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Participatory Variety Selection of Improved Bread Wheat Varieties for Moisture Stress Areas of Guji Zone, Southern Oromia

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ABSTRACT

Wheat is a major cereal crop produced at different agro-ecologies of Guji Zone, Southern Oromia. However, an access of improved bread wheat variety is highly limited, especially for moisture stressed areas of the Zone. Due to this and other preceding factors, the potential of the area to wheat crop is not exploited. So, there is a need to develop and promote technologies that suit for the area. As a result, the current experiment was conducted at two moisture stressed areas of two districts (Adola and Wadera) to select and recommend high yielding, early maturing, moisture stress and diseases tolerant improved bread wheat varieties through participatory variety selection. Seven moisture stress tolerant improved bread wheat varieties with one local check were used as testing materials. The treatments were arranged in randomized completed block design with three replications for mother trial and farmers were used as replication for baby trials. Both agronomic and farmers data were collected based on the recommended standards. Data collected from mother trail were subjected to analysis of variance where as matrix ranking was used for data's collected from baby trial. The analysis of variance indicated presence of significant differences at ($P \leq 0.01$) among the evaluated bread wheat varieties for days to heading, days to maturity, plant height, thousand seed weight and grain yield. However, non-significant difference was observed among the varieties for grain filling period, spike length, total number of tillers per plant, number of fertile tillers per plant, number of spikelet per spike and number of kernels per spike. Significant variability was observed among the tested bread wheat varieties for grain yield qt/ha, which was ranged from 11.97 to 28.62 qt/ha with the mean value of 23.07 qt/ha and coefficient of variation 14.31%. The highest grain yield (28.62 qt/ha) was recorded for Mekelle 02 followed by Mekelle 01 (27.09qt/ha). But, low yield of 11.97 qt/ha was obtained from local variety (control).In other cases, farmers were allowed to evaluate the varieties using their own criteria. Accordingly, variety Mekele 02 and Mekele 01 were selected by farmers due to their best performance. Thereby, these two improved bread wheat varieties are selected based on agronomic data result and farmers preference and recommended for production to the study areas.

Keywords: *Bread wheat, participatory variety selection, improved variety.*

INTRODUCTION

Wheat is an important cereal crop which is cultivated worldwide and extensively grown in temperate regions. It is the staple food for 40% of the world's population (Peng *et al.*, 2011). Wheat is the second only to rice which provides 21% of the total food calories and 20% of the protein for more than 4.5 billion people in 94 developing countries (Braun *et al.*, 2010). Global wheat grain production must increase 2% annually to meet the requirement of consistently increasing world population (around 9 billion) till 2050 (Rosegrant and Agcaoili, 2010). Wheat is produced under a wide range of climactic conditions and geographical areas and due to its high adaptability with various climactic conditions of environment, its distribution range is more than any other plant species and it is the staple food for most of the world's increasing population (Jalal Kamali, 2008). It is grown from temperate, irrigated to dry and high-rain-fall areas and from warm, humid to dry, cold environments. The optimum growing temperature is about 25°C, with minimum and maximum growth temperatures of 3° to 4°C and 30° to 32°C, respectively (Briggle, 1980). Although about three-fourths of the land area where wheat is grown receives an average of between 375 and 875 mm of annual precipitation, it can be grown in most locations where precipitation ranges from 250 to 1750 mm (Leonard and Martin, 1963). Undoubtedly, this wide adaptation has been possible due to the complex nature of the plant's genome, which provides great plasticity to the crop. In Ethiopia, wheat is the second most important crop next to tef in terms of area coverage, but most of the production is concentrated in the highland plateaus of the country (AU-SAFGRAD, 2013).

