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Participatory Varietal Selection of Spring Bread Wheat Cultivars (*Triticum aestivem* L.) under Lowland Irrigated Environments of Afar and Oromia Regional States, Ethiopia

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Abstract

The different sites selected from Agro-pastorals communities at Gewane and Fentale districts (Ftaledy and Alge) in 2017-18 under lowland irrigated areas. Fifteen (15) irrigated bread wheat cultivars used using RCBD in two replications on 5 m^2 plot area. The ANOVA revealed highly significant difference (p 0.01) among cultivars and Environments for the different traits under study. The Genotypes by environment interaction was highly significant difference (p 0.01) for plant height, thousand kernel weight and Grain yield. By mean yield (kg/ha) outperformed cultivars were Amibara-2 (4005), G14 (3924), Fentale 3909 followed by Lucy and Fentale-2 with 3838 and 3773 respectively. GLADIUS/2*BAVIS cultivar is the best in its thousand kernel weight and earliness followed by Fentale-2 and Amibara-2 and preferred similarly by Agro-pastorals. Winners at respective environment were G3 (Lucy) and G7 (Amibara-2) at gewane in 1st and 2nd respectively, and G14 (WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLL1*2/4/ND643/2*WBLL1), G6 (Fentale-2) and G4 (Fentale) won at Alge environment, and also at Fateledy G5 (Amibara) was the winner. The most stable cultivar were G4 (Fentale), G6 (Fentale-2), G5 (Amibara) and G10 (ETBW5898). The farmers' preference for biomass (Fentale, Ga'ambo and ETBW 5955), spike length and spike density (Fentale and Fentale-2) and for uniformity the leading cultivars are Fentale-2 as the 1st rank, and Fentale, ETBW 5898, G15 as the 2nd choices. By the Awn characteristics; Fentale-2 is most preferred followed by Fentale and G15. In crop stand Fentale-2 and Fentale got 1st and 2nd rank respectively followed by the Ga'ambo, G8, G15 and ETBW5898. Based on total value of selection and general ranking mean the three out most preferred varieties were identified as Fentale-2, Fentale and Ga'ambo orderly.

Keywords: Agro-pastoral; Bread wheat cultivars; Participatory variety selection; Stability

Introduction

Ethiopia is the second largest wheat growing area in SSA next to South Africa covering an area of more than 1.67 million hectares with the productivity of 27.36 quintals/hectares [1]. Wheat is the important staple crop in Ethiopia and ranked 4th in area and production of total grain crops which has resulted increase in a production mainly by smallholder farmers using rain-fed based production system [1]. 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 countries over 90 million population [2].

The potential lowland areas of Ethiopian especially the irrigated agro-ecology is not yet utilized as much as possible for improved wheat varieties and other main food crops to contribute its share to the national production, food security and the economic growth with existing resources. Since last decade the continual wheat research and technology generation, demonstration and popularization in some lowland irrigated areas was very promising that showed the production potentials for wheat. The progress in irrigated wheat varieties release and related development works can justify the possibility of utilizing the existing resources and opportunities [3]. The efficient way to attain the goal of improved variety dissemination in short time could be the participation of end users in wheat crops technology generation, adaption and adoption tasks which helps to achieve required impact and improve the livelihoods of peoples.

Participatory varietal selection fastens the dissemination of improved varieties to marginal areas [4-6]. Farmers evaluate multiple traits that are important to them and help to increase on farm varietal diversity, faster varietal replacement helps better understanding of farmers' criteria for variety selection and enhances varietal diversity [7]. Most of the pastoral and Agro-Pastoral communities in rift valley of Ethiopia have less exposure to wheat production for long ages which needs strategic ways to enhance their skill and make them able to produce and benefit from the current irrigated wheat production initiatives by the Government at large. Therefore; this study was targeted to participate end users in varietal selection, share experiences, develop skill and identify Agro-pastorals main traits of interest on wheat varieties then enhance irrigated wheat production in lowland areas.

