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# Deployment of Malt Barley Technologies in Ethiopia

## Achievements and Lessons Learned


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Cover picture: Malt barley seed production by Hundie Gudina Seed Producer Cooperative in Munesa district, Arsi Zone (2768 masl, 7°31.55’ N and 38°59.72’ E)

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Copy editor: Abebe Kirub

**ISBN: 978-0929127-545**

**AGROVOC descriptors**
Ethiopia; malt barley; high yielding varieties; breeder seed; basic seed; certified seed; quality declared seed; demsontration; scaling; food security; nutrition security; institutions; research institutions; production costs; profit; yields; farm income; variety suitability mapping

**Citation**
Zewdie Bishaw and Adamu Molla (eds). 2020. Deployment of Malt Barley Technologies in Ethiopia: Achievements and Lessons Learned. International Center for Agricultural Research in the Dry Areas, Beirut, Lebanon. 239 pp.

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Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, Consortium of International Agriculture Research Center that focuses on delivering innovative solutions for sustainable agricultural development in the non-tropical dry areas of the developing world. We provide innovative, science-based solutions to improve the livelihoods and resilience of resource-poor smallholder farmers. We do this through strategic partnerships, linking research to both development and capacity development, and by taking into account gender equality and the role of youth in transforming the non-tropical dry areas.

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# Preface


This work was undertaken by ICARDA as part of project, Deployment of Malt Barley and Faba Bean Varieties and Technologies for Sustainable Food and Nutritional Security and Market Opportunities in the Highlands of Ethiopia and funded by the United States Agency for International Development. The editors and authors are grateful for the financial support, without, which this Book would not have been possible.

The authors would also like to thank several institutions for providing the valuable information needed to produce this Working Paper. These include the Ministry of Agriculture, Ethiopian Institute of Agricultural Research and Regional Agricultural Research Institutes of Amhara, Oromia, Southern Nations, Nationalities, and Peoples and Tigray Regions, Ethiopian Seed Enterprise, Amhara Seed Enterprise, and Oromia Seed Enterprise. Special thanks go to the kind and generous Ethiopian barley farmers who contributed their time and provide information to this study.


The views and opinions expressed in this book are purely those of the authors and do not necessarily reflect the views of their employers.

***Editors***

# Foreword

This Book is the outcome of the collaborative endeavors of diverse stakeholders addressing the challenges of seed systems and scaling of malt barley production in Ethiopia. It is the first of two forthcoming books, which focuses on malt barley. Ethiopia is one of the major Vavilovian centers of origin for many agricultural crops and a center of diversity for crops like barley. Generally, both food (six-row) and malt (two-row) barley are cultivated in the country. Traditionally six-row barley is predominantly grown as major food security crop in the extreme highlands where alternative cereals are absent or limited. It can also be used for preparation of local beverages such as tella (local beer) and areke (local spirit). Malt barley based on two-row is a recent introduction to meet the domestic malt demand of growing malt factories and breweries. The country has been significantly deficient in meeting the ever-increasing malt barley demand of local breweries from domestic production where the net import bill for malt barley continues to increase and projected to reach as high as US$420 million by 2025. Given the favorable environment and available improved malty barley technologies, farmers can cost-effectively grow malt barley to meet the rapidly growing domestic demand reducing import and improve their livelihoods through increased income.

The Book with its title ***"Deployment of Malt Barley Technologies in Ethiopia-Achievements and Lessons Learned"*** provides a synthesis of the research for development and rich experience gained in scaling of malt barley technologies through effective partnership with broad range of stakeholders including the federal Ministry of Agriculture and regional Bureaus of Agriculture, the federal and regional agricultural research institutes, the federal and regional public seed enterprises, seed producer cooperatives or farmer seed producer groups, the International Center for Agricultural Research in the Dry Areas (ICARDA), and ultimately malt barley farmers. Many of the contributors to this volume provide sound evidence in favor of diversified interventions with due focus on mechanisms for institutionalizing the research approaches to ensure sustainability in addressing the challenges of domestic malt barley production and with the potential for export. The experiences and knowledge gained are put in context aimed at decision-makers, not only in Ethiopia but in other developing countries for wider application and spill overs. The Book provides useful insights to policy makers, researchers, students, development practitioners and donors involved in international development for generating and moving technologies out to the farmers' fields.

***Dr Jacques Wery***

***Deputy Director General, Research***

***ICARDA***



# CHAPTER I

## OVERVIEW OF ACHIEVEMENTS AND BASELINE SURVEY

## *Achievements of Seed Production and Scaling up Malt Barley Technologies in the Highlands of Ethiopia*

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## Introduction

Ethiopian agriculture is predominantly a crop and livestock mixed farming system. Small-scale, semi-subsistence crop farming, and livestock keeping are the conspicuous features of Ethiopian agriculture where crop residues serve as feed sources and manure used as organic fertilizers for crop production in the highland areas. Agriculture is the most important sector of the national economy, contributing 39% of the total GDP of the country (NPC, 2016) where 81% of the total population was rural (FAO, 2016), employing 75% of the labor force (NPC, 2016) in 2015, and serving as the source of 85% of the export earnings in 2010 (FAO, 2014).

Agriculture being a dominant sector, its performance explains the level of rural poverty, food insecurity and low economic growth in the country. Population growth, land degradation, and frequent droughts due to climate change in addition to other abiotic and biotic stresses are making food and nutrition insecurity an increasing concern of smallholder farmers. Moreover, rainfall variability, poor access to improved technologies, poor coordination among agricultural research and services, remain critical factors influencing the performance and sustainability of agricultural sector.

Agriculture is primarily rainfed and smallholders dominate the sector with 15.6 million farm households cultivating 14.8 million ha, an average farm size of 0.95 ha per household (FAO, 2016). Cereals occupied 73.1% of cultivated crop land in 2014/15 meher (main) cropping season (CSA, 2015) and accounted for roughly 60% of rural employment (Wassie, 2014, citing Abu and Quintin, 2013). In 2015, 4.1 million farm households planted barley on 994 thousand ha with an average productivity of 1.97 t ha$^{-1}$ (Table 1). Barley constituted 9.8 and 8.3% of the total cultivated land area and production of cereal crops, respectively. Most (> 99%) of the barley cultivated area and production in 2014/15 meher cropping season happened in four Regions (Amhara, Oromia, Southern Nations Nationalities and Peoples, and Tigray) (Table 1).





Ethiopia is one of the major Vavilovian centers of origin for many agricultural crops and a center of diversity for crops like barley. Generally, both food (six-row) and malt (two row) barley are cultivated in the country with distinct use serving two important functions as major food security crop in the extreme highlands where alternative cereals are absent and/or as a cash crop for malt production for the growing brewing industry. Malt barley is a recent introduction to meet the domestic malt demand of breweries and malt factories. Nevertheless, accurate statistical information on area coverage in the country is scanty. It was reported that malt barley's land area share was between 10-15% of total land area covered by barley (Anonymous, 2013; Alemu et al., 2014) and the production is hardly meet the domestic demand.

Ethiopia has been significantly deficient in meeting the ever-increasing malt barley demand of local breweries from domestic production. As a result, the net import bill for malt barley jumped from US$240 thousand in 1997 to US$40 million in 2014 and is projected to reach as high as US$420 million by 2025 (Rashid et al., 2015). Given the country's balance of payment situation in recent years, this is an alarming trend and not sustainable. On the other hand, if farmers can cost-effectively grow malt barley to meet the rapidly growing domestic demand, their livelihoods could be significantly improved.

*Table 1. Area, productivity and production of barley in 2014/2015 meher cropping season*

| Study locations | Area (ha) | Productivity (t ha$^{-1}$) | Production (t) | Number of households |
|---|---|---|---|---|
| Ethiopia | 993,939 | 1.97 | 1,953,385 | 4,095,273 |
| Amhara NRS | 362,739 | 1.72 | 625,623 | 1,471,386 |
| Oromia NRS | 456,192 | 2.25 | 1,027,533 | 1,620,777 |
| SNNP RS | 73,615 | 1.72 | 126,845 | 591,362 |
| Tigray NRS | 99,052 | 1.71 | 169,542 | 399,537 |

*Note: NRS = National Regions targeted in malt barley seed production and scaling project in 2015-2018*

A review of the Growth and Transformation Program I (GTP I) at the end of 2014/15 cropping season indicated that limitations in coverage and quality of implementing the agricultural extension system, limited supply of inputs such as improved seeds and fertilizers, and limitations in applying and scaling of full packages of crop technologies were the key limiting factors to achieve higher productivity and production of cereal

*[1] According to CSA, meher (main) season are crops produced during September (Meskerem) to February (Yekatit) and belg (short) season are crops planted and harvested during the months of March (Megabit) to August (Nehase)*

crops in Ethiopia (NPC, 2016). In case of malt barley, the priority is both improving productivity and production while maintaining malt grain quality.

Significant achievements have been made in malt barley productivity and production in the last decade due to use of improved crop technologies developed by the federal and regional agricultural research institutes. However, limited knowledge, skills and information are also hindering to meet the ever-increasing national demand. For example, there is huge gap observed between national average yield, achievable yield with recommended packages and potential yield for malt barley as indicated in the succeeding parts of this publication. This paper describes the approaches and summarizes the achievements of the malt barley under the project *Deployment of Malt Barley and Faba Bean Varieties and Technologies for Sustainable Food and Nutritional Security and Market Opportunities in the Highlands of Ethiopia* implemented during 2015-2018 in partnership with federal and regional research for development partners and stakeholders along the value chain of malt barley.

## Goal and objectives of the Project

The overall goal of the Project was to improve the livelihoods of malt barley producing smallholder farmers in the Ethiopian highlands through increased productivity, production and linkages to emerging markets. The objectives were:

- Increase awareness, ensure access and adoption of improved malt barely varieties with integrated crop production packages;
- Increase the involvement of organized farmer groups and seed companies in multiplying and marketing quality seed of malt barley varieties;
- Understand the malt barley seed and grain value chains and create market linkages among key actors; and
- Strengthen the capacity of NARS, seed companies, farmer groups, farmers and other seed and grain sector value chain stakeholders.

## Approaches

A framework for scaling has been developed and used for dissemination of crop technologies for a meaningful adoption and impact at scale (Figure 1). The approaches included:

- Identification, validation, demonstration, and popularization of new malt barley varieties and integrated crop management practices. Farmers hosted demonstrations in, which field days were organized for farmers, development agents and subject matter specialists as well as technical and administrative staff and senior and policy makers from the district, zonal, regional and federal offices for experience sharing and improving linkage;
- Accelerated early generation seed (breeder, pre-basic and basic) production by National Agricultural Research System (NARS) during the main and off-seasons. NARS engaged farmer groups such as cooperatives and unions to produce seed under their strict supervision and linked them to regional seed certification agencies to ensure quality and enhance marketing and sustainability. The seed produced being used for further multiplication of certified or quality declared seed (QDS) through formal or informal sectors;
- Accelerated certified seed or QDS production through distribution of small seed packs and mobilizing, organizing and training farmers to engage in seed production and marketing. Seed producers were linked to regional seed certification agencies to ensure quality. Farmers had the options of marketing the seed produced through formal and/or informal sectors; and paying back the seed in kind as revolving seed fund scheme to produce quality seed for scaling or local distribution by district Office of Agriculture (OoA);
- Strengthening capacity of project partners and stakeholders including farmers through training to upgrade knowledge and skills and providing facilities for NARS and seed producers; and
- Characterizations of farm households to establish benchmarks and measure the impact of the project on adoption and impact on farmers' food and nutritional security and income.

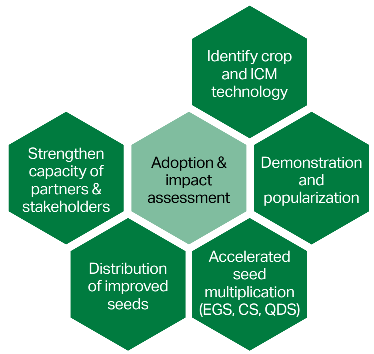


*Figure 1. Scaling framework for crop and agronomic technologies*

## Partners and Stakeholders

Scaling for impact at scale is a multifaceted activity involving a broad spectrum of partners and stakeholders consisting of multi-disciplinary team of researchers, development practitioners, policy makers and target beneficiaries. The partnership went beyond the public sector domain bringing in the commodity value chain operators including the private sector. It operated in a participatory mode and being inclusive where the clarity of their roles and responsibilities were defined and implemented accordingly (Figure 2).

A broad range of research for development partners and stakeholders along the malt barley value chain from the federal and the four target Regions were involved in the multistakeholders platform including the research, seed producers and suppliers, agricultural input providers, development agencies, extension services and farmers as well as traders, agro-industry, policy makers and donors. These included:

- The Ministry of Agriculture (MoA) and four regional Bureaus of Agriculture (BoA) and extension system at zonal, district and kebele levels;
- Federal Ethiopian Institute of Agricultural Research (EIAR) and regional agricultural research institutes (Amhara Regional Agricultural Research Institute (ARARI), Oromia Agricultural Research Institute (OARI), South Agricultural Research Institute (SARI), and Tigray Agricultural Research Institute (TARI)). Holetta and Kulumsa ARCs from EIAR; Adet, Debre Birhan, Gonder and Sirinka ARCs from ARARI; and Sinana ARC from OARI; Areka and Hawassa ARCs from SARI; and Alamata and Mekelle ARCs from TARI were the main partners implementing the projects in the respective target regions;
- Federal Ethiopian Seed Enterprise (ESE) and regional public seed enterprises (PSEs) such as Amhara Seed Enterprise (ASE), Oromia Seed Enterprise (OSE) and South Seed Enterprise (SSE);
- Private seed producers, farmer's cooperative unions, and seed producer associations including 30 seed producer and marketing cooperatives; and six farmers' cooperatives unions;
- Regional seed regulatory and quality control and quarantine agencies of respective Regions;
- Farmers in 76 Agricultural Growth Program (AGP) and Productivity Safety Net Program (PSNP) districts. Farmers were engaged not only as beneficiaries of the project, but as main actors of the project involved in hosting demonstration, producing and marketing seeds;
- Development projects and NGOs involved in promoting and scaling improved technologies;
- Asella and Gonder Malt Factories; and breweries such as Dashen, Habesha, Heineken, Meta and Raya; and
- Projects like Africa RISING and ICARDA-Austrian Development Agency projects working in study locations, Integrated Seed Sector Development-Ethiopia, and Agricultural Transformation Agency (ATA).

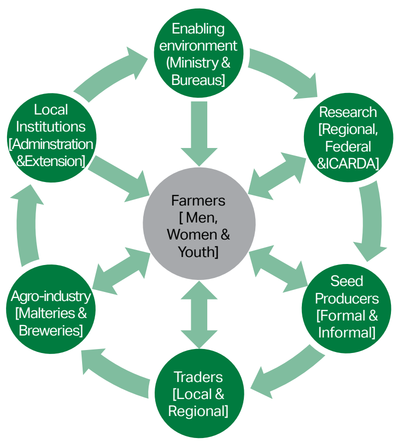


*Figure 2. Partnership platform for scaling new crop technologies for impact at scale*



**CHAPTER I**: Overview of achievements and baseline survey

## Project Target Regions

The malt barley project focused on four major administrative regions, namely; Amhara, Oromia, SNNP and Tigray, which collectively contribute 99% of barley area and production in the country. The project covered 62 districts in AGP and PSNP intervention areas (Figure 3).

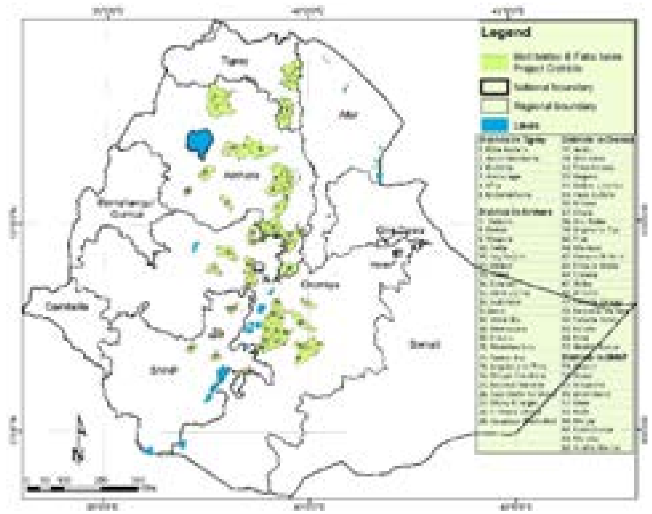

*Figure 3. Malt barley seed production and scaling districts*

## Achievements

The major achievements of the seed production and scaling of malt barley under the project "Deployment of Malt Barley and Faba Bean Varieties and Technologies for Sustainable Food and Nutritional Security and Market Opportunities in the Highlands of Ethiopia" during 2015-208 cropping seasons are summarized below.

### Validation, Demonstration and Popularization of Technologies

A combination of factors limits famers' adoption of new improved crop technologies. Apart from weak extension services, farmers' lack of information and access to technologies are factors that limit technology adoption and achievement of impact at scale. Although malt barley production is now over half a century old, the production of the crop is still limited to Arsi Zone in southeastern Ethiopia. However, to meet increasing demand from the newly established malt factories and breweries, efforts have been made in promoting malt barley production in major barley growing areas of central and northern Ethiopia. Currently, malt barley production is gaining momentum and farmers acceptance not only as malt but food crop in food barley growing areas of Ethiopia.

## Demonstration

A number of high grain yield and quality malt barley varieties with end-user preferred traits and associated production technologies had been developed, but their adoptions were very limited due to lack of awareness and access to improved technologies among farmers, development agents and extension services. Therefore, the demonstration of existing or new improved varieties and associated crop management technologies were conducted during 2015-2017 particularly with recommended packages and improved weed management practices such as selective grass and broadleaf herbicides, and their combinations.

Good agricultural practices including land preparation, planting time, seed rates, post-harvest handling and storage were among important practices promoted. Moreover, judicious use of fertilizers and pesticides (herbicides) were also prompted to protect the environment. NARS and ICARDA coordinated the implementation in target districts and beyond using farmers' fields, farmers' cooperatives and unions.

About 243 demonstration plots were planted on 243 farmers' fields (14.4% female farmers). Most of improved malt barley varieties increased grain yield by 2.6-53.3% over the respective checks (Table 2). Few improved varieties gave lower grain yield than either Holker [the oldest malt barley variety released in 1979 (NSIA, 1998) and still being widely under production]. IBON174/03, the most promising and being widely promoted variety, is likely expected to replace Holker. The results obtained suggest that we should go for location specific recommendations of malt barley varieties (Table 2).

*Table 2. Average productivity and yield advantage of demonstrated improved malt barley varieties and management practices demonstrated in different districts from 2015 to 2017*

| Malt barley varieties (grain yield in t ha$^{-1}$)* | Yield advantage over control (%) | Target district |
|---|---|---|
| EH1847 (1.82), IBON 174/03 (2.04), Sabini (1.38), Holker (ck 1.68) | -17.9 to +21.4 | Farta, Lay Gaynt, Gusha-Shin-kurta |
| Bekoji-1 (1.38), EH1847 (2.43), IBON 174/03 (1.99), Holker (ck, 1.92) | -28.1 to +26.6 | Doyogena, Sodo Zuria |
| Fanaka (2.12), HB1963 (3.14), Singitan (2.32), IBON174/03 (ck, 3.06) | -30.7 to +2.6 | Bassona-Worana |
| Bekoji-1 (3.35), EH1847 (3.17), IBON 174/03 (3.75), Holker (ck, 2.63) | 20.5-42.6 | Degem, Ejerie, Jeldu, Ker-samalima, Wolmera |
| Bahati (3.12), EH1847 (3.02), HB1963 (3.48), HB1964 (2.81), IBON 174/03 (2.93), Traveler (ck, 2.27) | 23.8-53.3 | Dara, Hulla, Melga |
| EH1847 (3.45), Sabini (ck, 2.51) | 37.5 | Atsbi, Duga-Temben |
| IBON 174/03 (3.45), Sabini (3.1), HB1533 (ck, 2.98) | 4.0-15.8 | Gumer, Alicho-Woriro |

Note: ck=check against, which comparison was made; *figures in parenthesis are grain yield in t ha$^{-1}$





## Validation of crop management

Good agricultural practices such as land preparation, planting time, seed rates, post-harvest handling and storage were among important practices promoted. Moreover, judicious use of fertilizers and herbicides were also prompted to protect the environment. NARS and ICARDA coordinated the implementation in target districts and beyond using farmers' fields, farmers' cooperatives and unions. Validation and demonstration of grass weed herbicides were conducted in Amhara, Oromia and Tigray Regions (Table 3). Herbicidal weed control increased grain yield of malt barley by 41.8-287.8% over the weedy check. However, experiences in Ethiopia show that most farmers do not practice either herbicidal or manual weed control in barley where substantial yield reduction wasreported in the country (Beyene et al., 1996; Negewo et al., 2011; Rashid et al., 2015).

*Table 3. Herbicidal weed management for improving yield of malt barley*

| Region | Zone | District | Treatment | Yield (t ha$^{-1}$) |
|---|---|---|---|---|
| Amhara | North Shewa | Ankober and Bassona-Worana | Axial + Derby | 2.20 |
| | | | Derby alone (check) | 1.39 |
| Oromia | West Shewa | Wolmera | Ralon Super | 2.87 |
| | | | Two hand weeding | 2.60 |
| | | | Weedy check | 0.74 |
| | Bale | Dinsho & Goba | Axial + 2,4-D | 3.20 |
| | | | 2,4-D alone | 2.32 |
| | | | Weedy check | 1.16 |
| Tigray | South Tigray | Ofla | Axial + 2,4-D | 2.58 |
| | | | Two hand weeding | 2.31 |
| | | | Weedy check | 1.82 |

## Field days

Technology demonstrations, community-based seed production, and scaling-up activities of the project are believed to provide farmers the opportunity to be aware of the performance of the improved varieties and accompanying production technolgies in their environments. Besides, organizing field days enhances their knowledge, accelerates awareness creation by reaching more farmers to exchange experiences, enhances farmer-to-farmer seed exchange, and improve linkage among value chain actors of malt barely.

Since the insception of the project in 2015, several field days had been jointly organized by partner agricultural research centers and district offices of agriculture, which worked together in promotion and scaling up/out of the improved technologies. Reports from partner research centers on organized field days in 2015-2018 indicated that 21,833 farmers (20.4% female) and 4,863 other research for development actors (15.3% female) of malt barley value chain participated in various field days. Among the value chain stakeholders were district and zonal political and sectoral authorities, distrtict and zonal experts of agricultural extension, zonal seed quality inspection and certification experts, zonal cooperatives organizing and licensing agency experts, malt factories and breweries, agricultural marketing and input suplying unions, seed marketing and input supplying unions, public and private seed enterprises, development agents, researchers from NARS and ICARDA.

Such higher performances were achieved since district and kebele level offices and development agents of ooffices of agriculture conducted local field days. This is in addition to the high level field days jointly organized by zonal bbureaus of agriculture and the respective agricultural research centers in each target location of the project. These field days, also focused on linkages among of various actors in malt barley value chains for promoting farmer-based seed production and maintaining sustainability to overcome the prevailing critical shortage of improved seed supply. Quality seed production and timely certification mechanisms were also major issues of discussion. Some of the significant achievements observed in the field days include:

- Introduction of widely adapted early maturing and high yielding malt barley variety. IBON 174/03 was highly appreciated by farmers and the officials of Legambo District for its impressive performance particularly under low input production system on low fertile soils of rugged highlands of South Wollo Zone; and
- Expansion of malt barley from southeastern (Arsi and Bale Zones) to non-traditional areas in central and northeastern highlands of Ethiopia, and adequate linkage with malt factories will enable increase in domestic malt barley production.

## Accelerated Seed Production

Variety development and release should be linked to commercialization to benefit from genetic gains of the crop improvement programs. Generally, there is a time lag between a release of new improved variety and availability of quality seed to farmers. Availability, access and use of quality seed of well adapted and preferred varieties remain a challenge for many crops in Ethiopia including malt barley.

Ethiopia follows an OECD Seed Scheme where four seed classes are recognized: Breeder, pre-basic, basic and certified seed. Moreover, it has introduced a Quality Declared Seed to encourage SMEs like seed producer cooperatives, farmer associations or groups to engage in local seed business.



**CHAPTER I**: Overview of achievements and baseline survey

## Early generation seed multiplication

Atilaw et al. (2017) provided a review of early generation seed (EGS) production and advocated for its institutionalization in Ethiopia. Bishaw and Atilaw (2016) identified four critical issues that are important for streamlining EGS production by the federal and regional agricultural research systems: adequate variety maintenance, coordinated EGS multiplication plan, decentralized EGS multiplication and quality assurance. Accordingly, NARS are responsible for breeder and pre-basic seed production while public seed enterprises are responsible for basic seed production of public-bred varieties. The main limiting factors for malt barley seed supply have been limited availability of breeder and pre-basic seed from the agricultural research centers, and critical shortage of basic seed from the public seed enterprises. Apart from lack of physcial resources (land, irrigation), facilities (farm machinery, processing and storage) and financial resources for EGS production, priroity has been given to other crops.

Cognizant of the issue, the project strived to produce EGS for further multiplication to enhance seed availability and access to certified seed by smallholder farmers, and large scale technology scaling up/out in 2015-2018. The performance of three years (2015-2017) EGS production showed that the project supported planting of 19.0 ha for breeder, 60.9 ha for pre-basic and 272.2 ha for basic seed production with the respective production of 40.3, 154.5 and 554.7 t. Apart from on-station land scarcity in partner research centers, shortage of nucleus seed limited breeder seed production. Pre-basic and basic seed production with seed producer cooperatives under irrigated and rainfed conditions contributed to higher performance. However, average productivity was low (2.54 t $ha^{-1}$ for pre-basic seed and 2.04 t $ha^{-1}$ for basic seed mainly due to frost and waterlogging damage) in some areas. Most of the basic seed was produced on-farm with farmers under the supervision of respective ARCs. These experiences on malt barley seed production imply that pre-basic and basic seed production could be undertaken on seed producer cooperatives if the physical facilities and human resources capacities are strengthened to satisfy seed certification requirements.

