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Genotype x Environment Interaction and Stability Analysis of Orchardgrass (*Dactylis glomerata* L.) Ecotypes for Seed Yield in Turkey

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Abstract: The objective of this study was stability parameters estimation of orchardgrass ecotypes in order to identify stable ecotype for seed yield in Erzurum ecological condition in Turkey. The experiment was conducted in terms of randomized complete block design with three replications. Plant materials were seeds collected from 16 promising lines obtained from different local orchardgrass ecotype populations (Oltu and Ulubag) along with standard local variety (control) for seed yield. In order to estimate stability parameters, different methods have been used including mean yield, environmental variance (S_i^2, genotypic Coefficient of Variation (CV_i, ecovalence (W_i^2), stability variance (σ_i^2), regression coefficient (b_i), mean of regression deviation (S_{di}^2) mean variance ($\bar{\theta}_i$), superiority index (P_i), rank analysis (L_i) and (R_i). Cluster analysis based on all stability parameters was applied as well. There were significant effects for year, genotype and their interactions for seed yield trait. According to stability parameters, biplot diagram of mean yield and CV_i along with cluster analysis, ecotype U7 with a good combination of yield and stability can be recommended.

Key words: Genotype×Environment interaction, orchardgrass, seed yield, stability analysis, variance, Iran

INTRODUCTION

Orchardgrass (*Dactylis glomerata* L.) is one of the valuable perennial pasture species in Erzurum ecological condition in Turkey. This plant is adapted to more temperate and humid regions (Casler *et al*., 2004). Due to its shade-tolerant and widely stable in various soil and environmental conditions, it is mostly grown in orchards and wooded areas (Sahin, 2008). Due to having much more leaves and being nutrient-rich, obtained forage of this crop has digestibility and quite high nutritional value. Orchardgrass is suitable as silage feed because of its higher dry hay and chopped green fodder. Since, this crop is early growing in spring (Miller, 1984), it can be used as a base pasture forage crop.

Achieving high yield hay per area unit with high quality is one of the important aims of breeding forage crops. In Turkey, forage crops cultivation and breeding at various climate and soils with high yield and quality is an important issue but not in desired level. One of the main reasons of this issue is having little breeding programs and strategies on forage crops and lack of new high potential with improved varieties for Turkish farmers. In order to provide farmers with suitable cultivars for different environments and utilization systems, variability among cultivars is required for a successful forage crop species (Kolliker *et al*., 1999).

Genotype by Environment (G x E) interaction by rank changes of genotypes through environments can reduce the correlation between the genotype and the phenotype and inaccurate estimation of the genotypes genetic potential (Bantayehu, 2010). Therefore, crop breeding researchers are always looking for high yield potential genotypes with low G x E interactions.

In Erzurum region of Turkey, some studies on orchardgrass (*Dactylis glomerata* L.) were investigated for different purposes. However, there has not been any report about genotype by environment interactions and stability analysis yet. The objective of this study was stability parameters estimation of orchardgrass ecotypes in order to identify stable ecotype for seed yield in Erzurum ecological condition of Turkey.

MATERIALS AND METHODS

Field study and experimental design: This study was conducted under rainfed conditions in Faculty of Agriculture Research Institute experimental farm in Erzurum, Turkey during 2006 and 2007 growing seasons. This region is located in Northeast of Turkey (39°55'N and 41°61'E) with 1853 m altitude. Experiment was conducted in terms of randomized complete block design with three replications.

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Plant: In this study, seeds collected from 16 promising lines obtained from different local ecotype populations (Oltu and Ulubag) of orchardgrass along with standard local variety (control) were investigated. Seed yield of genotypes have been used for stability analysis.

Data analysis: In order to estimate stability parameters, different methods have been used including: mean yield, Roemer's environmental variance (S_i^2), Francis and Kannenberg (1978)'s genotypic Coefficient of Variation (CV_i) Wricke's ecovalence (W_i^2), Shukla's stability variance (σ_i^2), Finaly and Wilkinson's regression coefficient (b_i), mean of regression deviation (S_{di}^2), Plaisted and Peterson's mean variance ($\bar{\theta}_i$), Lin and Binns's superiority index (P_i), rank analysis (L_i) and (R_i). Cluster analysis was applied based on all stability parameters as well. Data were analyzed by SAS and SPSS statistical softwares.