Materials and Methods

The study areas and agronomic practice

The study was conducted by Werer Agricultural Research Centre (WARC) under Ethiopian Institute of Agricultural Research (EIAR) in Afar Regional State at Gewane district located at 620 m a.s.l (10°10'N, 40°32'E). It was done in Easten showa of Oromia regional state in Fentale distric at two kebles namely Ftaledy and Alge/Garadima (Gara dima (08°42'39"N and 39°49'35"E at 1129 m a.s.l). The 15 bread wheat cultivars were used in randomized completed block design (RCBD) with two replications and planted mid-October to November during cool season under irrigation on 5 × 5=25 m^2 plot area. The seed rate were used in 100 kg/ha basis. The fertilizers (UREA=100 N Kg/ha, DAP=50P_2O_5 kg/ha) was applied based on previous practice in the irrigable areas. DAP applied whole at planting and UREA Fertilizer application was on split basis; half at seedling growth stage and the second half at booting stage. The irrigation was applied at 10 day interval using furrow method. Data were recorded for Days to 50% heading, Days to 75% Maturity, Spike length, spikelet number per spike, Plant height (cm), Number of kernel per spike, Thousand kernel weight (g) and Grain yield (kg ha^{-1}). The Agro-pastoral selection criteria were set based on the importance of traits and their preference.

Statistical analysis of data

The yield components and yield data across locations were subjected to analysis of variance (ANOVA) and Varieties by environment interaction (GGE) biplot analysis using appropriate software GenStat statistical package 18th Edition (VSN International 2015). Comparison of means were using Fischer's Least Significant Difference (LSD) test at 5% probability levels.

Farmers selection

The Agro-pastoral and farm were selected at different sites. The different Agro-pastorals group both male and female of the community, district experts and Development agents were participated in selection with breeders at all the three districts. The decisions were mainly leaded by the Agro-pastorals view and interest with the exiting situation of the agro-ecology and challenging issues. Ranking were done for the nine each and every traits under study based on scale of 1-Excellent, 2-Very good, 3-Good, 4-satisfactory and 5-Poor. The selection was done at grain filling to maturity stage.

Results and Discussion

Analysis of variance among cultivars

The analysis of variances from bread wheat cultivars evaluated revealed that highly significant (p 0.01) difference among Genotypes and Environments for all the traits studied (Table 1). The Genotypes by environment interaction was highly significant difference (p 0.01) for plant height, thousand kernel weight and Grain yield (Table 1). The result shows the existence of variability among considered cultivars and the different environmental factors. The cultivars distinguishing future also helps to consider the producers preference more clearly which can be utilized in further breeding with more required specific traits. The location variation could be temperature and soil variability which can help to identify widely and specifically adapted cultivars.

Traits	Env	Mean square			Means	CV
		Genotype	G*E	Error		
DF	247.3**	66.34**	8.84 ns	2.334	57.8	5.3
DM	2194.5**	47.38**	12.01 ns	11.06	93.1	3.6
PH	2065.09**	211.6*	104.6**	65.7	88.1	9.2
SPL	12.1**	4.3**	1.3 ns	0.86	8.5	10.9
NSPS	75.1**	6.5*	3.83	2.25	15.4	9.7
NKPS	281.6*	106.3*	35.8 ns	43.3	38.4	17.1
TKW	563.5**	55.4**	16.02*	7.5	33.2	8.3
GY	27262505**	1447736**	924298*	410907	3333	19.2

Table 1: Analysis of Variance for 8 different traits of different bread wheat genotypes.

Mean performance of bread wheat cultivars

The mean performance of the evaluated bread wheat cultivars traits across different environment presented in Table 2. From all the cultivars evaluated in different locations the outperformed were Amibara-2 with mean yield of 4005 kg/ha, WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBL L1*2/4/ND643/2*WBLL1 (3924 kg/ha), Fentale 3909 kg/ha followed by Lucy and Fentale-2 with 3838 kg/ha and 3773 kg/ha mean performance respectively. GLADIUS/2*BAVIS cultivar is the best in its thousand kernel weight and earliness followed by Fentale-2 and Amibara-2 (Table 2). Fentale and Ga'ambo are the leading bread wheat varieties by their kernels number per spike respectively. Superior cultivars were well identified with their yield and related traits mean performance which helps for further irrigated wheat development works in lowland areas.

