Farmers Participatory Evaluations and Selection of Bread Wheat (*Triticum aestivum.* L) Varieties in Cheha District, Gurage Zone, Ethiopia.

Kifle Zerga, Birhanu Tsegaye and Mekonen Gebru

Wolkite University, Department of Horticulture

DOI: 10.29322/IJSRP.8.12.2018.p8497
http://dx.doi.org/10.29322/IJSRP.8.12.2018.p8497

Abstract- In participatory varietal selection farmers have the opportunity to select varieties of their own preference based on selection criteria in their own fields. In the present experiment, eight released bread wheat varieties were tested in 2016/17 main cropping season at YeYefereziye research site which is located in Cheha district of Gurage zone, Ethiopia. The objective of the experiment was to identify bread wheat variety by participating the farmers using their own criteria. Pair-wise ranking result performed by farmers showed that Alidoro is top ranked and first selected variety followed by ETBW5879 and Millan. According to direct matrix ranking technique, grain yield and disease resistance were very important criteria for selection of bread wheat variety by the farmers. Statistically, the analysis of variance showed that the genotypes differed highly significantly ($p \leq 0.01$) in spike length, plant height, spikes per spike, days to heading and days to maturity. Genotypes differed significantly ($p \leq 0.05$) in above ground biomass and grain filling period. This study can confirmed that, PVS is a practicable and more reliable approach for generating, disseminating and popularization of bread wheat technologies to the end user farmers. Therefore, variety Alidoro was selected for seed multiplication and dissemination, due to its grain yielding ability and disease resistance as compared to the other tested genotypes.

Index Terms- PVS, Bread Wheat, Alidoro

I. Introduction

Bread wheat (Triticum aestivum L.) has originated from natural hybrids of three diploid wild progenitors native to the Middle East. These are T. monococcum, T. tauschii (syn. Aegilops squarosa) and Aegilops speltoides (Lelley 1976; Ribaut *et al.*, 2001). It is an annual cool season cereal crop but it can grow in a wide range of environments around the world. Its production is highly concentrated between the latitudes of 30o and 60o N, and 27o to 40o S (Heyne, 1987), and within the temperature range of 3oC to 32o C. Wheat can grow best on well-drained soil from sea level to about 3000 masl. In Ethiopia, wheat is an introduced crop, although its time of introduction is immemorial (Hailu, 1991).

Moreover, the bread wheat process, which began some ten thousand years ago, involved the following major steps. Wild einkorn *T. urartu* crossed spontaneously with *Aegilops speltoides* (Goat grass 1) to produce Wild Emmer *T. dicoccoides*; further hybridizations with another *Aegilops (A. taushi)*, gave rise to Spelt (*T. spelta)* and early forms of Durum Wheat (cultivated emmer); Bread Wheat finally evolved through years of cultivation in the southern Caspian plains. This evolution was accelerated by an expanding geographical range of cultivation and by human selection, and had produced bread wheat as early as the sixth millennium BC. Modern varieties are selections caused by natural mutation starting with emmer wheat up to husk less modern wheat. Cytological and cytogenetic evidences showed that wheat consists of diploid, tetraploid and hexaploid (two, four and six sets of chromosomes respectively) species with a basic chromosome set of x=7. Three genomes designated as A, B (G), and D was involved in the formation of the polyploidy series (Feldmann, 2001). *T. urartu* and *Aegilops squarossa* (syn. *Triticum tauschii*) are the diploid progenitors of the A and D genomes, respectively. It is believed that *T. monoccocum* naturally hybridized with the yet unknown B-genome donor to give rise to the tetraploid emmer group. Emmer wheat in turn hybridized with *Ae. Squarossa* and a spontaneous chromosome doubling of the triploid resulted in the formation of hexaploid wheat (Feldmann, 2001).

Wheat provides more nourishment for the people of the world than any other crop, and provides the nutrition for the greater part of the world population. The world wheat market production is 727.2 million tons, the market supply is 905.9 million tons, world wheat market utilization is 703.8 million tons, world wheat trade market is 151 million tons and wheat market ending stocks is 198.6 million tons (FAOSTAT, 2015).

The objective of any breeding program is to develop genotypes with high productivity, and to achieve this goal selection is a prerequisite. Selection is an integral part of breeding programs for the development of desirable genotypes. Yield is the product of several yield contributing characters; therefore, selection for high yield requires an integrated approach.
The nature of yield and yield contributing traits are highly variable and significantly modified by external factors. The effectiveness of selection depends on the amount of variability present in the genetic material for grain yield and

related traits. Hence, estimation of variability is of prime importance (Johnson ***et al.,*** 1955b).