Variety maintenance and breeder seed production are critical for any seed production program. Not only shortage of land, but lack of proper planning of breeder seed production significantly constrained both EGS multiplication and subsequently large-scale certified seed production. The decentralized EGS production plan advocated by the project was not fully implemented and some regional ARCs continue to depend on federal institutes, which released the varieties. Without adequate planning and contract based EGS production, the availability and access to quality seed of improved varieties remain problematic.

## Certified seed multiplication by public/private seed enterprises

From the outset the project had no direct role or objective in large-scale certified seed production rather it aimed at filling the gap in basic seed supply for further multiplication by public or private sector. The project anticipated the public or private seed suppliers to directly access pre-basic seed from NARS to produce their own basic seed or linked to NARS-cum-farmer seed producer groups to get access to basic seed for undertaking certified seed production using their own resources.

Significant efforts were made to establish sustainable linkages in certified seed production of malt barley with federal and regional public seed enterprises, and emerging private sectors. These partners participated in project launching workshops, consultative meetings, and partnership meetings as well as annual review and planning meetings. Efforts were also made to engage the public seed enterprise (PSEs) to produce basic seed and further produce and market certified seed using their own resources. Although the PSEs were not able to fully accommodate all certified seed production plan envisaged in the project in target districts in 2016 and 2017, they accessed limited amount of EGS of some varieties from NARS partners involved in the project and produced certified seed within the centrally managed production plan under the Ministry of Agriculture and Natural Resources (MoANR).

In 2017, however, through a concerted effort and continuous engagement of the project, the Amhara Seed Enterprise (ASE) and Oromia Seed Enterprise (OSE) planted 3.7 ha for basic and 1,175.8 ha for certified seed production of malt barley with the participation of 3,154 farmers (307 female farmers). The amount of seed produced was 2,534.13 t, of which 9.28 t was basic seed. The seed produced in 2017 could cover about 25,341 ha of land in 2018 with the participation of 10,178 direct beneficiary farmers producing about 63,352 t of malt barley.

Our effort shows that public and private seed enterprises are yet to be convinced with the availability of sustained seed demand and profit. Therefore, the project made tremendous efforts to produce basic seed and certified seed by strengthening and/or establishing farmers' seed producer cooperatives or farmer seed producer groups. Some of the farmers who had already been organized into seed producers' cooperatives had established contractual agreement for basic or certified seed production and marketing with public seed enterprises. This contractual arrangement not only accelerated seed production but also opened market opportunities to seed producer cooperatives for improving sustainability and livelihood security.

## Farmer-based seed production and scaling

Seed production through farmer cooperatives or farmer groups through small seed pack distribution were a priority intervention of the project. This intervention aimed at improving access to improved seed to smallholder farmers in the project study locations. Moreover, malt barley seed production long neglected by PSEs, and smallholder resource poor farmers observed that certified seed produced by PSEs are not only expensive but are also not easily accessible and are delivered late for timely planting by farmers. Alternatively, decentralization through community-based seed production scheme avails seed at a lower cost and is easily available and accessible to smallholder farmers, which encourages farmers adopt and use the technology. Since the seed is produced in their community, smallholder farmers have a chance to see the field performance of the improved varieties being produced and develop confidence to use them.



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Therefore, since 2015, the project worked diligently to establish sustainable farmer-based seed production in the project study locations. This effort enabled the project work with 22 licensed farmers' seed producer and marketing cooperatives, one licensed farmer's multi-purpose cooperative and eight non-licensed seed producers' cooperatives or farmers' groups with 4,153 member farmers (13.8% females). Six seed cooperatives/multipurpose unions also participated for enhancing seed production and marketing. Each union comprised of 23-43 multi-purpose and/or seed producer cooperatives.

Some of these cooperatives and farmers' groups have been linked not only to unions, but also in some cases to PSEs, and malt factories. For example, eight cooperatives in North Shewa Zone of Amhara Region working with Debre Birhan Agricultural Research Center have made linkage with Wodera Multipurpose Union and Tegulet Seed Producers Union. Ten seed producer cooperatives in Arsi working with Kulumsa Agricultural Research Center had no seed-marketing problem as there had been seed demand from various research centers, NGOs (e.g. Self Help Africa), contract seed production with the Ethiopian Seed Enterprise, and Asella Malt Factory. However, efforts for better linkage arrangements with seed cooperative unions should continue by responsible parties for future sustainability. One of these efforts could be establishing public-private-partnership comprising the research system, federal ministry of agriculture and regional agricultural extension bureaus, seed enterprises, seed and other inputs quality control and certification agencies, federal and regional agricultural transformation agencies, cooperatives and unions organization agencies, trade and industry bureau, credit and saving institutes, and malt factories and breweries.

These organized and other individual farmers were provided with small seed packs for community and cooperative based seed production and scaling up/out activities. The small seed pack distributed handled in two ways: First, all farmers who receive the seed take the full responsibility to produce and market the seed directly through formal and informal sectors based on demand from users. Second, farmers pay back the amount of seed provided to them in kind as revolving seed fund which can be used to produce quality seed for local distribution by district Office of Agriculture. The latter exercise termed as 'scaling' as it aimed at reaching more farmers with the new technology. Farmers were supervised by district Offices of Agriculture and ARCs and linked to regional seed certification laboratories to produce and market quality seed of new malt barley varieties.

The cooperatives can market the seed formally or informally within or beyond their villages through direct sales, exchange with other farmers or use for their own production. Farmer seed producers were linked to projects and formal sector institutions working in their area. For example, PSEs, Seed Business Network, Wollo University, Self Help Africa, ILRI-Africa RISING, ATA, Gonder Malt Factory, Dashen Brewery and Raya Brewery purchased malt barley seed from project partner seed producer cooperatives and farmers in South Wollo and North Shewa Zones in Amhara; Arsi Zone in Oromia; and South Tigray Zone of Tigray.

From the new seed provided every year since 2015 in the form of small packs for distribution, the amount paid back in kind as a revolving fund scheme to district Offices of Agriculture. Then the Office could distribute it to other farmers to reach a greater number of farmers enhancing the dissemination of seed of improved varieties and accompanying technologies and continue to expand in the form of concentric circle in each community and district.

In total 381.11 t of malt barley seed for production of basic, certified and QDS was provided to farmers during 2015-2018 (covering 3,262.9 ha of land) of, which revolving seed comprised 33.02%. The basic seed produced on-farm was 548.27 t from 265.0 ha with the participation of 596 farmers (11.4% female) where the seed was used for further multiplication of certified seed. The number of farmers participated in certified and/or 'quality' seed production through small pack was 7,738 (11.6% female farmers) who planted 2,998 ha and produced 7,642.56 t.

The average productivity of 2.55 t $ha^{-1}$ for seed production was substantial. This level of productivity by smallholder farmers who have been facing many environmental and socio-economic constraints is very promising compared to national average barley productivity of 1.97 t $ha^{-1}$ in 2014/15 meher cropping season (CSA, 2015), which reached 2.16 t $ha^{-1}$ in 2017/18 (CSA, 2018) and the achievable potential yield of 3-6 t $ha^{-1}$ of different malt barley varieties under the optimum management and environmental condition of the research system of Ethiopia. Soil acidity and waterlogging, soil degradation through erosion, frost, and low input use by subsistent smallholder farmers due to high price of inputs are among the major factors contributing to low productivity. Similarly, these yield reducing factors have also been reported to have major impacts on productivity and production of food and industrial crops in Ethiopia (ATA, 2017; Chanie et al., 2018; Merga and Ahmed, 2019; Mellor and Dorosh, 2010; Molla, 2020; Rao and Suryanarayana, 2015; Sime and Aune, 2018).

In addition to seed production through small pack seed distribution from the project, farmer-to-farmer seed exchange and farmers linked to projects and formal sector institutions enhanced seed production and technology scaling up to reach a greater number of farmers. Although not fully tracked, these approaches deployed 1391.3 t of seed for planting on 12,194.5 ha of land by an estimated number of 51,317 direct beneficiary farmers, potentially producing 30,486.3 t of malt barley, which can be partly used as seed. The performance of farmer-based malt barley seed production proved to be feasible approach to improve timely access, low cost deployment of technologies and scaling (see Abiro et al. in Chapter 3). However, the main limiting factor in malt barley seed supply and expansion of malt barley production was the competition from malt factories and supermarkets, which collected the seed produced for use as grain ahead of time.





## Strengthening Capacity of Human Resources and Facilities

Strengthening the capacity of partners and stakeholders in terms of human resources and provision of critical facilities was part of the project activities.

### Human resources

Community seed production, marketing and enterprise development and management are less known among smallholder farmers and development practitioners in project study locations. Training activities covered broader topics and included introducing available improved malt barley technologies (improved varieties and integrated crop management); seed technology (production, processing, storage, marketing, quality assurance, sustainability and management of farmer-based seed enterprises), pesticide use and management, i.e., safe use, disposal, personal protective equipment; and importance of bio-fertilizer and use.

**Technical staff:** To bridge this gap, training of the trainer's (ToT) courses was organized for researchers and subject matter specialists who in turn provided hands-on practical training for farmers and development agents in 2015-2018. Most of the participants in the short-term ToT courses were primarily researchers from the 12 project partnering research centers, and district and zonal agricultural extension experts. Ten courses were organized (six by ICARDA and four by partner research centers) and trained 386 participants (10.1% female). In addition, 2,122 staff of stakeholders (18.1% female), which included development agents, extension experts, and junior researchers were trained by the ToT trainers.

**Farmers:** Biru et al. (2020) reported that poor crop management is the most important yield limiting factor of improved varieties across agro-ecologies in Ethiopia. Crop pests (weeds, diseases, and insects) not only reduce yield but also reduce seed quality in the field and in the storage if not adequately controlled by farmers. The trainers from the 12 partner ARCs and the extension staff trained 11,750 farmers (15.3% female). This very high success was achieved because district and kebele agricultural extension staff had also organized training activities to promote the dissemination of improved malt barley technologies. Farmer training activities provided during September and October were mainly practical oriented as the crops were in the field.

### Provision of critical facilities

Many partner cooperatives still lack basic facilities required to produce quality seed that meet standards acceptable by seed certification agencies in Ethiopia. One of these facilities is access to threshers by which farmers would make timely threshing to escape the erratic rainfall, which usually comes in February to March and cause spoiling seed quality of harvested crops in the field. In addition to training, provision of critical physical facilities was critical to ensure success and sustainability of the project. After identifying critical gaps of facilities required for NARS and seed producer cooperatives, a strong effort was made to provide support by the project. Physical facilities provided to project partners include two double cabin pickup cars for two agricultural research centers from NARS; three water pumps for supporting irrigated seed production for two agricultural research centers; 35 multipurpose mobile threshers- 10 for ARCs and 25 for seed producer cooperatives; 30 bag sealers-13 for ARCs and 17 for seed producer cooperatives.

Due to the lack of mechanization, production of food and industrial crops in developing countries like Ethiopia is highly labor intensive in smallholder agriculture (Houmy et al., 2013). The manual work carried out by farmers and their families is very arduous, time consuming, and is a major constraint to increasing agricultural production in Ethiopia. In addition, the day-to-day drudgery of farming is a major contributory factor in the migration of people, particularly young people, from the rural countryside to the prospect of a better life in towns and cities. In Ethiopia, agriculture is the activity of smallholder farmers largely practiced by draught animal power and human labor.

## Land suitability mapping

Apart from demonstrations, mapping of land suitability for malt barley production in Ethiopia was carried out for further scaling of the technology in a cost and time efficient manner in the country. Crop level suitability mapping showed that there is about 1.9 million ha of highly suitable land area for malt barley production in the country (Nigussie et al., 2019). Thus, suitability maps for six malt barley varieties were developed to identify potential areas for further scaling up/out of improved technologies in non-project target areas. The main factors considered in land suitability analysis include climate layers (rainfall and temperature during the growing period and length of growing period-LGP), topography (altitude and slope), soil types and soil properties (pH, depth, texture, and drainage). Even though there are still limitations in availability of detailed data, these suitability maps could serve as a guide for prioritizing varieties for more efficient targeting of technology introduction and dissemination. Detailed results and discussions had already been published (Nigussie et al., 2019) and, therefore, only summary result (Table 4) and sample map (Figure 4) for one variety (IBON 174/03) are presented. Table 4 shows that malt barley varieties IBON 174/03 and Grace have larger areas, which are highly suitable compared to other varieties. IBON 174/03 has shown its broader adaptation and has the potential to expand the frontiers of malt barley production across the country. The variety is very popular with farmers due its high grain yield, early maturity, and comparable straw yield, which is an important feed source in the mixed crop-livestock farming system of the country. Moreover, its malting quality is also acceptable by the malt quality standards of Ethiopia (ESA, 2001).





*Table 4. Land area (ha) under different suitability class for malt barley production in Ethiopia*

| Variety | S1 (85-100%) | S2 (60-85%) | S3 (40-60%) | N (0-25%) | Key traits |
|---|---|---|---|---|---|
| Bekoji-1 | 125,332 | 4,342,044 | 163,244 | 108,387,600 | Bekoji-1, EH1847 & Holker are tall and late maturing varieties with the respective seed sizes of 46.6, 46 & 41.1 g per1000 seeds; they are resistant or tolerant to scald with the respective grain yield of 3.5-5.0, 3.5-4.4 & 2.4-3.1 t ha$^{-1}$. Bekoji-1 is also resistant to net blotch |
| EH1847 | 124,004 | 4,330,932 | 174,260 | 108,389,024 | |
| Holker | 125,356 | 4,342,756 | 162,508 | 108,387,600 | |
| Grace | 775,312 | 20,648,764 | 303,272 | 91,290,872 | Grace, IBON 174/03 & Sabini are short to medium height early maturing varieties with the respective grain yield of 2.0-4.5, 3.0-5.7 & 2.5-4.9 t ha$^{-1}$ with the respective seed size of 42, 46.5 & 45.0 g per1000 seeds. Grace & Sabini are susceptible to scald while IBON 174/03 is resistant/tolerant. Grace is resistant to net blotch. |
| IBON 174/03 | 1,677,388 | 11,588,156 | 32,792 | 99,719,884 | |
| Sabini | 307,952 | 16,358,348 | 189,948 | 96,161,972 | |

*Note: Potential productivity of S1 (highly suitable, 85-100%), S2 (moderately suitable, 60- 85%), S3 (marginally suitable, 40-60%) and N (not suitable, 0-40%), of the optimum yield under the recommended management (Elsheikh & Abdalla, 2016).*

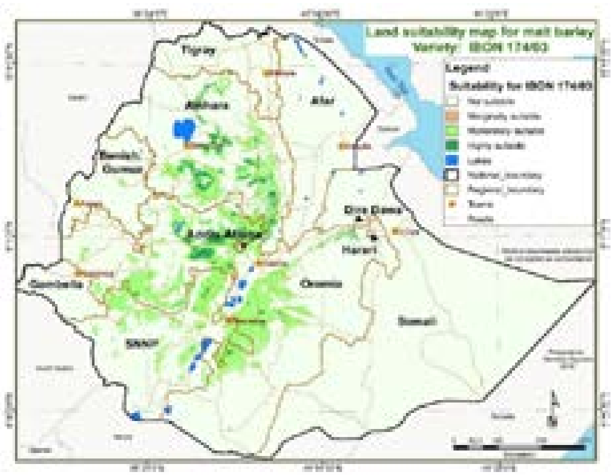


*Figure 4. Land suitability map for malt barley variety IBON 174/03*

## Project Impacts

At the start of the project in 2015, detailed characterization of the actual and potential market performances of malt barley producers and consumers was conducted in order to hinge the entire effort on realism and in order to make sure that producers actually meet the requirements of the existing and/or new markets. The baseline survey conducted on malt barley value chain (producer node) in Amhara, Oromia, SNNP, and Tigray Regions generated a comprehensive data set. This data set was used to establish benchmarks and measure the impact of the project on adoption, food and nutritional security. The baseline data based on the information generated from a survey of 2,160 farm households within 36 kebeles of 9 purposively selected districts indicated that:

- Low adoption of malt barley improved varieties and low level of input use (e.g. fertilizers) observed among producer farmers;
- Malt barley was found not being grown so widely: only 7.49% of the sample households reported to have grown malt barley in 2014/15, almost all improved;
- Farmers were found to be the main sources of seed of improved varieties;
- Farmers in Amhara region traveled long distances to access certified seed, fertilizers and herbicides compared to those in other regions;
- Seed grower's associations were not common in the study locations where very few farmers (3.6%) were already members of such associations while 41.3% and 40.7% of sample households were members of multi-purpose cooperatives, and saving and credit associations, respectively;
- Land allocated to malt barley during 2014/15 cropping season in study locations as determined by observations on 1,921 sample households was on average 0.08 ha;
- Malt barley productivity in project study locations ranged from 1.5 to 1.8 t $ha^{-1}$ in most study locations but reached 3.2 t $ha^{-1}$ at Endamehoni district in South Tigray; and
- Computed gross margin without considering non-commercial inputs such as labor, and taking into consideration costs of fertilizers, pesticides, and seed purchased indicate that malt barley producing households earn about Birr 20,175 per year.

Preliminary data analysis on impact assessment survey was conducted in May-June 2018 on 1,958 observations. Two types of econometric models were used to estimate the impact of adoption of improved malt barley on income and food security. The models employed were simple difference-in-difference and kernel propensity score matching difference-in-differences. These different models were used to estimate the impact and check whether the results are robust. The estimations show that these two models resulted in comparable treatment effects. The income was measured by summing up all agricultural income generated by the household over 12 months. The food security was based on declared food shortage at least once in the last 12 months.

The preliminary impact assessment results indicated that the adoption of improved malt barley varieties was found to have no effect on the annual income per capita of the sample households (Table 5). Adoption of improved malt barley varieties improved





food security of the sample households. Given the fact that the farm households are essentially subsistence oriented, it is not surprising that the impact on food security is positive and significant. To make this preliminary result more meaningful in the final analyses, the impact assessment effort in general will be made more comprehensive by considering not only varieties but also by including complementing components of the recommended packages. The impact assessment will also be expanded to include other outcome variables including productivity, gross return from crop production, and poverty.

*Table 5. Impact of adoption of improved malt barley varieties on income and food security*

| Outcome variable | Annual income per capita | | Food security | |
|---|---|---|---|---|
| | Model 1 | Mode 2 | Model 1 | Mode 2 |
| Before intervention | | | | |
| Control | 5.817 | 5.863 | 0.71 | 0.686 |
| Treated | 5.862 | 5.862 | 0.572 | 0.572 |
| Diff (T-C) | 0.045 | -0.001 | -0.137 | -0.114 |
| After intervention | | | | |
| Control | 7.834 | 7.848 | 0.672 | 0.666 |
| Treated | 8.041 | 8.041 | 0.762 | 0.762 |
| Diff (T-C) | 0.207 | 0.193 | 0.09 | 0.096 |
| Diff-in-Diff | 0.162(0.291) | 0.194 (0.318) | 0.227***(0.055) | 0.21***(0.051) |
| N | 1767 | 1767 | 1761 | 1761 |
| R2 | 0.15 | | 0.01 | |

*Note. N = number of observations; Inference: *** p<0.01; ** p<0.05; * p<0.1*

## Success stories

### Building sustainable local seed supply through farmer mobilization and participation

Linkages with district office of agricultural and farmer groups enabled decentralized on-farm quality seed production and certification. This increased the availability, accessibility and use of quality seed of malt barley by farmers in target districts and beyond. However, it needs further support in providing critical facilities for seed production, access to credit services for working capital and strengthening the linkages amongst stakeholders in the value chains to ensure sustainability.

### Scaling up of early maturing and higher yielding varieties

Our seed production and scaling project since 2015 proved that the demand for IBON 174/03 malt barley variety (ICARDA origin) is ever increasing due to its high and stable yield, early maturity and broad adaptation in almost all project sites in the country with the potential to replace the old commercial variety Holker, which is in production for almost over three decades. This national demand of the variety is continuing to increase and needs further support for production of early generation and certified seed for matching the demand by farmers.

### Farmer-to-farmer seed exchange

This is important and much advocated by the project as one of the strategies of technology diffusion among smallholder farmers. Although not fully tracked by partner agricultural research centers and agricultural development agents in each target district, the achievements in the project period show that 30,486.3 t of certified/quality seed for malt barley was produced through farmer-to-farmer seed exchange. This approach enabled farmers have easy access to improved seed in time and affordable price including bartering.

### Functional partnership among research for development partners

The project established functional partnership with district agriculture and administration at local level and key public and private sector stakeholders at federal and regional states during project implementation, which would definitely bring about lasting changes in raising agricultural productivity and production while maintaining environmental sustainability and improving the livelihoods of smallholder farmers.

## Lessons learned and way forward

- Improved malt barley technology demonstrations even under soil acidity and waterlogging limitations showed that productivity could be increased at least up to 100%. If we invest in soil acidity and waterlogging management practices and develop tolerant varieties, productivity would be significantly improved;
- Yield gaps in farmers' fields emanated from partial adoption of technological packages by subsistent smallholder farmers. This has been a serious limitation to improve productivity and production, and commercialization of agriculture in general;
- Access to credit services is required to improve investment capacity of farmers, and aggregation of land for mechanization calls for revisiting the land tenure system;
- Development of niche varieties suitable to diverse agro-ecologies and farming systems are required since breeding for developing resilient variety across variable environments depresses potential productivity. This approach goes with ensuring decentralized farmer-based seed production scheme;
- Decentralized seed production through seed producer cooperatives and farmers groups, and farmer-to-farmer seed exchange scheme ensured availability of, access to and use of seed technologies;
- Policy reforms for recognition of diversity of seed business models (formal, intermediate and informal) and diversity of seed certification schemes (certified seed and QDS) are required especially for ensuring sustainability of seed production for enhancing technology scaling at wider scale;





- Provision of incentives to produce and market seed of malt barley may require forging an effective public-private partnership to ensure commercialization and sustainability of seed supply;
- It is required to create a robust mechanism for seed production planning including decentralization of EGS production and strengthening NARS. NARS lacks the land, which is the very basic need for production of enough breeder seed let alone other resources;
- Improving capacity of stakeholders along the seed value chain including investments in mechanization, financial and human resources are important areas of further interventions.
- Capacity building of smallholder farmers is very critical since landholding size is ever decreasing and fragmented while human population is increasing, which demands knowledge intensive agriculture to enhance efficiency and higher productivity;
- Strengthening capacity of quality control and quarantine services is also important investment to ensure timely seed quality control and certification; and
- The extension system should be reformed to ensure staff retention, continuity and concerted effort of technology scaling as one of priority national agenda of implementation.

## Conclusion

The project aimed at expanding malt barley production to meet the domestic demand of malt factories and breweries, which are largely dependent on imports. The project demonstrated the scaling frameworks and catalyzed the partnership platform to transform malt barely production in Ethiopia. It is expected that research for development partners and stakeholders take this forward.

To ensure the sustainability of the work, the project proposed the public-private partnership for malt barley production in central and northern Ethiopia bringing together bureau of agriculture, agricultural research, seed producers and suppliers, malt factories and breweries, which yet to take off the ground.

Demonstrations of improved malt barley varieties and integrated crop management technologies proved successful in raising productivity and increasing production in target project areas, but the partial adoption of the full package of improved technologies by smallholder farmers remains an outstanding and persistent reason for a significant yield gap in the farmers' fields.

EGS production by NARS and certified seed production by public and private commercial seed suppliers remain a critical challenge that currently limits the adoption of improved malt barley varieties. Strengthening and consolidating decentralized production and planning of EGS with RARIs remains critical to overcome the chronic problem of source seed in the seed sector.

The seed production and scaling-up project created awareness and stimulated adoption of improved malt barley technologies. Farmer-based seed production and marketing facilitated availability and access to malt barley technologies. These efforts need to be strengthened to ensure sustainable malt barley production and marketing.

The effort made in strengthening capacity and linkage among actors in malt barley value chain has been very limited in the face of ever demanding seed supply continuum and malt barley marketing and commercialization, which need bulk production and aggregation. This needs further effort for strengthening capacity, linkage among actors, bulk production and aggregation, and marketing of malt barley.

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# Survey of Barley and Faba bean Production in North Shewa Zone of Amhara Region

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## Introduction

Barley and faba bean are compatible crops grown by smallholder farmers in the highlands of central Ethiopia. They are the major crops grown in rotation by the farmers for both home consumption and household income. Ethiopian farmers preferred to produce faba bean because of its low labor and external input requirements compared to cereals, and its advantage of enhancing soil fertility and health to the succeeding cereal crops as a rotation crop (Asfaw et al., 1994). According to Central Statistics Agency (CSA) of Ethiopia, during 2009-2014 production years the share of faba bean was 31% in area coverage and 33% in volume of production from the pulse crops grown by smallholder farmers in the country.

Barley (*Hordeum vulgare* L) is a versatile crop used for human food, malt and livestock feed. It could adapt to multiple biotic and abiotic stresses and relatively tolerant to drought. According to (Berhane et al., 1997), the most important barley growing areas are Shewa and Arsi mainly central highlands of Ethiopia. Barley grain is produced primarily for household consumption whereas the straw is sued for livestock feed.

In the study locations, barley is currently grown primarily under rainfed agriculture in both short (belg season) and long (meher season) rainy seasons because it is an early maturing and food security crop in the central highlands of Ethiopia. Malt barley was insignificant in terms of area coverage and production in Ethiopia, has been expanding since recent years although its supply is very much lagging the demand of malt factories and breweries in the country.