Trt	Bread wheat cultivars	DF	DM	PH	SPL	SPS	KPS	TKW	YLD
G1	Ga'ambo	60.8	92.8	96.7	9.4	16.8	43.9	33.9	2962
G2	Werer-2	62.3	98.2	84.8	7.6	15.1	37.1	30.9	3197
G3	Lucy	62.2	94	92	8.2	15.4	37.1	27.2	3838
G4	Fentale	59.3	96.5	98.2	9.6	16.4	45.4	30.1	3909

G5	Amibara	59.2	96.3	91.2	10.1	17.3	39.1	29.2	3629
G6	Fentale-2	56.8	92.3	90.2	9.2	15.2	37.4	36.2	3773
G7	Amibara-2	55.5	90.2	84.9	8	14.6	35.7	33.6	4005
G8	SERI 82/SHUHA'S'/PASTOR-2	58.3	94	93.7	8.9	15.9	40.2	35.1	3182
G9	REYNA-28	55.8	93.3	83.1	7.8	15.1	39.7	32.6	2973
G10	ETBW 5898	58.2	93.2	83.6	7.9	15.6	38.1	32.2	3439
G11	ETBW 5955	60.2	93.5	85.4	9.5	16.1	38.9	31.4	2659
G12	GLADIUS/2*BAVIS	49.7	86.7	80.7	7.2	13.2	27.7	38.2	2482
G13	VEE/MJI//2*TUI/3/PASTOR /4/BERKUT/5/BAVIS	59.2	92.7	92.4	8.6	15.1	41.7	34.4	3052
G14	WHEAR/KUKUNA/3/C80.1 /3*BATAVIA//2*WBLL1*2 /4/ND643/2*WBLL1	54	92.3	85.7	8.3	14.2	39.9	36.4	3924
G15	WHEAR/VIVITSI//WHEAR /3/FRNCLN	56	90	77.8	8	15.1	33.6	36.1	2970
Mean		57.8	93.1	88	8.5	15.4	38.4	33.2	3333
LSD		3.5	3.9	9.5	1.1	1.8	7.7	3.2	7.5
CV		5.3	3.6	9.2	10.9	9.7	17.1	8.3	19.2

Table 2: Mean values of different bread wheat Cultivars for grain yield and other agronomic characters from the trials.

Comparison of cultivars preference by agro-pastorals on different traits

The 15 different bread wheat cultivars were evaluated on different traits (maturity date, Plant height, Yield and yield component traits). Participatory variety selection is very important which helps to involve producers to know their best preference and making ownership [8]. The farmers preferences on maturity revealed that four cultivars GLADIUS/2*BAVIS, WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLL1*2/4/ND643/2*WBLL1, WHEAR/VIVITSI//WHEAR/3/FRNCLN, Fentale-2 were more preferred by communities for their earliness. Ga'amboo, Lucy and Fentale varieties are more preferred by their plant height and tillering and the three cultivars Fentale, Ga'ambo and ETBW 5955 are selected by the communities for their biomass. Fentale and Fentale-2 are the most preferred varieties in spike length and spike density performance. By their uniformity preferences the leading cultivars are Fentale-2 the 1st rank, and Fentale, ETBW 5898, WHEAR/VIVITSI//WHEAR/3/FRNCLN the 2nd choices. The awn characteristics of Fentale-2 selected most followed by Fentale and WHEAR/VIVITSI//WHEAR/3/FRNCLN. In overall crop stand Fentale-2 and Fentale got the 1st and 2nd rank respectively followed by the Ga'ambo, SERI 82/SHUHA'S'/PASTOR-2, WHEAR/VIVITSI//WHEAR/3/FR NCLN and ETBW 5898. Based on the total value of selection by ranking and the general mean the three out most preferred varieties were identified as Fentale-2, Fentale and Ga'ambo in 1st, 2nd and 3rd rank respectively (Table 3). The participatory varietal selection (PVS) is very important to facilitate the adoption and adaptation process of irrigated wheat to pastoral and agro-pastoral communities of Ethiopia. The similar studied showed the same trend of technology dissemination [4,6]. The study clearly showed agro-pastorals interest on different traits next to yield (uniformity, crop stand, awn characteristics) which are on better progress. The best early maturing cultivars similarly most preferred by agro-pastoralists (Tables 2 and 3) and similar to Fano and Tadeos, 2017 findings. Earliness is very important to save resources (time, irrigation and land) especially for agro-pastoral irrigated areas which can augment multiple cropping.

