DOI: http://dx.doi.org/10.4314/star.v4i1.1
ISSN: 2226-7522(Print) and 2305-3372 (Online)
Science, Technology and Arts Research Journal
Sci. Technol. Arts Res. J., Jan-March 2015, 4(1): 01-08
Journal Homepage: http://www.starjournal.org/

Original Research

Evaluation of Bread Wheat (*Triticum aestivum* L.) Breeding Lines for Yield and Yield Related Characters in Horo Guduru Wollega Zone, Western Ethiopia

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Abstract

A total of thirty-six bread wheat (*Triticum aestivum* L.) breeding lines were evaluated for yield and yield related traits at high and midland environments of Horo Guduru Wollega Zone, western Ethiopia during 2013 cropping season. The genotypes were grown in a 6 x 6 simple lattice design. Data were collected for 12 morpho-agronomic characters. Since heterogeneity of variance test due to location was significant for most of traits, separate analyses for ANOVA, correlation and principal components were done. The differences between two means for significances were tested using SNK. The results of ANOVA showed that significant differences were observed among the breeding lines at both locations for DH, PH, SPL, SPS, BY, GY and TKW; while for DM and GFP at Gitilo and for HI at Guduru. At both locations, genotypes which showed superior performances compared to the standard checks 'Danada' and 'Kubsa' for biomass yield, grain yield, thousand kernel weight and harvest index include: ETBW7238, ETBW7235, ETBW7220, ETBW7191, ETBW7199, ETBW7182, ETBW7204, ETBW7258, ETBW7264, ETBW7247; and these genotypes are selected for multi-location trials for wide adaptations. Principal components analysis showed that the first four PCs contributed about 81.06 % of the total phenotypic variation in the genotypes at Gitilo; while the first three PCs contributed about 77.01 % to the total phenotypic variations in the genotypes at Guduru. Analysis for traits association showed that at Gitilo, GY had strong and positive associations with SPL and BY, indicating that genotypes with long spike had more kernels or yield than the short spike types. Similarly, at Guduru, GY was significantly and positively correlated with SPS, BY and HI. At both locations, traits which showed strong associations with GY could be used for indirect selection criteria during genotypes evaluation for better adaptabilities to the environment.

Article Information

Article History:

Received : 12-01-2015

Revised : 13-03-2015

Accepted : 16-03-2015

Keywords:

Breeding lines

Correlations

Ethiopia

Horo Guduru

Principal component

Triticum aestivum

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INTRODUCTION

Wheat is the major cereal food crop in the world and also in Ethiopia. Two types of wheat are majorly produced in Ethiopia: durum wheat (tetraploid wheat, 2n=4x=28; *T. durum* Desif.) and bread wheat (hexaploid wheat, 2n=4x=28; *T. aestivum* L.) (Geleta and Grausgruber, 2011; Geleta and Grausgruber, 2013a, b). However, emmer wheat (*Triticum dicoccon* Schrank) is produced in marginal lands in Ethiopia (Zaharieva *et al*., 2010). Bread wheat (*Triticum aestivum* L.) has originated from natural hybrids of three diploid wild progenitors native to the Middle East. These are *T. monococcum, T. tauschii* (syn. *Aegilops squarosa*) and *Aegilops speltoides* (Lelley, 1976; Ribaut *et al.,* 2001). It is an annual cool season cereal crop but it can grow in a wide range of environments around the world. Its production is highly concentrated between the latitudes of 30^0 and 60^0 N, and 27^0 to 40^0 S (Heyne, 1987), and within the temperature range of 3 to 32 ^{0}C. Wheat can grow best on well-drained soil from sea level to about 3000 m.a.s.l.

About one third of the developing world's wheat area is located in environments that are regarded as marginal for wheat production because of drought, heat and soil problems. Gains in wheat productivity in marginal environments are important because it is unlikely that increased productivity in the favourable environments will be sufficient to meet the projected growth in demand for wheat from the present to 2020. The demand for wheat is projected to be 40 percent greater than its current level of 552 million metric tonnes by 2020 (Rosegrant, 1997: Cited in Lantican *et al*., 2002). Environmental stress is the most important factor, which affects crop production. According to Christiansen and Lewis (1982) only about 10% of world arable land may be classified into non-stress category. About 20% of the land is limited by mineral stress, 26% by drought stress and 15% by freezing stress. Modifying the environment for proper crop growth means the alleviation of environmental stresses through the current crop management practices (Arkin and Taylor, 1983). In many cases it may not be possible to modify the environment but the genetic modification of plants to successfully grow in stress conditions is feasible or at least has been demonstrated to be feasible.

Of the total arable land of Ethiopia, more than 50% is classified as semi-arid and arid agro ecological zones. Moisture stress is the major problem in such areas. In semi-arid and arid areas, rainfall is inadequate, erratic and non-uniform in distribution. Moreover, because of degradation and poor vegetation cover, soils in semi-arid and arid area have low fertility with poor water holding capacity. In addition to the above-mentioned problems, weeds also compete with the food crops for the meagre available moisture (Reddy and Kidane, 1991); besides, there are occasional out breaks of pests and diseases. In Ethiopia, wheat is an introduced crop, although its time of introduction is immemorial (Hailu, 1991), and this crop is one of Ethiopian's staple foods and the main source of calorie in the major producing regions; and it is grown between latitudes of 6^0 to 16 ^{0}N, and 35^0 to 42^0 E, with altitudes ranging from 1500 to 2800 m.a.s.l. Wheat stands fourth and 3rd in total national area and grain production respectively; and 2nd in yield per hectare (CSA, 2014). Grain yield and yield related traits are highly variable and significantly modified by environmental factors. The effectiveness of selection depends on the amount of variability present in the genetic material for grain yield and related traits. The relative influence of various traits and their degree of associations can be estimated statistically by correlation (Dewey and Lu, 1959). Determination of relationships of characters can help to identify traits of economic importance. Hybridization provides a chance to combine the desirable characters from two or more lines into a single genotype. The effectiveness, however, depends on the genetic divergence among the lines being crossed. The greater the divergence, the greater are the chances of developing superior yielding genotypes. The present study was carried out with the objectives to select the promising variety/ies for yield and other desirable agronomic traits and to estimate the magnitude of correlation among grain yield and other agronomic traits.

