World Journal of Agricultural Sciences 4 (1): 53-57, 2008
ISSN 1817-3047

Stability Analysis for Quality Traits in Durum Wheat (*Triticum durum* Desf) Varieties under south Eastern Ethiopian Conditions

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Abstract: Stability of quality of Ethiopian-grown durum wheat varieties was investigated using many quality traits including TKW, test weight, vitreousness, ash content, flour protein, wet gluten and SDS sedimentation test. The experiment was conducted at five locations during two seasons (2004 and 2005) using randomized complete block design with three replications. Five stability parameters covering a wide range of statistical approaches and techniques were used to define stable genotypes in relation to 7 quality traits considered in this study. Some varieties were stable for one quality trait and unstable for another, suggesting that the genetic factors involved in g-e interactions differ between traits. The study of genotypic stability demonstrated that variety Ude had high stability for quality traits considered and proved to be the best with in the pool of the studied genotypes.

Key words: Durum wheat · quality traits · stability

INTRODUCTION

High quality wheat grains are required for milling and baking industries. Farmers are capable of meeting requirements concerning the production of high quality wheat grains. However, the annual and local variation in both grain yield and quality can be considerable. The industry, however, demands a constant quality of the raw material.

Stability of a quality of the raw material, designated as economic stability by Robert and Dennis [1], guarantees constant procedures and low product loss during processing [2]. The genotypic main effect of a cultivar is by definition constant over the environments from which the industry processes the harvested grain. Hence, economic instability, as defined by the end users, is commonly caused by both environment and genotype-environment (g-e) interaction effects.

Roemer [3] indicated that stability of quality parameters is of economic importance for the cultivation of certain cultivars. He used the variance across environments, the standard deviation and the coefficient of variability as parameters for yield stability in rye, wheat, oats and beets. These first stability parameters follow a static concept meaning that a stable genotype is defined as one having an unchanged performance regardless of any variation in the environmental conditions [4]. Peterson *et al.* [5] reported that the concept of optimal genotype stability and response for quality parameters differs somewhat from that conventionally used to describe yield stability. For breeders, stability of quality parameters is important in terms of changing ranks in evaluating of genotypes across environments and affects selection efficiency. For end-user, such as millers and bakers, consistency in quality characteristics of cultivar is very important regardless of changing cultivar ranks. However, as mentioned by Grausgruber *et al.* [2], the quality of a genotype usually reacts like other quantitative characters to favorable or unfavorable environmental conditions. A genotype is therefore considered to be economically stable if its contribution to the g-e interaction is low.

Several statistical methods have been proposed for analysis of stability with the aim of explaining the information contained in the g-e interaction data matrix. These ranges from univariate parametric, such as regression slope value and deviation from regression [6] and environmental variance, to multivariate methods (e.g. AMMI analysis introduced by Zobel *et al.* [7]. The study of genotypes according to their slope through joint regression analysis provides information on both stability and adaptation. This study can also be evaluated

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by AMMI analysis, which extracts genotype and environment main effects and uses Principal Component Axes (PCAs) to explain patterns in the g-e interaction or residual matrix [8]. These two statistical methods can be used to evaluate stability after reduction of noise from the interaction effects. Stability can also be measured across all interaction effects, as devised by Shkula [9] environmental variance (σ^2) and the environmental variance statistics (S^2x_i) of Baker and Leon [4]. Any of these two measures may be of interest for breeding programmes as an alternative to the regression statistic, given their simplicity of computation as compared to the AMMI method.

Durum wheat is an indigenous crop in Ethiopia and its use is increasingly growing with the current emerging food processing agro-industries. To date, no information is available on this crop with regard to its stability and adaptation patterns for quality traits especially under South East Ethiopian conditions. Hence, the objective of this study was

- To highlight stability of important durum wheat quality traits of Ethiopian-grown durum wheat cultivars

MATERIALS AND METHODS

Field experiments and methodology: Eight durum wheat varieties and one advanced breeding line were included in this trial (Table 1). The trial was laid down in randomized complete block design with three replications. The experiment was conducted at five locations during two seasons (2004 and 2005). Environments were defined by the location-year combination. In total, data from 10 environments were available. Seed rate and fertilizer rate was 150 kg ha^{-1} and 41/46 N/P_2O_5 respectively. All other agronomic practices were done as recommended for each particular location.

