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Performance of Bread Wheat (Triticum Aestivum L.) Line Originating from Various Sources

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Abstract

The performance of 78 bread wheat (Triticum aestivum L.) lines, 26 from the crossing block of the National Wheat Research Block and 52 lines introduced from CIMMYT and ICARDA, were evaluated at Kulumsa (WRCoE), Adet, and Holetta Agricultural Research Centers during the 2012 main cropping season. The trial was laid out in simple lattice design with two replications. Data were collected on yield and yield parameters. The combined ANOVA showed that the main effect of environment, genotype, and genotype by environment (G x E) interactions were significantly ($p < 0.05$) different for all traits. The grain yield of the test lines ranged from 2.69-5.93t/ha, with a mean of 4.37t/ha. Genotypes ETBW6595, ETBW6596, and ETBW6597 performed better in grain yield and were found to be early in maturity. However, ETBW6598, ETBW6616 and ETBW6579 were high yielders, but late in maturity compared to the standard check. The mean grain yields of 36 of the 78 test lines, six from local crosses, twenty-nine from CIMMYT origin, and one from ICARDA, were greater than the grand mean. Diversifying the sources of germplasm is essential for using in a national breeding program to enhance national and regional capacities for focused and targeted germplasm development.

Keywords: Genotype by Environment; Bread Wheat; Grain Yield; Germplasm

Introduction

Wheat is the most widely grown cereal crop globally and feeds 4.5 billion people in 95 developing countries [1]. The most common species grown are Triticum aestivum L. (Bread wheat) and Triticum turgidum var. durum L. (durum wheat). Bread wheat accounts for 95% of the total wheat consumed worldwide [2]. It is one of the most important cereal crops in the world. In Ethiopia, it is also one of the major cereal crop and largely grown in the southeast, central and northwest parts. Small amount is also produced in the north and south regions. Its productivity however has been very low because of lack of early maturing, drought tolerant, disease resistance, high yielding genotypes, poor soil fertility and high moisture stress [3].

On average, from 2004-2009, wheat production in Ethiopia covered 1.51 million hectares of land, and yielded 2.60 million metric tons of wheat [4]. In 2013/14, Ethiopia wheat production covered 1.61 million hectares of land and produced 3.93 million tons of wheat, almost twice the quantity produced in 2010 [5] and its rank fourth in area coverage and third in total production among cereal crops in different regions of Ethiopia. Wheat is exclusively produced under rain fed conditions, meher and belg (long and short rainy seasons), respectively. Smallholders are major producers and suppliers of bread wheat, accounting for more than 89% of the market supply. Bread wheat is one of a major cereal of choice in the country, due to its higher productivity, broader adaptation and input responsive high yielding improved varieties. This significantly increased the national wheat area from almost 0 to 60% of the area [6]. Generally wheat has an important place in nourishment of people all over the world. It is necessary to increase wheat production to remove nourishment needs of the excessive population. Borlaug and Dowswell (1997) estimated that global wheat production must increase by 40 % by 2020 to meet the rising demand for wheat grain. In order to increase total production, while the breeders develop new wheat cultivars, on the other hand these new cultivars were tested for their yield performances in the different locations. The success of a new wheat variety depends upon its yield and adaptation potential in those locations [7].

Genotype x environment interactions are of major importance, because they provide information about the effect of different environments on cultivar performance and have a key role for assessment of performance stability of the breeding materials. Increasing genetic gains in yield is possible in part from narrowing the adaptation of cultivars, thus maximizing yield in particular areas by exploiting genotype x environment interaction [8].

Breeding methods play major role in developing high yielding cultivars, resistant to disease with better quality. Yield is a complex character controlled by a large number of genes because it is affected by several yield components i.e. Plant height, hectoliter weight, 100-kernel weight. Therefore, wheat breeders have been concerned with the simultaneous improvement of more than one of these components. Yield potential (YP) is defined as the "yield of a cultivar grown in environments to which it is adapted when nutrients and water are no limiting, and when pests, diseases, weeds, lodging, and other stresses are effectively controlled" [9].

The successful process of wheat breeding is based on the knowledge of characteristics of genotypes, environment and its interaction. The ideal cultivar for high grain yield or for any other desirable traits needs to express genetic potential with low value of variance in different environmental factors of growing. Understanding causes of genotypic-environment interaction helps to establish breeding objectives identify ideal test conditions and formulate recommendations for areas of optimal cultivar adaptation [10].

