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Participatory Variety Selection for Enhanced Promotion and Adoption of Improved Sorghum [Sorghum bicolor (L) Moench] Varieties for the Humid Lowland of Assosa Zone, Western Ethiopia

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ABSTRACT

The development of Successful improved sorghum varieties for the western part of Ethiopia particularly Benishangulgumuz requires the incorporation of farmer's perceptions and desires into the end product. Failure to do this in the past probably explains the low rates of adoption of improved varieties in Benishangulgumuz national regional state. Therefore, a variety developed through PVS usually meets demand of different stakeholders as a result the lowland sorghum varieties were evaluated in randomized complete block design (RCBD) with three replications in main cropping season during 2018 at Kurmuk district. Participatory rural appraisal tools such as focus group discussions, matrix ranking and individual reviews were used to collect data from farmers from their sorghum selection criteria, preferences and acceptance of the new improved sorghum varieties. Therefore the experiment was initiated with the objective to evaluate and select well adapted and best performing humid lowland sorghum varieties to the targeted location. The result of current study clearly showed a significant difference between the tested varieties from most morphological traits. Biomass, and threshability, of improved varieties were the most important criteria for farmers to choose a new variety. Accordingly, farmers overwhelmingly selected Melkam followed by Assosa-1 sorghum variety. Farmers' also gave priority for grain yield and earliness of varieties. Generally, early maturing varieties with high yield potential, resistance to foliar and grain diseases, would be welcomed by farmers. However, they had indicated they would not totally reject their local varieties because of social considerations.

Keywords: Adaptability, Direct matrix, Improved variety, Traits of interest,

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INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench], is one of the most important cereal crops in the semi-arid tropics (SAT). It is a globally cultivated cereal, unique due to its tolerance to drought, water logging, saline - alkaline, infertile soil and high temperatures [1]. The crop is a C4 photosynthetic plant which increases efficiency of carbon dioxide fixation in plants. Such plants are well adapted to regions of lower latitude that have higher temperatures and are prone to drought [2]. Sorghum is widely used for food, feed and beer brewing [3], especially in Africa. The crop is utilized in different forms, where the grain is used for human food and homemade beverages, and for feed. The juice from sorghum can be converted to alcohol using currently available, conventional fermentation technology [4].

In Ethiopia, sorghum is grown over a wide range of ecological zones due to its tremendous genetic diversity. It is the third important crop in terms of area coverage and fourth in volume of production. It is adapted to a wide range of environment, and hence can be produced in the highlands, medium altitude and lowland areas. It has widely produced more than any other crop, in areas where there is moisture stress. In 2015/16 cropping season, sorghum was produced on about 1,854,710.93 hectares of land from which 4,323,300 tons of yields were obtained [5, 6].

Benishangul-Gumuz Region (BGR) is one of the dominant sorghum producing where the crop is used as staple food for majority of the people. Most sorghum varieties planted in Benishangulgumuz region are farmer's conserved landraces, although formal sector breeding has been undertaken for more than 25 years [7]. Among grain crops, cereals cover over 78% 162,954.80 of the land cultivated by grain crops (cereals, pulses and oil crops) the major cereals being sorghum, millet and maize. Out of the area cultivated sorghum, have a share of and 31.79% of the area in the regional grain production. The area covered, the total production and the average grain yield of sorghum was estimated to be 51,803.23 6 ha, 116895.603 tons and respectively [5].

Plant breeding programs have made major contributions to cropping system productivity in Ethiopia. The last 40 years research in this country has resulted in the release of over 50 sorghum cultivars in lowland, intermediate and highland agro ecologies of the country [8]. However, the level of adoption is not appreciably high because of the lack of appropriate varieties. Researchers have previously developed new varieties to provide solutions to problems perceived independently from the farmers. Research and extension methods that have been used by researchers did not take in to account farmers participation. [9], indicated improved sorghum varieties had not been well assimilated in Ethiopia due to the loose research extension-farmer linkage and farmers in many places do not know the improved varieties at all. [10]. Pointed out the importantly to participate farmers during variety development and cultivar (s) selection based on

its (their) positive traits associated to farmers benefit in their socio-cultural and micro-climate.

Even though, the crop is important for the region particularly to Kurmuk district, lack of improved varieties and their accessibility associated with edaphic and biotic factors that have been identified as one of the primary sources of lower sorghum production in the areas are the number one constraints [11]. No matter these entire constraints, farmer's participatory varietal selection has not been done on nationally released lowland sorghum varieties for the district having niche agro ecology irrespective to the region. Therefore, to tackle the aforementioned problem, in addition to the existing varieties, introduction of nationally released improved varieties to the areas and testing of their performance became necessary. As a result, the experiment was conducted with the objective to evaluate and select well adapted and the best performing humid lowland sorghum variety(s) to the targeted location.