Quality determinations consisted of the following parameters: Thousand Kernel Weight (TKW) and test weight determined by following a standard procedure [10]. Vitreousness, ash content, wet gluten and SDS volume (SDS): These quality parameters were analyzed as per ICC standard methods [11]. Flour protein content on whole meal: this was determined by NIR using Inframatic 8620. The instrument was previously calibrated based on Kjeldhal method. Samples of grain were tempered at 14% moisture basis and milled using laboratory mill (Chopin Laboratory mill CD1, France).

Table 1: Name, pedigrees and year of release of durum wheat genotypes studied

No.	Name	Pedigree	Year of release
1	Ilani	Imilo/Rahum//A4#72/3/Gerardo	2004
2	Oda	DZ046881/imlo//cit 71/3/RCHI/LD 357//imlo/4/Yemen /Cit's'//Plc's'/3/Taganroy	2004
3	Obsa	ALTAR 84//ALTAR 84/SERI/3/6*ALTAR 84	2006
4	HC/3/GUIL /CIT 71/CII	HC/3/GUIL//CIT 71/CII	Advanced line
5	Ude	CHEN/ALTAR 84//Jo69	2002
6	Ejersa	LABUD/NIGRIS 3// Gan CD98206	2005
7	Bekelcha	98 OSN Gedilfa/Guerou	2005
8	Leliso	Cocorit 71/3/Gerardo//61-130/G/ /"S"/4/Boohai/Hora//Gerardo /3/Boohai	2002
9	Ingiliz	Local landraces	Landrace

Statistical analysis: Several statistical methods and techniques were used to define stable genotypes regarding the seven quality parameters considered in this work.

Joint regression analysis was performed according to Eberhart and Russell [6] and the slope value (b_i) was determined for each quality trait. Deviation from regression (S^2d_i) for each genotype was also calculated [6]. Additive main effects and multiplicative interaction (AMMI) asnalysis was also performed as described in Zobel *et al.* [7] using IRRI stat computer software [12]. From this analysis, the stability coefficient D_i, the distance of interaction principal component (IPC) point with the origin in space was estimated according to Zhang *et al.* [13]. This was used as a stability parameter. Wricke stability, W_i [14] and the environmental variance, S^2xi, [4] were also used as stability parameters. Totally, five stability parameters were applied to the data so that a wide range of philosophies in stability analysis were considered.

To define genotypic stability, a genotype was considered stable for a given quality trait if it appeared stable in more than three (out of five) stability analysis as suggested by Rharrabti *et al.* [15]. A cultivar was regarded as stable if its contribution to the g-e interaction was less than the average for all stability parameters except b_i, the average being defined as the mean of the respective stability parameter. For b_i, cultivar with b_i values non-significantly different from unity were considered stable. Genotypes that proved to be stable for most stability analysis were then selected as the best.

RESULTS AND DISCUSSION

The five statistical parameters used in this study to define genotypic stability gave fairly similar results (Table 2 and 3). Between varieties, varieties such as Ude, Ejersa, Oda and Leliso demonstrated a high stability for the majority of quality traits. Also within these four best varieties, Ude was stable for all quality traits except for ash content and Ejersa, Oda and Leliso showed instability for test weight, a commercial trait that is highly valued in the cereal market. The other varieties showed some variation in their degree of stability from one quality trait to another. The advanced line HC/3/GUIL//CIT 71/CII is unstable for the majority of the quality traits except for test weight and SDS volume.

The stability analysis revealed a high stability for variety Ude with regard to almost all quality traits. It seems that the excellent stability in quality was, besides its yield stability, one main reason that made Ude the most popular cultivar through the country. Recently, Ejersa and Bekelcha were released which are high yielder and both of which also exhibit the highest level of resistance against fungal diseases among Ethiopian grown quality durum wheat. The penalty of Bekelcha, the lower values for protein content, can usually be corrected by a higher rate of application of fertilizer with out agronomic problems due to the semi-dwarf character and higher resistance to lodging of this cultivar. Ude, popular commercial variety especially in the central part of the country, demonstrated higher stability for grain quality. This variety was released by the Debre Zeit Agricultural Research Center for a wide adaptation in Ethiopian durum wheat growing areas. It is not only appears to have stability for quality traits but can also be grown successfully with other desirable agronomic traits such as yield in other zones of Ethiopia, particularly under high epidemics of disease conditions. Thus, this variety could be recommended to farmers dealing with the production of good quality durum. Variety Ejersa also showed high stable quality traits and may still be of interest for growers in Ethiopia. HC/3/GUIL/CIT 71/CII, the advanced lines of the CIMMYT-ICARDA durum wheat breeding programme, besides its instability for majority of quality traits, it could be used successfully as progenitors in breeding programmes for the improvement of quality parameters such as test weight and SDS volume. Some variability between measurements of stability within each genotype was also observed in this study. Thus, some genotypes were stable for one trait and unstable for another, suggesting that the genetic factors involved in the g-e interactions differed between traits [2, 15].