Although barley and faba bean are major crops being produced by smallholder farmers in the highlands of North Shewa of Amhara Region in the central highlands of Ethiopia, there is no detailed baseline data available to compare and measure any changes that has happened in improved technological interventions. Therefore, this study was conducted to assess the state of production and productivity of barley and faba bean as a reference for future interventions. Moreover, the study was aimed at evaluating farmers' access to different agricultural services, and to assess the critical role of barley and faba bean as drivers for economic growth and food availability in the Study locations.

## Methodology

### Study locations

The study was conducted in 2014-2015 at Bassona-Worena and Tarmaber districts of North Shewa Zone of Amhara Region. The altitude of the study locations in the two districts ranges from 2800 to 3100 m and receives average annual rainfall of 929 mm with the annual average minimum and maximum temperatures of 9.0 and 21.4 $^{o}$C, respectively.



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### Sampling, data collection and analysis

The districts were selected purposely based on secondary data whereas kebeles and representative producer households were selected randomly based on probability proportional to sample size. Twelve kebeles, six kebeles per district, was selected from barley and faba bean growing areas. Following the selection of kebeles, 550 rural households were selected in simple random selection techniques and interviewed.

Data were collected using different approaches. Primary data were collected from sample households using structured and semi structured questionnaires with the help of Computer Assisted Personal Input (CAPI) electronic devices. Secondary data were collected from published and unpublished data sources such as CSA and Office of agriculture reports, and different literatures.

Data were analyzed using descriptive statistics such as mean, percentages, standard error and frequency to evaluate the farm household characteristics and the production status of barley and faba bean.

## Results and Discussion

### Household characteristics

The most common household characteristics important for agricultural activities identified in this study include sex, age, family size, adult equivalent, level of education, farming experience and access to extension service. The results showed that the proportion of female-headed households constituted about 20% of the total sample households and the balance was their counter parts. Relatively more proportion of women headed households found in Tarmaber than Bassona Worana areas (Table 1).

*Table 1. Sex category of the respondent household heads*

| District | Sex distribution of the household head | | | | | |
|---|---|---|---|---|---|---|
| | Female | | Male | | Total | |
| | Frequency | % | Frequency | % | Frequency | % |
| Bassona Worana | 59 | 19.6 | 241 | 80.4 | 300 | 100 |
| Tarmaber | 51 | 20.4 | 199 | 79.6 | 250 | 100 |
| Total | 110 | 20.0 | 440 | 80.0 | 550 | 100 |

Age is the household characteristics important to describe households and can provide age structure of the sample and the population. Age of the household head can determine agricultural production activities as age composition of a family members, family size and adult equivalent in the agrarian family. The mean age of the household head was 43.9 years ranged from 18 to 86 years. The average year of faba bean and barley production experience in the main season was 19.5 years with low years of experience in the irrigated production system. The average family size and adult equivalent ratio of the households were estimated at 5.24 and 4.39, respectively (Table 2). Adult equivalent is a magnitude of individuals in the household in, which each person's expenditure and labor contribution is determined regardless of age, physical size, sex or functionality. It is a unit of analysis designed by Ebert in 1997and adopted for expenditures and family labor attributable to individuals of different characteristics and converts those expenditures into equivalent expenditures (Creedy et al., 2005).

*Table 2. Socioeconomic characteristics of respondent farm household heads*

| Variable | Number of respondents | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Age of the household head (years) | 550 | 43.9 | 12.3 | 18 | 86 |
| Family size (number) | 550 | 5.24 | 2.1 | 1 | 14 |
| Adult equivalent ratio (number) | 550 | 4.39 | 1.3 | 1 | 10.2 |
| Farming experience in main season (years) | 550 | 19.5 | 12.6 | 0 | 60 |
| Farming experience in belg season (years) | 550 | 11.5 | 13.3 | 0 | 60 |
| Farming experience with irrigation (years) | 550 | 3.3 | 8.3 | 0 | 46 |
| Literacy rate | 550 | 3.15 | 3.4 | 0 | 17 |

Note: SD = standard deviation; Min = minimum; Max = maximum

## Social capital, network linkages and their roles in critical support

Different social groups established in the study locations and farmers participated in membership and leadership positions (Table 3). Higher proportion (71%) of the respondents' participated in membership of farmers' multipurpose cooperatives for the purpose of getting agricultural inputs and consumable household commodities. In addition, the cooperatives also provide market access for their agricultural produces. Other social institutions include women associations, seed producer and marketing cooperatives, saving and credit cooperatives, and water users associations. All the social institutes have their own role for the improvement of agricultural activities.

*Table 3. Social institutions and membership of respondent farm household heads in study locations*

| Membership in social institutions | Participation | | Continue membership | |
|---|---|---|---|---|
| | Number of respondents | % | Number of respondents | % |
| Multipurpose cooperatives | 393 | 71.45 | 390 | 99.23 |
| Seed producer cooperatives | 41 | 7.45 | 41 | 100.00 |
| Women associations | 217 | 39.45 | 215 | 99.08 |
| Saving and credit cooperatives | 255 | 46.36 | 248 | 97.25 |
| Water user associations | 78 | 14.18 | 77 | 98.72 |



CHAPTER I: Overview of achievements and baseline survey

## On-farm and off-farm activities

Almost all (99%) of the respondents and their family members were involved in farming practices and a quarter of them were involved in off-farm activities for additional income generation (Table 4).

*Table 4. On-farm and off–farm activity involvements of respondent farm household heads*

| Farmers involvement | Participant | |
|---|---|---|
| | Frequency | % |
| Involvement in on-farm activity | 544 | 98.91 |
| Engagement in off-farm activity | 144 | 26.18 |

## Landholdings and land use

The average number of plots operated by the farmers was about 5 with the average land holding of 1.3 ha. Farmers allocated their farmlands for different agricultural purposes such as crop production, pasture for livestock, forest products and others. The highest proportion of farmland (78%) is primarily allocated for crop production. An average of 4.1 plots from 5.24 plots is used for crop production, which means about 1.05 ha from 1.34 ha of land owned by the smallholder farmers (Table 5).

*Table 5. Land holding and land use systems of respondent farm household heads*

| Land use type | Land allocation (ha) | | | |
|---|---|---|---|---|
| | Mean | SD | Minimum | Maximum |
| Crop production | 1.05 | 0.26 | 0.26 | 0.25 |
| Feed and forage | 0.25 | 0.17 | 0.17 | 0.25 |
| Forest land | 0.25 | 0.12 | 0.12 | 0.25 |
| Homestead | 0.25 | 0 | 0 | 0.25 |
| Others | 0.4 | 0.3 | 0.3 | 0.25 |
| Average number of plots | 5.26 | 2.55 | 2.55 | 1 |
| Average land holding | 1.34 | 0.74 | 0.74 | 0.25 |

## Farming practices

The study indicated that there was low level of improved practices being implemented, which resulted in low productivity during the study time. Most farmers did not practice modern agricultural practices like proper crop rotation system, proper weed management practices, use of improved seed, and application of seed cleaning and use of appropriate seed rate; only few of them implemented by small number of farmers (Table 6). Few farmers applied recommended seed rates of barley and faba bean of 125 and 200 kg $ha^{-1}$, respectively for broadcasting. Most farmers used broadcast seed rate of 175 kg $ha^{-1}$ for barley, and 250 kg $ha^{-1}$ for faba bean.

*Table 6. Application of barley and faba bean production technologies by the respondent 550 farm household heads*

| Improved technology | Number of respondents | % |
|---|---|---|
| Row planting | 54 | 9.82 |
| Proper weed management | 104 | 18.91 |
| Use of improved varieties | 23 | 4.18 |
| Recommended seed rate | 39 | 7.09 |
| Soil fertility conservation | 37 | 6.73 |
| Drainage of excess water | 52 | 9.45 |
| Seed cleaning | 6 | 1.09 |
| Seed treatment | 3 | 0.55 |

Food barley had large share of area coverage and production than others crops because it is high priority crop for human food (grain) and livestock feed (straw). The average area of production covered by the target crops per household was 0.44, 0.18 and 0.03 ha for food barley, faba bean and malt barley, respectively (Table 7).

*Table 7. Average area coverage (ha) of target crops per household in study locations*

| Crop | Mean | Minimum | Maximum |
|---|---|---|---|
| Food barley | 0.44 | 0.063 | 1.53 |
| Faba bean | 0.18 | 0.01 | 1.93 |
| Malt barley | 0.03 | 0.01 | 0.13 |
| Other crops | 0.39 | 0.17 | 1.48 |

Faba bean, food barley and malt barley had a large share (63%) of farmlands compared to other crops. Among these, food barley had larger share (67%) of production coverage compared to faba bean (28%) and malt barley (5%). During the study period, the share of malt barley area was the lowest since it was a newly introduced crop to the area, and it needs special crop management skills to maintain malt quality requirements.





## Applying improved technologies

Farmers used different agricultural inputs for the improvement of crop production and productivity. In general, less numbers of farmers applied farm inputs for production of crops indicated in Table 8. Number of farmers producing malt barley was the least but the use of mineral and natural fertilizers, and herbicides of these farmers was comparable to that of food barley. Faba bean producer farmers were the least in using mineral fertilizers and herbicides.

*Table 8. Application of improved technologies for production of target and other crops*

| Input | Crops grown | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Malt barley | | Food barley | | Faba bean | | Other crops | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| Urea | 12 | 37.5 | 215 | 40 | 9 | 2 | 253 | 48 |
| DAP | 14 | 43.7 | 238 | 44 | 15 | 3 | 230 | 44 |
| Compost | 10 | 31.2 | 218 | 42 | 178 | 35 | 89 | 18 |
| Herbicide | 10 | 31.2 | 219 | 41 | 4 | 1 | 218 | 42 |

## Adopting improved varieties

Among the respondent farmers, about 34% adopted and produce improved food barley but only 6% of farmers adopt and produce malt barley crops and 30% of the farmers adopted improved faba bean varieties (Table 9) during the previous five years. There are no local malt barley varieties, hence 6% of respondent farmers producing malt barley is meant that they have adopted improved malt barley since 2010.

*Table 9. Adoption of improved varieties*

| Crop | Response | Frequency | % |
|---|---|---|---|
| Food barley | Yes | 185 | 33.6 |
| | No | 365 | 66.4 |
| Malt barley | Producers | 32 | 5.8 |
| | Non-producers* | 516 | 93.8 |
| Faba bean | Yes | 164 | 29.8 |
| | No | 386 | 70.2 |

*Note: About 516 farmers were not growing malt barley*

# Varieties under production

## Food barley

The major challenges of food barley production in the study locations include low productivity, diseases, frost and lack of early maturing varieties. Farmers preferred high yielding varieties for high potential areas and early maturing varieties for frost prone areas. Improved food barley variety HB-1307 was more popular for its high yield in high potential areas than other introduced improved varieties and is widely grown by farmers. Food barley varieties such as Agegnehu, Basso, Meserach, and Mulu are being produced in low proportions and are targeted to less fertile areas due to their lodging susceptibility on fertile soils. These food barley varieties also had lower preference than the local varieties, but farmers produce them for early maturity to escape frost prone cold areas. Food barley varieties under production and their prioritization by farmers are presented in Table 10.

*Table 10. Food barley varieties under production priority for yield*

| Variety | Year released | First priority | | Second priority | |
|---|---|---|---|---|---|
| | | Frequency | % | Frequency | % |
| Agegnehu | 2007 | 22 | 6 | 3 | 1.3 |
| HB-1307 | 2006 | 160 | 45 | 9 | 3.9 |
| Basso | 2004 | 10 | 3 | 5 | 2.2 |
| Meserach | 1998 | 2 | 1.5 | 1 | 0.4 |
| Mulu | 2004 | 1 | 0.5 | – | – |
| Local | - | 154 | 44 | 212 | 92.2 |
| Total | | 349 | 100 | 230 | 100 |

*Note: – = data not available*

Food barley improved varieties had higher area coverage than the local varieties. Farmers allocated more farmland for the improved varieties particularly for variety HB-1307 than local ones. In the study locations, most farmers (Figure 1) produce introduced improved varieties.

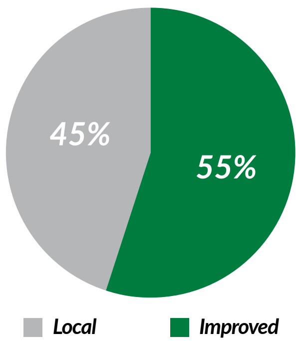


*Figure 1. Area coverage of improved and local food barley varieties*





According to farmers' rating, the local cultivars had high preference for their disease tolerance than the improved ones (Figure 2), the major diseases identified in the study locations are scald and net blotch.

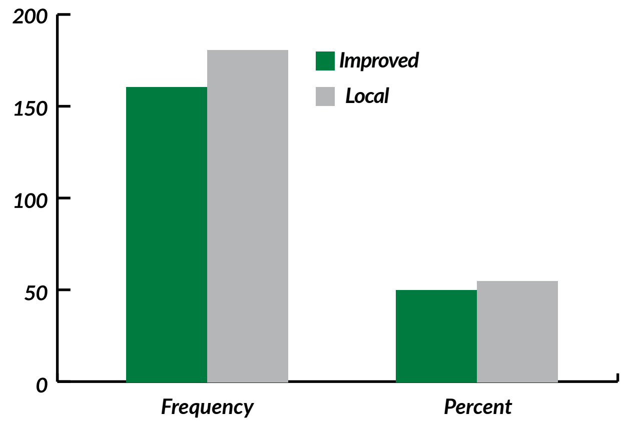


*Figure 2. Farmers' preference of food barley varieties based on disease tolerance*

## Faba bean

The faba bean varieties under production in the study locations include Walki and Gabelcho. Walki variety was selected by the producers for its higher yield compared with others under production (Table 11).

*Table 11. Farmers' preference to faba bean varieties based on productivity and disease tolerance*

| Variety | Year released | First priority | | Second priority | |
|---|---|---|---|---|---|
| | | Frequency | % | Frequency | % |
| Walki | 2008 | 215 | 76.7 | 12 | 7.3 |
| Gabelcho | 2006 | 1 | 0.3 | 1 | 0.6 |
| Local | | 65 | 23 | 150 | 91.5 |
| Total | | 280 | 100 | 164 | 100 |

## Malt barley

The malt barley varieties introduced in the study locations and continuously produced by the farmers include Holker, Bekoji-1, and Miscal 21 in the order of frequency and percentage from the highest to the lowest share. Farmers got access to malt barley varieties from 2013; and currently only 6% of farmers produce malt barley. Holker was relatively popular and produced by more farmers than others due to access to seed, high market demand and high adaptability to the areas (Figure 3). Holker variety continued under production in the country for about 40 years particularly in commercial farms though malt barley is a recent crop for the study locations.

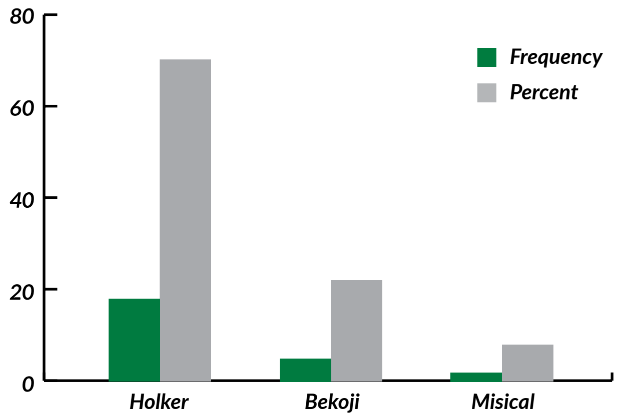


*Figure 3. Malt barley varieties under production in the study locations*

## Production and productivity

The average yield obtained per households from the target crops was also high for food barley compared with other crops in the study locations. This relatively high production of food barley was the result of better technology adoption of improved varieties and relative use of inputs such as fertilizers and agro chemicals to protect the crop from weeds and diseases (Table 12). Based on this study, food barley and faba bean were by far higher yielding than malt barley (Table 12). Lower yields of malt barley were due to low level of input uses such as low fertilizer application rates and poor weed management practices since the crop is new to the area. For food barley and faba bean, which have been traditional major crops, farmers apply compost and other household waste such as farmyard manures for improvement of productivity and production.

*Table 12. Grain yield and productivity of crops produced per household*

| Crop | Production (kg) per household | | | Productivity (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Mean | Min | Max | Mean | Min | Max |
| Malt barley | 80.9 | 10 | 1000 | 821 | 453 | 1800 |
| Food barley | 784.2 | 123 | 5200 | 1857 | 817 | 5078 |
| Faba bean | 347.9 | 165 | 3500 | 3421 | 1240 | 6041 |
| Others | 643.7 | 237 | 4200 | 1648 | 948 | 2837 |

Note: Min = minimum; Max = maximum





## Product distribution and utilization

The producers allocated their food barley and faba bean produce for different purposes according to their home needs. The average produce of food barley and faba bean in 2014/15 production year by producers was allocated primarily for consumption, selling, carryover for next production risks and donations to others (Table 13).

*Table 13. Food barley and faba bean production and utilization in the farm households*

| | Food barley (kg) | | Faba bean (kg) | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| Current grain harvest | 784.2 | 69.8 | 511.56 | 375.76 |
| Grain sold | 127.25 | 25.67 | 262.76 | 289.49 |
| Grain used for in kind loan repayment | 133.1 | 12.88 | 55.00 | 27.39 |
| Grain given for donation or gift for others | 27.6 | 5.34 | 44.94 | 38.25 |
| Grain in stock when harvesting | 149 | 23.87 | 180.26 | 166.33 |

# Conclusions and Recommendations

Our survey results indicated barley and faba bean have been produced by the farmers for the primary use of home consumption and income generation to fulfill the household needs. Food barley and faba bean had larger share of area coverage and volume of production. The crops are important for the farmers' food security and adaptive to the environment. Barley was produced in short rainy seasons (belg) in Tarmaber district; small proportion of faba bean was also produced in short rainy season with the supplementary irrigation while larger proportion is mainly grown in main rainy season. Malt barley is produced only in the main rainy season in all study locations.

Farmers use improved technologies such as improved seeds and fertilizers. The sub-optimal application rates of improved technologies are the main causes of low crop productivity. Farmers used poor quality seed, which also contributed to low productivity. Soil types, which are prone to waterlogging in heavy rainfall conditions also contributed to low response to applied improved technologies and depressed crop growth with the combined effect of complete crop failure or very low yield. Abiotic stresses like frost and desiccating winds usually starting in late September also reduced productivity.

Therefore, improving the seed supply system and optimum input use may significantly improve productivity and production. Awareness creation to farmers to improve the proper applications of seed rates, fertilizer rates and use of agrochemicals will reduce the productivity gaps. Farmers should practice seed cleaning for the management of weeds and diseases. Providing proper drainage system for high rainfall and waterlogging soils or avoiding such waterlogging soils will improve productivity of crops especially malt barley, which is relatively more sensitive to waterlogging. Development of early maturing varieties to escape frost and desiccating wind damages and developing disease resistant varieties may also significantly improve productivity and production.

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# CHAPTER II

## MALT BARLEY TECHNOLOGY VALIDATION AND DEMONSTRATION

## *Participatory Malt Barley Variety Selection in Northwestern Ethiopia*

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# Introduction

Malt barley is becoming the source of income for smallholder farmers in the highlands of Ethiopia particularly where the agroecology is less productive for other cereal crops. In Ethiopia barley productivity stands at 2.11 t ha$^{-1}$ (CSA, 2016), which is low due to the combination of bio-physical and socio-economic constraints and inappropriate use of integrated crop technologies (Mulatu et al., 2011) compared to other barley producing countries elsewhere where yields are reaching over 7 t ha$^{-1}$ (FAOSTAT, 2016). The responses of varieties in terms of agronomic and phenological traits are influenced by the genotype, environment, management and their interaction (Misganaw 2017; Fentaw et al., 2015; Arega et al., 2013; Haile et al., 2013; Leta et al., 2013; Girma et al., 2012; Efrem et al., 2002). Although advances in performance of new malt barley varieties has been reported by the national agricultural research systems their timely adaptation trials, promotion and diffusion to smallholder farmers is limited in western Amhara Region. Most farmers widely and commonly grow older malt barley variety Holker, released in 1979.

Participation of farmers in variety evaluation has also been very limited, which negatively affected adaptability, acceptance, and diffusion of improved technologies (Chiara et al., 2017; Assefa et al., 2006). Farmers' participation in variety evaluation is relevant to alleviate their concerns on the technologies and to select well adapted and preferred (demand-led) varieties and to create awareness, skills and knowledge of diversities in the breeding program (Ceccarelli, 2012) and to reduce time and resources wasted for technology diffusion (Bellon and Reeves, 2002). Therefore, this study was initiated to assess the recently released malt barley varieties through participatory variety evaluation with the objectives of selecting and promoting high grain yielding varieties and creating awareness and promotion of technology to the end users.

# Materials and Methods

## Study locations

The study was conducted in Debaytilatgn district (East Gojam Zone), Farta and Lay Gaynt districts (South Gonder Zone) and Guagusa Shikudad district (Awi zone), which





represent major barley growing areas of western Amhara Region. Lay Gaynt is located between 11°32' and 12°16'N latitude and between 38°12' and 38°19'E longitude with an altitude range from 1500 to 4235 m. Farta district was located at 11°51'N latitude and 38°1'E longitude with elevation of 2,706 m asl. Guagusa Shikudad district is located between 11°91' and 11°92'N latitude and 38°61' and 38°87'E longitude with an altitude ranging from 2562 to 2718 m asl. Debaytilatgn district is located between 10°45'N and 37°50'E. The agro-ecological data of the experimental sites are presented in Table 1.

*Table 1. Agro-ecological data of the experimental environments in 2017 cropping season*

| District | Environment | Altitude (masl) | Soil type | Rainfall (mm) | Temperature (ºC) | | Humidity |
|---|---|---|---|---|---|---|---|
| | | | | | max | min | |
| Lay Gaynt | E1 | 3002 | Brown | 1106 | 18.5 | 9.4 | 75.8 |
| Lay Gaynt | E2 | 2950 | Yellowish brown | 1106 | 18.5 | 9.4 | 75.8 |
| Farta | E3 | 2883 | Light brown | 779 | 21.8 | 11 | 69.7 |
| Farta | E4 | 2650 | Light brown | 779 | 21.8 | 11 | 69.7 |
| Debaytilatgn | E5 | 2862 | Brown | 1082 | 21.1 | 6.2 | - |
| Debaytilatgn | E6 | 2660 | Light brown | 1082 | 21.1 | 6.2 | - |
| Guagusa Shikudad | E7 | 2413 | Light red | - | - | - | - |

*Source: Bahir Dar Branch of Ethiopia Meteorology Agency for climate data*

## Experimental materials and management

Twelve malt barley varieties were used as experimental treatments (Table 2). The treatments were laid out in randomized complete block design with three replications. Varieties were row planted with inter-row spacing of 20 cm. The gross and net harvestable plot area were 3 m$^2$ and 2 m$^2$, respectively. The trial was planted during end of May to second week of June at the seed rate of 100 kg ha$^{-1}$. Fertilizers applied at the rates of NPS 100 kg ha$^{-1}$ for all environments and urea 100 kg ha$^{-1}$ for Debaytilatgn, and 150 kg ha$^{-1}$ for Guagusa Shikudad, Farta and Lay Gaynt. All NPS and one third of urea was applied at planting whereas the remaining two third of urea was applied at tillering stage. Weeding was done two times at tillering and booting growth stages across environments.

Kebele agricultural experts regardless of their age, sex, and religion and education level per district selected participant Farmers. Farmers set up their preference traits through Focus Group Discussion (FGD). Forty farmers, 10 farmers per environment evaluated malt barley varieties from dough to physiological maturity growth stages.

Each farmer per environment ranked each variety per preference traits in three groups very good (1), good/medium (2) and poor (5).

## Data collection and analysis

The collected data were grain yield and farmers' preference evaluation of malt barley varieties. The data were analyzed using GenStat software (17th edition) for the analysis of variances of varieties, environments and their interactions. Fisher's protected Least Significant Difference method ($P < 0.05$) was used for mean separation among varieties. Farmers' preferred traits were analyzed using pair wise ranking. Ranking varieties by farmers were done using preference ranking for Debaytilatgn and Guagusa Shikudad districts while matrix ranking was used for Farta and Lay Gaynt. Rank correlation analysis was done in between varieties grain yield rank and varieties rank by farmers as per the following equation:

$$Rs = 1-(6\sum d^2/(n^3-n)) = 1- \frac{6\sum d^2}{(n^3-n)}$$ expereséd in percentage

where,

***d*** = difference in the ranks assigned to the same individual or phenomenon and

***n*** = number of individuals or phenomena ranked.



**CHAPTER II**: Malt barley technology validation and demonstration

*Table 2. Description of tested malt barley varieties*

| Variety | Code | Year of release | Altitude (m) | Rainfall (mm) | DM | Grain yield ($t\ ha^{-1}$) | | Protein (%) | Extraction (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Research field | On farm | | |
| HB1963 | V6 | 2016 | >2300 | 500-700 | 146 | 3.5-6.0 | - | 10.6 | 81 |
| HB1964 | V7 | 2016 | >2300 | 500-700 | 138 | 3.3-5.6 | - | 11.5 | 80 |
| Singitan | V11 | 2016 | 2200-2600 | 750-1000 | 119 | 3.1-4.1 | 2.1-3.5 | 11.5 | 78 |
| Fanaka | V4 | 2015 | 2000-2600 | 500-1000 | 125 | 2.6-3.8 | 2.3-3.1 | 10.5 | 78 |
| Traveler | V12 | 2013 | 2000-2600 | 500-1000 | 145 | 2.5-4.5 | 2.0-4.0 | 10.5 | - |
| Grace | V5 | 2013 | 2000-2400 | 500-1000 | 125 | 2.0-4.0 | 1.8-3.5 | 10.4 | - |
| IBON174/03 | V9 | 2012 | 2000-2800 | 500 | 120 | 3.0-5.7 | - | 10 | - |
| Sabini | V10 | 2011 | 2300-2500 | >700 | 135 | 4.9 | 2.5-4.0 | 8.5 | - |
| EH1847 | V3 | 2011 | 2200-2800 | >500 | 141 | 4.4 | 3.5 | 11 | - |
| Bahati | V1 | 2011 | 2300-2800 | >700 | 142 | 4.8 | 2.5-4.0 | 8.7 | - |
| Bekoji-1 | V2 | 2010 | 2300-2800 | >700 | 142 | 5.0 | 2.3-2.8 | 11.7 | - |
| Holker | V8 | 1979 | 2300-3000 | 500-800 | - | 2.4-3.1 | - | - | - |

*Source: MoANR (1979-2016)*
*Note. DM = days to maturity; - = data not available*

# Results and Discussion

## Grain yield

The results of AMMI analysis of variances for grain yield of malt barley varieties, environments and their interaction are presented in Table 3. The source of variation for grain yield in malt barley varieties accounted by environments, variety by environment interactions and varieties were 73.58%, 16.62% and 9.79%, respectively.

