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Evaluation of Durum Wheat Genotypes for Grain Yield in Southern Tigray, Ethiopia

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Abstract
An experiment was conducted with the objective of assessing the seasonal adaptation and grain yield stability of durum wheat genotype in ofla district. In this trial, twelve durum wheat genotypes were evaluated in three consecutive cropping seasons during 2011-2013.The trial was laid out in randomized complete block design (RCBD) with two replication . The analysis of variance (ANOVA) revealed that there was *significant difference (P< 0.05) for* genotype and genotype by season interaction. The genotypes captured (34.5%) sum of square implying the presence large differentia in the durum wheat genotypes. Using the additive main effect and multiplicative interaction biplot analysis and additive main effect and multiplicative interaction stability value, the genotypes Yerer and Kokate were with higher grain yield and stable in performance across seasons. The genotypes Tate and Local were unstable genotypes contributing more to the increased magnitude genotype by season interaction.
Keywords: AMMI, ASV, Durum Wheat, Season

INTRODUCTION

Bread wheat (*Triticum aestivum* L) and durum wheat (*T. turgidum* L) are the two principal types of wheat grown in Ethiopia. Ethiopia is considered to be one of the centers of genetic diversity to durum wheat while bread wheat has been introduced recently(Tesfaye,1978).World wheat production is almost entirely based on two species, bread wheat (*Triticum aestivum* L.), Which accounts for about 90% of world production, and durum wheat (*Triticum turgidum* subsp. *durum*), which accounts for the remaining 10% of wheat production (CSA,2013) In Ethiopia, total area production during 2012 growing season of wheat was approximately 1.4 million ha with national average productivity of 2.03 tons ha $^{-1}$ (CSA,2010) reported that, in Ethiopia durum and bread wheat species each occupy approximately equal proportion of the area under wheat production. However, change in the relative proportions of wheat types grown in Ethiopia has been reported more recently, with durum and bread wheat occupying approximately 30% and 70%, respectively (Gorfu *et al.,*2001)

Durum wheat is grown specifically for its semolina, a high-protein- content flour that is used in making macaroni, spaghetti and other noodle products. Semolina produces a firm translucent product that imparts a rich yellow color to noodles. The high- quality grain has protein content near 13 % and is free of a black point, a fungal disease that discolors the kernel and semolina. The incidence of the disease is usually influenced by the choice of durum cultivar and cultural practices such as irrigation frequency and the amount and timing of nitrogen fertilizer application.

This low productivity of durum wheat in the country and specifically in Tigray region may be due to production constraints such as shortage of well-adapted improved varieties, poor soil fertility, high incidence of weeds, pests and diseases, and drought. Therefore, the trial was conducted with the aim of filling some production gaps with respect to variety development and adoption of durum wheat varieties in the region in general and South Tigray in particular.

MATERIALS AND METHODS

The present research was carried out in Ofla district, Tigray, Ethiopia, that is located at 12^{o}31'N latitude and 39^{o}33'E longitude. Twelve durum wheat genotypes (ODA, Local, Megenagna, Werer, Illani, Tate, Yerer, Bichena, Ginchi, Mossobo, Kokate and Bakalca) were evaluated during 2011-2013 cropping season. The trial was laid out in randomized complete block design with two replication. A plot consisting of six rows of 2.5 meter length and spacing of 0.2 meter between rows were used. A seed rate of 150 kg ha^{-1} and fertilizer rates of 62 and 46 kg ha^{-1} N and P_2O_5, respectively, were applied. The data were collected on plot basis from the four central rows.

Statistical analysis

The additive main effect and multiplicative interaction (AMMI) were done based on the model suggested by reference (Crossa *et al*.,1991). Analysis was done using the Crop stat 7.2 software.

$$y_{ij} = \mu + G_i + E_j + (\sum_{1}^{n} K_n U_{ni} S_{nj}) + Q_{ij} + e_{ij}$$

