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Stability Analysis of Durum Wheat *(Triticum Durum* Desf*)* Genotypes by Regression Measurement In Ethiopia

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ABSTRACT

In this study, 13 advanced lines with 4 standard and a local check of Durum wheat (Triticum turgidum var. durum Desf.) were evaluated for two consecutive cropping seasons (2014-2015) at six research stations for grain yield in Ethiopia. The combined analysis of variance indicated that the main effects of location and genotype and interaction effects of genotype × year, genotype × location and genotype × year × location were highly significant for grain yield. GE interaction was analyzed using linear regression techniques. There was a considerable variation in grain yield among genotypes and environments. Stability was estimated using the Eberhart and Russell method. Stability analysis of grain yield in deferent environments showed that the variance of genotypes and genotypes × environment interactions were significant. Due to the stability analysis, Genotypes 2, 3, 4 and 15 have b value close to one, i.e. genotypes are responsive to good environments, and it may be considered stable for grain yield in all of the environments. The deviation from regression for G7, G9, G10 and G11 are also low and because of the low value of the genotypic mean, these genotypes are intermediate stable and poorly adapted to all environments. None of the genotypes evaluated was perfectly stable in all of the environments due to lack of b- the value equal to unity. The broad sense heritability was 69.2%, indicating selection should give a good response for grain yield.

Key words: Durum wheat, heritability, Grain yield, stability, g-e interaction.

1. INTRODUCTION

Durum wheat (*Triticum durum* Desf.) produced in most parts of Ethiopia. Durum wheat productivity in developing countries is generally low. This may be attributed to the fact that the crop is grown under low inputs in high rain fall and other marginal areas characterized by sharp annual fluctuations in cropping conditions. Under favorable environments where moisture and other resources are not limiting, higher yield levels, approaching or surpassing bread wheat, are obtained (CIMMYT, 1992).Wheat is grown in the all regions of Ethiopia mostly under the rain fed conditions including Eastern shewa regions. Therefore, annual production is affected to large extent by the annual and seasonal distribution of precipitation, environmental states and crop managements like sowing time, soil fertility, etc. Like to the other crops, increasing the potential of yield is an important target of durum wheat improvement programs production. However, durum wheat yields in most production regions seem to be no more than the potential yields of the cultivars and far below the theoretical maximum yields (Rharrabti, Y., L. F et al., 2003). The improved genotypes evaluated in multi-environment trials to test their performance across different environmental conditions. In most trials, crop yield fluctuates due to suitability of genotypes to different conditions which is known as genotype × environment interaction (G×E) (. Kang M. S. 1998). G ×E can be defined as the difference between the phenotypic value and the value expected from the corresponding genotypic and environmental values (Baker, R. J. .1988).Modern agriculture requires determining the stable genotypes and high performance (Becker, H. C. and J. Leon. 1988). In order to increase total production, while wheat cultivars are tested for their yield performances in the different locations and different agriculture practices via sowing time. A genotype is considered to be stable if (i) its variance among the environments is small (static or a biological stability), (ii) its response to environments is parallel to the mean response of all genotypes in the experimental (dynamic or agronomic stability) or (iii) the residual mean square from the regression model on the environmental index is small (Lin et al., 1986).

Methods of Eberhart and Russell (1966), Perkins, and Jinks (1968) are the methods to describe the third type of stability. Lin and Binns(1988) proposed stability concepts on the basis of predictable and unpredictable non-genetic variation. The predictable component related to locations and the unpredictable component related to years. They suggested the use of regression approach for the predictable portion and the mean square for years × locations for each genotype as a measure of the unpredictable variation. Afzal Arain *et al.* (2011) was applied the regression analysis to estimate the grain yield stability parameters viz., regression coefficient (b) and deviation from regression coefficients (S^2d) for each genotype and indicated wide adaptation and stability of performance of Msh-14 in all environments according to its regression coefficient (b) close to unity (0.86) and S_2d close to zero (0.7923). Pompiliu et al. (2009) used coefficient of variation (CV%), the regression intercept(a), Ecovalence (W2), regression slope (b) and Deviations from regression (S^2d) for evaluation of fourteen Romanian winter wheat cultivars in 52 testing environments. The current investigation was carried out evaluate the performance of durum wheat genotypes and to investigate their yield stability by several stability parameters across a range of environments over two consecutive years.

