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On-farm Demonstration of Improved Sorghum (*Sorghum bicolor L. Moench*) Technologies in Cluster-based Large Scale Approaches at Gofa Zone, Southern Ethiopia

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Abstract

Sorghum is used as a source of food and cash for smallholder farmers in drought-prone areas of Gofa zone. Farmers produce sorghum traditionally without proper management and input use and as a result yield obtained by farmers ways far below the crop potential. Therefore, Arba Minch Agricultural Research Center carried out a cluster-based large-scale demonstration of improved sorghum in Melo-Koza and Zala districts of the Gofa zone in Southern Ethiopia during the 2022/23 main cropping season to further demonstrate the improved sorghum technologies in wider scale. A total of three kebeles (two from Melo-Koza and one from Zala) were selected based on potential of sorghum. A total of 103 farmers were chosen from two districts using a clustering approach, in partnership with Kebele development agents and district extension personnel, encompassing an 87.5 ha area. Before conducting the demonstration, the farmers were organized into a Farmer Research Group and 146 participants (109 farmers and 37 other stakeholders) were trained from the two districts. Improved seeds were provided by the Arba Minch Agricultural Research Center, and fertilizers and other chemicals were provided by farmers. A seed rate of 12 kg ha^{-1}, with fertilizer rate of 100 kg ha^{-1} NPS and 50 kg ha^{-1} for UREA applied. The row planting technique involved spacing rows 75 cm apart with plants placed 15 cm apart within each row. All other agronomic practices and farm activities were done by farmers based on the recommendations given with near help from development agents. Data were collected by measurements, interview and focus group discussion and also analyzed by using mean, percentage and perception score. The adjusted mean grain yield in Melo-Koza and Zala districts was 3,710 kg ha^{-1} and 3,966 kg ha^{-1}, respectively which was greater than districts average sorghum productivity. To popularize the technology demonstrated, field days were held in each district with the participation of various stakeholders to exchange experiences. Extension materials such as banners, posters, brochures and leaflets were used during the field day. Based on the feedback, demand for this technology was created. Therefore, the technology is recommended for other wider communities and districts that have the same problems and agro-ecology.

Keywords: cluster, extension gap, Gofa, large scale, Melkam variety, perception, Sorghum

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INTRODUCTION

Sorghum stands as a crucial cereal crop cultivated in arid and semi-arid regions globally. Ranking fifth among cereal grains worldwide, following wheat, rice, maize, and barley, it boasts an average yield of 1.4 tons per hectare, spanning approximately 40 million hectares in total coverage and yielding a combined output of 61.1 million tons [1].

In Ethiopia, it is fourth following maize, teff and wheat, both in area coverage and production [2]. Sorghum grows in different agro-ecologies; its ability to resist drought makes it special crop in rain shortage areas. Sorghum in Ethiopia is grown in three major agro-ecologies. Generally to provide good yield it should be planted on 400–2700 m.a.s.l, 250–500 mm average annual rainfall and 5.5–8.5 soil pH value. It is the major crop in the dry lowland environment which accounts for more than 60% of the cultivated land [3]. Currently, it is produced by more than 5 million holders and its production is estimated to be 45,173,502.18 quintals from 1,679,277.06 hectares of land and the number of farmers growing improved lowland varieties reached 28%. The average productivity of the crop is 26.90 quintals per hectare. It covers 15.93% of the total area allocated to grains [3].

In Ethiopia, sorghum is produced for food, feed, and stalks for fodder and building material. Desirable characteristics of sorghum such as wide range of adaptation, drought tolerance and salinity tolerance make it an attractive crop as biofuel for use on marginal lands [4].

