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Identification of Stable Bread Wheat (Triticum Aestivum L) Genotypes using AMMI Analysis in Ethiopia

Zerihun Tadesse[1*], Habtemariam Zegeye, Dawit Asnake, Tafesse Solomon, Yewubdar Shewaye, Tolessa Debele[2]

1Kulumsa Agricultural Research Center (KARC), Assela, Ethiopia
2Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia

***Corresponding Author:** Zerihun Tadesse, Kulumsa Agricultural Research Center (KARC), Assela, Ethiopia.*

ABSTRACT

Developing high yielding and stable genotypes are important in wheat variety development strategy across locations. Twenty-eight bread wheat advanced lines along with two check varieties were evaluated for two years across eight locations in Ethiopia. The experiment was conducted during 2014 and 2015 main cropping season to identify and release best performing genotypes as a variety for resource poor farmer. Experiment was laid out in alpha lattice design in three replications. The analysis of variance for AMMI model of grain yield showed that environment, genotypes and genotype by environment interaction (GEI) effects were highly significant ($p \leq 0.01$) and accounted for 64.7%, 7.2% and 17.1% for the total sum of squares (SS) variations, respectively. The mean grain yield of all genotypes was 4.78 t ha-1 ranging from 3.48 t ha-1 (G12) to 5.47 t ha-1 (G9). Both locations and genotypes are dispersed widely in all quadrants in AMMI-1 biplot which is explaining 95.7% of the total sum of square. In addition, AMMI-2 showed genotypes G6, G5 and G15 were non-sensitive to environmental interactive forces; and hence, these genotypes are considered as stable genotypes while G17, G12, G23 and G3 were unstable genotypes. Based on the grain yield performance of the genotypes across environment, adaptability and other agronomic parameters, G2 was perform better than the standard check G1. Therefore, after one-year variety verification trial, G2 is released as a commercial variety and designated local name called "LEMU" and recommended for high land part of wheat production agro ecology of the country.

Keywords: *Wheat, GEI, AMMI, Stability;*

INTRODUCTION

In Ethiopia, bread wheat (*Triticum aestivum* L.) is one of the most important cereal crops in terms of production and consumption. It is predominantly grown by small-scale farmers under rainfed condition. About 4.9 million farmers produce close to 4.5 million tons of wheat across 1.7 million hectares of land with average productivity of 2.6 t/ha [1]. According to Central Statistic Authority report (1995-2016), wheat area production and productivity increased by 38,762.98 ha/year, 0.16 million tons/year and 0.07 tons/ha/year, respectively. It shows increasing scenario of area (92.29%), production (321.61%) and productivity (119.26%). However, the productivity of wheat per unit area is low as compared to world average (3.41 t/ha) [2].

In Ethiopia, a different climate extreme events are increasingly time to time. Changes in weather and climate form a potential threat to agricultural production and food security throughout the region. Recent evidence suggests that the incidence of droughts and floods in Ethiopia has increased in the last ten years relative to the decade before [3]. This will likely be confounded by additional loss of agricultural productivity due to changes in climate [4]. Targeted intervention can lead to increases in yields in some of Ethiopia's most challenging Environments [5].

Since a variety of climate extreme events are increasing time to time in Ethiopia, developing of widely adaptable, high yielding and disease resistant bread wheat varieties are the main strategy to increase wheat production and productivity in the country. Grain yield is a result of the combined effects of genotype (G), environment (E), and their interaction. Genotype × environment interaction (GEI) is related to component of yield variation across environments for a genotype that cannot be explained either by G or E alone [6]. GEI, defined as the variation in relative performance of genotypes in different environments [7]. Knowledge on the nature, pattern and causes of GEI is vital in plant breeding, including varietal development, parent selection, establish breeding objectives, identify ideal test sites and formulate recommendations domains that can optimize wheat adaptation [8].

Wheat researchers in Ethiopia have been continuously developing wheat genotypes for disease resistance, wide adaptability and high yield, which resulted in the release of many cultivars to farmers. However, most of these cultivars were abandoned from production due to their susceptibility to rust disease [9]. Developing high yielding, stable and rust resistance genotypes are important in wheat variety development strategy and evaluation across locations would form a basis for breeding. Therefore, this study aimed to evaluate and identify bread wheat genotypes for their yield performance and to assess the nature and magnitude of genotype by environment interaction across different wheat agroecologies of Ethiopia to identify and release as a variety for resource poor farmers.