GGE-biplot analysis

Polygon view of the gge biplot: The polygon view of the GGE-biplot analysis helps one detect cross-over and non-crossover genotype-by-environment interaction and possible mega environments in multi-location yield trials [9]. G14, G11, G12 and G1 were vertex genotypes (Figure 1). They are best in the environment lying within their respective sector in the polygon view of the GGE-biplot; thus these genotypes are considered specifically adapted [10]. The 5 rays divide the biplot into 5 sectors, and the environments fall into 2 of them. Genotypes close to the origin of axes have wider adaptation [11]. The environments fall into two quadrants. G14 performed well in E1 (Alge) and E2 (Fateledy). This genotype performed well in environments with relatively higher altitude and medium temperature. Vertex genotype G3 (Lucy) performed well at Gewane (Afar), thus being adapted to relatively lower altitude and high temperature. Three vertex genotypes, G11, G12 and G1, had the highest yield in none of the environments. Figure 1 suggests that there exist 2 possible lowland irrigated bread wheat Mega Environments (MEs) in the Middle Awash: one (ME-1) represented by genotypes G14 and the other (ME-2) by G3. However, this ME pattern needs verifying through multi-year environment trials to be carried out in the target region.

Trt	Genotype/ Cultivars	Parameter and Score											
		Earliness	Plant height	Tiller number	Biomass yield	Spike length	Spike density	Uniformity	Awn xts	Crop stand	Total	mean	Rank
G1	Ga'ambo	3.2	2.1	2.3	2.3	2.2	2.7	2.3	2.4	2.3	21.7	2.41	3
G2	Werer-2	3.8	3.5	2.7	2.7	3.4	2.6	2.9	2.8	3	27.3	3.04	15
G3	Lucy	3.4	2.1	2.3	2.4	3	2.8	2.7	2.8	2.6	24.1	2.68	10
G4	Fentale	3.5	2.6	2.3	2.3	2.2	2.2	2.1	2.2	2.1	21.5	2.39	2
G5	Amibara	3.5	2.8	2.8	2.9	2.4	2.7	2.9	2.6	2.8	25.4	2.82	12
G6	Fentale-2	2.7	2.6	2.5	2.5	1.9	2.3	1.9	2.1	1.9	20.3	2.26	1
G7	Amibara-2	2.8	2.7	3	2.9	3	3.2	2.9	2.6	2.7	25.9	2.87	13
G8	SERI 82/ SHUHA'S'/ PASTOR-2	3.2	2.7	2.4	2.5	2.5	2.5	2	2.4	2.3	22.6	2.51	4
G9	REYNA-28	2.9	2.9	2.6	2.6	2.7	2.5	2.4	2.4	2.5	23.5	2.61	9
G10	ETBW 5898	3.2	3.2	2.6	2.6	2.7	2.4	2.1	2.4	2.3	23.5	2.61	8
G11	ETBW 5955	3.3	2.4	2.4	2.3	2.3	2.7	2.8	2.7	2.4	23.2	2.58	7
G12	GLADIUS/2*BAVIS	1.8	2.8	3.3	3.6	3.5	3.7	2.5	2.9	3	27.1	3.01	14
G13	VEE/MJI//2*TUI/3/PASTOR/4/BERKUT/5/ BAVIS	2.9	2.9	2.5	2.5	2.6	2.4	2.3	2.4	2.3	22.8	2.53	5
G14	WHEAR/KUKUNA/3/C80.1/3*BATAVIA// 2*WBLL1*2/4/ ND643/2*WBLL1	2.2	3.1	3	2.9	3	2.8	2.3	2.6	2.4	24.2	2.69	11
G15	WHEAR/VIVITSI//WHEAR/3/FRNCLN	2.4	3.1	2.6	2.7	2.9	2.6	2.1	2.2	2.3	23	2.56	6
Total		44.8	41.5	39.3	39.7	40.3	40.1	36.2	38	36.9	356	39.6	120
Mean		2.99	2.77	2.62	2.65	2.69	2.67	2.41	2.5	2.46	23.7	2.64	8
Rank		9	8	4	5	7	6	1	3	2	-	-	-
1-Earliness, 2-Plant height, 3-Tiller number, 4-Biomass yield, 5-Spike length, 6-Spike density, 7-Uniformity, 8-Awn characteristics, 9-Crop stand.													