RESULTS AND DISCUSSION

Analysis of variance: There were significant effects for year, genotype and their interactions for seed yield trait (Table 1). Overall, 39.85% of the Total Sum of Squares (SS) was attributed to environmental effects; only 18.46% to genotype and 18.23% were attributed to genotype x environment interaction effects, respectively. It means that there is a great environmental effect of total variance on genotypes and different genotypes reactions to environments. The big influence of environment on yield performance was reported in Alberts (2004) and Bantayehu (2010)'s study.

Stability analysis: To determine and choose the best genotype of the experiment, different stability parameters have been estimated. Table 2 shows the parameters along with mean seed yield. The results of study indicated that the surveyed ecotypes of orchrdgrass had a great variability and affected by genotype x environment interactions. For mean seed yield, U7 has had the maximum yield during 2 years (Table 2).

Using environmental variance (S_i^2, U4, U2 and U7 with lowest variances considered to be stable ecotypes. Static conception of this stability estimates variance of each genotype in different environments and therefore strongly it depends on the other genotypes and can not be always recommended, unless surveyed genotypes represent region's cultivars. Although, a genotype may be stable with a group of genotypes, it may not be stable with the others (Farshadfar, 1998).

This type of stability is more useful for qualitative traits such as resistance to diseases and abiotic stresses. However for quantitative traits such as yield, plant breeders are always looking for stable genotypes with high yield performances (Farshadfar, 1998). Using genotypic Coefficient of Variation (CV_i, U4, U2 and

Table 1: Combined analysis of 17 orchardgrass (*Dactylis glomerata* L.) ecotypes for seed yield

Sources	DF	Sum of squares	Mean square
Year	1	7024.456192	7024.456192**
Block (year)	4	446.043666	111.510916
Genotype	16	3254.768833	203.423052**
Year x Genotype	16	3214.138441	200.883653**
Error	64	3686.755280	57.605550
Total	101	17626.162420	

* and **significant at p = 0.05 and 0.01, respectively

Table 2: Parametric and non-parametric stability analysis of 17 orchardgrass (*Dactylis glomerata* L.) ecotypes for seed yield

Ecotypes	Mean yield ($\bar{Y}_i$)	Environmental variance (S_i^2)	Genotypic coefficient of variation (Cv_i)	Wricke's ecovalence (W_i^2)	Stability variance (σ_i^2)	Regression (b_i)	Mean of regression deviation (S_{di}^2)	Mean variance ($\bar{\theta}_i$)	Superiority index (P_i)	Rank (L_i)	Rank (R_i)
O1	5.865	126.99	43.57	0.2182	-4.217	0.9602	5.2638	10708.69	4269.772	0.330	26
O2	27.585	226.77	54.59	11.042	8.0505	1.2831	-50.0410	10937.88	4293.638	2.350	23
O3	24.923	208.49	57.93	7.3067	3.8168	1.2303	-39.0300	10898.01	4325.353	1.911	27
O4	20.587	120.02	53.22	0.6093	-3.774	0.9335	8.5517	10691.30	4361.798	0.552	32
O5	29.110	137.45	40.27	0.0001	-4.464	0.9990	0.1430	10734.36	4230.237	0.009	22
O6	25.460	143.59	47.07	0.0610	-4.395	1.0211	-2.9607	10749.21	4284.827	0.175	26
O7	32.938	75.932	26.46	9.1332	5.8869	0.7425	26.3340	10573.87	4156.113	2.137	15
O8	33.537	1113.6	99.51	468.06	526.00	2.8434	-721.9700	12536.67	4567.494	15.298	18
U1	35.200	296.06	48.88	29.923	29.449	1.4661	-94.1220	11083.21	4248.650	3.868	13
U2	32.883	0.3472	1.792	124.25	136.35	0.0502	6.5683	10250.52	4086.005	7.882	18
U3	34.103	23.989	14.36	46.760	48.531	0.4173	33.4920	10402.04	4109.713	4.835	14
U4	37.933	0.2689	1.367	150.17	165.73	-0.0442	-6.3545	10218.85	4048.842	8.665	12
U5	35.082	59.441	21.98	16.210	13.908	0.6569	31.0410	10525.23	4129.832	2.847	12
U6	41.368	393.78	47.97	65.735	70.036	1.6908	-160.8900	11277.05	4270.832	5.733	8
U7	40.138	1.9801	3.506	106.69	116.45	0.1199	14.5340	10275.82	4056.375	7.304	6
U8	38.050	303.40	45.78	32.289	32.130	1.4842	-98.9780	11098.18	4238.318	4.018	11
Local	31.560	180.75	42.60	2.9187	-1.156	1.1456	-22.9690	10835.98	4224.976	1.208	16