MATERIALS AND METHODS

Descriptions of the Study Areas

The experiment was carried out at two districts (i.e. Gitilo experimental site in Horo woreda and Guduru Animal Production and Research Centre, in Guduru Woreda) of Horo Guduru Wollega Zone, Western Ethiopia. Gitilo experimental site and Guduru Animal Production and Research Centre, represents the highland and mid altitude environments of the wheat growing areas in the Zone respectively. Gitilo is located at 070 12'N and 390 20'W, and altitude 2800 masl; it receives mean minimum and maximum temperature of 9 and 23 ^{0}C respectively; and it receives annual precipitation of 1844 mm. Guduru is located at 080^0 04' N and 390^0 00' W and altitude 1760 masl; it has annual mean minimum and maximum temperature of 16 and 26 ^{0}C respectively, and it receives annual rainfall of 1817 mm.

Experimental Materials

Thirty-six bread wheat breeding lines including two standard checks varieties were selected from 121 materials (bread wheat lines) grown in preliminary yield trial at Shambu during the 2012 cropping season. The 121 genotypes were obtained from Kulumsa Agricultural Research Centre, National Wheat Research Coordination Centre.

Experimental Design and Trial Management

The trials were established in the field on July 17, 2013 at Gitilo and on July 19, 2013 at Guduru. The genotypes were grown in 6 x 6 simple lattice design. Each plot had five rows of 2.5 m length with 20 cm spacing between rows. A 1.5 m space was left between blocks. Recommended rates of the non-experimental variables for the specific testing site such as seed and fertilizer were used. Hence, 100/100 Urea/DAP kg/ha was used for Guduru and 100/90 Urea/DAP kg/ha was used for Gitilo. A seed rate of 150 kg/ha was used at both locations. All other pre and post-stand establishment management practices were done as required.

Data Collection

Data were collected for the following attributes: Days to 50 % heading (DH); days to 95 % maturity (DM); Grain filling period (GFP); grain yield (GY); thousand seed weight (TSW); biological yield (BY); harvest index (HI), tillers/plant (TPP); plant height (PH); number of grains per spike (NGS); spikelet per spike (SPS) and spike length (SPL).

Statistical Data Analysis

All statistical data analyses procedures were done following the procedures of Gomez and Gomez (1984) and computed using SAS software, version 9.0, 2002, USA. Since test for hmogeniety of variance for locations showed significant for most of the traits, separate analysis of variance and other subsequent tests were done for each location. The significance between two means were tested using SNK method at 5% probability level. In addition principal component analysis was carried out to identify traits which contributed more for genotypes differentiation. Pearson's simple phenotypic correlation coefficients between two pairs of traits were calculated from the phenotypic and environmental co-variances obtained by covariance analysis for the traits showed significant differences in ANOVA.

RESULTS

Analysis of Variance

At highland (Gitilo) site, the results of analysis of variance showed that there were significant differences ($P \leq 0.01$) among the genotypes for all traits except for tiller number per plant, number of grains per spike and harvest index (Table 1). The coefficient of variation and range values was higher for GY, BY and TKW indicating that the genotypes were variable. Similarly, at Guduru significant differences ($P \leq 0.01$) were observed among the genotypes for traits including DH, PH, SPL, SPS, BY, GY and TSW and for HI at $P \leq 0.05$ (Table 2). The coefficients of variation and range values for GFP, BY, GY and HI were higher for the genotypes indicating further variability to select genotypes of desirable traits. The characters which showed significant differences among the genotypes at each location are used for the subsequent statistical analyses like correlation and principal component analysis. Further, these traits are important for designing future breeding scheme in the genotypes.

Mean and Range Values for Phenologic and Vegetative Parameters

At Gitilo, the mean values for DH, DM, GFP, PH and TPP and SPL were presented in Table 3. Mean values of the genotypes for DH, DM, GFP, PH, TPP, and SPL ranged from 71 days to 91.0 days, 125 days to 141 days, 41 to 60 days, 67 to 95 cm, 2.0 to 3.40, and 6.0 to 11.0 cm, respectively. The proportion of the genotypes which gave above the average mean of the genotypes for DH, DM, GFP, PH, TPP, and SPL were 47.22, 36.11, 55.56, 47.22, 47.22, and 36.11 %, respectively. The average mean values of the genotypes for the above traits were 80.80 days, 131.74 days, 50.31 days, 81.16 cm, 2.88, and

Table 1: Mean square values for different agronomic traits in bread wheat genotypes tested at Gitilo, 2013

Traits	MSB (Df=1)	MSG(Df=35)	MSE(Df=35)	Min.	Max.
Days to 50% heading	24.50	53.64***	2.50	70.00	93.00
Days to 90 % maturity	0.014	18.53***	3.014	124.00	141.00
Grain filling period	9.39	52.67***	7.39	39.00	61.00
Plant height, cm	0.117	67.28***	1.30	66.50	95.30
Tiller number per plant	0.061	0.25ns	0.15	1.50	3.50
Spike length, cm	0.014	4.78***	0.014	6.00	11.00
Spikelets per spike	2.00	5.30***	1.37	12.00	20.00
Number of grains per spike	1.84	0.185ns	0.15	2.20	4.50
Biological yield (t/ha)	23.99	9.88***	2.106	6.01	18.44
Grain yield (t/ha)	7.17	3.27***	0.59	2.48	8.62
Harvest index	0.0012	0.0025ns	0.003	0.30	0.60
Thousand grain weight, g	0.014	22.67***	1.014	33.00	49.00

*and ** significant at P ≤ 0.05 and P≤ 0.01, respectively; Df- degrees of freedom.

Table 2: Mean square values for different agronomic traits in bread wheat genotypes tested at Guduru, 2013

Traits	MSB (Df=1)	MSG (Df=35)	MSE (Df=35)	Min.	Max.
Days to 50% heading	8.68	46.19***	9.51	53.00	75.00
Days to 90 % maturity	5.01	113.10ns	64.93	91.00	126.00
Grain filling period	26.89	65.51ns	52.80	21.00	68.00
Plant height, cm	194.08	65.98**	26.80	31.55	76.30
Tiller number per plant	0.67	0.51ns	0.30	1.44	5.100
Spike length, cm	1.46	1.51***	0.42	3.65	9.100
Spikelet per spike	5.02	4.56***	1.66	6.44	14.22
Number of grains per spike	0.002	0.221ns	0.28	2.00	4.50
Biological yield (t/ha)	0.73	3.78***	1.20	2.36	8.83
Grain yield (t/ha)	0.158	0.85***	0.21	0.66	3.62
Harvest index	0.0001	0.016*	0.008	0.15	0.80
Thousand grain weight, g	8.000	19.26**	8.31	28.00	45.00

*and ** significant at P ≤ 0.05 and P≤ 0.01, respectively; Df- degrees of freedom; ns- non-significant.

