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Promotion of Improved Sorghum Technologies through Large-Scale Demonstration in Gololcha Woreda, Arsi Zone of Oromia Regional State, Ethiopia

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Abstract

The study was carried out to improve farmers' awareness, enhance the adoption of full package sorghum production technologies. The large-scale demonstration was implemented at Gololcha woreda of Arsi zone for one year (2019/2020) using Melkam variety. The demonstration was implemented in three kebeles and a total of 100 hectares of land was covered by participating 117 household heads (farmers) out of which 12 of them were women-headed. In the demonstration farmers contributed a land size of 0.25 hectares (the minimum) and 2 hectares of land (maximum). Totally, from the demonstration 4030 quintals of sorghum were harvested with 42.3 quintals per hectare average productivity. The yield obtained by farmers practices was 18.23 $q \cdot ha^{-1}$ which is lower as compared to the average yield obtained by large scale demonstration. The technology gap (TG) was 15.70 $q \cdot ha^{-1}$ which indicated that technologies have not been adopted. Extension gap was 24.07 $q \cdot ha^{-1}$ and this result indicated that the extension approach should be more strengthened. It has been ascertained that "Melkam" variety is the best fitted variety and promotion of improved sorghum technologies via large scale demonstration has shown a considerable yield increment as compared to farmers practices. According to 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. For sustainable production of improved sorghum technologies, the seed system should be taken into consideration to deliver the seed supply for the entire sorghum producers.

Keywords

Demonstration, Extension Gap, Large-Scale, Sorghum, Technology Gap

1. Background

Sorghum is the third most important cereal grain after Teff and Maize in Ethiopia both in area and production in Ethiopia. In Ethiopia, sorghum is produced for food, feed, and stalks for fodder and building material. Currently, sorghum is produced by more than 5 million holders and its production is estimated to be 51,692,525 quintals from 1,896,389 hectares of land. The average productivity of the crop is 27.26 quintals per hectare. It covers 14.96% of the total area allocated to grains [1].

Sorghum in Ethiopia is grown in three major agro-ecologies. It is the major crop in the dry lowland environment which accounts for more than 60 percent of the cultivated land [1]. As it is grown in diverse environments, the productivity of sorghum is constrained by several biotic and abiotic factors. The major constraints in the dry lowlands are drought, striga, low yield, and insects [2].

In Ethiopia, considerable achievements have been obtained in developing early maturing and drought tolerant sorghum varieties and production management practices. According to Taye [3], since the establishment of the sorghum program more than 50 sorghum varieties have been released and the number of farmers growing improved lowland varieties reached 28 percent. 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 [4].

To enhance the adoption of improved sorghum varieties, large-scale demonstration of improved Sorghum technologies has been conducted in collaboration with agricultural extension research process and agricultural office of Gololcha which is one of the major sorghum growing areas in Oromia region. The main objectives of demonstration of improved sorghum technologies on wider farmers acreages have been indicated as follows.

- To improve farmers' awareness and knowledge;
- To enhance adoption of full package sorghum production technologies;
- To document and share best practices, experiences, and lessons learned from the large-scale demonstration of sorghum varieties.

Melkam Variety

2. Materials and Methods

2.1. The Intervention Area

The intervention was done in Gololcha woreda of Arsi zone, Oromia regional state. The woreda is situated at southeast of Mount Arba Gugu, bordered by Aseko district in the north, Amigna district in the south, Daro Lebu district in the east and Chole district in the west. The altitude of the woreda is ranging from 1400 and 2500 meters above sea level. Generally, the district has a total area of 178,102 hectares and is classified into two agro-ecologies, the midland and the lowland with a share of 25% and 75% respectively. The average temperature of the district is 35˚C and the average rainfall is 900 mm/year. The main rainy season of the district is in April, May, June, July, August and September. The soil type of the district is silt and sandy soil. Major crops produced in the district include Coffee, Maize, Sorghum, Teff and Groundnut [5].

2.2. Description of Sorghum Varieties/Cultivars

In the study area, improved varieties of sorghum were introduced by different stakeholders. The introduced improved Sorghum varieties were Gobye, Abshir, Teshale and Dekeba. However, the varieties were not as much scaled up to the larger sorghum producer farmers because of the farmers trait preference and lack of strong extension services. As a result of this, farmers were not producing the improved varieties. The locally popular cultivars known as Arkabas (white grain color and matures in 5 - 6 months) and Alewalem (red grain color and matures in 9 months) are the main farmers varieties produced in the area. For the last few years small scale demonstration of improved sorghum varieties were conducted in the Woreda and hence farmers preferred "Melkam" variety for its desirable characteristics. 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 (**Table 1**).

