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Evaluation of bread wheat varieties (*Triticum aestivum*) in selected areas of Gamo District, Southern Ethiopia

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Abstract

Bread wheat is cultivated in a wide range of high and mid-altitude areas of Ethiopia ranking 4th in area coverage and 2nd in productivity. Although many improved bread wheat varieties have been released nationally and regionally, these varieties are not well disseminated and popularized. In southern Ethiopia "Gamo" district, there is only little bread wheat variety under production which is risky if there would be an occurrence of new diseases and other stresses.

To alleviate such a crop's potential challenge, recently released bread wheat varieties were tested for their phenotypic performance to confirm their environmental adaptation.

The average productivity of the tested genotypes were evaluated at three locations (Dita, Kamba and Bonke) using randomized complete block design with three replication for two consecutive years (2020/21 to 2021/22).The experimental material consists of ten improved bread wheat genotypes including standard check.

The Combined analysis of variance showed significant ($P<0.05$) difference among tested genotypes on collected parameters except spike length and productive tiller number indicating the presence of adequate variability among the tested genotypes. The highest combined mean grain yield recorded was 3789.5kg ha-1 from Bondena variety while the lowest obtained was 2797.5 kg ha-1 from Lemu variety.

Keywords: Adaptability; Bread Wheat; Evaluation; Performance; Variety

1. Introduction

In Ethiopia, wheat is one of the major cereal crops and largely grown in the southeast, central and northwest parts with moderate rainfall, humidity and temperatures. The most common species grown are *Triticumaestivum L.* (Bread wheat) and *Triticumturgidum* var. durum L. (Durum wheat) (Shewaye Y and Solomon T., 2018). Bread wheat is one of the major crops predominantly grown by small-scale farmers under rain fed condition in the highlands of Ethiopia (Bishawa Z, and Alemu D., 2017).

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 (Etten JV., et al., 2019) contributing to the increase in agricultural production in several regions worldwide (Gunasekare MTK..,2006).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 (Tamene M, et al.,2018). 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. With these

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objectives, the Ethiopian institute of agricultural research 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. Farmers however have subjective preferences for different varietal attributes and their varietal demand is significantly affected by their perceptions (Bishawa Z, and Alemu D., 2017).

Although there are recently released and better performing bread wheat varieties in Ethiopia, farmers of the south nation nationality people regional state grow relatively older varieties (Shibeshi S.,2019). In the study area called "Gamo highlands of Dita, Kamba and Bonke" districts there is only few improved bread wheat varieties under cultivation by most local farmers that makes it risky if there will be an occurrence of new disease that can destroy the whole wheat production in the area. Thus, an adaptation trial was conducted in three locations for two years on ten improved bread wheat varieties including one standard check so as to increase the diversity and productivity of bread wheat varieties in the tested area with the objective of evaluating and recommending the best performing varieties.

2. Materials and Experimental Design

Ten improved and promising bread wheat varieties (Table 1) were selected and their seeds were received from Kulumsa agricultural research center of Ethiopian institute of agricultural research.

Table 1 Nationally released bread wheat varieties used in the experiment

S/No	Genotypes	Breeder Center	Year of release	Grain yield at time of release (tha-1)		Recommended Agro-ecology zone	
				On station	On farm	Alt(mas)	RF(mm)
1	Kokate	Hawassa	2005	>>	>>	>>	>>
2	Biqa	>>	>>	>>	>>	>>	>>
3	Kingbird	EIAR?	2015	>>	>>	>>	>>
4	Ogolcho	KARC	2012	2.8-4	2.2-3.5	1600-2100	400-500
5	Danda'a	KARC	2010	3.5-5.5	2.5-5	2000-2600	>600
6	Hidase(check)	KARC	2012	4.4-7	3.5-6	2200-2600	>500
7	Hulluka	KARC	2012	>>	>>	>>	>>
8	Wane	Sinana	2016	50-60	40-50	2100-2700	700-1000
9	Bondana	Areka	2018	3.5-5.5	3.5-4.4	2100-2450	1400-2400
10	Lemu	KARC	2016	50-60	40-50	>2200	800-1100

Where: KARC=kulumsa Agricultural Research Center, tha-1=tone per hectare, Alt-altitude, masl-meter above sea level, RF-rain fall