2. MATERIALS AND METHODS

2.1. Plant materials and experimental designs

The experimental materials consist of eighteen genotypes selected from the joint project of ICARDA and CIMMYT and four standard checks (Hitosa, Mangudo, Ude and Yerer) and a local check were evaluated during two cropping seasons (2014–2015) at six research sites.

Table 1: Durum wheat cultivars included in the study

Code	Selection history	Origin
G1	IDON-MD-2009_off/12/2009	ICARDA
G2	IDON-MD-2009_off/34/2009	ICARDA
G3	IDON-MD-2009_off/53/2009	ICARDA
G4	DSP2009_off.F3.2H.22_meh.1H.26	CIMMYT
G5	DSP2009_off.F4.1H.783_meh.4H.259	CIMMYT
G6	DSP2009_off.F4.1H.785_meh.2H.262	CIMMYT
G7	DSP2009_F6off/1508/2009	CIMMYT
G8	IDON-MD-2009_off/25/2009	ICARDA
G9	DSP2009_off.F4.1H.378_meh.4H.187	CIMMYT
G10	DSP2009_off.F4.3H.639_meh.1H.240	CIMMYT
G11	DSP2009_off.F4.2H.712_meh.1H.248	CIMMYT
G12	DSP2009_off.F4.2H.735_meh.2H.251	CIMMYT
G13	DSP2009_off.F4.3H.976_meh.2H.292	CIMMYT
G14	Hitossa	CIMMYT
G15	Mangudo	ICARDA
G16	Ude	CIMMYT
G17	Yerer	CIMMYT
G18	Local	Ethiopia

*CIMMYT = International Centre for Wheat and Maize Improvement
ICARDA = International Center for Agricultural Research in the Dry Areas

The genotypes were grown in a randomized complete block design with four replications at each site. Plot size was 3 m2, 6 rows with 2.5 m long, and 1.2 cm between rows. Where 4 rows harvested to estimate grain per plot and then converted to kg ha^{-1}. At harvest grain yield was determined for each genotype at each environments

2.2. Description of experiment

The seed was drilled by hand at seed rate of 125 kg/ ha which is equivalent of 45gm/3m^2 and planting depth was ~5cm. Planting carried out at appropriate planting time for each location and fertilizer applied according to the specific recommendation (150kg/ha of Urea and 150kg/ha of DAP) of each location. All phosphorous, in the form of Diamonium phosphate (DAP) was applied at planting while nitrogen, in the form of Urea was applied half at planting and the rest half during tillering stage of crop development. Weeding done twice at tillering and at booting stage of the crop by hand..

2.3. Description of experimental sites

The experiment conducted in six locations namely; **Debrezeit, Haromaya, Chefe Donsa, Denbi, Manjra and Hosanna f**or national Durum wheat research project and is representative of different wheat growing agro- ecologies of Ethiopia. Locations are represent the high land zone (1800-3000 Meters above sea level) and are received high rainfall (>750-1300mm) and drained to poorly drained black (vertisol) soils.

Generally, the experimental sites vary considerably in their edaphic and climatic conditions. Maximum and minimum monthly temperature (°C) and monthly rainfall (mm) was considered during the growing periods.

