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Promotion of Durum Wheat (*Triticum turgidum var. durum*) Technologies Through Cluster-Based Large Scale Demonstration in Potential Growing Areas of Ethiopia

Truayinet Mekuriaw, Mohammed Ahmed

Ethiopian Institute of Agricultural Research (EIAR), Debre Zeit Agricultural Research Center, Debre Zeit, Ethiopia

Email address:

truyem@gmail.com (T. Mekuriaw), Moxe86@gmail.com (M. Ahmed)

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Abstract: Durum wheat (*Triticum turgidum var. durum*) is one of the most economically important crops produced predominantly by smallholder farmers in the Gojam, Gonder, Shewa, and Bale zones of Ethiopia. But, the adoption of durum wheat technologies by farmers remains very low, mainly due to the lack of high yielding varieties, along with the high cost of purchasing quality seeds and a national seed system incapable of reaching more areas. This activity is, therefore, conducted with the objectives of creating awareness of and wider access to recently released improved durum wheat technology using a cluster-based Large-Scale Demonstration (LSD) in East Shewa and Bale zones of the Oromia Region, and in the East Gojam Zones of the Amhara Region during the 2019/20 main planting season. The utuba variety was demonstrated along with the full production package. A total of 87 interested farmers have directly participated in four potential producing districts and five technology demonstration clusters established on 64 hectares of land. For this activity, 75 quintals of basic seed was distributed to the participating farmers free of charge on a revolving basis. The yield data and the feedback of the farmers' on the variety were collected and analyzed using descriptive statistics and narration. The observed large scale demonstration yield indicates that an average grain yield of 29.2 q/ha to 38.5 q/ha was recorded. The result further showed a positive and higher yield gap in the large scale technology demonstration clusters over the farmer's practice in all clusters of the farmer's field. The higher-yield performance of the technology might be due to the use of technology as a package (the high yielding new variety along with all the recommended management practices). Thus, it is important to conclude that the application of the full package technology approach should be taken into consideration when disseminating the technology among farmers. Furthermore, the selected variety (Utuba) should be promoted and scaled up to address more farmers in the target areas and other unaddressed areas with similar agroecology by involving all the concerned stakeholders, including the government sectors, non-governmental organizations, and other private sectors at a different level.

Keywords: Demonstration, LSD, Durum Wheat, Variety

1. Introduction

Wheat is one of the most important crops grown in Ethiopia, both as a source of food for consumers and as a source of income for farmers. Wheat and wheat products represent 14% of the total caloric intake in Ethiopia, making wheat the second most important food, behind maize (19%) and ahead of *Tef*, sorghum, and enset [8]. Durum wheat (*Triticum turgidum var. durum*) is one of the dominantly grown and economically important species of wheat that is indigenous to Ethiopia, with a wide genetic diversity. Ethiopia is considered as the secondary center of diversity for tetrapod wheat [1, 9] and the largest producer of durum wheat in Sub-Sahara Africa (SSA), devoted about 0.6 million ha of land for durum wheat production by involving about 1.39 million smallholder households [15].

Durum wheat is mainly grown on heavy black clay soils (vertisols) of the central and northern highlands of Oromia and the Amhara region between 1800 and 2800 meters above sea level. More specifically, it is produced in the East Shewa, North Shewa, Bale, Arsi, and East Gojam zones. The main

growers are smallholder farmers, where the environmental characteristics are relatively low temperatures and high rainfall on black swelling/shrinking vertisol soils, with 1waterlogging as a common problem [2].

