International Journal on Data Science and Technology
2025, Vol. 11, No. 2, pp. 18-26
https://doi.org/10.11648/j.ijdst.20251102.11

Research Article

Bread Wheat (Triticum aestivum L.) Variety Adaptation Trial for Moisture Stress Areas at Yabello District, Southern Oromia, Ethiopia

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Abstract

The field experiment was conducted at Yabello Onsite for three years; 2018, 2019 and 2023 on main cropping seasons. Six bread wheat varieties were evaluated. The trial was laid out in randomized complete block design (RCBD) with three replications. The experiment was objected to increase production and productivity of bread wheat and recommend best variety for agro-pastoralists and farmers in lowland agro-ecology and specifically to identify cultivars with better adaptability, high yielder and tolerant to drought. The combined analysis of variance showed that there was significant difference among varieties in yield and yield related traits in all cropping years. The highest grain yield was obtained from "Amibara-2" variety (3918.2 kg/ha) followed by "Fentalle-2" (3700.5 kg/ha) while the lowest grain yield was recorded from werer-2 variety (3073.8 kg/ha). The result of the experiment suggests conducting research work on adaption trials of different crop enhances production and productivity for end users. Therefore, the identified varieties were suggested for further demonstration and popularization in Borana lowland and areas with similar agro-ecology.

Keywords

Adaption, Bread Wheat, Lowland

1. Introduction

Wheat (*Triticum aestivum, 2n = 6x = 42*) is an important staple food crop and is grown on about 225 Mha annually worldwide [18]. It is an important cereal crop which is cultivated worldwide and extensively grown in temperate regions. Wheat is produced under a wide range of climactic conditions and geographical areas and due to its high adaptability with various climactic conditions of environment, its distribution range is more than any other plant species and it is the staple food for most of the world's increasing population. It is the staple food for 40% of the world‟s population [29]. It is the 2nd to rice which provides 21% of the total food calories and 20% of the protein for more than 4.5 billion people in 94 developing countries [8]. Global wheat grain production must increase by 2% annually to meet the requirement of consistently increasing world population till 2050 [32]. Wheat is the most important food security crops in Ethiopia. It is the 2nd most important crop next to tef in terms of area coverage in Ethiopia, but most of the production is concentrated in the highland plateaus of the country [6, 7]. Bread wheat was introduced to Ethiopia in the early 1940's and

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Received: 14 January 2025; **Accepted:** 27 April 2025; **Published:** 12 June 2025

since 1970's; it is the dominant wheat type covering currently more than 90% of the total wheat production area in Ethiopia [10, 19]. The demand for wheat in Ethiopia has been increasing over the years because of rapid population growth and urbanization which necessitated change in food preferences that are easy and fast to prepare such as bread, biscuits, pasta and porridge from the wheat flour. It is cultivated on a total area of 2.1 million (1.7 million ha rain fed and 0.4 million ha irrigated) hectares annually with a total production of 6.7 million tons of grain at an average productivity of 3.0 and 4.0 t/ha under rain-fed and irrigated conditions, respectively during 2021/22 [9].

Wheat production in Ethiopia is constrained by lack of improved varieties, biotic factors (weeds, diseases and insect pests etc.) and a biotic factors frequent drought (rain fall variability (intensity as well as duration), declining soil fertility, mono-cropping, poor management practices and climate change [28]. Additionally, growing populations, increased rural-urban migration, low public and private investments, weak extension systems, inappropriate agricultural policies, and yield gaps because of low adoption of new technologies remains to be major challenges [26, 33].

Wheat is one of the most important food grain crops in Oromia region. The grain is used for food and local beer preparation in different forms. In addition to this, farmers used wheat grain for marketing to generate income and cover other required costs. Its straw is also very important for animals feed. The popularity of wheat comes from the variability of its use in production of variable food products. It has different important nutritive value such as protein (>10%), lipid (2.4%), and carbohydrate (79%); thus, it accounts about 20% of the calorie intake of human diet [23, 16].

Crop adaptation to climate change requires accelerated crop variety introduction accompanied by improvement and recommendations to help farmers match the best variety with their field contexts [12] contributing to the increase in agricultural production in several regions worldwide [17]. The main objectives of wheat breeding in Ethiopia are to develop varieties with high and stable grain yield and quality, and resistant to biotic and abiotic stresses. Many wheat varieties have been released by national and regional research institutes that are adaptable to a wide range of environments for commercial production. With these objectives, the Oromia agricultural research institute has developed different improved bread wheat varieties with key characteristics such as high grain yield and quality, resistance to rusts, tolerance to drought and consumer preferences such as taste, baking and nutritional quality.