The presence of genotype x environment (G x E) interaction complicates selection of superior genotypes, and understanding the effect of genotype, environment and G x E interaction is important in all stages of plant breeding [11]. The development of improved varieties of bread wheat (Triticum aestivum L.) has always remained a focal point for wheat breeders all over the world [12]. Therefore, the objective of this study is to evaluate the performance of bread wheat genotypes obtained from various sources in different wheat growing environments.

Materials and Methods

The experimental materials consisted of 78 genotypes and of which 52 were introductions from CIMMYT and ICARDA; and 26 lines developed at Wheat Regional Center of Excellence (WRCoE). In addition, three released varieties (Danda'a, Digelu and Kubsa) were used as a check. The genotypes were evaluated in a simple lattice design with two replications at Kulumsa, Adet and Holetta Agricultural Research Centers during 2012 main cropping season. Each genotype was sown with four rows of 2.5m length with 0.2m space between the rows, being plot size of 2m2. Four rows were harvested and the net harvested plot was 2m2 (2.5m x .8m). Recommended agronomic practices were applied in all sites. The seed rate was maintained at 150 Kg ha-1. The fertilizer was applied at the rate of 70kgN/ha (24kg from P2O5 and 46 from DAP) and 69kg/ha DAP. The N fertilizer in the form of Urea was applied at planting and tillering time (top dressing). But the P fertilizer was applied in the form of Diammonium phosphate during planting time. These three locations were the main variety testing site for wheat regional center Excellence a growing and these three sites (Kulumsa, Adet, Holeta,) were fall in the highland zone (2200-2750 meter above sea level).Data's for heading date, maturity date, plant height, grain yield, thousand kernel weight and hectoliter weight were collected. To estimate significant differences among genotypes the data were subjected to statistical analysis by using AGROBASE20. Data on grain yield and yield component were recorded from each location and statistically analyzed using analysis of variance method for all location and the means were compared using LSD taste.

Results

The result of analysis of variance (ANOVA) for grain yield and yield related traits measured showed significant differences among the genotypes. In breeding programs, genotype x environment (G x E) interactions cause many difficulties, whereas the environmental factors such as temperature and drought stress affect the performance of genotypes. Genotype + environment (GE) interaction reduces the genetic progress in plant breeding program through minimizing the association between phenotypic and genotypic values. Multi-environment yield trails are essential in estimation of genotype by environment interaction (GEI) and identification of superior genotypes in the final selection cycles.

The combined ANOVA showed that the main effect of environment, genotype, and genotype by environment (G x E) interactions were significantly ($p < 0.05$) different for grain yield and yield related traits. Reported that the combined ANOVA analysis for grain yield of bread wheat was significantly affected by environment, which explained 75.01% of the total treatment (genotype + environment + genotype by environment interactions) variation, whereas the G and GEI were significant and accounted for 9.48 and 15.5%, respectively [4]. The grain yield of the test lines ranged from 2.69-5.93t/ha, with a mean of 4.37t/ha. Genotypes ETBW6595, ETBW6596, and ETBW6597 performed better in grain yield and were found to be early in maturity. However, ETBW6598, ETBW6616 and ETBW6579 were high yielders, but late in maturity compared to the standard check. Four genotypes ETBW6600, ETBW6615, ETBW6584, and ETBW6512 were early in maturity and had intermediate grain yield. ETBW6614 and ETBW6605 performed better in hectoliter weight and TKW, indicating their plumpness in grain and high flour content (Table 1). The mean grain yields of 36 of the 78 test lines, six from local crosses, twenty-nine from CIMMYT origin, and one from ICARDA, were greater than the grand mean. Few bread wheat genotypes were significantly different from standard check of grain yield and yield related traits.