Table 3: Mean values for different phenology and vegetative traits in bread wheat genotypes tested at Gitilo, 2013

S/No	Genotypes	DH	DM	GFP	PH (cm)	TPP	SPL
1	ETBW 7178	84.5 cdef	135.5 bcd	51.0 abcdefg	84.50 bcde	2.85	10.0 c
2	ETBW 7252	86.0 cde	133.0 bcde	47.0 bcdefg	81.40 defghijk	2.45	10.5 b
3	ETBW 7238	93.0 a	140.5 a	42.5 fg	79.05 hijkl	3.25	11.0 a
4	ETBW 7198	84.5 cdef	132.5 bcde	47.0 bcdefg	71.40 n	3.40	8.0 e
5	Kubsa	76.0 jkl	130.5 cdef	54.5 abcd	95.25 a	3.20	9.0 d
6	ETBW 7237	91.0 ab	133.0 bcde	41.0 g	76.30 lm	2.65	9.0 d
7	ETBW 7171	83.0 cdefgh	131.5 bcde	48.5 bcdefg	80.75 efghijk	3.15	8.0 e
8	ETBW 7208	87.5 bcd	133.0 bcde	45.5 bcdefg	94.25 a	3.15	9.0 d
9	ETBW 7236	84.5 cdef	128.0 ef	43.5 efg	67.30 o	3.15	7.0 f
10	ETBW 7248	81.5 efghij	129.0 def	47.5 bcdefg	70.35 n	2.50	6.0 g
11	ETBW 7173	85.5 cde	129.5 def	44.0 defg	77.75 jkl	3.20	8.0 e
12	ETBW 7235	88.5 BC	129.5 def	41.0 g	81.25 defghijk	2.70	7.0 f
13	ETBW 7268	84.5 cdef	127.5 ef	43.0 fg	84.25 bcdef	3.20	6.0 g
14	ETBW 7174	75.5 kl	131.5 bcdef	56.0 ab	87.45 b	2.90	8.0 e
15	ETBW 7220	77.0 ijkl	132.0 bcde	55.0 abc	85.35 bcd	2.60	7.0 f
16	ETBW 7221	77.5 ghijkl	132.0 bcde	54.5 abcd	84.05 bcdef	2.35	6.0 g
17	ETBW 7227	75.5 kl	132.5 bcde	59.0 a	86.35 bc	3.15	8.0 e
18	ETBW 7239	75.5 kl	128.0 ef	52.5 abcdef	84.65 bcde	3.00	9.0 d
19	ETBW 7160	77.0 ijkl	128.5 def	51.5 abcdefg	85.35 bcd	3.25	9.0 d
20	ETBW 7161	79.0 fghijk	132.0 bcde	48.5 bcdefg	84.20 bcdef	2.8	10.0 c
21	ETBW 7191	75.5 kl	128.5 def	52.5 abcdef	81.70 defghij	2.85	10.0 c
22	ETBW 7199	83.5 cdefg	131.5 bcdef	48.0 bcdefg	83.30 cdefg	3.10	11.0 a
23	ETBW 7182	78.0 ghijkl	128.5 def	50.5 abcdefg	81.00 efghijk	2.80	10.0 c
24	ETBW 7194	78.5 ghijkl	131.0 bcdef	52.5 abcdef	80.20 fghijk	3.15	6.0 g
25	ETBW 7204	78.5 ghijkl	131.0 bcdef	52.5 abcdef	78.05 jkl	3.30	7.0 f
26	ETBW 7234	73.0 lm	131.5 bcdef	56.0 ab	79.55 ghijkl	2.00	8.0 e
27	ETBW 7164	84.5 cdef	132.5 bcde	48.0 bcdefg	86.40 bc	3.30	10.0 c
28	ETBW 7195	78.0 ghijkl	133.5 bcde	55.5 abc	79.15 hijkl	2.65	8.0 e
29	ETBW 7244	80.5 efghijk	134.5 bcde	54.0 abcde	77.40 kl	2.80	6.0 g
30	ETBW 7258	70.5 m	130.5 cdef	60.0 a	82.30 defghi	3.10	10.0 c
31	ETBW 7264	73.0 lm	125.0 f	52.0 abcdef	82.95 cdefgh	2.75	9.0 d
32	ETBW 7215	78.5 ghijkl	136.5 abc	59.0 a	74.30 m	2.30	6.0 g
33	ETBW 7156	82.5 defghi	134.5 bcde	52.0 abcdef	78.75 ijkl	3.15	7.0 f
34	ETBW 7247	81.5 efghij	134.5 bcde	53.0 abcdef	81.40 defghijk	2.35	7.0 f
35	DANADA'A	83.5 cdefg	132.0 bcde	47.5 bcdefg	71.75 n	2.80	7.0 f
36	ETBW 7175	82.5 defghi	137.5 ab	45.0 cdefg	82.45 cdefghi	2.35	8.0 e
	MEAN	**80.80**	**131.74**	**50.31**	**81.16**	**2.88**	**8.21**
	CV (%)	**1.96**	**13.20**	**5.40**	**1.41**	**13.42**	**1.44**

8.21 cm respectively. The mean values of the above traits for standard checks 'Kubsa' and 'Danada' were 76.0 and 83.50 days, 130.50 and 132.0 days, 54.50 and 47.50 days, 95.25 and 71.75 cm, 3.20 and 2.80, and 9.0 and 7.0 cm, respectively.

At Guduru, the mean values for DH, DM, GFP, PH, TPP and SPL were presented in Table 4. Mean values of the genotypes for DH, DM, GFP, PH, TPP, and SPL ranged from 54.0 days to 75.0 days, 92.0 days to 124.0 days, 35.0 to 60 days, 42.99 to 71.49 cm, 2.15 to 4.21, and 4.6 to 8.10 cm, respectively. The proportions of the genotypes which gave above the average mean of the genotypes for DH, DM, GFP, PH, TPP, and SPL were 36.11 %, 50.0 %, 38.89 %, 50.0 %, 44.44 %, and 52.78 %, respectively. The average mean values of the genotypes for the above traits were 63.51, 105.46 days, 41.94 days, 59.43 cm, 3.10, and 6.29 cm respectively. The mean values of the above traits for standard checks 'Kubsa' and 'Danada' were 68.50 and 59.0 days, 113.50 and 96.50 days, 45.0 and 37.50 days, 62.55 and 56.89 cm, 2.94 and 2.70, and 6.96 and 6.65 cm, respectively.