MATERIALS AND METHODS

The experiment was carried out during the main cropping season of 2017/18 in Assosa zone, kurmuk district, which is located at 765 km to the west away from Addis Abeba and about 105 km North West Assosa. Kurmuk is one of the woreda's of Assosa Zone in the semi-arid belt of the north western lowlands in the Benishangul-Gumuz Regional State. The site is situated at 730 meters above sea level altitude and characterized by uni-modal rainy seasons, "*Meher*" which extends from Mid-May to October. In this area, the annual maximum and minimum temperature are 38.9^0C and 20^0C, respectively, and receives an average annual rainfall of 431 mm.

Experimental Materials, Design and Field Management Procedures

The experiment consist a total of nine released sorghum varieties (three medium maturity three striga resistance and two humid lowland varieties) and one local sorghum landrace collected from MARC and AsARC (Table1). The experiment was designed as a Randomized Complete Block Design (RCBD) with 3 replications. The individual plot size was 4 rows wide, 75 cm between rows, and 5 m long. At approximately 30 days after emergency the seedling were thinned to 15 cm distance between plants. Nitrogen and phosphorus fertilizer were applied in the form of urea (46% N) and NPS (19% N, 23% S and 38% PO) @ 100 kg/ha selection has not been done on regionally released recommendation. NPS fertilizer was applied at the time of planting (as basal application) whereas urea was applied in the form of split application, half of it together two weeks at thinning and the rest as top dressing before heading at knee stage of the crop. Hand weeding was practiced as frequently as needed.

Farmers' Participatory variety Evaluation and Procedures

Farmers who participated in varietal selection trials were selected in collaboration with the development agent of the district based on their experience in sorghum production. Accordingly,

twenty-one farmers were invited to the stations to evaluate the varieties that were nearly ready to harvest. Fourteen of the participants were men whereas six are women. The criteria farmers use in selecting suitable varieties depends on the existing constraints opportunities and their indigenous knowledge. Therefore, the first step was identifying and prioritizing production constraints and selection criteria. Participatory varietal selection (PVS) takes into consideration a number of traits in addition to yield, and they include: Biomass, threshability, earlier maturity, ear type (usually compact is preferred) and size, grain color, Lodging resistance, Bird damage resistance and disease resistance. Using 21 farmers in group discussion (GD), selection criteria were identified and prioritized in the experiment areas. A direct matrix table was prepared by putting varieties and preferred traits in row and column respectively, and the score were given to each variety based on the selection criteria(5=very good, 4=good, 3=moderate, 2=poor, 1=very poor)

Table 1. Sorghum varieties used in the study

No	Varieties	Year of release	Maintainer
	Gobiye	2000	MARC/EIAR
	Abshir	2000	MARC/EIAR
	Birhan	2002	SARC/ARARI
	Dekeba	2012	MARC/EIAR
	Gambella 1107	1976	MARC/EIAR
	Melkam	2009	MARC/EIAR
	Meko-1	1998	MARC/EIAR
	Adukara	2015	AARC/EIAR
	Assosa 1	2015	AARC/EIAR
	Bobe adi		Farmer(local landraces)

Source: Ministry of Agriculture, 2016.

Data collected and Analysis

Agronomic data were collected on days to flowering plant height (cm), Lodging resistance Bird damage, days to maturity, thousand seed weight (gm), grain yield (kg/ha). The data generated was subjected to the analysis of variance [12] using R Software package version 3.4.4 and the means were separated

using LSD (Least Significant Difference) at the 5 % level of significance. Farmers' preference data were analyzed using pairwise matrix preference ranking method. Pairwise Comparison Matrix is a good way of weighing up the relative importance of different courses of action. It is a tool that provides a framework for comparing each course of action against all others, and helps to show the difference in importance between factors. For each comparison, we decided which of the two options was more important, and then assigned a score to show how much more important it was [13].