Compared to bread wheat, the most common alternative, durum wheat is appreciated by farmers mainly for its resistance to biotic and abiotic stress, better food quality, better weed competition, and straw production. Durum wheat is consumed as leavened bread, common bread, macaroni, spaghetti, biscuits, and pastries. Furthermore, it is particularly suitable for the preparation of certain traditional dishes such as *kinche* (cracked and boiled grain), *genfo* (porridge), *nifro* (boiled grain) and *kolo* (roasted grain) [7]. Besides the role of grain in traditional food and processed products, durum wheat straw is also greatly appreciated for its high palatability for livestock in the mixed farming systems of the highlands of Ethiopia [20]. Recently, improved durum wheat varieties have been highly demanded by agro-industries because of their best qualities for fast and testy foods. Owing to its economic importance, however, both the area under durum wheat production and the national average yield have been lower (2.78 t/ha) compared to the bread wheat production, which is much lower than the potential yields of 8 to 10 t/ha [4, 19]. This is due to a lack of improved varieties with associated packages, low crop management practices, diseases and insect problems and low use of recommended full packages [13, 11, 21].

Over the past 50 years, the agricultural research and extension systems of the country have been making efforts to overcome these challenges and enhance durum wheat yield through the generation of improved varieties along with their management practices. To this end, the Ethiopian Agricultural Research System released 36 improved durum wheat varieties by 2018 [11]. The agricultural extension system has also been demonstrating, popularizing, and scaling-up the improved durum wheat varieties and the associated input package and management practices using different extension approaches like pre-extension demonstration and popularization.

Despite the efforts made so far to generate and transfer durum wheat technologies, the adoption of these technologies by farmers remains very low [6], primarily because of the inadequate capacity to multiply source technologies and uncoordinated demand creation demonstration activities. Moreover, the extension approaches commonly used so far to disseminate the research outputs have not been visible enough to create excitement among the wider community. To address these challenges, a new approach known as large scale technology demonstration (LSD) was designed towards the demonstration and dissemination of agricultural technologies that have a prominent feature of using technology as a package instead of the variety alone, using a clustered large scale farmer's field and the involvement of a coordinated multi-stakeholder partnership [3]. Thus, this activity is intended to demonstrate durum wheat technologies in potential agro-ecologies of Ethiopia using full production package technology and a large scale-clustered farm approach and to improve the production and productivity that would finally lead to enhanced food security.

2. Material and Methods

2.1. Description of the Study Area

This activity was conducted in four districts of the Oromia and Amhara regions during the 2019/20 main planting season. These are the Ada'a and Liben - Chiquala districts of the East Shoa Zone; the Gololcha district of the Bale Zone of the Oromia regional state; and the Shebel Berenta district of the East Gojam Zone of the Amhara region. The districts were selected based on the production potential of durum wheat. Relatively, all districts are located in the highlands, with high production potential and a suitable climate for durum wheat production. These areas are generally characterized by a mixed crop-livestock farming system. Farmers in the study area produce mostly staple crops, namely, durum wheat, sorghum, maize, wheat, barley, potato, and fababean.

Ada'a district is located about 40 km south-east of Addis Ababa, covering 1,750 km^2. The district lies between longitudes 38°51' to 39°04' East and latitudes 8°46' to 8°59' North covering a land area of 1750 km^2 to east of Addis Ababa (Figure 1). Most of the land (90%) is plain highland ranging between 1600 to 2000 meters above sea level. The district is characterized by sub-tropical climate and receives 860 mm rainfall/annum. In general, the main rainy season occurs between mid-June and September, followed by a dry season that might be intercepted by the short rainy season in February and March. Mean annual temperature ranges from about 8–28°C. Black clay vertisol is the dominant soil type, with good soil fertility but with water logging problems in those areas where the land slope is below 8%. Household average farm size varies from 1 to 2.5 ha and the major farm operation is done by oxen power. The farming system is a mixed crop and livestock production system. Major crops grown are *Tef*, wheat, barley, fababean, (mainly bread variety) and pulses. Chickpea is the main pulse crop grown in the district and used as a crop rotation for wheat and teff crops.