Table 2: Stability parameters for the considered quality traits in 9 durum wheat varieties during 2004-2005[a]

TKW	[b]b_i	[c]S^2d_i	[c]S^2x_i	[c]D_i	[c]W_i
Ilani	2.61	23.63	33.46	3.936	158.12
Oda	0.49	5.38	5.85	2.459	58.67
Obsa	0.29	7.78	6.74	2.766	94.24
HC/3/GUIL/CIT 71/CII	0.38	6.14	5.64	2.405	73.40
Ude	1.22	2.53	11.29	1.302	23.24
Ejersa	0.76	0.21	3.77	0.483	5.58
Bekelcha	1.49	0.53	14.31	1.007	19.35
Leliso	0.91	2.32	7.06	1.258	18.99
Ingiliz	0.86	13.13	15.07	2.787	106.38
Mean		6.85	11.47	2.04	62.00
Test weight					
Ilani	1.26	1.00	2.97	1.360	8.886
Oda	0.349	0.79	0.80	1.648	12.278
Obsa	1.11	0.27	1.91	0.576	2.283
HC/3/GUIL/CIT 71/CII	0.60	0.79	1.12	1.496	8.467
Ude	1.32	0.38	2.69	1.039	4.438
Ejersa	1.03	1.73	2.85	1.647	13.741
Bekelcha	1.45	0.31	3.13	1.024	5.252
Leliso	0.83	2.15	2.67	1.858	17.643
Ingiliz	1.05	0.63	2.03	1.027	5.077
Mean		0.89	2.24	1.30	8.67
Vitreousness					
Ilani	1.38	21.90	241.68	3.539	345.778
Oda	1.21	15.70	184.33	3.318	176.748
Obsa	1.15	16.19	169.49	2.432	157.489
HC/3/GUIL/CIT 71/CII	1.08	25.06	158.87	2.923	209.535
Ude	0.95	5.75	110.29	1.268	49.178
Ejersa	0.93	5.01	104.72	1.106	46.595
Bekelcha	0.87	9.86	96.16	2.129	99.883
Leliso	0.65	23.35	69.06	3.266	326.856
Ingiliz	0.77	19.60	86.46	2.910	215.718
Mean		15.82	135.67	2.54	180.86
Ash content					
Ilani	0.72	0.08	0.354	0.036	0.698
Oda	1.22	0.08	0.395	0.021	0.639
Obsa	1.36	0.07	0.356	0.587	0.661
HC/3/GUIL/CIT 71/CII	0.96	0.07	0.363	0.384	0.552
Ude	1.14	0.08	0.347	0.504	0.666
Ejersa	0.94	0.14	0.413	0.749	1.114
Bekelcha	1.33	0.08	0.388	0.488	0.653
Leliso	0.57	0.02	0.259	0.127	0.268
Ingiliz	0.75	0.04	0.337	0.167	0.325
Mean		0.07	0.36	0.34	0.62
Flour protein					
Ilani	0.93	0.10	0.43	0.445	0.836
Oda	0.84	0.19	0.44	0.818	1.614
Obsa	0.80	0.18	0.40	0.754	1.447
HC/3/GUIL/CIT 71/CII	0.77	0.25	0.45	0.946	2.227
Ude	1.07	0.11	0.55	0.535	0.874
Ejersa	1.22	0.02	0.62	0.073	0.393

