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Participatory Varietal Evaluation and Grain Yield Performance of Improved Bread Wheat Varieties

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Abstract
The activity was conducted in Guagusa-shikudad district using a randomized complete block design (RCBD) with three replications to evaluate the agronomic performance of four improved bread wheat varieties and their acceptability among local farmers. The agronomic traits such as days to 50% heading, days to 85% maturity, plant height, spike length, 1000 seed weight and grain yield were collected and subjected to a statistical analysis using SAS 9.4 statistical software. The varieties differed significantly for all traits except for their grain yield. Relatively, the highest grain yield was recorded by the variety ''Lemu'' (2721kgha^{-1}) followed by the varieties ''Ogolcho'' (2665kgha^{-1}), Wane (2649kgha^{-1}) and ''Hidasse'' (2342kg ha^{-1}) respectively. The varieties were also qualitatively evaluated considering their resistance to disease and lodging. Farmers' preference analysis through participatory varietal selection (PVS) approach using two different gender-based farmers discussion groups (FDG) confirmed that the varieties ''Lemu'' and ''Wane'' ranked 1st and 3rd respectively by both women and men FDG. The variety ''Ogolcho'' ranked 4th and 2nd by men and women FDG respectively. Generally, Lemu, Ogolcho and Wane were selected by the FDGs for their better grain yield, 85% physiological maturity, better tillering capacity, strong stem, resistance to disease and lodging, better biomass yield, larger grain size, and longer spike length when compared to the standard check called Danda'a which is widely cultivated in the testing location. Therefore, based on the above result, the variety ''Lemu'', ''Ogolcho'' and ''Wane'' are recommended to be demonstrated and disseminated in the small hold farms of Guagusa-Shikudad district and other agro-ecologically similar areas of Ethiopia.
Keywords: Bread wheat varieties, Participatory varietal evaluation, Grain yield performance.
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INTRODUCTION

In Ethiopia wheat is one of the major cereal crops and largely grown in the south-east, central and north-west parts of the country where predominantly grown by small-hold farmers under rain-fed condition in the highlands of Ethiopia (Shewaye and Solomon, 2018) ranking 4th and 2nd in its national production and productivity respectively among the cereal crops (Zewdie and Dawit, 2017). The most common wheat species grown are "*Triticum aestivum* L." (Bread wheat) and "*Triticum turgidum var*. durum L." (Durum wheat). Although there are recently released and better performing bread wheat varieties, the farmers in the area of the testing location are cultivating relatively older varieties such as "Kubsa" and "Tay" which (Misganaw et al., 2015).

The successful process of wheat breeding based on the farmers' knowledge on the characteristics of genotypes and its interaction with a particular environment is a successful research process and understanding the agricultural concepts that crop adaptation to a particular climatic change requires accelerated crop variety introduction accompanied with a pre suggested recommendations so as to help farmers for identifying the best variety with their field backgrounds (Beres *et al*., 2020). Thus, four improved and released bread wheat varieties including a local check were introduced and tested for their environmental adaptability and phenotypic acceptance by the local farmers. Farmers however have subjective preferences for different varietal characteristics and the varietal demand is significantly affected by their perceptions (Zewdie and Dawit, 2017). Hence, this research activity was conducted to evaluate the performance of four nationally released improved bread wheat varieties through participatory varietal selection (PVS) approach involving the local farmers.

METHODOLOGY

Materials and Design

Four improved bread wheat varieties (table 1) and one standard check were introduced and tested for their environmental adaptation and over-all agronomic performance in Guagusa-shikudad district of Awi zone, north-western Amhara regional state of Ethiopia for two consecutive cropping seasons (2018/19 and 2019/20) on strategically selected small hold farm lands using a randomized complete block design (RCBD) with three replications on a plot size of 25m^2 with 20 rows per a plot and 25cm spacing between rows. Seeds of each variety were drilled at approximately 2-3cm soil depth using the seed rate of 125kgha-1. Inorganic fertilizers were applied at the rate of local recommendation (100kgha^{-1} of DAP and 150kg^{-1} of Urea). Seed drilling and the crop management practices (weeding and harvesting) were done manually.

Table 1. Nationally released improved bread wheat varieties used in the experiment

Name of Genotypes	Seed source	Year of release	Grain yield at the time of release (kgha-1)	
			On-research	On-farm
Ogolcho	KARC	2012	2800-4000	2200-3500
Hidase	KARC	2012	4400-7000	3500-6000
Wane	KARC	2016	5000-6000	4000-5000
Lemu	KARC	2016	5000-6000	4000-5000
Danda'a (check)	KARC	2010	3500-5500	2500-5000

Note: KARC -Kulumsa Agricultural Research Center; Kha^{-1}-kilogram per hectare

Methods of data collection and analysis

Phenological data such as days to 50% heading, days to 85% physiological maturity, plant height(cm), spike length(cm), thousand seed weight(gm) and grain yield($kgha^{-1}$) were collected at appropriate growing stages of the crop. A qualitative data such as lodging and a disease data (leaf rust, stem rust and strip rust) were also collected. The phenological data were collected from five different plants sampled from the central four rows of a plot and their mean value was used for final analysis. **Plant height (PH):** the average height in centimeter (cm) from ground level to the tip of the spike. **Spike length (SL):** the average spike length in centimeter from its base to the tip. **Grain yield (GY)**: grain yield in kilogram per hectare ($kgha^{-1}$) obtained from the harvested plot size of $23m^2$ and converted to kilograms per hectare. **1000 seed weight (TGW)**: the weight of 1000 seeds in gram. The level of disease susceptibility among the tested bread wheat varieties was also assessed following the 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%)(Koyshibayev and Muminjanov,2016).