MATERIALS AND METHODS

Twenty-eight bread wheat advanced lines (Table 2) along with two check varieties (Danda'a and Hidasse) were evaluated for two years across eight locations in Ethiopia (Table 1) during 2014/15 and 2015/16 main cropping season (June - November). The locations are different in altitude, mean annual rainfall and soil types. These locations are representing the major wheat growing agro-ecologies ranging from mid to high altitude. Each year at each location was considered as a separate environment, making a total of sixteen test environments for this study. The genotypes were planted in alpha lattice (5x6) with three replications in all locations. Each plot had six rows of 2.5 m length with 0.2 m inter-row spacing. Planting, fertilizer application and other agronomic practices were carried out as per the recommendation of each location. Grain yield data was recorded on plot basis and convert to t ha^{-1} for analysis.

Statistical Analysis

Separate analysis of variance for grain yield for each location was performed prior for combined analysis. However, due to high heterogeneity result of error variance of individual locations for combined, two years' data treated as individual environment for each location. Therefore, a total of sixty environments is used to analyze this data set.

The mean square of genotype by environment interaction (GEI) for grain yield was used to test the effect of genotypes. The genotypes (G) and environments (E) were subjected to AMMI method of analysis [10]. The AMMI model combines the analysis of variance for main effects of G and E with principal components analysis of GEI.

The bi-plot constructed from main effect of means vs the first Interaction Principal Component Analysis Axis (IPCA) from AMMI analysis was used to study the pattern of response of G, E, and GEI. It was also used to identify genotypes with broad or specific adaptation to target environments for grain yield. AMMI-2 biplot was constructed in the dimension of first two IPCA, using a singular-value decomposition procedure [11].

The equation for AMMI model [12]:

$$Y_{ij} = \mu + G_i + E_j + \sum_{n=1}^{N} \lambda_n \alpha_{in} \gamma_{jn} + e_{ij}$$

Where: *Y_{ij} is the yield of the i^{th} genotype in the j^{th} environment; μ is the grand mean; G_i and E_j are the genotype and environment deviations from the grand mean, respectively; λn is the eigen value of the PCA axis n; αin and γjn are the genotype and environment principal component scores for axis n, respectively; N is the number of principal components retained in the model and eij is the error term.*

AMMI model does not make provision for a specific stability measure to be determined, such a measure is essential in order to quantify and rank genotypes according their yield stability. Since the IPCA-1 score contributes more to GEI sum of squares, it has to be weighted by the proportional difference between IPCA-1 and IPCA-2 scores to compensate for the relative contribution of IPCA-1 and IPCA-2 in to the total GEI sum of squares called AMMI stability values (ASV). The following measure was proposed by [13]:

$$ASV = \sqrt{\left[\frac{IPCA1\ sum\ of\ squares}{IPCA2\ sum\ of\ squares}(IPCA1\ score)\right]^2 + (IPCA2\ score)^2}$$

Where: *ASV is AMMI stability values; IPCA-1 is Principal Component Analysis Axis 1; IPCA-2 is Principal Component Analysis Axis 2*

Table1. *Description of the test locations used in 2014/15 and 2015/16*

Location	Geographical Location		Elevation (m.a.s.l)	Climate data		
	Latitude	Longitude		Annual R.F ssss(mm)	Temperature	
					Min	Max
Adet	11^0 15' 41" N	37^0 29' 17" E	2240	869	9.27	25.7
Asasa	07^0 06' 12" N	39^0 11' 32" E	2300	620	5.8	23.6
Bekoji	07^0 31' 22" N	39^0 14' 46" E	2780	1020	7.9	16.6
Denbi	09^0 37' 51" N	39^0 46' 00" E	2473	851	NA	NA
Kulumsa	08^0 01' 00" N	39^0 09' 32" E	2200	820	10.5	22.8
Sagure	07^0 44' 47" N	39^0 09' 24" E	2580	850	7.5	18.4
Shambu	09^0 58' 48" N	37^0 95' 99" E	2550	1200	NA	NA
Debretabor	11^0 51' 00" N	38^0 01' 00" E	2828	1416	6	24

Note: ***E-1****=Adet-2014;* ***E-2****=Asasa-2014;* ***E-3****=Bekoji-2014;* ***E-4****=Denbi-2014;* ***E-5****=Kulumsa-2014;* ***E-6****=Sagure-2014;* ***E-7****=Shambu-2014****;*** ***E-8****= DebreTabor-2014****;*** ***E-9****=Adet-2015;* ***E-10****=Asasa-2015****;*** ***E-11****=Bekoji-2015****;*** ***E-12****=Denbi-2015;* ***E-13****= Kulumsa-2015;* ***E-14****=Sagure-2015;* ***E-15****=Shambu-2015****;*** ***E-16****=DebreTabor-2015*