Table 1. Description sorghum varieties released between 2000 and 2012 and introduced in Gololcha Woreda.

Varieties	Released year	Productivity (Qu/ha)		Grain color	Maturity date
		Research	Farmers		
Melkam	2009	37 - 58	35 - 43	White	118
Dekeba	2012	37 - 45	26 - 37	White	119
Teshale	2002	26 - 52		White	118
Abshir	2000	15 - 25		White	120
Gobye	2000	19 - 27		White	120
Birhan	2002	40		Brown	101

Source: EIAR, 2016.

2.3. Site and Farmer Selection

The activity was carried out in Gololcha woreda of the Arsi Zone of Oromia region. The activity was implemented for one year (2019). In executing the activity 127 farmers were proactively involved from theoretical training to the actual implementation of improved sorghum technologies demonstration. The woreda agricultural office experts and Development Agents had also taken part in the implementation process. An interdisciplinary team composed of researchers (Agricultural Extensionist, Breeder, and Agronomist), woreda experts, and development agents was established to implement the activity successfully.

Representative kebeles were purposively selected based on the potential area of sorghum production and accessibility for field monitoring and follow-ups. Accordingly, Minne Adayo, Weragu Urgessa, and Mine Tulu were selected based on accessibility in collaboration with woreda offices of agriculture. Similarly, farmers' selection was conducted in collaboration with experts and development agents. Participating farmers were selected based on their willingness and interest, ability to risk-taker, and the ability to allot land for the intended purpose.

Finally, a total of 117 farmers were selected to implement the demonstration in 100 hectares of land. In each kebele the minimum area that farmers contributed was 0.25 ha. Improved sorghum variety (Melkam) was provided to selected farmers for large-scale demonstrations. To keep the optimal plant population per one hectare spacing between rows and plants was 0.75 m and 0.20 m respectively. Soil fertilizer of DAP and UREA (100 $q \cdot ha^{-1}$ and UREA and 100 $q \cdot ha^{-1}$) were applied. The recommended amount of DAP applied at sowing time and UREA at the knee development stage of the plant. The overall agronomic practices have been implemented as per recommendation [4] (**Table 2**).

2.4. Yield Potential and Yield Gaps

Yield potential is the genetic potential, which is dependent on biological or plant factors under the ideal environmental conditions and crop management practices, having one definite yield level for the species or variety. One definite yield level is because there is only one ideal environment and set of crop management practices. Potential yield is the yield of a variety × environment combination under the best crop management and will be different in environments differing in temperature and solar radiation regimes for a given variety [5]. Demonstration yield is the amount of grain yield of demonstrated improved Sorghum variety (Melkam) obtained per unit area with recommended production packages. At the same time farmers yield was computed as the grain yield of local sorghum variety with farmers agronomic practices. Technology gap is the difference between potential yield and demonstration yield of improved Sorghum variety (Melkam) per unit area. At the same time technology index is the difference between technology gap and potential yield and then multiplied by hundred. Technology gap, extension gap and technology index were calculated as per the formula given by Samui *et al.* [6].

Table 2. Large scale demonstration participants and area coverage.

Keblele	Area (ha)	Participant farmers	
		Male	Women
Minne Adayo	40	36	4
Minne Tullu	20	21	3
Wergu Urgess	40	48	5
Total	100	105	12

$$\text{Technology gap } \left(q\cdot ha^{-1}\right) = \text{potential yield } \left(q\cdot ha^{-1}\right) - \text{Demonstration yield } \left(q\cdot ha^{-1}\right) \tag{1}$$

$$\text{Extension gap } \left(q\cdot ha^{-1}\right) = \text{Demonstration yield } \left(q\cdot ha^{-1}\right) - \text{Farmers yield } \left(q\cdot ha^{-1}\right) \tag{2}$$

$$\text{Technology index}(\%) = \left[\text{Technology gap } \left(q\cdot ha^{-1}\right) / \text{potential yield } \left(q\cdot ha^{-1}\right)\right] \times 100 \tag{3}$$

2.5. Data Collection and Analysis

Both qualitative and quantitative data were collected through supervision and follow up of the activity with the joint action of the stakeholders and analyzed. A data record sheet was developed to collect the data. Thus, field observation, contacting the target farmer, and focus group discussion during the field visit were the data collection methods. Yield data and farmers' preference toward the variety were collected from the farmer's field. The number of farmers participated in training and field day, the number of locations addressed, the amount of seed distributed and the number of farmers benefited from the demonstration process were major types of data collected during the activity. Finally, the collected data were analyzed using descriptive statistics, gap analysis and preferences were analyzed using narrations and tables.

