Global Scientific JOURNALS

GSJ: Volume 9, Issue 8, August 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

Performance Evaluation of Improved Bread Wheat (*Triticum aestivum* L.) Varieties at Southern Tigray, Northern Ethiopia

Girma Degife[1] and Esuyawkal Demis[2]

[1,2]Ethiopian Institute of Agricultural Research, Mehoni Agricultural Research Centre, P.O. Box 47, Mehoni, Ethiopia

Corresponding authors E-mail: girmadegife12@gmail.com and esuyawkaldemis@gmail.com

ABSTRACT

Bread wheat is an important staple food for Ethiopian people, and it is one of the most important cereal crop being cultivated in the mid and high land areas of Tigray region particularly in Southern Tigray Zone. However; it has an important cereal crop the productivity of the crop has been very low in the Southern zone as compared to world average yield and from national average productivity, which may be due to lack of improved varieties in the area and this could lead to less productivity of bread wheat in the areas. Therefore, this study was conducted to evaluate the adaptability and performance of improved bread wheat varieties and identify and select the best high yielding varieties. An experiment was conducted during 2016/17 main cropping season at Endamehoni and Emba Alaje districts, of Southern zone, Tigray, Ethiopia. Fifteen improved bread wheat varieties were evaluated in a randomized complete block design with three replications at both locations. Data on agronomic traits of wheat varieties were collected and subjected to analysis of variance. The combined analysis of variance showed that there were significant variations among the tested varieties on days to maturity, plant height, thousand seed weight and grain yield but, no significant difference was observed on days to heading. Based on the combined result the highest grain yield (5.51t ha $^{-1}$ was recorded for Liben followed by Ogolcho (5.38 t ha^{-1}. Therefore, these two varieties Liben and Ogolcho that showed better performance for grain yield among the tested varieties were selected and recommended as promising varieties for the study areas.

Keywords: Bread wheat; Grain yield; improved varieties

INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is the world's leading cereal grain and more than one third of the population of the world uses as a staple food (Obsa, 2014). It is an important industrial and food grain which ranks second among the most important cereal crops in the world after rice and traded internationally (Asadallah, 2014; Falola *et al*., 2017). Africa produces more than 25 million tons of wheat on 10 million hectare. Sub-Sahara Africa (SSA) produced a total of 7.5million tone on a total area of 2.9 million hectare accounting for 40 and 1.4 percent of the wheat production in Africa and at global levels, respectively (FAO, 2017). In Sub-Saharan African countries, wheat is also a strategic commodity which generates farm income and improves food security status (Negassa *et al*., 2013; Minot *et al*., 2015; Amentae *et al*., 2017). Wheat is a major cereal crop in Ethiopia, which is largely grown in the highlands and the country is considered the largest producer of the crop in the Sub-Saharan Africa (FAOSTAT, 2015). It is cultivated on 1.7 million hectares of land and has the production of 4.54 million tons with a low rate productivity of 2.67 t ha^{-1} (CSA, 2017) in the country as compared to world average yield (3.34 t ha^{-1}) (FAO, 2017). In Tigray regional state, particularly in the southern part of the region, wheat is a dominant crop in the medium and highland areas (Melesse, 2007). The total wheat area and production in Tigray region is 107.7 thousand hectares and 212.8 thousand tons with the average yield of 1.98 t ha^{-1}. In Southern zone of Tigray regional state, wheat stands first both in area and production among all crops followed by barley, sorghum and *tef*. In this zone, the area coverage and productivity of wheat was thousand hectare and 101.9 tons, with the average yield of 2.07 t ha^{-1} respectively which is lower than the national average productivity (CSA, 2017).

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 (Jalal, 2008). It is grown from temperate, irrigated to dry and high-rain-fall areas and from warm, humid to dry, cold environments (Acevedo *et al*., 2002). Wheat is one of the major cereal crops grown in the Ethiopian highlands, which are situated between 6-16^0 N, and 35-42^0 E, at altitudes ranging from 1500 to 3000 meters above sea level. However, the most suitable agro-ecological zones of wheat fall between 1900 and 2700 meters above sea level (Bekele *et al*., 2000; White *et al*., 2001; Abu, 2012). The ideal daily temperature for different stages of wheat development varies from 20-25^{o}C for germination, 16-20^{o}C for good tillering and 20-26^{o}C for proper plant development (Bekele *et al*., 2000).