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Table 2.Description of experimental sites

Sl. No.	Location	Altitude Meters above see level	Soil type	Recommended Dates of sowing
1	Minjar	1600	Light soil	July 10
2	Denbi	1900	Pellicvertisol	July 30
3	Debrezeit	1860	Pellicvertisol	July15
4	Haromaya	2900	Pellicvertisol	July 21
5	Chefe Donsa	2460	Pellicvertisol	July 25
6	Hosaena	1875	Light soil	July15

2.4. Statistical Procedures

Combined analysis of variance was done on grain yield that obtained from twelve environments according to the Comstock and Moll (1963) Method. Three stability parameters were applied to assess stability performance of genotypes and to identify superior genotypes; bi, the linear regression of the phenotypic values on environmental index (Finlay and Wilkinson, 1963), S^2d, the deviation mean square from regression (Eberhart and Russell, 1966) and coefficient of determination (R2).All analysis was performed using the statistical package GEA-R and SAS 9.2

The statistical model was given for experimental design is:

Yijkl = μ + Ei + R(E)j(i) + Gk + GEik + eijk,

Where

μ .... general mean, Ei ....effect of i^{th}

Environment (i = 1, 2,…, 3), R(E)j(i) .... Effect of j^{th} block within the i^{th}

Environment (j = 1, 2, 3, 4), Gk .... effect of k^{th} genotype (I = 1, 2, …, 20),

GEik ... effect of the interaction of the k^{th} genotype with the i^{th} environment,

Eijk -------------- Experimental Error.

3. RESULT AND DISCUSSION

Stability analysis of grain yield in different environments indicated that the variance of genotypes and genotypes × environment (linear) interactions were significant at 1% probability, the average yield across all of environments and some of stability parameters such as coefficient of regression (bi) and deviation from regression (S^2d) presented in Table 4. Mohammad *et al.* (2013) also found significant differences in grain yield of different wheat genotypes in response to different environmental conditions. This indicates the big influence of environmental effects on grain yield performance of durum wheat genotypes in six considered station. The equal proportion of genotype × year and genotype × year × location variance with genotypes main effect is an important consequence and indicating the significance of genotype × environmental interaction effects. The highest grain yield obtained from genotype 3(Utuba), while the lowest grain yield obtained from genotype 18. Seven genotypes (G2, G3, G9, G10, G11, G14, and G15) provided yields above the average yield.

The combined analysis of variance indicated that the main effects of location and genotype and interaction effects of genotype × year, genotype × location and genotype × year × location were all highly significant (P < 0.01) for grain yield (Tab. 3). Karimizadeh et al. (2012) considered stability parameters of twenty durum wheat genotypes in twelve environments and indicated that genotype ×environment interaction effects significantly influenced genotypes yield. Environment mean yield for all of the genotypes ranged from 2364.92 kg/ha in Denbi to 3854.60 kg/ha in Haromaya.

Table 3. Analysis of variance (ANOVA) for grain yield of 18 durum wheat genotypes in six locations

Source	DF	SS	MS
Bloc	3	176947.7	58982.6 ns
Year	1	5208352.8	5208352 ***
loc	5	222169158.3	44433831.7 ***
Trt	17	79811795.8	4694811.5 ***
trt*Year	17	5517594.1	324564.4***
loc*trt	85	91228137.9	1073272.2***
loc*trt*Year	90	70046006.5	778289.0***
Coefficient of Variation		**11.3**	

ns, non- significant, *** significant at 0.01 probability level.