3. Results and Discussions

3.1. Sex of the Household Heads

In the large-scale demonstration, a large number of men were participated compared with women farmers. The larger percentage (96) of men were participants in Mine Adayo Keble. At the same time larger number of men farmers' participation in the large-scale demonstration was recorded in Mine Tulu Kebele. The majority of the farmers were male and only 14.02 percent of the total participant farmers were women (Table 3).

3.2. Age of the Household Heads

Age is one of the household characteristics important to describe the households and can provide a clue as to the age structure of the population. The age of the households ranged from 23 to 50 years. In Mine Tulu kebele the maximum age (50) and In Weragu Urgessa kebele the minimum age (23) of farmers was recorded (Table 4).

In this study age and sex of the household have been considered just to show the involvement of farmers in technology demonstration of improved sorghum variety. Based on this, gender disparities were observed for large scale demonstration of improved sorghum variety and hence the participation of women was not more than 10% from the total household headed farmers. This indicated that women should be more encouraged to involve and play a key role in technology dissemination and popularization. Regarding to the age structure, majority of the household headed farmers were categorized in productive age stage and this indicated that high percentage of productive ages have been engaged in technology demonstration and popularization of Improved sorghum variety.

3.3. Demonstration Area Coverage

The large-scale demonstration was done in 100 hectares of land. The minimum area allocated by farmers was 0.25 hectares. Whereas the maximum was 2 hectare and allocated from Weragu Urgessa kebele. The minimum area for the large-scale demonstration was allocated by the Mine Tulu Kebele farmers (20 ha) and the larger area (40 ha) was in both Mine Adayo and Weragu Urgessa kebele (Table 5).

Table 3. Sex of the household head # 117.

Kebele	Sex of the HH	Frequency	Percentage
Mine Adayo	Women	4	10
	Male	36	96
Mine Tulu	Women	3	12.5
	Male	21	87.5
Weragu Urgessa	Women	5	9.43
	Male	48	90.56

Table 4. Age of the household head # 117.

Kebele	Minimum	Maximum	Mean	Std. Dev.
Mine Adayo (# 40)	25	43	31.8	3.5
Mine Tulu (# 24)	24	50	35.4	7.9
Weragu Urgessa (# 53)	23	43	31.4	5.73

Table 5. Sorghum area coverage (ha).

Kebele	Total area coverage	Minimum	Maximum	Mean	Std. Dev.
Mine Adayo	40	0.25	1	0.5	0.11
Mine Tulu	20	0.25	0.5	0.42	0.12
Weragu Urgessa	40	0.5	2	0.85	0.41

3.4. Training

Training delivered to farmers, experts, and development agents believed to be one of the prominent inputs to improve the adoption of high yielding varieties and its agronomic practices. In this regard, the Melkassa research center had jointly organized training programs to farmers, experts, and development agents. Sorghum production, the concept of the cluster-based large-scale demonstration, the importance of improved varieties, conservation agriculture, and commitment and responsibilities of stakeholders. Totally 117 farmers (105 male and 12 women), and 15 experts and development agents (12 male and 3 women) attended the training.

3.5. Yield Potential and Yield Gap Analysis

3.5.1. Sorghum Grain Yield

Mean grain yield of improved sorghum variety demonstrated at Minne Adayo, Weragu Urgessa and Mine Tulu were 42 q·ha^{-1}, 42.5 q·ha^{-1} and 42.4q·ha^{-1} respectively. The total mean yield was 42.30 q·ha^{-1} which was 132.01% higher than the farmer practices (18.23 q·ha^{-1}). This difference is due to the utilization of best-fit variety (Melkam) and the application of the recommended agronomic practices and field management. From these results it is evident that the performance of Melkam variety was found better than the farmer's practice. A similar yield result was also reported by [7] [8] [9]. The result also conforms with [10] and suggests the positive effects of demonstrations over the existing farmers practice towards enhancing the yield of sorghum with its positive effect on yield attributes. This result clearly elucidated that farmers practices of grain yield performance were by far lower as compared to grain yield obtained by large scale demonstration (**Table 6**). Hence, large scale demonstration of improved sorghum varieties should be more emphasized in the targeted environment of potential sorghum growing regions in the country.