Wheat is one of the major cereals grown for use as food and industrial raw materials in Ethiopia. It is an important staple food in the diets of many Ethiopians, providing an estimated 12% of the daily per capita caloric intake for the country's over 90 million population (FAO, 2017). Wheat has many uses like that of other cereal crops produced in the country. In Ethiopia, wheat grain is used in the preparation of different traditional as well as modern processed food products such as "injera" and other industrial processed products like pasta and macaroni (Nigussie *et al*., 2015). Besides, wheat straw is commonly used as a roof thatching material and as a feed for animals. Whole grains as part of the diet is recommended for health reasons because they are good source of minerals, fibers, protein and antioxidants and also wheat bran is a good source of minerals and fibers, and can be used to supplement bread (Heshe *et al*., 2016). The crop is also one of the most important cereal crops being cultivated in the mid and high land areas of Tigray region (Gebru and Abay, 2013).

However; the crop have many importance in the country and in the region the productivity of the crop has been very low in the country as compared to world average yield particularly in the Southern Tigray zone which is lower than even from national average productivity. The low productivity is attributed to less availability of improved varieties for different agro-ecologies preferred by the farmers (Singh, 2014); disease, soil fertility problems and moisture stress (Tesfaye *et al*., 2001). In Southern Tigray zone, so far very few improved varieties of bread wheat are being cultivated, which may be due to lack of improved varieties in the area and this could lead to less productivity of bread wheat in the areas. Therefore, the experiment was carried out to evaluate the adaptability and performance of improved bread wheat varieties and identify and select the best high yielding varieties for the study areas.

MATERIALS AND METHODS

The study was conducted at two locations of the northern part of Ethiopia in Southern zone of Tigray regional state during 2016/17 cropping season at Hizba Teklehayimanot kebele of Endamehoni district and at Tekha kebele of Emba Alaje district. The locations were expected to represent the major and potential bread wheat production areas of Southern zone. Endamehoni district is located about 120 km south of Mekelle, the capital city of Tigray regional state. Geographically, Endamehoni district is extends between 39^{0} 18' 10'' E to 39^{0} 39' 50'' E and 12^{0} 33' 20'' N to 12^{0} 55' 0'' N with an average altitude of 2250 meters above sea level. The area is characterized by bimodal rainfall pattern and receives a mean annual rainfall of 757.7 mm. The average minimum and maximum temperatures were 10.4^{0}C and 22.5^{0}C, respectively (Gidena, 2015). Emba Alaje district is located 12^{o}51' to 13^{o} 00'

N latitude and 39°15'to 39° 35' E longitude, and lies at an altitude of 2350 meters above sea level. Long-term meteorological data indicate that the mean annual rainfall for the area is 912 millimeters with a mean daily temperature ranging between 9-23ºC, and the area is characterized by bimodal rainfall pattern (Girmay *et al*., 2014). The experimental materials consist of fifteen improved bread wheat varieties; namely Wane, Lemu, Kingbird, Liben, Bulluk, Hobora, Dembel, Honqolo, Biqa, Sanete, Mandoyu, Hidasse, Ogolcho, Hulluka and Shorima were obtained from Kulumsa Agricultural Research Center and used for the experiment. The treatments were laid out in Randomized Complete Block Design (RCBD) with three replications at each location. Each experimental plot had 6 rows at a spacing of 20 cm, having plot length of 2.5m and width of 1.2m. Spacing between plots was 1m and the distance between replications was 1.5m.

The land was ploughed three times and labeled manually at the time of planting. After leveling, rows were made by hand-pulled row-marker, and after preparing the experimental plots, bread wheat seeds were sown. Sowing was done by hand drilling in both locations. Seeding was done at the rate of 125 **kg ha^{-1}**. **Fertilizers were** applied at the rate of 125 **kg ha^{-1}** Di ammonium Phosphate (DAP) and 100 **kg ha^{-1}** urea at the time of planting and tillering. Sowing was done by hand drilling and covered lightly with soil. All other crop management practices were applied uniformly to all plots as per recommendations for both locations, so that the test varieties could express their full genetic potential for the traits under consideration.