There is a need to emphasize the magnitude and extent of varietal performance across the tested environments. In this case, GGE biplot is found more appropriate to explain the adaptability as well as the stability of the varieties across the tested environments (Figure 1). GGE ranking biplot examines the performances of all genotypes in the specific environments. The malt barley variety EH1847 (V3) was the highest yielder and stable followed by HB1963 (V6) and IBON 174/03 (V9) across tested environments. Malt barley variety Grace (V5) followed by Fanaka (V4) and HB1964 (V7) is more specific in adaptation and is unstable in the tested environments (Table 4; Figure 1). In the biplot, the best performing malt barley varieties are closer to the average environmental coordinate (AEC) circle with the ranking lines (Yan & Kang, 2003). In addition, the varieties in the biplot with PC1 scores>0 and PC2 scores near to zero or biplot lines are adaptable and stable respectively whereas PC1 scores<0 and higher PC2 scores both + and – sings or from the biplot lines unadaptable and unstable respectively across the environments (Zerihun, 2011).

*Table 3. The AMMI analysis of variances for grain yield of 12 malt barley varieties across environments in 2017 cropping season*

| Source | DF | SS | MS | F pr | % SS (Var+Env+Var*Env) |
|---|---|---|---|---|---|
| Total | 251 | 19279 | 76.8 | | |
| Treatments | 83 | 15794 | 190.3 | <0.001 | |
| Genotypes | 11 | 1547 | 140.7 | <0.001 | 9.79 |
| Environments | 6 | 11622 | 1937.1 | <0.001 | 73.58 |
| Block | 14 | 1107 | 79.1 | <0.001 | |
| Interactions | 66 | 2625 | 39.8 | <0.001 | 16.62 |
| IPCA 1 | 16 | 1226 | 76.6 | <0.001 | |
| IPCA 2 | 14 | 786 | 56.2 | <0.001 | |
| Residuals | 36 | 613 | 17 | 0.334 | |
| Error | 154 | 2377 | 15.4 | | |





*Table 4. Grain yield (kg ha$^{-1}$) of 12 malt barley varieties across environments (E1-E7)*

| Code | Variety | Environment | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | | Lay Gaynt (E1) | Lay Gaynt (E2) | Farta (E3) | Farta (E4) | Debaytilatgn (E5) | Debaytilatgn (E6) | Guagusa-Shikudad (E7) | |
| V1 | Bahati | 5334 | 3496 | 4251 | 2761 | 5076 | 3906 | 3470 | 4042 |
| V2 | Bekoji-1 | 5084 | 3556 | 3893 | 2701 | 3890 | 4136 | 3971 | 3890 |
| V3 | EH1847 | 5712 | 3857 | 4457 | 3061 | 4492 | 3919 | 3991 | 4213 |
| V4 | Fanaka | 5238 | 3822 | 3608 | 2816 | 3528 | 3195 | 3491 | 3671 |
| V5 | Grace | 4646 | 3134 | 3176 | 2066 | 4616 | 3303 | 2391 | 3333 |
| V6 | HB1963 | 5085 | 3770 | 4421 | 3095 | 4760 | 4017 | 3511 | 4094 |
| V7 | HB1964 | 4866 | 3567 | 3412 | 3330 | 3567 | 3233 | 3582 | 3651 |
| V8 | Holker | 4340 | 3833 | 3628 | 2041 | 4330 | 4369 | 3592 | 3733 |
| V9 | IBON174/03 | 5735 | 4160 | 4254 | 3610 | 4100 | 3825 | 3716 | 4200 |
| V10 | Sabini | 5217 | 3483 | 4164 | 2800 | 4540 | 3395 | 2902 | 3786 |
| V11 | Singitan | 5211 | 3579 | 3494 | 2695 | 4055 | 3867 | 3407 | 3758 |
| V12 | Traveler | 5846 | 4447 | 3795 | 2969 | 4258 | 3552 | 3125 | 3999 |
| | Mean | 5193 | 3725 | 3879 | 2829 | 4268 | 3726 | 3429 | 3864 |
| | CV % | 9.4 | 9 | 10.9 | 11.6 | 10.6 | 10 | 9 | 11.6 |
| | LSD (5%) | 826 | 570 | 716 | 557 | 769 | 630 | 525 | 732 |
| | P-level | 0.03* | 0.01** | 0.01** | <0.01** | 0.01** | 0.01** | <0.01** | <0.01** |

***=Highly significant at p<0.01, *=significant at p<0.05*

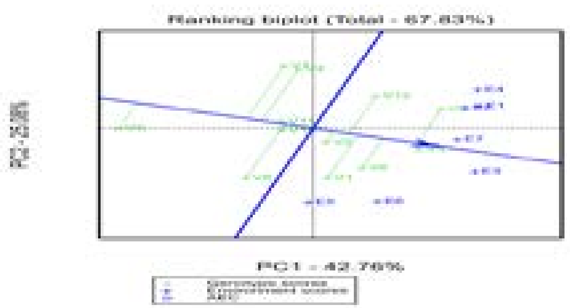

*Figure 1. GGE biplot analysis using ranking biplot type by scaling environmental eigenvector in 12 malt barley varieties grain yield response across environments*

## Farmers preferred traits

Farmers ranked their preference traits in malt barley varieties using pair wise ranking methods. Farmers' preference traits were relatively similar across environments. Among the preference traits, disease resistance was ranked first across all environments and all other traits ranked relatively similar across tested environments (Table 5). The study was in line with (Semagn et al., 2017) who reported that farmers' selection criteria were very diverse and different in potato varieties across agro-ecologies and growing seasons. On the other hand, (Chiara et al., 2017) reported that farmers selected desirable traits in about 400 durum wheat genotypes different in ranks across environments. In this study, disease reaction was more emphasized by farmers, but in study by (Chiara et al. , 2017) early maturity was prioritized by farmers. The difference might be because; the studies were conducted in different agro-ecologies.

*Table 5. Pairwise ranking of traits by farmers across environments in 2017 cropping season*

| *Rank* | *Environment* | | | |
|---|---|---|---|---|
| | *Farta* | *Lay Gaynt* | *Debaytilatgn* | *Guagusa Shikudad* |
| 1 | Disease resistant | Disease resistant | Disease resistant | Disease resistance |
| 2 | Spike morphology | Grain morphology | Spike morphology | Spike morphology |
| 3 | Tillering | Spike length | Tillering | Tillering |
| 4 | Plant height | Tillering | Plant height | Plant height |
| 5 | | Plant height | | |

## Farmers' ranking of varieties

Results of farmers' preference ranking of malt barley varieties are presented in Tables 6, 7, and 8. According to matrix and preference ranking of the varieties, HB1963



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was ranked 1st in Farta, Lay Gaynt and Debaytilatgn and 2nd in Guagusa Shikudad; and EH1847 was ranked 1st, 2nd, 3rd and 6th, in Guagusa Shikudad, Debaytilatgn, Farta, and Lay Gaynt, respectively; these varieties had higher grain yield across environments. Traveler was ranked 9th in Farta, and 11th in Laigaynt, Debaytilatgn and Tilili, but its grain yield was highest only at Lay Gaynt and Farta. Grace was ranked 10th in Farta and 12th in Lay Gaynt, Debaytilatgn and Guagusa Shikudad. Similarly, its grain yield was lower across environments (Tables 3 and 6). Although the farmers' preference traits were relatively similar across the tested environments, the ranks of varieties by farmers were relatively different across the tested environments. Hence, it is important to correlate varieties' grain yield rank and farmers' preference rank in malt barley varieties. The rank correlation between varieties grain yield rank and farmers' preference rank were rs=0.5 at Farta and rs=0.56 at Guagusa Shikudad (Table 9), indicating strong positive relationship to select the potential higher yielding malt barley varieties. The rs=0.05 at Lay Gaynt and rs=0.12 at Debaytilatgn (Table 9) showed weak positive relationships, which might be due to environments that were not discriminating the varieties, thus showing relatively similar performance and farmers preferred traits such as plant height and disease reaction, which had no strong positive correlation to grain yield. Whenever disease appeared on a variety, farmers did not prefer the variety without considering the economic threshold level. The study was in line with (Reza et al., 2012) who reported that farmers were efficient in identifying the best genotypes for their specific environment. Farmers were able to identify the higher yielding varieties the same as breeders (Zerihun et al., 2012) and there was significant positive correlation between the farmers' score and the grain yield (r=0.6) in barley genotypes at all locations (Mahmoud et al., 2014). (Molla et al., 2012) also indicated that there was statistically significant correlation (p<0.01) among farmers and breeders' preferences ranks for grain yield of the varieties.

*Table 6. Matrix ranking of malt barley varieties by farmers in Farta and Lay Gaynt in 2017 cropping season*

| District | Traits weighted score | Farmers' scores of varieties | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sabini | EH1847 | Grace | Holker | HB1963 | HB1964 | Bahati | Bekoji-1 | Traveler | IBON 174/03 | Fanaka | Singitan |
| Farta | Disease resistance (1) | 19 | 12 | 30 | 18 | 10 | 11 | 13 | 11 | 21 | 20 | 12 | 30 |
| | Spike morphology (2) | 26 | 28 | 22 | 44 | 34 | 24 | 36 | 44 | 32 | 32 | 40 | 26 |
| | Tillering (3) | 45 | 39 | 39 | 63 | 33 | 54 | 60 | 60 | 48 | 39 | 60 | 90 |
| | Plant height (4) | 84 | 40 | 116 | 48 | 40 | 52 | 72 | 48 | 116 | 84 | 96 | 108 |
| Total score | | 174 | 119 | 207 | 173 | 117 | 141 | 181 | 163 | 217 | 175 | 208 | 254 |
| Rank | | 6 | 2 | 9 | 5 | 1 | 3 | 8 | 4 | 11 | 7 | 10 | 12 |
| Lay Gaynt | Disease resistant (1) | 18 | 16 | 30 | 21 | 18 | 17 | 17 | 18 | 20 | 14 | 18 | 21 |
| | Grain filling status (2) | 40 | 34 | 38 | 50 | 28 | 40 | 44 | 34 | 54 | 26 | 26 | 50 |
| | Spike length (3) | 48 | 54 | 51 | 78 | 42 | 30 | 54 | 63 | 51 | 36 | 45 | 36 |
| | Tillering (4) | 96 | 68 | 100 | 100 | 60 | 80 | 64 | 48 | 84 | 72 | 52 | 80 |
| | Plant height (5) | 105 | 80 | 140 | 95 | 60 | 70 | 65 | 55 | 150 | 100 | 55 | 100 |
| Total score | | 307 | 252 | 359 | 344 | 208 | 237 | 244 | 218 | 359 | 248 | 196 | 287 |
| Rank | | 9 | 7 | 12 | 10 | 2 | 4 | 5 | 3 | 12 | 6 | 1 | 8 |

*Note: score of the variety= Summation of rank of varieties (1-3) for each traits*number of farmers (1-10); Total score= Summation of traits weighted score *score of the variety. The lower the score the higher the preference of the malt barley variety under comparison.*





*Table 7. Preference ranking of malt barley varieties by farmers at Debaytilatgn in 2017 cropping season*

| Variety | Preference ranking by farmers | | | | | | | Rank index | Rank |
|---|---|---|---|---|---|---|---|---|---|
| HB1964 | 1 (1) | 2 (6) | 6(1) | 7(1) | 8(1) | | | 33 | 2 |
| HB1963 | 1 (6) | 2(4) | | | | | | 14 | 1 |
| Singitan | 10(2) | 11(1) | 12(7) | | | | | 115 | 12 |
| Traveler | 4(1) | 5(1) | 6(1) | 7(5) | 8(1) | 9(1) | | 67 | 7 |
| Fanaka | 3(2) | 4(6) | 6(1) | 8(1) | | | | 36 | 3 |
| Grace | 2(1) | 3(1) | 6(1) | 7(1) | 8(1) | 9(1) | 10(4) | 75 | 9 |
| EH1847 | 2(1) | 4(1) | 5(1) | 7(1) | 8(2) | 9(2) | 11(2) | 74 | 8 |
| IBON 174/03 | 4(1) | 6(1) | 7(1) | 8(1) | 9(2) | 10(2) | 11(2) | 85 | 10 |
| Sabini | 2(1) | 6(1) | 9(2) | 10(1) | 11(2) | 12(3) | | 94 | 11 |
| Bahati | 4(2) | 5(3) | 7(1) | 8(1) | 9(2) | 10(1) | | 66 | 6 |
| Bekoji-1 | 4(2) | 5(1) | 6(3) | 7(1) | 8(3) | | | 62 | 5 |
| Holker | 3(1) | 5(2) | 6(4) | 7(2) | 9(1) | | | 60 | 4 |

*Note: Numbers outside and in the parenthesis indicates the rank and number of farmers, respectively; Rank index=Summation of variety rank * number of farmers; the lower the rank index the higher the desirability of the variety by farmers*

*Table 8. Preference ranking of malt barley varieties by farmers at Guagusa Shikudad in 2017 cropping season*

| Variety | Preference ranking by farmers | | | | | | Rank | Rank |
|---|---|---|---|---|---|---|---|---|
| HB1964 | 1 (8) | 6 (1) | 9(1) | | | | 23 | 1 |
| HB1963 | 1 (1) | 6(3) | 7(1) | 8(3) | 10(1) | | 60 | 8 |
| Singitan | 2(6) | 3(1) | 4(1) | 9(1) | 10(1) | | 38 | 3 |
| Traveler | 11(4) | 12(6) | | | | | 116 | 12 |
| Fanaka | 5(1) | 6(2) | 7(2) | 8(2) | 9(2) | 10(1) | 57 | 6 |
| Grace | 7(1) | 10(1) | 11(5) | 12(3) | | | 108 | 11 |
| EH1847 | 3(1) | 4(3) | 5(1) | 6(1) | 7(1) | 8(1) | 41 | 4 |
| IBON 174/03 | 2(4) | 3(3) | 4(2) | 5(1) | | | 30 | 2 |
| Sabini | 3(4) | 4(1) | 6(1) | 8(1) | 9(1) | 10(2) | 59 | 7 |
| Bahati | 6(2) | 8(1) | 9(2) | 10(5) | | | 88 | 10 |
| Bekoji-1 | 3(2) | 4(2) | 5(6) | | | | 44 | 5 |
| Holker | 5(1) | 6(1) | 7(5) | 8(1) | 9(1) | 12(1) | 75 | 9 |

*Note: Number outside the parenthesis and in the parenthesis indicates rank and number of farmers, respectively. Rank index=Summation of variety rank * number of farmers; the lower the rank index the higher the desirability of the variety by farmers*





*Table 9. Spearman rank correlation analysis between variety grain yield response rank and farmers' rank across environments*

| Variety | Farta (E3) | GYR | FR | DNR | D2 | Laigaynt (E1) | GYR | FR | DNR | D2 | Debaytilatgn (E6) | GYR | FR | DNR | D2 | Guagusa-Shikudad (E7) | GYR | FR | DNR | D2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bahati | 42.51 | 4 | 8 | (4-8) | 16 | 53.34 | 8 | 5 | (8-5) | 9 | 39.06 | 5 | 6 | (5-1) | 1 | 34.7 | 8 | 10 | (8-10) | 4 |
| Bekoji-1 | 38.93 | 6 | 4 | (6-4) | 4 | 50.84 | 9 | 3 | (9-4) | 36 | 41.36 | 2 | 5 | (2-5) | 9 | 39.71 | 2 | 5 | (2-5) | 9 |
| EH1847 | 44.57 | 1 | 2 | (1-2) | 1 | 57.12 | 3 | 7 | (3-7) | 16 | 39.19 | 4 | 8 | (4-8) | 16 | 39.91 | 1 | 4 | (1-4) | 9 |
| Fanaka | 36.08 | 9 | 10 | (9-10) | 1 | 52.38 | 5 | 1 | (5-1) | 16 | 31.95 | 12 | 3 | (12-3) | 81 | 34.91 | 4 | 6 | (4-6) | 4 |
| Grace | 31.76 | 12 | 9 | (12-9) | 9 | 46.46 | 11 | 12 | (11-12) | 1 | 33.03 | 10 | 9 | (10-9) | 1 | 23.91 | 12 | 11 | (12-11) | 1 |
| HB1963 | 44.21 | 2 | 1 | (2-1) | 1 | 50.85 | 8 | 2 | (8-2) | 36 | 40.17 | 3 | 1 | (3-1) | 4 | 35.11 | 7 | 8 | (7-8) | 1 |
| HB1964 | 34.12 | 11 | 3 | (11-3) | 64 | 48.66 | 10 | 4 | (10-4) | 36 | 32.33 | 11 | 2 | (11-2) | 81 | 35.82 | 6 | 1 | (6-1) | 25 |
| Holker | 36.28 | 8 | 5 | (8-5) | 9 | 43.40 | 12 | 10 | (12-10) | 4 | 43.69 | 1 | 4 | (1-4) | 9 | 35.92 | 5 | 9 | (5-9) | 16 |
| IBON 174/03 | 42.54 | 3 | 7 | (3-7) | 16 | 57.35 | 3 | 6 | (3-6) | 9 | 38.25 | 7 | 10 | (7-10) | 9 | 37.16 | 3 | 2 | (3-2) | 1 |
| Sabini | 41.64 | 5 | 6 | (5-6) | 1 | 52.17 | 6 | 9 | (6-6) | 9 | 33.95 | 9 | 11 | (9-11) | 4 | 29.02 | 11 | 7 | (11-7) | 16 |
| Singitan | 34.94 | 10 | 12 | (10-12) | 4 | 52.11 | 7 | 8 | (7-8) | 1 | 38.67 | 6 | 12 | (6-12) | 36 | 34.07 | 9 | 3 | (9-3) | 36 |
| Traveler | 37.95 | 7 | 11 | (7-11) | 16 | 58.46 | 1 | 11 | (1-11) | 100 | 35.52 | 8 | 7 | (8-7) | 1 | 31.25 | 10 | 12 | (10-12) | 4 |
| ∑d2 | | | | | 142 | | | | | 273 | | | | | 252 | | | | | 126 |
| SRC =1-(6*∑d2/(n3-n)) | | | | | 0.5 | | | | | 0.05 | | | | | 0.12 | | | | | 0.56 |

## Conclusions and Recommendations

The AMMI analysis of variances for grain yield of the varieties, environments and their interaction were significant. Grain yield variations accounted by varieties, environments, and their interactions were 9.79%, 73.58% and 16.62%, respectively. According to GGE rank and comparison of biplot analysis among 12 malt barley varieties, EH1847 (V3) followed by HB1963 (V6) and IBON 174/03 (V9) showed higher grain yield and stability across tested environments. The preference traits and the rank of traits by farmers were relatively similar across tested environments as the study was conducted in relatively similar highland barley growing areas. Disease resistance in malt barley was ranked first across all environments.

The ranks of varieties by farmers were relatively different across the tested environments. Considering both statistically significant grain yield differences and varieties rank by farmers as well as the seed multiplication strategies in Ethiopia, it is suggested that recently released malt barley variety HB1963 and relatively older varieties EH1847 and IBON 174/03 should be scaled for wider production in Farta, Lay Gaynt, Guagusa Shikudad, Debaytilatgn and similar agro-ecologies in barley growing highlands of northwest Ethiopia.

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# Evaluation and Demonstration of Malt Barley Technologies in Western Amhara Region

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## Introduction

Ethiopia is well known for its agricultural development challenge given its large and rapid growing population and limited and deteriorated land resource. These two factors together have caused extreme land shortages in the highlands of Ethiopia. Population pressure has led to expanded cultivation into forest areas and steep slopes. This creates serious consequence for the environment, which, together with fluctuation in rainfall, has made agricultural production very vulnerable to weather shock and low productivity of crops.

Ethiopia is the second largest barley producer in Africa, next to Morocco, accounting for about 25% of the total barley production in the continent (FAO, 2014). Barley (***Hordeum vulgare*** L.) is one of the staple food crops in the country, accounting for 6% of the per capita calorie consumption (Rashid et al., 2015).

In Ethiopia, malt barley is the major (90%) raw material for beer production (MoARD, 2010). In fact, the St. George Brewery Company started modern malting of barley in the country in 1974. In 1984, the state-owned Asella Malt Factory (AMF) was established with the purpose to supply malt to local breweries (Legese et al., 2007). Currently, there are 11 breweries in the country with a total capacity of 10.55 million hectoliter (HL) that need 1,793,500 t of malt barley grain as raw material every year. Accordingly, in 2015, malt barley supplies in Ethiopia met only 35% of the total demand of the country of, which the remaining 65% of malt was imported at a cost of 38 million US Dollars (Lakew, 2016).

In Ethiopia, the favorable agroecology for barley in the highlands represents a huge opportunity and potential to increases domestic malt barley production and bridge the supply and demand gap (ICARDA, 2016). Despite the favorable environment and potential market opportunity, the share of malt barley production is quite low, i.e., 10-15% compared to food barley (Lakew et al., 2016). Increase in malt barley productivity and production depends mainly on the development of improved technologies and proper and timely supply of inputs and efficient extension systems. Malt barley production has not expanded sufficiently because of minimal use of improved varieties and poor agronomic practices, indicating the potential of improving its productivity and production. Currently, Holker is the dominant and the only malt barley variety under production in farmers' fields in potential malt barley production areas of Amhara Region. Based on this, Adet Agricultural Research Center conducted on-farm variety evaluation and demonstration trial with the participation of farmers with the objectives of providing farmers with a choice of improved malt barley technologies, and assessing farmers' preferences of malt barley technologies and enhance demand driven technology dissemination.





## Materials and Methods

### Study locations

The demonstration activity was conducted in the 2016/17 main cropping season in Farta and Lay Gayint districts (South Gonder Zone) and Guagusa Shikudad district (Awi Zone), which represent suitable agroecology of malt barley growing areas of Amhara Region. Lay Gaynt is located between 11°32' and 12°16'N latitude and between 38°12' and 38°19'E longitude with an altitude range from 1500 to 4235 m. The demonstration of malt barley technologies was conducted in areas with the altitude of ≥2700 m. The mean annual rainfall of the district is 1020 mm. The rainfall pattern is bimodal with erratic distribution and the main rainy season is long rainy season (meher) that occurs between June and September while the short rainy season (belg) occurs in March to May. The temperature ranges from 6.9 to 21.9OC. The soil type is 55 % brown, 15% red, 15% black, 10% grey (%) and 5% others in color (LGWAO, 2016) although barley is dominantly produced on brown and red soils. Mixed crop-livestock agriculture is the dominant cropping system and crop production is entirely rainfed except in some very specific pocket areas that use traditional small-scale irrigation. Potato, barley, tef, wheat, triticale, faba bean and field pea are the dominant crops being grown. Malt barley is produced both for malt factories supply through producer farmers' cooperatives and local consumption as fried grain, enjera, local beer preparation and market.

One of the testing sites in Farta district was located at 11°51′N latitude and 38°1′E longitude with elevation of 2,706 m asl where malt barley technologies demonstration was conducted. Annual rainfall ranges from 1250 to 1599mm. The rainfall pattern of the areas is unimodal with erratic distribution and effective rainy period extending from June to October annually. Nitosols is the dominant soil type. Mixed crop-livestock agriculture is dominant farming system and crop production is mostly rainfed. The most grown annual crops are barley, potato, tef, wheat, triticale, faba bean and field pea in the highlands. Barley is mainly produced for local consumption and market while supplying for malt factories is not common in this district.

Guagusa Shikudad district is located between 11°91' and 11°92'N latitude and 38°61' and 38°87'E longitude with an altitude ranging from 2562 to 2718 m asl. The annual total rainfall is ≥ 1140 mm. The area has a uni-modal rainfall pattern with erratic distribution. The rainy months extend from March to the end of November, but peak rainfall occurs during July and August. The District has high potential for irrigation and farmers are currently producing crops including malt barley under irrigation using both traditional river diversion and constructed small-scale irrigation schemes. Nitosols is the dominant soil type where malt barley is produced. Barley, potato, field pea and faba bean are the major crops being grown by farmers in the highlands. The district is the main source of malt barley grain produced under irrigation for malt factories.

## Research Design

Four improved malt barley varieties, namely; Sabini, EH1847, IBON 174/03 and Holker (standard check) with the associated improved management technologies were demonstrated in all locations. Single plot observation (with no replication at each farmer's field) with the plot size of 100m$^2$ for each variety was used. Seed rate of 125 kg ha$^{-1}$ with fertilizer rate of 121 kg ha$^{-1}$ NPS and 50 kg ha$^{-1}$ urea were the recommended technologies applied on each variety. All NPS was applied during planting while urea was applied after 30 days of sowing during the first weeding. All varieties were row-planted with the spacing of 20 cm between rows. The plots were planted between 20 and 23 June 2016 at Farta and Guagusa Shikudad, and between 26 and 28 June 2016 in Lay Gaynt district with the collaboration of kebele Development Agents (DAs). The plots were hand-weeded twice, and no chemical was applied for disease and pest control since there was no incidence. Harvesting was carried out on 13 and14 October 2016 at Farta and Guagusa Shikudad; while it was on 25 and 26 October 2016 at Lay Gaynt. Sabini variety was harvested separately one week ahead due to early maturity. The demonstration was conducted on 15 sites, i.e., 5 at Farta, 6 at Guagusa Shikudad, and 4 at Lay Gaynt.