3.5.2. Technology Gap, Extension Gap and Technology Index

Grain yield gap was analyzed based on the actual implementation of improved sorghum technologies and the trend of farmers practices to grow sorghum in the district. Based on this the yield gap of sorghum has been explicated in terms of technology and extension gaps. Technology Gap (TG) analysis indicates the extent to which technologies have not been adopted. This feedback information is essential to identify the weakness of technology transfer program, to remove bottlenecks and accelerate adoption of improved technologies [11]. The mean value of technology gap (TG) analysis and overall gaps against the recommended technology practices were computed. Hence, the overall technology gap was calculated using the formula (1) and it was found 15.70 q·ha^{-1}. The yield difference may be observed due to the environmental differences. The same result was also reported by Bedru, Yonas and Mekonen [4] [12].

Similarly, extension gap (EG) was calculated using the formula (2) and found 24.07 q·ha^{-1} and the result indicated that it needs emphasis to strengthen the extension approach using various methods like offering training to farmers, skill and experience sharing, awareness enhancement via information dissemination channels and other pertinent methods. It is also believed that advanced improved sorghum technology production package with acceptable quality grain quality will subsequently change the extension gap. Hence, dissemination of newly released improved sorghum technologies including production packages will have a significant contribution to replace farmers sorghum varieties and then hasten adoption rate. At the same time technology index (TI) was computed using formula (3) and recorded 27.07%. This is an indication that realized yields at farmers farm and even at the demonstration sites still have huge potentials for increase. If this gap is closed, the sorghum production and productivity will be enhanced [10] (**Table 6**, **Table 7**).

3.6. Farmers' Trait Preference

To collect farmers' traits preference of sorghum, 30 farmers (15 women) were selected from different age and sex category from the community. Trait preference was done separately for women headed, men and women in male-headed households. In all separate groups ten sorghum producer farmers, a total of thirty farmers have participated in trait preference. Farmers described that early maturity, drought-tolerant, high yielding ability, marketability, stalk palatability (sweetness) and quality food making were the main traits listed. Accordingly, Melkam variety was preferred by farmers because of its high yielding ability, consumption quality, early maturity, palatability, and drought-tolerant traits respectively. Besides, the study showed 84.6 percent of women-headed households

Table 6. Grain yield performance of Melkam sorghum variety tested at Gololcha in 2019 crop season.

Name of variety	Name of Kebeles	Area (ha)	Potential yield ($q\cdot ha^{-1}$)	Demonstration yield ($q\cdot ha^{-1}$)	Farmers practice ($q\cdot ha^{-1}$)	% Yield increases over farmers practices
Melkam	Minne Adayo	40	58	42.00	18.00	133.33
	Weragu Urgessa	40	58	42.50	18.50	129.73
	Mine Tulu	20	58	42.40	18.20	132.97
			Mean	**42.30**	**18.23**	**132.01**
	Total	**100**				

*Percentage of yield increase over farmers practice = {(demonstration yield − farmers practice)/farmers practice} × 100.

Table 7. Sorghum grain yield gap analysis of Melkam variety.

Name of variety	Name of Kebeles	Technology gap ($q\cdot ha^{-1}$)	Extension gap ($q\cdot ha^{-1}$)	Technology index (%)
Melkam	Minne Adayo	16.00	24.00	27.59
	Weragu Urgessa	15.50	24.00	26.72
	Mine Tulu	15.60	24.20	26.90
	Mean	**15.70**	**24.07**	**27.07**

and 89.5 percent of women in male-headed households preferred Melkam variety than the local cultivars because of its high yielding ability, baking quality, and market preference. Male-headed households (91.3 percent) preferred Melkam compared with the local cultivars because of its high yielding ability, market preference, and drought-tolerant characteristics.