Wheat is a major cereal crop produced in different agro-ecologies of Guji Zone. Out of the total grain production area of the Zone, about 70.75% (87 thousand hectares) with 73.84 %(2 million quintals) of production is shared by cereals crops from which wheat accounted 5.6 %(4.8 thousand hectares) and 5.8 %(117.9 thousand quintals) of production. However, the productivity of the crop remains low to the Zone (24.17 qt ha-1) as compared to the regional and national average yield of the crop which is 28.2qt ha-^{1} and 25.35 qt ha-^{1} respectively (CSA, 2016). This might be, due to lack of improved varieties, poor management practices, biotic factors (weeds, diseases and insect pests etc.) and a biotic factors (frost), rain fall variability (intensity as well as duration) (Obsa *et al*.,2017). As a result, the potential of the area to wheat crop is not exploited. Many wheat varieties have been released by national and regional research institutes that are adaptable to a wide range of environments for commercial production. Some of these varities were tested at high land agro-ecology of the Zone and selected varities are recommended for production. However, there is no selected and recommended improved bread wheat varities for moisture stress area of the Zone. To overcome such problems, introducing improved technologies by involving users through participatory variety selection is very imperative. Because, it enables faster adoption of new cultivars than the formal crop improvement and also the spread of varieties from farmer-to-farmer through the local seed system can be very fast, thus guaranteeing a further good adoption(Assefa *et al*.,2014). It also enables the farmers to evaluate the materials based on important traits of their interest, help to increase on farm varietal diversity, faster varietal replacement and rapid scaling up (Asaye *et al*., 2013). In view of this, the current study was conducted to address the following objectives;

- To evaluate and recommend high yielding, early maturing , diseases and moisture stress tolerant improved bread wheat varieties through PVS
- To assess farmers' selection criteria for improved bread wheat varieties and
- To identify the most important criteria for future bread wheat improvement work to the study area.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at two locations (Adola on station, on farm and Wadera on farmers' field) during short season of 2017/18 cropping season to select and recommend high yielding, early maturing, moisture stress and diseases tolerant improved bread wheat varieties through PVS. Adola and Wadera districts are located at about 470 KM and 530 KM to the south from Addis Abeba. Both districts are characterized by three agro-climatic zones, namely Dega (high land), Weina dega(mid land) and Kola(low land) with different coverage. The mean annual rain fall and temperature of the districts are about 900mm and 12-34 ^{0}c respectively. Based on this condition two time cropping season was commonly practiced i.e Arfasa (main cropping season) which start from March to April especially for maize, haricot bean, wheat and barley. The second cropping season is called Gana (short cropping season) which was practiced as double cropping using small size cereal crops like tef, wheat and barley after harvesting the main cropping season crops. This study was also conducted during short cropping season at selected moisture stress area.

Description of Planting Materials and Experimental Design Employed

Seven moisture stress tolerant improved bread wheat varieties (Lucy, Fantale, Gambo, Mekele 02, Amibara, Adel Werer and Mekele 01) were used as testing materials with one local check. The treatments were arranged in randomized completed block design with three replications for mother trial (planted on station) and farmers were used as replication for baby trials. For this purpose, one farmer field was used as replication for baby trials in which selected farmer's plant materials in one replication and the other host farmers were planted the two non-replicated trials. At both trial sites, the materials were planted on a plot size of, 2.5mX1.2m having 6 rows with 20 cm between rows. In puts (seeds, fertilizers) and management practices were applied as recommended for wheat production. Data was collected in two ways: agronomic data & farmer's data. For agronomic data phenological, Growth, yield and its component were collected following their own principles.

Data Collection

Data was collected from a net plot of four rows and selected plants of the plot for agronomic and diseases data. Collected agronomic data includes; Days to heading (DTH), Days to 90% maturity (DTM), Grain filling period (GFP), Plant height (cm), Spike length (cm), Total number of tillers/plant, Total number of fertile tillers/plant, Number of spiklet per spike, Number of kernels per spike,1000-kernel weight (TKW) and Grain yield/ha (kg/ha).Diseases data was also recorded for major diseases including YR,LR and SR based on the recommended recording methods and scales.