Table2. *List of 28 genotypes along two checks evaluated across eight locations in 2014 and 2015*

Code	Designation	Pedigree
G1	Danda'a	KIRITATI//2*PBW65/2*SERI.1B
G2	ETBW 6861	WAXWING*2/HEILO
G3	ETBW 8506	AGUILAL/FLAG-3
G4	ETBW 8507	DURRA-4
G5	ETBW 7120	QAFZAH-23/SOMAMA-3
G6	ETBW 8508	REYNA-8
G7	ETBW 7213	CHAM-4/SHUHA'S'/6/2*SAKER/5/RBS/ANZA/3/KVZ/HYS//YMH/TOB
G8	ETBW 8509	REYNA-29
G9	ETBW 7038	ATTILA/3*BCN//BAV92/3/TILHI/5/BAV92/3/PRL/SARA//TSI/VEE#5/4/CROC_1/AE.SQUARROSA (224)//2*OPATA
G10	ETBW 8510	HIJLEEJ-1
G11	ETBW 7058	ROLF07//TAM200/TUI/6/WBLL1/4/HD2281/TRAP#1/3/KAUZ*2/TRAP//KAUZ/5/TACUPETO F2001
G12	ETBW 8511	BOW #1/FENGKANG 15/3/HYS//DRC*2/7C
G13	ETBW 7147	CROC-1/AE.SQUARROSA(224)// OPATA/3/QAFZAH-21/4/SOMAMA-3
G14	ETBW 8512	BABAX/LR42//BABAX*2/3/KURUKU/4/KINGBIRD #1
G15	ETBW 7871	PAURAQ/4/PFAU/SERI.1B//AMAD/3/WAXWING
G16	ETBW 8513	MUTUS//WBLL1*2/BRAMBLING/3/WBLL1*2/BRAMBLING
G17	ETBW 6940	UTIQUE 96/FLAG-1
G18	ETBW 8514	TUKURU//BAV92/RAYON/3/WBLL1*2/BRAMBLING/4/WBLL1*2/BRAMBLING
G19	ETBW 7368	D.56455
G20	ETBW 8515	BECARD/3/PASTOR//MUNIA/ALTAR 84
G21	ETBW 7364	ACSAD1115
G22	ETBW 8516	KACHU/KIRITATI
G23	ETBW 7194	VAN'S'/3/CNDR'S'/ANA//CNDR'S'/MUS'S'/4/TEVEE-5
G24	ETBW 8517	FRNCLN*2/TECUE #1
G25	ETBW 7101	KAMB2/PANDION
G26	ETBW 8518	SUP152/AKURI//SUP152
G27	ETBW 7872	QUAIU/5/FRET2*2/4/SNI/TRAP#1/3/KAUZ*2/TRAP//KAUZ
G28	ETBW 8519	ATTILA/3*BCN*2//BAV92/3/KIRITATI/WBLL1/4/DANPHE
G29	ETBW 6937	AGUILAL/FLAG-3
G30	Hidasse	YANAC/3/PRL/SARA//TSI/VEE#5/4

ETBW = Ethiopian Bread Wheat

Table3. *AMMI analysis of variance for grain yield (t ha^{-1}) of 28 genotypes tested along checks across eight locations in 2014 and 2015*

Source of Variation	df	SS	MS	Sum of square Explained (%)		
				Total variation	G x E Explained	G x E Cumulative
Environments	15	2473.28	164.89***	64.70		
Reps within Env.	32	51.51	1.61	1.30		
Genotype	29	275.62	9.50***	7.20		
Genotype x Env.	435	655.08	1.51***	17.10		
IPCA 1	43	198.95	4.63***		32.51	32.51
IPCA 2	41	131.42	3.21***		21.48	53.99
IPCA 3	39	82.62	2.12***		13.5	67.49
IPCA 4	37	66.16	1.79***		10.81	78.3
IPCA 5	35	43.24	1.24***		7.07	85.36
IPCA 6	33	31.09	0.94***		5.08	90.45
IPCA 7	31	24.94	0.81***		4.08	94.52
IPCA 8	29	19.93	0.69*		3.26	97.78
IPCA 9	27	13.60	0.50ns		2.22	100
IPCA Residual	120	43.13	0.36			
Residual	928	369.77	0.40	9.70		
Total	1439	3825.25				
Grand Mean = 4.78 t ha^{-1}			**R-squared = 0.90**	**C.V = 13.2 %**		**LSD (5%) = 0.25**

*Significant Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1; ***= significant at P ≤ 0.01 and ns= non-significant; IPCA= Interaction principal component axis*

Result and Discussions

The result of analysis of variance (ANOVA) for grain yield revealed highly significant (P ≤ 0.01) differences between genotypes (G), environment (E) and genotype by environment interaction (GEI) (Table 3). Highly significant differences between G and E for grain yield indicating the presence of genetic variability among the genotypes as well as the environments. This is indicated by the mean yield of genotypes across environment range from 3.48 t ha^{-1} (G12) to 5.47 t ha^{-1} (G9) and environmental index ranged from 2.54 t ha^{-1} (E-12) to 6.92 t ha^{-1} (E-11) (Table 4).