Wheat is among the major cereal crop produced in Borana Zone. However, the potential of the area to wheat crop is not exploited. About 68,789.65hectars of land was covered by Cereals & 735,226.4 quintals was obtained from this; Bread wheat was sown on 8321.4hectars & 194658.4 quintals was obtained (Borana Zone Agr., 2015 E.C). Although, there is no selected and recommended improved bread wheat varieties for moisture stress area of Borana Zone. To overcome such problem, introducing improved technologies by testing for adaptation trial for variety selection is very imperative [5]. Therefore, this experiment was conducted to address the following objectives;

1. To evaluate and recommend high yielding, early maturing and drought tolerant varieties and.
2. To identify the most important criteria for future bread wheat improvement work to the study area.

2. Materials and Methods

2.1. Study Area Description

These experiment was conducted at Yabello, southern Oromia on main Cropping season for three cropping years on research field. Yabello is found 565km from capital city of Ethiopia; Addis Ababa to south direction. It is situated at 02° 88' 006" and 038°14' 761" latitude and longitude, respectively, at an altitude of 1650 masl. The study areas is characterized by an average annual rainfall of <600, which is erratic and not evenly distributed with average annual Temperature ranged 24℃ to 33℃. The soil of the study area is characterized by sandy loam to sandy clay with low moisture holding capacity. The rainfall distribution pattern of the study area is described in Figure 1 below. well-drained sandy loam with a pH of 7.03. The most commonly cultivated crops in its surrounding areas are maize, tef, haricot bean and sorghum.

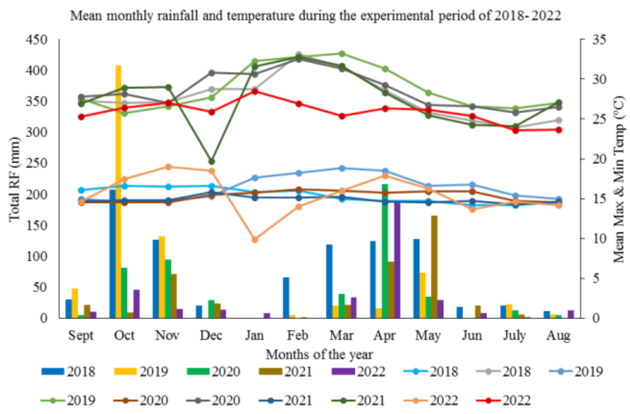

Figure 1. Meteorological Information of Experimental Area.

2.2. Experimental Materials and Design

The testing materials or bread wheat varieties were introduced from Werer Agriculture Research Center (EIAR) in 2018. Six bread wheat varieties were used (Table 1). Randomized complete block design (RCBD) with three replications were used. The seed rate of 120kg/ha was used and sown by Seed drilling application method manually by using recommended spacing (20cm between rows). Recommended cultural practices like, weeding, earthening and field management were accompanied for all tested plots equally at the same time and growth stage. Recommended fertilizer rates were used accordingly, 100kg/ha NPS and 50kg/ha Urea.

Table 1. *Description of Experimental Materials.*

Variety Name	Year of release	Maintainer/Producer
Fentale-1	2015	Werer ARC/EIAR
Fentale-2	2017	Werer ARC/EIAR
Lucy	2013	Werer ARC/EIAR
Amibara-2	2017	Werer ARC/EIAR
Gambo	2011	Kulumsa ARC/EIAR
Werer-2	2013	Werer ARC/EIAR

2.3. Data Collection

2.3.1. Phenological Data

Days to 50% heading (DH):- It will be counted as the number of days from the date of emergence to the date at which about 50% of the plants in each plot.

Days to 90% maturity (DM):- It is the number of days from date of emergence to the date when 90% of the plants in each plot are physiologically matured.

Grain filling duration (GFD):- Was calculated as a number of days required from date of 50% flowering to date of 90% physiological maturity.

2.3.2. Growth Parameters

Plant height (PH):- A height of five randomly taken plants from each plot was measured from the ground level to the base of spike and the average was recorded in cent meter.

Spike Length (SL):- The length of five randomly taken plants from each plot was measured from the base of spike to the tip and the average was recorded in cent meter.

Tiller Number (TN):- The average number of productive tillers randomly selected at the middle of the harvested from the two middle rows of each plot.

Number of Seed per Spike (NSPS):- The average number of grains per individual plant from five randomly selected main plants head.

2.3.3. Yield and Yield Related Data

Biological yields (BY):- will be determined by weighing the total air dried above ground plant biomass of the two middle rows and converted in to tones per hectar.

Thousand kernels weight (TKW):- 1000 seeds randomly taken from each plot and adjusted to the standard moisture content (12.5%). Then weighed using sensitive balance.

Grain yield (GY):- the grain yield will be harvested from the middle rows of each plot and adjusted to 12% and converted to t/ha. Grain yield is the most complex trait because it is influenced by all factors (known and unknown) that determine productivity [4]. Consequently, the inheritance and interrelationships of grain yield and of characters influencing grain yield are highly important.

Harvest Index (HI %):- = $\frac{Grain\ yield}{Biological\ yield}$ x100 dried grain to the dried above ground biomass yield. It can be defined as the ratio of grain yield to above ground biological yield [11, 25, 31]. Selection for harvest index may have advantages over selection for grain yield; hence it measures the plant's ability to partition the photosynthate so that more is distributed to the grain and, therefore, measures one aspect of physiological efficiency rather than just yield [31].