The trial involving nine improved bread wheat varieties and one standard check (Hidase) was conducted in Dita, Kamba and Bonke districts of Gamo zone in southern Ethiopia for two consecutive cropping years (2020/21 and 2020/22) on three separate and strategically selected small holder farmer field and farmers training center (FTC) using a randomized complete block design (RCBD) with three replications per a location on a plot area of (1.2 m x 2.5 m = $3m^2$) with 6 rows per plot and 20cm spacing between rows. Seeds of each variety were manually drilled approximately 2-3cm deep into the prepared plots at all locations with the seed rate of 120 kgha-1. Mineral fertilizer was applied at the rate of 100 kgh-1 NPS and 150kg h-1 of Urea. Crop management practices for each location in each year were done manually. The research area is located at an altitude range between 2415 masl, 2531 masl and 2774 masl and Latitude N 06.06360^0, $N06.32427^0$, $N06.10688^0$ and longitude E 037.27883^0, 037.52191^0 and 037.321550 for Kamba, Dita and Bonke districts respectively.

2.1. Methods of Data collection and analysis

A plant based quantitative data such as plant height (PH): the average height in cm from ground level to the tip of the spike and spike length (SL): the average spike length in cm from its base to the tip, a plot based quantitative data such as grain yield (GY): grain yield obtained from the harvested plot size of 1.2 mx2.5m ($3m^2$) in gram and converted to kilograms per hectare and thousand seed weight (TGW): the weight of 1000 seeds in gram were collected. Disease

reactions of the wheat varieties to rusts and rust severities were collected according to the following scale: O – No disease, R– Resistant (pustules formed distinct chlorosis spots, the leaves' severity up to 5-10%), MR– Moderately Resistant (very small pustules surrounded by a chlorotic area with the leaves' severity up to 10-30%), MS – Moderately susceptible (small/medium pustules, the leaves' severity up to 40-50%) and S Susceptible (large pustules, the leaves' severity up to 75-100%) (Manandhar et al., 2016).

SAS 9.3 statistical package (Inc, Cary, NC, USA.Version SAS 9.3, 2012) was used to analyze the both quantitative and qualitative data. The least significant difference (LSD) test at 5% significance level was used to determine significant differences between the tested bread wheat varieties on the measured parameters. Coefficient of variation (CV) was calculated for each test to indicate the variability in the trial.

3. Results and Discussion

3.1. Analysis of Variance

The combined ANOVA results of five quantitative two qualitative traits of the bread wheat varieties (Table 2) indicated a highly significant difference among the tested bread wheat varieties (P≤ 0.05) for all the quantitative and qualitative traits except for the tiller number and thousand seed weight. Similarly, (Misganaw F.2016) reported a significant yield difference among the varieties under the study at 5% probability level. In contrast with this study (Dagnachew et al., 2017) obtained a non-significant grain yield difference and a significant variation for plant height and spike length among the studied varieties. These results are also in agreement with those of(Falaki *et al.,*2009) 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 under which the study was conducted.

Table 2 Combined analysis of variance for grain yield and yield related traits of bread wheat varieties tested on three locations over two years.

Source of variation	Mean squares							
	DF	DTF	DTM	PH	PL	TN	TSW	GY
Trt	9	335.75**	69.727**	378.19**	4.32**	0.10ns	14.93ns	1508354.7**
Rep	2	423.89**	230.123**	200.96ns	1.88**	0.07ns	0.62ns	946746.5ns
Yr	1	2.08ns	600.863**	709.78**	12.13**	45.42**	91.28**	196597180.2**
Loc	2	2939.81**	17772.783**	3680.80**	11.91**	20.06**	63.85**	3591795.7**
Trt*Yr	9	20.13**	29.02262**	188.85ns	0.50ns	0.28ns	15.79ns	1986169.1**
Trt*Loc	18	57.69**	17.59789**	159.23ns	0.31ns	0.45ns	20.90**	1307153.7**
Yr*Loc	2	6251.91**	10359.181**	70.91ns	1.93ns	25.70**	130.13**	4854635.9**
Trt*Yr*Loc	18	47.92**	27.10742**	175.35**	0.62**	0.34ns	11.90ns	1407237.3**
Error		7.15	7.13498	129.84	0.29	0.32	9.79	349698.4
R^2		0.97	0.98	0.60	0.77	0.82	0.60	0.89
CV		3.6	1.77	12.77	6.72	29.39	7.90	16.92

Where: DF- degree of freedom, DTF- date to flowering , DTM- date to maturity, PH-plant height in cm, PL-panicle length in cm, TN- tiller number ,TGW-1000 grain weight, GY-grain yield in kilogram per hectare, *- significant, **-highly significant, ***-very highly significant

The combined mean value of each quantitative and qualitative trait over the three locations for each year was computed at which the tested bread wheat varieties showed a significant variation in all measured quantitative and qualitative traits except productive tiller number in the both first (2020/21) and second (2021/22) cropping year (Table 3 & 4) which resulted in the over-all significant year over location combined grain yield variation of the varieties.