Significant GEI suggested the linier function of the additive environment effects and was reflected by the change in the ranking order of genotypes under varying environments. Similar results have been reported by different authors [14], [15], [16] and [17]. However, overall performance of genotypes depends upon the magnitude of GEI. From the total treatment sum of square of the model, 64.7% was attributed to environmental effects and the rest to genotypic effects (7.2%) and GEI (17.1%). The larger sum of square and highly significant mean squares of environment indicated that the environments were diverse, with large differences among environmental means causing most of the variation in grain yield. This shows that the overpowering influence that environments have on the yield performance of wheat genotypes.

GEI component of variation was partitioned into nine possible interaction principal component axes (IPCA). The F-test indicates that except the ninth IPCA, all the first eight IPCA were highly significant (P≤0.01) and they can explain the interaction effect of genotype by environment (Table 3). The first eight significant IPCA explained 97.78% of the total GEI sum of square while the remaining IPCA explained only 2.22%. Therefore, the first eight significant IPCA can be taken as adequate dimensions for this data set. However, the prediction assessment indicated that AMMI model with only two IPCA was the best predictive model [11]. The first two IPCA explain 53.99% of the total GEI sum of square and used for biplot.

Table4. *AMMI adjusted mean grain yield (t ha^{-1}) of 28 genotypes along checks tested across eight locations in 2014/15 and 2015/16*

Entry	Genotype	E-1	E-2	E-3	E-4	E-5	E-6	E-7	E-8	E-9	E-10	E-11	E-12	E-13	E-14	E-15	E-16	Genotype Mean	Rank	IPCA-1	IPCA-2	ASV

1	G1	5.13	6.14	4.72	4.26	3.69	7.60	6.80	5.32	4.85	3.93	7.00	3.01	3.88	7.12	3.89	5.56	5.18	3	-0.16	-0.30	0.39
2	G2	4.53	5.26	6.67	2.95	4.37	7.14	6.03	6.02	4.01	3.10	7.99	2.43	3.55	6.31	4.95	6.00	5.08	9	1.09	-0.16	1.66
3	G3	5.01	6.30	6.51	3.53	4.82	8.13	7.41	5.31	4.41	3.53	7.40	2.94	3.40	6.90	4.33	5.99	5.37	2	0.55	-0.86	1.20
4	G4	4.13	4.85	2.57	3.64	1.87	6.08	5.16	4.47	4.08	3.14	5.85	1.98	3.23	6.16	2.72	4.29	4.01	29	-0.54	0.21	0.84
5	G5	4.36	5.18	4.56	3.34	3.16	6.73	5.78	5.09	4.06	3.14	6.79	2.24	3.32	6.28	3.70	5.10	4.55	23	0.20	-0.09	0.31
6	G6	3.98	4.67	3.63	3.14	2.39	6.11	5.11	4.76	3.79	2.86	6.32	1.85	3.10	5.93	3.22	4.59	4.09	28	0.01	0.14	0.14
7	G7	4.46	4.99	4.45	3.54	2.97	6.48	5.36	5.61	4.27	3.33	7.17	2.32	3.74	6.36	4.08	5.26	4.65	20	0.23	0.31	0.47
8	G8	4.55	4.90	4.35	3.72	2.84	6.33	5.11	5.97	4.44	3.49	7.42	2.40	4.04	6.45	4.33	5.37	4.73	18	0.23	0.58	0.68
9	G9	5.19	6.43	6.22	3.85	4.71	8.17	7.45	5.42	4.66	3.77	7.41	3.10	3.64	7.10	4.33	6.02	5.47	1	0.36	-0.75	0.93
10	G10	4.66	5.03	3.09	4.22	2.18	6.22	5.09	5.60	4.71	3.75	6.85	2.48	4.15	6.65	3.72	4.98	4.59	22	-0.39	0.68	0.90
11	G11	5.12	6.48	4.98	4.11	4.05	8.04	7.45	4.77	4.71	3.81	6.63	3.02	3.46	7.13	3.51	5.48	5.17	4	-0.21	-0.81	0.87
12	G12	3.11	3.21	3.82	2.04	1.77	4.77	3.36	5.24	2.94	1.99	6.74	0.95	2.85	4.91	3.68	4.36	3.48	30	0.75	0.82	1.40
13	G13	3.94	4.36	4.35	2.91	2.62	5.91	4.70	5.42	3.72	2.78	7.00	1.80	3.33	5.80	3.92	4.94	4.22	27	0.47	0.42	0.82
14	G14	4.39	5.17	3.03	3.84	2.28	6.45	5.56	4.68	4.30	3.36	6.12	2.25	3.42	6.42	2.99	4.60	4.30	26	-0.48	0.10	0.74
15	G15	4.94	5.77	3.88	4.29	3.02	7.10	6.22	5.25	4.80	3.87	6.75	2.80	3.92	6.95	3.63	5.23	4.90	15	-0.37	0.02	0.56
16	G16	4.96	6.21	5.18	3.87	4.02	7.81	7.13	4.93	4.54	3.64	6.80	2.87	3.43	6.94	3.70	5.51	5.10	8	0.00	-0.68	0.68
17	G17	4.49	4.86	6.95	2.87	4.30	6.75	5.40	6.72	4.03	3.11	8.60	2.38	3.91	6.20	5.58	6.24	5.15	6	1.41	0.30	2.15
18	G18	5.02	5.87	3.20	4.59	2.69	7.07	6.25	5.04	4.96	4.03	6.44	2.87	3.98	7.09	3.29	5.03	4.84	17	-0.72	0.05	1.09
19	G19	5.15	5.89	3.74	4.61	2.98	7.15	6.24	5.50	5.07	4.13	6.91	3.00	4.22	7.17	3.78	5.35	5.06	12	-0.48	0.16	0.75