2.4. Data Analysis

The collected phenological, yield and yield related data were subjected to "SAS" computer software (version 9.0) to evaluate the variability of the tested varieties. This was done through computing analysis of variance for all characters studied according to the method given by [15]. Least significant difference was used to compare means of varieties ($P<0.05$). The mathematical model used for analysis of variance was:

$\boldsymbol{Yijk} = \boldsymbol{\mu} + \boldsymbol{Gi} + \boldsymbol{Yj} + \boldsymbol{GYij} + Bk(\boldsymbol{j}) + \boldsymbol{Eijk}$ Where:

$Yijk$ is observed value of genotype I in block k of year j, μ is grand mean, Gi= effect of genotype i, Yi=effect of year j, GYij is the interaction effect of genotype I and year j, Bk (j) is effect of block k in year j, and Eijk = random error or residual effect of genotype in block k of location j.

3. Results and Discussion

In this experiment combined analysis of variance showed that there were significant difference among varieties in days to heading, days to maturity, grain filling duration, plant height, spike length, Tiller number, above ground biomass yield and grain yield in all cropping years (Table 2). In 2018 there were significance differences between genotypes in all parameters except biological yield and thousand kernel weight. During 2018 Amibara-2 variety was recorded as high grain yielder (4860.7kg/ha) followed by Fentale-2 (4237.4kg/ha). In 2019 non-significant difference was observed for tested genotypes in days to flowering, plant height, number of tiller per plant, thousand kernel weight and harvest index. Amibara-2 variety was recorded as high yielder relatively to others (4420.3 kg/h) followed by Fantale-2 (4054.kg/h) this is may be because of the genetic potential of the crop is tolerating moisture stress or high water use efficiency of the genotype. Crop yield reduction was declining was recorded due to the late moisture happened for the last six rainy seasons in Borana Zone; In 2020 cropping year Fentale-1 variety was recorded as high yielder relatively to others (2766.4 kg/h) followed by Fantale-2 (2762.2). In 2023 cropping season almost all genotypes shows statistical differences in all parameters except Grain filling period and biological yield. During 2023 Lucy (3906.9 kg/h) was recorded as relatively high Grain yielder followed by Fentale-2 (3747.7 kg/h). From the last four experimental years varieties werer-2 and Gambo were showed low performance for grain yield and yield related traits.

Table 2. *Mean performance Evaluation of bread wheat genotypes for lowland Areas, at Yabello 2018, 2019 and 2023 cropping seasons.*