Table 4: Mean values for phenology and vegetative traits in bread wheat genotypes tested at Guduru, 2013

S/No.	Genotypes	DH	DM	GFP	PH	TPP	SPL
1	ETBW 7178	66.0 abcde	104.0	38.0	64.83 ab	2.75	7.66 abc
2	ETBW 7252	59.5 bcde	94.0	34.5	58.55 abc	4.05	6.49 abcd
3	ETBW 7238	60.0 bcde	98.0	38.0	60.72 abc	2.66	5.77 abcd
4	ETBW 7198	67.5 abcd	115.0	47.5	58.55 abc	3.05	7.93 ab
5	Kubsa	68.5 abcd	113.5	45.0	62.55 abc	2.94	6.96 abcd
6	ETBW 7237	63.5 abcde	102.5	39.0	62.66 abc	2.49	6.44 abcd
7	ETBW 7171	59.5 bcde	96.5	37.0	42.99 c	3.27	4.66 d
8	ETBW 7208	67.0 abcd	112.0	45.0	66.22 ab	3.10	5.94 abcd
9	ETBW 7236	64.0 abcde	124.0	60.0	60.16 abc	2.93	6.82 abcd
10	ETBW 7248	63.5 abcde	102.0	38.5	45.82 bc	3.27	5.10 cd
11	ETBW 7173	67.0 abcd	114.5	47.5	60.00 abc	2.71	6.82 abcd
12	ETBW 7235	71.5 ab	112.5	41.0	71.49 a	3.05	6.71 abcd
13	ETBW 7268	65.0 abcde	102.5	37.5	62.99 abc	3.60	7.43 abc
14	ETBW 7174	57.0 de	111.0	54.0	57.61 abc	2.99	6.38 abcd
15	ETBW 7220	59.5 bcde	109.5	50.0	63.33 abc	3.99	6.38 abcd
16	ETBW 7221	67.5 abcd	110.0	42.5	59.94 abc	4.21	6.27 abcd
17	ETBW 7227	66.0 abcde	104.5	38.5	56.55 abc	3.55	5.60 abcd
18	ETBW 7239	60.0 bcde	97.5	37.5	56.10 abc	2.54	5.27 cd
19	ETBW 7160	59.0 bcde	105.0	46.0	59.33 abc	3.27	5.38 bcd
20	ETBW 7161	67.5 abcd	108.5	41.0	55.22 abc	3.66	5.60 abcd
21	ETBW 7191	63.0 bcde	100.5	37.5	64.44 ab	3.33	6.82 abcd
22	ETBW 7199	60.5 bcde	112.0	51.5	61.54 abc	3.83	6.33 abcd
23	ETBW 7182	75.0 a	110.0	35.0	66.77 ab	3.49	5.82 abcd
24	ETBW 7194	58.5 cde	106.0	47.5	55.27 abc	3.16	8.10 a
25	ETBW 7204	65.5 abcde	108.0	42.5	51.75 abc	2.94	6.71 abcd
26	ETBW 7234	59.0 bcde	95.0	36.0	70.15 a	3.10	5.53 abcd
27	ETBW 7164	54.0 e	92.0	38.0	56.05 abc	2.10	5.32 bcd
28	ETBW 7195	62.0 bcde	100.0	38.0	61.25 abc	3.40	5.15 cd
29	ETBW 7244	68.0 abcd	110.0	42.0	54.44 abc	3.40	5.60 abcd
30	ETBW 7258	63.0 bcde	101.0	38.0	61.00 abc	2.65	6.65 abcd
31	ETBW 7264	64.0 abcde	106.5	42.5	56.96 abc	2.50	6.50 abcd
32	ETBW 7215	71.0 abc	113.0	42.0	64.28 ab	2.15	6.30 abcd
33	ETBW 7156	58.5 cde	96.5	38.0	60.95 abc	2.70	5.75 abcd
34	ETBW 7247	70.0 abc	116.0	46.0	57.95 abc	3.35	8.05 a
35	DANADA'A	59.0 bcde	96.5	37.5	56.89 abc	2.70	6.65 abcd
36	ETBW 7175	56.5 de	96.5	40.0	54.10 abc	2.75	5.30 cd
	MEAN	**63.51**	**105.46**	**41.94**	**59.43**	**3.10**	**6.29**
	CV (%)	**4.86**	**7.64**	**17.32**	**8.71**	**17.59**	**10.28**

Yield and Yield Components

The mean values for SPS, NGPS, BY, GY, HI and TKW at Gitilo were presented in Table 5. Mean values of the genotypes for SPS, NGPS, BY, GY, HI and TKW ranged from 13.0 to 19.50, 2.4 to 3.8, 6.59 to 14.80 t/ha, , 2.78 to 7.56 t/ha, 0.35 to 0.54, and 33.50 to 48.0 g, respectively. The proportion of the genotypes which gave above the average mean of the genotypes for SPS, NGPS, BY, GY, HI and TKW were 63.89, 47.22, 47.22, 50.0, 41.67, and 52.78 %, respectively. The average mean values of the genotypes for the above traits were 19.92, 3.02, 11.19 t/ha, 5.08 t/ha, 0.45, and 41.99 g respectively. The mean values of the above traits for standard checks 'Kubsa' and 'Danada' were 17.50 and 13.50, 3.40 and 2.90, 8.45 and 9.10 t/ha, 3.95 and 4.55 t/ha, 0.45 and 0.45, and 48.0 and 33.50 g, respectively. Genotypes which are superior to the best standard check 'danada (4.55 t/ha)' for grain yield, thousand kernel weight and harvest index include: ETBW 7252, ETBW7238, ETBW7198, ETBW7208, ETBW7235, ETBW7220, ETBW7227, ETBW7161, ETBW7191, ETBW7199, ETBW7182, ETBW7204, ETBW7258, ETBW7264, ETBW7215, ETBW7247, and ETBW7175. And these genotypes are selected for further over locations testing.