In southern region of Ethiopia, farmers practice producing sorghum on their farms, but its productivity was constrained by several biotic and abiotic factors. The major constraints in the dry lowlands are drought, striga, low yield, and insects [5]. The low level of improved sorghum variety adoption is attributed to the low availability of farmer-preferred varieties in sorghum variety generation and dissemination endeavors [6]. The locally popular variety (red grain color and matures in 5–6 months) are the main farmers varieties produced in the areas. Research centers releases many improved variety of sorghum with their full packages. For the last few years pre-extension demonstration of improved sorghum varieties (Meko, 76T1#23, Seredo, Melkam, Gubiye, Teshale and Dekeba) were conducted in the respective districts (Table 1).

Based on the farmers' trait preference, Melkam variety was preferred by farmers because of its high yielding, consumption quality, early maturity, palatability, and drought-tolerant traits, respectively. However, the technologies were not demonstrated to the larger sorghum farmers because of the farmer's preference, lack of strong extension services and fear of failure. Therefore, the main objectives of the study was to popularize sorghum technologies by demonstration on a wider scale.

Objectives

- To avail improved seed of sorghum for the community for wider dissemination.
- To increase productivity of sorghum in the study area through large scale demonstration.
- To assess farmers perception toward improved sorghum technologies.

MATERIALS AND METHODS

Description of the Study Areas

Melo-Koza district is located at an altitude of 900 m, longitude 036°28'07"N and latitude 06°25'03" E. The district has three agro-ecologies: Dega (21.73%), woyina Dega (52.43%), and Kola (25.84%). The soil of the district is mainly clay-loam (50%), sand-loam (35%), and clay (15%). The district has two rain-seasons, 'Meher' season (from July to October) and 'Belg' season (from last week of January to April).

Table 1. Description of some sorghum varieties released between 2000 and 2012 and introduced in Melo-Koza and Zala districts.

Varieties	Released year	Productivity (Qtha-1)		Grain color	Maturity date
		Research	***Farmers***		
Melkam	2009	37–58	35–43	White	118
Teshale	2002	26–52		White	118
Gubiye	2000	19–27		White	120
Dekeba	2012	37–45	26–57	White	119

Source, EIAR, 2016

The average annual rainfall is 500 mm and the average temperature is 21.3°C. (Gofa Zone Finance and Economic Development Socio-economic unpublished). The soil type of the district is silt and sandy soil. Major crops produced in the district include coffee, maize, sorghum, teff, sesame, mung bean and korerima.

Geographically, Zala district extended from 6°04'00" North to 6°30'00" North latitude and 36°58'20" East to 37°13'30" East longitude. It has an estimated area of 71,511.86 hectares, of which 68% are farmland, 8% are grazing land, 20.2% are settlement and the rest 3.8% are forest and others. It has two cropping seasons known as Meher (July to August) which receives the highest rain and Belg (March to May). Agriculture—both farming and livestock—is the main livelihood of the pezople.

Site and Farmers Selection

Melo-Koza and Zala districts from Gofa zone were purposively selected based on potential of sorghum production. Accordingly, Salayish mender-1 and mender-3 from Melo-Koza and Mela-Kaysha from Zala district were selected purposively based on representativeness and potential for sorghum production in collaboration with district offices of agriculture. Additionally, farmers' selection was conducted in collaboration with subject matter specialists and Kebele level development agents. A total of 103 farmers were selected to conduct the activity based on clustering approach (Table 2).

Mode of Implementation

Before implementing the activity, Farmers-Research-Extension Group (FREG) with total of 10 FREGS and 125 members from the two districts were organized having 120 males and 15 female members of 24 farmers (seven females) was established by setting some selection criteria. The FREG members were composed of active participants (nine host farmers) and passive participants (seven learning groups). The groups were assigned their leaders and they could talk together on different issues and work in close relationship with researchers and development agents.

Local regulations were created and implemented to define the duties and obligations of the group members. Subsequently, the Arba Minch Agricultural Research Center collaborated to conduct training sessions for farmers, experts, and development agents in the two districts. A one-day training was given to farmers development agents and Zonal and district agricultural experts about the purpose and concept of the Cluster Based Large Scale Demonstration, improved management practices, production package, agronomic practices and crop protection and responsibilities of stakeholders before planting in the selected kebeles. Totally 146 farmers (131 male and 15 female) attended the training (Table 3). After the training, necessary inputs (seed, fertilizer) was distributed.