Genotypes	DH	MD	GFP	PH	SL	TN	NSPS	By	TKW	HI	GY
2018 Cropping season											
Fentale-1	56^{bc}	86.33^{b}	30.33^{ab}	91.1^{a}	8.23^{a}	1^{bc}	28.33^{c}	9.01^{a}	30.67^{a}	44.28^{a-c}	3873.8^{ab}
Fentale-2	49^{d}	82.67^{c}	33.67^{a}	77.1^{b}	6.93^{b}	2^{a}	39.33^{ab}	7.62^{a}	32.67^{a}	55.87^{ab}	4237.4^{ab}
Lucy	58.67^{ab}	89.67^{a}	31^{ab}	92.66^{a}	8.43^{a}	1.4^{b}	29^{c}	9.46^{a}	30.67^{a}	41.88^{bc}	3846^{b}
Amibara-2	55^{c}	84b^{c}	29^{b}	80.9^{b}	7.33^{b}	2^{a}	40.33^{a}	8.41^{a}	33^{a}	58.1^{a}	4860.7^{a}
Gambo	60.33^{a}	92^{a}	31.67^{ab}	97.57^{a}	8.8^{a}	0.87^{c}	36.67^{ab}	7.96^{a}	31.33^{a}	47.81^{a-c}	3824.4^{b}
Werer-2	60^{a}	90.33^{a}	30.33^{ab}	79.57^{b}	7.27^{b}	0.93^{c}	33.33^{bc}	8.53^{a}	31.67^{a}	38.46^{c}	3290.4^{b}
LSD	3.2	2.95	3.53	7.07	0.59	0.40	6.81	1.88	5.75	16.21	990.55
2019 Cropping season											
Fentale-1	61^{a}	90^{b}	29^{b}	53.67^{a}	7.67^{ab}	1.33^{a}	27^{cd}	6.09^{c}	28.67^{a}	61.73^{a}	3757.2^{c}
Fentale-2	62^{a}	92^{a}	30^{ab}	51^{a}	6.67^{b}	1.67^{a}	35^{ab}	6.78^{b}	30^{a}	59.98^{a}	4054.7^{b}
Lucy	62.33^{a}	92^{a}	29.67^{ab}	51.67^{a}	7.33^{ab}	1.67^{a}	28^{cd}	6.26^{bc}	27.67^{a}	60^{a}	3760^{c}
Amibara-2	60.67^{a}	91.33^{ab}	30.67^{a}	60.67^{a}	7.67^{ab}	1.07^{a}	38^{a}	7.36^{a}	27.87^{a}	60.11^{a}	4420.3^{a}
Gambo	60.67^{a}	90^{b}	29.33^{ab}	55.67^{a}	7.67^{ab}	1.07^{a}	31.33^{bc}	6.09^{c}	28.63^{a}	60.01^{a}	3650^{c}
Werer-2	61^{a}	91.33^{ab}	30.33^{ab}	69.67^{a}	9.33^{a}	1.2^{a}	26.67^{d}	5.46^{d}	30^{a}	60.53^{a}	3289.5^{d}
LSD	1.81	1.98	1.37	21.39	2.24	0.94	4.47	0.55	3.34	4.15	260.69
2020 Cropping Season											
Fentale-1	56.67^{ab}	89.33^{a}	32.67^{a}	60.93^{bc}	8.13^{ab}	1.42^{a}	29.07^{a}	4.36^{bc}	35.63^{a}	63.64^{a}	2766.4^{a}
Fentale-2	57^{ab}	89^{a}	32^{a}	59.37^{c}	7.73^{b}	1.47^{a}	35.4^{a}	4.89^{a}	41.1^{a}	56.72^{b}	2762.2^{a}
Lucy	58^{a}	90.33^{a}	32.33^{a}	68.77^{ab}	8.3^{ab}	1.58^{a}	29.07^{a}	5.04^{a}	36.57^{a}	43.29^{c}	2183.4^{b}
Amibara-2	56^{ab}	88.33^{a}	32.33^{a}	69.37^{a}	9.27^{a}	1.65^{a}	34.03^{a}	4.67^{ab}	35.67^{a}	57.95^{ab}	2706^{a}
Gambo	55.67^{b}	87.67^{a}	32^{a}	65.07^{a-c}	8.4^{ab}	0.92^{a}	26.87^{a}	4.08^{c}	35.77^{a}	56.11^{b}	2283.6^{b}
Werer-2	55^{b}	87.33^{a}	32.33^{a}	66.33^{a-c}	8.8^{ab}	0.8^{a}	24.8^{a}	4.07^{c}	35.23^{a}	56.04^{b}	2279.9^{b}
LSD	2.24	3.20	2.14	8.11	1.42	0.88	13.24	0.52	6.11	6.59	310.03
2023 Cropping season											
Fentale-1	58.67^{ab}	88.67^{b}	30^{a}	66.03^{b}	9.03^{b}	2^{a}	32.5^{ab}	6.62^{a}	37.23^{b}	56.46^{a}	3725.7^{a}
Fentale-2	59^{ab}	90^{ab}	31^{a}	68.6^{b}	10^{a}	1.83^{ab}	34.37^{ab}	6.66^{a}	47.5^{a}	56.28^{a}	3747.7^{a}
Lucy	60^{a}	92^{a}	32^{a}	76.13^{a}	8.97^{b}	2.07^{a}	34.77^{ab}	6.74^{a}	37^{b}	57.99^{a}	3906.9^{a}
Amibara-2	57.33^{b}	89.67^{ab}	32.3^{a}	75.63^{a}	10.33^{a}	1.98^{a}	38.23^{a}	6.55^{a}	33.6^{b}	56.24^{a}	3685.9^{a}
Gambo	58.33^{ab}	88.67^{b}	30.3^{a}	63.77^{b}	8.07^{c}	1^{c}	29.73^{b}	6.55^{a}	47.27^{a}	52.37^{b}	3423.8^{b}
Werer-2	58^{b}	88.33^{b}	30.3^{a}	65.13^{b}	9.1^{b}	1.33^{bc}	30.3^{b}	6.16^{a}	45^{a}	55.84^{ab}	3435.4^{b}

Genotypes	DH	MD	GFP	PH	SL	TN	NSPS	By	TKW	HI	GY
LSD	1.72	2.83	4.18	6.97	0.82	0.55	6.78	0.67	6.66	3.59	244.55

Means with the same letter are not significantly different, DH=days to heading, DM=days to maturity, PH=plant height, SL=Spike length, NSPS=number of seed per spike, TKW=thousand kernel weight, BY=biomass yield, GY=grain yield and HI=harvest index.

*From Combined Analysis of Variance a*mong several factors, yield related traits highly influence the amount of grain yield that can be obtained. Some of the yield related traits include days to flowering, days to maturity, plant height, number of tillers per plant, thousand-kernel weight and number of seeds per panicle. These traits affect yield positively or negatively; and their effect on yield depends on the influence of environment on these traits. Wheat exhibits considerable genetic variation for yield and yield related traits (Table 4).