The mean values for SPS, NGPS, BY, GY, HI and TKW at Guduru were presented in Table 6. Mean values of the genotypes for SPS, NGPS, BY, GY, HI and TKW ranged from 7.6 to 13.53, 2.10 to 3.50, 3.10 to 8.74 t/ha, , 0.78 to 3.01 t/ha, 0.22 to 0.64, and 30.50 to 41.50 g, respectively. The proportion of the genotypes which gave above the average mean of the genotypes for SPS, NGPS, BY, GY, HI and TKW were 63.89, 30.56, 50.0, 50.0, 41.67, and 50.0 %, respectively. The average mean values of the genotypes for the above traits were 10.81, 2.69, 5.10 t/ha, 1.67 t/ha, 0.33, and 35.19 g respectively. The mean values of the above traits for standard checks 'Kubsa' and 'Danada' were 13.10 and 11.80, 2.60 and 2.40, 5.63 and 5.83 t/ha, 1.71 and 1.38 t/ha, 0.30 and 0.23; and 33.0 and 33.0 g, respectively. Genotypes which are superior to the best standard check 'Kubsa' for grain yield (1.71 t/ha), thousand kernel weight and harvest index include: ETBW 7178, ETBW 7238, ETBW 7236, ETBW 7248, ETBW 7173, ETBW 7235, ETBW 7174, ETBW 7220, ETBW 7191, ETBW 7199, ETBW 7182, ETBW 7204, ETBW 7234, ETBW 7258, ETBW 7264 and ETBW 7247. And these genotypes are selected for further over locations testing.

Table 5: Mean values for different grain yield & other yield components in bread wheat genotypes tested at Gitilo, 2013.

S/No.	Genotypes	SPS	NGPS	BY (t ha^{-1})	GY (t ha^{-1})	HI	TKW (g)
1	ETBW 7178	18.0 abc	2.6	9.10 abcde	4.42 bcdef	0.46	47.0 abc
2	ETBW 7252	14.0 cd	3.5	13.86 ab	6.32 abcd	0.45	45.0 abcdef
3	ETBW 7238	19.0 ab	3.8	14.11 ab	7.56 a	0.54	45.5 abcde
4	ETBW 7198	16.5 abcd	2.8	14.75 a	7.31 ab	0.49	41.5 fghij
5	Kubsa	17.5 abcd	3.4	8.45 bcde	3.95 def	0.45	48.0 a
6	ETBW 7237	16.5 abcd	2.8	11.17 abcde	5.12 abcdef	0.46	38.5 jklmn
7	ETBW 7171	15.5 abcd	3.1	12.24 abcd	5.36 abcdef	0.43	36.0 n
8	ETBW 7208	16.0 abcd	3.2	14.80 a	7.04 abc	0.48	44.5 bcdefg
9	ETBW 7236	16.0 abcd	2.6	10.98 abcde	5.26 abcdef	0.48	39.5 ijklm
10	ETBW 7248	16.5 abcd	2.6	6.59 e	2.78 F	0.42	47.5 ab
11	ETBW 7173	16.0 abcd	2.8	10.32 abcde	4.31 bcdef	0.41	38.0 klmn
12	ETBW 7235	17.0 abcd	2.8	12.49 abcd	5.64 abcdef	0.45	43.5 defgh
13	ETBW 7268	15.5 abcd	3.1	9.30 abcde	4.16 cdef	0.44	46.0 abcd
14	ETBW 7174	13.0 d	2.8	8.55 bcde	3.04 ef	0.35	44.0 cdefgh
15	ETBW 7220	15.5 abcd	2.6	14.57 a	7.10 abc	0.49	43.0 defghi
16	ETBW 7221	14.0 cd	2.8	7.20 de	2.95 ef	0.41	36.0 n
17	ETBW 7227	16.5 abcd	2.4	13.42 abc	5.87 abcde	0.43	41.5 efghij
18	ETBW 7239	13.5 cd	3.1	11.78 abcde	5.63 abcdef	0.47	37.5 lmn
19	ETBW 7160	17.0 abcd	2.7	9.12 abcde	3.87 def	0.42	41.0 ghijk
20	ETBW 7161	16.5 abcd	2.8	12.40 abcd	5.78 abcdef	0.47	43.0 defghi
21	ETBW 7191	16.0 abcd	3.2	11.22 abcde	5.22 abcdef	0.47	44.5 bcdefg
22	ETBW 7199	19.5 a	3.3	13.04 abc	6.21 abcd	0.47	42.5 defghi
23	ETBW 7182	16.5 abcd	3.2	12.57 abcd	6.09 abcd	0.48	40.5 hijkl
24	ETBW 7194	16.5 abcd	3.3	8.40 bcde	3.68 def	0.43	43.0 defghi
25	ETBW 7204	13.5 cd	3.3	12.79 abcd	6.22 abcd	0.48	43.5 defgh
26	ETBW 7234	15.5 abcd	3.2	10.65 abcde	4.77 abcdef	0.44	37.0 mn
27	ETBW 7164	19.0 ab	2.8	9.77 abcde	4.00 def	0.41	43.0 defghi
28	ETBW 7195	14.5 bcd	2.8	9.18 abcde	3.82 def	0.41	41.5 FGHIJ
29	ETBW 7244	13.5 cd	3.2	9.89 abcde	3.69 def	0.38	42.5 defghi
30	ETBW 7258	16.0 abcd	3.2	11.89 abcde	5.26 abcdef	0.44	45.0 abcdef
31	ETBW 7264	17.0 abcd	2.9	13.25 abc	6.31 abcd	0.47	43.5 defgh
32	ETBW 7215	13.5 cd	2.8	13.65 abc	6.26 abcd	0.45	41.5 fghij
33	ETBW 7156	16.0 abcd	2.8	7.89 cde	3.47 def	0.44	41.0 ghijk
34	ETBW 7247	16.50 abcd	3.3	12.37 abcd	5.01 abcdef	0.40	42.0 efghi
35	Danda'a	13.5 cd	2.9	9.10 abcde	4.55 bcdef	0.45	33.5 o
36	ETBW 7175	16.0 abcd	3.2	10.41 abcde	5.04 abcdef	0.48	40.5 hijkl
	Mean	**15.92**	**3.02**	**11.19**	**5.08**	**0.45**	**41.99**
	CV (%)	**7.36**	**12.84**	**12.96**	**15.10**	**11.83**	**2.40**

Principal Component Analysis

The results of the principal component analysis for Gitilo and Guduru sites are presented in the Table 7 and 8 respectively. At Gitilo, the first four PCs accounted bout 81.06 % of the total phenotypic variation in the genotypes. The PC1 accounted about 30.73 % variations in the genotypes; and DH, GFP, SPL, SPS, BY, and GY are among the traits which contributed more to the phenotypic variations in the PC1; while DH, GFP, PH, SPL, and TSW showed more disparities to show differentiation in the genotypes in PC2 (21.62%). At Guduru, the first three PCs (PC1, PC2, and PC3) contributed about 77.01 % to the total phenotypic variations in the genotypes. All traits (DH, PH, SPL, SPS, BY, GY and HI) had more contributions in the PC1 (40.49 %); while PH, SPL, GY and HI had more contributions to the phenotypic variations in PC2 (20.68%).