Data on agronomic traits of wheat varieties were collected on plot and plant basis from the four central rows for both locations. Data on days to heading, days to maturity, thousand seed weight (g) and grain yield **t ha^{-1}** were assessed on a plot basis. While the data for plant height was recorded from ten randomly selected plants previously selected and tagged from the central parts of each plot. Mean values of the ten randomly selected plants per plot were then used for the analysis of data. Seed yield of each plot was harvested and recorded from the middle four rows out of the six rows and then converted into **tone ha^{-1}**.

The collected data were subjected to analysis of variance (ANOVA), according to General Linear Model (GLM) using SAS statistical software version 9.2 procedure. Combined analysis of variance over locations was carried out and means comparisons were made using Least Significance Difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

Days to heading

As the study result indicates, no significant difference was observed among the tested varieties for days to heading. Interaction between location by variety was also non significant from the combined analysis of variance (Table 1). Days to heading was recorded the range of 73.17 days (Ogolcho) to 76.83 days (Lemu) with an average value of 74.82 days as indicated in Table 2. These results are in agreement with those of Obsa and Yeared (2017) who reported non- significant difference in days to heading of different bread wheat varieties. In contrast to current finding, Astawus (2016) and Ayalew (2017) reported significant difference among improved bread wheat varieties in days to heading. Also these results are in contrast to the present study; Obsa (2019) conducted evaluating agronomic performance and yield stability of improved bread wheat varieties across low moisture stress areas of Guji zone, southern Oromia and reported significant variation in days to heading.

Days to maturity

The analysis of variance revealed that days to maturity was significantly ($P<0.001$) affected by variety (Table 1); however, it did not exert any significant influenced ($P>0.05$) on the interaction between location by variety. The variation with respect to maturity ranged from 115.67 to 126.17 days; indicating considerable range of variation among the tested varieties for days to maturity. Variety Mandoyu (125.67 days) followed by Wane and Dembel varieties (117 days) had short period for maturity while Hobora (126.17 days), Lemu (125.67 days) and Biqa (124.33 days) had long period for maturity (Table 2). Considering this character for variety selection is very crucial in order to select early maturing varieties for different agro ecologies. The present results are in line with earlier studies reported by Kifle *et al*. (2016) who reported significant variation in days to maturity among different bread wheat genotypes. These results also supported by Obsa *et al*. (2018) observed significant different among the tested varieties in days to maturity.

Plant height

The combined analysis of variance showed that plant height had significantly ($P<0.001$) affected by varieties but it was no significant difference for the interaction over location (Table 1). The average plant height was 86.42 cm, with a range 75.93 cm to 95.30 cm. Among the tested varieties, the longest plant height was recorded from variety Ogolcho (95.30 cm) followed by Liben (93.62 cm). Whereas, the shortest plant height was recorded at Mandoyu (75.93 cm) variety followed by Hulluka and Biqa varieties with a height of 80.83

cm and 81.23 cm respectively (Table 2). This indicates that Ogolcho and Liben varieties proved to be both of the promising varieties for future planting in the study areas as regards its plant height. These results are in harmony with the work of Longove *et al*. (2014) who noted that plant height was significantly affected by wheat varieties. Similar studies Kifle *et al*. (2016) reported plant height ranged from 50.93 to 74.70 cm on different bread wheat genotypes. In agreement with the present study, Solomon (2019) conducted performance evaluation of released bread wheat varieties at mid altitude areas of Southern Ethiopia and reported significant variation in plant height among different bread wheat varieties. Asaye *et al*. (2013) and Obsa *et al*. (2018) also reported significance difference among the tested varieties for plant height.

Table 1. Combined analysis of variance for various traits of improved bread wheat varieties evaluated at two locations during 2016/17 cropping season

SOV	DF	**DH (days)**	**DM (days)**	**PH (cm)**	**TSW (g)**	**GY (t ha^{-1})**
Rep	2	25.08	9.34	33.65	16.48	0.003
Location	1	0.40^{ns}	170.84***	18.41^{ns}	1400.28***	34.92***
Variety	14	6.56^{ns}	59.84***	159.41***	83.26***	1.88**
Loc x Var	14	3.64^{ns}	2.94^{ns}	35.86^{ns}	20.99^{ns}	1.27^{ns}
Error	58	6.10	2.75	31.94	20.11	0.74
CV (%)	-	3.30	1.38	6.54	9.93	19.16