3.1. Phenology and Growth Characters of the Crop

3.1.1. Days to Heading and Maturity

Analysis of variance showed that days to heading varied highly significantly (P<0.001) within evaluated wheat varieties (Table 3). The variation with respect to days to heading and days to maturity ranged from 56.75-59.75 and 88.33-91 respectively. Indicating considerable range of variation among the varieties for heading and maturity. The varieties Fentale-2 and Amibara-2 were early heading which tooks 56.75 and 57.25 on average of days to heading. This early flowering character also made the varieties to mature early within 88.42 and 88.33 days on average. Late heading was recorded for variety lucy (59.75 days) and Gambo (58.75days). Whereas Lucy, Gambo and were-2 were late for days to maturity which took 91, 89.58 and 89.33 days respectively. Comparative results were reported by [3] that range for days to heading 46 to 70 days, with an average value of 55 days. Nowadays as Ethiopia has been experiencing gradually shorter rain seasons due to climate change, [1] reported that selection for early maturing genotypes is highly recommended for localities with short and erratic rain seasons.

3.1.2. Grain Filling Duration (Days)

From combined analysis of variance non-significant difference was observed among tested varieties in grain filling duration this may be due to environmental conditions. All tested materials experienced shorter grain filling duration which ranged from 30.5 days up to 31.67 days with mean of 31.03 days. High temperature during the grain filling stage reduced grain weight via reduction of grain filling duration [34].

3.1.3. Plant Height (cm)

Analysis of variance showed that the differences in plant height of the wheat varieties studied were non-significant between varieties and highly significant (P<0.01) for variety x year interaction (Table 3). Data for plant height ranged from 65.57 cm to 73.49 cm with a mean value of 70.91 cm. Among wheat varieties, plant height was maximum (73.49cm) in Lucy followed by 70.27 cm and 71.42 cm in Fentale-1 and Werer-2 respectively. The lowest plant height of 65.57 cm was determined in Fentale-2. This indicates that Fentale-2 variety proved to be one of the promising varieties for future planting in Borana moisture stress areas as regards its plant height. Similar and balanced results was obtained by [24] who reported the presence of significant (P<0.05) difference among five promising wheat varieties in the case of plant height.

3.1.4. Spike Length (cm)

Analysis of variance showed highly significant (P<0.01) for variety x year interaction (Table 3). Mean for spike length of varieties ranged from 7.83 cm to 8.65cm with the mean value of 8.31 cm. Among the varieties the maximum spike length (8.65 cm) was recorded for Amibara-2 while the lowest spike length (7.83 cm) was recorded for Fentale-2. (Table 4). A similar result was reported for bread wheat genotypes by [2] who found that the mean value of spike length was 7.29 cm with maximum of 8.87 cm and minimum of 5.87 cm. However, combined interaction exhibited a non-significant difference for spike length and thousand kernel weight. [35] reported highly significant differences among thirteen bread wheat genotypes for grain yield, days to heading, days to maturity and thousand seed weight.

3.1.5. Number of Seed per Spike (Number)

Analysis of variance showed highly significant difference (p<0.001) was observed between all tested varieties. The mean for number of seed per spike of tested varieties ranged from 28.78 to 37.65 with the mean value of 32.17. Among the varieties the maximum number of seed per spike (37.65) was recorded for Amibara-2 while the lowest number of seed per spike (28.78) was recorded for Were-2 (Table 4).

3.1.6. Tiller Number (Number)

Analysis of variance showed highly significant variations (p<0.001) was observed within tested varieties in number of productive tillers (Table 3). Mean for tiller number of varieties ranged from 0.96 to 1.74 with the mean value of 1.43. Among the varieties the maximum tiller number (1.74) was recorded for Fentale-2 while the lowest tiller number (0.96) was recorded for Gambo (Table 4). Similar finding was obtained by [36] who reported that tillering capacity and spike length were genetically influenced by the breeding material.

Table 3. *Combined Mean Square values of evaluated bread wheat varieties for growth, yield and yield related traits.*

S.V	df	DH	DM	GFD	PH (cm)	SL (cm)	TN	NSPS	BY (tone)	TKW (g)	HI (%)	GY (kg)
Year	3	94.61***	41.72***	17.94**	2778.99***	8.84***	0.62*	80.43*	47.67***	545.24***	498.11***	8232878.51***
Variety	5	13.95***	12.36***	1.96ns	111.25ns	1.09ns	1.37***	167.8***	1.22**	52.2***	97.37**	1067381.87***
Rep (Year)	8	0.46ns	3.07ns	2.76ns	92.56ns	2.33**	0.1ns	16.15ns	0.21ns	2.77ns	48.7ns	150910.45ns
Var*year	15	15.89***	13.79***	3.22ns	129.18**	1.92**	0.21ns	18.93ns	0.69*	25.92**	77.33**	176384.68**
Error		1.63	2.34	2.75	46.95	0.61	0.16	21.73	0.34	9.51	25.41	91024.86

DH=days to heading, DM=days to maturity, GFD= grain filling duration, PH=plant height, SL=spike length, NSPS=number of seed per spike, BY=Biomass Yield, TKW=thousand kernel weight, GY=grain yield, CV=coefficient of variation, df=degree of freedom, S, V=source of variation, ns=non-significant, ***, ** and *=very highly significant, highly significant and significant at $p<0.001$, $p< 0.01$ and $p< 0.05$ respectively.

