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# Bridging Yield Gap in Food Barley Crop Production: Evidence from Large Scale Demonstration in Central Highland of Ethiopia

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## Abstract

Barley (Hordeum vulgare) is an important food crop in the highland parts of Ethiopia. The main purpose of this activity is to demonstrate improved food barley technology through a cluster based crop production approach. Sites and farmers are selected purposively from the major food barley producing areas of West, and North Shewa, zones of Oromia. About 182 participant smallholder farmers are involved through clustering their farm fields. In this study, one popular food barley variety (HB1307) with its recommendation packages is used for demonstration purpose. Accordingly, a total of 113 hectares of land with 15.65 ton of seed of food barley is covered. The quantitative and qualitative data are collected using participatory rural appraisal tools. The yield data are collected from the entire participants of the cluster and analyzed by simple descriptive statistics. Generally, the variety (HB 1307) demonstrated is found it acceptable by farmers in field visits and field days because of its resistance to disease, adaptation, and productivity. Moreover, the finding of the three years demonstration result revealed that the full package food barley variety (HB1307) demonstration through cluster approach has higher grain yield than the national and regional average recorded in the season. Therefore, the best-performing variety of food barley in the study area is HB1307, based on the data. Thus, improved variety with recommended production packages should be further scale out in the study area and similar agro-ecology using cluster farming approach.

## Keywords

HB1307, Large Scale Demonstration, Cluster Base, Technology

## 1. Introduction

Barley (Hordeum vulgare L.) is the fourth most important cereal crop grown in the world after maize, wheat and rice with productivity of 3.3 ton $ha^{-1}$ [1-3]. On the African continent, Ethiopia, Algeria, Morocco, South Africa and Tunisia are the top five largest barley producers [4]. In Ethiopia barley is the most important cereal crop following teff, maize, wheat and sorghum in bulk production and area coverage and fifth in yield (ton $ha^{-1}$) after maize, rice, wheat and sorghum with around 0.92 million ha and 2.3 million tons. In addition, the productivity of barley is 2.53 ton [5].

In the highlands of Ethiopia, barley is an important staple crop [6]. In order to alleviate the severe food scarcity that occurs in September, food barley is an emergency crop that matures early [7]. Although barley is considered a highland

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crop, it is also grown in marginal and low rainfall areas of the country including the rift valley [8, 9]. Its grains have historically been used for making "Injera" and local drinks for festivals and domestic usage. Currently, it goes through several value-added processes and is made into a variety of food that can be consumed as roasted grain (kolo), bread, powder, soup, or porridge [10]. With a productivity of 19.66 quintal $ha^{-1}$, barley produced 18,567,042.76 quintals of grain from 944,401.34 ha of the 9,974,316.28 hectares of land allocated for cereals during the 2015–16 production seasons [11]. Its productivity is 1.2 tons per hectare, which is quite low when compared to other grains, despite its immense economic and nutritional significance. The crop's decreased output was caused by numerous factors. These include low soil fertility, water logging, leaf and grain diseases, pests, weed competition, inadequate agronomic and low crop management methods, and limited demonstration of improved varieties [12, 15]. Additionally, one of the possibilities for improving output for smallholder farmers who had limited access to desired seeds of better varieties in the areas of barley growing agro-ecologies is the transfer activity for improved food barley technologies [5]. Due to an absence of improved seed and a weak connection between the agricultural office and research, the speed at which improved technologies were transferred from research to farmers was extremely low.

The country's national and regional research systems have been releasing numerous crop varieties and carrying out a number of research activities on crop improvement in order to address the productivity issue in the study area. In order to increase barley productivity in the target Zone's highland area, the Holetta Agricultural Research Center (HARC) conducted adaptation trials and participatory varieties selection of the best-performing and high-yielding food barley variety (HB1307). However, the farmers have not yet had a chance to see the highly-performing and chosen varieties in action.