20	**G20**	5.05	5.99	4.03	4.37	3.22	7.34	6.53	5.17	4.87	3.94	6.72	2.91	3.89	7.07	3.59	5.30	**5.00**	**14**	**-0.41**	**-0.14**	**0.63**
21	**G21**	4.48	5.02	3.80	3.76	2.61	6.39	5.31	5.41	4.37	3.43	6.86	2.33	3.76	6.43	3.76	5.04	**4.55**	**24**	**-0.07**	**0.36**	**0.38**
22	**G22**	4.56	5.58	4.42	3.61	3.28	7.09	6.28	4.82	4.25	3.33	6.54	2.45	3.30	6.53	3.44	5.08	**4.66**	**19**	**-0.05**	**-0.33**	**0.34**
23	**G23**	4.31	4.45	3.43	3.70	2.09	5.74	4.43	5.86	4.33	3.37	7.13	2.13	4.04	6.22	4.03	4.98	**4.39**	**25**	**0.02**	**0.92**	**0.92**
24	**G24**	5.11	6.22	4.18	4.38	3.44	7.60	6.90	4.96	4.87	3.95	6.60	2.99	3.76	7.15	3.47	5.31	**5.06**	**11**	**-0.44**	**-0.38**	**0.77**
25	**G25**	5.09	6.35	5.00	4.08	3.99	7.90	7.24	4.94	4.70	3.80	6.76	2.99	3.55	7.09	3.65	5.52	**5.16**	**5**	**-0.14**	**-0.67**	**0.70**
26	**G26**	5.00	5.98	3.49	4.47	2.92	7.25	6.49	4.90	4.88	3.95	6.39	2.87	3.81	7.07	3.25	5.06	**4.86**	**16**	**-0.64**	**-0.15**	**0.98**
27	**G27**	5.23	5.85	3.19	4.91	2.64	6.99	6.04	5.59	5.28	4.32	6.86	3.07	4.46	7.29	3.72	5.27	**5.04**	**13**	**-0.71**	**0.39**	**1.14**
28	**G28**	4.93	5.91	5.17	3.87	3.84	7.48	6.63	5.37	4.58	3.66	7.14	2.82	3.70	6.87	4.05	5.60	**5.10**	**7**	**0.14**	**-0.32**	**0.38**
29	**G29**	4.67	5.47	6.06	3.30	4.13	7.23	6.21	5.79	4.22	3.31	7.67	2.57	3.62	6.51	4.61	5.84	**5.07**	**10**	**0.73**	**-0.19**	**1.12**
30	**G30**	4.66	5.23	3.38	4.12	2.47	6.50	5.48	5.35	4.62	3.68	6.72	2.51	3.93	6.66	3.59	4.99	**4.62**	**21**	**-0.35**	**0.38**	**0.66**
ENV Mean ($t\ ha^{-1}$)		**4.67**	**5.45**	**4.40**	**3.80**	**3.18**	**6.92**	**5.97**	**5.31**	**4.44**	**3.52**	**6.92**	**2.54**	**3.68**	**6.62**	**3.82**	**5.26**	**4.78**				
CV (%)		**7.75**	**13.30**	**11.63**	**18.20**	**15.18**	**11.76**	**14.31**	**14.02**	**8.49**	**12.59**	**8.30**	**18.44**	**10.84**	**12.17**	**20.19**	**13.54**					
LSD (5 %)		**0.60**	**2.05**	**0.84**	**1.14**	**1.37**	**1.34**	**1.41**	**1.23**	**0.62**	**0.73**	**0.95**	**0.77**	**0.66**	**2.28**	**1.27**	**1.18**					
R-squared		**0.89**	**0.74**	**0.93**	**0.77**	**0.87**	**0.75**	**0.84**	**0.69**	**0.89**	**0.74**	**0.85**	**0.83**	**0.84**	**0.65**	**0.75**	**0.79**					
IPCA-I		**-0.40**	**-0.55**	**1.70**	**-1.00**	**0.70**	**-0.20**	**-0.40**	**0.53**	**-0.62**	**-0.61**	**0.80**	**-0.38**	**-0.27**	**-0.56**	**0.86**	**0.41**					
IPCA-II		**0.04**	**-0.65**	**-0.68**	**0.35**	**-0.78**	**-0.85**	**-1.24**	**1.02**	**0.32**	**0.28**	**0.64**	**-0.02**	**0.83**	**0.00**	**0.64**	**0.10**					