Wheat in Ethiopia is an important cereal crop; it ranks fourth in total area coverage and production next to teff, maize and sorghum. Around 4.23 million tons of wheat is produced on an area of 1.7 million ha and about 4.6 million farmers were involved. Oromia, Amhara, SNNP and Tigray are the major wheat producing regions in the country with the area coverage of 875641.45, 529609.63, 137294.72 and 108865.39 ha respectively. Furthermore, 86314 farmers were involved with area coverage of 14778.01 ha in Gurage Zone and more specifically 11 kebeles are wheat growing with area coverage of 7000 ha of land in cheha wereda in 2014 main production season (CSA, 2014).

The production, productivity, and expansion of wheat has been limited. This are attributed to lack of alternative improved varieties for the different wheat growing agro-ecological zones, unavailability of sufficient and poor quality seed and poor agronomic practices which are among the technical constraints and pose great research challenges to come up with appropriate technological solutions for resource poor farmers. Diseases (Rusts, fusarium, spetoria, spot bloch), pest, poor soil fertility, new epidemics, climate change and other long term evolutional effects are also the constraints of wheat production (EIAR, 2010).

In participatory varietal selection (PVS) farmers select finished or nearly finished products (released cultivars, varieties in advanced stages of testing, and advanced non-segregating lines) from plant breeding programs in their own fields (Muchow *et al*., 1994). A very important advantage of PVS is that the adoption of new cultivars is much faster than under the formal crop improvement and also the spread of varieties from farmer-to-farmer through the local seed system, guaranteeing a further good adoption (Bellon and Reeves, 2002).

According to Sperling *et al*. (2001), participatory crop improvement may have many advantages, such as increased and stable crop productivity, faster release and adoption of varieties, better understanding farmers' criteria for variety selection, enhanced biodiversity, increased cost effectiveness, facilitated farmers learning and empowerment. Farmers have a broad knowledge base on their environments, crops and cropping systems built up over many years and do experiments by their own and generate innovations, even though they lack control treatment for comparison and statistical tools to test the hypothesis (Bänziger *et al*., 2000). In many situations, formal seed supply has been unable to meet farmers' need, due to its limited supply capacity, a focus confined to only a few crops and varieties, or because it supplies inappropriate varieties for a specific locality.

The dependency of farmers on a single crop variety could be due to lack of participatory variety selection activities at cooperative level and no link with technology generating research institutes to have access for varietal choice (unpublished base line survey from LSB South, 2010). Wheat seed has huge problem both in supply and quality (Gezahagn, 2008). As a result farmers are paying more for poor quality seed and traveling long distance to acquire seed of improved varieties suited for their locality, and most of Ethiopian farmers grow their own saved seeds of the local varieties.

Previously in the study area, less priority was given to farmers for varietal choice to select and multiply variety of their own preference based on their own selection criteria. A possible option for addressing this constraint is increasing varietal portfolios through participatory variety selection and mobilizing farmers to produce good quality seed of the improved varieties suited for their environment and seed marketing at local levels. Therefore, this study was conducted with the objectives of:

1. To identify farmers' preference and selection criteria for bread wheat varieties
2. To select best performed bread wheat variety/ies based on farmers' preference

II. Materials and Method

3.1. Site Description

The experiment was conducted in Yefereziye Kebele situated in Cheha District, Gurage Zone of SNNPR.\

Table 1. Location, descriptions and weather condition of the testing site.

Site	Annual Temperature (^oC)		Annual Rainfall (mm)	Location	Altitude
	Max	Min			
YeYefereziye	24.37	10.2	1336.8	08.14794N & 037.91896E	1980

3.2. Experimental Materials

Experimental materials were comprised of eight bread wheat varieties released from different agricultural research center.

Table 2. List of the varieties, source center and year of release

	Name of Variety	Source	Year of Release
1	UTQUE96/3/PYN/BAU//MILLAN	Sinana	2014
2	ETBW 5879	Kulumsa	2014

3	Hoggana	Kulumsa	2011
4	Hulluka	Kulumsa	2012
5	Mekelle-4	Mekelle	2013
6	Mekelle-2	Mekelle	2011
7	Alidoro	Holleta	2007
8	Digelu	Kulumsa	2005

3.3. Experimental Design and Field Management Practices

The varieties were sown in early July 2016 main cropping season. The experiment was conducted using mother-baby methodology approach. Randomized complete block design (RCBD) was used with three replications. The mother trail was conducted at the main testing site whereas the baby trials were conducted at three selected farmers' field under their own cultural practices. Thus, each farmer's field was considered as replication. The varieties were randomized in each replicated field. plot size was 9m^2 (3mx3m) and seeds were sown at spacing of 20 cm between rows. Distance of 1m and 0.5m was left between each block and each plot, respectively.