Abbreviations: CD= Chefedonsa,MN=Minjar, DN=Denbi and DZ= Debrezeit

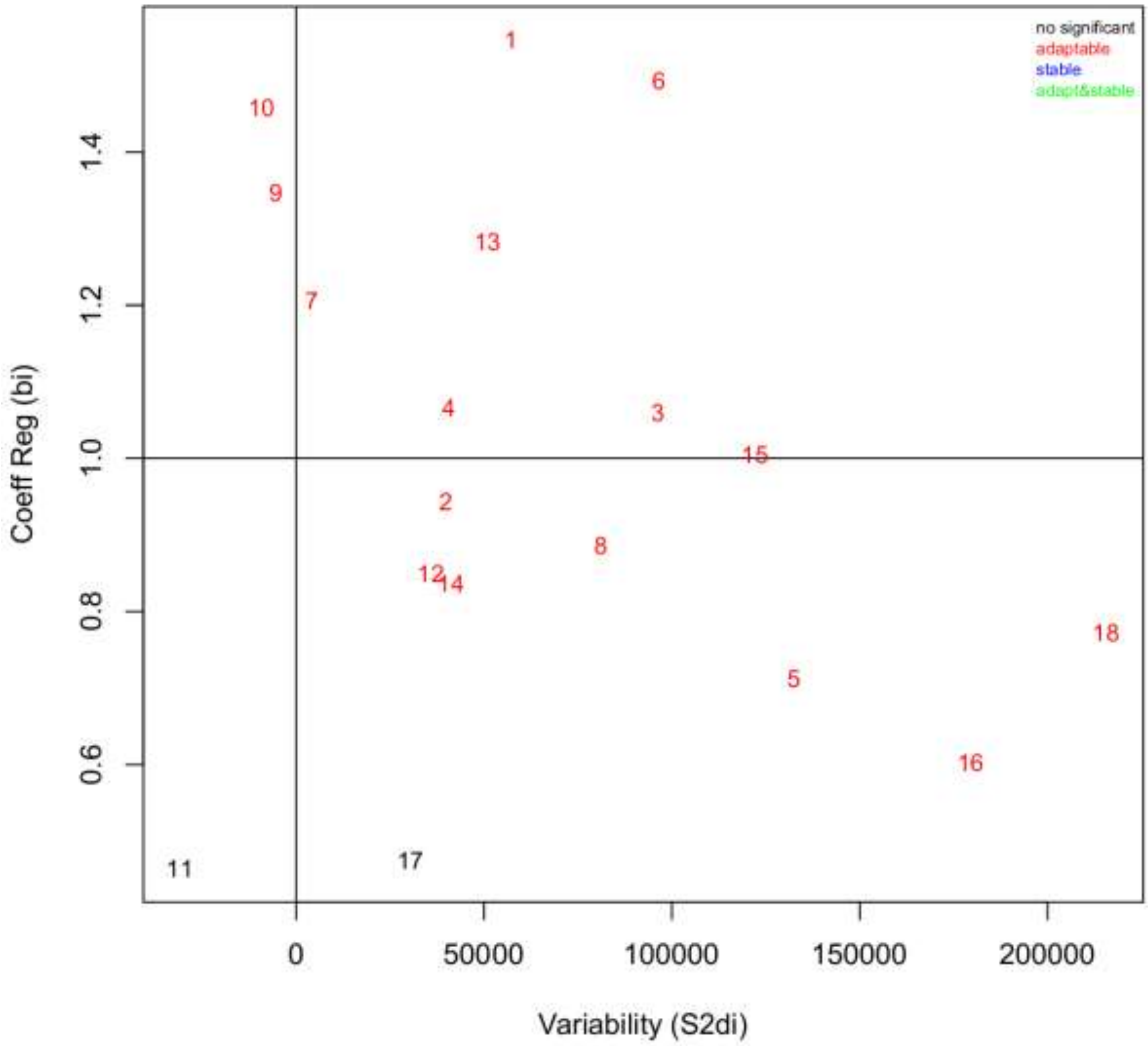

Figure 1. Plot of Eberhart and Russell deviation from regression and coefficient of regression.

Table 4. Mean grain yields and estimates of stability parameters for yield of 18 durum wheat genotypes during 2014 to 2015 in Ethiopia

GEN	Mean	Sd	CV(%) Francis	Eberhart & Russell bi	S^2di	R2	Wricke's Ecovalence
G1	3090.91	908.2327	29.384	1.5465	57110.55	0.8945	895806.659
G2	3455.598	589.6763	17.0644	0.9431	39939.12	0.7892	371430.3448
G3	3818.898	681.9023	17.856	1.0598	96431.72	0.7452	597922.7393
G4	2920.826	651.2114	22.2955	1.0655	40602.7	0.8259	375711.3667
G5	3009.208	550.9641	18.3093	0.7116	132517.6	0.5146	865098.8942
G6	3005.188	897.8703	29.8773	1.4929	96552.06	0.8529	967622.2319
G7	3086.748	701.9114	22.7395	1.205	4154.181	0.9094	288159.4113
G8	2895.762	590.3657	20.3872	0.8861	81198.24	0.695	551495.9
G9	3151.915	772.5518	24.5105	1.347	-5348.66	0.9379	371021.5855
G10	3115.43	830.2525	26.6497	1.4574	-9137.09	0.9506	492847.2481