Correlation Analysis

The results of phenotypic correlation analysis were presented in Table 9 and 10 for Gitilo and Guduru respectively. At Gitilo, GY had strong and positive associations with SPL and BY, indicating that longer spike genotypes had more kernels/yield than the short spike types. Genotypes with higher biomass due to high productive tillers had higher GY and productivity than

Table 6: Mean values for different yield and other yield components in bread wheat genotypes tested at Guduru, 2013

S/No.	Genotypes	SPS	NGPS	BY (t ha^{-1})	GY (t ha^{-1})	HI	TKW
1	ETBW 7178	12.7 ab	2.6	5.05 abc	1.76 abcde	0.34 ab	37.5
2	ETBW 7252	12.5 ab	2.3	4.68 abc	1.22 abcde	0.26 b	36.0
3	ETBW 7238	9.7 ab	3.0	5.31 abc	2.03 abcde	0.38 ab	38.0
4	ETBW 7198	9.0 ab	2.8	5.70 abc	1.29 abcde	0.24 b	34.0
5	KUBSA	13.1 a	2.6	5.63 abc	1.71 abcde	0.30 ab	33.0
6	ETBW 7237	11.0 ab	3.1	4.59 abc	1.18 abcde	0.25 b	38.5
7	ETBW 7171	8.7 ab	2.3	3.14 c	1.10 cde	0.36 ab	36.0
8	ETBW 7208	11.1 ab	3.1	3.20 c	0.97 de	0.32 ab	41.5
9	ETBW 7236	13.53 a	2.6	7.08 abc	2.67 abcde	0.37 ab	37.0
10	ETBW 7248	9.1 ab	2.3	6.46 abc	2.96 ab	0.45 ab	32.5
11	ETBW 7173	13.2 a	3.1	4.76 abc	3.01 a	0.64 a	31.5
12	ETBW 7235	11.5 ab	2.5	5.13 abc	1.91 abcde	0.38 ab	35.5
13	ETBW 7268	12.7 ab	2.6	3.38 c	0.93 de	0.27 b	38.5
14	ETBW 7174	9.8 ab	2.3	6.66 abc	1.81 abcde	0.26 b	34.0
15	ETBW 7220	11.1 ab	2.6	4.90 abc	1.73 abcde	0.36 ab	35.5
16	ETBW 7221	8.9 ab	2.45	4.25 bc	1.05 cde	0.25 b	33.0
17	ETBW 7227	10.7 ab	3.5	4.82 abc	1.55 abcde	0.34 ab	34.5
18	ETBW 7239	12.0 ab	2.3	3.10 c	1.11 cde	0.36 ab	32.5
19	ETBW 7160	10.9 ab	2.6	3.82 bc	0.91 de	0.28 b	31.0
20	ETBW 7161	9.0 ab	2.1	4.55 abc	1.01 cde	0.22 b	30.5
21	ETBW 7191	11.5 ab	2.9	6.20 abc	1.86 abcde	0.30 ab	30.5
22	ETBW 7199	11.3 ab	3.1	5.27 abc	2.36 abcde	0.45 ab	34.0
23	ETBW 7182	11.8 ab	2.4	6.17 abc	2.79 abcd	0.45 ab	38.0
24	ETBW 7194	9.2 ab	2.6	4.91 abc	1.57 abcde	0.33 ab	33.0
25	ETBW 7204	11.0 ab	2.6	5.54 abc	1.87 abcde	0.33 ab	41.0
26	ETBW 7234	11.8 ab	2.8	4.13 bc	1.79 abcde	0.43 ab	37.0
27	ETBW 7164	7.6 b	2.6	3.41 c	1.01 cde	0.29 ab	37.5
28	ETBW 7195	10.9 ab	2.3	3.59 c	0.78 e	0.22 b	38.5
29	ETBW 7244	9.0 ab	2.9	3.82 bc	1.00 cde	0.26 b	35.0
30	ETBW 7258	11.5 ab	3.2	6.05 abc	2.87 abc	0.47 ab	31.5
31	ETBW 7264	11.3 ab	2.8	6.79 abc	2.32 abcde	0.36 ab	38.0
32	ETBW 7215	11.8 ab	2.4	8.74 a	1.72 abcde	0.19 b	31.5
33	ETBW 7156	9.3 ab	3.2	5.41 abc	1.34 abcde	0.25 b	31.5
34	ETBW 7247	11.0 ab	2.7	8.07 ab	2.50 abcde	0.31 ab	41.0
35	Danda'a	11.8 ab	2.4	5.83 abc	1.38 abcde	0.23 b	33.0
36	ETBW 7175	8.5 ab	2.6	3.46 c	1.13 cde	0.32 ab	35.5
	Mean	**10.81**	**2.69**	**5.10**	**1.67**	**0.33**	**35.19**
	CV (%)	**11.92**	**19.68**	**21.49**	**27.40**	**27.56**	**8.19**

those with low biomass yield and less productive tillers. Therefore, simultaneous selections for the above traits for individual genotype will improve both traits. DH was highly but negatively correlated with GFP, indicating those genotypes with longer DH had short GFP and vice versa. If the two traits are not controlled by similar or linked genes, selection could be done separately. SPL was positively and highly correlated with SPS indicating the two traits could simultaneously be improved through selection. DH and DM were positively and strongly associated; and PH and SPL were also positively and strongly associated; But GFP and SPS were highly but negatively associated. TSW had positive and strong association with PH and SPS, indicating longer stalks genotypes had higher TSW and productivity than the short stalk types; though longer stalks genotypes are not important due to the lodging effect in wheat.

At Guduru, GY was significantly and positively correlated with SPS, BY and HI, hence higher biomass with more productive tillers give more grain yield than others. Similarly, higher SPS are highly associated with higher GY. Both traits are important yield components which could be used for selection criteria during genotypes evaluation for better adaptabilities to the environment. BY was also positively and significantly correlated with DH and SPL; and SPS was positively and highly correlated with PH and SPL.