Fertilizers (both Urea and NPS) was applied at the rate of 150 and 100 kg/ha respectively, full dose of P_2O_5 and half dose of N was applied at the time of planting and the remaining half dose of N at the time of tillering. Seed was sown at the rate of 150Kg/ha. Seed and fertilizer was drilled uniformly by hand. The experimental field was kept clean from weeds through hand weeding.

3.4. Data collection

Data was collected on the following attributes from the central 12 rows in each plot.

1. Days to heading (DTH): recorded as the number of days from sowing to the stage where 75% of the spikes have fully emerged.

2. Days to maturity (DTM): The number of days from sowing to the stage when 90% of the plants in a plot have reached physiological maturity.

3. Grain filling period (GFP): recorded as the number of days from heading to maturity.

4. Grain yield (GY): Grain yield in grams obtained from the central four rows of each plot was converted to kilograms per hectare at moisture content of 12.5%.

5. 1000-kernel weight (TKW): Weight of 1000 seeds in gram.

6. Above Ground Biomass (AGB): The total above ground parts of plants in the four central rows was harvested and weighed in grams

7. Harvest index (HI): On a plot basis, the ratio of dried grain weight to the dried above ground biomass weight multiplied by 100

Additionally, Ten plants were randomly selected from the 12 central rows for recording the following growth and yield components of bread wheat varieties:

1. Tillers/plant (TPP): The average number of tillers per plant

2. Plant height (PHT): The average height from ground level to the tip of the spike in cm.

3. Kernels per spike (KPS): The average number of kernels per spike

4. Spikelet per spike (SkPS): The average number of spikelet's per spike.

5. Spike length (SL): The average spike length from its base to the tip in cm.

6. Spikes per plant (SPP): The average number fertile spikes per plant including tillers.

3.5. Participatory Varietal Selection

3.5.1. Farmers' evaluation of bread wheat varieties

Farmers have evaluated bread wheat genotypes based on their selection criteria. Farmers' awareness creation was done before the field evaluation started. Farmer's field evaluation day for varietal selection was organized at different growth stages of the bread wheat crop. These are at the growth stages (which includes the vegetative, flowering and maturity stage) and at harvesting period for evaluating bread wheat varieties for yield, seed color, spike length, number of seeds per spike. 30 famers were selected and used to held the focus group discussion (FGD).

The varieties were ranked based on both direct matrix ranking and pair-wise ranking techniques. Farmers interest in that each criterion was ranked from 1 to 5 (5 = excellent, 4 = very good, 3 = good, 2 = poor and 1 = very poor). The ranking procedure was explained to participating farmers and the final ranking was done on consensus where differences were resolved through discussion (De Boef and Thijssen, 2007). Similar methodology has been used by Alebachew (2012) and Seifu et al. (2018) on wheat participatory varietal evaluation. In direct matrix ranking farmers have given rating of importance (a relative weight) of a selection criterion ranked from 1 to 3 (3= very important, 2= important and 1= less important) and rating performance of a variety for each traits of interest (selection criteria) was given based on their level of importance on the basis of common agreement of evaluators'. The score of each variety was multiplied by the relative weight of a given character to get the final result and then added with the results of other characters to find out the total score of a given variety and their ranks (Seifu et al., 2018). In the case of pair-wise ranking the varieties were compared and ranked pair-wise (Alebachew, 2012).

3.6. Data Analysis

The data recorded was subjected to analysis of variance (ANOVA) using the statistical analysis software (SAS version 9.2) package for the following statistical procedures.

3.6.1. Analysis of variance

The analysis of variance was conducted using randomized complete block design (RCBD). Both direct matrix ranking and pair-wise ranking from the mother trail was calculated. Least significant difference (LSD) test was used to compare means at 5% probability level.

ANOVA model

ANOVA of randomized complete block design was computed using the following mathematical model:

$$Yij = \mu + rj + gi + \varepsilon ij,$$

Where: Y_{ij} =the observed value of the trait Y for the i^{th} genotype in j^{th} replication

μ= the general mean of trait Y

rj = the effect of j^{th} replication

gi= the effect of i^{th} genotypes and

εij= the experimental error associated with the trait y for the i^{th} genotype in j^{th} replication.

Least significant Difference (LSD) and coefficient of variation in percent (CV in %) was computed for all characters using the statistical procedure described by Gomez and Gomez (1984).

LSD= $\alpha\,(2\sigma^2 e/r)^{½}$

CV%= $[(\sigma^2 e)^{½} / \bar{X}$) x100] where, α = t- value at 5% and 1% probability level.