Even though this variety is available, the majority of farmers in the Zones still does not have access to it and continue to use local varieties, which are known for their extremely low yield and disease vulnerability. The majority of barley's production and consumption in Ethiopia's highlands are by subsistence farmers. Lack of better seed types, poor adoption of new production technologies, and high rust disease infestation linked to both biotic and edaphic variables are the main causes of the areas low production yields. Therefore, the main objective of this study was to demonstrate and popularize improved food barley technology through clustered based approach with its full packages to increase food barley crop production and productivity in the study area.

## 2. Materials and Methods

### 2.1. Description of the Study Areas

Large-scale food barley technology demonstration carried out for three years (2020/21-2022/23) cropping season in West shewa, and North shewa, zone of Oromia at 6 districts. The zones located in the central part of Ethiopia, with best road facilities, its known for mixed crop-livestock farming systems. The zones is one of the major barley producing area in the country; farmers usually produce barley for home consumption and market; barley is used in this zones to prepare local liquor and local beers, which have great demand for market. Additionally farmers produce suitable landraces to prepare the main dish (injera). Large scale food barley technology demonstration was carried out within this zones of Chobi, Wolmera, Menagesha, Adaberga, Metarobi and Sululta districts from 2020/21-2022/23 cropping season (Table 1).

Welmera Woreda (one of the eight Oromia special zones surrounding Addis Ababa but administrated by West Shewa zone). The capital town of the Woreda is Holetta which is located at 40 km West of Addis Ababa on the main road of Addis to Ambo. Geographically, the area ranges 8°50' - 9°15'N and 38°25' - 38°45'E with an area of 775 $km^2$. According to Welmera Woreda Agriculture and Rural Development Office (WWARDO 2010), most of the areas of the Woreda are high lands (Dega) and mid highlands (Weyna Dega) with an altitude above sea level ranges from 2060 to 3380 m. The area has bimodal rainfall pattern. One is a belg rainfall season (usually from December to April) and the other is a summer season (meher) which covers months from June to September accounting more than 80% of the annual rainfall. The average, maximum and minimum annual temperature of the area is 24, 27, and 0.1°C, respectively.

Sululta Woreda is situated approximately 40 kilometers northwest of Addis Ababa and is administered under the Special Zone Surrounding Finfinne (SWARDO, 2014). The district has three main agro-ecological conditions: Kola (low altitude), which makes up 3.6% of the study area, Dega (high altitude), which makes up 71% of the study area, and Woina Dega (mid altitude), which makes up 25.4% of the area. The study area has an altitude range of 1500 to 3571 meters, with an average annual temperature of 15.36°C, with a mean minimum of 6.2°C in December and a maximum of 22.9°C in February and May. The district's typical soil composition is composed of cambisols, nitisols, and vertisols, which make up 49%, 24.5%, and 0.5% of the soil composition, respectively. Twenty-six percent of the land is made up of the remaining soil types. Population projection for 2014–2017, there are 160,837 people living in the study area; 138,552 (86.1%) of them are rural residents, and 50.2% are women. The area has a population density of 147 persons per $km^2$. Three towns and twenty-three rural kebeles make up the Sululta district. Three of the rural kebeles are at the lowland altitude, nine are in the highland, and eleven are in the midland [6].

The remaining soil typologies make up 26 percent of the land. As per to [6] population projection from 2014-2017, the study area has 160,837 total population; 138,552 (86.1%) are rural dwellers and 50.2 percent are females. Population density of the area is 147 people per $km^2$. Sululta district has 23

rural kebeles and 3 towns. Of the rural kebeles 9 are in highland, 11 in midland and 3 are in the lowland altitude.

Ada'a Berga district which is 64 km far away from Addis Ababa. Adda Berga is bordered on the South by Walmara, on the Southwest by Ejerie, on the West by Meta Robi, and on the North and East by the Muger River. The District has 34 kebeles and three towns include Enchini, Muger and Reji. The total estimated human population of the district is about 146,920 among male 73,192 and female 73,728 [14] the inhabitants are practiced Orthodox Christianity, protestant, Wakefeta and Muslim religions. Temperature ranges from 16-27.5 ℃ and rainfall from 880-1200 mm. The district has three agro-climatic condition Dega, woina dega and Kola.