*ns= non-significant, **= highly significant, ***= very highly significant at P<0.05, SOV= Source of variance, DF = Degree of freedom, CV=Coefficient of variation, Rep= replication, Loc x Var= location by variety, DH= days to heading, DM= days to maturity, PH (cm) = plant height in centimeter, TSW (g) = thousand seed weight in gram and GY (t ha^{-1}) = grain] yield in tone per hectare.*

Table 2. Combined mean values of performance evaluation of improved bread wheat varieties tested at two locations during 2016/17 cropping season

Varieties	**DH (days)**	**DM (days)**	**PH (cm)**	**TSW (g)**	**GY (t**
Wane	74.00	117.00^{ef}	85.00^{d-f}	44.00^{c-f}	5.02^{a-c}
Lemu	76.83	125.67^{a}	86.10^{cdef}	47.33^{b-e}	5.08^{a-c}
Kingbird	75.00	117.83^{de}	82.53^{ef}	42.17^{e-g}	4.36^{c-e}
Liben	74.33	118.67^{c-e}	93.62^{ab}	42.67^{d-g}	5.51^{a}
Bulluk	73.67	120.83^{b}	89.27^{abcd}	49.33^{ab}	4.53^{a-e}

Hobora	74.67	126.17^{a}	84.50^{d-f}	47.67^{a-d}	3.99^{de}
Dembel	75.17	117.00^{ef}	88.87^{a-e}	48.00^{a-c}	3.89^{de}
Honqolo	73.50	118.00^{c-e}	86.97^{c-f}	46.67^{b-e}	4.01^{de}
Biqa	75.17	124.33^{a}	81.23^{fg}	44.00^{c-f}	4.44^{b-e}
Sanete	74.83	120.67^{b}	92.20^{a-c}	43.00^{c-g}	3.77^{e}
Mandoyu	76.00	115.67^{f}	75.93^{g}	41.00^{fg}	4.24^{c-e}
Hidasse	74.83	119.67^{b-d}	88.37^{b-e}	47.33^{b-e}	4.77^{a-d}
Ogolcho	73.17	119.83^{bc}	95.30^{a}	52.67^{a}	5.38^{ab}
Hulluka	76.50	119.33^{b-d}	80.83^{fg}	38.00^{g}	3.91^{de}
Shorima	74.67	118.67^{c-e}	85.57^{d-f}	43.33^{c-f}	4.26^{c-e}
Mean	**74.82**	**119.96**	**86.42**	**45.14**	**4.48**
CV (%)	**3.30**	**1.38**	**6.54**	**9.93**	**19.16**
LSD (5%)	**NS**	**1.92**	**6.53**	**5.18**	**0.99**

Column of means with the same letter (s) are not significantly different at P< 0.05; where, CV= coefficient of variation, LSD= least significant difference, DH= days to heading, DM= days to maturity, PH (cm) = plant height in centimeter, TSW (g) = thousand seed weight in gram, GY= grain yield in tone per hectare (t ha^{-1}).

Thousand seed weight

Analysis of variance for thousand seed weight exhibited significant difference among bread wheat varieties (*P<0.001*) indicating that the genetic variations among varieties; but the interaction between location by variety was non-significant (Table 1). Thousand seed weight ranges from 52.67 to 38.00g with the mean value of 45.14g. From the tested varieties, Ogolcho (52.67g) produced heaviest seed weight, while Hulluka variety obtained the lowest thousand seed weight 38.00g (Table 2). Comparative result was reported by Obsa (2014) thousand seed weight ranged from 25g to 46.67g; with the average weight of 39.67g showing high genetic variability among the genotypes. Similar results also reported in that of Obsa *et al*. (2018) and Khan *et al*. (2019) noted significant differences among varieties for thousand grain weight. But this result is in contrast to Khan *et al*. (2011) who reported non-significant differences among the genotypes for thousand grain weight.