III. Result and Discussion

4.1. Range and mean of characters

The analysis of variance (ANOVA) revealed that the parameters; spike length, plant height, spikelet per spike, days to heading and days to maturity were highly significantly different ($p<0.01$), whereas the parameters; above ground biomass and grain filling period were significantly different ($p<0.05$). However, spike per plant, kernels per spike, grain yield, harvest index and thousand kernel weight were not significantly different (Table 2).

The highest spike length (9.15cm) was recorded from Alidoro variety whereas the lowest (6.28cm) was obtained from Hoggana. The highest plant height (84.88cm) was obtained from Alidoro whereas the lowest (66.57cm) was recorded from Mekelle 4. This indicates that Alidoro is the tallest variety and Mekelle 4 is the shortest as compared to all tested varieties. However, this result disagree with the report of Fanos and Tadeos, 2017 who reported non-significant difference among wheat varieties on plant height. The maximum value for spikelet per spike was recorded from Millan whereas the minimum value (6.30) was recorded from Mekele 4 (Table 1). The maximum number of tiller per plant (7.27) was recorded from Hoggana which was in statistical parity with Millan, ETBW 5879, Huluka and Mekelle 2 whereas the minimum number (5.77) was recorded from Mekelle 4. This result was in agreement with Asaye *et al.,* 2013 who reported significant difference among wheat varieties at Womberma district.

The highest value for spikelet per spike (19.50) was recorded from Alidoro whereas the lowest value (14.37) was obtained from Millan. The maximum days to heading (45) was recorded from Digelu whereas the minimum days to heading (27.67) was recorded from Mekelle 2. This indicates that from the tested varieties Digelu took short period of time to reach heading stage whereas Mekelle 2 took prolonged period of time. The maximum period for maturity (94) was recorded from Digelu whereas the minimum days to maturity (71.67) was recorded from Mekelle 2 (Table 1). His result is in agreement with the study of Fanos and Tadeos, 2017 who reported significant difference of wheat varieties for the parameter days to maturity. This showed that Mekelle 2 was early maturing whereas Digelu was late maturing variety compared to the other tested varieties.

The maximum above ground biomass yield (5592.60g) was recorded from Alidoro whereas the minimum (2259.30g) was recorded from Mekelle 4. This indicates that Alidoro had the highest above ground biomass yield compared to the other tested varieties. The maximum period for grain filling (53.67) was recorded from Alidoro whereas the minimum period (40.67) was recorded from Mekelle 4 which was not statistically different with Mekelle 2. The shortest grain filling period recorded from Mekelle 2 might be due to the shortest period required by same variety to reach to heading stage.

Table.3 The mean performance of bread wheat varieties for different characters for the mother trail at Yefereziye

Genotype	SL	SPP	PH	TPP	SPKPS	KPS	GY	AGB	HI	TKW	DH	DM	GFP
MILLAN	8.29	7.70	75.99	7.13	14.37	47.73	1777.80	3592.60	0.49	45.00	35.00	77.33	42.33
ETBW 5879	7.62	7.53	70.11	7.00	14.73	51.53	2740.70	4814.80	0.58	45.00	36.00	82.00	46.00
Hoggana	7.45	7.70	74.78	7.27	14.93	48.60	2333.30	4444.40	0.53	43.33	41.00	89.33	48.33
Hulluka	7.77	7.00	71.28	6.47	15.73	54.63	2481.50	4814.80	0.51	43.33	33.00	81.67	48.67
Mekelle-4	8.27	6.3	66.57	5.77	16.6	48.47	1037.10	2259.30	0.41	41.67	33.67	74.33	40.67
Mekelle-2	8.31	6.8	73.73	6.30	15.13	47.70	2074.10	4074.10	0.50	43.33	27.67	71.67	44.00
Alidoro	9.15	6.43	84.88	5.83	19.50	61.73	2888.90	5592.60	0.51	45.00	35.67	89.33	53.67
Digelu	6.28	6.47	81.28	5.97	14.23	46.27	1740.70	2666.70	0.65	45.00	45.00	94.00	49.00
CV %	6.57	15.74	5.60	17.25	7.50	13.62	31.24	29.02	14.05	6.14	5.69	3.8475	7.5625
LSD 0.05	0.91	1.93	7.34	1.95	2.05	12.12	1167.50	2049.00	0.13	4.73	3.57	5.5559	6.1693
Mean	7.89	6.99	74.83	6.47	15.65	50.83	2134.27	4032.41	0.52	43.96	35.88	82.46	46.58
Range	9.15-6.28	7.70-6.30	84.88-66.57	7.27-5.77	19.50-14.23	61.73-46.27	2888.90-1037.10	5592.60-2259.30	0.65-0.41	45.00-41.67	45.00-27.67	94.00-71.67	53.67-40.67