Farmers' preference analysis was also implemented through participatory variety selection (PVS) approach following the procedures described by Rahman et al. (2015) so as to know the acceptability of the well adapted bread wheat varieties among the local farmers and recommending the best fitted variety to be cultivated in the testing and other similar location of the country.

Method and approaches of the Participatory Varietal Selection (PVS)

The Participatory varietal evaluation was conducted at 85% physiological maturity stage of the wheat crop using 30 farmers (15 women and 15 men separately) by grouping them as a women and men farmers discussion group based on the Mississippi Agricultural and Forestry Experiment Station rice variety trials participatory varietal selection (PVS) protocol (MAFES, 2020). A numerical tag was assigned to each variety for the farmers' varietal evaluation. A group leader among the farmer discussion groups and a group facilitator among the participant researchers was assigned to each group. A questionnaire with five different questions was prepared and given to each discussion group. Each variety was evaluated based on the farmer groups acceptability and ranking rates with yes or no response, where yes means acceptable and no means unacceptable. Ranking was computed using 1-5 scales to determine the varietal preferences of the farmers (1 for the highest preferred variety and 5 for the least preferred variety).

Primarily, a discussion was made with farmers with giving them a chance for setting their own criteria to be used for evaluating the bread wheat varieties, and we decided that physiological maturity, strong stem, tillering capacity, disease resistant, spike length, seed size, shattering resistance, biomass yield, and grain yield were identified as the main preference criteria for evaluating and ranking the tested bread wheat varieties. Most farmers identified grain yield, biomass yield, disease resistant and physiological maturity as the top selection criteria.

Figure 1: A photo showing the PVS session while evaluating the agronomic performance of the varieties

RESULTS AND DISCUSSION

Participatory Varietal evaluation of the varieties

Through participatory varietal evaluation (table 2), both men and women farmers discussion group (FDGs) preferred the variety ''Lemu'' and ranked 1st due to its good population density, uniform physiological maturity, tillering capacity, strong stem, resistant to disease, higher biomass yield, higher grain yield, larger seed size & longer spike length.

The participants also preferred the variety ''Ogolcho'' and ranked 2nd in its better tillering capacity, better physiological maturity, disease resistant & better biomass yield (due to its longest plant height) and grain yield. The variety ''Wane'' has been ranked 3rd and 4th by the women and men farmers discussion group respectively with getting acceptance in its better tillering efficiency, disease resistant, good in its spike length and relatively higher grain yield. The standard check ''Danda'a'' ranked 4th by the women farmers discussion group whereas the men farmers discussion group ranked the variety 3rd.The variety ''Hidasse'' was not preferred by the local farmers due to its non-uniform physiological maturity, shorter spike length, highly susceptible to disease (yellow stem rust & leaf rust) though expected to be a high grain yielder variety. The farmers stated that the bread quality of the variety is not good while comparing with the other tested varieties in terms of its taste.

Table 2: The PVS result of the collective farmers' field evaluation of the Bread wheat varieties

S/No.	Variety Name	Preferred traits	Ranks given to the variety by Farmer Groups	
			Men	Women
1	Ogolcho	• high grain yielder • relatively disease resistant • good spike length • better tillering capacity • very good physiological maturity • disease resistant • higher biomass yield	2	2
2	Wane	• good tillering capacity • disease resistant • good in its spike length • relatively high grain yielder	4	3
3	Lemu	• uniform physiological maturity • good tillering capacity • strong stem • resistant to disease • high biomass yield • larger seed size & • longer spike length. • highest grain yielder	1	1

S/No.	Variety Name	Preferred traits	Ranks given to the variety by Farmer Groups	
			Men	Women
4	Danda'a (Check)	• uniform physiological maturity • better tillering capacity • high biomass yield • medium spike length • resistant to disease	3	4
5	Hidasse	• good tillering capacity • high grain yielder • highly susceptible to yellow rust disease	5	5

The phenotypic performance of the tested bread wheat varieties

In addition to the farmers preference analysis, it has been also tried to statistical analyze the measured quantitative traits using SAS 9.4 statistical software so as to strengthen the result obtained from the participatory varietal evaluation of the varieties by the FDGs (table 3). Additionally, the extent of disease and lodging resistance potential of each variety has been also measured so as to confidently recommend the best performing and more preferred bread wheat varieties to be disseminated and cultivated in the testing and other similar wheat producing areas of the country (table 4).