No	Name	Pedgree	source
1	Danda'a	Breeder Seed	Breeder seed
2	ETBW 6548	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/PYN/BAU//MILAN	ICARDA
3	ETBW 6549	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/PYN/BAU//MILAN	ICARDA
4	ETBW 6550	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/PYN/BAU//MILAN	ICARDA
5	ETBW 6551	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/PYN/BAU//MILAN	ICARDA
6	ETBW 6553	HAAMAM-2/3/ PYN/BAU//MILAN	ICARDA
7	ETBW 6554	PASTOR-2/3/ PYN/BAU//MILAN	ICARDA
8	ETBW 6555	ZOLOTARA//SHA3/SERI/3/SAMAR-12/DOLLARBIRD	ICARDA
9	ETBW 6556	GOUMRIA-15/3/ PYN/BAU//MILAN	ICARDA
10	ETBW 6557	FLORKWA-2/3PYN/BAW//MILAN	ICARDA
11	ETBW 6558	HOOSAM-8/3/PYN/BAU//MILAN	ICARDA
12	ETBW 6559	HOOSAM-8/3/PYN/BAU//MILAN	ICARDA
13	ETBW 6560	HUBARA-16/3/PYN/BAU//MILAN	ICARDA
14	ETBW 6561	HUBARA-16/3/PYN/BAU//MILAN	ICARDA
15	ETBW 6562	SERI.1B//KAUZ/HEVO/3/AMAD/4/PYN/BAU//MILAN	ICARDA
16	ETBW 6563	GIZA-164/3//PYN/BAU//MILAN	ICARDA
17	ETBW 6564	HUDHUD-10/3/ PYN/BAU//MILAN/4/ANGI-2	ICARDA
18	ETBW 6565	HUDHUD-10/3/ PYN/BAU//MILAN/4/ANGI-2	ICARDA
19	ETBW 6566	HAAMA-16/3/ PYN/BAU//MILAN/4/ANGI-2	ICARDA
20	ETBW 6567	15F/HAR 1522	ETHIOPIA
21	ETBW 6568	15F/HAR 1522	ETHIOPIA
22	ETBW 6569	15F/HAR 1522	ETHIOPIA
23	ETBW 6570	15F/HAR 1522	ETHIOPIA
24	ETBW 6571	15F/HAR 1522	ETHIOPIA
25	ETBW 6572	15F/HAR 1522	ETHIOPIA
26	ETBW 6573	15F/HAR 710	ETHIOPIA
27	ETBW 6574	15F/HAR 710	ETHIOPIA
28	ETBW 6575	15F/HAR 710	ETHIOPIA

29	ETBW 6576	15F/HAR 710	ETHIOPIA
30	ETBW 6577	14F/HAR 1685	ETHIOPIA
31	ETBW 6578	14F/HAR 1685	ETHIOPIA
32	ETBW 6579	14F/HAR 1685	ETHIOPIA
33	ETBW 6580	14F/HAR 1685	ETHIOPIA
34	ETBW 6581	GALAMA/ETBW4698	ETHIOPIA
35	ETBW 6582	GALAMA/ETBW4698	ETHIOPIA
36	ETBW 6583	GALAMA/ETBW4698	ETHIOPIA
37	ETBW 6584	GALAMA/ETBW4698	ETHIOPIA
38	ETBW 6585	GALAMA/ETBW4698	ETHIOPIA
39	ETBW 6586	GALAMA/ETBW4728	ETHIOPIA
40	Digalu	breeder Seed	ETHIOPIA
41	ETBW 6587	DIGELU/(BOW/FENGKANG15)	ETHIOPIA
42	ETBW 6588	DIGELU/(BOW/FENGKANG15)	ETHIOPIA
43	ETBW 6589	SIMBA/ETBW4698	ETHIOPIA
44	ETBW 6590	SIMBA/ETBW4698	ETHIOPIA
45	ETBW 6591	K6295-4A/ETBW4919	ETHIOPIA
46	ETBW 6592	K6295-4A/ETBW4919	ETHIOPIA
47	ETBW 6593	KBG-01/TOWPE	ICARDA
48	ETBW 6594	KBG-01/TOWPE	ICARDA
49	ETBW 6595	KS82W418/SPN/3/CHEN/AE.SQ//2*OPATA/4/FRET2	CIMMYT
50	ETBW 6596	KS82W418/SPN/3/CHEN/AE.SQ//2*OPATA/4/FRET2	CIMMYT
51	ETBW 6597	KS82W418/SPN/3/CHEN/AE.SQ//2*OPATA/4/FRET2	CIMMYT
52	ETBW 6598	VOROBEY	CIMMYT
53	ETBW 6599	CROC_1/AE.SQUARROSA (205)//BORL95/3/2*MILAN/4/TIMBA	CIMMYT
54	ETBW 6600	KS82W418/SPN/3/CHEN/AE.SQ//2*OPATA/4/FRET2	CIMMYT
55	ETBW 6601	PFAU/MILAN//SOVA/3/PBW65/2*SERI.1B	CIMMYT
56	ETBW 6602	ZCL/3/PGFN//CNO67/SN64/4/SERI/5/UA2837/6/BRBT1/7/PRL/2*PASTOR	CIMMYT
57	ETBW 6603	MILAN//PRL/2*PASTOR/4/CROC_1/AE.SQUARROSA (213)//PGO/3/BAV92	CIMMYT
58	ETBW 6604	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/BERKUT	CIMMYT
59	ETBW 6605	CHRZ//BOW/CROW/3/WBLL1/4/CROC_1/AE.SQUARROSA (213)//PGO	CIMMYT
60	ETBW 6606	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/BERKUT	CIMMYT
61	ETBW 6607	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/BERKUT	CIMMYT
62	ETBW 6608	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/BERKUT	CIMMYT
63	ETBW 6609	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/BERKUT	CIMMYT
64	ETBW 6610	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/BERKUT	CIMMYT
65	ETBW 6611	CHRZ//BOW/CROW/3/WBLL1/4/CROC_1/AE.SQUARROSA (213)//PGO	CIMMYT
66	ETBW 6612	CHRZ//BOW/CROW/3/WBLL1/4/CROC_1/AE.SQUARROSA (213)//PGO	CIMMYT
67	ETBW 6613	CHRZ//BOW/CROW/3/WBLL1/4/CROC_1/AE.SQUARROSA (213)//PGO	CIMMYT
68	ETBW 6614	CHRZ//BOW/CROW/3/WBLL1/4/CROC_1/AE.SQUARROSA (213)//PGO	CIMMYT
69	ETBW 6615	SHA3/CBRD//2*WBLL1	CIMMYT
70	ETBW 6616	AZAR 2/4/CROC_1/AE.SQUARROSA (205)//BORL95/3/2*MILAN/5/BERKUT	CIMMYT
71	ETBW 6617	CROC_1/AE.SQUARROSA (205)//BORL95/3/2*MILAN/4/TIMBA	CIMMYT
72	ETBW 6618	SNB//CMH79A.955/3*CNO79/3/ATTILA/4/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/2*KAUZ	CIMMYT
73	ETBW 6619	CROC_1/AE.SQUARROSA (205)//BORL95/3/2*MILAN/4/TIMBA	CIMMYT
74	ETBW 6620	CROC_1/AE.SQUARROSA (205)//KAUZ/3/SASIA/4/TROST	CIMMYT
75	ETBW 6621	MILAN//PRL/2*PASTOR/4/CROC_1/AE.SQUARROSA (213)//PGO/3/BAV92	CIMMYT
76	ETBW 6622	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/BERKUT	CIMMYT
77	ETBW 6623	CHRZ//BOW/CROW/3/WBLL1/4/CROC_1/AE.SQUARROSA (213)//PGO	CIMMYT

