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STUDIES ON STABILITY OF SUGAR BEET GENOTYPES UNDER OLD AND NEW RECLAIMED LANDS

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ABSTRACT:

The stability measures are useful in characterizing genotypes by showing their relative performance in various environments. Ten sugar beet genotypes were evaluated across eight different environments in old lands and four environments in new land reclaimed with two sowing dates and two locations. Two years to study their yield potential and stability. Four statistical parameters (Wricke's Ecovalence, Shukla's (two measures), kang and Coefficient of variation) were used for determining yield and other traits stability of the genotypes. Highly significant differences due to genotypes (G) in old land and all environments for all studied traits except sucrose % in combined data were found. Environments (E) and GxE interaction had the same trend in all lands and combined data except sucrose % in old land, which is suggesting differential responses of the genotypes. Results showed that the statistics parameters were differed in their efficiency for determining the true stable genotypes. But all proposed parameters were in line for determining stability of G_4 in old land for root yield and sucrose yield and over all the environments with considering mean yield, so it could be recommended for growing under conditions of old land and G_6 for root yield and G_3 for sugar yield in new reclaimed land. Concerning sucrose (%), the genotype G_9 in old land and the genotypes (G_4, G_5, G_6, G_9 and G_{10}) concerning yields in new reclaimed land were recorded by all proposed parameters (C.V., $\sigma^2 i$, $S^2 i$, Eco. and Ysi) for stability. So they could be recommended for growing under these conditions. The relative small value for the heritability in all traits studied means that the large effect by environmental on the studied traits.

INTRODUCTION:

Sugar beet (*Beta vulgaris* L.) provides about 40% of the world sugar production ranked second sugar resource after sugar cane in Egypt. The importance of sugar beet crop doesn't only come from its ability to grow in the newly reclaimed lands but also from giving high sugar recovery. In addition the growing period of sugar beet is about half than sugar cane.

Successful new varieties must show high performance for yield and other essential agronomic traits. Their superiority should be reliable over a wide range of different environmental conditions. Plant breeders generally agree on the importance of good phenotypic stability, but there is much less accord on the most appropriate definition of stability and on a statistical measure of stability in yielding trials, which is an appropriate measure of phenotypic stability. Wricke (1962) proposed to calculate the ecovalence, this is the contribution of a genotype to the total genotype x environment interaction sum of squares. If small ecovalence values are desired, this may be called an agronomic concept of stability, for it describes properties desirable in crop production. Shukla (1972) developed an unbiased estimate of stability variance of the ith genotype (δ_i^2) and also a criterion for testing the significance of δ_i^2 to determine whether or not a genotype was stable Shukla's method can be extended to use a covariate/covariates to remove its/ their linear effect from GE interaction. The remainder of GE interaction variance can be assigned to each cultivar (S^2_i parameter) and the significance of each component can be tested. The statistic S_i^2 (Shukla, 1972) was also well rank related with S_{di}^2. The yield-stability statistic (YS_i) has developed by Kang (1993) for simultaneous selection for yield and stability. Francis and Kannenberg (1978) in which the yield of each entry averaged over environments were plotted against its coefficient of variation (CV) over environments. A stable genotype in this case is one with low average coefficient of variation. Kang *et al.,* (1987) reported on the relationship between Shukla's (1972) stability variance and Wricke's (1962) ecovalence and concluded that these measures identically ranked cultivars for stability (rank correlation coefficient = 1.00). These types of measures are useful to breeders and agronomists because they provide contribution of each genotype in a test to total GE interaction. Kang and Magari (1996) discussed new developments in phenotypic stability analysis; Kang (1988, 1993) integrate yield and stability into one statistic that can be used as a selection criterion. An universally acceptable selection criterion takes GE interaction into consideration does not exist (Kang and Magari, 1995).

Whenever an interaction is significant, the use of main effects (e.g., overall genotype means across environments) is questionable. Researchers need a statistic that provides a measure of stability or consistency of performance across a range of environments, particularly one that reflects the contribution of each genotype to the total GE interaction. Recently, Kang (1993**)** developed a yield **-** stability (Ys_i) statistic to be used as a selection criterion when GE interaction is significant.

There is worldwide interest among plant breeders, geneticists and production agronomists in genotype X environment (GE) interaction. A stability analysis is often conducted to estimate and interpret GE interactions. It has been observed in sugar beet by various authors Gandorah and Refay (1994), in Saudi Arabia, Weber and Muller (1996), in Germany, AI-Jbawi, (2000), Shalaby (2003) and Abd El-Aal and Mohamed, (2005) in Egypt.

The objectives of this study were to increase sugar beet productivity and adaptability under different conditions by identifying and developing genotypes that are more adapted and more stable in production under these harsh environments and to study the stability parameters of ten genotypes of sugar beet grown at different planting dates at three locations and two seasons.

MATERIALS AND METHODS

Two field trials were carried out at three locations i.e. Kafre El-Sheikh Governorate (Sakha Experimental Station, ARC), El-Dakahlia Governorate (Belkas province) and El-Fayoum Governorate (Kom Oshim Province) in the two successful seasons 2004- 2005 and 2005-2006) The monthly meteorological data of locations and seasons was collected (Table-3). Sugar beets10 varieties were sown and planting dates were 25th Oct. and 25th Nov. Stability statistics were calculated for each of the four methods Wricke's Ecovalence, Shukla's (two measures), kang, and Coefficient of variation).

The monogerm and multigerm genotypes were used in this study. A list of these genotypes and the country of the origin are presented in Table-1.

Table-1: Identification of genotypes used, classification (N, E and Z), origin, and the important agronomic characteristics.