Note: ***E-1***=*Adet-2014;* ***E-2***=*Asasa-2014;* ***E-3***=*Bekoji-2014;* ***E-4***=*Denbi-2014;* ***E-5***=*Kulumsa-2014;* ***E-6***=*Sagure-2014;* ***E-7***=*Shambu-2014;* ***E-8***= *DebreTabor-2014;* ***E-9***=*Adet-2015;* ***E-10***=*Asasa-2015;* ***E-11***=*Bekoji-2015;* ***E-12***=*Denbi-2015;* ***E-13***= *Kulumsa-2015;* ***E-14***=*Sagure-2015;* ***E-15***=*Shambu-2015;* ***E-16***= *DebreTabor-2015*

AMMI-1 biplot for grain yield of 30 wheat genotypes and eight locations for two years plotted from the main effect against IPCA-1 scores of the genotypes and environment (Figure 1). Accordingly, the IPCA-1 scores range from 1.70 down to -0.99 and grain yield means from 2.54 up to 6.92 t ha^{-1}, which is explained 95.7% of the total sum of square. Both locations and genotypes are dispersed widely in all quadrants in the biplot (Figure 1). The AMMI biplot on the relative magnitude of the position and direction of genotypes on the plane of stability parameters (i.e., interaction principal component axis) regressed on environmental mean yields (main effect) is considered an important measure of not only the pattern of adaptation (wide *vis-à-vis* specific adaptation) but also that of performance stability [12].

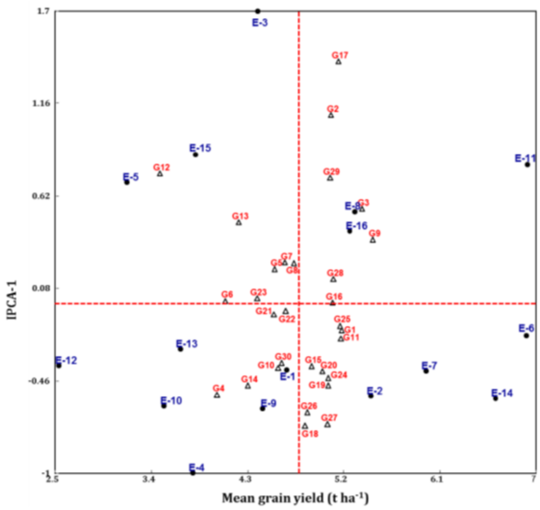

Figure1. *AMMI-1 biplot for grain yield of 28 genotypes along checks evaluated in 2014 and 2015*

Genotypes with IPCA-1 scores close to zero showed better general adaptation than specific adaptation and vice versa. Genotypes; G16 (0.00), G6 (0.01) and G23 (0.02), with IPCA-1 scores closer to zero, showed lesser differential response to the changes in the growing environments as compared to the other genotypes.

However, except G16, these genotypes scored lower grain yield below the mean across tested locations. In the other hand, G17 (1.41), G2 (1.09) and G12 (0.75) scored the highest IPCA-1 and they are considered as non-stable but except G12 the other genotypes showed better grain yield performance across the locations (Table 4). All location and genotypes having the same sign of IPCA-1 score interacts each other positively and different IPCA-1 score sign interacts negatively [11].