Table 3 Combined mean of grain yield and yield related parameters of the three locations in 2020/21.

Varieties	DTF	DTM	PH	PL	TN	TSW	GY
Kokate	71.66C	148.8E	87.44CB	8.01DC	2.17	38.22BC	2479.1B
Biqa	71.33C	150.7ED	87.33CB	9.15A	2.44	38.8B	2210.8B
Kingbird	66.11 D	149.0 E	84.33C	7.63DE	2.48	38.11BC	2391.6B
Ogolcho	76.77 B	154.6BA	90.00B	8.42BC	2.48	38.22BC	2178.3B
Danda'a	80.66 A	157.0A	94.04 A	8.35BC	2.5	39.11BA	2635.1BA
Hidase(check)	72.11 C	150.6ED	88.06CB	8.13DC	2.68	40.44A	2398.0B
Huluka	80.77 A	154.0BC	84.42C	8.46BC	2.64	37.1C	2303.0B
Wana	72.33 C	150.4ED	85.40C	7.42E	2.33	40.44A	2376.0B
Bondana	70.66 C	151.4ECD	85.44C	8.82BA	2.57	39.1BA	2961.4A
Lemu	79.66 A	153.1BCD	84.51C	8.44BC	2.13	38.88B	2511.4B
G. mean	74.2	152.0	87.10	8.28	2.44	38.85	2444.46
CV	3.7	1.70	4.90	6.17	24.79	3.54	17.68
Sig. (p<5%)	2.60	2.45	4.04	0.48	ns	1.30	408.5

Table 4 Combined mean of grain yield and yield related parameters of the three locations in 2021/22.

Varieties	DTF	DTM	PH	PL	TN	TSW	GY
Kokate	72.7C	149.44BA	107.42A	7.17ED	1.55	42.88A	5023.5A
Biqa	71.22E	146.22DC	87.42B	8.20BA	1.46	42.00BA	4765.8A
Kingbird	70.00DE	143.88D	82.75B	7.26ED	1.46	38.77BA	4979.8A
Ogolcho	74.33C	147.44BC	94.55BA	7.68BDC	1.46	40.33BA	5097.7A
Danda'a	78.11B	149.88BA	93.57BA	7.42EDC	1.48	40.11BA	4561.0A
Local	74.11C	149.55BA	96.62BA	7.95BAC	1.37	39.22BA	3837.5B
Huluka	81.00A	150.66A	89.00B	8.44A	1.40	40.11BA	4604.4A
Wana	72.77C	148.33BAC	86.51B	7.0E	1.26	41.22BA	4772.7A
Bondana	72.44DC	149.44BA	89.86B	8.24BA	1.31	40.66BA	4617.7A
Lemu	79.37BA	148.87BAC	84.75B	8.30A	1.55	37.87 B	3119.4C
G. mean	74.35	148.37	91.32	7.76	1.43	40.34	4553.88
CV	3.47	1.85	17.08	7.31	37.15	10.46	15.76
Sig. (p<5%)	2.45	2.61	14.85	0.54	NS	4.01	683.2

While considering the combined mean of grain yield and yield related parameters of three locations over the two consecutive cropping years (Table 5), The average days to flowering ranged from 70 to 81 days and minimum and maximum days was recorded on varieties Kingbird (70 days) and Hulluka (81days). The average maturity days ranged from 143 to 150 days, The Shortest maturity days were recorded on variety kingbird (143 days) and the longest maturity days were recorded on Hulluka (150 days) respectively. This result was in lines with the study of Tilahun et al. (2009). The variety 'Kokate' was measured as the tallest plant (97.43cm) and 'Kingbird' as the shortest plant (83.54cm). The tested varieties were significantly varied on their spike length which has a positive contribution for

yield increment and variety 'Bondena' recorded the tallest spike length with 8.53cm whereas "Wane" recorded the shortest spike length of 7.21cm. Thus, the highest spike length for 'Bondena' is an indication of its genetic advantage over the other tested varieties. The tiller number and 1000 grain weights of all the tested bread wheat varieties were not significantly different.