SL= spike length, SPP=spikelet per spike, PH= plant height, TPP= tiller per plant, SPKPS= spikelet per spike, KPS= kernel per spike, GY= grain yield, AGB= above ground biomass, HI= harvest index, TKW= thousand kernel weight, DH= days to heading, DM= days to maturity, GFP= grain filling period

3.2. Analysis of Variance

The analysis of variance for different characters of bread wheat at Yeferezíye is presented in Table 2. Genotypes differed highly significantly (p≤0.01) for spike length, plant height, spikes per spike, days to heading and days to maturity. Genotypes differed significant (p≤0.05) for above ground biomass and grain filling period. However, no significant difference was observed in tiller per plant, kernel per spike, grain yield, harvest index and thousand kernel weight. Khan (2013), observed non-significant differences among bread wheat genotypes for days to maturity, spike length, fertile tillers, spikelet per spike, grain per spike and grain yield per plot in which is similar with some of the traits with the present study.

Table. 4 Analysis of variance (ANOVA) for 13 bread wheat characters at Yefereziye site

Source	Rep (df=2)	SS gen	MS of gen (df=7)	Error (df=14)
Spike length	1.97	14.77	2.11**	2.08
Spike per plant	9.19	7.20	1.028^{NS}	1.21
Plant height	376.60	745.10	106.44**	17.56
Tillers/plant	19.08	7.61	1.088^{NS}	1.24
Spikelet per spike	2.79	63.02	9.00**	1.38
Kernels per spike	30.60	553.83	79.12^{NS}	47.93
Grain yield	551399.3	7760317.64	1108617^{NS}	444441.60
Above ground biomass	2293735	27098274.30	3871182*	1368978.00
Harvest index	0.000954	0.10	0.01478^{NS}	0.01
Thousand kernel weight	7.29	32.29	4.613095^{NS}	7.29
Days to Heading	18.88	572.63	81.80**	4.16
Days to maturity	26.54	1311.96	187.42**	10.07
Grain filling period	13.79	370.50	52.93*	12.41

Estimated range and mean is presented in (Tables 3) for the mother trail at Yefereziye. Wide ranges were recorded for grain yield, above ground biomass and days to heading. Based on the mean separation, the highest grain yield (2889.90kg/ha) was recorded from Alidoro, while the lowest yield (1037.10 kg/ha) was obtained from Mekele 4.

The mean spike length of 7.89 with the range of 6.28-9.15, the mean spike per plant of 6.99 with the range of 6.30-7.70. The mean plant height 74.83 with the range of 66.57-84.88, the mean tiller per plant of 6.47 with the range of 5.77-7.27 and the mean spikelet per spike of 15.65 with the range of 14.23-19.50 were recorded. Moreover the mean kernel per spike of 50.83 with the range of 46.27-61.73, the mean grain yield of 2134.27 with the range of 1037.10-2888.90 and the mean above ground biomass of 4032.41 with the range of 2259.30-5592.60 were recorded. The mean harvest index of 0.52 with the range of 0.41-0.65, the mean thousand kernel weight of 43.96 with the range 41.67-45.00, the mean days to heading of 35.88 with range of 27.67-45.00, the mean days to maturity of 82.46 with the range of 71.67-94.00 and the mean grain filling period of 46.58 with the range of 40.67-53.67 were recorded.

3.3. Pair-wise ranking of bread wheat varieties

In pair-wise ranking each variety was compared in pair based up on farmers bread wheat selection criteria presented in (Table 6). The selected variety in pair comparison was counted and recorded as total score (Table 5).

Pair-wise ranking performed by group of farmers at Yefereziye indicated that Alidoro, ETBW 5879 and Millan varieties had scored a total of 7, 6 and 5 values, respectively. However, the varieties Digelu, Huluka and Mekele 4 had scored 1,1 and 0 values, respectively (Table 3). Thus, pair wise ranking result performed by farmers showed that Alidoro is top ranked and first selected variety followed by ETBW5879, and Millan. However, the varieties Mekele 4, Digelu and Huluka were the least ranked and selected by the farmers. Because this variety was susceptible to disease and they were low yielder compared to the other tested varieties.

3.4. Direct matrix ranking of bread wheat varieties

From the bread wheat selection criteria listed in table 4, grain yield and disease resistance were proposed as very important for selection of bread wheat variety by the farmers

(Table 4). This result is in agreement with varietal selection of rice reported by Sangay *et al* (2010) and wheat varietal selection reported by Alebachew (2012). Disease resistance was the other most important criteria for selection of bread wheat varieties, this is because stem rust, leaf rust and yellow rust is becoming a major threat in the study area, and the area becoming hot spot for the mentioned wheat diseases due to favorable environmental condition for disease occurrence.