Genotypes		***Type***	***Origin***	***Agronomic traits***
Monte Bianco	G_1	E	Germany	Root yield high and Sugar content are medium
Farida	G_2	E	Holland	
Oscar poly	G_3	E	Germany	
Lp 12	G_4	E	France	
Kawemira	G_5	N	Germany	Root yield and Sugar content are normal
Deprezpoly N	G_6	N	France	
Samba	G_7	N	Holland	
Carola	G_8	Z	Germany	Root yield and Sugar content are high
Dema poly	G_9	Z	France	
Lp 13	G_{10}	Z	France	

Mechanical and chemical analyses of the soil at experimental locations were carried out according to Piper (1955) and presented in Table (2).

Table-2: The properties of the soil at three investigated (Kafr,El Sheikh, El Dakahlia and El Fayoum) locations**.**

Soil Sample		Particle size distribution			Textural	Available Nitrogen			
		SAND	SILT	Clay			$CaCo_3$	E.C mmhos /cm 25C°	PH Soil paste
		%	%	%	Class	P.P.M	%		
2004 2005	K. El Sheikh	25.0	28.5	46.5	Clay	37.1	4.5	1.3	8.8
	El Dakahlia	25.3	33.4	41.3	Clay	29.5	3.3	0.8	8.3
	EL FAYOUM	52.0	23.0	25.0	Sandy loam	10	36.50	10.81	8.2
2005 2006	K. El Sheikh	26.1	27.1	46.0	Clay	38.0	3.4	1.4	8.6
	El Dakahlia	26.0	33.1	40.0	Clay	30.1	3.1	0.9	8.4
	EL FAYOUM	50.0	24.0	26.0	Sandy loam	8	36.40	11.00	8.5

A split-plot design with three replications was maintained for each location. Planting dates were assigned to the main-plots, while genotypes occupied the sub-plots. The area of each sub-plot size was 21 m^2 (1/200 fad.), which consisted in 6 ridges 7 meters in length and 50 cm in width. Spacing between hills were 20 cm. Agronomic cultural practices were carried out as usual to assure optimum production. Beetroots were harvested after 210 days of sowing ±2 days between locations.

Twelve environments (Eight in old lands and four in new reclaimed land) were used as follows: E_1, the first season in the first sowing date at K. El Sheikh, E_2 the first season in the second sowing date at K. El Sheikh, E_3 the second season in the first sowing date at K. El Sheikh. E_4 the second season in the second sowing date at K. El

Sheikh, E_5 the first season in the first sowing date at El Dakahlia, E_6 the first season in the second sowing date at El Dakahlia, E_7 the second season in the first sowing date at El Dakahlia and E8 the second season in the second sowing date at El Dakahlia : E_9, the first season in the first sowing date at El Fayoum,E_{10} the first season in the second sowing date at El Fayoum, E_{11} the second season in the first sowing date at El Fayoum and E_{12} the second season in the second sowing date at El Fayoum. The studied traits were root yield/(ton/Fadden), sugar yield (ton/ Fadden) and Sugar %.

Statistical analysis: Plot means were used for statistical analysis. Data from each macro environment (combinations of years and locations) were analyzed and Barteltt's test for heterogeneity of error variances across environments indicated that error terms were homogeneous. In the combined analysis across environmental effect has assumed to be fixed. Analysis of variance was computed for each trait in each location. A combined analysis for the three locations was done according to Gomez and Gomez (1984). The form of the variance analysis and the mean square expectations from which estimates of variance components were obtained is presented in Table-4. Separate estimates of the components of variation in each mean square expectation were calculated to evaluate the magnitude of the different effects .The estimates of these variance components and the expected composition of the mean squares were determined by the procedures described by Miller and Robenson (1959).

RESULTS AND DISCUSION

1- Analysis of variance and genotype performance: Mean squares of the environments, genotypes, their interactions and combined analysis of variance for the ten genotypes evaluated fewer than twelve divergent environments for all traits studied are given in Table-5. In old land environments, the mean squares of genotypes were significant for all the studied traits. Also, the differences between the environments were significant for all traits studied except for sucrose %. The interaction between genotypes (G) and environments (E) were found to be significant for all the studied traits except for sucrose %. This indicates that genotypes interacted differently with the environments. The partitioning of the G x E interaction variance into its components, heterogeneity or non-additively and residual for the three traits studied is also shown in Table-5. The residual represents variation after the differential effect of a covariate (differenttial fertility, cultural practices at different environments) has been removed. The residual was significant for all traits studied except sucrose % in old land environments.

In new reclaimed environments the mean squares of genotypes were found to be insignificant for all the studied traits. While the differences between the environments were significant for all traits studied. The interaction between genotypes (G) and environments (E) were found to be significant for all the studied traits. This indicates that genotypes interacted differently with the environments. The partitioning of the G x E interaction variance into components, heterogeneity or nonadditivity and residual for the three traits studied is also shown in Table-5. The residual represents variation after the differential effect of a covariate (differenttial fertility, cultural practices at different environments) has been removed. The residual was significant for all traits studied. In all environments the mean square of genotypes were found to be significant for all the studied traits except for sucrose % while the differences between the environments were significant for all traits studied. The interaction between genotypes (G) and environments (E) were found to be significant for all the studied traits. This indicates that genotypes interacted differently with the environments. The partitioning of the G x E interaction variance into components, heterogeneity or nonadditivity and residual for the three traits studied is also shown in Table-5. The residual represents variation after the differential effect of a covariate (differential fertility, cultural practices at different environments) has been removed. The residual was significant for all traits studied. Similar results have obtained by Gherman and Kavots (1983) in Romania, Abo El-Ghait (1993) Al-Jbawi (2000) in Egypt and Gandorah and Refay (1994) in Saudi Arabia. They found that Genotypes x environment interaction had a significant effect on root fresh weight/plant, and sugar yield/fad, but insignificant on sucrose %.