78	ETBW 6624	CHRZ//BOW/CROW/3/WBLL1/4/CROC_1/AE.SQUARROSA (213)//PGO	CIMMYT
79	ETBW 6625	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/4/BERKUT	CIMMYT
80	ETBW 6626	MILAN//PRL/2*PASTOR/4/CROC_1/AE.SQUARROSA (213)//PGO/3/BAV92	CIMMYT
81	Kubsa		Breeder seed

Table 1: Source of genotypes with their Pedigree.

C.V	DF	HD	MD	PHT	TKW	HLW	GY
E	2	8979.811**	44619.595**	2899.755**	1476 .175*	5581.521**	693021209.0**
R(E)	3	7.383	23.798	72.241	107.418	18.84	14956283.6
G	80	211.386**	42.038**	444.988**	215.126**	466.905*	3867901.6*
GXE	160	8.577 **	16.588**	31.641**	30.833*8	343.387*8	2823562.1**
Error	240	4.108	6.353	22.253	13.214	17.586	751013.093
Mean CV (%) R2		66.897	124.379	97.224	34.039	71.058	4373.508
		3.03	2.03	4.85	10.68	5.9	19.81
		0.09735	0.9843	0.8973	0.8891	0.9608	0.924

DF = degree of freedom; GY = grain yield; MD =maturity date; HD =heading date; TKW = thousand kernel weight; HLW = hectoliter weight; PHT = plant height.

Table 2: Mean squares for grain yield and yield related traits of 81 (78 tested and 3 checks) bread wheat genotypes tested across three locations in Ethiopia.

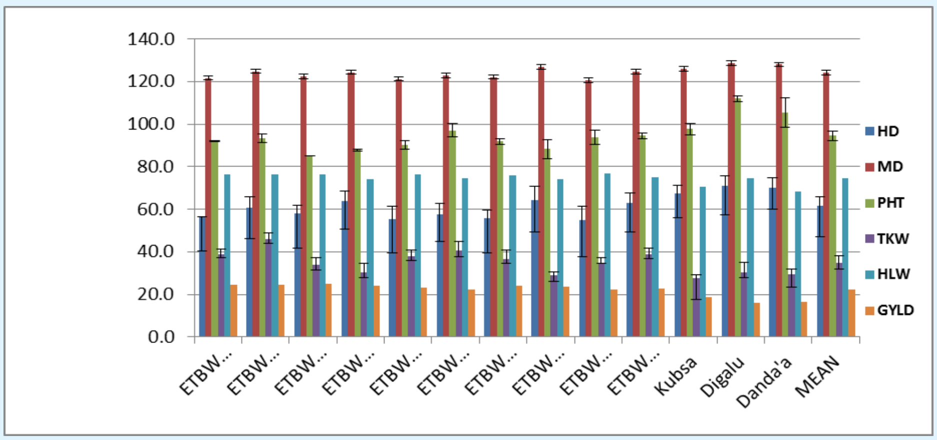

Figure 1: GYLD, HLW, TKW, PHT, MD and HD of significantly high yielder genotypes as compared to the check and grand mean.