Tillering capacity and spike length were important criteria for selection of bread wheat varieties by the farmers. Because they do have valuable contribution for yield increment and for an increase in biomass yield. This is in harmony with increasing tillering capacity succinct with high yield of grain and biomass yield. In addition to this, seed color, seed size, seed uniformity and market value were also ranked as an important criteria for selection of bread wheat varieties by the farmers. However, plant height was given lower rank and is the least criteria for selection of bread wheat varieties by the farmers (Table 4).

Farmers were made to identify and select the best bread wheat varieties for their agro-ecology. Farmers participatory variety selection (PVS) have significant contribution in increasing the option of wheat varieties for the farmers and to select the best one for an increase in yield and productivity of wheat. However, farmers did not have the opportunity for variety choice in the study area. This approach also coincides with the research finding of Sangay and Mahesh (2010), regarding participatory variety selection for increasing rice varietal diversity and Alebachew (2012) for wheat varietal selection.

Generally, according to direct matrix ranking technique for selection of bread wheat varieties, Alidoro was selected at the first place with total score of 87, which was followed by ETBW5879, Millan, Mekelle 2, Hoggana, Huluka and Digelu with a total score of 85, 79, 72, 71, 59, 53 and ranked as 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th} and 7^{th}, respectively (Table 4). However, Mekelle 4 was the least selected variety by the farmers due to the fact that it is highly affected by disease.

Table 5. Pair-wise ranking of bread wheat varieties by group of farmers at Yefereziye

Varieties	ETBW 58 79	Millan	Mekele 4	Huluka	Alidoro	Hoggana	Mekele 2	Digelu
ETBW 5879								
Millan	ETBW 5879							
Mekele 4	ETBW 5879	Millan						
Huluka	ETBW 5879	Millan	Huluka					
Alidoro	Alidoro	Alidoro	Alidoro	Alidoro				
Hoggana	ETBW 5879	Millan	Hoggana	Hoggana	Alidoro			
Mekele 2	ETBW 5879	Millan	Mekele 2	Mekele 2	Alidoro	Mekele 2		
Digelu	ETBW 5879	Millan	Digelu	Huluka	Alidoro	Hoggana	Mekele 2	
Total Score	6	5	0	1	7	3	4	1

Table 6. Direct matrix ranking of bread wheat varieties by group of farmers' at Yefereziye

Selection criteria	Relative weight	ETBW 5879	Millan	Mekele 4	Huluka	Alidoro	Hoggana	Mekele 2	Digelu
Grain yield	3	(15)5	(12)4	(3)1	(9)3	(15)5	(12)4	(12)4	(9)3
Spike length	2	(6)3	(6)3	(2)1	(6)3	(10)5	(6)3	(6)3	(6)3
Plant height	1	(3)3	(3)3	(2)2	(4)4	(5)5	(3)3	(4)4	(3)3
Tillering capacity	2	(8)4	(6)3	(2)1	(6)3	(10)5	(6)3	(6)3	(6)3
Disease resistance	3	(15)5	(12)4	(3)1	(12)4	(15)5	(12)4	(12)4	(3)1
Seed color	2	(10)5	(10)5	(4)2	(4)2	(6)3	(8)4	(8)4	(6)3
Seed size	2	(8)4	(10)5	(4)2	(6)3	(10)5	(8)4	(8)4	(4)2
Market value	2	(10)5	(10)5	(6)3	(4)2	(6)3	(8)4	(8)4	(8)4
Seed uniformity	2	(10)5	(10)5	(6)3	(8)4	(10)5	(8)4	(8)4	(8)4
Total score		85	79	32	59	87	71	72	53
Rank		2	3	8	6	1	5	4	7

Note: Total number of Participants (Farmers) are 30 (male=20, female=10)

Rating of performance of a variety for a selection criteria: 5=excellent, 4=very good, 3=good, 2=poor, and 1=very poor. Relative weight of a selection criteria: 3=Very important, 2=Important 1=less important

In pair wise ranking at Yefereziye, Alidoro, Millan and ETBW5879 were considered as best varieties, whereas Digelu, Huluka and Mekele 4 were the least preferred varieties by farmers (Table 3). According to direct matrix ranking at Yefereziye, Alidoro, ETBW 5879 and Millan varieties were considered as best followed by Mekele 2, Hoggana and Huluka. However, Mekele 4 and Digelu varieties were the least preferred ones because of their less resistance to diseases (Table 4).

Grain yield and disease resistance were proposed as very important criteria as indicated in (Table 4). Grain yield was considered as the most selection criteria for each bread wheat varieties and this is also in agreement with varietal selection of rice reported by Sangay *et al* (2010) and Alebachew (2012) for wheat varietal selection. The second most important selection criteria was disease resistance because stem and leaf rust is becoming a major threat in most wheat growing areas including the study area. Especially, cheha wereda is a hot spot area for various diseases which is related to the warm and humid weather condition of the environments. In view of this disease resistance was important selection criteria that were suggested by farmers.