For root yield (ton/fed) in old land, the average of the genotypes was 30.87 ton /fed. The highest values recorded for the genotype G_2 (34.47 ton/fed) while the lowest value recorded for the genotype G_3 27.48 ton / fed Table-6. The average of the environments was 30.78 ton /fed, the environment E_2 and E_3 recorded the highest values of root yield (33.06 and 33.03 ton /fed) while the lowest value recorded for the E_7 environment (26.14 ton / fed). The highest value of root yield ton/Fadden obtained from the genotype G_9 under E_5 environment (44.35) ton / fed.

For root yield (ton/ fed) in new reclaimed land Table-6, the average of the genotypes was 24.35 ton/ fed. The highest values recorded for the genotype G_6 25.68 ton / faded while the lowest value recorded for the genotype G_7 23.36 ton / fed. The average of the environments was 24.35 ton/fed, the environment E_{11} recorded the highest values of root yield (25.23 ton /fed) while the lowest value recorded for the E_{10} environment (23.49 ton / fed). The highest value of root yield obtained from the genotype G_{10} under E_{11} environment (27.56 ton /fed).

The combined data over the environments showed that the genotypes G_1, G_2 and G_9 recorded the highest values for root yield (30.60, 30.92 and 30.05 ton /fed, respectively) over all environments.

Concerning old land for sugar yield (ton/fed) Table-7, the average of the genotypes was 5.50 ton/ fed. The highest value was recorded for the genotype G_2 (6.16 ton / fed) while the lowest value was recorded for the genotype G_3 (4.67 ton / fed.). The average of the environments was 5.50 ton / fed .The environments E_2 and E_3 recorded the highest values of root yield (6.01and5.89 ton /fed) while the lowest value has recorded by the E_7 environment (4.62 ton / fed). The highest value of sugar yield was obtained from the genotype G_9 under E_5 environment (7.70 ton / fed).

Data of newly reclaimed land concerning sugar yield Table-7 revealed that the average of the genotypes was 4.05 ton/ fed. The highest value was recorded for the genotype G_5 (4.39 ton / fed), while the lowest value was recorded for the genotype G_3 (3.80 ton / fed). The average of the environments was 4.05 ton/fed. The environment E_{11} recorded the highest values of sugar yield (4.13 ton / fed) while the lowest value was recorded for the E_9 environment (3.97 ton / fed). The highest value of sugar yield was obtained from the genotype G_5 under E_{11} environment (4.56 ton / fed).

The combined data over the environments showed that the genotypesG_2 and G_9 recorded the highest values for sugar yield ton/Fed (5.43 and 5.36 ton /fed respectively) over all environments.

Moreover, sucrose % in old land (Table 8), the average of the genotypes was 17.81%. The highest values recorded for the genotype G_8 and G_9 (18.41 and 18.54 %) while the lowest value recorded for the genotype $G_{1,}$ which recorded percent of sucrose 16.86%. The average of the environments was 17.81%. The environments E_2, E_3 and E_8 recorded the highest values of sucrose % (18.18, 18.14 and 18.21% respectively) while the lowest value recorded for the E_5 environment (17.45 %). The highest value of sucrose % obtained from the genotype G_9 under E_7 environment (19.68%).

Regarding sucrose % in new reclaimed land Table-8, the average of the genotypes was 16.63%. The highest values recorded for the genotype G_5 (17.16%), while the lowest value recorded for the genotype G_3 (16.07%). The average of the environments was 16.63%. The environment E_{10} recorded the highest values of sucrose% (17.10%) while the lowest value recorded for the E_9 environment (16.26%). The highest sugar percent obtained from the genotype G_7 under E_{10} environment (19.17%). The combined data over the environments showed that the genotypes G_8, G_9 and G_{10} recorded the highest values for sucrose % (17.75, 17.77 and 17.67 % respectively) over all the environments.

2-Stability parameters: the methods of partitioning GE interaction, which provide a means of assigning a variance component to each genotype and a test of significance of the variance component, should be more useful in determining the stability of genotypes than those which do not assign a variance component to individual genotypes.

Estimates of the stability parameters and means for each of the ten genotypes are given in Table - 9 for root yield (ton /fed), in Table-10 for sugar yield (ton /fed) and in Table-11 for sucrose %. Genotypes with a significant F value were considered to be unstable.

For root yield (ton /fed) data showed that the genotype G_4 recorded insignificant variance (ecovalence, σ^2i and S^2i) statistics and low C.V values and G_2 recorded insignificant values for S^2i and low C.V indicating their stability compared to the other genotypes. The integrating yield and stability of performance (Y si) showed stability for four genotypes (G_1, G_2, G_4 and G_9) in old land environments and four genotypes (G_4, G_5, G_6 and G_9) in new reclaimed land and G_6 recorded insignificant variance S^2i statistics and low C.V values indicating their stability compared to the other genotypes. Also, this genotype seemed to have high root yield above the grand mean.

In combined data, overall the environments data showed that G_4 genotype recorded insignificant values for ecovalence, σ^2i, S^2i and low C.V indicating the stability compared to the other genotypes. The integrating yield and stability of performance (Y S_i) showed stability for five genotypes (G_1, G_2, G_4, G_5 and G_9) over all environments. The aforementioned discussion showed that the statistical parameters were differed in their efficiency for determining the true stable genotypes. But the four proposed parameters were in line for determining stability of G_4 in old land and over all the environments with considering mean yield so it could be recommended for growing under conditions of old land and three proposed parameters were in line for determining stability of G_6 in new land reclaimed with considering mean yield so it could be recommended for growing under conditions of new land reclaimed environments.