Source	Df	ss	MS
Total	8747	1.03E+10	
Environments	17	6.06E+09	356327264.4**
Reps within Env.	18	4152118	230673.2
Genotype	242	2.28E+08	943612.7**
Genotype x Env	4114	3.8E+09	924794**
IPCA 1	258	3.8E+09	14739542
IPCA 2	256	651548	2545.1
IPCA 3	254	314672.8	1238.9
IPCA 4	252	278550.5	1105.4

IPCA 5	250	168993.6	676
IPCA 6	248	114673	462.4
IPCA 7	246	88925.1	361.5
IPCA 8	244	84694.2	347.1
IPCA 9	242	46890.8	193.8
IPCA10	240	28689.3	119.5
IPCA11	238	6726.1	28.3
IPCA12	236	6089	25.8
PCA13	234	4224.8	18.1
IPCA14	232	2846.8	12.3
IPCA15	230	1519.7	6.6
IPCA16	228	831.3	3.6
IPCA17	226	675.3	3
IPCA18	224	0	0
Residual	4356	1.68E+08	38662.16

Table 3: Partitioning of the sum of squares (SS) and mean of squares (MS) from the AMMI analysis of 78 wheat advanced genotypes and 3 checks yield performance evaluated across 3 environments.

GEI was further partitioned by principal component analysis (Table 2). AMMI analysis of 78 bread what genotypes tested in 3 environments showed that bread wheat grain yield was significantly affected by environments (E), genotypes (G) and genotype × environment interaction (GEI) indicating the presence of genetic variation and possible selection of stable entries. AMMI statistical model could be a great tool to select the most suitable and stable high yielding hybrids for specific as well as for diverse environments. In this study, AMMI model has shown that the largest proportion of the total variation in grain yield was attributed to environments.

Discussion

Highly significant differences were observed among bread wheat genotypes evaluated for heading date, maturity date, plant height, TKW, HLW and grain yield. (i.e. Highly significant differences were observed among all the studied characters). Obtained similar result and reported highly significant differences were observed among bread wheat advanced lines evaluated for all the 10 studied characters [6]. Positive and highly significant association were obtained between grain yield plot-1, number of tillers plant-1and grains spike-1at both phenotypic and genotypic levels.

For grain yield ten genotypes (ETBW6595,ETBW6616, ETBW6597, ETBW6579, ETBW6596, ETBW6598, ETBW6600, ETBW6578, ETBW6615 and ETBW6625) had best performance as compared to the standard check and grand mean, in the case of hectoliter weights even genotypes (ETBW6595, ETBW6616, ETBW6597, ETBW6596, ETBW6600, ETBW6615 and ETBW6625)and for thousand kernel weight six genotypes (ETBW6595, ETBW6616, ETBW6596, ETBW6598, ETBW6600 and ETBW6625) had perform better as compared to standard check and grand mean respectively. However, five genotypes (ETBW6616, ETBW6595, ETBW6596, ETBE6660, and ETBW6625) had better performance for hectoliter weight, thousand kernel weight and grain yield as compared to the standard check and grand mean. So, these genotypes can be advanced to preliminary variety trails or other further yield trial evaluation. reported analysis of variance showed significant differences were observed among genotypes in terms the number of spikelet, harvest index, grain yield and grains weight per spike at 1% level and in terms of 1000 grain weight, chaff weight, grain weight per total plant and total plant weight at the 5% level. In case there was no significant difference among genotypes for grain number per spike [13,14].

According to the results, all the traits showed significant difference among different wheat genotypes indicating the existence of genetic variation among genotypes of bread wheat. Results showed that the genotypes, ETBW6595, ETBW6596 and ETBW6597 were high yielder with early maturing nature and there were also four genotypes intermediate yield with early maturity. There were three genotypes that were higher in terms of grain yield, but late in maturity. Therefore, the genotypes that had high yielders with late maturity recommended for high land areas that have optimum moisture and the genotypes that had good yield but early in maturity will recommended for lowland and midland areas for moisture stress after further evaluation.

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