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G11	3702.796	288.1866	7.7829	0.4639	-30840.6	0.7993	526724.3329
G12	2862.774	540.7219	18.888	0.8487	35988.82	0.7601	385930.9487
G13	2882.827	767.6228	26.6274	1.2821	50916.49	0.8607	533144.5706
G14	3318.345	538.7574	16.2357	0.8365	41316.65	0.7437	413203.577
G15	3116.244	671.2311	21.5397	1.0047	122200.9	0.6913	695522.8022
G16	2997.095	544.8139	18.1781	0.6022	179512.3	0.3769	1168876.209
G17	2971.308	367.7988	12.3783	0.4747	30525.87	0.5139	754483.835
G18	2480.544	630.7791	25.4291	0.7724	215604.3	0.4626	1149018.272

* bi: regression coefficient; S^2di: mean square deviation from regression line; R2: coefficient of determination.

The deviation from regression for G7, G9, G10 and G11 are also low and because of low value of genotypic mean, these genotypes are intermediate stable and poorly adapted to all environments. A desirable genotype with stability and above average grain yield should have a regression line with a positive intercept and slope equal to 1.0 (Eberhart and Russell, 1966). Mohammadi et al. (2012) used linear regression and deviations from the regression model for estimation of stability of twenty durum wheat genotypes in dry land conditions and determined the stable genotypes. However, according to Eberhart and Russell (1966), an ideal genotype would have both a high average performance over a wide range of environments and stability. Therefore, the genotypes including G2, G3 and G14 have good performance and stable cultivars.

Coefficient of determination ranged from 30 to 95% (Tab.3). The coefficient of determination of some durum wheat genotypes was very high. Genotypes 2, 3, 4 and 15 have β value close to one, i.e. genotypes are responsive to good environments. I.e. Genotypes are agronomic stable.

The regression analysis as one of the important parameter which has been frequently employed by plant breeders for stability analysis, showed that there were wide ranges of deviations in genotypes. Deviation from regression for any of the genotypes were not equal to zero ($S^2d = 0$) and the range of this stability parameter varied from -30840.6 (G11) to 179512.3 (G16) (Tab. VI). The estimate of deviations from regressions suggests the degree of reliance that should be put to linear regression in interpretation of the data.

Extra beauty of Genotype 3 (Utuba)

According to pre extension demonstration, “Utuba” has several preferred advantages that make it attractive to farmers. The first is its great tillering capacity. On one hand, this provides more spikes and therefore more yield, the trait most appreciated by farmers. However, the extra stems also provide more straw to be used for feeding livestock, another critical trait for smallholder farmers. Another advantage is early heading, which allows it to avoid the negative effect of the terminal drought and desiccating wind that occur with higher frequency toward the end of the season. Farmers near East shewa saw their neighbors’ bread fields completely wiped by stems rust, but with Utuba, even the worst rust infections only affected 5% of the stem. This high level of resistance to rust was one of the most visually compelling decision points for farmers to adopt the variety. Protein content in this variety tends to be high, the gluten is strong, and the color of the semolina is excellent amber yellow.

Heritability of a trait is important for plant breeders, because it reflects its response to selection. The broad sense heritability (phenotypic variance due to genetic variability) was 69.2% indicating genotype plays a significant role in the expression of the phenotype and selection should give a good response. The important purpose for breeders is to find genotypes with good and stable not only for end-users, but also to provide parents in the future breeding programs. The results of this study indicated that grain yield was significantly influenced by changes in environmental conditions because there were significant variations in grain yields of the genotypes were tested in response to the environment. None of the genotypes evaluated was perfectly stable in all of the environments due to lack of b value equal to unity.