Tillering capacity and spike length were ranked as one of important criteria that would have valuable contribution for yield. This is in harmony with increasing tillering capacity succinct with high potential of yield and biomass. Seed color, seed size, market value and seed uniformity also were ranked as one of important criteria. However, plant height was given lower rank by farmers.

As described above farmers were able to identify and select the best wheat varieties for their agro-ecology. From the research finding the approach of PVS have significant contribution in increasing the option of wheat varieties because farmers did not have choice of variety before. This approach also coincides with the research finding of Sangay and Mahesh, (2010), regarding participatory variety selection for increasing rice varietal diversity and Alebachew (2012) for wheat varietal selection.

IV. Conclusion

South nation, nationality people region especially Cheha, Ezha, Gumer and Sodo districts are potential for wheat production in Ethiopia. However, due to lack of promising released wheat varieties for those areas the farmers were not able to obtain varietal options. In the last few years, a number of promising wheat varieties were released but not reached to farmers. In order to tackle this problem, it is imperative to evaluate the performance of bread wheat varieties in the highland ecosystems with involvement of farmers in the varietal selection for sustainable technology dissemination and faster adoption of improved varieties.

Accordingly, eight released bread wheat varieties were tested at Yefereziye research site which is located in Cheha district, Gurage zone. With the objective of to identify appropriate and farmer preferred bread wheat varieties under participatory variety selection trials using farmers' selection criteria. The analysis of variance showed that genotypes differed highly significantly ($p \leq 0.01$) at Yefereziye in spike length, plant height, spikes per spike, days to heading and days to maturity. Genotypes differed significantly ($p \leq 0.05$) in above ground biomass and grain filling period. However, genotypes did not differed significantly for tiller per plant, kernel per spike, grain yield, harvest index and thousand kernel weight.

In pair wise and direct matrix ranking result performed by farmers showed that Alidoro is top ranked and first selected variety followed by ETBW5879, and Millan. Grain yield and disease resistance were proposed as very important for selection of bread wheat variety by the farmers. Generally, the approach of PVS is the most practical and reliable way for bread wheat technology generation, popularization and dissemination.

Acknowledgement

We would like to thank Wolkite University for financial support, giving the opportunity to use research field, allocating the required labor, materials for field work and vehicle for the research field supervision.

Conflict of Interest

There is no conflict of interest between the authors or anybody else

References

[1] Alebachew, H. (2012). Participatory and Performance Evaluation of Improved Bread wheat Varities in Degua Tembien and Ofla woredas of Tigray Region , Ethiopia (*Triticum aestivum* L.) MSc Thesis Haramaya University, School of Graduate studies Haramaya Ethiopia.

[2] Almekinders, C.J.M., Thiele, G. and. Danial, D.L. (2006). Can cultivars from participatory plant breeding improve seed provision to small-scale farmers. *Euphytica*, 153: 363-372.

[3] Asaye Demelash L., Tadesse Desalegn and Getachew Alemayehu. (2013). Participatory varietal selection of bread wheat (*Triticum aestivum* L.) genotypes at Marwold Kebele, Womberma Woreda, West Gojam, Ethiopia. African journal of agricultural research. Vol.9(3),pp.327-333

[4] Ashby, J.A. and Lilja, N. (2004). Participatory Research: Does it work? Evidence from Participatory Plant Breeding. In: New directions for a diverse planet. Proceedings of the 4th International Crop Science Congress, 26, September to October 1, 2004. Brisbane, Austria. Published on CDROM.

[5] Bänziger, M.; G.O. Edmeades; D. Beck and M. Bellon. (2000). Breeding for drought and nitrogen stress tolerance in maize: From theory to practice. CIMMYT, pp.68.

[6] Bellon, M. R. and Reeves, J. (2002). Quantitative Analysis of Data from Participatory Methods in Plant Breeding. *Agricultural Economics*, 103: 233-244. .

[7] CSA (Central Statistics Authority). (2014). Agricultural Sample Survey. Report on Area, Production and Yield of Meher Season Crops for Private Peasant Holdings. Statistical Bulletin 532, CSA, Addis Ababa, Ethiopia.

[8] de Boef, W.S. and Ogliari, J.B. (2008). Participatory crop improvement and supporting informal Seed supply. *In*: M.H., Wageningen, Wageningen International. Pp. 177-185.