For sugar yield (ton /fed), data showed that the genotypes G_2 and G_4 genotype recorded insignificant variances (ecovalence, σ^2 and S^2i) and low) C.V values indicating their stability compared to the other genotypes. The integrating yield and stability of performance (Y S_i) showed stability for five genotypes (G_1, G_2, G_3, G_4 and G_9) in old land environments and six genotypes (G_3, G_4, G_5, G_6, G_7 and G_9) in new reclaimed land and G_3 recorded insignificant variances (ecovalence, σ^2i and S^2i) statistics and low *C.V* values indicating their stability compared to the other genotypes.

In combined data, overall the environments data showed that G_4 genotype recorded insignificant variances (ecovalence, σ^2 and S^2i) and low C.V indicating its stability compared to the other genotypes. G_2 genotype recorded insignificant values for S^2 i indicating its stability compared to the other genotypes. The integrating yield and stability of performance (Y S_i) showed stability for five genotypes (G_1, G_2, G_3, G_4 and G_9) over all environments. The afore-mentioned discussion showed that the statistics parameters were differed in their efficiency for determining the true stable genotypes. But the four proposed parameters were in line for determining stability of G_4 in old land and over all the environments with considering mean yield so it could be recommended to grow under conditions of old land and four proposed parameters were in line for determining stability of G_3 in new land reclaimed with considering mean yield so it could be recommended to grow under conditions of new land reclaimed environments.

For sucrose %, data showed that the genotypes except G_9 had insignificant variances statistic (ecovalence, σ^2i and S^2i) and low C.V values indicating their stability in old lands. The integrating yield and stability of performance (Y S_i) showed stability for six genotypes (G_2, G_4, G_7, G_8, G_9 and G_{10}) in old land environments and four genotypes (G_4, G_5, G_7 and G_{10}) in new reclaimed land .In new reclaimed land five genotypes (G_4, G_5, G_6, G_9 and G_{10}) had insignificant variances statistic (ecovalence, σ^2i and S^2i) values indicating their stability compared to the other genotypes. However, the other genotypes gave different responses for variances statistic (ecovalence, σ^2i and S^2i) values.

In combined data of over all the environments showed that four genotypes (G_2, G_4, G_7 and G_{10} recorded insignificant values for σ^2i and S^2i indicating their stability compared to the other genotypes. The other genotypes gave different responses for variances statistic (ecovalence, σ^2i and S^2i) values. The integrating yield and stability of performance (Y S_i) showed stability for six genotypes (G_2, G_4, G_7, G_8, G_9 and G_{10}) over all environments. The afore-mentioned discussion showed that the statistics parameters were differed in their efficiency for determining the true stable genotypes. But the three proposed parameters were in line for determining stability of four genotypes (G_2, G_4, G_7 and G_{10}) in over all the environments with considering sucrose % so it they could be recommended.

The provision of testing the significance of w-mean square (ecovalence) would increase the utility and effectives of ecovalence as a stability index. It is significant that testing the w-mean square showed the same genotypes to be unstable in sugar beet genotypes as were shown by σ^2i for all three traits (Tables-9,10 and 11). The magnitude of σ^2i and w- mean square for each genotype was about equal and the relative rankings of genotypes for the two parameters within a crop were exactly the same. This requires that a decision must be made which of the two methods should be used to obtain stability- variance parameters for genotypes. The calculations involved in determining ecovalence are fewer and relative simpler than those for σ^2 I. Shukla's method would be preferred, however, if a covariate were used (Kang and Miller, 1984).

3-Variance components in all traits studied: Estimates of pertinent variance components for root yield, sugar yield and sucrose % are presented in (Table-12). For root yield the relative magnitude of these components indicates the relative importance of the corresponding source of variation. The plot error variance σ^2e and the components of variance σ^2g, σ^2gl, σ^2gp and σ^2glp were higher in magnitude than the σ^2gy component. The relatively small value for σ^2gy indicated that the heritability was low. It means that the large effect by environmental.

Estimates of variance components for sugar yield indicated that the relative magnitudes of these components in relative importance of the corresponding sources of variation. The plot error variance σ^2e and the components of variance σ^2g, σ^2gp and σ^2gld were very much higher in magnitude than the σ^2gy and σ^2glp component. The large σ^2g may be due to the large stability of these genotypes. The relative magnitude of these components indicates the relative importance of the corresponding source of variation. Estimates of variance components for sucrose % showed that the relative magnitude of plot error variance σ^2e and the components of variance σ^2g were much higher than the interaction σ^2gl components. The small values of interaction σ^2gp and σ^2glp indicate that there were no environmental effects.

Table-3: Monthly meteorological data of location and seasons.

MONTHS	Temperature ^oC						Relative Humidity %		
	Maximum			Minimum					
	Kafr El-Sheikh	Dakahlia	Fayoum	Kafr El-Sheikh	Dakahlia	Fayoum	Kafr El-Sheikh	Dakahlia	Fayoum
2004/2005 SEASON									
Oct.	30.2	30.5	31.8	19.2	17.7	18.3	71	66	54
Nov	25.7	26.0	28.1	16.7	16.3	13.7	57	68	54
Des.	20.8	20.2	21.2	11.9	11.0	8.2	75	73	59
Jan.	19.0	19.0	21.1	9.6	9.0	7.6	57	65	55
Feb.	19.1	19.4	21.0	9.3	8.1	6.9	71	64	60.5
March	22.6	22.1	25.2	10.8	10.1	9.4	56	64	53
April.	25.2	25.8	30.1	14.2	13.1	13.0	54	63	51
2005/2006 Season									
Oct.	28.5	27.2	29.9	18.2	15.6	16.7	71	65	55
Nov	24.4	24.1	24.4	14.7	12.5	11.0	70	65	57
Des.	21.1	20.1	21.3	12.1	10.7	8.9	75	70	59
Jan.	18.7	18.6	19.4	9.9	7.7	6.6	74	69	59
Feb.	20.8	20.0	22.2	11.1	8.8	8.4	76	68	60.5
March	23.0	22.8	26.3	11.4	10.3	9.7	56	64	51.9
April.	26.3	26.6	30.4	16.4	13.6	16.3	57	62	50.0