U7 have had the lowest genotypic coefficient of variation and considered to be stable ecotypes. This type of stability depends on the other genotypes of experiment similar to the environmental variance.

Francis and Kannenberg (1978) used mean yield and genotypic coefficient of variation to measure the performance and CV for each genotype over all the environments using a biplot as a simple graphical approach to assess yield performance and stability concurrently. They divided biplot into four groups and indicated that the stable genotype is the one that provides a high yield performance and consistent low CV (Group I). According to Fig. 1, U2-U7 and O7 were stable ecotypes with maximum yield.

Utilizing Wricke's ecovalence (W_i^2) stability variance (σ_i^2) and regression coefficient (b_i) analysis, O5 and O6 ecotypes were determined as stable ones. According to Table 2, negative estimates of some stability parameters such as stability variance (σ_i^2) and mean of regression deviation (S_{di}^2) may occasionally occur. For example, the stability variance is the difference between two sums of squares and can be negative.

Negative estimates can be considered zero in such conditions (Shukla, 1972). Using mean variance ($\bar{\theta}_i$), superiority index (P_i) and rank analysis (R_i), U7 was the stable ecotype but according to rank analysis (L_i), O5 and O6 ecotypes were determined stable (Table 2). These two parameters were nonparametric estimation of stability.

Some advantages of nonparametric statistics compared to parametric ones are: no reduction of the bias caused by outliers, no need to homogeneity of variances and additivity (linearity) of effects assumptions and being distribution-free (Huehn, 1990). To choose stable genotype using various methods of stability, cluster analysis has applied based on mean yield and estimated parameters. Following the cluster analysis, four distinct groups have been detected (Fig. 1).

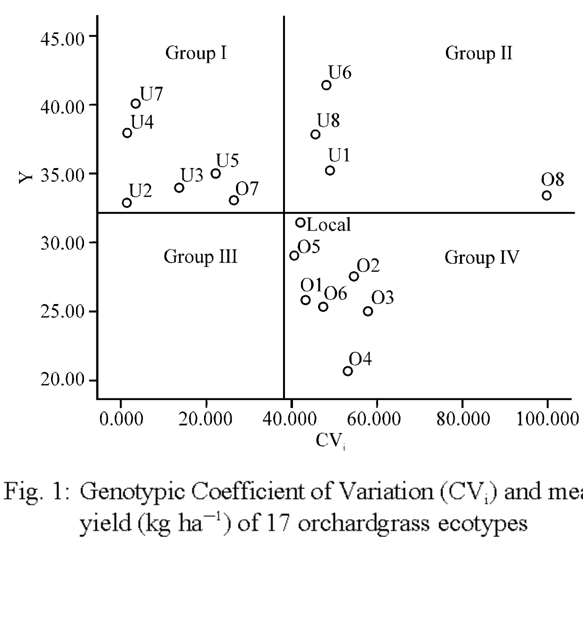

Fig. 1: Genotypic Coefficient of Variation (CV_i) and mean yield (kg ha^{-1}) of 17 orchardgrass ecotypes

Group I (O1-O6 and local ecotype) has had low yield and high CV_i. Group II (U1, U6 and U8) high yield and CV_i. Group III (U2-U5, U7 and O7) high yield and low CV_i. Group IV (O6) high yield and CV_i (Fig. 1). Cluster analysis confirmed biplot diagram method of Francis and Kannenberg (1978) (Fig. 2).