Research Design

Improved sorghum variety—Melkam–was demonstrated in cluster bases with seed rate of 12 kg ha^{-1} and fertilizer applied at a rate 100 kg ha^{-1} NPS and 100 kg ha^{-1} of UREA (1/3 during sowing and 1/3 knee height) with row planting method of 75 cm between rows and 20 cm between plants. Farmers were used as replication. The overall agronomic practices have been implemented as per recommendation.

Table 2. Number of participant farmers.

District	Kebele	No of farmers selected			Area covered (ha)	No of clusters
		M	***F***	***T***		
Melo-Koza	Salayish Mender-1	31	1	32	23	4
	Salayish Mender-3	35	3	38	34	4
Zala	Mela-Kaysha	29	4	33	30.5	2
Total		*95*	*8*	*103*	*87.5*	*10*

Table 3. Number of training participants.

Participants	Melo-Koza			Zala		
	Male	*Female*	*Total*	*Male*	*Female*	*Total*
Farmers	67	9	76	31	2	33
Development agents	6	-	6	5	1	6
Administrative bodies	4	-	4	3	1	4
Agricultural experts	4	-	4	3	2	5
Researchers	4	-	4	4	-	4
Total	*85*	*9*	*94*	*46*	*6*	*52*

Methods of Data Collection

A data record sheet was developed to collect the data. The agronomic data were collected by the researchers directly from the field. Data on grain from the cluster was taken from participant farmers by using quadrant (2 m*2 m) areas of high, medium, and low performance of the sample fields from 40 participant farmers from two districts threshed manually. Farmers' perception about the varieties was collected using interview during evaluation periods using Likert scale questions. In addition, socioeconomic data, feedback of participants/stakeholders/ farmers towards the technology were collected through focus group discussion.

Method of Data Analysis

The data were analyzed using SPSS (Version -27) software. Descriptive statistics (mean, minimum and maximum) were used to analyze the result and presented using tables and graphs. Farmers' perception was analyzed by using perception score and farmers' feedback was analyzed qualitatively. The extension gap of the demonstration was analyzed by using the formula given in Equation (1).

$$\text{Extension gap (kg ha}^{-1}\text{)} = \text{Demonstration yield (kg ha}^{-1}\text{)} - \text{Farmers yield (kg ha}^{-1}\text{)} \quad (1)$$

RESULTS AND DISCUSSIONS

Yield Performance of the Crop

Sample data were taken from 40 farmer fields and measured to estimate grain yield. The adjusted average grain yield recorded in the Melo-Koza district was 3,710 kg ha^{-1}, with minimum and maximum yields of 3,100 kg ha^{-1} and 4,250 kg ha^{-1}, respectively. Similarly, at Zala district, the adjusted average grain yield was 3,966 kg ha^{-1}, with minimum and maximum yields of 3,660 kg ha^{-1} and 4,272 kg ha^{-1}, respectively (Figures 1 and 2). This yield difference was due to management practices and the site. This is higher than Ethiopian national average yield of sorghum (26.90 quintals per hectare) [3].