Grain yield

Grain yield was significantly (*P<0.01*) difference due to varieties, but there was non-significant difference at the interaction between location by variety (Table 1). The variation for grain yield ranged from 3.77 t ha^{-1} to 5.51t ha^{-1} with the mean value of 4.48 t ha^{-1} The maximum grain yield was harvested from Liben variety which is (5.51 t ha^{-1}) followed by Ogolcho (5.38 t ha^{-1}), while the smallest grain yield was recorded at variety Sanete 3.77 t ha^{-1} (Table 2). Grain yield had the most important trait in any bread wheat evaluation program. The grain yield of Liben was markedly higher than the rest of the tested varieties. This higher grain yield might be associated with the adaptability and genetic make-up of the parental material of these varieties tested under similar field conditions. These results are 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. These results are further supported by Voltas *et al*. (2005) and Khan *et al*. (2016) who reported marked difference in grain yield of wheat varieties developed in different ecologies. Also these results are in line with the study of Gebru and Abay (2013), Fano and Tadeos (2017), Obsa *et al*. (2018) and Solomon (2019) who were reported significant differences of bread wheat varieties for grain yield.

CONCLUSION

The effect of varieties on grain yield was significant and the best performed bread wheat varieties Liben (5.51 t ha^{-1}) and Ogolcho (5.38 t ha^{-1}) gave the highest grain yield and showed better performance than other varieties. Therefore, these two varieties Liben and Ogolcho that showed better performance among the tested varieties were selected and recommended as promising varieties for the study areas.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abu T (2012). Grain and feed annual report. Grain report number: ET1201, Addis Ababa, Ethiopia. Research in Plant Biology, 3(1): 33-36.

Acevedo E, P. Silva, H. Silva (2002). Wheat growth and physiology. Pp. 39-70. In: Curtis, B.C., S. Rajaram and H.M. Gomez (eds.). Bread wheat improvement and production, FAO, Rome.

Amentae T K, Hamo T K, Gebresenbet G and Ljungberg D (2017). Exploring wheat value chain focusing on market performance, post-harvest loss and supply chain management in Ethiopia: The case of Arsi to Finfinnee market chain. Journal of Agricultural Science, 9(8), 22. https://doi.org/10.5539/jas.v9n8p22.

Asadallah N (2014). Wheat production price performance prediction in the Iranian north province. African Journal of Agricultural Research, 9(1), 74-79. https://doi.org/10.5897/AJAR11.429.

Asaye D, Tadesse D and Getachew A (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), Pp 3543-3550.

Astawus E (2016). Participatory and performance evaluation of improved bread wheat (*Triticum aestivum* L.) varieties in two districts of Arsi zone, Ethiopia. MSc Thesis Haramaya University, School of Graduate studies Haramaya Ethiopia.

Bekele HK, Verkuijl H, Mwangi W and Tanner D (2000). Adaptation of improved wheat technologies in Adaba and Doddola wordas of Bale highlands, Ethiopia. CIMMYT/EARO, Addis Ababa, Ethiopia. 26p.

Ayalew S (2017). Participatory demonstration and evaluation of improved variety of tef in selected districts of west and Kellem Wollega zones. International Journal of Education, Culture and Society, 2, 143-146.

CSA (Central Statistical Agency) (2017). Report on area and production of major crops (Private peasant holdings, meher season). Agricultural Sample Survey 2016/2017. Central Statistics Agency, Addis Ababa, Ethiopia.

Falaki A M, Miko S, Mohammed I B, Abubakar I U and 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.

Falola A, Achem B A, Oloyede W O and Olawuyi G O (2017). Determinants of commercial production of wheat in Nigeria: A case study of Bakura local government area, Zamfara state. Trakia Journal of Sciences, 15(4), 397–404. https://doi.org/10.15547/tjs.2017.04.024.

Fano D and Tadeos S (2017). Participatory varietal selection of bread wheat cultivars (*Triticum aestivum* L.) for moisture stress environment of Somali regional state of Ethiopia. Journal of Biology, Agriculture and Healthcare, 7, 61-63.

FAOStat (Food and Agricultural Organization Statistics) (2015). Agricultural production statistics. (http://www.fao.org/faostat) Accessed on 08 November 2016.

Food and Agricultural Organization of the United Nations (FAO) (2017). Crop prospects and food situation. Rome, Italy.

Gebru H and Abay F (2013). Evaluation of bread wheat genotypes for their adaptability in wheat growing areas of Tigray region, northern Ethiopia. J Biodivers Endanger Species 1:104. doi:10.4172/2332-2543.1000104.

Gidena T (2015). Effects of potassium rates and sources on yield and yield components of barley (*Hordeum vulgare* L.) in Enda Mokoni district of Tigray, MSc. Thesis, November 2015 Haramaya University, Haramaya Ethiopia Pp: 16-17.