Data Analysis

Data collected from mother trials was subjected to ‘’SAS’ ’software (version 9.0) to evaluate the variability of the tested varieties. This was done through computing analysis of variance for all characters studied according to the method given by Gomez and Gomez (1984). For data’s collected from baby trials, matrix ranking suggested by De Boef *et al*., (2007) was employed.

Result & Discussion

The analysis of variance (ANOVA) for grain yield and other agronomic characters of 8 bread wheat varieties sown at research station as mother trail is presented in table 1. The analysis of variance (ANOVA) indicated presence of significant differences at ($P \leq 0.05$ and $P \leq 0.01$) respectively among the evaluated bread wheat varieties for days to heading, days to maturity, plant height, thousand seed weight and grain yield. However, non-significant difference was observed among the varieties for grain filling period, spike length, total number of tillers per plant, number of fertile tillers per plant, number of spikelet per spike and number of kernels per spike. Comparative result of significant difference among bread wheat varieties for days to maturity, grain yield and harvest index was also reported by Fano and Tadeos, 2017. Asaye *et al*., 2013 was also reported significant difference among bread wheat varieties in plant height, days to maturity and days to heading but non-significant difference in grain yield in mother trial. Significant difference among bread wheat genotypes for grain yield was also reported by Vamshikrishna *et al*., 2013, Asefa *et al*.,2014, Obsa *et al*., 2017, Alsalimiya *et al*., 2018.

Table1. *Analysis of Variance for different agronomic parameters of different bread wheat Varieties from mother trial*

Source of variation	Mean square										
	DH	GFP	DTM	PH(cm)	SL(cm)	SPPS	KPS	TPP	NPT	TSW(gm)	Gy(kg/ha)
Genotype(7)	26.80^{*}	152.17^{ns}	161.56^{*}	56.78^{*}	0.27^{ns}	0.79^{ns}	7.44^{ns}	0.34^{ns}	0.42^{ns}	60.21*	81.14^{**}
Rep(2)	0.88^{ns}	1824.59^{**}	1905.26^{**}	16.91^{ns}	0.19^{ns}	0.61^{ns}	5.85^{ns}	0.29^{ns}	0.61^{ns}	30.23^{ns}	9.66^{ns}
Error(14)	8.88	76.43	55.65	19.43	1.03	1.46	13.11	0.51	0.32	10.48	10.89
R	0.6	0.79	0.86	0.61	0.13	0.25	0.26	0.29	0.48	0.77	0.79

*** = highly significant at $P \leq 0.001$; *= significant at $P \leq 0.05$; ns = not significant at P= 0.05; a Numbers in parentheses are degrees of freedom associated with the corresponding source of variation; DH: Days to heading, DTM: Days to maturity, GFP: grain filling period, PH: plant height in centimetre, SL: spike length in centimetre, TPP: tillers per plant, NPT: Number of productive tillers, TSW: thousand seed weight in gram, Gy: grain yield/ha in quintals.*

Mean Performance of the Varieties

Phenological Parameters

Range and mean values for the 8 characters are shown in Table 2. The variation with respect to days to heading and days to maturity was ranged from 53 to 62 and 103 to 126.67 days respectively, showing a wide range of variation among the varieties for maturity. Based on the study result, the longest days to heading was revealed by control (62 days) followed by Gambo (58.33 days). However, early heading was recorded for varieties Fantale and Amibara (53 days) followed by Mekelle 02(56 days), Mekelle 01(56.33 days), Lucy (57 days) and Adel Werer (57 days). In other cases, variety Mekelle 02 was early maturing variety (103 days) followed by Mekelle 01 (111.33days). Among the tested varieties, local variety (Control) was late maturing with 126.67 days followed by Fantale (124 days). Early maturity is an important selection criteria in areas of moisture deficient to produce significant crop yield through sustaining effective crop growth stages. According to Din *et al*. (2010), higher temperature reduced the growth and development of wheat plant and the early maturity due to high temperature was one factor of reduced yield in wheat. Kifle Zerga *et al., 2017 also reported c*omparative result of 57.67 and 112.67 days to heading and maturity respectively for variety Mekele 01 and 62.33 and 109 days to heading and maturity for variety Mekele 02.