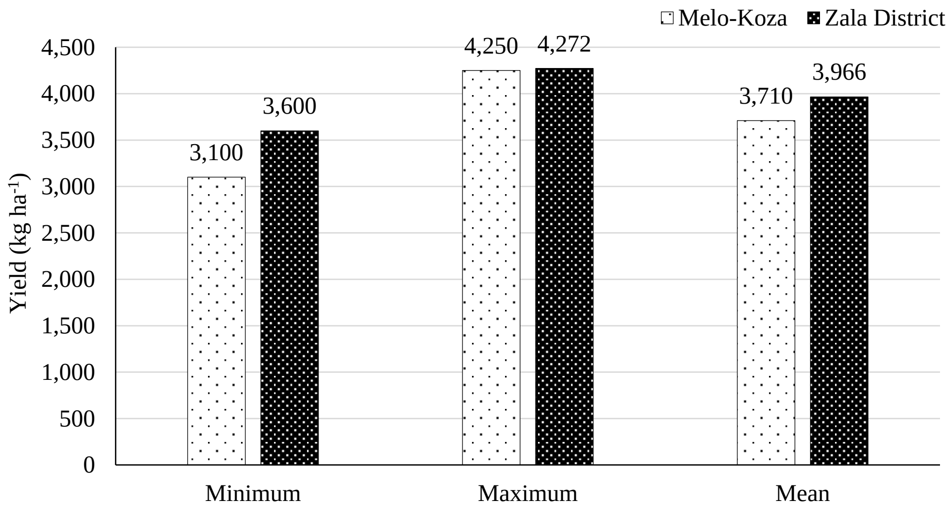

Figure 1. Adjusted average grain yield of Sorghum across two districts (N=40).

Figure 2. Field level performance of Melkam variety at the study districts.

Table 4. The extension gap of Sorghum technologies in the study districts.

Name of variety	Name of district	Demonstration yield	Farmers practice (collected through interview)	Extension gap (kg ha^{-1})
Melkam	Melo-Koza	3,710	2,100	1,610
	Zala	3,966	2,755.7	1,210.3

The extension gap was 1,210.30 kg ha^{-1} at Zala and 1,610 kg ha^{-1} at Melo-Koza districts and the result of the higher extension gap in both the districts indicated that there is a strong need to motivate the farmers to adopt the improved technologies over their local practices (Table 4). Therefore, it needs emphasis to strengthen the extension approach using various methods such as offering training to farmers, skill and experience sharing, awareness enhancement via information dissemination channels and other pertinent methods. If this gap is closed, the sorghum production and productivity will be enhanced. Similar result was observed by Worku et al. [7].

Farmers' Perception towards Sorghum Technologies

In terms of farmers' perceptions collected in the form of interview, on an average, all farmers positively agreed on variety escape moisture stress season, and high yield, the approach is good to share ideas with others, it was easy to contact development agent, facilitated mechanization (tractor service) and simplified production costs because Arba Minch Agricultural Research Center provided improved seed, training and technical support, prepared field days, respective districts provided fertilizer (NPS and UREA) and farmers provided their land and undertaken all farm operations in the form of cost sharing. Other stakeholders also demonstrated this technique that per plant holds more than two ears of maize and got higher grain yields and better flour quality as compared to that being used before. Farmers perception on CBLSD is depicted in Table 5.

Field Days and Experience Sharing

The feedback was fundamental to identify the shortcoming of the demonstration, to avoid the bottlenecks and quicken adoption of the new technologies [8]. Field day was organized and different stakeholders (farmers, development agents, district and zonal experts, researchers from Arba Minch Agricultural Research Center, Southern Agricultural Research Institute administrative, cooperatives, seed inspection and quarantine experts, NGO's and zonal agricultural offices) participated (Figure 3). At last, during the field day session, group discussion was conducted to gather farmer's feedback on the strong and weak side of the demonstration. Farmers responded no debate to adopt sorghum technologies and training was necessary before planting. As a result, farmers decided to replace the widely used local variety and practice with low production and productivity with the improved variety (Melkam) with improved management practices that bring about increment in sorghum yield [9]. Farmers in both the districts reported that Melkam variety was best for homemade food such as injera and bread preparation than local variety which was used only for '*Kita*' and preparing local drink called '*cheka'*. A total of 315 farmers (192 male and 123 female) participated from the two districts (Table 6). Besides, during field day, the technology was promoted through different mass media such as Facebook and South Television and Radio to disseminate information for the development partners and wider communities those who could not participate directly [10].

Table 5. Farmers perception on CBLSD of Sorghum technologies at Melo-Koza and Zala districts (N=40).