Table 3: Farmers' preference scores and ranking on different traits of Irrigated bread wheat Cultivars.

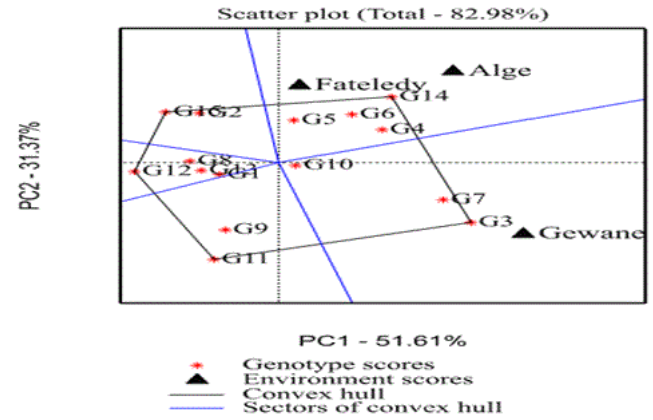

Figure 1: Polygon views of the GGE-biplot based on symmetrical scaling for the which-won where pattern for genotypes and environments.

Evaluation of genotype based on the ideal genotype: The best genotype can be defined as the one with the highest mean grain yield and stable across environments and is located in the first concentric circle in the biplot. Desirable genotypes are those located close to the ideal genotype which used as benchmark for selection [12]. Thus, genotypes G14 (WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLL1*2/4/ND643/2*WBLL1) and G4 (Fentale) can be thus used as benchmarks for evaluation of bread wheat genotypes under lowland irrigated conditions of Middle Awash. G6 (Fentale-2), G7 (Amibara-2), G5 (Amibara), G3 (Lucy), and G10 (ETBW 5898) were located near the ideal genotype, thus being desirable genotypes. All selected cultivars are desirable genotypes except G14 which were not selected and G1 (Ga'ambo) selected by the Agro-pastorals. Undesirable genotypes were those distant from the first concentric circle, namely, G15 (WHEAR/VIVITSI//WHEAR/3/FRNCLN), G12 (GLADIUS/2*BAVIS), G8 (SERI 82/SHUHA'S'/PASTOR-2), G13 (VEE/MJI//2*TUI/3/PASTOR/4/BERKUT/5/BAVIS), G9 (REYNA-28) and G11 (ETBW 5955) (Figure 2). Our results confirm those by Sharma et al. (2010), who found outstanding genotypes near to the ideal genotype in wheat for five consecutive years.

Genotypes G7 (Amibara-2), G6 (Fentale-2), G4 (Fentale), G3 (Lucy), G10 (ETBW5898) and G5 (Amibara) had mean grain yield higher than the grand mean. The rest of the genotypes yielded lower than the grand mean (Figure 2). Considering simultaneously yield and stability, G4 (Fentale), G6 (Fentale-2), G5 (Amibara) and G10 (ETBW5898) showed the best performances because they showed the shortest distance from the average environment, suggesting their adaptation to a wide range of environments [12]. The rest of the genotypes had a large contribution to the genotype by environment interaction; they were unstable across environments, having the longest distance from the average environment.