Where: (i = 1, 2……….12: j = 1…….3); Y_{ij} = The performance of the i^{th} genotype in the j^{th} environment; μ= The grand mean; G_i = Additive effect of the i^{th} genotype (Genotype mean minus the grand mean); K_n = Eigen value of the PCA axis n,; E_j = Additive effect of the j^{th} environment (Environment mean deviation); U_{ni} and S_{nj} = Scorer of genotype i and environment j for the PCA axis n; Q_{ij} = Residual for the first n multiplicative components, and; e_{ij} = error.
The additive main effect and multiplicative interaction effect stability value (ASV) was done by the formula suggested by reference (Purchase, 1997) and ASV was calculated using Microsoft excel (2007).

$$ASV = \sqrt{\frac{SS_{IPCA1}}{SS_{IPCA2}}(IPCA1score)^2 + \left[IPCA2sccore\right]^2}$$

Where
ASV= AMMI stability value
IPCA1 = interaction principal component analysis 1.
IPCA2 = interaction principal component analysis 2.
SSIPCA1 = sum of square of the interaction principal component one.
SSIPCA2 = sum of square of the interaction principal component two.

RESULT AND DISCUSSIONS

Analysis of Variance for Individual Environments

The analysis of variance (ANOVA) revealed that there was a significant difference (P<0.05) for genotypes and genotype by season interaction. Across the three consecutive cropping seasons the average grain yield of Durum wheat genotypes ranged 29.5-70.4 quintal per hectare. The lowest yield was obtained from the local check and the higher yield obtained from the genotype Kokate (Table 1).

Table 1 Combined analysis of grain yield of durum wheat genotypes.

Name of variety	2011	2012	2013
Bakalca	60	54.3	55.5
Bichena	61.3	46.4	55
Ginchi	65.3	56.5	57.5
Illani	38.9	58.2	55.6
Kokate	50.7	54.9	70.4
Local	29.5	58.9	50.6
Megenagna	39.3	46	57.8
Mossobo	57.5	45.9	59.8
ODA	35.9	51.5	49.8
Tate	69.5	48.9	57.5
Werer	39.9	47.3	59.2
Yerer	59.5	69.7	57
cv	16.6		
Grand mean	53.7		

Additive main effect and multiplicative interaction analysis (AMMI)

The AMMMI analysis additive main effect showed that durum wheat genotypes and genotype by season interaction was significant (P<0.05).Genotype by season interaction explained 56.94% while, the genotypes explained 34.5%.The contribution of season for grain yield variation was very low 8.49%.The magnitude of genotype by season interaction was 1.6 times greater than the genotypes. The genotypes also had profound effect on the yield variation (Table 2).

The grain yield of the durum wheat genotypes were less influenced by the variation in season but most importantly the genotypes were highly diversified and the higher interaction sum of square is caused by the differential of the genotypes. The lower magnitude and less fluctuation of the season is important for selecting stable genotype with no error and farmers considered the season to season stability is the most important rather than location (Annicchiarico and Perenzin ,1994)

The multiplicative interaction component of the AMMI model also showed the interaction principal component 1 explained 76.5% and the interaction principal component 2 explained further 23.5% and the two interaction principal component explained 100% of the variation (Table 2).The AMMI analysis showed that the interaction principal component 1was significant and captured most of the variation. The significant principal component can represent adequately the model without error. Generally When AMMI 2 analysis used for agricultural data, usually a dominated by noise and have no predictive value and no biological interpretability (Van Eeuwijk ,1995)

Table 2. Additive main effect and multiplicative interaction of 12 durum wheat

Source	df	SS	MS	% explained
Treatments	35	6106	174.5	68.09
Genotypes	11	2110	191.8*	34.55
Environments	2	519	259.4ns	8.49
Block	3	304	101.2	
Interactions	22	3477	158.1*	56.94
IPCA 1	12	2660	221.6**	76.50
IPCA 2	10	818	81.8ns	23.52
IPCA 3	8	0	0	
Error	33	2558	77.5	

AMMI 1 bipot analysis

The AMMI biplot analysis is a glance for the genotype and environment evaluation in multi season data. The G3 (ODA), G9 (Local), G5 (Megenagna), G8 (Werer) and G11 (Illani) were lower yielder genotypes below the grand mean G2 (Tate), G4 (Yerer), G6 (Bichena), G7 (Ginchi), G1 (Mossobo), G10 (Kokate) and G12 (Bakalca) where higher yielder genotypes greater than the grand mean (Fig 1). Generally G4(Yerer),G10(Kokate) G12(Bakalca)and G7(Ginchi) were genotypes that had higher yield and stability across the three consecutive cropping seasons and such genotypes can be used as bench mark for selections of durum wheat genotypes (Yan and Tinker,2006). G2 (Tate) and G9 (Local) were unstable genotypes contributing massively to the increased magnitude genotype by season interaction (Fig 1).