The stability parameter also favors G2, G3, G11 and G14 for their stability in high yielding environment (Haromaya and Chefe donsa). None of the genotypes was favored to low yielding environment (Denbi)

Table 5. Grain yield (kg/ha) of 18 durum wheat genotypes in the six environmental conditions during 2014 to 2015 in Ethiopia

Genotypes	CD	DN	DZ	HM	HN	MN
1.IDON-MD-2009_off/12/2009	3804.69	2384.63	2998.75	4631.90	2543.88	2244.32
2. IDON-MD-2009_off/34/2009	3567.50	2918.46	3407.14	4597.04	3284.86	3037.01
3. IDON-MD-2009_off/53/2009	4089.29	3154.16	4444.27	4695.22	3088.90	3483.39
4. DSP2009_off.F3.2H.22_meh.1H.26	3706.25	2078.21	3218.13	3445.81	2392.43	2686.31

5. DSP2009_off.F4.1H.783_meh.4H.259	3071.38	3068.85	3058.85	3965.82	2771.08	2309.40
6. DSP2009_off.F4.1H.785_meh.2H.	3290.31	1591.47	3550.88	4194.89	2707.21	2799.54
7. DSP2009_F6off/1508/2009	3974.69	2044.68	3077.94	3719.99	3087.35	2728.61
8. IDON-MD-2009_off/25/2009	3236.25	1924.83	2737.19	3662.01	2753.25	3143.75
9. DSP2009_off.F4.1H.378_meh.4H.	3890.00	1939.41	3434.00	3927.19	2988.01	2687.83
10. DSP2009_off.F4.3H.639_meh.1H.	4179.02	1890.93	3143.57	3990.89	2874.79	2774.33
11. DSP2009_off.F4.2H.712_meh.1H.	3834.13	3505.12	3482.71	4238.39	3716.65	3458.88
12. DSP2009_off.F4.2H.735_meh.2H	3677.38	2530.79	2656.80	3439.27	2568.95	2371.69
13. DSP2009_off.F4.3H.976_meh.2H	3640.56	1798.71	3499.52	3607.43	2383.45	2797.83
14. Hitossa	3669.69	2872.50	2877.41	4219.10	3302.47	2913.63
15. Mangudo	3579.85	2080.50	3618.29	3685.88	3558.49	2431.33
16. Ude	2745.00	2626.16	2686.56	4028.51	3209.95	2785.60
17. Yerer	3548.69	2868.66	2803.50	3283.18	2945.74	2525.76
18. Local	3508.38	1534.10	2154.44	2698.02	2486.50	2597.74
Grand Mean	**3611.84**	**2378.45**	**3158.33**	**3890.59**	**2925.78**	**2765.39**
LSD (0.05%)	**633.39**	**333.58**	**551.79**	**441.01**	**355.70**	**555.26**
CV%	**16.90**	**12.46**	**16.18**	**10.35**	**11.11**	**18.01**
Broad sense Heritability	**0.53**	**0.94**	**0.77**	**0.85**	**0.84**	**0.67**

*CD=Chefe donsa,DN=Denbi,DZ=Debrezeit,MH=Haromaya,HN=Hosana,MN=Minjar

4. CONCLUSION

Eighty durum wheat genotypes, including 13 advanced lines with 3 standard and a local check were evaluated during two cropping seasons (2014–2015) at six research sites, representative of major durum wheat producing areas of Ethiopia. Stability parameters were applied to assess stability performance of genotypes and to identify superior genotypes; bi, the linear regression of the phenotypic values on environmental index, S2d, the deviation mean square from regression and coefficient of determination. Genotypes 2, 3, 4 and 15 have β value close to one, i.e. genotypes are responsive to good environments, considered stable for grain yield in all of the environments. G7, G9, G10 and G11 are also low and because of low value of genotypic mean, these genotypes are intermediate stable and poorly adapted to all environments.

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