In addition, AMMI-2 biplot generated by using the first two interaction principal component axes (IPCA 1 and 2) used to visual interpretation of the GEI patterns and identify genotypes or locations that exhibit low, medium or high levels of interaction effects [6]. AMMI-2 interaction biplots for grain yield of 30 bread wheat genotypes tested in 2014 and 2015 showed in figure 2. Generally, most of the environment having longer vectors projected from the origin and it indicates the ability of the environment to discriminate the tested genotypes and they are providing good information among genotypes.

Accordingly, **E-3** (BEKOJI-2014), **E-7** (SHAMBU-2014) and **E-8** (TABOR-2014) were the most discriminating environments among the genotypes evaluated as indicated by the longer vectors projected from the origin, indicating that these locations gives good information among genotypes as compared to the other locations. In contrary; **E-12** (DENBI-2015), **E-1** (ADET-2014) and **E-16** (TABOR-2015) identified as a least interactive environment with the tested genotypes and it indicates lower interaction of this location with the genotypes evaluated (Figure 2).

Genotypes near the origin are non-sensitive to environmental interactive forces and those distant from the origin are sensitive and have large interactions [18]. Accordingly, genotypes G6, G5 and G15 are non-sensitive to environmental interactive forces; and hence, these genotypes are considered as stable genotypes based on AMMI-II biplot. Whereas;

G17, G12, G23 and G3 were highly influenced by the interactive force of environment and sensitive to environmental changes, so these varieties were considered as unstable genotypes due to the long projections from the origin (Figure 2).

AMMI stability value (ASV)

In ASV method genotypes with least ASV score is the most stable than genotypes with higher ASV [19]. Accordingly, genotypes with small ASV values were G6, G5 and G22 found stable in the current study but except G26, all the genotypes had low grain yield performance across locations (Table 4).

The most unstable genotypes according to the ASV approach are G17, G2, G12 and G3 having high ASV values. However, except G12, these genotypes had above average grain yield potentials.

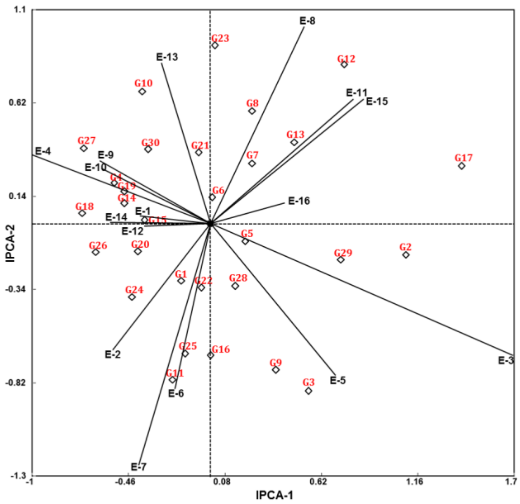

Figure2. *AMMI-2 interaction biplots for grain yield (t ha^{-1}) of 28 genotypes along checks tested in 2014 and 2015*

Generally, based on the grain yield performance of the genotypes, relative adaptability and other agronomic performance of the genotypes including disease resistance (mainly rust), G2 and G3 is selected for further verification. G3 (5.37 t ha^{-1}) was the 2nd high yielding genotypes next to G9 (5.47 t ha^{-1}); and G2 (5.08 t ha^{-1}) is the 9th in terms of mean grain yield rank.

However, there is no significant difference in terms of mean grain yield between G2 and the standard check G1 (Hidasse) (Table 4) and G9 was very susceptible for stem and yellow rust. Therefore, from disease resistance and other agronomic parameters, G2 was perform better than G9 and the standard check G1. Based on this result, after one-year variety verification trial, G2 is released as a variety for commercial production as a local name called "LEMU" in 2016.

Conclusion

The present study revealed that bread wheat yield was liable to a significant fluctuation with changes in the growing environment. Significant differences among the G and E for grain yield indicating the presence of genetic variability among the genotypes as well as the variability of environments under study. Two years' data showed different response of the same location and this indicate there was high seasonal variation within the location. Location contribution for the total variation was high and it contributes for GEI effect being almost nine times higher than that of the genotype effect. AMMI-1 bi-plot clearly displayed the main and interaction effect of genotypes and environment. Based on AMMI-2 biplot, most of the environment having longer vectors projected from the origin and it indicates the ability of the environment to discriminate the tested genotypes and they are providing good information among genotypes.