RESULTS and DISCUSSION

The analysis of variance (ANOVA) for grain yield and other agronomic characters of 10 sorghum varieties evaluated at farmer training center is presented (Table 2.) and indicated presence of significant differences at ($P \leq 0.05$ and $P \leq 0.01$). Comparably similar result was reported by [14]. The morphological and phenological characters as well as grain yield are significantly affected by genetic potential of the genotypes. Significant grain yield was obtained from Melkam variety followed by Assosa-1 and Gambella1107. The two varieties Melkam and Gambella1107 were significantly better in medium maturing which was a farmer preferable trait (Table.2)

Table2. Mean values of different Sorghum varieties for grain yield and other agronomic characters

Entry#	Genotype	DTF	PHT	DTM	INSCT	BD	PAS	GYLD (Kg/ha)	TSW
1	Birhan	61 b	150 ab	98.3 b	2 b	1.333 a	2.667 bc	1048 fg	22.57 b
2	Gobiye	60 b	143.3 a	99.7 c	2.667 c	0 a	3 c	816 g	18.27 c
3	Abshir	62.33 bc	163.3 abc	101.3 d	2.667 c	0 a	2.667 bc	701 g	18.43 c
4	Melkam	62.33 bc	173.3 bcd	101 d	2 b	10 b	1 a	3256 a	23.17 ab
5	Deqaba	67.33 d	145 a	102.7 e	2.667 c	1.667 a	2.667 bc	1433 ef	14.83 d
6	Meko	56.67 a	181.7 cde	97 a	2 b	3.333 a	2 abc	2020 cd	25.77 a
7	Gembella1107	64.67 c	193.3 de	101 d	2 b	0 a	1.667 ab	2406 bc	22.3 b
8	Assosa-1	120.67	200 e	160 g	1 a	15 c	2 abc	2523 b	15.87 cd

		e							
9	Adukara	121.33 e	193.3 de	157.7 f	1 a	0 a	2.667 bc	1659 de	15.43 d
10	Bobe adi(local)	126.67 f	328.3 f	163 h	2 b	0 a	3 c	1687 de	15.2 d
Gmean		80.3	187.2	118.17	2	3.13	2.33	284.351	19.18
CV		1.8	8.2	0.6	13.9	73.7	17.2	16.2	8.4
Pvalue		**	**	**	**	**	*	**	**

Farmers in the study area were allowed to evaluate and select sorghum varieties based on their own selection criteria (Figure 1). Assosa-1, Melkam, Meko and Gembella1107 were the farmers preferred varieties. Threshability, medium maturity, diseases resistance and grain yield were traits of interest by which farmers prioritize those varieties (Table 3 and 4). Ranking of varieties using individual traits could show clearly the relation between the farmers' preferences and the researcher's view across the varieties. Therefore, the best varieties could be identified using the rank sum method.

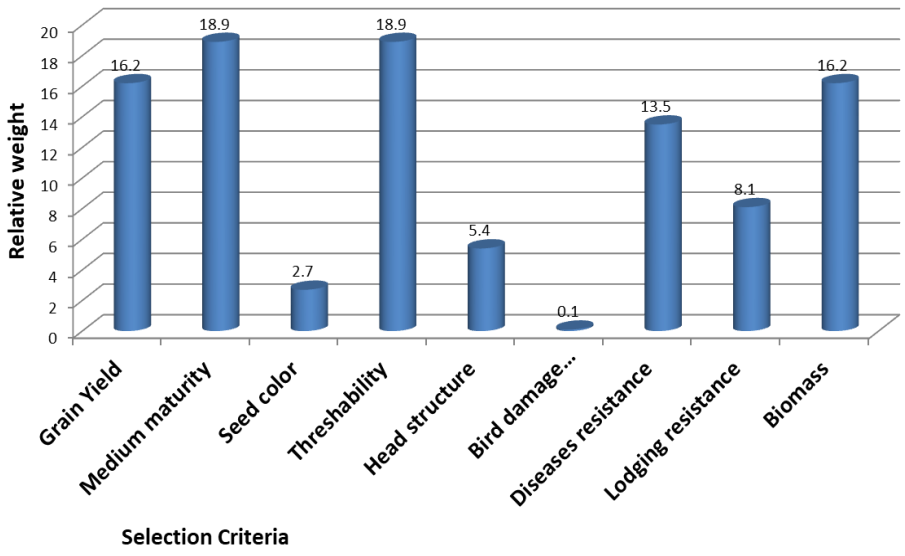

Figure 1: Farmers' preferred selection criteria of improved sorghum varieties at Kurmuk district during 2018

Farmers of Assosa zone particularly Kurmuk district were grow their own local land races due to the fact that no improved sorghum varieties targeted to this environment. They are expected a good number of characters in their sorghum varieties during PVS. Among those,

top nine characters, prioritized according to total scores and ranked through matrix system as shown in (Fig. 1.). Each variety received a rating for each trait, after a discussion among the group to agree on the score. The positive traits in all varieties with highest scores were listed, and these again were pairwise prioritized. This pairwise prioritization resulted in a priority matrix (table 2.). Grain yield and easy threshability has got the highest score and ranked 1st followed by grain yield and biomass.

Table 3. Direct ranking matrix evaluation of sorghum varieties by group of farmers' at Kurmuk (Dulhode) (2018).