Table 2: Continued

Bekelcha	1.32	0.08	0.77	0.543	1.029
Leliso	0.94	0.08	0.42	0.432	0.661
Ingiliz	1.13	0.20	0.68	0.881	1.675
Mean		0.13	0.53	0.60	1.20
Wet gluten					
Ilani	0.82	13.94	33.26	2.006	122.070
Oda	0.82	12.23	31.79	0.363	108.052
Obsa	0.74	14.59	28.86	2.082	141.227
HC/3/GUIL/CIT 71/CII	1.23	13.66	60.63	2.122	126.779
Ude	0.71	3.93	19.68	1.442	58.949
Ejersa	1.05	7.04	41.22	1.023	56.819
Bekelcha	0.86	16.95	37.79	2.551	142.362
Leliso	1.42	14.41	77.03	2.845	172.287
Ingiliz	1.36	16.60	73.82	2.697	175.612
Mean		12.59	44.90	1.90	122.68
SDS					
Ilani	2.63	59.19	98.59	4.542	669.658
Oda	0.57	14.77	14.23	1.636	131.558
Obsa	2.08	20.24	48.22	2.830	248.552
HC/3/GUIL/CIT 71/CII	0.76	10.62	12.75	1.799	89.314
Ude	0.27	16.39	12.71	1.915	170.507
Ejersa	0.37	12.27	10.83	2.267	127.425
Bekelcha	1.08	8.18	15.20	0.108	66.009
Leliso	0.57	3.57	5.26	0.807	41.984
Ingiliz	0.66	19.08	18.76	2.178	161.185
Mean		18.26	26.28	2.01	189.58

[a]b_i: regression slope (Finlay and Wilkinson, 1963). S $\bar{d}_i$ deviation from regression (Eberhart and Russell, 1966), S^2x_i: environmental variance.Wi: Wricke's ecovalence (Wricke 1962). D_i: the distance of interaction principal componenet (IPC) point with origin in space [13]

[b]Values in italics are non-significantly different from the unity at $P< 0.05$. Cultivars with values in italics are considered stable

[C]Values in italics are lower the mean. Cultivars with lower values than the mean are regarded as stable

Table 3: Summary of the stability analyses of 9 durum wheat varieties grown during 2004-2005 seasons

Genotypes	TKW[a]	Test weight	Vitreousness	Ash content	Flour protein	Wet gluten	SDS volume
Ilani	-[b]	-	-	+	+	-	-
Oda	+[c]	-	+	-	-	+	+
Obsa	-	+	+	+	-	-	-
HC/3/GUIL /CIT 71/CII	-	+	-	-	-	-	+
Ude	+	+	+	-	+	+	+
Ejersa	+	-	+	-	+	+	+
Bekelcha	-	-	+	-	-	-	+
Leliso	+	-	-	+	+	-	+
Ingiliz	-	+	-	+	-		-

[a]Thousand kernel weight, [b]Unstable,

[c]Stable for more than three stability parameters

Genotypes selected according to stability of quality in this study verified the possibility of combining both stable and high quality. However, breeders must be aware of the difficulties in selection. As reported by Grausgruber *et al.* [2] and Rharrabti *et al.* [15], an integrated selection system designed to maximize the probability of producing stable quality wheat with a high level of performance should be developed.

The cultivation of more unstable cultivars should be recommended only for specific regions where they can attain a high performance with regard to quality traits independent of seasonal effects. Some authors suggested that stability for quality traits should be an important breeding goal. However, for early generation trials, genotypes are usually tested at a few environments so that the emphasis is on the estimation of the main effect of the genotypes with less interest in the interpretation of the g-e interactions [16]. Moreover, early generation testing requires reproducible methods on a micro-scale for the evaluation of durum quality. However, small scale tests often explain less than one-half the observed variation in commercial scale test procedures [17]. Selection on a micro-scale and/or indirect selection are therefore often only suitable to discard the truly inferior breeding lines.

CONCLUSIONS

Stability of wheat quality characteristics over locations and years is important to milling and baking industry whose processing technology requires consistent raw materials in order to produce a quality end product. In breeding programmes, the crossing of adapted cultivars identified as having an acceptable stability and superior quality performance with genotypes exhibiting high yield is necessary. For genotypic stability, the variety Ude showed high stability for quality characteristics and proved to be the best within the pool of the studied genotypes.

In stability analyses, various statistics should be applied to characterize the genotypes for responsiveness to environments as much as possible and to be sure of the g-e interaction effects. Check cultivars for stability (and even for instability) can be used in the further experiments as standards.

ACKNOWLEDGEMENTS

The authors wish to thank the Oromiya National Regional State for financial support to execute the experiment. They are also grateful to Mr. Mohammed

Abinasa,Mr. Desalegn Lemma, Mr. Gezahagn Tadesse and Mr. Habtamu Leggese for their help in collecting and compiling the data and Debre Zeit Agricultural Research Center durum wheat breeding program for providing genetic materials.

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