Growth Parameters

Among the considered growth parameters, significant variation was observed among the tested bread wheat varieties only in plant height with the mean value of 81.12cm and coefficient of variation 5.13 %(Table 2). The longest plant height was exhibited by Gambo Variety (89.66cm) followed by variety Mekelle 02(85.00cm). However, the shortest plant height was revealed by Amibara variety (76.5cm). Significant variation among bread wheat genotypes for plant height was also reported by many authors including by Inamullah *et al***.,**2011, Asaye *et al*., 2013, Asefa *et al*.,2014,Obsa *et al*.,2017. Incontrast, non-significant variation among bread wheat varieties was reported by Fano and Tadeos, 2017.

Table2. *Mean values of different bread wheat varieties for grain yield and other agronomic characters from mother trial*

Varieties	DH	GFP	DTM	PH(cm)	SL(cm)	SPPS	KPS	TPP	NPT	TSW(gm)	Gy(qt/ha
Lucy	57.00^{bc}	56.0^{abc}	113.00^{bc}	77.9^{bc}	7.01^{a}	13.89^{a}	41.56^{a}	3.37^{a}	2.94^{ab}	35.47^{cde}	23.98^{ab}
Fantale	53.00^{c}	71.0^{a}	124.00^{ab}	81.27^{bc}	7.33^{a}	14.44^{a}	43.33^{a}	2.46^{a}	2.17^{b}	33.33^{de}	21.85^{b}
Control	62.33^{a}	64.3^{ab}	126.67^{a}	81.23^{bc}	7.82^{a}	15.44^{a}	46.33^{a}	3.22^{a}	3.11^{ab}	43.4^{a}	11.97^{c}
Gambo	58.33^{ab}	54.5^{bc}	112.83^{bc}	89.66^{a}	8.01^{a}	15.11^{a}	45.33^{a}	3.22^{a}	3.28^{a}	40.8^{abc}	22.38^{b}
Mekele 02	56.0^{bc}	47.3^{c}	103.33^{c}	85.00^{ab}	7.72^{a}	15.22^{a}	45.67^{a}	3.39^{a}	3.06^{ab}	42.3^{ab}	28.62^{a}
Amibara	53.00^{c}	60.8^{abc}	113.77^{abc}	76.5^{c}	7.72^{a}	14.44^{a}	43.33^{a}	3.4^{a}	3.21^{a}	37.07^{bcd}	26.94^{ab}
Adel Werer	57.00^{bc}	57.7^{abc}	114.67^{abc}	77.95^{bc}	7.69^{a}	14.56^{a}	43.67^{a}	2.78^{a}	2.61^{ab}	30.67^{e}	21.69^{b}
Mekele 01	56.33^{bc}	55.0^{bc}	111.33^{bc}	79.45^{bc}	7.33^{a}	14.99^{a}	45.00^{a}	3.05^{a}	3.16^{a}	35.6^{cde}	27.09^{ab}
Mean	56.63	58.33	114.95	81.12	7.58	14.76	44.28	3.11	2.94	37.33	23.07
CV (%)	5.26	14.99	7.5	5.43	13.56	8.18	8.18	23.01	19.23	8.67	14.31
LSD(0.05)	5.22	15.31	13.06	7.72	1.8	2.12	6.34	1.25	0.99	5.67	5.78

DHT: Days to heading, DTM: Days to maturity, GFP: grain filling period, PHT: plant height, SL: spike length, SPPS: Spikelet per spike, KPS: kernels per spike, TPP: tillers per plant, NPT: Number of productive tillers, TSW: thousand seed weight, Gy: grain yield/ha.