## Research Approach

Demonstration sites were selected with close collaboration and discussion with agricultural extension agents and farmers themselves to meet the objectives of the study. Fifteen voluntary host farmers and 6 kebeles were selected (5-6 per district and 2-3 per kebele) based on their willingness and interest to participate and allocate their land for the demonstration of malt barley technologies. Generally, participatory agricultural research approach was followed in implementing the demonstration activity. Innovation platforms (IPs) comprising small groups acting at lower level and Farmers Research Extension Groups (FREGs) were established to enhance stakeholders' engagement in problem identification, joint planning, implementation, monitoring and evaluation events. IPs comprised farmers, researchers, agricultural experts, primary farmers' cooperative union experts and experts from Brewery Company who met for joint planning, implementation, and evaluation events.

FREG groups were formed in each kebele comprising 20-30 member farmers and participated throughout the planning to implementation of the demonstration. Moreover, for easy communication and facilitation, farmers were organized themselves and elected their chairperson and secretary following discussion of multidisciplinary team of researchers with the targeted farming communities and extension workers on the objectives and implementation of the already planned demonstration activity.

## Evaluation and demonstration

Evaluations of the technologies were carried out by FREG member farmers with the help and facilitation of researchers and development agents. Participatory variety evaluations





were carried out at the maturity stage of the crop and farmers were able to identify evaluation criteria based on their own experiences related to malt barley production. The criteria were ranked and prioritized in order of their importance by using pair wise ranking method. Each variety was evaluated by each criterion with direct scoring methods (1= the best). The scores given to each variety with each criterion of group results were added together and then ranked in ascending order in each district (the variety with lowest sum of scores being the best).

Sum of preference values (score * weight) of each variety across all criteria were used to determine final acceptability ranking among the varieties in each location. Additionally, Spearman's rank correlation coefficient (rs) was used to see the degree of coincidence between farmers' preference acceptability rank and the rank of actual yield obtained. Farmers were grouped in to 4 to 6 groups with a maximum of 6 members within a group and 17 evaluation groups were formed during the evaluation event, i.e., 10 in Farta, 3 in Lay Gant and 4 in Guagusa Shikudad with 83 (12.1% females) farmers. Moreover, 11 (3 female) agricultural experts and development agents participated in facilitating the overall evaluation of varieties with farmers.

# Partnership arrangement

It is well known that the linkage among stakeholders is vital for successful technology transfer and delivery system. The role of different stakeholders in technology demonstration and modality for partnership was properly designed and the roles and responsibilities of each actor were outlined as follows

## Adet Agricultural Research Center (AdARC)

The major role of AdARC in malt barley participatory evaluation and demonstration was delivering seeds and fertilizers, organizing training, field days, joint monitoring and evaluation events to build effective and efficient coordination and collaboration among stakeholders to ensure a smooth flow of information and knowledge about the technologies among stakeholders for future technology scaling.

## Farmers

The major role of farmers in the technology evaluation and demonstration was providing their own labor and land for the implementation of the experiment. Moreover, they were participating in planning, implementation, and evaluation of activities.

## District and kebele agricultural offices

The offices are the main government organization responsible for technology dissemination and transfer. The main roles of the offices were facilitating selection of experimental host farmers and mobilizing farmers for technology evaluation, training and field day events. The agricultural office also participated in the joint monitoring and evaluation events.

## International Center for Agricultural Research in the Dry Areas (ICARDA)

Being the national coordinator of malt barley scaling project, ICARDA was making funds available for timely operation of activities and participated in the joint monitoring and evaluation events; organizing training of trainers, workshops, and annual review and planning meetings.

## Organizing trainings and field days

Training is one of the capacity building methods in extension research to create awareness and improve skills and knowledge of farmers and experts. Training was given to farmers and experts on 24 May 2016 at Lay Gayint and 5 June 2016 in Guagusa Shikudad to improve and strengthen their attitude, skills and knowledge by different researchers comprised of breeders, agronomist, plant protectionists, seed specialists and social scientists. Field days were organized at the crop maturity stages of the demonstration plots inviting different stakeholders across the value chain of malt barley and the event was broadcasted on mass media in order to create awareness and demand of the technologies.

## Joint monitoring and evaluation

Team of researchers, district and kebele level agricultural experts and development agents and farmers jointly monitored and evaluated the implementation of the planned participatory evaluation and demonstration activity at least two times per season. During M and E, application of agronomic practices (package) and cultivation practices by farmers and any challenges and constraints were assessed and correction measures were suggested according to the roles and responsibilities of each actor.

## Data collection and analysis

Qualitative and quantitative yield related, and social data were collected. Yield data was collected after harvest and social data (farmers' and experts' opinions/feedbacks) were collected during M and E and field day.

Data were analyzed using simple descriptive statistics such as mean, maximum and minimum values and social data (farmers' and experts' opinions/feedbacks) were qualitatively described and classified by themes and contents.

Spearman's Rank correlation coefficient, "rs" was used to see the degree of coincidence between farmers' preference with actual value of measured attributes. Spearman's rank correlation coefficient rs was calculated as indicated below

$$rs = 1 - \frac{6\sum d^2}{n(n^2-1)} \times 100 \text{ (expresed in \%)}$$

Where,

$d$ = difference in the ranks assigned to the same individual or phenomenon (actual yield rank minus farmers' preference rank in this case) and

$n$ = number of individuals or phenomena ranked (number of varieties in this case).





# Results and Discussion

## Trainings and field days

Training was given for 95 (11 female) farmers and 20 agricultural experts and development agents (6 female) at all participatory evaluation and demonstration sites. The training content included malt barley production, disease and pest management system, seed production technique and marketing linkage aspects. During training, computer power point presentations in Amharic, leaflets, posters, and audio visuals were used as training materials.

Two field days were organized and 60 (12 females) farmers and 53 (11 female) agricultural experts and other stakeholders participated. During the field day event, zonal, district and kebele level agricultural experts, officials (heads) and administrators, researchers, seed agency experts and heads had the opportunity to provide their reflections and feedbacks about the performance of the demonstrated technologies. Moreover, Amhara mass media broadcasted the field day event on Amhara Television and radio programs. Therefore, demand and awareness have been created on the improved malt barley technologies.

## Yield of malt barley varieties

Yield performance of malt barley varieties are presented in Table 1. On average across all demonstration sites, IBON 174/03 gave the highest grain yield (2.04 t $ha^{-1}$) followed by EH1847 (1.82 t $ha^{-1}$), Holker (1.68 t $ha^{-1}$) and Sabini (1.38 t $ha^{-1}$). On the other hand, Holker variety was the highest in straw yield (3.62 t $ha^{-1}$) followed by IBON 174/03 (3.48 t $ha^{-1}$), EH1847 (3.09 t $ha^{-1}$) and Sabini (2.48 t $ha^{-1}$). The performance of the malt barley varieties was relatively low due to hail damage at Farta and Guagusa Shikudad districts towards the maturity stages of the crop. Moreover, there was security problem in 2016 in Amhara Region so that demonstration plots were not properly monitored and second time weeding, and top dressing were done late compared to the recommendations in most of the demonstration sites.

IBON 174/03 improved malt barley variety with improved management gave grain yield advantage of 23.2, 12.28 and 32.2% over the check (Holker) in Farta, Lay Gaynt, Guagusa Shikudad districts, respectively (Table 1). Overall, it had mean yield advantage of 21.3 % over Holker variety. Similarly, EH1847 variety had mean yield advantage of 21.3 % over Holker.

*Table 1. Yield advantage of malt barley varieties at each district in 2016/17*

| Variety | Yield (t $ha^{-1}$) | | | | | | Average yield (t $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | Farta | | Guagusa Shikudad | | Lay Gaynt | | | |
| | GY | SY | GY | SY | GY | SY | GY | SY |
| Sabini | 1.72 | 3.40 | 0.99 | 1.79 | 1.43 | 2.25 | 1.38 | 2.48 |
| EH1847 | 2.37 | 4.12 | 1.33 | 2.13 | 1.77 | 3.01 | 1.82 | 3.09 |
| IBON 174/03 | 2.19 | 4.35 | 1.74 | 2.73 | 2.20 | 3.35 | 2.04 | 3.48 |
| Holker | 1.78 | 4.34 | 1.31 | 2.60 | 1.96 | 3.91 | 1.68 | 3.62 |
| Total | 2.02 | 4.05 | 1.34 | 2.31 | 1.84 | 3.13 | 1.73 | 3.17 |

*Note: GY= grain yield and SY= straw yield*

## Farmers' preference

Pair wise ranking and final preference values analysis result showed that farmers gave higher emphasis or weight for disease resistance followed by high grain yield potential of varieties (Tables 2-10). Holker was selected 1st by its relative disease tolerance ability while EH1847 and IBON 174/03 varieties were selected 1st and 2nd, respectively, by their high yield potential. In overall evaluation criteria, EH1847, IBON 174/03, Holker and Sabini were ranked 1st, 2nd, 3rd and 4th, respectively, at Farta district. Sabini variety was ranked the least due to its short stature (low straw yield) and its susceptibility to rain damage due to its earliness in the long rainy season of study locations (Tables 2 and 3).

*Table 2. Pair wise ranking results of malt barley varieties evaluation criteria in Farta in 2016/17*

| Evaluation criteria | Identified evaluation criteria and their relative ranks | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total | Rank |
| | Gy | Ph | Tc | DR | Sl | Lo | Ns | | |
| Grain yield (Gy) | | Gy | Gy | DR | Gy | Gy | Gy | 5 | 2 |
| Plant height (Ph) | | | Tc | DR | Sl | Ph | Ns | 1 | 6 |
| Tillering capacity (Tc) | | | | DR | Sl | Tc | Ns | 2 | 5 |
| Disease resistance (DR) | | | | | DR | DR | DR | 6 | 1 |
| Spike length (Sl) | | | | | | Sl | Ns | 3 | 4 |
| Lodging resistance (Lo) | | | | | | | Ns | 0 | 7 |
| Number of seeds per spike (Ns) | | | | | | | | 4 | 3 |

IBON 174/03 and EH1847 were selected 1st and 2nd, respectively by their high yield potential and disease tolerance at Guagusa Shikudad and Lay Gaynt districts (Table 5). In overall evaluation criteria, IBON 174/03 was selected 1st while EH1847 and Holker were ranked 2nd interchangeably (Table 6 and 7). Sabini variety was the least selected due to its low straw yield and earliness; early maturity in such extended rainfall environment results in yield and grain quality loss.

*Table 3. Sum of scores given to each variety (1 to 4; 1= the best) with each criterion in Farta in 2016/17*

| Evaluation criteria | Sum of scores given to each variety in each site | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sabini | | | EH1847 | | | IBON 174/03 | | | Holker | | |
| | Ata | Tse | T | Ata | Tse | T | Ata | Tse | To | Ata | Tse | T |
| Grain yield | 20(4) | 14(4) | 34 | 8(1) | 5(1) | 13 | 18(3) | 11(3) | 25 | 14(2) | 10(2) | 28 |
| Plant height | 24(4) | 16(4) | 40 | 16(3) | 10(2) | 26 | 13(2) | 10(2) | 33 | 7(1) | 4(1) | 11 |
| Tillering capacity | 23(4) | 14(4) | 37 | 8(1) | 4(1) | 12 | 12(2) | 9(2) | 31 | 17(3) | 13(3) | 30 |
| Disease resistance | 22(4) | 10(2) | 32 | 14(2) | 13(4) | 27 | 16(3) | 11(3) | 27 | 8(1) | 6(1) | 14 |
| Spike length | 21(4) | 12(3) | 33 | 7(1) | 11(2) | 11 | 14(2) | 4(1) | 25 | 18(3) | 13(4) | 31 |
| Lodging resistance | 6(1) | 4(1) | 10 | 13(2) | 10(2) | 23 | 17(3) | 10(3) | 27 | 24(4) | 16(4) | 40 |
| Number of seeds per Spike | 19(3) | 12(3) | 31 | 8(1) | 4(1) | 12 | 11(2) | 10(2) | 21 | 22(4) | 14(4) | 36 |

*Note: Tse=Tsegur, T= Total; numbers in brackets are the relative ranks of each criterion*





*Table 4. Preference values and final rank of varieties by farmers in Farta in 2016/17*

| Evaluation criteria | Sum of scores given to each variety in each site | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sabini | | EH1847 | | IBON 174/03 | | Holker | |
| | Ata | Tsegur | Ata | Tsegur | Ata | Tsegur | Ata | Tsegur |
| Grain yield | 8 | 8 | 2 | 2 | 6 | 6 | 4 | 4 |
| Plant height | 24 | 24 | 18 | 12 | 12 | 12 | 6 | 6 |
| Tillering capacity | 20 | 20 | 5 | 5 | 10 | 10 | 15 | 15 |
| Disease resistance | 4 | 2 | 2 | 4 | 3 | 3 | 1 | 1 |
| Spike length | 16 | 13 | 4 | 5 | 12 | 8 | 8 | 14 |
| Lodging resistance | 8 | 7 | 16 | 15 | 22 | 22 | 24 | 26 |
| Number of seeds per Spike | 9 | 9 | 3 | 3 | 6 | 6 | 12 | 12 |
| Sum of scores | 89 | 83 | 50 | 46 | 71 | 67 | 70 | 78 |
| Rank of varieties | 4 | 4 | 1 | 1 | 3 | 2 | 2 | 3 |

*Table 5. Pair wise ranking of evaluation criteria in Guagusa Shikudad and Lay Gaynt in 2016/17*

| Identified evaluation criteria | Identified evaluation criteria and their relative ranks | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total | Rank |
| | Gy | Ph | Tc | DR | Ss | Sl | Lo | Ns | | |
| Grain yield/Gy/ | | Gy | Gy | Gy | Gy | Gy | Gy | Gy | 7 | 1 |
| Plant height/Ph/ | | | Tc | DR | Ss | Sl | Lo | Ns | 0 | 8 |
| Tillering capacity/Tc/ | | | | DR | Tc | Tc | Tc | Ns | 4 | 4 |
| Disease resistance/DR/ | | | | | DR | DR | DR | DR | 6 | 2 |
| Seed size/Ss/ | | | | | | Sl | Lo | Ns | 1 | 7 |
| Spike length/Sl/ | | | | | | | Sl | Ns | 3 | 5 |
| Lodging resistant (Lo) | | | | | | | | Ns | 2 | 6 |
| Number of seeds per spike (Ns) | | | | | | | | | 5 | 3 |

*Table 6. Sum of scores given to each variety (1 to 4; 1= the best) with each criterion by 15 farmers in Guagusa Shikudad and Lay Gaynt in 2016/17*

| Evaluation criteria | Sum of scores given to each variety in each site | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sabini | | EH1847 | | IBON 174/03 | | Holker | |
| | Gobgob | Gusha | Gobgob | Gusha | Gobgob | Gusha | Gobgob | Gusha |
| Grain yield | 10(3) | 16(4) | 5(2) | 13(3) | 4(1) | 4(1) | 11(4) | 7(2) |
| Plant height | 12(4) | 16(4) | 9(3) | 10(3) | 6(2) | 8(2) | 3(1) | 6(1) |
| Tillering capacity | 12(4) | 11(4) | 5(2) | 9(3) | 4(1) | 5(1) | 9(3) | 15(2) |
| Disease resistance | 9(3) | 13(4) | 3(1) | 12(3) | 6(2) | 6(1) | 12(4) | 9(2) |
| Seed size | 9(3) | 12(3) | 6(2) | 8(2) | 3(1) | 4(1) | 12(4) | 16(4) |
| Spike length | 12(4) | 14(4) | 3(1) | 9(2) | 6(2) | 5(1) | 9(3) | 12(3) |
| Lodging resistant | 3(1) | 4(1) | 6(2) | 9(2) | 9(3) | 11(3) | 12(4) | 14(4) |
| Number of seeds/spikes | 9(3) | 13(3) | 3(1) | 14(4) | 6(2) | 9(2) | 12(4) | 4(1) |

Note: Numbers in brackets are elative ranks of each criterion

*Table 7. Preference values and final rank of varieties in Guagusa Shikudad and Lay Gaynt in 2016/17*

| Evaluation criteria | Sum of scores given to each variety | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sabini | | EH1847 | | IBON 174/03 | | Holker | |
| | Gobg | Gusha | Gobg | Gusha | Gobg | Gusha | Gobg | Gusha |
| Grain yield | 3 | 4 | 2 | 3 | 1 | 1 | 4 | 2 |
| Plant height | 32 | 32 | 24 | 24 | 16 | 16 | 8 | 8 |
| Tillering capacity | 16 | 16 | 8 | 12 | 4 | 4 | 12 | 8 |
| Disease resistance | 6 | 8 | 2 | 6 | 4 | 2 | 8 | 4 |
| Seed size | 21 | 21 | 14 | 14 | 7 | 7 | 28 | 28 |
| Spike length | 20 | 20 | 5 | 10 | 10 | 5 | 15 | 15 |
| Lodging resistant | 6 | 6 | 12 | 12 | 18 | 18 | 24 | 24 |
| Number of seeds per spike | 9 | 9 | 3 | 12 | 6 | 6 | 12 | 3 |
| Sum of scores | 113 | 116 | 70 | 93 | 66 | 59 | 111 | 90 |
| Rank of varieties | 4 | 4 | 2 | 3 | 1 | 1 | 3 | 2 |





Reasons given by farmers for each criterion they set according to their locality for malt barley variety selection and characteristics of each malt barley variety according to the selection criteria are given in Table 8 and 9. It is believed that the information in these summary tables would help breeders, agronomists and protectionists to design research accordingly in future malt barley breeding and development strategy.

*Table 8. Reasons of malt barley varieties evaluation criteria set by farmers in 2016/17*

| Criteria | Reason |
|---|---|
| Disease resistance (1st) and high yield potential (2nd) | Frequency of disease occurrence and the yield loss incurred is increasing |
| Spike length | Malt barley variety with long spike would give more yield |
| Number of seeds per spike | A variety with a greater number of seeds per spike would give more yield |
| Tillering capacity | High tillering capacity up to first weeding is an indicator for more yield but tillering after 1st weeding leads to non-uniformly in maturity |
| Lodging resistant | High lodging causes yield and grain quality loss; lodging increases liability to damage by termite and rat, which are common problems in Guagusa Shikudad district |
| Seed size | Bigger seed size is an indicator of good grain feeling and better yield |
| Early maturity | Early maturity is a grain yield and quality loss causing problem due to the extended rainfall season of the target districts |

*Table 9. Merits and demerits of improved malt barley varieties as characterized by farmers in 2016/17*

| Variety | Merit | Demerit |
|---|---|---|
| EH1847 | Long spike length, high tillering capacity with good population stands, medium plant height, high yielder, bigger seed size, a greater number of seeds per spike, good seed setting and filling potential. | At the time of emergence and early stage, the crop stand is not attractive (it is weak and thinner), susceptible for hail damaged. |
| Sabini | Disease resistant, bigger seed size, early mature, lodging resistant | Less tillering capacity, short plant height resulting in low biomass yield, relatively low grain yield |
| IBON 174/03 | Higher tillering capacity, relatively tall plant height, long spike length, higher number of seeds per spike, good grain filling, higher grain and straw yield | Late matured as compared to others, crop stand at early stage is not attractive (weak and thinner stand) |
| Holker | Tall plant height, high biomass (straw) yield) | Relatively low grain yield, susceptible to lodging due to thin stalk, low tillering capacity, a smaller number of seeds per spike |

As shown in Table 10, Spearman's Rank correlation coefficient, "rs", i.e. degree of coincidence between farmers' preference rank and actual yield obtained was about 0.8 (80%) and this indicates that the farmers' preference and actual yield obtained are almost in a good match so that farmers' preferred varieties could be promoted to farmers for wider use. Therefore, EH1847 malt barley variety was selected best Farta while IBON 174/03 variety was selected best in Guagusa Shikudad and Lay Gaynt.

*Table 10. Farmers' preference value and actual yield rank comparison of varieties in 2016/17*

| *Variety* | *Farta* | | *Guagusa Shikudad* | | *Lay Gaynt* | |
|---|---|---|---|---|---|---|
| | ***Preference value*** | ***Actual yield*** | ***Preference value*** | ***Actual yield*** | ***Preference value*** | ***Actual yield*** |
| *Sabini* | *4* | *4* | *4* | *4* | *4* | *4* |
| *EH1847* | *1* | *1* | *3* | *2* | *2* | *3* |
| *IBON 174/03* | *3* | *2* | *1* | *1* | *1* | *1* |
| *Holker* | *2* | *3* | *2* | *3* | *3* | *2* |
| | *0.8* | | *0.8* | | *0.8* | |

*Note: 0.8 = overall Spearman's Rank correlation coefficient (rs)*

## Field day feedbacks from farmers

Field day participant farmers said that these malt barley varieties under evaluation and demonstration are new to our localities and are better in performance than the Holker variety we are growing. Farmers added that, we are eager to produce these newly introduced varieties in wider scale in the next growing season if we got seeds. They suggested that the researcher center should continue in introducing, demonstrating and promoting of new varieties such as these ones with the collaboration of other stakeholders for monitoring quality and marketing issues.

## Field day feedback from stakeholders (heads and experts)

Heads of office of agriculture, universities and breweries highly appreciated the performance of malt barley varieties under evaluation and demonstration and thanked the research center for conducting the research activity. They reiterated that such activities on promoting higher yielding improved technologies have larger contributions in fulfilling the food security of smallholder farmers and increasing population pressure. During the field day event, each variety was evaluated by the participants who selected IBON 174/03 and EH1847 varieties as the 1st and 2nd, respectively, compared to the widely grown Holker variety.

Experts said that there is shortage of improved varieties in these areas. Moreover, the promotion of improved malt barley technologies was not much done before and we expect from the research center that these evaluated and demonstrated as well as demand created varieties should be promoted to wider scale in the next production season; and seed multiplication of selected varieties, market linkage with seed agencies and breweries, and further capacity building activities should be planned ahead.

# Lessons Learned

- Involvement of farmers at each phase of demonstration activities increased the demand of improved varieties that would help to promote the varieties at larger scale in the future;





- Institutional linkage and intensive communication between stakeholders were important for malt barley technology promotion so that it was easy to address farmers' problems and make corrective measures;
- Partnership with seed enterprises and unions has proved to be effective so that the selected and demanded variety seeds would be multiplied and readily available to farmers in the next production season; and
- Capacity building, field day and mass media events played great role for wider demand creation on the demonstrated malt barley technologies.

# Challenges

- The major challenge was occurrence of political instability (social unrest), which impede timely monitoring, evaluation and follow-up of activities difficult to properly monitor and evaluate the demonstration sites. Moreover, it was difficult to arrange trainings, field days and evaluation events in some locations.

# Conclusions and Recommendations

## Conclusions

- IBON 174/03 improved malt barley variety was selected 1st by farmers own selection criteria, which was matched with the actual grain yield results at Lay Gaynt and Guagusa Shikudad. Moreover, the grain yield advantage of this variety in Farta, Lay Gaynt, and Guagusa Shikudad was 23.2%, 12.28% and 32.2% respectively over the check (Holker variety). Overall, it has mean grain yield advantage of 21.3 % over Holker variety. Similarly, EH1847 variety was selected 1st by farmers own selection criteria in Farta and has mean grain yield advantage of 33.15 % over Holker;
- The combined analyses showed that farmers' preference rank and actual yield rank matched in improved malt barley selection across all locations and this indicates that, farmers preferred varieties could be promoted in those areas. In all target districts, Sabini variety was selected least by farmers and gave lower grain yield than the check (Holker variety); and
- Farmers' preferences and assessment feedbacks from field evaluation and field day events showed that high demand was created among farmers for improved malt barley varieties under evaluation and demonstration.

## Recommendations

- Since it has been preferred by farmers and gave higher grain yield, IBON 174/03 improved malt barley variety should be scaled up and out at Guagusa Shikudad and Lay Gaynt districts; and
- EH1847 and IBON 174/03 should be promoted to wider scale at Farta district since they are preferred by farmers and gave higher grain yield than the check variety (Holker).

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# Evaluation and Demonstration of Malt Barley Varieties in Wolayita and Kembata-Tembaro Zones, Southern Ethiopia

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## Introduction

According to CSA (2018), about 554,571 smallholder farmers cultivated barley on area of about 81,161.32 ha producing 154 505 t with an average yield of 1.904 t ha$^{-1}$ in Southern Nations Nationalities and Peoples Region (SNNPR). Barley is the least crop among cereals in terms of area and production. However, there is a potential area for malt barley production. However, malt barley production in SNNPR in general is very limited mainly due to lack of access and availability of malt barley production technologies. Low productivity, poor malt quality and market access also contributed to the limitations of malt barley production. Cognizant of this fact, evaluation, and demonstration of malt barley technologies in potential districts of Wolayita and Kembata Tembaro Zones was initiated. The objectives were to evaluate malt barley varieties on farmers' fields in order to identify better yielding varieties; and create awareness and demand on improved malt barley production technologies.

## Materials and Methods

### Study locations

Participatory evaluation and demonstration study on malt barley was conducted in Sodo Zuria districts of Wolayita Zone and Doyogena district of Kembata-Tembaro Zone in Southern Nations Nationalities and Peoples Region (SNNPR). One of the testing sites in Delbowogene kebele in Sodo Zuria is located at 6°53'N and 37°48'E at an altitude of 2203 m asl. The mean annual rainfall ranges from 1200 to 1300 mm and mean annual temperature is 18°-28°C. The dominant soil type is sandy loam.