No.	Perception	Agree	Disagree	Do not know
	*Positive perception**			
1	The variety escape moisture stress season	1		
2	Resistant to disease		-1	
3	High yield as compared to former varieties	1		
4	The approach is good to share ideas with others	1		
5	Easy to contact experts once	1		
6	The approach facilitated mechanization	1		
7	Cost sharing approach in the demonstration simplified production costs	1		
	*Negative perception***			
1	Its taste is not that much good as others			0
2	Difficult to thresh		-1	
3	No means of recovery designed if the whole farm lost with some event		-1	

Note: ** For positive perception values were agree = 1, disagree = -1, do not know = 0*
***For negative perception values were agree = -1, disagree= 1 do not know = 0*
CBLD indicate Cluster-Based Large Scale Demonstration

Table 6. Summary of field day participants from the two districts.

Participants	Locations						Total		
	Melo-Koza			***Zala***					
	Male	*Female*	*Total*	*Male*	*Female*	*Total*	***Male***	***Female***	***Total***
Farmers	65	35	100	122	80	202	187	115	302
Development agents	2	-	2	2	4	6	2	4	6
Administrative bodies	4	-	4	4	1	5	8	1	9
Agricultural experts	3	-	3	6	3	9	9	3	11
Researchers	3	-	3	4	-	4	7	-	7
Others	2	-	2	5	-	5	7	-	7
Total	*79*	*35*	*114*	*143*	*88*	*231*	*192*	*123*	*315*

Figure 3. Photos during field day at two districts. (a) Sample field day photo at Zala district, (b) Field day photo at Melo-Koza district

Challenges Faced and Measures Taken During the Demonstration

From the start to the end of the activity, many challenges were encountered in both the districts. The social and abiotic factors encountered and measures taken are indicated in Table 7.

Table 7. Challenges faced and measures taken during the demonstration.

No	Challenges encountered	Measures taken
1	At the beginning, some farmers resisted for accepting the idea, because they fear risk	Convincing and creating awareness
2	Farmers and development agents have no experience on sorghum technologies demonstration	Give training and continuously advice and supervise
3	Birds attack	Guarding and using traditional methods (putting locally known as “asferaricho” at each side and middle of the demonstration farm
4	‘Striga’ weed infestation (locally known as “akenchira”)	Manual weed by using all able bodies of the household

Lessons Learnt

Farmers learnt about the space between the plants and rows and the amount of input needed per hectare. Additionally, they learnt about the procedures associated with land preparation, harvesting and storing. Merging several small farms in cluster (large number of farmers and large size of land) opens the doors for the small land holding farmers to work together and share ideas and skills that they acquired from researchers.

CONCLUSION AND RECOMMENDATIONS

Cluster-based large scale demonstration of improved sorghum technology was carried out with total of three potential Kebeles and 103 farmers' field on 87.5 hectare of land in Melo-Koza and Zala districts of Gofa Zone, in 2022/2023 cropping season with the objectives of popularizing best performing sorghum varieties. Totally, 146 people (94 from Melo-Koza and 52 from Zala district) attended awareness creation training. This led to increased awareness and inspired additional farmers to embrace the enhanced set of sorghum cultivation practices.

The adjusted average grain yield performance recorded in the Melo-Koza district was 3,710 kg ha^{-1} and that of Zala district was 3,966 kg ha^{-1} which was greater than district average sorghum productivity. It has been determined that conducting extensive demonstrations is an effective method for enhancing sorghum production and productivity by advancing farmers' knowledge and skills. Seed producer cooperatives or organized farmer groups should be bolstered to consistently and reliably multiply and distribute the seeds of this variety to ensure a viable seed supply. Hence, the office of agriculture and rural development of the respective districts should further disseminate and scale-out Melkam variety to a large number of farmers in similar agro-ecologies. Therefore, the technology is recommended for further community use with active participation and collaboration of district expert, development agent, and farmers through different extension methods. Improved varieties with their recommended technology packages and management practices play an important role in the increment of crop production and productivity.

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