Table 4. *Combined Mean Performance of bread wheat varieties for growth, yield and yield related traits.*

Varieties	DH	DM	GFD	PH	SL	TN	NSPS	BY (tone/h)	TKW (g)	HI (%)	GY (Kg)
Fentale-1	58.08^{bc}	88.58^{b}	30.05^{a}	67.94^{ab}	8.27^{ab}	1.44^{a}	29.23^{b}	6.52^{ab}	33.05^{bc}	56.53^{ab}	3530.8^{bc}
Fentale-2	56.75^{d}	88.42^{b}	31.67^{a}	64.02^{b}	7.83^{b}	1.74^{a}	36.03^{a}	6.49^{ab}	37.82^{a}	57.21^{a}	3700.5^{ab}
Lucy	59.75^{a}	91^{a}	31.25^{a}	72.31^{a}	8.26^{ab}	1.68^{a}	30.21^{b}	6.88^{a}	32.98^{bc}	50.79^{c}	3424.1^{c}
Amibara-2	57.25^{cd}	88.33^{b}	31.08^{a}	71.64^{a}	8.65^{a}	1.68^{a}	37.65^{a}	6.75^{a}	32.53^{c}	58.1^{a}	3918.2^{a}
Gambo	58.75^{ab}	89.58^{b}	30.83^{a}	70.51^{a}	8.23^{ab}	0.96^{b}	31.15^{b}	6.17^{b}	35.75^{a}	$54.07^{a\text{-}c}$	3295.5^{cd}
Werer-2	58.5^{b}	89.33^{b}	30.83^{a}	70.14^{a}	8.63^{a}	1.07^{b}	28.78^{b}	6.05^{b}	35.48^{ab}	52.72^{bc}	3073.8^{d}
Mean	58.18	89.21	31.03	69.43	8.31	1.43	32.17	6.48	34.6	54.9	3490.47
LSD	1.05	1.26	1.37	5.65	0.64	0.33	3.85	0.48	2.54	4.16	248.94
CV	2.19	1.71	5.34	9.87	9.40	28.1	14.49	9.06	8.91	9.18	8.64

Means with the same letter are not significantly different. DH=days to heading, DM=days to maturity, GFD=grain filling duration PH=plant height, SL=spike length, NSPS=number of seed per spike, BY=Biomass Yield, TKW=thousand kernel weight, GY=grain yield.

3.2. Yield and Yield Components

3.2.1. Biomass Yield (Tones)

Analysis of variance showed highly significant difference ($p<0.001$) was observed for tested varieties between cropping years in their above ground biomass yield. The mean value of biomass yield ranged from 6.05 tones (Werer-2) to 6.88 (Lucy) with an average value of 6.48 tones. The maximum biomass yield (6.88 tone/ha) was recorded for variety Lucy, followed by variety Amibara-2 (6.75 tone/ha) (Table 4).

3.2.2. Thousand Kernel Weight (g)

Highly significant variations was ($P<0.001$) between varieties and variety over year interactions (Table 3). The mean value of thousand kernel weight ranged from 32.53 g (Amibara-2) to 37.82g (Fentale-2) with an average value of 34.6g. The varieties Fentale-2, Gambo and Werer-2 had weights higher than the mean weight of 34.6g. Similar results was obtained by [27] who reported that thousand seed weight that was ranged from 25g to 46.67g; with the average weight of 39.67g showing high genetic variability among the genotypes. Opposite findings was obtained by, [22] who reported nonsignificant difference between genotypes for seed weight.

3.2.3. Grain Yield (Kg)

From the analysis of variance, highly significant differences was observed among tested varieties (P<0.001). The maximum grain yield (3918.2 kg/ha) was recorded for variety Amibara-2, followed by variety Fentale-2 (3700.5kg/ha) (Table 4). The lowest grain yield was recorded in variety Werer-2 (3073.8 kg/ha). The grain yield of Amibara-2 was markedly higher than the rest of the evaluated bread wheat varieties. This higher grain yield might be associated with adaptability and the genetic make-up of the parental material of these varieties since under similar soil, climatic, input and crop management conditions the grain yield differed significantly. Similar and balanced results was obtained by [13] who reported different responses of wheat varieties in respect to the yield and yield components examined and suggested that it could be due to their varied genetic composition and adaptation to the soil and climatic conditions. Additionally; [21]; [20] reported that grain yield is the product of tillers per plant, thousand-kernel weight and kernels per spike when each of these characters is measured without error.

3.2.4. Harvest Index (%)

From the analysis of variance, significant differences were observed among tested varieties (P<0.001) (Table 3). The highest value of harvest index (58.1%) was recorded for variety Amibara-2, followed by variety Fentale-2 (57.21%) (Table 4). The lowest harvest index was recorded in variety Lucy (50.79%). The value of harvest index of variety “Amibara-2” was higher than other tested varieties. Harvest index (HI) appears to be approaching maximum because of increasing yield in wheat, which resulted from reduction in height [30].