One of the testing sites in Awora Arara kebele in Doyogena district is located at 7°19'N and 37°46'E at an altitude of 2712 m asl. The area receives an annual mean rainfall of 1200 to 1800 mm. The average annual temperature of the area is 16°C. The dominant soil type is red and black clay loams soil (Demalo, 2014).

Crop production systems are almost identical in each district. Enset and potato are some of the major root crops grown in the districts. Bread wheat and barley are the only cereals grown in the areas except limited tef production in Sodo Zuria. Malt barley; however, is the new introduction to both study locations where high demands are emerging due to increasing demands and number of malt factories and breweries in the country.

## Experimental materials

Four malt barley varieties, namely; Bekoji-1, EH1847, Holker and IBON 174/03 were demonstrated on the fields of 12 farmers (2 female). Fields were planted at the seed rate of 125 kg $ha^{-1}$ with rows spaced at 30 cm on a total plot size of $50m^2$ for each variety at each farmer's field. Fertilizers NPS and Urea were applied a rate of 120 and 50 kg $ha^{-1}$. NPS was applied at sowing while urea was applied in a split base, one third during planting and two-thirds after 35 days after seedling emergence. Weeds were controlled manually once just before the second application of urea. At both Study locations, planting was done during second week of July followed by harvesting during third week of November in 2017.

## Data collection and analysis

The six farmers in each kebele were considered as replications. Farmers' preferences on malt barley varieties were assessed based on spike length, uniformity (in terms of maturity), tillering capacity, seed size and grain yield using the criteria set by farmers. Grain yield data were collected at plot base and data were analyzed in RCBD using SAS software.

## Organizing trainings and field days

Awareness on trial management and malt barley production technologies were created through trainings organized prior to implementation of the experiments at both study locations. Field days were also organized at maturity stage of malt barley.

# Results and Discussion

Farmers have evaluated the varieties only by visual observation; and direct ranking, which was done using farmers' selection criteria indicated in Tables 1 and 2 for Doyogena and Sodo Zuria, respectively. In previous studies, malt barley genotypes were also selected based on differences in the agronomic traits of crop stand establishment, number of tillers per plant, spike length, number of kernels per spike, and 1000 kernel weight (Aynewa et al., 2013). (Soudabeh et al., 2013) also supported use of highly and genetically associated morphological traits in selection of barley genotypes for grain yields. In the current study, in Doyogena district, both EH1847 and Holker were ranked first based on the farmers' criteria whereas variety Bokoji-1 was ranked least. Although both ranked first, varieties EH1847 and Holker were significantly different in grain yield at Doyogena indicating that yield is not the only parameter to make selection decision among different varieties. Similarly, (Jarius et al., 2015) also used different parameters in selection of malt barley varieties in their study.



**CHAPTER II**: Malt barley technology validation and demonstration

*Table 1. Ranking of malt barley varieties using the selection criteria set by farmers in Doyogena district in 2017*

| *Selection criteria* | *Variety* | | | |
|---|---|---|---|---|
| | *IBON 174/03* | *EH1847* | *Bekoji-1* | *Holker* |
| *Spike length* | 2 | 1 | 4 | 1 |
| *Uniformity** | 2 | 1 | 4 | 1 |
| *Tillering capacity* | 2 | 1 | 4 | 2 |
| *Seed size* | 3 | 2 | 4 | 1 |
| *Total score* | 9 | 5 | 16 | 5 |
| *Mean score* | 2.25 | 1.25 | 4 | 1.25 |
| *Overall rank* | 3 | 1 | 4 | 1 |

*Note: *uniformity in terms of maturity*

*Table 2. Ranking of malt barley varieties using the selection criteria set by farmers' in Sodo Zuria in 2017*

| *Selection criteria* | *Variety* | | | |
|---|---|---|---|---|
| | *IBON 174/03* | *EH1847* | *Bekoji-1* | *Holker* |
| *Spike length* | 1 | 3 | 4 | 2 |
| *Uniformity** | 1 | 4 | 3 | 2 |
| *Tillering capacity* | 1 | 3 | 4 | 2 |
| *Seed size* | 1 | 3 | 4 | 1 |
| *Total score* | 4 | 13 | 15 | 7 |
| *Mean score* | 1 | 3.25 | 3.75 | 1.75 |
| *Rank* | 1 | 3 | 4 | 1 |

*Note: *uniformity is in terms of maturity*

EH1847 had a superior grain yield of 3.55 t $ha^{-1}$ while Holker had 2.425 t $ha^{-1}$ in Doyogena (Table 3). Although EH1847 showed significant yield advantage over Holker in Doyogena district, famers in the area were highly impressed with the seed size of Holker. They described that Holker is better for preparing locally roasted snack called kolo compared to other varieties. Moreover, the grain price of Holker is also better in local market, 1500 Birr per 100 kg grain whereas other varieties fetch lower price.

Variety EH1847 was depressed at Sodo Zuria where only 1317 kg $ha^{-1}$ grain yield was recorded (Table 4) implying less adaptability to the area. Jarius et al. (2015) also evaluated promising malt barley varieties in Kenya and found differential response of varieties between two different locations. A variety, which was superior in one location, was found depressed in other location. In the current study, farmers at Sodo Zuria (Table 2) did not prefer EH1847 variety. Therefore, it is essential to make specific recommendation based on the performance of barley varieties in each district.

Average grain yield obtained from all varieties was generally low in Sodo Zuria where the highest grain yield of 1500 kg ha$^{-1}$ was obtained from variety IBON 174/03 (Table 4). This may imply that the acidic soil with pH of as low as 5.6 in this study site has disfavored all the malt barley varieties included under the present study. However, the farmers in the district ranked IBON 174/03 first based on the criteria indicated in Table 2. Therefore, lime application to neutralize the acidic soil in Sodo Zuria is required to improve productivity and grain quality of malt barley.

*Table 3. Grain yield of malt barley varieties demonstrated in Doyogena district in 2017*

| Variety | Grain yield (t ha$^{-1}$) | | | | | | Mean | Rank |
|---|---|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | F5 | F6 | | |
| IBON 174/03 | 3.100 | 2.300 | 2.500 | 2.000 | 2.465 | 2.485 | 2.475 | 3 |
| EH1847 | 4.800 | 4.100 | 2.500 | 2.800 | 3.530 | 3.570 | 3.550 | 1 |
| Bekoji-1 | 2.000 | 1.400 | 1.400 | 2.000 | 1.710 | 1.690 | 1.700 | 4 |
| Holker | 2.900 | 2.100 | 2.100 | 2.600 | 2.405 | 2.445 | 2.425 | 2 |
| CV | | | | | | | 20.4 | |
| LSD (5%) | | | | | | | 0.366 | |

*Note: F1-F5 are farmer's fields*

Variety Bekoji-1 had only 1,050 kg ha$^{-1}$ in Sodo Zuria and it was also the least in grain yield compared to other barley varieties in Doyogena where only 1,700 kg ha$^{-1}$ was recorded. Muluken (2013) also reported the same trend where malt barley genotypes behaved differently for grain yield and economically important malting quality traits across various test locations and further recommended the development of both specific and wide adaptable varieties.

*Table 4. Grain yield of malt barley varieties demonstrated in Sodo Zuria in 2017*

| Variety | Grain yield (t ha$^{-1}$) | | | | | | Mean | Rank |
|---|---|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | F5 | F6 | | |
| IBON 174/03 | 1,400 | 0.800 | 1.200 | 1.600 | 2.400 | 1.600 | 1.500 | 1 |
| EH1847 | 1,200 | 0.500 | 1.100 | 2.100 | 1.800 | 1.200 | 1.317 | 3 |
| Bekoji-1 | 1,800 | 0.400 | 0.800 | 1.600 | 1.100 | 0.600 | 1.050 | 4 |
| Holker | 1,800 | 0.600 | 1.200 | 1.700 | 1.000 | 2.200 | 1.417 | 1 |
| CV | | | | | | | 21.39 | |
| LSD (5%) | | | | | | | 0.240 | |

*Note: F1-F5 are farmer's fields*





## Trainings and field days

Fifty (12 female) and 30 (8 female) participants from Doyogena and Sodo Zuria, respectively, were trained. Male and female farmers and agricultural experts at each district level as well as development agents at each trial hosting kebele were trained on management of trials and malt barley production technologies.

Field days with the participation of 318 farmers (15.4% female) and 72 technical staff (11.1% female) of partner institutions were conducted just before harvesting the trials, to demonstrate malt barley varieties as well as production techniques of the crop. Farmers at each district, experts at district and zonal levels of study locations participated in the event. This event has also provided opportunities to evaluate all varieties at each farmer field.

# Lessons learned

We have learnt that farmers can be good partners in evaluation and identification of varieties to provide specific recommendations. They were capable to provide important criteria for evaluation of varieties.

Farmers also shared their knowledge on challenges of marketing grain of malt barley. They were aware of and raising questions on extent of benefits that the local malt barley grower earns. Field day participant farmers were asserting that the fellow growers are disfavored due to low income resulted from poor market linkages. Therefore, the market issue needs to be resolved through value chain studies.

Malt barley production without application of lime on acidic soil in Sodo Zuria significantly depressed yield, which should be given due attention for future intervention to improve productivity and grain quality.

# Conclusions and Recommendations

To maximize the benefit of breweries and enhance income of malt barley growing farmers, it is essential to improve malt barley productivity at farm level through use of improved crop production technologies. Evaluation and demonstration of malt barley varieties in Doyogena and Sodo Zuria revealed that yield response of varieties varied across locations, suggesting that it is essential to consider specific recommendations following the routes of better adaptability of malt barley varieties. Thus, EH1847 to Doyogena and IBON 174/03 to Sodo Zuria are recommended for scaling up and out. However, acidic soil of Sodo Zuria needs lime application for improving productivity and grain quality of malt barley.

# Acknowledgments

The authors thank Kulumsa and Holetta Agricultural Research Centers for generous provision of seeds of malt barley varieties tested in these experiments.

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**CHAPTER II**: Malt barley technology validation and demonstration

# Demonstration of Malt Barley Technologies in North Shewa Zone of Amhara Region

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## Introduction

Ethiopia has enormous potential for malt barley production though its current share is very small compared to food barley. The demand for quality malt barley grain has been increasing from malt factories and breweries. With the introduction of several new malt factories in the country, domestic demand is growing and is showing no signs of slowing down. Malt barley may offer better opportunities linking the agriculture sector to agro-processing industry and could be an important cash crop for small-scale farmers in the highlands of North Shewa who have limited access to other alternative options to participate in market transaction.

Malt barley requires a favorable environment to produce a plump and mealy grain like potential areas in North Shewa. Several malt barely varieties were released by federal and regional public agricultural research institutes and the private sector in Ethiopia. However, the oldest variety is still popular and under production because the new releases have not yet been widely promoted and there is lack of awareness, and access to new varieties. The demonstration of malt barley technologies was initiated from the results of national variety adaptation trials conducted in the potential areas of North Shewa in 2016 cropping season. Therefore, the demonstration of improved malt barley technologies was carried out to demonstrate the improved malt barely technologies to farmers and other stakeholders; and create awareness about the improved malt barley technologies to farmers and stakeholders.

## Materials and Methods

### Study locations

Demonstrations were conducted in Bassona-Worana and Tarmaber districts in the highlands of North Shewa Zone of Amhara Region (fore locations see Chapter 1 under Tigabie et al.). The testing sites represent dark brown soil, which is prone to waterlogging in the altitude range of 2700-3100 m asl. Tarmaber district has bimodal rainfall while that of Bassona-Worana is unimodal. The two districts dominantly produce barley, wheat and faba bean.

### Treatments and management

The demonstration was conducted on 7 male farmers, each farmer as a replication comprising four malt barley varieties: Fanaka, HB1963, HB1964 and IBON 174/03 (check), which are described and presented in Table 1. The plot size for each variety was 100 $m^2$. The demonstration was planted at the seed rate of 100 kg $ha^{-1}$ with broadcast during the last week of June 2017 by preparing broad beds and furrows (BBF) to drain out excess soil water. Urea and NPS fertilizer at the rate of 50 and 100 kg ha$^{-1}$ was applied during planting, respectively. Selective grass weed killer, Axial herbicide was applied once during the fourth week after planting. The crop was harvested from second week of October to last week of November due to differences of the sites and varieties in terms of altitude and maturity time.

## Implementing, monitoring and promoting participatory activities

The approach followed during the implementation of the activities was Farmers Research and Extension Group (FREG) with multidisciplinary team of researchers (such as breeders, agronomists, crop protectionists, extensionists, and socio-economists with different level of participation when necessary), extension workers and farmers. Training was given for participant farmers and development agents. Researchers, experts, development agents and farmers did continuous field monitoring and evaluations. Field days and variety evaluations were done by inviting different stakeholders and farmers during the maturity stage of the crop.

*Table 1. Description of malt barely varieties selected for demonstration*

| Variety | Year of release | Grain protein (%) | TKW (g) | Grain yield (t ha$^{-1}$) | Dates to maturity | Altitude (m) |
|---|---|---|---|---|---|---|
| Fanaka | 2015 | 9-12 | 45.0 | 2.6-3.8 | 110-140 | 2000-2600 |
| HB1963 | 2016 | 10.6 | 47.9 | 3.5-6.0 | 146 | >2300 |
| HB1964 | 2016 | 11.5 | 55.1 | 3.3-5.6 | 138 | >2300 |
| IBON 174/03 | 2012 | 10.0 | 46.5 | 3.0-5.7 | 120 | 2000-2800 |

*Source: MoA, 2012, 2016a, 2016b*
*Note: TKW = thousand kernel weight*

# Data collection and analysis

Both biological and social data were recorded starting from training to variety selection and harvesting. Biological data like plant height, spike length, number of tillers, number of seed per spike, and 1000-grain weight were recorded. Yield data of each variety in each farmer's field were collected from 5 samples using x- fashion sampling methods, each sample being a 1 m$^2$ quadrant. These agronomic data were analyzed by ANOVA and non-parametric correlation (Spears' Man correlation).

Feed backs from farmers and experts during training; monitoring and field day were recorded. The farmers and development agents set selection criteria and evaluated varieties accordingly. Finally, social data and farmers' preferences were analyzed by using pair wise and preference ranking techniques. Pair wise comparison matrix is often used in multi-attribute decision making for weighting the attributes or for the evaluation of the alternatives with respect to a criterion.





# Results and Discussions

## Trainings and field days

Multi-disciplinary team of researchers from Debre Birhan Agricultural Research Center (DBARC) provided training to 65 farmers (3 female) and 11 experts (5 female) about the agronomic performances of the malt barley varieties selected for demonstration; available technologies of malt barley to improve productivity and production; and grain quality of malt barley and how to improve it.

A total of 84 farmers (12 female) and 31 technical staff of stakeholders (4 female) participated in the field days organized after heading stage of malt barley varieties demonstrated in the two districts. The demonstrated malt barley varieties were evaluated and ranked by farmers during the field day. Farmers and experts from agricultural development offices of the two districts were very impressed by the performance of the newly introduced malt barley varieties and they promised to expand the production of the best-ranked variety in the two districts. Farmers also promised to produce the variety in large scale for market if the linkages are created or for home consumption being barley is a major food crop.

## Farmers' preference

Farmers evaluated the three newly released varieties (Fanaka, HB1963 and HB1964) against the check (IBON 174/03) by setting their own selection criteria, which were weighted. Eighty four (12 female) randomly selected farmers participated during evaluation of the varieties in each district. The results of each district are presented independently in Tables 2, 3, 4 and 5 because of the traits selected by farmers for variety evaluations were different. The major selection attributes listed by farmers in Tarmaber were spike length, plant height, seed size, number of seed per spike, tiller number, frost tolerance and earliness.

*Table 2. Pair wise ranking matrix of attributes for malt barely varieties demonstrated in Tarmaber district*

| Attribute | SL | TL | FT | PH | GS | E | NSPS | Score | Rank |
|---|---|---|---|---|---|---|---|---|---|
| SL | | TL | FT | SL | SL | E | NSPS | 1 | 6 |
| TL | | | FT | TL | SL | TL | NSPS | 3 | 4 |
| FT | | | | FT | FT | FT | FT | 6 | 1 |
| PH | | | | | SS | E | NSPS | 0 | 7 |
| SS | | | | | | SS | SS | 5 | 2 |
| E | | | | | | | NSPS | 2 | 5 |
| NSPS | | | | | | | | 4 | 3 |

*Note: SL=spike length, TL= number of tillers, FT= frost tolerance, PH= plant height, GS= grain size, E =earliness, NSPS= number of seed per spike*

According to the criteria prioritized in Table 2, farmers preferred HB1964, HB1963, IBON 174/03 and Fanaka malt barley varieties as the first, second, third and fourth, respectively, by all attributes in Tarmaber district (Table 3).

*Table 3. Farmers' preference ranking matrix of malt barely varieties demonstrated in Tarmaber District*

| Variety | SL | TL | FT | PH | SS | E | NSPS | Total | Rank |
|---|---|---|---|---|---|---|---|---|---|
| HB1964 | 1.2 | 1.5 | 1.2 | 1 | 1.2 | 2.7 | 1.1 | 1.03 | 1 |
| HB1963 | 2.6 | 2.4 | 2.5 | 2.3 | 2.2 | 2.2 | 2.6 | 2.40 | 2 |
| IBON 174/03 | 2.4 | 2.3 | 2.5 | 2.7 | 2.5 | 1.8 | 2.7 | 2.41 | 3 |
| Fanaka | 3.4 | 3.7 | 3.8 | 3.9 | 3.8 | 2.7 | 3.6 | 3.8 | 4 |

*Note: SL=spike length, TL= number of tillers, FT= frost tolerance, PH= plant height, SS=seed size, E =earliness, NSPS= number of seed per spike; 1= best and 4=least preferred*

The major attributes listed by farmers in Bassona-Worana district were seed size (boldness), spike length, plant height, frost tolerance, earliness, and tiller number (Table 4).

*Table 4. Pairwise ranking matrix of selected attributes for malt barely at Bassona-Worana district*

| Attribute | SS | SL | PH | FT | E | TL | Score | Rank |
|---|---|---|---|---|---|---|---|---|
| SS | | SS | SS | FT | SS | SS | 4 | 2 |
| SL | | | SL | FT | SL | SL | 3 | 3 |
| PH | | | | FT | PH | TL | 1 | 5 |
| FT | | | | | FT | FT | 5 | 1 |
| E | | | | | | TL | 0 | 6 |
| TL | | | | | | | 2 | 4 |

*Note: SS=seed size, SL=spike length, PH=plant height, FT=frost tolerance, E =earliness, TL= number of tillers*

Based on the criteria prioritized in Table 4, farmers preferred HB1964, HB1963, Fanaka and IBON 174/03 malt barley varieties as the first, second, third and fourth, respectively, by all attributes in Bassona-Worana district (Table 5).

*Table 5. Farmers' preference ranking matrix of malt barely varieties demonstrated in Bassona-Worana district*

| Variety | SS | SL | PH | FT | E | TL | Average | Rank |
|---|---|---|---|---|---|---|---|---|
| HB1964 | 1.4 | 1.5 | 1.3 | 1.4 | 3.4 | 2.3 | 1.88 | 1 |
| HB1963 | 2.4 | 2.5 | 2.1 | 2.6 | 3.2 | 1.4 | 2.37 | 2 |
| Fanaka | 2.6 | 2.75 | 2.9 | 2.5 | 2.2 | 2.9 | 2.64 | 3 |
| IBON 174/03 | 3.6 | 3.25 | 3.7 | 3.5 | 1.2 | 3.0 | 3.04 | 4 |

*Note: SS=seed size, SL=spike length, PH=plant height, FT=frost tolerance, E=earliness, TL=number of tillers; 1=best and 4=least preferred*





In Bassona-Worana and Tarmaber districts, the common farmers' preference traits were spike length, number of tillers, plant height, grain size, earliness and frost tolerance. The farmers' preference ranking agreed with most of the agronomic data of the varieties (Table 6).

*Table 6. Farmers preference and values of agronomic traits, combined over locations*

| Variety | Preference ranking | PH | TN | SL | NSPP | TGW | SY | GY |
|---|---|---|---|---|---|---|---|---|
| HB1963 | 2 | 74.47 | 7.0167a | 7.45b | 25.933 | 40.3b | 6580 | 3059.6a |
| IBON 174/03 | 4 | 78.35 | 5.2667ab | 9.75a | 28.167 | 47.807a | 6077 | 2324.4ab |
| HB1964 | 1 | 74.1 | 6.9833a | 7.825b | 26.167 | 40.04b | 7068 | 3138.8a |
| Fanaka | 3 | 76.28 | 4.7167b | 6.75b | 26.633 | 45.22a | 5137 | 2122.6b |
| CV | | 10.6 | 25.8 | 11.4 | 6.4 | 8.7 | 26.5 | 25.6 |
| Sig | | ns | * | ** | ns | ** | ns | * |

*Note: PH = plant height (cm); SL= spike length (cm); TN = tiller number per plant; NSPP = number of seeds per spike, TGW = thousand grain weight (g); SY = straw yield (kg ha$^{-1}$); GY = grain yield (kg ha$^{-1}$); ns = not statistically significant; *significant at 5%; **significant at 1%; ranking: 1= best and 4=least.*

## Cost benefit analysis

The cost benefit analysis helps to evaluate agricultural productivity of experimental materials in terms of inputs (costs) and outputs (benefits) and see how smallholders decide to use improved technologies. In cost-benefit evaluation, every transaction was monetized so that calculating the net benefits to cost ratio to determine the optimal productivity and treatment choice that smallholders could most likely prefer. The total amount spent on treatment was spread out against each treatment; and spread to all the potential benefits across each treatment in monetary form. The results are presented in Table 7.

The net benefit to total cost ratio for each treatment were 1.22, 1.57, 2.20 and 2.00 for Fanaka, IBON 174/03, HB1964 and HB1963, respectively. The principle is that the higher the net benefit to total cost ratio per treatment productivity, the most preferable would that smallholders use treatment. Therefore, the most preferred variety by the farmers was HB1964 with 2.20 net benefits to total cost ratio.

*Table 7. Cost-benefit analysis of malt barley varieties demonstrated in the districts*

| Parameter | Fanaka | IBON 174/03 | HB1964 | HB1963 |
|---|---|---|---|---|
| Grain yield (t ha$^{-1}$) | 2.12 | 2.32 | 3.14 | 3.06 |
| Adjusted grain yield (t ha$^{-1}$) | 1.91 | 2.09 | 2.83 | 2.75 |
| Straw yield (t ha$^{-1}$) | 5.14 | 6.58 | 7.07 | 6.08 |
| Total benefit (Birr ha$^{-1}$) | 38160 | 44252 | 55141 | 51602 |
| Seed cost (Birr ha$^{-1}$) | 1750 | 1750 | 1750 | 1750 |
| Labor cost (Birr ha$^{-1}$) | 9020 | 9020 | 9020 | 9020 |
| Land rent (Birr ha$^{-1}$) | 4500 | 4500 | 4500 | 4500 |
| Fertilizer cost (Birr ha$^{-1}$) | 1800 | 1800 | 1800 | 1800 |
| Herbicide cost (Birr ha$^{-1}$) | 150 | 150 | 150 | 150 |
| Total cost (Birr ha$^{-1}$) | 17220 | 17220 | 17220 | 17220 |
| Net benefit (Birr ha$^{-1}$) | 20940 | 27032 | 37921 | 34382 |
| Net benefit to total cost ratio | 1.22 | 1.57 | 2.2 | 2.0 |

## Conclusion and Recommendation

Farmers' preference and agronomic data results were mostly in agreement in all districts. The two best varieties HB1964 and HB1963 as per farmers' preferences also gave the corresponding highest grain yields of 3.14, and 3.06 t ha$^{-1}$ with their respective preference ranking of first and second across the test locations. These results suggest that varieties HB1964 and HB1963 should be promoted for scaling up and out in the test locations and similar areas in the highlands of North Shewa. The late maturing variety HB1963 should be avoided in frost prone areas.

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# Demonstrating Malt Barley Technologies in the Central Highlands of Ethiopia

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## Introduction

Barley cultivation is an old heritage in Ethiopia with many landraces and traditional practices. Production of malting barley, however, has a very short history and it is mainly associated with the establishment of the St. George Brewery in the early 1920s in Ethiopia (Tadesse, 2011). Malt barley production has not expanded as expected, despite the potential of the country to grow malting barley both in quality and quantity. The National Agricultural Research System (NARS), has developed more than 12 malt barley varieties over the last three decades where the contribution of ICARDA was significant in the provision of germplasm and technical support in the development of the malt barley technologies. Even though barley grows in many highland regions of the country, only a few malt barley varieties are adopted in the Arsi highlands and to a lesser extent in Bale highlands in southeastern Ethiopia where farmers can sell their produce to the Asela Malt Factory. Currently, there is an attempt to promote malt barley production in the central highlands and northwestern (Amhara Region) of Ethiopia to produce and provide malt to breweries through contractual production.

Currently, the demand for good malt product is increasing due to the expansion in the number of malt factories and the number of breweries in Ethiopia. The recent data indicate that from the total malt demand, the domestic market covers about 35% whereas the remaining 65% is imported from outside (Lakew et al., 2016). This implies that Ethiopia has been spending a huge amount of foreign currency to import malt to meet the demand for malt factories and breweries. Improving the knowledge and skill of farmers through demonstrating new malt barley varieties would be vital to increase productivity and production to fill the existing supply gap in the country. Cognizant of this, demonstration of malt barley technologies was conducted to create awareness and demand of new malt barley technologies; enhance rapid diffusion, dissemination and adoption of improved malt barley technologies; and collect feedback and assess farmers' preferences on the technologies.