Meta Robi Woreda is one of the 18 woredas of West Shewa Zone in Oromia Regional State. This geographically located in the Eastern part of the Zonal Center, Ambo. When we see its relative location it bounded in north with north shewa (Salalie) Zone, in south with Ejere and Jeldu woreda, Adea-Berga woreda in east and Abuna Gindeberet woreda in west. Meta Robi woreda is ecologically characterized by by 20% dega (high land), 35% Wayinadega (middle temporal), and 45% spatial variability in wet kola, with annual precipitation ranging from 1000mm to 2000mm.

### 2.2. Data Collection and Analysis

Both yield and social data was collected with appropriated data recording sheet; The collected quantitative data were analyzed using descriptive statistics (mean, yield advantage and % yield increase) similarly qualitative data collected using focus group discussion and direct field observation were narrated.

## 3. Results and Discussion

### 3.1. Location and Farmer Selection

The target districts, kebeles and host farmers were selected purposively based on their potential in barley production and farmers who are willing to organize in cluster farms. Site and farmer selection was done by the participation of woreda agricultural experts and Kebele DAs. In this activity a total of 182 farmers were participated out of which 160 were male and 22 were female farmers. Farm operation activities like land preparation-plowing using oxen plough, planting, first and second hand weeding, harvesting and threshing were held by the host farmers. HARC supplied only the recommended amount of seed and fertilizer for top dressing. For this study HB 1307 improved variety of food barley were used. The total amount of seed distributed and the area covered by this technology was 15.65 ton and 113 hectares respectively.

***Table 1.*** *Summary of varieties demonstrated, number of beneficiaries, and area Covered by LSD of Food barley technology from 2020/21-2022/23 cropping season.*

| Cropping season | Zone | District | Variety | Amount of seed dist / ton/ | Area covered /ha. | Direct beneficiary | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Male | Female | Total |
| 2020/21 | West shewa, | Metarobi | HB 1307 | 3.0 | 21 | 27 | 3 | 30 |
| | | Adaberga | HB 1307 | 2.6 | 21 | 25 | 6 | 31 |
| | | Chobi | HB 1307 | 3.1 | 25 | 25 | 3 | 28 |
| Sub-total | 1 | 3 | 1 | 8.7 | 67 | 77 | 12 | 89 |
| 2021/22 | Finf. Special | wolmera | HB 1307 | 2.3 | 15 | 37 | 1 | 38 |
| Sub-total | 1 | 1 | 1 | 2.3 | 15 | 37 | 1 | 38 |
| 2022/23 | Finifine special | Sululta | HB 1307 | 3.0 | 20 | 34 | 5 | 39 |
| | | Menagesha | HB 1307 | 1.6 | 11 | 12 | 4 | 16 |
| Sub-total | 1 | 2 | 1 | 4.65 | 31 | 46 | 9 | 55 |
| Total | 2 | 6 | 1 | 15.65 | 113 | 160 | 22 | 182 |

Training Field days and advisory services

Training is one of the instruments used in extension to create awareness and improve the knowledge, skill and attitude of farmers, DAs and agricultural experts towards crop production. Hence, farmers, development agents and agricultural experts from Wolmera districts were trained on barley

crop production and management practices, field clustering approaches, acid soil reclamation and management, field follow up, data collection and post-harvest handling. In this event farmers development agents and agricultural experts were participated. Field days were organized at grain filling stage to evaluate the performance of the technologies, key actors farmers, agricultural experts and researchers were participated for technology evaluation.