[9] De Boef, W.S. and M.H. Thijssen, 2007. Participatory Tools Working with Crops, Varieties and Seeds: A Guide for Professionals Applying Participatory Approaches in Agro-biodiversity Management, Crop Improvement and Seed Sector Development. Wageningen International, Wageningen, The Netherlands, ISBN: 9789070785161, Pages: 83.

[10] EIAR (Ethiopia Institute of Agricultural Research). (2010). Bread Wheat Research Project for increased production and productivity, EIAR, Kulumsa, Ethiopia.

[11] FAOSTAT (Food and Agricultural Organization Statistics). (2015). Cereal production, carry over stock, supply and Demand Brief, March 05 U.S.A.

[12] Feldmann, M.,2001. Origin of cultivated wheat. Pp.3 - 56. In A. P. Bonjean and W. J. Angus (Eds.). The world wheat book. A history of wheat breeding. Lavoiser Publishing, France.1

[13] Gezahagn, W. (2008). Determinants and role of farmers' seed and seedling multiplication in the SNNP region seed system, MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

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

[15] Hailu Gebre-mariam. 1991. Bread wheat breeding and genetics research in Ethiopia. *In* Hailu Gebre-Mariam, D.G. Tanner and Mengistu Huluka (ed.) Wheat Research in Ethiopia: A Historical Perspective. IAR/CIMMYT. Addis Ababa

[16] Hannachi, A., Fellahi, Z., Bouzerzour, H. and Boutekrabt, A. (2013). Diallel-cross analysis of grain yield and stress tolerance-related traits under semi-arid conditions in Durum wheat (Triticum durum Desf.). *Electronic Journal of Plant Breeding,* 4 (1): 1027 - 1033.

[17] Johnson H.W., H.F. Robinson and R.E. Comstock. 1955b. Estimates of genetic and environmental variability in soybeans. *Agronomy Journal* **47**: 314-318.

[18] Joshi, A. and Witcombe J.R., (1996). Farmer participatory crop improvement, II. Participatory Varietal Selection: a case study in India. *Experimental Agriculture,* 32(4): 461-477.

[19] Khan, S.A. (2013). Genetic Variability and Heritability Estimates in F2 wheat Genotypes. *International Journal of Agriculture and Crop Sciences,* 5 (9): 983-986.

[20] Monty, J., Timoty, D., Nila, L. and Amadou, B. (2000). Participatory Varietal Selection. West Africa Rice Development Association (WARDA), 01 BP 2551, Bouake, Coted Ivoire.

[21] Muchow, R.C., Hammer, G.L. and Vanderlip, R.L. (1994). Assessing climate risk to sorghum production in water limited subtropical environments. Effects of planting date, soil water at planting, and cultivar phenology. *Field Crops Research,* 36: 246-53.

[22] Ortiz-Farrara, G., Joshi, A.K., Chand, R., Bhatta, M.R., Mudwari, A., Thapa, D.B. and Sufian, M.A. (2007). Partnering with farmers to accelerate adoption of new technologies in South Asia to improve wheat productivity. *Euphytica,* 157: 399-407.

[23] Seifu, A.E., Frew, M. and Tadesse, D. 2018. Performance and farmers selection criteria evaluation of improved bread wheat varieties. *African Journal of Agricultural Research*. Vol. 13(44), pp. 2477-2498.

[24] Sperling, L.E., Ashby, J.A., Smith, M.E., Weltzen, E. and McGuire, S. (2001). Participatory plant breeding approaches and results. *Euphytica,* 122: 439-450.

[25] Weltzien, E., Smith, M.E., Meitzner, L.S. and Sperling, L. (2003). Technical and institutional issues in participatory plant breeding from the perspective of formal plant breeding: A global analysis of issues, results and current experience. Participatory Plant Breeding Monograph No. 1. Cali, Colombia: PRGA program. 226 Pp.

[26] Witcombe, J.R., Joshi, K.D., Gyawali, S., Musa, A.M., Johansen, C., Virk, D.S. and Sthapit, B.R.. (2005). Participatory plant breeding is better described as highly client-oriented plant breeding. *Experimental Agriculture,* 41: 299-319.

[27] Yadaw, R.B., Khatiwada, S.P., Chaudhary, B., Adhikari, N.P., Baniya, B., Mudwari, A. and Tripathi, B.P. (2006). Participatory Varietal Selection (PVS) of rice varieties for rain fed conditions. International Rice Research Institute (IRRI) rice fact sheet.

AUTHORS

First Author – Kifle Zerga, He was contributed starting from proposal development, field lay out, Planting, field management, data collection, data analysis and research write up.
Second Author – Birhanu tsegaye, He contributed in field lay out, Planting, field management, data collection and research write up.
Third Author – Mekonen Gebru, He contributed in field lay out, Planting, field management, data collection and research write up