Monthly report, Agro meteorological data ARC, Egypt

Table -4: Form of variance analysis and mean square expectations in combined analysis

Souree of variation	*Degree of freedom*		*Expected mean square*
Years (Y)	y-1	= 1	
Reps with years (R)	y(r-1)	= 2	
Location (L)	l- 1	= 2	
Y x L	(y-1)(l-1)	= 2	
Pooled Error (y)	y(r-1)(l-1)	= 3	
Planting date (P)	p-1	= 1	
Y x P	(y-1)(p-1)	= 1	
L x P	(l-1)(p-1)	= 2	
Y x L x P	(y-1)(l-1)(p-1)	= 2	
Pooled Error (P)	yl(r-1)(p-1)	= 7	
Genotypes (G)	g-1	= 9	Mi $\sigma^2e + r\sigma^2_{lpgy} + ry\,\sigma^2_{lpg} + rl\sigma^2_{ypg} + rp\sigma^2_{ylg} + rly\sigma^2_{pg} + rpy\sigma^2_{lg} + rlp\sigma^2_{yg} + rlpy\sigma^2_{g}$
Y x G	(y-g)(g-1)	= 9	Mh $\sigma^2e + r\sigma^2_{lpgy} + rp\,\sigma^2_{lyg} + rl\,\sigma^2_{pyg} + rlp\sigma^2_{yg}$
L x G	(l-1)(g-1)	= 18	Mg $\sigma^2e + r\sigma^2_{lpgy} + rp\,\sigma^2_{ylg} + ry\,\sigma^2_{plg} + rpy\sigma^2_{lg}$
P x G	(p-1)(g-1)	= 18	Mf $\sigma^2e + r\sigma^2_{lpgy} + ry\,\sigma^2_{lpg} + rl\,\sigma^2_{pgy} + rly\sigma^2_{pg}$
Y x L x G	(y-1)(l-1)(g-1)	= 9	Me $\sigma^2e + r\sigma^2_{lpgy} + rp\sigma^2_{ylg}$.
Y x P x G	(y-1)(p-1)(g-1)	= 9	Md $\sigma^2e + r\sigma^2_{lpgy} + rl\sigma^2_{ypg}$.
L x P x G	(l-1)(p-1)(g-1)	= 18	*Mc* $\sigma^2 e + r\sigma^2_{lpgy} + ry\sigma^2_{lpg}$.
Y x L x P x G	(y-1)(l-1)(p-1)(g-1)	= 18	Mb $\sigma^2e + r\sigma^2_{lpgy}$.
Pooled Error (g)	ylp (r-1)(g-1)	= 108	Ma σ^2e .

Table - 5: Mean squares across 8 old land., and 4 new reclaimed land, and all 12 environments for root yield, sugar yield(ton/fed.) and sucrose % sugar beet genotypes.

S.V	In old Land, Environments				New reclaimed Environments				All Environments			
	d.f	Mean square			d.f	Mean square			d.f	Mean square		
		Root yield Ton/fed.	Sugar yield ton/fed.	Sucrose %		Root yield Ton/fed.	Sugar yield ton/fed.	Sucrose %		Root yield Ton/fed.	Sugar yield ton/fed.	Sucrose %
Genotypes (G)	**9**	90.585**	3.176*	4.654**	**9**	4.72 ns	0.260	0.947	**9**	62-639*	2.166*	2.818
Environments (E)	7	171.484**	5.947**	2.052	**3**	10.17 **	0.116**	3.159*	**11**	318.221**	13.869**	8.893**
G x E	**63**	40.337**	1.295**	1.301	**27**	5.68 **	0.218**	2.254**	**99**	30.188**	0.999**	1.696**
Heterogeneity	**9**	40.118	1.514	2.614*	**9**	4.32 ns	0.106	3.036	**9**	65.933*	2.203*	2.460
Residual	**54**	40.373**	1.259**	1.082	**18**	6.35 **	0.273**	1.864*	**90**	26.614**	0.879**	1.620**
Pooled Error	**72**	5.977	0.253	1.072	**36**	0.786	0.021	0.869	**108**	6.427	0.271	0.997

*&** denote significant or 0.05 and 0.01 probability, respectively

Table - 6: **Root yield (ton/fed.) means of 10 sugar beet varieties grown in old (E_1-E_8) and new reclaimed land (E_9-E_{12}) during combined analysis of the two seasons of study.**