SN	Selection Criteria	Relative weghit	Gobiye	Abshir	Birhan	Dekaba	Gembella 1107	Melkam	Meko	Adukara	Assosa-1	Bobeadi (local)
1	**GY**	**16.2**	49 (3)	49 (3)	49 (3)	32 (2)	65 (4)	81 (5)	65 (4)	65 (4)	81 5	49 (3)
2	**MM**	**18.9**	57 (3)	57 (3)	57 (3)	57 (3)	57 (3)	76 (4)	76 (4)	38 (2)	38 (2)	38 (2)
3	**SC**	**2.7**	11 (4)	8 (3)	5 (2)	8 (3)	11 (4)	11 (4)	11 (4)	5 (2)	14 5	8 (3)
4	**THSH**	**18.9**	76 (4)	76 (4)	57 (4)	38 (2)	76 (4)	76 (4)	76 (4)	57 (3)	95 5	76 (4)
5	**HST**	**5.4**	16 (3)	16 (3)	16 (3)	11 (2)	16 (3)	27 5	22 (4)	11 (2)	22 (4)	16 (3)
6	**BDR**	**0.1**	0.3 (3)	0.3 (3)	0.4 (4)	0.2 (2)	1 5	0.4 (4)	0.4 (4)	0.2 (2)	0.3 (3)	1 (5)
7	**DR**	**13.5**	41 (3)	54 (4)	41 (3)	27 (2)	54 (4)	68 5	54 (4)	68 5	68 5	54 (4)
8	**LDGR**	**8.1**	32 (4)	32 (4)	32 (4)	24 (3)	16 (2)	41 5	32 (4)	32 (4)	41 (5)	24 (3)
9	**BMS**	**16.2**	65 (4)	65 (4)	65 (4)	49 (3)	65 (4)	65 (4)	65 (4)	81 (5)	81 (5)	65 (4)

GY= Grain Yield, MM= Medium maturity, SC= Seed color, THSH= Threshability, HST= Head structure, BDR= Bird damage resistance, DR= Diseases resistance, LDGR= Lodging resistance, BMS= Biomass; Numbers in

parenthesis indicated the performance rating value of each variety given from 1-5 (5= excellent, 4=very good, 3= good, 2= poor and 1=very poor),

Table 4. Pair wise Ranking of humid lowland sorghum varieties at Kurmuk district in 2018 main season

N	Varieties	Gobiye	Abshir	Birhan	Dekeba	Gambella1107	Melkam	Meko	Adukara	Assosa-1	Bobeadi (local)	Total score	Rank
1	**Gobiye**		Abshir	Gobiye	Gobiye	Gambella1107	Melkam	Meko	Adukara	Assosa-1	Bobeadi	2	7
2	**Abshir**			Abshir	Abshir	Gambella1107	Melkam	Meko	Adukara	Assosa-1	Bobeadi	3	6
3	**Birhan**				Birhan	Gambella1107	Melkam	Meko	Birhan	Assosa-1	Bobeadi	2	7
4	**Dekeba**					Gambella1107	Melkam	Meko	Adukara	Assosa-1	Bobeadi	0	8
5	**Gambella1107**						Melkam	Meko	Gambella1107	Assosa-1	Bobeadi	5	4
6	**Melkam**							Melkam	Melkam	Assosa-1	Melkam	8	2
7	**Meko**								Meko	Assosa-1	Bobeadi	6	3
8	**Adukara**									Assosa-1	Bobeadi	3	6
9	**Assosa-1**										Assosa-1	9	1
10	**Bobeadi (local)**											7	3

Figure 2: Farmers' group discussion and evaluation of sorghum varieties at Kurmuk district during 2018

SUMMARY and CONCLUSION

In areas where improved technologies are not widely addressed like Assosa Zone of Western Ethiopia, 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. This was especially so for the criteria of grain quality, earliness, and productivity for which the farmers' definition encompasses factors such panicle size and shape, grain flour yield, cooking and brewing quality for traditional beers. The pairwise matrix analysis explained that farmers in Kurmik District gave priority to earliness threshability, grain yield and biomass respectively.

The farmers selected varieties and grain yield were highly correlated, Farmers participation was therefore very important in variety evaluation and selection. Based on agronomic traits and farmers' visual observation at field, varieties Melkam and Assosa-1 were selected for continued cultivation. As a result, this variety needs to be multiplied and distributed to the farmers. If yield is taken as the only selection criterion, Assosa-1, Adukara and local check should have been selected. It also proved crucial that truly representative community representation is essential suggesting that

participatory selection has to be coupled early on with decentralized seed

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