The mean value results of the collected agronomic quantitative trait (table 3) indicated that the four tested varieties including the check differed significantly ($P \leq 0.05$) for all the traits except for their grain yield. The average plant height of the varieties ranged from 92.07cm to 80.23cm. With a similar study Zerga *et al.* (2017) reported a plant height ranged from 54.7 to 82.57cm on different wheat genotypes. In this study the variety "Ogolcho" was measured as the tallest plant (90.07cm) and "Hidasse" as the shortest plant (80.23cm). The tested varieties were significantly varied on their spike length ranged from 7.88cm to 5.83cm for "Ogolcho" and "Wane" respectively. A mean grain yield difference among the tested bread wheat varieties was not significant. But, in contrast with this study Girma (2016) reported a significant yield difference among the bread wheat varieties of "Ogolcho", "Hidasse" and "Danda'a" at a 99% and 95% level of confidence. However, the highest combined mean grain yield was recorded by the variety "Lemu" (2721kgha^{-1}) followed by "Ogolcho" (2665kgha^{-1}) and "Wane" (2649kg ha^{-1}). Shibeshi (2019) reported a yield potential of 5080kgha^{-1} for the variety "Ogolcho" which tells that the genetic potential of the variety might not expressed during this experiment.

Table 3: The combined mean summary of grain yield and yield related traits over two years

No.	Variety	DH	DM	PH	SL	TGW	GY by year (kg ha^{-1})		
							2018/19	2019/20	Mean
1	Ogolcho	66	120	92.07	7.88	42.5	2872.40	2457.65	2665.00
2	Wane	66	120	82.3	5.83	36.75	3177.08	2121.14	2649.00
3	Lemu	64	120	83.4	7.22	35.83	3027.75	2413.41	2721.00
4	Danda'a	72	122	85.9	6.75	39.42	3321.42	1602.72	2462.00
5	Hidasse	69	119	80.23	6.43	36.5	3124.17	1560.18	2342.00
Grand mean		67	120	84.78	6.82	38.2	3104.56	2031.02	2615.00
CV		**4.19**	**0.84**	**4.82**	**10.05**	**7.26**	**12.84**	**15.96**	**14.15**
LSD (0.05)		**3.45***	**1.24***	**3.57***	**0.59***	**2.37***	**488.02 (ns)**	**396.85 (ns)**	**302.19 (ns)**

Note: DH-days to 50% heading; DM-days to 85% physiological maturity; PH-plant height in centimeter; SL-spike length in centimeter; TGW-1000 seed weight in gram; GY-grain yield in kilogram per hectare; CV-coefficient of variation; LSD-least significant difference at 0.05 level of probability

The variety "Hidasse" produced the lowest grain yield (2342kgha^{-1}) but non-significantly differed from "Lemu" (the best performed and firstly preferred bread wheat variety) and other varieties. In contrast with this study Shibeshi (2019) recorded a yield potential of 5210kgha^{-1} for "Hidasse" variety in the mid altitude areas of southern Ethiopia directing that the variety might perform better if re-introduce and evaluated with some sort of improvement. With high significant gaps with this study, 5210 kgha^{-1} yield potential of "Hidasse" has been reported by Shibeshi (2019). The grain yield decrement of the variety "Hidasse" might be due its devastation by yellow rust diseases (stem and leaf rust) as it has been indicated under table 4. Misganaw (2016) reported a mean grain yield of 3730 kgha^{-1}, 4970 kgh-1 and 3650 kgha^{-1} for "Hidasse", "Ogolcho" and "Danda'a" respectively. These two literatures confirmed that the variety "Ogolcho" is a promising variety among the tested varieties for Guagussa-shikudad district where the experiment was conducted and other agro-ecologically similar areas. The highest 1000 grain weight was recorded by "Ogolcho" (42.50gm) whereas the lowest 1000 grain weight was recorded by the variety "Lemu" (35.83gm). The 1000 grain weight of all the tested varieties were significantly

differed with a least significant difference (LSD) value of 2.37gm.

Table 4. The extent of diseases and Lodging resistance of the tested bread wheat varieties

No.	Variety	Leaf Rust	Stem Rust	Septoria	Lodging
1	Ogolcho	O	O	O	O
2	Wane	R	O	O	O
3	Lemu	R	O	O	O
4	Danda'a	O	O	O	O
5	Hidase	MR	S	O	O

Note: O –No disease occurrence; R –Resistant (severity up to 5-10%); MR –Moderately Resistant (severity up to 10-30%); MS – Moderately Susceptible (severity up to 40-50%)

CONCLUSION

From the two years combined grain yield result of the tested bread wheat varieties it has been concluded that the varieties "Lemu", "Ogolcho" and "Wane" are relatively stable varieties in their grain yield performance and obtained a better acceptance among the local farmers. Therefore, the variety "Lemu", "Ogolcho" and "Wane" could be disseminated to the local farmers of the testing and other similar areas after being demonstrated on the small hold farms owned by the corresponding local farmers. The varieties are also relatively resistance to yellow leaf rust and stem rust diseases which are the main bread wheat production constraint of the area. Hence, cultivation of these bread wheat varieties is recommended in Guagusa-shikudad district and other similar wheat growing areas of north western Ethiopia.

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