Liben-Chiquala district is located 80 km east of Addis Ababa in the East Shewa zone of the Oromia regional state. The district has 18 kebeles with a total population of 93,367 (45,783 females) or 15,153 households. The district has a total cultivated area of 48,125 hectares with main crops such as *Tef*, maize, and wheat.

Gololcha district is located in the Northern extreme parts of the Bale zone. Geographically, the district lies between 7°N-71/2°N latitude and 4°E-4 1/2°E longitude. It is bounded on the east by the Gasera district, on the west by the Lega-hidha and Sawena districts, on the north by the Ginir district and on the south by the Arsi zone. Gololcha district is one of the administrative territories of the Bale zone with an area of 2,392 km^2 (239,200ha).

Shebel Berenta district is located in the East Gojam Zone, in the North Central Highlands of Ethiopia in the Amhara region. It extends from 10° 15′ N to 10° 30′ N latitude and 38° 15′ E to 38° 27′ longitude (CSA, 2007 cited in [14]). It is bordered on the south-west by the Dejen district; on the north-west by the Enemay district; on the north by the Enarj Enawga district, and on the south and south-east by the Abay

River Gorge, which separates it from the Oromia region. The district covers a total land area of 89,714 ha. Its altitude ranges from 1800 to 2150 masl. It has 2 agro-ecological zones with (28%) *Woyina-Dega* and (72%) *Kolla*. Shebel Berenta district has 26 Kebeles, of which 2 are urban and 24 rural Kebeles. Agriculture is the mainstay of the district livelihood activities for rural residents characterized by subsistence crop production, mainly dependent on rainfall, which is erratic in nature; the dominantly traditional farming system results in low input-output crop yields [14, 12].