4. Conclusion

World food production is mainly expected from crops; to survive fast growing world population and climate change, one way to solve this challenge is to improve the crops and particularly sorghum will be preferred as it grows across different agro-ecologal zones. However, plant breeding is a continuous work to develop high yielder, well adapted and early maturing varieties than the existing ones. The experimental area has been experiencing increasingly shorter rain seasons due to climate change and early flowering and maturing varieties are more suitable. Therefore, conducting adaptability study is crucial. Bread wheat is one of the most important cereal crops grown in Ethiopia and it is multipurpose crop that acclimates effortlessly to a wide variety of production set of conditions. The field experiment was conducted at Yabello on research site from 2018 to 2023 on main cropping season for the last four years. This investigation demonstrated the beneficial effect of different bread wheat varieties for lowland areas of Borana zone and similar Agro-ecologies of Ethiopia. Based on the result, yield and yield related traits, “Amibara-2” variety was selected for its high yielding capacity and drought tolerance capacities followed by Fentalle-2.

Abbreviations

EIAR	Ethiopian Institute of Agricultural Research
Mha	Metric Tons per Hectare
OARI	Oromia Agricultural Research Institute
RCBD	Randomized Complete Block Design

Acknowledgments

The authors would like to thank Oromia Agriculture Research Institute (OARI) for granting research fund. We wish to express our gratitude to Yabello Pastoral and Dryland Agricultural Research Center for facilitating financial assistance during the study and adjusting logistic. My deepest appreciation and special thanks goes to Werer Agricultural research center for providing us experimental materials. We also express our sincere appreciations and thanks to all cereal crop team members for their effort on trial management and data collection.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Abrham Belay, John W. Recha, Teshale Woldeamanuel, and John F. Morton. (2017). "Smallholder farmers’ adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia." Agriculture & Food Security, vol. 6 (1); Pp 1-13.

[2] Adhiena M, Mohammed W, Dessalegn T. (2015). Estimation of Heritability and Genetic Advance of Yield and Yield Related Traits in Bread Wheat (Triticum aestivum L.) Genotypes at Ofla District, Northern Ethiopia. International Journal of Plant Breeding and Genetics, 10: 31-37.

[3] Alemu D B. (2016). Genetic Variability and Association among Grain Yield and Yield Related Traits of Bread Wheat (Triticum aestivum L.) Genotypes. MSc Thesis Postgraduate Program Directorate, Haramaya University, Ethiopia.

[4] Araus, J. L., J. Casadesus and J. Bort. (2001). Recent tools for the screening of physiological traits determining yield. In Reynolds, M. P., J. I. Ortiz-Monasterio and McNab (ed.) Application of Physiology in Wheat Breeding. Mexico, D.F.: CIMMYT.

[5] Asaye Demelash, Tadesse Desalegn, Getachew Alemayehu, (2013). Participatory Varietal Selection of Bread Wheat (Triticum aestivum L.) Genotypes at Marwold Kebele, Womberma Woreda, West Gojam, Ethiopia. International Journal of Agronomy and Plant Production. Vol., 4 (S), 3543-3550.

[6] AU-SAFGRAD (African Union Semi-Arid Food Grain Research and Development). (2013). Climate Change and Agricultural Input Use in East Africa with Special Emphasis on Drought Tolerant Varieties: Case Study of Ethiopia and Uganda.

[7] Bishawa Z, Alemu D., (2017). Farmers' perceptions on improved bread wheat varieties and formal seed supply in Ethiopia. Int J Plant Prod. 11(1): 117-130.

[8] Braun, H. J., Atlin, G., Payne, T., (2010). Multilocation testing as a tool to identify plant response to global climate change. In: Reynolds, CRP (Eds.) Climate change and crop production, CABI, London, UK.

[9] Central Statistical Agency (CSA) of Ethiopia. (2022). Agricultural sample survey of area and production of major crops. Available from: https://www.statsethiopia.gov.et/

[10] Chilot Y, Takale M, Menale K, Moti J, Bekele S, Hugo de G, (2022). Analysis of adoption and diffusion of improved wheat technologies in Ethiopia.

[11] Donald, C. M., and J. Hamblin. (1976). The biological yield and harvest index of cereals as agronomic and plant breeding criteria. Advances in Agronomy 28: 361-405.

[12] Etten JV, Sousa KD, Aguilar A, Barrios M, Coto A, (2019). Crop variety management for climate adaptation supported by citizen science. PNAS. 116: 10.

[13] Falaki A M, Miko S, Mohammed I B, Abubakar I U, Valencia J A. (2009). Evaluation of some Improved Bread Wheat Varieties at Chiyako, Jigawa State, Nigeria. ARPN Journal of Agricultural and Biological Science, 4(4): 40- 43.

