	X2,x3			Leave/root % x Root diameter
7	2	67.51	0.650	X1,x4			
8	1	53.94	0.921	X1,x2			

***, **: Significant at 0.05 and 0.01 probability levels, respectively.**
 # Denote the genotype that means exceed the overall mean.
Note: Bold and underline cells indicate the stable genotypes according to different models of stability.

Figure.4 Hierarchical Cluster Analysis of observations for genotypes

Dendrogram using average linkage (Between Groups)according to hierarchical rescaled distance cluster analysis of Dendrogram using variable.



A linkage of this sort would make it easier to fodder beet breeder to improve these traits through selection programs. These results were similar to those indicated by Dursun (2007).

Cluster Analysis

Results in Table 10 and Fig. 4 were clustered for the nine traits into three clusters, the fodder beet root dry yield t fed^{-1} (x7), total dry yield t fed^{-1} (x9) with similarity level 99.55% between others (first nod) and root fresh yield t fed $^{-1}$ (x4) and total fresh yield t fed $^{-1}$ (x6) with similarity level 99.07% between others (second nod) in the first cluster. The second cluster included leaves fresh yield t fed^{-1} (x5) and leaves dry yield t fed^{-1} (x8) with similarity level 91.66% and leaves fresh yield t fed^{-1} (x5) and root dry yield t fed^{-1} (x7) with similarity level 90.65% between others. While cluster 3 included leaves root ratio (x2), leaves fresh yield t fed^{-1} (x5) and root diameter (cm) (x2) with similarity level 91.66%, 85.65% between others indicating that root length (cm) only in single nod. Fig. 4 collects between root fresh yield t fed^{-1} and leaves root ratio in the farthest nod.

Hierarchical Cluster Analysis of Variables

The results in Table 11 and Figure 5 indicated that (x7) dry root yield is the common denominator in all clusters nearly. So, it could be recommended by fodder beet breeders that dry root yield trait is most efficient in the fodder breeding program.

Cluster analysis was used to give graphical inter relationships of fodder beet between cultivars, based on agronomic performance. Hierarchical techniques produced a dendrogram as shown in Figure (5). All of the seven genotypes under this study were in distance of 1.0 as similarity coefficient matrix shown in Figure (5) and Tables (9) and (10) which showed that the smallest similarity between Monro and Rota genotypes with 75.17%, Starmon and Monro was 69.12. Hence, at this similarity level one cluster only was found. The next smallest similarity recorded between genotypes Jary, Jamon and Voros henger, Rozsa Szinu Beta were 49.70 and 54.24 %, respectively (cluster 2). The (cluster 3) indicated similarity between Starmon, Jary and Voros henger genotypes which were 54.24 and 48.69%, respectively.

From the dendrogram in Figure 5, it appears that Monro, Rota and Starmon are closely related to each other. It seems fair to say that in these results the cluster analysis has produced a sensible description of relationships between the different clusters. It could be concluded that genotype Rozsa Szinu Beta has low similarity coefficient with each of Beta Voros henger, Jary and Starmon. Good results could be obtained if we cross between them because there was dissimilarity between them. It is noteworthy that including similarity and dissimilarity one's and has a great value from the breeder's point of view for initiating fodder beet hybrid program. Dayou Chengi *et al.* (2012) and (Lumini a *et al.* 2011) reported that cluster analysis showed clear genetic relationships among beat cultivars, their results were in agreement with our results.

Conclusion

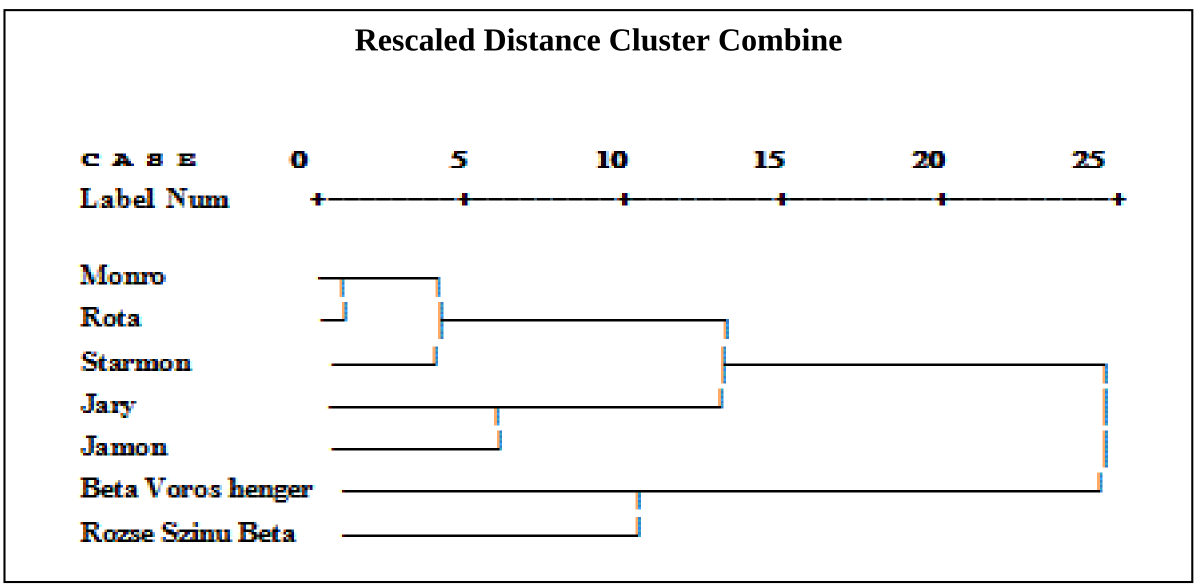
Based on the results obtained in the study focusing on the yielding properties and quality of seven genotypes of fodder beet genotypes grown under four locations in different environmental conditions in Egypt, the following conclusions can be drawn:

- According to the study years, root yield and total yield were found to be significantly affected by environmental conditions;
- On average and according to genotypes, root yield and total yield content were significantly higher across all genotypes;

Table.11 Similarity and distance levels % (dissimilarity) of studied fodder beat genotypes according to hierarchical cluster analysis

Steps	N of cluster	Similarity level%	Distance level %	Cluster joined	Cluster 1 content	Cluster content	Cluster 3
1	6	75.17	2.04	V2,V3	V2,V3		
2	5	69.12	2.54	V1,V2	V1,V2		
3	4	57.53	3.49	V4,V5		V4,V5	
4	3	54.24	3.76	V1,V4		V1,V4	
5	2	49.70	4.14	V6,V7			V6,V7
6	1	48.69	4.22	V1,V6			V1,V6

Figure.5 Dendrogram using average linkage (Between Groups) according to hierarchical cluster analysis of genotypes



- Total fresh yield and total dry yield of fodder beet genotypes ranged from 28.22 to 59.02 t fed^{-1} and 3.88 to 11.00 t fed^{-1}, respectively;

- Sakha location had the highest total fresh yield t fed^{-1} across all growing locations; Hybrid Rozsa Szinu Beta was shown to be the highest yielding, crude protein and most stable genotype across locations.

- There was a positive significant relations found between total dry yield t fed^{-1} and all studied traits except for root length (cm) (x1) had negative correlation.

- Rozsa Szinu Beta hybrid had the highest yield and considered as the most stable across all locations, whereas, described by three estimated stability parameters.

- Cluster analysis pointed that dry root yield is the nearly character relationships between all clusters.

- Cluster analysis pointed that Monor and Rota is the nearly genetic relationships between all clusters.

- Cluster analysis pointed that Rozsa Szinu Beta is the farther genetic relationships between all clusters.

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