Further, this study demonstrates the importance of multi-location variety trial in Ethiopia to select best genotypes adapted wide range of environment and specific location. Based on the performance of genotypes across locations, G2 and G3 selected for further test. This two candidate genotypes were submitted to variety verification trial and G2 (ETBW 6861) is released as a commercial variety and designated local name called "**LEMU**" and recommended for high land part of wheat growing agroecologies of the country.

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REFERENCE

[1] Central Statistical Agency (CSA). 2015/16. *Agricultural sample survey for 2015/2016 (2008 E.C).* Volume I. Report on Area and Production of major crops. Private peasant holdings, Meher season. Statistical Bulletin 584. Addis Ababa, Ethiopia.

[2] FAOSTAT. (2016). Statistical Database of the Food and Agriculture of the United Nations.

[3] FDRE. 2013. Ethiopia's Climate Resilient Green Economy: Climate Resilient strategy Agriculture. Fdre, Addis Ababa, Ethiopia.

[4] Jones, P.G., Thornton, P.K., 2003. The potential impacts of climate change on maize production in Africa and Latin America in 2055. Glob. Environ. Chang. 13,51–59.

[5] Mann, M., Warner, J., 2015. Ethiopian Wheat Yield and Yield Gap Estimation: A Small Area Integrated Data Approach. Research for Ethiopia's AgriculturalPolicy, Addis Ababa, Ethiopia.

[6] Yan, W. 2002. Singular-value partition for biplot analysis of multi-environment trial data. Agronomy Journal 94:990–996.

[7] Cooper M. and Byth DE. 1996. Understanding plant adaptation to achieve systematic applied crop improvement- a fundamental challenge. pp 5-23. In Cooper M. and Hammer G.L. (eds.) Plant adaptation and crop improvement. CAB International.

[8] Kemelew Muhe and Alemayehu Assefa. 2011. Diversity and Agronomic Potential of Barley (*Hordeum vulgare* L) Landraces in Variable Production System, Ethiopia: World Journal of Agricultural Sciences 7 (5): 599-603, 2011 ISSN 1817-3047. IDOSI Publications.

[9] Ayele Badebo and RW Stubbs. 1995. Valuable sources of resistance of wheat to the East African yellow rust isolates. In: Danial DL (ed.). Breeding for disease resistance with emphasis on durability. Proceedings of a regional workshop for Eastern, Central and Southern Africa. October 2-6, Njoro, Kenya. 206-214. pp.

[10] Gauch, H.G. and Zobel, R.W. 1997. Identifying mega-environments and targeting genotypes. Crop Science 37(2): 311-326.

[11] Yan, W., Hunt, L.A., Sheng, Q. and Szlavnics, Z. (2000). Cultivar evaluation and mega environment investigation based on the GGE biplot. Crop Science 40: 597-605

[12] Zobel, R.W., Wright, M.J. and Gauch, Jr. H.G., (1988). Statistical analysis of a yield trial. Agronomy Journal 80: 388-393.

[13] Purchase, J.L. (1997). Parametric analysis to describe Genotype x Environment interaction and yield stability in winter wheat. Ph.D. Thesis, Department of Agronomy, Faculty of Agriculture, University of the Free State, Bloemfontein, South Africa.

[14] Zerihun T., A. Dawit, Z. Habtemariam, P. Njau and R. Mongi. 2016. Leveraging from genotype by environment interaction for bread wheat production in eastern Africa. African Crop Science Journal, Vol. 24, Issue Supplement s1, pp. 1 – 10.

[15] Cotes, J.M., Crossa, J., Sanches, A. and Cornelius, P.L.. (2006). A Bayesian approach for assessing the stability of genotypes. *Crop Science* 46: 2654-2665.

[16] Ali, A. (2006). Genetic variation for and correlation among yield traits of wheat under irrigated and rainfed environments. M.Sc (Hons) Thesis. Department of Plant Breed & Genetics, Agric. Univ. Peshawar, Pakistan.

[17] Amin, M., Mohammad, T. Khan, A.J., Irfaq, M., Ali, A. and Tahir, G.R. (2005). Yield stability of spring wheat (Triticum aestivum L.) in the Khyber Pukhtunkhwa, Pakistan. Songklanakarin Journal of Science Technolology 27(6): 1147-1150.

[18] Samonte, S.O.P.B., Wilson, L.T., McClung, A.M. and Medley, J.C. (2005). Targeting Cultivars on to Rice Growing Environments Using AMMI and SREG GGE Biplot Analyses. Crop Science 45:2414-2424.

[19] Purchase, J.L., H. Hatting and Cs. Van de venter. (2000). Genotype by environments interaction of wheat in South Africa: stability analysis of yield performance. South Africa Journal of plant science 17:101-107.

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