Gen\Env.	In old Land, 8 environments (E_1-E_8)									In new reclaimed Land, 4 environments (E_9-E_{12})					Grand mean
	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	Mean	E_9	E_{10}	E_{11}	E_{12}	Mean	
E types															
G_1	30.40	41.65	35.45	40.20	33.73	39.80	24.23	24.63	**33.76**	25.28	23.55	24.68	23.67	**24.29**	**30.60**
G_2	37.20	39.15	37.80	37.08	34.25	37.83	25.62	26.80	**34.47**	25.10	22.08	25.18	23.00	**23.84**	**30.92**
G_3	36.48	20.73	32.45	23.95	32.53	24.30	24.75	24.67	**27.48**	24.92	24.03	24.52	21.05	**23.63**	**26.20**
G_4	37.25	33.23	33.45	32.48	33.15	34.58	26.98	26.53	**32.20**	23.28	24.40	27.47	24.13	**24.82**	**29.74**
N types															
G_5	36.28	28.40	36.25	26.33	36.23	24.15	28.63	27.38	**30.45**	24.80	26.85	25.13	25.18	**25.49**	**28.80**
G_6	23.23	34.91	22.88	32.53	26.70	34.38	28.80	28.13	**28.94**	25.33	26.53	25.25	25.62	**25.68**	**27.85**
G_7	33.95	28.00	33.98	23.68	33.38	21.45	25.88	28.44	**28.59**	23.15	20.55	23.88	25.85	**23.36**	**26.85**
Z types															
G_8	29.70	35.23	32.95	33.95	30.53	22.13	23.83	25.58	**29.24**	23.33	21.73	23.13	27.39	**23.89**	**27.45**
G_9	34.94	33.38	35.51	31.05	44.35	32.35	25.28	27.23	**33.01**	26.10	21.55	25.58	23.28	**24.13**	**30.05**
G_{10}	29.85	35.90	29.55	35.80	24.85	35.23	27.45	25.90	**30.57**	22.70	23.70	27.56	23.47	**24.36**	**28.50**
Mean	**32.93**	**33.06**	**33.03**	**31.70**	**32.97**	**30.62**	**26.14**	**26.53**	30.87	**24.40**	**23.49**	**25.23**	**24.26**	24.35	28.70
LSD at 0.05 levels															
E									**1.320**					**0.489**	**1.370**
G									**1500**					**N.S**	**1.244**
E x G									**3.970**					**1.469**	**4.112**

Table -7: **Sugar yield (ton/fed.) means of 10 sugar beet varieties grown in old (E_1-E_8) and new reclaimed land (E_9-E_{12}) during combined analysis of the two seasons of study.**

Gen. \Env.	**In old Land, 8 environments (E_1-E_8)**									**In new reclaimed Land, 4 environments (E_9-E_{12})**					**Grand mean**
	E_1	**E_2**	**E_3**	**E_4**	**E_5**	**E_6**	***E_7***	**E_8**	**Mean**	**E_9**	**E_{10}**	**E_{11}**	**E_{12}**	**Mean**	
E types															
G_1	5.05	7.25	6.30	6.55	5.80	6.75	4.00	4.00	**5.71**	3.63	4.22	4.36	4.01	**4.06**	**5.16**
G_2	6.50	6.80	6.90	6.65	6.00	6.60	4.90	4.95	**6.16**	4.36	3.46	4.02	4.00	**3.96**	**5.43**
G_3	5.95	3.45	5.70	3.90	5.75	4.35	4.50	4.45	**4.76**	3.64	3.84	4.18	3.53	**3.80**	**4.44**
G_4	6.40	6.30	6.05	6.10	5.80	6.55	4.50	4.50	**5.78**	4.12	4.11	4.54	4.07	**4.21**	**5.25**
N types															
G_5	6.25	4.95	5.70	4.80	5.90	4.40	4.55	4.85	**5.18**	4.38	4.56	4.51	4.10	**4.39**	**4.91**
G_6	4.10	6.50	3.75	6.25	4.50	6.40	5.20	4.90	**5.20**	4.24	4.72	3.97	4.10	**4.26**	**4.89**
G_7	6.05	5.40	6.00	4.40	5.65	4.05	4.60	4.90	**5.13**	3.66	3.94	3.78	4.50	**3.97**	**4.74**
Z types															
G_8	5.45	6.70	6.30	6.45	5.75	4.20	4.05	4.40	**5.41**	3.56	4.01	3.61	4.53	**3.93**	**4.92**
G_9	6.70	5.90	6.70	5.70	7.70	5.65	5.00	5.25	**6.08**	4.18	3.40	4.02	4.09	**3.92**	**5.36**
G_{10}	5.15	6.85	5.50	6.65	4.60	6.45	4.90	4.40	**5.56**	3.95	3.84	4.37	4.06	**4.05**	**5.06**
Mean	**5.76**	**6.01**	**5.89**	**5.75**	**5.75**	**5.54**	**4.62**	**4.66**	**5.50**	**3.97**	**4.01**	**4.13**	**4.10**	**4.05**	**5.02**
LSD at 0.05 levels															
E									**0.272**					**0.080**	**0.280**
G									**0.308**					**0.138**	**0.253**
E x G									**0.871**					**0.240**	**0.841**

Table - 8**: Sucrose % means of 10 sugar beet varieties grown in old (E_1-E_8) and new reclaimed land (E_9-E_{12}) during Combined analyfsis of the two seasons of study.**

Gen. \Env.	**In old Land, 8 environments (E_1-E_8)**									**In new reclaimed Land, 4 environments (E_9-E_{12})**					**Grand mean**
	E_1	**E_2**	**E_3**	**E_4**	**E_5**	**E_6**	***E_7***	**E_8**	**Mean**	**E_9**	**E_{10}**	**E_{11}**	**E_{12}**	**Mean**	
E types															
G_1	16.50	17.40	17.75	16.30	17.25	16.95	16.52	16.18	**16.86**	14.39	17.86	17.65	16.94	**16.71**	**16.81**
G_2	17.50	17.40	18.30	18.00	17.45	17.50	19.02	18.34	**17.94**	17.41	15.69	16.01	17.17	**16.57**	**17.48**
G_3	16.30	16.75	17.45	16.35	17.65	18.20	18.24	18.11	**17.38**	14.61	15.99	17.05	16.63	**16.07**	**16.94**
G_4	17.20	19.00	18.00	18.75	17.40	18.98	16.74	16.88	**17.87**	17.54	16.85	16.51	16.90	**16.95**	**17.56**
N types															
G_5	17.25	17.50	15.75	18.35	16.25	18.25	15.87	17.87	**17.14**	17.59	16.97	17.80	16.30	**17.16**	**17.15**
G_6	17.75	18.60	16.40	19.25	16.80	18.72	17.82	17.53	**17.86**	16.66	17.93	15.62	15.97	**16.54**	**17.42**
G_7	17.85	19.15	17.80	18.55	16.98	18.70	17.81	17.17	**18.00**	15.85	19.17	15.81	17.24	**17.02**	**17.67**
Z types															
G_8	18.30	19.10	19.13	18.95	18.90	18.90	16.84	17.14	**18.41**	15.28	18.47	15.63	16.38	**16.44**	**17.75**
G_9	19.20	17.85	18.98	18.33	17.35	17.60	19.68	19.30	**18.54**	16.02	15.82	15.71	17.38	**16.23**	**17.77**
G_{10}	17.35	19.05	18.57	18.60	18.45	18.35	17.91	17.05	**18.17**	17.23	16.33	15.84	17.28	**16.67**	**17.67**
Mean	**17.52**	**18.18**	**17.81**	**18.14**	**17.45**	**18.21**	**17.64**	**17.56**	**17.81**	**16.26**	**17.10**	**16.36**	**16.82**	**16.63**	**17.42**
LSD at 0.05 levels															
E									**N.S**					**0.515**	**0.538**
G									**0.635**					**N.S**	**0.565**
E x G									**N.S**					**1.545**	**1.614**