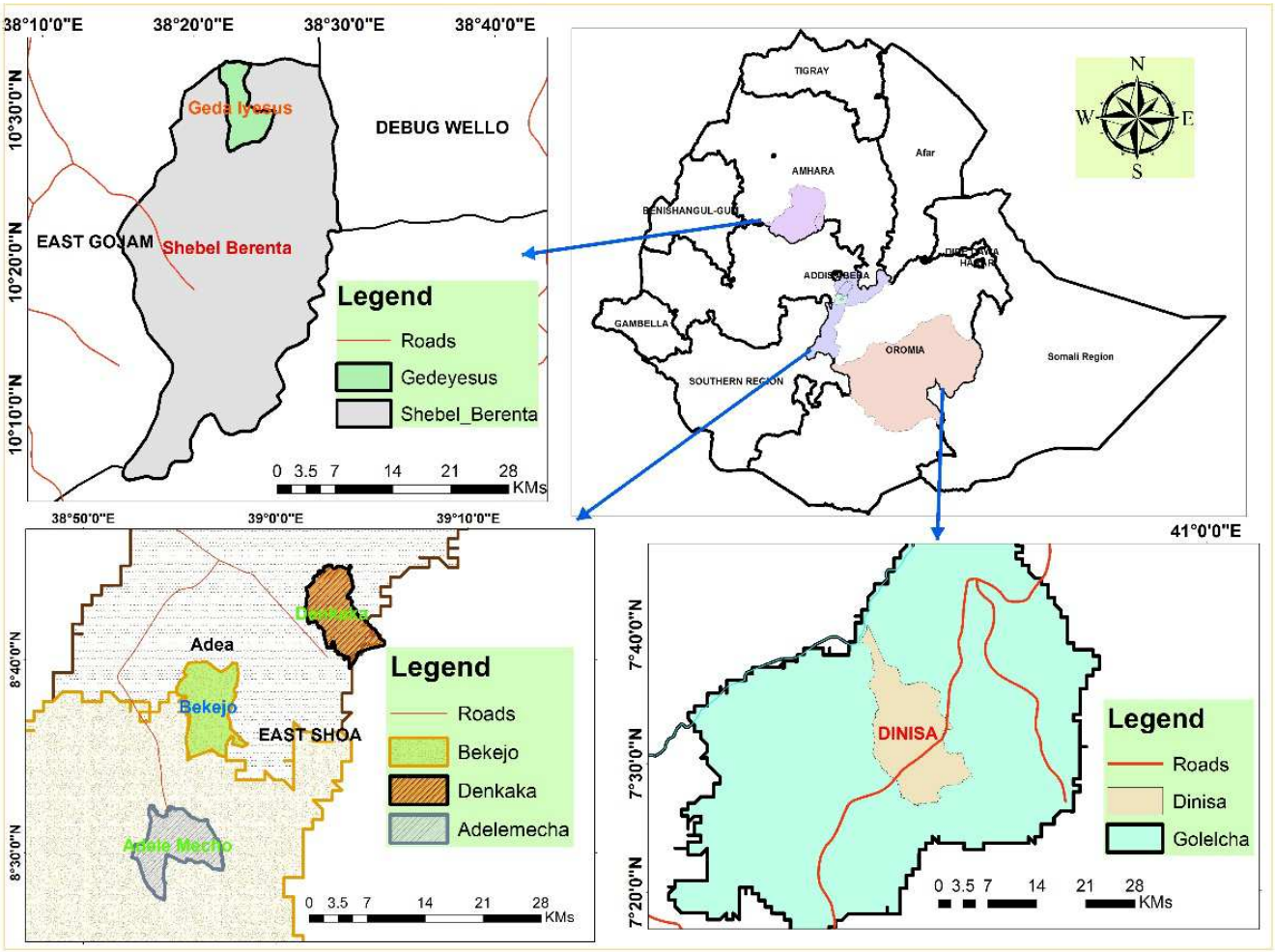


Figure 1. *Map of the study area.*

2.2. Site and Farmer Selection

Five representative kebeles were purposively selected based on their production potential of durum wheat in collaboration with the respective districts Office of Agricultural and Natural Resource. Similarly, the selection of the site and the farmer was carried out jointly with the Development Agents (DAs) of the respective kebeles based on the availability of the required adjacent plots of land (0.25 hectares of land per head), and the interest and willingness of farmers to participate. As a result, a total of five demonstration clusters were established by involving 87 farmers (4 of whom were women) and covering 50 ha of land. (Table 1)

Table 1. *Summary of the participating farmers and areas covered by the durum wheat technology demonstration (2019).*

Location			Area Covered (ha)	Participating Farmers'		
Zone	District	Kebele		M	F	T
East Shewa	Ada'a	Denkaka	10	7	-	7
		Bekejo	10	9	-	9
	Liben-Chiquala	Adele-Mecha	10	28	-	28
Bale	Gololcha	Dinssa	10	12	1	13
East Gojam	Shebel Berenta	Gedayesus	10	27	3	30
3	4	5	50	83	4	87

Source: field data, 2019/20.

2.3. Technology Demonstration and Evaluation Technique

Utuba variety was demonstrated along with the recommended production package using a cluster-based Large-Scale Demonstration (LSD) approach. Before implementing the activity, training was delivered for farmers, agricultural experts, and DAs on planting methods, input application, and general agronomic practices. A seed rate of 150 kg ha^{-1} was used and sowing was carried out in a row with a spacing of 20 cm between rows. Also, a fertilizer application rate of 150/100 kg ha^{-1} for N and P_2O_5 was applied respectively.

Throughout the implementation of the activity, continuous follow-up and evaluation was carried out by all the relevant stakeholders. Field days were also conducted at different levels (local, district, zonal, regional, and national) of the selected clusters to evaluate the overall successes, challenges, and opportunities of the intervention, to share the experiences and lessons obtained with other similar areas, and propose future directions. Farmers - Farmer's networking, printed media (such as leaflets, brochures, etc.), and mass media (such as radio, and television broadcasts) were also used as the technology dissemination approaches for wider dissemination of the technology in the target area.