Yield and Related Parameters

As indicated in table (2), significant variation in thousand seed weight between the eight examined wheat varieties was elucidate with the range of 30.67 to 43.4 gm and mean value of 37.33gm. Highest 1000-grain weight of 43.4gm was obtained from the local variety followed by mekelle 02(42.3gm) .In other case, Adel werer variety exhibited the lowest thousand seed weight (30.67gm). As the study result indicates, significant variability was observed among the tested bread wheat varieties for grain yield qt/ha, which was ranged from 11.97 to 28.62 qt/ha with the mean value of 23.07 qt/ha and coefficient of variation 14.31%. The highest grain yield (28.62 qt/ha) was recorded for Mekelle 02 followed by Mekelle 01 (27.09qt/ha). But, low yield of 11.97 qt/ha was obtained from local variety (control). Gebru and Abay, 2013 reported 31 and 29.6qt/ha for variety Mekelle 01 and Mekelle 02 respectively.

Farmer's Variety Selection Criteria's

In this case, farmers were allowed to evaluate the varieties using their own criteria. Because, 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). Based on this concept, farmers were informed to set criteria for selecting best bread wheat variety according to their area before undertaking varietal selection. This was done by making group discussion among the farmers which comprises elders, women and men.

After setting the criteria they were informed to prioritize the criteria according to their interest. By doing this, farmers were allowed to select varieties by giving their own value. Accordingly, *Diseases resistant, High yield, Early maturity, Marketability (white seed colour), Spike length, Tillering capacity, Palatablity, plant height are criteria's outlined by the farmers*. Based on set criteria, the evaluated varieties were revealed various values by the evaluators (farmers). With this regard, variety Mekelle 02 and Mekelle 01 were showed better performance in tolerance to various diseases, high grain yield, early maturity, spike length, tillering capacity and plant height. Better performance of these varieties to the set criteria may reflect the importance of the varieties to the study area. For instance, early maturity of the varieties to the area may enable the varieties to produce significant yield with the offered moisture during the crop growth. Asefa *et al.*, 2014 also justified early maturing variety in moisture deficit area enables the variety to produce high yield. Seed colour is also another selection criteria considered by the farmers.

Table3. *Farmers' preference scores and ranking for baby trial*

Variety name	Farmers selection criteria										
	1	2	3	4	5	6	7	8	Total	Average	Rank
Lucy	2.5	2.8	3.5	3.3	4.3	4.5	5.0	4.8	30.5	3.81	5
Fantale	1.8	3.0	1.8	3.5	4.0	3.8	4.8	4.3	26.8	3.34	6
Control	1.0	1.3	1.0	2.8	1.5	1.3	5.0	3.0	16.8	2.09	8
Gambo	3.5	3.8	2.8	4.8	4.5	4.3	5.0	5.0	33.5	4.19	4
Mekele 02	4.3	4.8	5.0	5.0	4.8	5.0	5.0	5.0	38.8	4.84	1
Amibara	4.5	4.5	4.0	4.8	4.8	4.8	5.0	5.0	37.3	4.66	3
Adel Werer	2.0	2.3	2.5	4.8	2.3	3.3	5.0	3.0	25.0	3.13	7
Mekele 01	4.3	4.5	4.8	4.8	5.0	5.0	5.0	5.0	38.3	4.78	2

1=Diseases resistant, 2=High yield, 3= Early maturity, 4=Marketability, 5=Spike length, 6=Tillering capacity, 7=Palatablity, 8=plant height

CONCLUSION

In areas where improved technologies are not widely addressed like Guji Zone of Southern Oromia, it's paramount to take immediate action towards setting appropriate research methods. In such case, Participatory variety selection is an effective tool in facilitating the adoption and extension of the improved technologies. Because, the users are allowed to participate in selecting appropriate technologies by employing their own indigenous knowledge. As the result, the current study was also verified that farmers were able to participate in selecting improved bread wheat varieties through employing their own selection criteria. Thereby, two improved bread wheat varieties i'e Mekele 02 and Mekele 01 are selected by the farmers and recommended for the study areas and similar agro-ecologies.

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