3.7. Field Day

A total of 323 farmers (276 male and 47 women), 36 development agents, and 20 experts from woreda agricultural offices and 20 researchers participated on field day. Besides, the field day program was transmitted on the news program by Oromia television to disseminate information for the wider community. A total of 500 leaflets were distributed for the participants which describe the production, agronomic practices, and overall management of improved sorghum varieties. Finally, at the end of the visit during field day, group discussion was conducted to grasp farmer's feedback on the strength and weakness of improved sorghum variety (Melkam variety). According to farmers' observation Melkam variety captured their interest mainly because of its uniformity, yield advantage and its early maturity characteristics. Besides, timely distribution of seeds is points risen by the participants on the program.

4. Conclusion and Recommendations

Large-scale demonstration of sorghum (Melkam variety) was undertaken at Golocha woreda in three potential kebeles with active participation and collaboration of woreda expert, development agent, and farmers. The findings of the study showed that the improved variety of sorghum (Melkam) had shown better performance in grain yield compared with the farmer's practice. In this study 132.01% of yield increment has been recorded for the demonstrated sorghum variety as compared to the overall farmers practices. This created greater awareness and motivated the other farmers to adopt the improved package of practices of sorghum. These demonstration trails also enhance the relationship and confidence between farmers, extension workers, and researchers. The host farmers of large-scale demonstration also played an important role as a source of information and quality seeds for wider dissemination of the improved variety of sorghum (Melkam) for other nearby farmers. It is concluded that the large-scale demonstration is a successful tool in enhancing the production and productivity of sorghum through improving the knowledge, attitude, and skill of farmers. 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. Seed producer cooperatives or organized farmers group should also be formed to continuously and consistently multiply and supply the seed of this variety so that there is sustainable seed supply.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Central Statistical Agency (CSA) (2018) The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey. Report on Area and Production of Crops. Statistical Bulletin No. 586. Addis Abeba, Ethiopia.

[2] Berhane, G. (2012) Effect of Tillage and Fertilizer Practices on Sorghum Production in Abergelle Area, Northern Ethiopia. *Momona Ethiopian Journal of Science*, **4**, 52-69. https://doi.org/10.4314/mejs.v4i2.80116

[3] Tadesse, T. (n.d.). Sorghum Research. http://www.eiar.gov.et/marc/index.php/anrl-research/crop-research

[4] Beshir, B. and Sime, M. (2013) Understanding Farmers' Improved Sorghum Variety Selection Criteria: The Case of Farmer Research Group Approach in Habro District, West Hararghe. Research Report 102. http://www.eiar.gov.et

[5] Gololcha Woreda Office Agricultural (GWoA) (2019). Annual Report.

[6] Samui, S.K., Maitra, S., Roy, D.K., Mondal, A.K. and Saha, D. (2000) Evaluation on Front Line Demonstration on Groundnut (*Arachis hypogaea* L.). *Journal of Indian Society of Coastal Agricultural Research*, **18**, 180-183.

[7] Abady, S., Liku, G. and Yadeta, D. (2017) Participatory Varietal Selection and Evaluation of Twelve Sorghum (*Sorghum bicolor* (L.) Moench) Varieties for Lowlands of Eastern Hararghe. *International Journal of Plant Breeding and Crop Science*, **4**, 281-285.

[8] Kinfe, H. and Tesfaye, A. (2018) Yield Performance and Adoption of Released Sorghum Varieties in Ethiopia. *Edelweiss Applied Science and Technology*, **2**, 46-55. https://doi.org/10.33805/2576.8484.115

[9] Brhane, G., Belay, F., Gebreselassie, T. and Desta, D. (2019). Enhancing Sorghum Yield through Demonstration of Improved Sorghum Varieties in Tanqua-Abergelle Wereda, Central Zone of Tigray, Ethiopia. *Journal of Agricultural Extension and Rural Development*, **11**, 11-16. https://doi.org/10.5897/JAERD2018.1020

[10] EIAR (2016) Cereal Crop Production and Management Manual. http://www.eiar.gov.et

[11] Neha, P., Neeraj, K., Singh, A.K. and Abhijeet, S. (2018) Technological Gap in Recommended Cultivation Practices of Cauliflower in Bokaro District of Jharkhand, India.

[12] Worku, Y., Yedemie, S., Melese, E. and Wubie, B. (2019) Pre-Extension Demonstration of Improved Sorghum Management in Gondar Zuria District. *Pre-Extension Demonstration of Agricultural Technologies Workshop Proceedings*, Bahir Dar, Ethiopia, 6-17 March 2017 and 30 April-4 May 2018, 132-141.