2.4. Data Collection and Analysis

2.4.1. Type and Method of Data Collection

Both quantitative and qualitative types of data were collected through direct field observations, focused group discussions (FGD), and Key Informant Interviews (KII). As a result, the quantitative types of data such as the grain yield performance of the variety, the number of farmers trained, the number of experience sharing events (field visits and field days) organised and the participants involved were collected using a structured checklist. While qualitative types of data such as farmers' preferences and farmers' feedback on the technology have been collected using FGD and KII.

2.4.2. Data Analysis

The quantitative types of data were analyzed through a simple statistical test, such as percentage and mean. Whereas, the qualitative types of data, such as farmers' perception, and feedback on the technology by users and other stakeholders were analyzed through narration. Furthermore, the technology gap and extension gap analyses were used as suggested by [20].

Technology gap (q/ha)=Potential Yield (q/ha)-Demonstration Yield (q/ha)

Extension gap (q/ha)=Demonstration Yield (q/ha)-Farmers Practice Yield (q/ha)

3. Results and Discussion

3.1. Grain Yield Performance of Durum Wheat Technologies

The average grain yield performance of the technology was assessed and compared with the potential yield of the technology and the yield of farmers' practice in each district. The observed large scale demonstrated yield shows that the average grain yield of 29.2 q/ha to 38.5 q/ha was recorded. The highest grain yield (38.5 q/ha) was observed in the Shebel Berenta district in the East Gojam Zone of the Amhara region while the lowest grain yield (29.2 q/ha) was recorded at Ada'a district in the East Shewa Zone, Oromia region. The result also showed that an average grain yield increment of 0.77% to 130% was observed in the demonstrated variety over farmers' practice. Thus, the grain yield gap analysis showed that the yield of the large scale demonstration was better than that of farmers' practice in each district. This yield gap could be due to the use of a high yielding potential variety of durum wheat and the application of the package approach (improved varieties along with the recommended production and management practices) during the demonstration activity.

Similarly, the findings of this study (Table 2) showed an extension gap of 0.2 to 20.8 q/ha between the large-scale technology demonstration and farmers' practice. The extension gap was highest (20.8 q/ha) in the Liben Chiquala district and lowest (0.2 q/ha) in the Ada'a district of the East Shewa Zone, Oromia Region. Technology gap indicates that the gap in the demonstration yield over potential yield. The observed technology gap is attributed to dissimilarities in fertility, acidity, rainfall and other natural calamities and its contribution is to narrow down the gap between the yields of different varieties and to provide location specific recommendations [5]. The wider extension gap might be because of the inadequate transfer of improved varieties and insufficient extension services for transferring the technology.

In terms of technology index 32.1%, 20%, 14.4% and 10.5 %, for Ada'a, Gololcha, Liben-Chiquala and Shebel Berenta districts respectively. That means the variety has an average technology index of 19.2% And this dictates that the variety is feasible to the farmers in the study areas and other similar agro-ecologies [16].

Table 2. *The grain yield performance (q/ha) of the demonstrated durum wheat technologies (2019/20).*

Zone	District	Area (ha)	Yield (q/ha)			Increase over Farmer Practices (%)	Technology Gap (q/ha)	Extension Gap (q/ha)	Technology index
			Potential	Demo	Farmer's practice				
East Gojam	Shebel Berenta	10	43	38.5	32.3	19.04	4.5	6.2	10.5
East Shewa	Ada'a	20	43	29.2	29.0	0.77	13.8	0.2	32.1
	Liben-Chiquala	10	43	36.8	16.0	130.00	6.2	20.8	14.4
Bale	Gololcha	10	43	34.4	34.0	1.03	8.6	0.4	20.0