## Materials and Methods

### Study locations

Demonstration of recently released improved varieties with full recommended agronomic packages were conducted for three years (2015-2017) in Degem, Ejere, Jeldu, Kersa-Malema, and Wolmera districts. These districts are found in West Shewa, North Shewa, and Southwest Shewa Zones of Oromia Region.



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Adadi testing site is situated at 8° 38'N and 38° 30'E at an altitude of 2050 m (Keneni, 2007) in Kersa Malema district (Southwest Shewa) with an average annual rainfall of 900 mm. The soil type of the area is Nitosols.

The testing site in Jeldu district is Nitisols located at an altitude of 2800 m in the vicinity of Gojo town at 9°16'N and 38° 05'E in West Shewa Zone. It receives an average annual rainfall of 1200 mm with an average annual maximum and minimum temperature of 16.9°C and 2.06°C, respectively. The soil type is characterized as humic Nitosols.

The sites in Wolmera and Ejere districts are situated at altitudes of ≥2435 m; the geographic coordinate of one of the sites is 09° 05' N latitude and 38°31' E longitude in West Shewa Zone. The major soil type of the barley growing area is characterized as Nitosols. The two districts have similar agro-ecologies where diverse crops such as bread wheat, food barley, potato, highland pulse crops (faba bean and field pea), and highland oil crops (linseed, mustard are largely produced.

The testing sites in Degem district in North Shewa Zone of Oromia Region are located at the altitude of 2700 to 3000 m and representing the high-altitude crop-livestock production systems.

In all the testing sites in the respective districts, the major rotation crops are faba bean, field pea, potato, linseed, and mustard.

## Demonstration packages

Both the improved varieties and the check received the recommended agronomic packages (Table 1). Plot size for demonstration of each variety was 300 $m^2$. All non-experimental variables determined by the host farmer were kept constant. In all three years, planting was done in June, and harvesting was completed from mid-October to early November depending on the weather condition of the area and maturity of the varieties. In collaboration with extension workers, three voluntary farmers from each district representing three sites per district were selected for conducting the demonstration on their farm fields.

*Table 1. Details of demonstration packages*

| Technology | Description | Remarks |
|---|---|---|
| Improved varieties | Bekoji-1, EH 1847, IBON 174/03 | Released in 2010 |
| Check | Holker | Released in 1973 |
| Seed rate | 125 kg $ha^{-1}$ | |
| Sowing method | Row spacing at 20 cm | |
| Weed management | Hand weeding, 1-2 times | |
| Fertilizer rate | 41/46 kg $ha^{-1}$ of $N/P_2O_5$ | |
| Disease control | No fungicide application | New varieties are tolerant to barley leaf diseases |

Source: National extension package, MoA

## Organizing trainings and field days

Prior to planting, theoretical training supported by on-farm practical training was organized to increase farmers' knowledge and skills about the new technologies. In addition, development agents were involved actively in the executing the demonstrations. Frequent monitoring was conducted to correct crop management problems on time. Field days, and participatory monitoring and evaluation events were organized to make farmers, development agents, and other stakeholders evaluate the performance of the three improved malting barley varieties and the check. Evaluation parameters were yield potential and farmers' perception of the attributes of the improved varieties. Finally, grain yield was recorded and analyzed using SPSS.

# Results and Discussions

## Yield and yield advantage

Grain yield data of malt barley varieties tested in the demonstration trials are presented in Tables 2 and 3. The analysis of variance showed that there was a significant difference between years, districts, and varieties ($p<0.05$). The mean yield of the years was 3.31, 1.76, and 4.12 t ha$^{-1}$ in 2015, 2016, and 2017, respectively. The 2016 crop season was poor for grain yield due to frost damage at the grain-filling period. Out of the five districts, the highest mean grain yield was recorded at Kersa Malima (4.26 t ha$^{-1}$) followed by Wolmera (3.00 t ha$^{-1}$), Degem (2.95 t ha$^{-1}$), and Ejere (2.69 t ha$^{-1}$) while the lowest was at Jeldu (1.75 t ha$^{-1}$) (Table 2). Mean grain yield of the varieties, EH 1847 (3.17 t ha$^{-1}$), Bekoji-1 (3.35 t ha$^{-1}$), and IBON 174/03 (3.75 t ha$^{-1}$) was higher than the mean yield of the variety Holker (Table 3). The mean grain yield of the varieties in some of the districts was below the national average due to the occurrence of a serious frost damage and end of season moisture stress in 2016 (Table 2).

*Table 2. Grain yield of malt barley varieties in North, West and Northwest Shewa Zones during 2015-2017*

| District/year | Mean grain yield (t ha$^{-1}$) |
|---|---|
| District | |
| Degem | 2.95 |
| Ejere | 2.69 |
| Jeldu | 1.75 |
| Kersa Malima | 4.26 |
| Wolmera | 2.93 |
| Year | |
| 2015 | 3.31 |
| 2016 | 1.76 |
| 2017 | 4.12 |



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*Table 3. Grain yield of malt barley varieties in North, West and Northwest Shewa Zones during 2015-2017*

| Variety | Number of demonstrations | Number of farmers involved* | Mean grain yield (t ha$^{-1}$) | Protein content (%) |
|---|---|---|---|---|
| EH1847 | 40 | 33 | 3.17 | 9.9 |
| Bekoji-1 | 40 | 33 | 3.35 | 10.6 |
| IBON 174/03 | 40 | 33 | 3.75 | 11.3 |
| Holker (check) | 40 | 33 | 2.63 | 9.8 |

Note: *Out of the 33 farmers involved in the demonstration, three of them are women

Yield advantage of the recently released varieties in demonstration plots over the check, Holker, was considerably high (Table 3). The yield increment over the check was 20.5, 27.4, and 42.6 % for EH1847, Bekoji-1, and IBON 174/03, respectively. The result indicated that the crop technology demonstration showed a good impression on the farming community as they were motivated by the recommended technologies applied in the demonstration fields. This suggests the positive impact of improved malt barley technologies in the demonstration trials over old technologies and farmer's practices. Similar impacts of on-farm demonstration were also observed by (Yirga et al., 2002; Keneni et al., 2002 and Agegnehu et al., 2002) in various crops in varied socio-economic conditions. In general, IBON 174/03 performed better than the two varieties, with better wider adaptation and enhanced agronomic performance in terms of earliness.

## Farmers' assessment

Summary of the farmers' ranking of malt barley varieties tillering capacity, disease tolerance, lodging resistance, spike length and biomass yield is shown in Table 4. Most of the respondents favored the improved varieties for their yield potential, biomass yield, and disease resistance than the check (Holker). Moreover, IBON 174/03 was the most favored variety for its earliness and good yield potential. EH 1847 was the second-preferred variety for its better lodging resistance and biomass yield while Bekoji-1 was ranked third for its weakness in lodging resistance. The overall farmers' assessment showed that IBON 174/03 was first followed by EH 1847 and Bekoji-1 and the check, Holker was the least preferred variety for its disease susceptibility, low yield potential and poor adaptation at some demonstration sites.

*Table 4. Farmer's direct matrix ranking of malt barley varieties*

| Attribute | Rank | | | |
|---|---|---|---|---|
| | EH1847 | Bekoji-1 | IBON 174/03 | Holker |
| Tillering capacity | 1 | 2 | 3 | 2 |
| Disease tolerance | 2 | 2 | 1 | 3 |
| Lodging resistance | 3 | 3 | 1 | 3 |
| Spike length | 2 | 3 | 1 | 2 |
| Biomass yield | 2 | 2 | 2 | 2 |
| Overall performance | 2 | 3 | 1 | 3 |

## Training, meetings, and field days

On-farm training and consultative meetings were organized during the past three consecutive years to increase the knowledge and skills of farmers and development agents on the new malt barley technologies. The training was designed and delivered on proper land management, advantage of row planting, the use of proper seed rate, and pest control. The number of participants from different organizations participated in various trainings and meetings are indicated in Table 5. In addition, a consultative meeting with zone and district officials, Oromia seed regulatory agency, and cooperative representatives gathered from four zones and 18 districts was conducted at Holetta Agricultural Research Center. The aim was to plan together, share responsibilities, and facilitate the overall demonstration activities and further follow up of the technologies.

*Table 5. Number of participants who attended trainings and meetings in 2015-2017*

| Category of participant | Participant | | |
|---|---|---|---|
| | Male | Female | Total |
| Farmers | 104 | 17 | 118 |
| District office of agriculture and DAs | 57 (24) | 14 | 71(24) |
| District administration | 5 | 0 | 5 |
| Union | 1 | 0 | 1 |
| Oromia Seed Regulatory Agency | 1(1) | 0 | 1(1) |
| Researchers | 27 | 0 | 27 |
| ICARDA | 1 | 0 | 1 |
| ISSD | 1 | 0 | 1 |
| Total | 165 (25) | 31 | 196(25) |

*Note: DAs = development agents at kebele level, which is the grass root administration unit; figures in parenthesis indicate additional district bureau officials and professionals who attended consultative meetings.*

Field days were organized in Wolmera district at Duffa kebele to promote the existing technologies to farmers, district agricultural offices, unions, and cooperative representatives (Table 6). After the field visit, the participants discussed seed production and quality issues such as agronomic management, production of quality seed, and post-harvest management.



**CHAPTER II**: Malt barley technology validation and demonstration

*Table 6. Type and number of field day participants*

| Category of participant | Number of participants | | |
|---|---|---|---|
| | Male | Female | Total |
| Farmers | 68 | 20 | 88 |
| District office of agriculture heads/experts and Das | 57 | 14 | 71 |
| District administration heads/experts | 5 | 0 | 5 |
| Union of farmers' cooperatives | 1 | 0 | 1 |
| Oromia Seed Regulatory Agency | 1 | 0 | 1 |
| Researchers | 14 | 0 | 14 |
| Total | 132 | 34 | 166 |

*Note: DAs = Development agents based at kebele level*

## Challenges

Among the challenges encountered, the major ones include lack of proper use of recommended packages and applying row planting by farmers. Farmers were not able to drill the correct amount of seed and fertilizer exactly in the furrow due to lack of experience in row planting. Hence, the distribution of the recommended rate of seed and fertilizer was not even and uniform; the early onset and continuous rainfall in 2016 led to poor land preparation, poor germination and emergence at some locations and frost damage at the grain filling stage were challenges encountered to effectively implement the full packages and evaluate the potential of the new technologies; and engagement of focal persons and development agents in other seasonal activities at the time of planting and limited follow up of the demonstration activities.

## Conclusions and Recommendations

All the three recently released varieties Bekoje-1, EH1847 and IBON 174/03 performed well in all the demonstration sites compared to the check (Holker). IBON 174/03 was consistent in overall performance compared to EH1847 and Bekoji-1, which were also good in most of the demonstration sites and are good alternative varieties for further production. Generally, based on farmers' assessment and agronomic performance, variety IBON 174 03 was recommended for further scaling up because of its high yield potential, disease resistance, and good malting quality traits. Varieties EH1847 and Bekoji-1 are also good candidates for further scaling up, especially in the potential highland areas with long production seasons for their good grain yield potential, biomass yield, and good malting quality traits. The results of these demonstration trials showed that participation and interaction with farmers in the evaluation and selection of varieties were useful to get feedback on the technologies for future improvement and promotion of farmers' preferred technologies on a wider scale.

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**CHAPTER II**: Malt barley technology validation and demonstration

# Demonstrating Malt Barley Technologies and Production Packages in Sidama Zone

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## Introduction

According to CSA (2016), in Southern Nations Nationalities and Peoples Regional State (SNNPRS), barley covers total area of about 80,861 ha (9.36 % of area allocated to cereals) and produces 142,437 t of grain (7.19% of cereals production) whereas in Sidama Zone alone it covers 13,231 ha (26.97% of area allocated to cereals) producing 23,809 t per year (18.45% of cereals production). Productivity of barley in SNNPRS (1.76 t ha$^{-1}$) as well as in Sidama Zone (1.80 t ha$^{-1}$) is less than the national average (1.97 t ha$^{-1}$), which could be attributed partly to low yielding potential of the existing varieties and lack or low adoption of the newly released varieties.

The lack or low adoption of new improved varieties could be due to farmers' limited access to those varieties (Witcombe et al., 1996; Courtois et al., 2001), their poor adaptation to specific environments (Courtois et al., 2001) and/or their failure to fulfill the post-harvest requirements of farmers (Joshi and Witcombe, 1996). The participation of farmers in selecting varieties helps to fit varieties to farmers' local environmental conditions (Sthapit et al., 1996) as well as to increase their adoption and dissemination (Witcombe and Joshi, 1996). Therefore, on-farm demonstrations of improved malt barley varieties with their associated production packages were conducted in 2016 and 2017 in order to identify high yielding and farmers' preferred variety.

## Materials and Methods

### Study locations

On-farm demonstrations of improved malt barley varieties was conducted in three districts (Dara, Hula and Melga) in Sidama Zone, southern Ethiopia. The soils of the testing sites are moderately to strongly acidic (ATA, 2016). Major crops in all on-farm demonstration villages of the three districts are barley, wheat, enset, potato and faba bean. The annual and crop growing period weather data at Wojigra Town of Melga district in 2016 and 2017 are presented in Table 1 for it is nearby to the demonstration villages. Altitude and geographic coordinates of the testing villages of Melga district in 2017 are presented in Table 2.

The annual and crop growing period (July to December) rainfall recorded at nearby town of Agere Selam and Hula districts in 2016 was 1492 and 833mm, respectively. The altitude of testing sites ranged from 2742 to 2797 m with geographic coordinates of 06°28'61" to 06°31'29" N and 38°29'16" to 38°30'50" E. The rainfall and temperature information from Agere Selam station equally works for Dara district because this station is the closest to demonstration villages of Dara district.

*Table 1. Rainfall and temperatures of sites in Malga district (recorded at Wojigra Station in 2016 and 2017)*

| Item | Annual | | Growing period (July to December) | |
|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 |
| Rainfall(mm) | 1279 | 994 | 545 | 573 |
| Max. temperature, °C | 23.2 | 23.2 | 22.5 | 22.2 |
| Mini. Temperature, °C | 12.5 | 12.0 | 12.0 | 11.6 |
| Aver. Temperature, °C | 17.9 | 17.6 | 17.3 | 16.9 |

Source: Ethiopian Meteorology Agency, Hawassa

*Table 2. Altitude and geographic coordinates of malt barley demonstration villages in Melga district*

| Farm | Altitude (masl) | Latitude (N) | Longitude(E) | Village |
|---|---|---|---|---|
| Farm 1 | 2648 | 06°58'56" | 38°42'09" | Guguma Burara |
| Farm 2 | 2650 | 06°59'51" | 38°42'16" | Guguma Burara |
| Farm 3 | 2629 | 06°59'57" | 38°42'35" | Guguma Burara |
| Farm 4 | 2652 | 06°58'95" | 38°41'86" | Gumesho Tulu |

## Treatments and cultural practices

On-farm demonstrations were conducted in 2016 in Dara, Hulla and Melga districts, and in 2017 Hula and Melga districts from July to December during main cropping season on 16 sites. In 2016, two farmers in Melga, three in Hula, and four in Dara; and in 2017, four in Melga and three in Hula districts were selected based on their prior experience on using improved varieties, willingness to conduct the demonstrations and proximity to village gate or main road. Land preparation involved four times plowing before planting whereas plot size was 100 $m^2$ for each variety planted in row spacing of 20 cm at the seed rate of 100 kg $ha^{-1}$. In 2016, four improved varieties [(Bahati, EH1847, IBON 174/03, Traveler (check in Melga)] and in 2017 three improved varieties [(HB1963, HB1964, IBON 174/03 (check)] were on-farm planted in late July. Urea and NPS fertilizers at the respective rate of 50 and 100 kg $ha^{-1}$ were applied at planting. Up to four times hand weeding were done whenever necessary. Harvesting was done in December.

## Organizing trainings and field days

Training on the content of the technologies to be demonstrated and management practices to be applied was provided to farmers, district level experts, development agents and researchers. During late grain filling stage towards maturity, field days were organized by inviting farmers, zonal and district level experts, development agents and researchers to evaluate the technologies, enhance stakeholders' linkage, to create awareness and demand for the technologies.





## Data collection

In addition to grain yield (kg $ha^{-1}$), farmers' preference was assessed on field days during grain filling period in both in 2016 and 2017. Farmers' selection criteria were spike length, seed size, number of seeds per spike, earliness to heading and maturity, and lodging resistance.

# Results and Discussions

## Training and field days

Seventy-three farmers (13 females), 28 district level experts, and village level development agents (1 female), and 20 researchers (all male) were trained (Table 3) on site selection, land preparation, sowing, fertilizer application, weed control, harvesting and threshing, seed inspection and certification, post-harvest handling and marketing, 3 or 4 weeks before planting.

*Table 3. Trainees of malt barley seed production and marketing in Dara, Hula and Melga districts in 2016 and 2017*

| Category of participants | Number of participants | | |
|---|---|---|---|
| | Male | Female | Total |
| Farmers | 60 | 13 | 73 |
| District level experts and village level development agents | 27 | 1 | 28 |
| Junior researchers | 20 | 0 | 20 |

Eight-five farmers (11 females), 26 zonal and district level experts and village level development agents (5 females), and 55 researchers (12 females) participated in field days (Table 4) organized by Hawassa Agricultural Research Center in cooperation with extension partners. During field days, participants discussed on the production constraints of malt barley, marketing and demands of breweries.

*Table 4. Participants of field days on malt barley demonstrations in Hula and Dara districts in 2016 and 2017*

| Category of participants | Number of participants | | |
|---|---|---|---|
| | Male | Female | Total |
| Farmers | 74 | 11 | 85 |
| Zonal and district level experts and village level development agents | 21 | 5 | 26 |
| Researchers | 43 | 12 | 55 |

## Grain yield and farmers' evaluation

Grain yield and yield gap (kg $ha^{-1}$) of malt barley varieties in on-farm demonstrations in Dara, Hulla, and Melga districts in 2016 are presented in Table 5. In 2016, varieties IBON 174/03 and EH1847 gave the respective average grain yield of 2800 and 2650 kg $ha^{-1}$ compared to the check variety Traveler, which gave 2270 kg $ha^{-1}$ in Melga. Similarly, these varieties gave the respective grain yield of 3630 and 3233 kg ha$^{-1}$ compared to the check variety Bahati, which gave 3000 kg ha$^{-1}$ in Hula. However, in Dara, the respective grain yield of these varieties was lower by 433 and 66 kg ha$^{-1}$ than the check variety Bahati, which gave 3233 kg ha$^{-1}$. Despite sufficient rainfall during crop duration and relatively similar soil reaction in all districts, the low yield of Melga compared to Hula and Dara could be partly attributed to poor weed control practices on demonstration plots by some host farmers in Melga. These problems also happened during demonstrations of 2017 in both Melga and Hula districts (Table 6).

*Table 5. Grain yield and yield gap (kg ha$^{-1}$) of malt barley varieties in on-farm demonstrations in Dara, Hulla and Melga in 2016*

| Variety | Melga (n=2)[1] | | Hula (n =3) | | Dara (n =4) | |
|---|---|---|---|---|---|---|
| | Yield | Yield gap | Yield | Yield gap | Yield | Yield gap |
| IBON 174/03 | 2800 | 530 | 3630 | 630 | 2800 | -433 |
| EH1847 | 2650 | 380 | 3233 | 233 | 3167 | -66 |
| Bahati (check) | - | | 3000 | | 3233 | |
| Traveler (check) | 2270 | | - | | - | |
| Mean | 2573 | | 3288 | | 3067 | |

In 2017, varieties HB1963 and HB1964 gave the respective higher grain yield of 700 and 325 kg ha$^{-1}$ over the check variety IBON 174/03, which gave 2925 kg ha$^{-1}$ in Melga district. However, variety HB1964 gave lower grain yield than the check variety IBON 174/03 in Hula (Table 6). Based on the farmers' assessment using 20 farmers (2 females) in Melga in 2017, HB1964 also exhibited highest average performance with the average rank of 2.4 compared to 1.8 for HB1963 and IBON 174/03 (Table 7), mainly because of its long spike length and high seed number per spike. However, in terms of earliness in heading and maturity, and lodging resistance variety IBON 174/03 was most preferred.

*Table 6. Grain yield and yield gap (kg ha$^{-1}$) of malt barley varieties in on-farm demonstrations in Hula and Melga in 2017*

| Variety | Melga (n=4)[1] | | Hula (n =3) | |
|---|---|---|---|---|
| | Yield | Yield gap | Yield | Yield gap |
| HB1963 | 3625 | 700 | 3333 | 833 |
| HB1964 | 3250 | 325 | 2367 | -133 |
| IBON 174/03 (check) | 2925 | | 2500 | |
| Mean | 3267 | | 2733 | |





*Table 7. Grain yield (kg ha$^{-1}$) and farmers' ranking of malt barley varieties demonstrations in Melga in 2017*

| Variety | GY | SL | SS | SN | EL | LR | Mean |
|---|---|---|---|---|---|---|---|
| HB1963 | 3625 | 2 | 3 | 2 | 1 | 1 | 1.8 |
| HB1964 | 3250 | 3 | 2 | 3 | 2 | 2 | 2.4 |
| IBON 174/03 (check) | 2925 | 1 | 1 | 1 | 3 | 3 | 1.8 |

Note:1=poor; 2=good; 3=very good; GY=grain yield; SL=spike length; SS=seed size; SN=seed number; EL=earliness in heading and maturity; LR=lodging resistance

Farmers most preferred large seeds, long spike and high number of seeds per spike because varieties having these characters would be expected to give high yield. However, this does not always hold true as the results in Table 7 show that the less preferred variety HB1963 gave higher grain yield of 3625 kg ha$^{-1}$ than the most preferred variety HB1964, which gave 3250 kg ha$^{-1}$. The importance of seed size as farmers' selection criterion has also been reported for common bean (Assefa et al., 2005), maize (Tadesse et al., 2014) and faba bean (Mulualem et al., 2012). In the present demonstrations, farmers preferred variety IBON 174/03 for its earliness in heading and maturity, which would give not only early food security in the season but also helps to escape frost and heavy rain damage late in the season. Earliness has also been considered as the most important selection criterion of farmers in drought prone areas for crops such as barley (Ceccarelli et al., 2001), common bean (Assefa et al., 2005), faba bean (Mulualem et al., 2012), maize (Mulatu and Zelleke, 2002; Tadesse et al., 2014) and sorghum (Muui et al., 2013).

## Conclusions and Recommendations

In 2016, variety IBON 174/03 in Melga and Hula, and variety Bahati in Dara Districts gave high yield. In 2017, variety HB1963 gave high yield compared to varieties HB1964 and IBON 174/03 in both Melga and Hula. The present demonstrations would indicate that variety HB1963 would be recommended for future dissemination in Melga and Hula Districts as an alternative to variety IBON 174/03, which has already been promoted.

## Acknowledgments

Melga, Hula and Dara districts' agriculture and natural resource development offices participation in selection of demonstration sites are highly acknowledged.

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**CHAPTER II**: Malt barley technology validation and demonstration

# Demonstrating Malt Barley Varieties in Eastern and Southeastern Zones of Tigray

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## Introduction

Malt barley has wide range of adaptability and opportunities in eastern and southeastern Tigray. However, the crop has not been widely introduced in the area due to various reasons. Among others, absence of adapted improved varieties is the major constraint in the wake of introducing the crop. To address this problem, introduction and evaluation of different malt barley technologies adapted to the environmental and social conditions of potential malt barley producing highlands of Tigray has been going recently by the Mekelle Agricultural Research Center. The results of adaptation experiments on malt barley varieties during 2015 cropping season identified EH1847 and Sabini varieties for further demonstration and promotion. The study was initiated with the objectives of demonstrating these improved malt barley varieties to create awareness and demand and assesses farmers' perception on their performance.

## Materials and Methods

### Study locations

Atsbi Wenberta district is located at 65 km from Mekelle in Eastern Tigray zone of Tigray Regional State (Figure 1). One of the testing sites in the district is located at 13° 36`N and 39° 36`E. Barley producing areas of the district have altitude ranges from 2400 to 3000 masl. Rainfall is usually intense and short in duration, with an annual average of about 550-668 mm. The annual temperatures range between 15°C and 20°C, averaging 17.5°C (Araya, 2016). Major crops produced in addition to barley include wheat, tef, beans, and field pea. The geological formation of the study area is characterized by sandstones, Paleozoic sedimentary rocks, Tillite, and recent alluvial sediments (Nata and Bheemalingeswara, 2010) and Leptosols, Regosols, Cambisols, and Fluvisols are the dominant soil types (Araya, 2016).

Degua Temben district is located at about 45 km west of Mekelle in Southeastern Tigray zone of Tigray Regional State. One of the testing sites in the district is located at 39°10'E longitude and 13°38'N latitude. The district's climatic zones are lowland (kola), mid highland (woinadega) and highland (dega) with proportion of 26%, 30.5% and 43.5% of the district's area, respectively. The altitude of barley producing areas in the district includes 2618 meters above sea level and its daily temperature ranges from 18°C to 25°C. The annual rainfall of the district ranges from 600 to 800 mm (Ayenew et al., 2011). The average land holding in the district is 0.64 ha per household. The rural people in this district are mainly dependent on rainfed subsistence agriculture. Major cops like barely, wheat, hanfets (a mixture of wheat and barley), pea, lentil and faba beans are cultivated in the area. Soils of the study site was classified into four major groups: Luvisols (Alfisols), Regosols (Nitisols), Cambisols (Inceptisols), and Calcisols (Aridisols) (WRB, 2006), but the site was dominated by Luvisols (Alfisols) and Cambisols (Inceptisols).