Table -9: Mean of root yield (ton/fed.) and estimates of stability parameters for ten sugar beet genotypes across each of the three sits of environments.

Genotypes	IN OLD LAND 8 ENVIRONMENTS (E_1-E_8)						In new reclaimed Land,4 environments(E_9-E_{12})						Overall 12 environments(E_1-E_{12})					
	Mean	C.V	σ^2_i	S^2_i	Eco.	Ysi	Mean	C.V	σ^2_i	S^2_i	Eco.	Ysi	Mean	C.V	σ^2_i	S^2_i	Eco.	Ysi
E types																		
G_1	33.76	20.3	60.54 **	8.96 **	367.3	4 +	24.29	3.40	0.48 **	0.83 **	10.66	-3	30.60	23.5	42.53 **	36.31 **	416.3	3 +
G_2	34.47	15.3	15.57 *	8.43 ns	115.4	9 +	23.84	6.49	1.84 **	1.65 **	6.12	-8	30.92	21.9	20.24 **	5.67 ns	211.3	4 +
G_3	27.48	20.2	36.76 **	8.40 **	357.3	-10	23.63	7.43	7.06 **	10.35 **		-9	26.20	18.7	43.27 **	43.41 **	414.0	-10
	32.20	11.4	2.69 ns	3.71 ns	43.6	8 +	24.82	7.37	4.44 **	5.81 **	14.10	2 +	29.74	16.0	3.01 ns	3.42 ns	59.7	8 +
N Types																		
G_5	30.45	16.4	41.46 **	8.79 **	260.4	-4	25.49	3.62	5.17 **	0.58 **	9.59	4 +	28.80	16.3	28.89 **	30.55 **	287.5	-1 +
G_6	28.94	16.2	78.69 **	7.98 **	468.9	-7	25.68	2.28	3.21 **	-0.53 ns	21.33	5 +	27.85	14.6	57.05 **	39.42 **	535.2	-5
G_7	28.59	16.9	44.39 **	0.51 **	276.5	-8	23.36	9.38	8.18 **	11.53 **	35.30	-10	26.85	17.8	31.11 **	32.90 **	306.9	-8
Z types																		
G_8	29.24	16.7	24.63 **	8.59 **	166.2	-6	23.89	10.20	14.0 **	20.89 **	2.86	-6	27.45	17.7	19.97 **	22.66 **	208.9	-7
G_9	33.01	17.6	33.49 **	1.83 **	215.8	2 +	24.13	8.75	5.60 **	4.95 **	15.14	-4	30.05	21.5	25.90 **	20.72 **	260.7	2 +
G_{10}	30.57	14.8	43.15 **	6.55 **	269.9	-3	24.36	8.94	6.75 **	7.52 **	17.90	0 +	28.50	17.1	28.99 **	31.48 **	200.3	-4

Ysi = Yield stability statistics , + **Simultaneous selection for yield and stability, C.V = Coefficient of variation, Eco. = Ecovalence, σ^2_I and S^2_i = Shukla's stability – variance statisties**

Table -10: Mean of sugar yield (ton/fed.) and estimates of stability parameters for ten sugar beet genotypes across each of the three sits of environments.

Genotypes	IN OLD LAND 8 ENVIRONMENTS (E_1-E_8)						In new reclaimed Land,4 environments(E_9-E_{12})						Overall 12 environments(E_1-E_{12})					
	Mean	C.V	σ^2_i	S^2_i	Eco.	YSI	Mean	C.V	σ^2_i	S^2_i	Eco.	Ysi	Mean	C.V	σ^2_i	S^2_i	Eco.	Ysi
E types																		
G_1	6.08	14.7	0.98**	1.17**	6.40	3 +	3.92	8.99	0.27 **	0.42 **	0.72	-8	5.36	24.1	0.99 **	0.84 **	983	3+
G_2	6.16	13.1	0.13 ns	0.37 ns	1.62	13 +	3.96	9.38	0.34 **	0.48 **	0.88	-5	5.43	23.5	0.51 **	0.13 ns	5.57	8+
G_3	5.56	17.3	1.37 **	1.63 **	8.59	-1+	4.05	5.66	0.04 ns	0.02 ns	0.17	7+	5.06	21.3	0.88 **	0.99 **	8.79	-1+
G_4	5.78	14.2	0.23 ns	0.18 ns	2.17	9 +	4.21	5.19	0.55 ns	0.07 *	0.20	8+	5.25	19.4	0.15 ns	0.15 ns	2.46	9+
N types																		
G_5	5.18	13.2	0.85 **	0.88 **	5.66	-7	4.39	4.63	0.11 **	0.12 **	0.33	5+	4.91	13.8	0.81 **	0.55 *	8.26	-5
G_6	5.20	20.7	3.34 **	3.22 **	19.62	-6	4.26	7.69	0.34 **	0.19 **	0.88	3+	4.89	20.3	2.36 **	2.13 **	21.85	-6
G_7	5.13	14.7	1.09 **	1.17 **	6.99	8-	3.97	9.39	0.27 **	0.39 **	0.72	-4+	4.74	18.0	0.80 **	0.80 **	8.16	-8
Z types																		
G_8	5.41	19.7	1.04 **	0.92 **	6.74	-4	3.93	11.40	0.45 **	0.67 **	1.14	-7	4.92	23.3	0.77 **	0.81 **	7.89	-4
G_9	5.71	21.7	1.54 **	1.05 **	9.54	0 +	4.06	7.79	0.16 **	0.16 **	0.44	0+	5.16	25.1	1.04 **	0.91 **	10.21	0+
G_{10}	4.76	19.6	2.28 **	2.32 **	14.25	-10	3.80	7.55	0.14 **	0.21 **	0.40	-10	4.44	20.1	1.68 **	1.49 **	15.89	-10