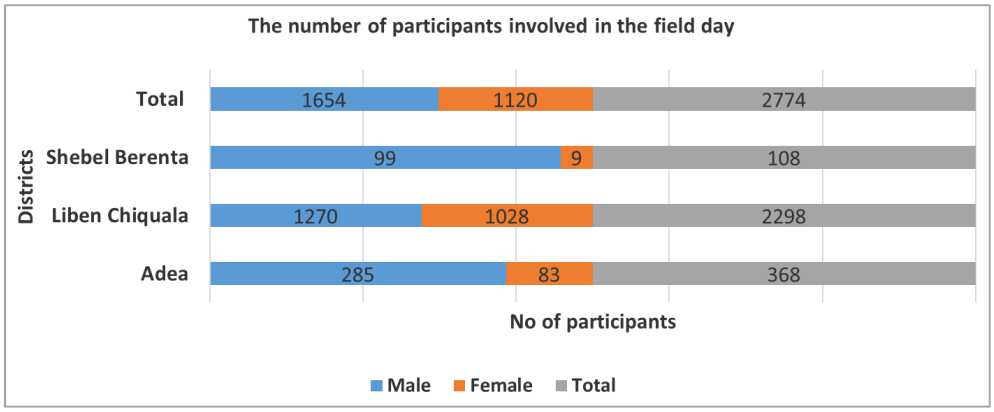
Source: field data, 2019/20.

3.2. Field Days and Stakeholders Feedback

Field days and field visits are important extension methods for creating wider awareness and facilitating farmer-to-farmer information and experience sharing. Thus, six field days were organized at different levels, and 1815 participants (274 of whom were women) took part, including the host farmers. During the field visit, the participants appreciated the practice of full package technology demonstration using a clustering approach. The beneficiary farmers stated that the demonstrated durum wheat variety (Utuba) was found superior to the local cultivar they used to plant because of its long spike, tillering capacity, relative resistance to rust and frost, and grain yield.

"In the past years, we were planting a local durum wheat cultivar which is less productive as compared to the introduced improved variety (Utuba). Most of the time, rust and frost damage it. This year, because of using the new variety along with all the recommended practices, its performance was very impressive and we expect a higher yield. The training we have received from the Debre Zeit Agricultural Research Center has also helped us learn how to produce and manage durum wheat crops for the upcoming seasons. Besides, the clusters on which technologies are tested on a larger scale than a parcel of the plot are very educational and persuasive. Besides, the clustering approach motivates each other. It is easy to share experience, good for getting clean seed as it protects mixing, good for joint planning and rotation, good for protection like assessing pests and diseases and chemical application, and good for mechanization" (Host farmers at Ada'a district, October 22, 2019).

During the field days, participant farmers showed interest in continuing to implement the technology on a larger acre of land and promised to give the seeds to other farmers in their vicinity. It also convinced the other farmers who were not engaged in the activity to adopt the technologies for the coming planting season and hence, demand the required amount of seeds from both the host farmers and the research center.



Source: field data, 2019/20

Figure 2. *The number of field day events organized and participants involved.*

4. Conclusions and Recommendations

The findings of this study revealed that the demonstrated durum wheat variety (Utuba) has a higher grain yield than the farmer's practice across all districts. Likewise, a positive and higher yield gap was noticed in the large scale technology demonstration clusters over the farmer's practice in all clusters of the farmer's field. The high performance of the technology could be due to the use of technology as a package (the new variety along with all the recommended management practices). This implies that the technology demonstrated in all districts shows promising in improving the production and productivity and hence contributing to the food security of farmers in the respective area.

In general, the large scale demonstration conducted at farmers' field' using a full package approach has shown that the adoption of the improved technologies as a package significantly improves the production and productivity of farmers and ensures food self-sufficiency and relieves the country from food shortages. The application of the full package technology approach should therefore be taken into account when disseminating the technology among farmers. Besides, the selected variety (Utuba) should be promoted and scaled up to address more farmers in the target areas and other unaddressed areas with similar agroecology by involving the concerned stakeholders, such as the government sectors, non-governmental organizations, and other private sectors at a different level.

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