Table 7: Principal component analysis for different agronomic traits of wheat genotypes tested at Gitilo, 2013

Traits	PC1	PC2	PC3	PC4
DH	0.374	-0.494	0.190	0.129
DM	0.186	-0.146	-0.049	0.896
GFP	-0.334	0.466	-0.239	0.306
PH	0.069	0.517	0.241	0.116
SPL	0.389	0.321	0.125	-0.114
SPS	0.369	0.102	0.445	-0.134
BY	0.425	0.152	-0.515	-0.056
GY	0.460	0.113	-0.474	-0.078
TKW	0.170	0.316	0.380	0.187
Eigen values	2.766	1.950	1.560	1.026
Proportion (%)	30.73	21.62	17.30	11.40
Cumulative variance(%)	30.73	52.36	69.66	81.06

Table 8: Principal component analysis for different agronomic traits of wheat genotypes tested at Guduru, 2013

Traits	Prin1	Prin2	Prin3
DH	0.358	0.241	-0.100
PH	0.298	0.432	0.496
SPL	0.363	0.335	-0.260
SPS	0.423	0.162	0.417
BY	0.412	-0.010	-0.587
GY	0.472	-0.479	-0.122
HI	0.281	-0.623	0.378
Eigen values	2.830	1.450	1.110
Proportion (%)	40.49	20.68	15.84
Cumulative variance (%)	40.49	61.17	77.01

Table 9: Pearson correlation coefficients for agronomic traits of wheat genotypes tested at Gitilo, 2013

Traits	DH	DM	GFP	PH	SPL	SPS	BY	GY	TKW
DH	1.00	0.41*	-0.85**	-0.24	0.09	0.31	0.15	0.21	0.02
DM		1.00	0.01	-0.03	0.07	0.06	0.14	0.15	0.04
GFP			1.00	0.24	-0.13	-0.35*	-0.09	-0.18	0.03
PH				1.00	0.37*	0.20	0.05	0.00	0.34*
SPL					1.00	0.52**	0.36*	0.41*	0.23
SPS						1.00	0.11	0.18	0.36*
BY							1.00	0.96**	0.05
GY								1.00	0.06
TKW									1.00

Table 10: Pearson correlation coefficients for agronomic traits of wheat genotypes tested at Gudru, 2013

Traits	DH	PH	SPL	SPS	BY	GY	HI
DH	1.00	0.32	0.31	0.33	0.37*	0.29	0.07
PH		1.00	0.30	0.53**	0.11	0.08	0.05
SPL			1.00	0.38*	0.45**	0.27	-0.03
SPS				1.00	0.26	0.37*	0.29
BY					1.00	0.66**	0.02
GY						1.00	0.74**
HI							1.00

DISCUSSION

At Gitilo (highland) and Guduru (midland) analyses of variance showed that significant differences among the genotypes for most of the traits indicating the genotypes are variable and can be used as source materials for subsequent breeding works. The range values were higher for the traits including DF, DM, GFP, PH and TSW; while coefficients of variations for traits were higher at Guduru (midland) than at Gitilo (highland) showing the more prominent effect of environment at Guduru than at Gitilo. Because at Guduru the rainfall amount was shorter and lower in intensity; and temperature was high as compared to the highland with longer rainfall period and low temperature. In addition, the soil characteristics of the two sites are different (Deressa, 2013). The mean values for all traits for the genotypes at Gitilo are higher than at Guduru except for tiller number per plant indicating the highland area is suitable for wheat production. The number of tiller per plant at Guduru is higher than at Gitilo. The mean values for productivity which could be expressed as seed yield per hectare, biological yield per hectare and harvest index are higher and it was 2, 3 and 1.4 times respectively higher than at Guduru. Wheat is suitably grown at higher altitude or cooler environments than warmer areas (Geleta, 2015) and in Ethiopia also wheat is suitably grown in range of altitudes between 2200 m.a.s.l and 2800 m.a.s.l (Geleta and Grausgruber, 2011). In present study Gitilo represents higher altitude areas while Guduru represents low altitude areas. Therefore, in Ethiopia altitude affects the rainfall distribution and temperature which is directly connected to photosynthetic efficiency of the crop.

The performances of the genotypes with respect to biological yield, grain yield, harvest index and thousand seed weight are different in the two sites. For instances, the rank of the genotypes with respect to the performance of the indicated traits are different. Regarding grain yield, the top ten best performed varieties at Gitilo include ETBW 7238, ETBW 7198, ETBW 7220, ETBW 7208, ETBW 7252, ETBW 7264, ETBW 7215, ETBW 7204, ETBW 7199, and ETBW 7182. The highest yielder variety ETBW 7238 gave 7.56 t ha^{-1}; 14.11 t ha^{-1}; 0.54 and 45.5 g for grain yield, biological yield, harvest index and thousand seed weight respectively. However; at Guduru the top ten ranking varieties for grain yield include ETBW 7173, ETBW 7248, ETBW 7258, ETBW 7182, ETBW 7236, ETBW 7247, ETBW 7199, ETBW 7264, ETBW 7238, ETBW 7235. The highest yielder variety ETBW 7173 gave 3.01 t ha^{-1}, 4.76 t ha^{-1}, 0.64 and 31.5 g for grain yield, biological yield, harvest index and thousand seed weight, respectively. Therefore, the ranks of the genotypes were changed due to genotype by environment interaction which could force the breeders to carry out adaptation trial in different environments. Effect of environment on quantitative traits is high since quantitative traits are controlled by many genes with small individual effects (Allard, 1960). In agreement with present findings, Girma *et al*. (2001) reported that moisture stress environments are the limiting factors in bread wheat production and expansion in Ethiopia and there is high interaction of genotypes with environment.

The results of the principal component analysis for traits showed that the first four and three PCs at Gitilo and Guduru, respectively, accounted about 81.06 % and 77.01 % of the total phenotypic variations in the genotypes indicating that variations among the genotypes are due to majorly the traits considered. However, there were unexplained variables accounted for variations which could be attributed to environment. Phenotypic traits including DH, GFP, SPL, SPS, BY, and GY; and DH, PH, SPL, SPS, BY, GY and HI are among the traits which contributed more to the phenotypic variations in the PC1 at Gitilo and Guduru respectively.