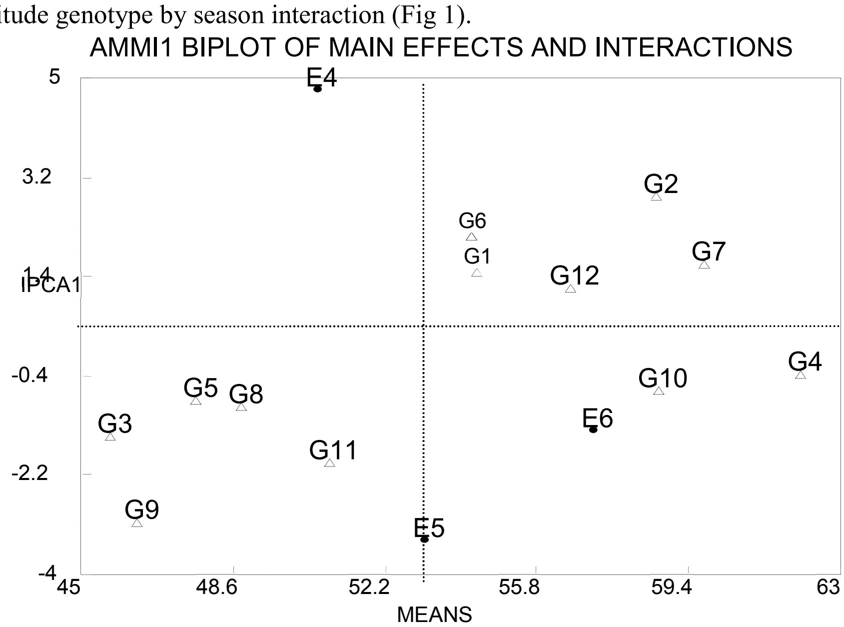

Figure 1. AMMI biplot analysis of 12 durum wheat genotypes
Genotypes abbreviated as G1, ---G12 and season is abbreviated S1, ----S3
S1=2011, S2=2012 and S3=2013, G1=Mossobo, G2=Tate, G3=ODA G4= Yerer, G5=Megenagna, G6=Bichena, G7= Ginchi, G8=Werer, G9= Local G10= Kokate, G11= Illani1 and Bakalca=12

Stability analysis (ASV)

The genotype Yerer was the most stable followed by the genotype Kokate when the interaction principal component one1 is considered.When interaction principal component 2 is only considered the genotype Bichena was stable with lower value followed by Tate. The two interaction principal components have their own extremes and the ASV is balanced measurement in between (Table 3).

The Genotype with lower ASV values is considered more stable and genotype with higher ASV is unstable (Purchase, 1997). Yerer was stable genotype followed by the genotype Kokate. However, the local check was unstable in performance (Table 3)

Table 3. AMMI stability value

Genotype	Mean	IPCA1	IPCA2	ASV
Bakalca	56.61	-1.19053	0.83569	3.96
Bichena	54.23	-2.1162	-0.06477	6.88
Ginchi	59.78	-1.6172	0.98653	5.35
Illani	50.89	1.95215	0.43294	6.36
Kokate	58.67	0.64916	-2.08827	2.97
Local	46.32	3.05207	0.99765	9.97
Megenagna	47.7	0.83417	-1.55379	3.13
Mossobo	54.4	-1.49343	-1.12477	4.98
ODA	45.7	1.49327	0.42436	4.87
Tate	58.66	-2.86855	0.17981	9.33
Werer	48.82	0.94587	-1.59011	3.46
Yerer	62.07	0.35922	2.56475	2.82

CONCLUSIONS

The combined analysis of variance showed genotypes and genotype by season interaction revealed significant difference ($P < 0.05$). Using the different stability and mean grain yield Yerer and Kokate were better genotypes and can be important commercial varieties in southern Tigray.

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