Girmay T, Girmay G, Alem G, Abrhaley G, Yemane G and Tesfay H (2014). Participatory rural appraisal report: Alaje woreda, Tigray region. Cascape working paper 2.6. 1.

Heshe GG, Haki GD, Woldegiorgis AZ and Gemede HF (2016). Effect of conventional milling on the nutritional value and antioxidant capacity of wheat types common in Ethiopia and a recovery attempt with bran supplementation in bread. Food Sci. Nutr. 4(4):534-543.

Jalal Kamali MR (2008). Review on wheat status in the past, present and future. Key papers for 10th conference on sciences of breeding in Iran. Pp: 23-45.

Khan Fu, Khan M, Khattak SG, Iqbal Z, Iqbal J and Saleem Z (2019). Performance of some improved bread wheat varieties grown in Khyber Pakhtunkhwa, Pakistan. Adv Plants Agric Res. 9(1):191–193. DOI: 10.15406/apar.2019.09.00434.

Khan Fu, Khan M, Khattak SG, Iqbal Z, Iqbal J, Saleem Z and Muhammad N (2016). Screening of wheat germplasm for morho-yield traits under rainfed condition. American-Eurasian Journal of Agriculture & Environmental Science. 16(2):266–269.

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 F_5 wheat (*Triticum aestivum* L.) populations. International Research Journal of Agricultural Science and Soil Science, 1(8): 344-348.

Kifle Z, Firew M and Tadesse D (2016). The mean performance of different bread wheat (*Triticum aestivum* L.) genotypes in Gurage zone, Ethiopia. Global Journal of Science Frontier Research: D Agriculture and Veterinary, 16 (8).

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.

Melesse H (2007). Response of bread wheat (*Triticum aestivum* L.) varieties to N and P fertilizer rates in Ofla district, Southern Tigray, Ethiopia. MSc Thesis Haramaya University, School of Graduate studies Haramaya Ethiopia.

Minot N, Warner J, Lemma S, Kassa L, Gashaw A and Rashid S (2015). The wheat supply chain in Ethiopia: patterns, trends and policy options. International Food Policy Research Institute (IFPRI) Washington, DC.

Negassa A, Shiferaw B, Koo J, Sonder K, Smale M, Braun HJ, Gbegbelegbe S, Guo Z, Hodson D, Wood S, Payne Tvand Abeyo B (2013). The potential for wheat production in Africa: analysis of biophysical suitability and economic profitability, CIMMYT, Mexico, D.F.

Nigussie A, Kedir A, Adisu A, Belay G, Gebrie D and Desalegn K (2015). Bread wheat production in small scale irrigation user's agro-pastoral households in Ethiopia: Case of Afar and Oromia regional state. Journal of Development and Agricultural Economics, 7 (4), 123–130. https://doi.org/10.5897/JDAE2014.0589.

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.

Obsa C (2019). Evaluating agronomic performance and yield stability of improved bread wheat varieties across low moisture stress areas of Guji zone, southern Oromia. Agri Res & Tech: Open Access J. 22(1): 556183. DOI: 10.19080/ARTOAJ.2019.22.556183.

Obsa C and Yeared T (2017). Participatory variety selection of improved bread wheat varieties for high land Guji zone, southern Ethiopia. Journal of Biology, Agriculture and Healthcare, 7(7), pp 11-14.

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.

Singh Y P, Nayak A K, Sharma D K, Gautam R K, Singh R K, Ranbir S, … Ismail A M (2014). Farmer's participatory varietal selection: A sustainable crop improvement approach for the 21st Century. *Agroecology and Sustainable Food Systems*, 38(4), 427-444.

Solomon S (2019). Performance evaluation of released bread wheat varieties at mid altitude areas of southern Ethiopia. International Journal of Research in Agriculture and Forestry, 6(11), Pp 21-26.

.

Tesfaye Z, Bedassa T and Shiferaw T (2001). Adoption of improved bread wheat varieties and inorganic fertilizer by small-scale farmers in Yelmana Densa and Farta districts of northwestern Ethiopia. Agricultural Research Organization, CIMMYT. 9p.

Voltas J, Lopez-Corcoles H and 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(2):309– 324.

White J W, Tanner D G and Corbett J D (2001). An agro-climatological characterization of bread wheat production areas in Ethiopia. NRG-GIS Series 01. Mexico, D.F. CIMMYT.