At Gitilo, GY had strong and positive associations with SPL and BY, indicating that they are direct and indirect contributors to grain yield and could be considered for indirect selection for grain yield. DH was highly but negatively correlated with GFP, indicating those genotypes with longer in DH had short GFP and vice versa. Corroborating the present findings, Guendouz and Maamari (2012) reported the negative correlation of days to heading and velocity of grain filling in durum wheat varieties. These could be due to two reasons: 1. The two traits might be controlled by linked genes or pleotropic genes, and selection could not be easy to improve both traits as the same time; 2. Genotypes with higher DH and Shorter GFP are due to external environmental factors such as late types genotypes encounter terminal moisture stress and higher temperature that hastens maturity or grain filling. However, further evidence could support the two assumptions. Spike length was positively and significantly correlated with SPS indicating the two traits could simultaneously be improved through selection. Yahaya (2014) also reported positive significant correlation of yield with length of spike, spike lets per spike, weight of main spike and plant height. DH and DM were positively and strongly associated; and PH and SPL were also positively and strongly associated; but GFP and SPS were significantly but negatively associated. TSW had positive and strong association with PH and SPS, indicating longer stalk genotypes had higher TSW and more productive than the short stalk types; though longer stalks genotypes are not important due to the lodging effect in wheat. At Guduru, GY was significantly and positively correlated with SPS, BY and HI, hence higher biomass with more productive tillers give more grain yield than others. Belay *et al.* (1993) reported strong associations of grain yield with thousand kernel weight and tiller number per plant in tetraploid wheat from Ethiopia. Fischer and Kertesz (1976) concluded from their experiment that harvest index is the best predictor of grain yield in wheat. Similarly, higher SPS are significantly associated with higher GY. Both traits are important yield components which could be used for indirect selection criteria during genotypes evaluation for better adaptabilities to the specific environment. BY was also positively and significantly correlated with DH and SPL; and SPS was positively and highly correlated with PH and SPL. Girma *et al.* (2001) also found strong associations of grain yield with test weight, plant height and thousand kernel weight in moisture stress environments for bread wheat varieties in Ethiopia.

CONCLUSIONS

The results of ANOVA showed that significant differences among the breeding lines at both locations for DH, PH, SPL, SPS, BY, GY and TKW; while for DM and GFP at highland (Gitilo) and for HI at midland (Guduru). High coefficients of variations were observed at Guduru as compared to at Gitilo indicating that high influence of environment on the performances of the genotypes at lowland areas. Higher mean values were observed for all traits at Gitilo than at Guduru indicating the high potential of the highland areas as compared to the lowland areas for wheat production. The rank of genotypes for grain yield potential were changed with respect to the two sites indicating genotype by environment interaction on the yield and yield related traits of wheat. However, at both locations, genotypes which showed superior performances compared to the standard checks 'Danada' and 'Kubsa' for biomass yield, grain yield, thousand kernel weight and harvest index include: ETBW7238, ETBW7235, ETBW7220, ETBW7191, ETBW7199, ETBW7182, ETBW7204, ETBW7258, ETBW7264, ETBW7247; and these genotypes are selected for multi-location trials for wide adaptations. Principal components analysis showed that the first four PCs contributed about 81.06 % of the total phenotypic variation in the genotypes at Gitilo; while the first three PCs contributed about 77.01 % to the total phenotypic variations in the genotypes at Guduru site. Analysis for traits association showed that at Gitilo, GY had strong and positive associations with SPL and BY, indicating that genotypes with long spike had more kernels or yield than the short spike types. Similarly, at Guduru, GY was significantly and positively correlated with SPS, BY and HI. At both locations, traits which showed strong associations with GY could be used for indirect selection criteria during genotypes evaluation for better adaptabilities to the environment. In conclusion separate breeding strategies are needed for highland and lowland areas for wheat production and the need to evaluate genotypes for their adaptabilities in the two environments.

Conflict of Interest

Conflict of interest none declared

Acknowledgments

The authors thank Kulumsa Agricultural Research Centre for providing the planting materials. The authors also thank Wollega University for financing the project.

REFERANCE

Allard, R.W. (1960). Principles of Plant Breeding. John Wiley and Sons. Inc. New York.

Belay, G., Tesemma, T., Becker, H.C. and Merker, A. (1993). Variation and interrelationships of agronomic traits in Ethiopian tetraploid wheat landraces. *Euphytica* 71(3): 181-188.

CSA (2014). Agricultural Sample Survey in 2013/2014 (2006 E.C.). Report on Area and Production of major crops for Private Peasant Holdings, Meher Season. Vol. 1, Statistical Bulletin Number 532, Addis Ababa, Ethiopia.

Deressa, A. (2013). Evaluation of soil acidity in agricultural soils of smallholder farmers in south western Ethiopia. *Science, Technology and Arts Research Journal* 2(2):1-6.

Dewey, D.R., Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal* 51: 515-518.

Fischer, R. A., Kertesz, Z. (1976). Harvest index in spaced populations and grain weight in microplots as indicators of yielding ability in spring wheat. *Crop Science* 16(1)*:55-59.*

Geleta, N. (2015). Patterns of variation for phenotypic traits in Tetraploid Wheat (*Triticum turgidum* L.) populations of Ethiopia. *Agricultural and Biological Sciences Journal* 1(2): 42-51.

Geleta, N., Grausgruber, H. (2013a). Morphological and quality traits variation in tetraploid and hexaploid wheat accessions from Ethiopia. *Agricultural Science Research Journal* 3(8): 229-236.

Geleta, N., Grausgruber, H. (2013b). On-farm diversity and genetic erosion in Tetraploid wheat landraces in Ambo and Dandi Districts, West Shewa, Ethiopia. *Science, Technology and Arts Research Journal* 2(1): 1-9.

Geleta, N., Grausgruber, H. (2011). Phenotypic variation of Ethiopian hexaploid wheat accessions. *East African Journal of Sciences* 5(2): 89-97.

Gomez, K.A., Gomez, A.A. (1984). Statistical Procedures for Agricultural Research, 2nd ed. John Wiley & Sons, USA.

Girma, B., Alemayehu, Z., Gelalcha, S. (2001). Drought tolerance of some bread wheat genotypes in Ethiopia. *African Crop Science Journal* 9(2): 385-392.

Guendouz, A., Maamari, K. (2012). Grain-filling, chlorophyll content in relation with grain yield component of durum wheat in a mediterranean environment *African Crop Science Journal* 20(1):31-37.

Lelley, J. (1976). Wheat breeding: Theory and practice. Akademial Kiado, Budapest.

Ribaut, J.M., William, H.M., Khairallah, M., Worland, A.J., Hoisington, D. (2001). Genetic basis of physiological traits, pp. 29-47. In: Reynolds, M.P., Ortiz- Monasterio, J.I., McNab, A. (Ed.) Application of Physiology in Wheat Breeding. Mexico, D.F. CIMMYT.

Yahaya, Y. (2014). Estimate of genetic variability and correlation coefficients for some quantitative characters in bread wheat (*Triticum aestivum* L.). *World Journal of Agricultural Sciences* 2(7):163-167.

Zaharieva, M., Geleta, N., Hakimi, A.A., Misra, S.C. (2010). Cultivated emmer wheat (Triticum dicoccon Schrank) an old crop with promising future: a review. *Genetic Resources and Crop Evolution* 57: 937-962.