Classification techniques such as cluster analysis, search for discontinuities in the data. These methods implicate grouping similar objects in clusters and are effective for summarizing data redundancy and finding data relationships (Crossa, 1990).

Correlations among stability parameters: Table 3 represents Spearman's rank correlations among all stability parameters. Mean yield were positively correlated with Wricke's ecovalence (W_i^2), stability variance (σ_i^2) and rank (L_i) and negatively correlated with superiority index (P_i) and rank (R_i) and non-significant negative correlation with the other parameters. But Bantayehu (2010) reported that there was significant negative correlation between mean yield and Wricke's ecovalence (W_i^2). According to Alberts (2004)'s study, there was high significant positive correlation among mean yield, (CV_i) and (P_i) but non-significant negative correlation with the other parameters. A rank correlation coefficient of 1.000 was found between (S_i^2) and (b_i), (S_i^2) and ($\bar{\theta}_i$), (W_i^2) and (σ_i^2), (W_i^2) and (L_i) and (b_i) and ($\bar{\theta}_i$) (Table 3). Such a correlation indicated that these parameters were equivalent for ranking procedure. The result was similar to Alberts (2004)'s study.

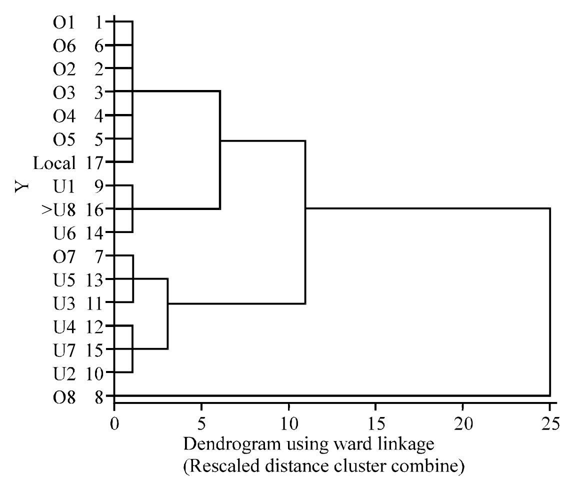

Fig. 2: Cluster analysis of 17 orchardgrass (*Dactylis glomerata* L.) ecotypes based on all stability parameters

Table 3: Spearman rank correlations among stability parameters of 17 orchardgrass (*Dactylis glomerata* L.) ecotypes

Ecotypes	Mean yield ($\bar{Y}_i$)	Environmental variance (S_i^2)	Genotypic coefficient of variation (CV_i)	Wricke's ecovalence (W_i^2)	Stability variance (σ_i^2)	Regression (b_i)	Mean of regression deviation (S_{di}^2)	Mean variance ($\bar{\theta}_i$)	Superiority index (P_i)	Rank (L_i)	Rank (R_i)
$\bar{Y}_i$	1										
S_i^2	-0.007	1									
CV_i	-0.392	0.846**	1								
W_i^2	0.723**	-0.098	-0.248	1							
σ_i^2	0.723**	-0.098	-0.248	1.000**	1						
b_i	-0.007	1.000**	0.846**	-0.098	-0.098	1					
S_{di}^2	-0.147	-0.838**	-0.650**	-0.196	-0.196	-0.838**	1				
$\bar{\theta}_i$	-0.007	1.000**	0.846**	-0.098	-0.098	1.000**	-0.838**	1			
P_i	-0.525*	0.760**	0.966**	-0.346	-0.098	0.760**	-0.549*	0.766**	1		
L_i	0.723**	-0.098	-0.248	1.000**	-0.098	-0.098	-0.196	-0.098	-0.346	1	
R_i	-0.979**	0.092	0.480	-0.634**	-0.098	0.092	0.031	0.092	0.614**	-0.634**	1

CONCLUSION

According to stability parameters, biplot diagram of mean yield and (CV_i) and cluster analysis, ecotype U7 with a good combination of yield and stability can be recommended whereas ecotype U6 was unstable but had high yield performance. Results of the study indicated that both mean yield and stability should be considered to make ecotypes selection. Among some stability parameters, rank correlation coefficients of 1.000 showed similar ranking procedure and were equivalent for sorting the genotypes.

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