Ysi = Yield stability statistics, + Simultaneous selection for yield and stability, C.V = Coefficient of variation, Eco. = Ecovalence

Table -11: Mean of sucrose % and estimates of stability parameters for ten sugar beet genotypes across each of the three sits of environments.

Geno types	IN OLD LAND 8 ENVIRONMENTS (E_1-E_8)						In new reclaimed Land,4 environments(E_9-E_{12})						Overall 12 environments(E_1-E_{12})					
	Mean	C.V	σ^2_i	S^2_i	Eco.	Ysi	Mean	C.V	σ^2_i	S^2_i	Eco.	Ysi	Mean	C.V	σ^2_i	S^2_i	Eco.	Ysi
E types																		
G_1	16.86	3.37	0.73 ns	0.77 ns	4.99	-1	16.71	9.56	4.47 **	.49 **	11.41	0	16.81	5.67	2.29 **	2.10 ns	22.08	-5
G_2	17.94	3.25	1.18 ns	0.79 ns	7.52	7+	16.57	5.11	2.69 *	.88 ns	7.14	0	17.48	5.33	1.48 ns	1.55 ns	14.85	4+
G_3	17.38	4.68	2.00 ns	1.73 ns	12.15	2	16.07	6.62	.37 ns	3.71 *	6.375	-2	16.94	6.33	1.90 *	2.09 *	18.62	-4
G_4	17.87	5.27	0.92 ns	0.22 ns	6.04	6+	16.95	2.53	.84 ns	.39 ns	2.69	9+	17.56	5.16	0.62 ns	0.93 ns	9.091	7+
G_5	17.14	6.12	1.92 ns	2.10 ns	11.66	0	17.16	3.94	.23 ns	.58 ns	6.02	11+	17.15	5.30	2.68 **	2.05 ns	25.46	-6
N types																		
G_6	17.86	5.43	1.32 ns	1.15 ns	8.29	5	16.54	6.17	.45 ns	.15 ns	4.15	3	17.42	6.55	1.21 ns	1.24 *	12.54	1
G_7	18.00	4.18	0.39 ns	0.12 ns	3.13	8+	17.02	9.29	3.22 *	.33 ns	8.64	6+	17.67	6.39	1.15 ns	1.16 ns	11.99	7+
Z types																		
G_8	18.41	4.98	1.42 ns	0.634 ns	8.87	10+	16.44	8.68	2.54 *	.61 ns	6.77	-2	17.75	8.03	1.94 *	1.36 ns	18.96	6+
G_9	18.54	4.70	2.59 *	1.67 ns	15.47	8+	16.23	4.77	.22 ns	.87 ns	3.60	1	17.77	7.83	2.72 **	2.87 **	25.83	3+
G_{10}	18.17	3.73	0.53 ns	0.62 ns	3.86	9+	16.67	4.22	.41 ns	.63 ns	4.06	7+	17.67	5.58	0.75 ns	0.82 ns	8.47	8+

Ysi = Yield stability statistics , + Simultaneous selection for yield and stability
C.V = Coefficient of variation, Eco. = Ecovalence, σ^2_I and S^2_i = Shukla's stability – variance statisties

Table -12: Variance component estimates from combined ANOVA for root yield , sugar yield and sucrose of 10 genotypes grown in 12 environments .

Variance Components	*Root yield ton/fed.*	*Sugar yield ton/fed.*	*Sucrose %*
	E.M. S	**E.M. S**	**E.M. S**
$\sigma^2 g$	**6.804 ****	**0.225 ****	**0.389 ***
$\sigma^2 gy$	**0.743 ***	**0.045 ***	**0.246 ***
$\sigma^2 g1$	**1.392 ****	**0.042 ****	**0.181 ***
$\sigma^2 gp$	**5.616 ****	**0.197 ****	**0.087**
$\sigma^2 glp$	**3.313 ****	**0.126 ****	**0.055 ****
$\sigma^2 gylp$	**8.184 ****	**0.209 ****	**0.268**
$\sigma^2 e$	**6.472**	**0.271**	**0.997**
σ^2_{Ph}	**26.324**	**1.115**	**2.223**
h_b^2	**25.85**	**20.22**	**17.51**

σ^2g, σ^2gy, σ^2g1, σ^2gp, σ^2glp and σ^2gylp are the variance attributed to genotypes, genotype x year genotype x location, genotype x planting date, genotype x location x planting date and genotype x year x location x planting date respectively. h_b^2 Heritability in broad sen

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