*Table 2. Mean Grain yield ton/ha Yield advantage (ton) and percent yield increase of food barley technologies in LSD across three districts, 2020/21 season.*

| District | variety | Demonstrated | national | regional | yield advantage national | Yield advantage regional | % yield increase national | % yield increase reg |
|---|---|---|---|---|---|---|---|---|
| Meta Robe | HB 1307 | 4.1 | 2.5 | 2.79 | 1.5 | 1.3 | 38.39 | 31.8 |
| Adaberga | HB 1307 | 3.95 | 2.5 | 2.79 | 1.4 | 1.1 | 36.05 | 29.22 |
| Chobi | HB 1307 | 4.0 | 2.5 | 2.79 | 1.4 | 1.2 | 36.85 | 30.1 |
| Mean | | 4.17 | 2.5. | 2.79 | 1.4 | 1.2 | 37.10 | 30.37 |

## 3.2. Yield Performance of Demonstrated Food Barley Variety Using LSD Approach

The mean grain yield, yield advantage and percent yield increase of the improved technologies across locations are illustrated (in Table 2). The improved food barley variety's mean grain yield during 2020/21 cropping season across the three districts was 4.17 ton/ha. When we compare the actual demonstrated mean grain yield with national and regional average yield, it has a 1.4 and 1.2 yield advantage and 37.10 and 30.37 percent yield increase respectively. The yield data showed that improved variety provides more grain yield than the national, regional and zonal average recorded in the season.

The second year (2021/22) result (in Table 3) below showed that the grain yield of improved barley variety gave 3.78 ton/ha better than the national as well as the regional average grain yield recorded in the season. The improved variety gave a yield advantage of 1.25 ton/ha and 1.0 ton/ha and a percent yield increase of 33.2% and 26.03% over the national and regional average yields.

*Table 3. Mean grain yield of food barley variety demonstrated in LSD in the study district, 2021/22.*

| District | Variety | Average grain yield ton/ha. | | | Yield advantage | | %yield increase | |
|---|---|---|---|---|---|---|---|---|
| | | Demonstrated | Regional | National | Regional | National | Regional | National |
| Wolmera | HB 1307 | 3.78 | 2.79 | 2.52 | 1.0 | 1.25 | 26.03 | 33.2 |

Moreover, the 2022/23 season yield data (in Table 4) indicate that the improved variety HB 1307 gave a mean grain yield of 3.6 ton/ha better than the national the regional as well as zonal average grain yield recorded in the season. When we compare the actual demonstrated mean grain yield with national regional and zonal average yield, it has a 1.0, 0.74 and 0.72 ton/ha yields advantage and 27.91, 20.60 and 20.10 percent yield increase respectively. The yield data showed that improved variety provides more grain yield than the national, regional and zonal average recorded in the season.

*Table 4. Mean Grain yield ton/ha, Yield advantage (ton) and percent yield increase of food barley technologies in LSD across two districts, 2022/23 season.*

| District | variety | Average grain yield ton/ha | | | Yield advantage ton/ha | | % yield increase | |
|---|---|---|---|---|---|---|---|---|
| | | Demonstrated | National | Regional | National | Regional | National. | National. |
| Sululta | HB 1307 | 3.5 | 2.59 | 2.85 | 0.90 | 0.64 | 25.91 | 18.40 |
| Menagesha | HB 1307 | 3.7 | 2.59 | 2.85 | 1.10 | 0.84 | 29.92 | 22.81 |
| Mean | | 3.6 | 2.59 | 2.85 | 1.00 | 0.74 | 27.91 | 20.60 |

## 4. Conclusion and Recommendation

Generally, the variety (HB 1307) demonstrated is acceptable by farmers during field visits and field days because of its productivity, adaptability, and disease tolerance. Moreover, the finding of the three years demonstration result revealed that the full package food barley variety (HB1307) demonstration through cluster approach has higher grain yield than the national, regional, and zonal average recorded in the season. Thus, according to the findings, HB1307 is the top-performing variety in the study area. Thus, improved variety with recommended production packages should be further scale out in the study area and similar agro-ecology using cluster farming approach.

## Abbreviations

| | |
|---|---|
| SWARDO | Sululta Woreda Agricultural and Rural Development Office |
| WWARDO | Wolmera Woreda Agricultural and Rural Development Office |
| CSA | Central Statistical Agency |

## Conflicts of Interest

The authors declare no conflict of interest.

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