[14] Girma Degife, and Esuyawkal Demis, (2020). Evaluation of Lowland Released Bread Wheat (Triticum aestivum L.) Varieties under Irrigation in Raya Valley Southern Tigray, Ethiopia. International Journal of Novel Research in Life Sciences Vol. 7, Issue 3, pp: (9-14), Available at: www.noveltyjournals.com

[15] Gomez, K. A. and A. A. Gomez. (1984). Statistical Procedures for Agricultural Research, 2nd edit. John Wiley and Sons, New York.

[16] Gooding, M. J. & Davies, W. P. (1997). Wheat production and Utilization. CAB Int., Wallingford, UK.

[17] Gunasekare MTK, (2006). Adapting crop varieties to environments and clients through decentralized participatory approach. J Agri Sci., 2(1): 34-45.

[18] Herrera-Foessel SA, Singh RP, Huerta-Espino J, William HM, Garcia V, Djurle A, Yuen J .(2008). Identification and molecular characterization of leaf rust resistance gene Lr14a in durum wheat. Plant Dis 92: 469–473. hesis, Alemaya University, Ethiopia.

[19] Hodson DP, Jaleta M, Tesfaye K, Yirga C, Beyene H, Kilian A, .(2020). Ethiopia’s transforming wheat landscape: tracking variety use through DNA fingerprinting. Sci Rep.; 10(1): 18532.

[20] Hsu, P., and P. O. Walton. (1971). Relationships between yield and its components and structures above the flag leaf node in spring wheat. Crop science 11: 190-193.

[21] Johnson, H. W.; H. F. Robinson and R. F. Comstock. (1955a). Genotypic and Phenotypic correlation in soybean and their implication in selection. Agronomy Journal 47: 477-483.

[22] Khan M., Malik T., Abbas S., Abbas Z., Khan A., Malik M. and Asghar S. (2011). Study of genetic variability and correlation among various traits of F5 wheat (Triticum aestivum L.) populations. International Research Journal of Agricultural Science and Soil Science, 1(8): 344-348.

[23] Khanna, K. R. (1991). Biochemical aspects of crop improvement. Boka Raton, Ann Arbor and Bosten: CRC press.

[24] Longove A M, Akbar F, Baqa S, Hidayatullah, Sher Azam. (2014). Performance Evaluation of Different Wheat Varieties under Agro-Ecological Conditions of Quetta (Balochistan). Journal of Biology, Agriculture and Healthcare www.iiste.org. 4(8): 39-43.

[25] Manfred Huehn. (1993). Harvest index versus grain/straw ratio: Theoretical comments and experimental results on the comparison of variation. Euphytica 68: 27-32.

[26] Negassa A, Shiferaw B, Koo J, Sonder K, Smale M, Braun HJ, et al; (2022). The Potential for Wheat Production in Africa: Analysis of Biophysical Suitability and Economic Profitability. Available from: https://www.researchgate.net/profile/Kai-Sonder/publication/281375711

[27] Obsa C. (2014). Genetic Variability among Bread Wheat (Triticum aestivum L.) Genotypes for Growth Characters, Yield and Yield Components in Bore District, Oromia Regional State. MSc Thesis Postgraduate Program Directorate, Haramaya University, Ethiopia.

[28] Obsa, C., Kabna, A. and Seyum, A. (2018). Participatory Variety Selection of Improved Bread Wheat Varieties for Moisture Stress Areas of Guji Zone, Southern Oromia. International Journal of Research in Agriculture and Forestry, 5(4), pp. 1-6.

[29] Peng J, Sun D, Nevo E., (2011). Wild emmer wheat, Triticum dicoccoides, occupies a pivotal position in wheat domestication. AJCS 5: 1127-1143.

[30] Richard, R. A., A. G. Condon and G. J. Rebetzke. (2001). Traits to improve yield in dry environments. In M. P. Reynolds, J. L. Ortiz-Monasterio and A. McNab (ed.) Application of Physiology in Wheat Breeding. Mexico, D.F.: CIMMYT.

[31] Rkmhay. (1995). Harvest index: A review of its use in plant breeding and crop physiology. Annals of Applied Biology, 126: 197-216.

[32] Rosegrant, MW, Agcoili M; (2010). Global food demand, supply and food prospects. International food policy research Institute, Washington, D.C., USA.

[33] Shiferaw B, Smale M, Braun HJ, Duveiller E, Reynolds M, Muricho G. (2013). Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. Food Sec. 5(3): 291-317.

[34] Sofield, I. L., T. Evans and I. F. Wardlaw. (1974). The effects of temperature and light on grain filling in wheat. Research Society. N. Z. Bulletin 12: 909-915.

[35] Tewodros T, Tsige G, Tadesse D. (2014). Genetic variability, heritability and genetic diversity of bread wheat (Triticum aestivum L.) genotype in Western Amhara region, Ethiopia. Wudpecker Journal of Agricultural Research, 3(1): 26 – 34.

[36] Voltas J, Lopez-Corcoles H, Borras G. (2005). Use of biplot analysis and factorial regression for the investigation of superior genotypes in multi-environment trials. European Journal of Agronomy. 22: 309-324.