The highest combined grain yield was recorded for the variety Bondena '3789.5kg/ha' with relatively higher spike length (8.53cm) while comparing with the other varieties. The variety 'Lemu' produced the lowest grain yield (2797.5kgha-1) but it was not significantly lower than the grain yield of 'Hidase (standard check)' which scored the grain yield (3117.7kgha-1) (Table 6). In the present study, the reduction in grain yield of 'Hidasse' might be due to devastation of rust diseases (yellow leaf rust and stem rust). (Ashamo M., 2020) reported a mean literatures confirmed that "Bondena " is one of the promising and high yielder bread wheat variety. When taking the complete details on the yield performance of each variety in each year over the combined test locations into account, the varieties 'Bondena' and 'Kingbird' were relatively better overall grain yielder when compared with the other tested varieties including the standard check 'Hidase'.

Even the varieties were relatively resistant to yellow leaf rust, stem rust and strip rust which is identified as the common disease of the study area. Therefore, based on this reference the variety 'Bondena' and 'Wane' could be disseminated to the local farmers of Dita, Kamba and Bonke district of Gamo after being demonstrated on the small land farms of the corresponding farmers.

Table 5 Combined mean of grain yield and yield related parameters of the three test locations in two year (2020 and 2021)

Varieties	**DTF**	**DTM**	**PH**	**PL**	**TN**	**TSW**	**GY**
Kokate	72.22C	149.16CD	97.43A	7.59DE	1.86	40.55	3651.3A
Biqa	70.27D	148.50D	87.37BDC	8.47A	1.95	40.44	3488.3BA
Kingbird	68.05E	146.44E	83.54D	7.45FE	1.97	38.44	3685.7A
Ogolcho	75.55B	151.05BC	92.27BAC	8.05BC	1.97	39.27	3638.0A
Danda'a	79.38A	153.44A	93.81BA	7.88DC	2.00	39.61	3598.0A
Hidase(check)	73.11C	150.11CD	92.34BAC	8.04BC	2.03	39.83	3117.7BC
Huluka	80.88A	152.33BA	86.71BDC	8.45A	2.02	38.61	3453.7BA
Wane	72.55C	149.38CD	85.95BDC	7.21F	1.80	40.83	3574.4A
Bondana	71.55DC	150.44BCD	87.65BDC	8.53A	1.94	39.88	3789.5A
Lemu	79.52A	151.11BC	84.62DC	8.37BA	1.85	38.41	2797.5C
G. mean	74.28	150.19	89.19	8.02	1.94	39.59	3493.27
CV	3.60	1.77	12.77	6.72	29.39	7.90	16.92
Sig. (p<5%)	1.77	1.77	7.55	0.35	0.37	2.07	391.9
Year 1	74.21A	152.00	87.10B	8.28A	2.44A	38.85B	2444.46B
Year 2	74.35A	148.37B	91.32A	7.76B	1.43B	40.34A	4553.88A
Sig. (p<5%)	0.79	0.79	3.37	0.16	0.16	0.92	175.2
Location 1	77.03B	143.94B	80.64C	7.97B	1.58B	40.37A	3245.8C
Location 2	66.35C	136.90C	90.84B	7.60C	1.62B	40.05A	3484.5B
Location 3	79.51A	169.63A	95.97A	8.49A	2.61A	38.38B	3745.5A
Sig. (p<5%)	0.97	0.96	4.13	0.19	0.20	1.13	214.6

Where, Location 1 =Dita, Location 2=Kamba, Location 3=Bonke

4. Conclusions and Recommendation

Generally the second year (2021/22 cropping season) was more productive than the first year (2020/21 cropping season) it might be due to conducive climatic condition during cropping season. The more yield was obtained from location3 (Bonke) during both cropping season compared to other locations (Dita and Kamba) it might be due to late maturing of varieties in the area compared to other locations.

Among the tested bread wheat varieties "Bondena" and "Kingbird" were identified as the well performing bread wheat varieties across the testing locations over two consecutive years when compared to the other tested bread wheat varieties. Hence, cultivation of these bread wheat varieties was recommended in Gamo highland of different districts and in other similar wheat growing areas of southern Ethiopia.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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