Evaluation of environments based on the ideal environment: The ideal environment is representative and has the highest discriminating power [10]. Similarly to the ideal genotype, the ideal environment is located in the first concentric circle in the environment-focused biplot, and desirable environments are close to the ideal environment. Nearest to the first concentric circle, Environment E2 (Fateledy) was close to the ideal environment; therefore, it should be regarded as the most suitable to select widely adapted genotypes (Figure 3).

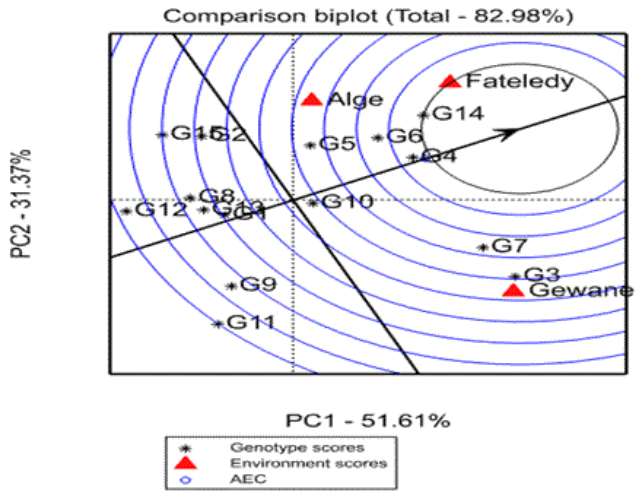

Figure 2: GGE-biplot based on genotype-focused scaling for comparison the genotypes with the ideal genotype. PC and G stand for principal component, genotypes and environments respectively.

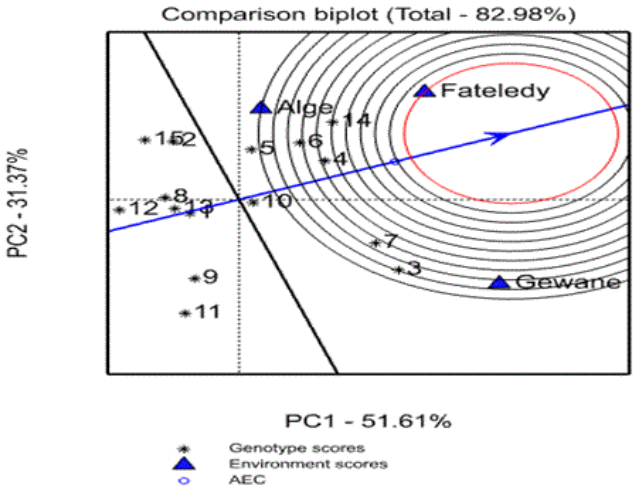

Figure 3: GGE biplot with scaling focused on environments, for the evaluation based on the ideal environment of 15 bread wheat genotypes across three environments (Alge, Fateledy and Gewane).

Conclusion and Recommendations

The study clearly identified the most preferred varieties (Fentale-2, Fentale, and Ga'ambo) and end users preferences on trait of interest (uniformity, crop stand, awn characteristics, and tillering capacity) in addition to grain yield by Agro-pastorals with existing conditions. The overall performance superiority and better stability matched with the Agro pastorals preferences strongly. Therefore participation of communities on the technology generation process is very important to enhance their knowledge to different traits of irrigated wheat

varieties and production skill. Following the Participatory Variety Selection (PVS); irrigated wheat production by agro-pastorals achieved promising result for a first time in Fateledy which showed impact of PVS in technology dissemination. Therefore it is better to reach the communities by the preferred varieties to scale out the irrigated wheat technology in fast. In future it is better to consider the different community groups to select at different wheat growth stages at various distinctive sites throughout the lowland irrigable areas in different seasons.

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