## Demonstration approaches

Demonstration of improved malt barley varieties (EH1847 and Sabini) was conducted in Degua Temben and Atsbi Wenberta districts in 2016. Since there was no local malt barley variety in the study area, we used the improved malt barley variety Sabini as a check since it had been introduced previously to the study locations. Twenty-three adjacent farmers were selected purposely from both districts based on their willingness and capability of managing the demonstration. Planting was done from late June to first week of July in all locations at the seed rate of 100 kg $ha^{-1}$ in rows spaced apart 30 cm. Urea and DAP each at the rate of 100 kg $ha^{-1}$ were applied during planting. Plot size of each variety was 100 $m^2$. Just before planting, training on malt barley technologies and value chain, how to implement and manage field demonstrations in each district was provided to the beneficiary farmers, development agents and agricultural experts. In addition, technical backstopping was given by researchers from Mekelle Agricultural Research Center, district experts and development agents starting from planting to harvesting. The time of harvesting was from October to November in both districts.

## Data collection and analysis

Sample yield data was collected using 1 $m^2$ quadrant in crisscross sampling method. Five quadrant samples were collected for each variety from each farmer's field to estimate yield per hectare. Besides, farmers' point of view on the attributes of the variety based on the composite indicators of yield and yield components was also evaluated. Perception data were collected from beneficiaries of the districts using Likert Scale method. Data collected were coded and entered to a computer program and analyzed by SPSS version 20.0. The data were analyzed using statistical analytical techniques such as descriptive, frequency and percentage.

Besides, different parameters suggested by (Yadav et al., 2004) were used for calculating gap analysis. Technology gap and technology index were calculated using the following formula:

$$\text{Technology gap} = \textit{Potential yield - Demonstration yield}$$

$$\text{Technology index (\%)} = \frac{\textit{Potential yield - Demonstration yield}}{\textit{Potential yield}} \times 100$$





# Results and Discussion

## Training

Trainings were provided on value chain, malt barley production practices (use of improved varieties, agronomic practices, integrated weed and pest management), and management and implementation of demonstration fields. Thirty-six participants (12 female) including farmers, development agents and agricultural experts attended the trainings (Table 1).

*Table 1. Participants attended the trainings in 2016 cropping season*

| District | Farmers | | Das | | Experts | | Total |
|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | |
| Atsbi Wenberta | 9 | 4 | 3 | 1 | 2 | 1 | 20 |
| Degua Temben | 8 | 2 | 3 | - | 3 | - | 16 |
| Total | 17 | 6 | 6 | 1 | 5 | 1 | 36 |

## Yield

The results of the demonstration showed that malt barley variety EH1847 gave higher grain and straw yield than that of Sabini (Table 2). Yield advantage of EH1847 over Sabini was 37.6% for grain yield and 17.1% for straw yield (Table 3).

*Table 2. Grain and straw yield of malt barley varieties*

| Variety | Grain yield (t $ha^{-1}$) | | | Straw yield (t $ha^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Mean | Minimum | Maximum | Mean |
| EH-1847 | 1.648 | 4.706 | 3.446 | 3.833 | 11.5 | 7.5 |
| Sabini | 0.62 | 3.22 | 2.505 | 1.489 | 7.333 | 6.403 |

The technology gap being the difference between potential and demonstration yield, the study revealed that overall average technology gap was 0.304 t $ha^{-1}$ (Table 3). The observed technology gap was mainly attributed to rainfed conditions prevailing in the district. The other reasons include dissimilarity in soil fertility, salinity, marginal land holdings and other vagaries of weather conditions in the area. Mukharjee (2003) indicated that depending on identification and use of farming situation, specific interventions might have greater implications in enhancing system productivity.

Technology Index (%) showed the feasibility of the evolved technology at the farmer's field. The lower the value of technology index is the more the feasibility of the technology demonstrated (Jeengar et al., 2006). The technology index 8.1% in Table 3 shows the feasibility of the improved varieties at the farmer's field. The findings of our study are in line with the findings of (Singh et al., 2007; Ahmed et al., 2013 and Lathwal 2010).

*Table 3. Grain yield, technology gap and technology index of demonstration*

| Variety | Yield (t $ha^{-1}$) | Yield increment (%) | Technology gap | Technology index% |
|---|---|---|---|---|
| EH1847 | 3.446 | 37.56 | 0.304 | 8.1 |
| Sabini | 2.505 | | | |

## Farmers' perception

Farmers' perception on attributes of malt barley technology needs to be understood. Farmers' perceptions and preferences of improved varieties were assessed mainly on pre-harvesting and post-harvesting attributes. The percentage scores of farmers' responses to the perception statements of each attributes that relate to perceived technological characteristics are given in Tables 4 and 5.

Attributes of varieties were identified from primary sources. Pre-harvest attributes have been grouped into five categories where most of the statements are assumed to offer the relative advantages of the varieties (Table 4). These attributes are early maturity, insect resistance, disease resistance, drought resistance, and tiller number. Accordingly, farmers' perception assessment on pre harvest of malt barley variety EH1847 was conducted. Most of the sample beneficiaries appreciate the variety in terms of phenotypic traits. But few of them perceived negatively/inferior on some of the attributes. In general, malt barley variety EH1847 was rated good to very good by the respondents for most of the attributes indicated in Table 4.

*Table 4. Farmers' perception scores of pre-harvest attributes of malt barley variety EH1847*

| Attribute | Perception score (%) | | | | |
|---|---|---|---|---|---|
| | Very poor | Poor | Moderate | Good | Very good |
| *Early maturity* | | 8.3 | | 41.7 | 50.0 |
| *Insect resistance* | | | | 41.7 | 58.3 |
| *Disease resistance* | | 8.3 | | 41.7 | 50.0 |
| *Drought resistance* | | | | 41.7 | 58.3 |
| *Tiller number* | | 8.3 | | | 91.7 |

The post-harvest attributes were also identified and grouped into 15 categories. These are ear size, threshability, seed weight, seed uniformity, seed size, seed color, purity, grain yield, straw yield, straw palatability, marketability, flour quality, baking quality, beverage quality and taste (Table 5). A positive statement was prepared on each of these attributes to assess farmers' perceptions. The assessment showed that malt barley variety EH1847 was rated very good by 66.6-100% of farmers in terms of the 15 attributes indicated in Table 5; the lowest percentage being for seed weight while the highest being for ear size and threshability. The farmers' positive perceptions on both pre- and post-harvest attributes call for scaling up and out of the EH1847 malt barley variety in target districts and similar areas in Tigray.





*Table 5. Farmers' perception scores on post-harvest attributes of malt barley variety EH1847*

| Attribute | Perception score (%) | | | | |
|---|---|---|---|---|---|
| | Very poor | Poor | Moderate | Good | Very good |
| *Head size* | - | - | - | - | 100 |
| *Threshability* | - | - | - | - | 100 |
| *Seed weight* | - | 16.7 | - | 16.7 | 66.6 |
| *Seed uniformity* | - | - | - | 33.3 | 66.7 |
| *Seed size* | - | - | - | 25 | 75 |
| *Seed color* | - | - | - | 16.7 | 83.3 |
| *Purity* | - | - | - | 16.7 | 83.3 |
| *Grain yield* | - | - | - | 33.3 | 66.7 |
| *Straw yield* | - | - | - | 16.7 | 83.3 |
| *Straw palatability* | - | - | - | 25 | 75 |
| *Marketability* | - | 8.3 | - | 16.7 | 75 |
| *Flour quality* | - | 8.3 | - | - | 91.7 |
| *Baking quality* | - | - | - | 16.7 | 83.3 |
| *Beverage quality* | - | - | - | 25 | 75 |
| *Taste* | - | - | - | 8.3 | 91.7 |

## Farmers' satisfaction in extension services

The results revealed that most of the respondent farmers were highly satisfied with training (66.7%), timeliness of services (83.3%), supply of inputs (91.7%) and performance of the variety (83.3%), respectively (Table 6). Some of the respondents (16.7, 8.3 and 16.7%) expressed medium level of satisfaction on training, supply of inputs and performance of the variety under demonstration, respectively. These high level of satisfactions with respect to provided services indicate stronger conviction, physical and mental involvement in the demonstration, which in turn would lead to higher adoption.

*Table 6. Farmers' satisfaction scores on provided services*

| Service | Satisfaction level % | | |
|---|---|---|---|
| | Low | Medium | High |
| *Training* | 8.3 | 16.7 | 66.7 |
| *Timeliness of input supply* | 16.7 | - | 83.3 |
| *Input supply* | - | 8.3 | 91.7 |
| *Performance of technology* | - | 16.7 | 83.3 |

Most of the respondents confirmed that they have high interest to produce improved malt barley variety EH1847 in wider scale. This shows that the improved varieties have good acceptance by the farmers, and it is an opportunity for wider scaling up and out to other barley growing areas with similar agroecologies.

## Lessons learned

The participant farmers were interested in the newly introduced malt barley variety and interested to expand production. In the beginning, farmers were not worried about the market as far as they can use it for home consumption. They were contented with the grain and straw yield they harvested. However, there has been a lot to do in early generation seed production and sustainable market linkages.

## Conclusions and Recommendations

The yield analysis and farmers' evaluation confirmed that improved malt barley varieties satisfied farmers' requirements in most of the parameters. The improved malt barley variety EH1847 outperformed Sabini in all parameters and had good acceptance by farmers with its high yield. Therefore, scaling up and out of these improved malt barley technology in the target districts and similar areas in Tigray should be a priority undertaking. Research and other stakeholders should work on the market linkages with the malt factories and breweries such as Raya Brewery, which is operating in the region.

## Acknowledgments

The authors would like to thank Mekelle Agricultural Research Center which provided logistic support to carry out the demonstration. We sincerely thank all the farmers on whose fields' the demonstration activities were conducted.

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# Demonstrating Malt Barley Varieties in Alicho Wuriro and Gumer Districts in Siltie and Gurage Zones

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## Introduction

Barley area coverage and production in Southern Nations, Nationalities and Peoples Regional State (SNNPRS) contributes 7.22 and 6.5 %, respectively, to the nation with average productivity of 1.72 t ha$^{-1}$ (CSA, 2014), which is lower than the potential yield of the crop, at 6.0 t ha$^{-1}$ (Hasan, 2014) in France, Germany and the Netherlands (Shahidur et al., 2015), due to different factors such as lack of high yielding cultivars, poor crop management practices, weeds and low fertility conditions. Although Siltie and Gurage zones have potential to produce malt barley, the production is negligible due to lack of availability and access of improved malt barley technologies.

Demonstration provides an opportunity of getting large number of varietal and technological choices to farmers; enhances farmer's access to crop varieties and increase in diversity; increases production and ensures food security; helps to disseminate the adoption of pre and released varieties in larger areas; allows doing varietal demonstration in targeted areas at cost-effective way and also in a lesser time; and enhances seed production at community level. One of the main consequences is that a large amount of breeding material is discarded without knowing whether it could have been useful in the real conditions of farmers' fields and the one that demonstrated is likely to perform well in environments similar to the research stations and may not perform as well in the fields of the poorest farmers (Lakew et al., 1996).

Even though some varieties of malt barley had been released in Ethiopia, most of them were not demonstrated and evaluated in high altitudes. Hence, farmers of the study locations used their own local variety, which is low yielder and susceptible to diseases and weeds. Therefore, this study was specifically initiated to demonstrate improved malt barley varieties under farmer's condition through their participation.

## Materials and Methods

### Study locations

This study was conducted in Alicho Wuriro and Gumer districts in Siltie and Gurage Zones during the main cropping season of 2017. One of the testing sites in Alicho Wuriro district is located at 7° 58' N latitude and 37° 29' E longitude with an altitude range of 2453-2984 m. One of the sites in Gumer is located at 7° 54'N latitude and 38° 04'E longitude with an altitude range of 2450 to 2825 m. The dominant soil type in Alicho Wuriro and Gumer is well-drained clay loam and loam, respectively. The total annual rainfall in 2017 was 825 mm at Alicho Wuriro, and 1015.1 mm at Gumer. Similarly, the annual average temperature





was 13.26°C in Alicho Wuriro, and 14.45°C in Gumer. The most cultivated crops in the test locations are food barley, bread wheat, field pea, Irish potato, carrot, head cabbage, and enset. Food barley, enset, and faba bean are the predominant and staple food crops in both study locations.

### Site selection, varieties and management practices

Site or kebele selection based on potential production of malt barley and farmer's selection was done with collaboration of agricultural office experts working on cereal production, kebele administration and development agent by considering different selection criteria such as farmers' interest to the technology, and farmers' willingness to manage the demonstration field as required. After selection, training was organized for farmers, development agents and experts at each district. The demonstrations were conducted in Bune-Sakemo and Shilimat kebeles in Alicho Wuriro district, and Denber and Abeke kebeles in Gumer district in 2017 main cropping season. Demonstrated malt barley varieties include IBON 174/03, Sabini and HB-1533. Plot size of each variety in each farmer's field was 100 m$^2$, with no replication per farmer. A total of 12 farmers, three in each kebele, planted the test varieties in mid-July 2017 at the seed rate of 100 kg ha$^{-1}$ being drilled in rows spaced 20 cm apart. Fertilizer rate was 38/19/7 kg ha$^{-1}$ of N/P2O5/S, respectively. Hand weeding was done as frequently as weed occurred and other management practices were done as required. Towards maturity, field days were organized in each district. Harvesting was done manually in mid-October 2017 from the whole plot.

### Data collection and analysis

Grain yield was measured from the whole plot and yield was adjusted to 12.5% moisture content for data analysis. Number of kernels per spike and spike length were determined on five randomly sampled plants from the central rows of three places diagonal from the 1 m$^2$ sampling plot at maturity. A group of farmers having forty members (15 females) were organized to participate in the variety evaluation process. Farmers evaluated and ranked the varieties before harvesting and after threshing. They used parameters like grain yield, resistance to lodging, spike length and kernel number to evaluate the varieties. These evaluation criteria were identified through brainstorming.

Farmers' preferences were collected and analyzed by using simple ranking method in accordance with the given value of De Boef and Thijssen (2006). The preference ranking value was computed as:

$$\text{Rank} = \sum \frac{N}{n}$$

Where N, is value given by group of farmers for each variety based on the selection criteria and n is number of selection criteria used by farmers. The rank sum method of each trait for each variety was used to rank varieties based on farmers' selection criteria. The value of each trait has equal weight.

Statistical Package for Social Science (SPSS) Version 20 was used to analyze the varietal demonstration data collected through farmer participation.

# Results and Discussions

## Training and field days

Training to strengthen the capacity was provided in two districts for a total of 362 participants (112 females) consisting of farmers, development agents and agricultural experts (Table 1). The training covered malt barley production technologies, diseases and weed control, post-harvest loss and use of improved storage materials like PICS (Perdue Improved Crop Storage) bags.

*Table 1. Farmers, and experts and development agents trained in Alicho Wuriro and Gumer in 2017*

| District | Farmer | | Experts and DAs | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Alicho Wuriro | 100 | 60 | 4 | 2 |
| Gumer | 140 | 50 | 6 | 0 |

Field days were conducted in the two districts for participants to observe and evaluate the performance of varieties under farm conditions. All field management issues, production challenges and future directions were discussed and agreed during field days. Three-hundred farmers (78 females), 15 researchers, 12 zonal agricultural and natural resource department and district experts, 9 development agents and 2 media experts participated to exchange experiences and learn from each other, create awareness and obtain feedbacks on improved malt barley production technologies. During the field visit, farmers showed an interest to produce high yielding malt barley varieties as source of income in Gumer and Alicho Wuriro.

## Yield

The analysis of paired samples for grain yield revealed that positive and highly significant mean difference at the ($p<0.01$) was observed between Gumer and Alicho Wuriro; and negative and highly significant mean difference ($p<0.01$) was observed between Alicho Wuriro and Gumer locations. Similarly, positive and significant mean difference at the ($p<0.05$) was observed between IBON 174/03 and HB-1533; and negative and significant mean difference ($p<0.05$) was observed between HB-1533 and IBON 174/03 varieties (Table 2). The grain yield difference between IBON 174/03 and Sabini and between Sabini and HB-1533 was not statistically significant.

The mean yield of Sabini and HB-1533 were 3.4 and 3.2 t $ha^{-1}$, respectively, while the variety IBON 174/03 gave 3.80 t $ha^{-1}$ at Gumer. Productivity at Alicho Wuriro was 2.80, 2.75, and 3.10 t $ha^{-1}$ for Sabini, HB-1533 and IBON 174/03, respectively. Malt barley variety IBON 174/03 performed best in both districts although the productivity of the varieties was relatively lower in Alicho Wuriro. In Gumer, the mean grain yield performance was better than that of Alicho Wuriro due to less weed infestation, fertile soil, and good rainfall distribution.





The percentage increase in the yield of IBON 174/03 variety over Sabini and HB-1533 was 11.77 and 19 % at Gumer; and 9.67 and 11.29 % at Alicho Wuriro, respectively. This result indicated that using IBON 174/03 was more advantageous for farmers.

*Table 2. Paired samples analysis results of grain yield of locations and varieties in 2017*

| Trait | Location | | Mean difference locations | SE | Sign | SD |
|---|---|---|---|---|---|---|
| Grain yield | G | A | 0.58** | 0.09 | 0.006 | 0.39 |
| | A | G | -0.58** | 0.09 | 0.006 | |
| | Variety | | | | | |
| | 1 | 2 | 0.70ns | 0.25 | 0.06 | 0.31 |
| | | 3 | 0.90* | 0.25 | 0.03 | |
| | 2 | 1 | -0.70ns | 0.25 | 0.06 | |
| | | 3 | 0.20ns | 0.25 | 0.29 | |
| | 3 | 1 | -0.90* | 0.25 | 0.035 | |
| | | 2 | -0.20ns | 0.25 | 0.29 | |

*Note: Sign = significant probability; **, * and the mean difference is significant at the 0.01 and 0.05 probability level, respectively and ns is no significant; Locations: G = Gumer and A = Alicho; Varieties: 1 = IBON 174/03, 2 = Sabini; and 3 = HB-1533*

Pearson correlation coefficient analysis results for grain yield and yield components of malt barley varieties are presented in (Table 3). Grain yield showed significant and positive correlation with spike length and total kernel weight but not with number of kernels per spike. Spike length, number of kernels per spike and thousand kernels weight showed significant and positive correlation among themselves.

*Table 3. Pearson correlation coefficients of yield and yield components of malt barley varieties at Gumer and Alicho Wuriro in 2017*

| | SL | NKS | TKW | GY |
|---|---|---|---|---|
| SL | | 0.93** | 0.82* | 0.75* |
| NKS | 0.93** | | 0.81* | 0.71 |
| TKW | 0.82* | 0.81* | | 0.95** |
| GY | 0.75* | 0.71 | 0.95** | |

*Note: *Correlation is significant at the 0.05 and ** at the 0.01 probability level; SL = Spike length, NKS = Number of kernels per spike, TKW = thousand kernels weight*

## Farmer's preference

Considering practicality, manageable groups of 15-20 farmers were involved in variety selection in the two districts. Farmers set out main selection criteria to rank the variety (Table 4). These criteria include grain yield, straw biomass, early maturity and resistance to lodging. Based on the selection criteria, farmers indicated that IBON 174/03 was preferred by farmers and other neighbor farmers during field day organized on farmers' fields. The scores of farmers' selection criteria ranged from 2 for Sabini to 7 for IBON 174/03 at Alicho Wuriro; and 5 for HB-1533 variety to 12 for IBON 174/03 variety at Gumer. Malt barley variety IBON 174/03 received the highest scores in grain yield, early maturity and lodging resistance across the two locations, but received the lowest score in biomass at Alicho Wuriro. In the mean scores of yield and yield components indicated (Table 4), IBON 174/03 received the highest scores across the two locations and hence it was selected as best variety by farmers.

*Table 4. Farmers' preference criteria and score of the malt barley varieties in 2017*

| District | Variety | Selection criteria and scores | | | | | |
|---|---|---|---|---|---|---|---|
| | | GY | BM | EM | RL | Mean | Rank |
| Alicho Wuriro | IBON 174/03 | 6 | 3 | 5 | 7 | 5.25 | 1st |
| | Sabini | 2 | 6 | 4 | 5 | 4.25 | 2nd |
| | HB-1533 | 3 | 4 | 4 | 4 | 3.75 | 3rd |
| Gumer | IBON 174/03 | 8 | 5.5 | 12 | 10.5 | 9.00 | 1st |
| | Sabini | 5.25 | 8.25 | 8 | 10.5 | 8.00 | 2nd |
| | HB-1533 | 5 | 6 | 7 | 6 | 6 | 3rd |

*Note: GY = Grain yield, BM = Biomass, EM = Early maturity, RL = Resistance to lodging*

## Lessons learned

Even though the agroecology of the study area has high potential, limited amount of malt barley production, lack of awareness by farmers to produce malt barley, minimal adoption of improved varieties, demonstration and dissemination of the available technologies have been limited. Yield gap in the study locations due to lack of full adoption of inputs like fertilizer as recommended and soil acidity are limiting productivity and production of malt barley.

Improved agricultural technologies, knowledge transfer with stakeholders, technology multiplication using farmers and participatory varietal selection tasks were lessons for future.

## Conclusion and Recommendation

This study was conducted to evaluate yield performance of malt barley varieties under farmers' environmental conditions. The results revealed that IBON 174/03 variety out-yielded all tested varieties and was selected as the best with grain yield advantage of 10.7 and 11.8% over the second-best performing variety Sabini with similar management in Alicho Wuriro and Gumer, respectively. Grain yield had significant and positive correlation with spike length and highly significant and positive correlations with thousand grain weights. Farmers' preference ranking analysis also indicated that IBON 174/03 variety was best in its grain yield, early maturity and resistance to lodging under farmers' conditions. Therefore, this variety was recommended for wider scaling up and out at Gumer and Alicho Wuriro and similar agro ecological conditions to improve malt barley productivity and production.



**CHAPTER II**: Malt barley technology validation and demonstration

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# Validation and Demonstration of Herbicides on Malt Barley in Ofla District of South Tigray

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## Introduction

Malt barley production was confined to primarily to Arsi highlands in southeastern Ethiopia. The increasing demand for malt (MoA 2012) has necessitated the expansion of malt barley production to other potential areas across the country. However, malt barley production is limited due to low adoption and the unavailability of improved technologies such as improved varieties, quality seeds, crop management options (row planting, weed management), and poor extension system for transferring available technologies. Improved varieties and management practices have the potential of doubling the current malt barley yields. Therefore, this on-farm validation of technologies was conducted to create awareness and demonstrate the efficacy and profitability of Axial + 2,4-D herbicides application for the control of both grassy and broadleaved weed species in malt barley production.

## Materials and Methods

### Study locations

Adigolo testing location with the altitude of 2446 m asl is found in Ofla district, South Tigray. Fourteen years' data collected from Ofla district office of agriculture indicate that the study area has minimum and maximum temperatures of 5.4 to 20.2 °C, respectively. Moreover, one of the testing sites in the district was located at 12°31'N latitude and 39°33'E longitude with annual rainfall of about 654.4 mm. The soil characteristics of the testing location are presented in Table 1.

*Table 1. Soil characteristics of the study area*

| pH | OM | OC | T N | C:N | P (ppm) | CEC | ECe | Soil type |
|---|---|---|---|---|---|---|---|---|
| 6.167 | 2.343 | 1.36 | 0.14 | 9.91 | 13.6 | 19.2 | 0.17 | CL |

*Note: OM: organic matter (%), OC: Organic carbon (%), TN: total nitrogen (%), P: phosphorus (ppm), CEC: cation exchange capacity ((cmol (+)/kg soil, ECe: electrical conductivity ((mS/cm), CL is clay loam*

### Treatments and design

The treatments used were T1 (farmers' practice of 2 times hand weeding at 20 and 40 days after sowing); T2 [one application of Axial herbicide (45g liter$^{-1}$ a.i of pinoxidan) at 0.5-liter ha$^{-1}$ + 2,4-D at one liter ha$^{-1}$]; and T3 (weedy check). The demonstration was carried out on five farmers' fields without replication around Adigolo Peasant Association known with high grassy weed infestation in Ofla district. Plot size of each treatment in each site (farmer's field) was 100m$^2$. One application of Axial was made at tillering stage of barley to control grassy weeds. One week after application of Axial, the broadleaf weed killer 2,4-D herbicide was applied. The malt barley variety used was Fregebs. All other recommended crop management practices were applied uniformly. Data on yield and yield components, weed densities, input and output price, and farmers' evaluation were collected. According to Auskalnis and Kadzys (2006) weed control ratings were made with the following formula:

$$WCR = \frac{WDc - WDt}{WDc} \times 100\% \quad \text{.......................Eq. 1}$$

Where,
WCR=Weed control ratings (%)
*WDc*= weed density per m$^2$ on control plot (weedy check)
*WDt*= weed density per m$^2$ on treated plot

## Results and Discussions

### Yield and yield components

The results of ANOVA for weed control treatments showed statistically significant difference for spike length, thousand seed weight, grain yield and straw yield of malt barley (Table 2). There was no significant difference in plant height, number of effective tillers per m$^2$ and above ground biomass yield of malt barley (Table 2). The treatment mean comparison showed that combination of Axial 100 % E.C and 2,4-D herbicides gave the highest values for number of effective tillers per m$^2$ and grain yield. The second-best treatment was the farmers' practice (two hand weeding). However, the highest value for spike length and TSW was obtained from the farmers' practice. This may probably be due to the growth inhibiting effect of chemical herbicides. Although not statistically significant, the weedy check had the highest values for plant height, biomass yield and straw yield. This may be due to growth characteristics of plants to grow higher when there is competition for light with weeds. The higher biomass yield was due to the harvest of grass weeds with the crop as these weeds are equally important feed sources and farmers deliberately leave in the barley field without weeding.

*Table 2. Mean values of tested agronomic parameters of malt barley grown under three weed control treatments*

| Treatment | ET per m$^2$ | PH (cm) | SL (cm) | TSW (gm) | BM (t ha$^{-1}$) | GY (kg ha$^{-1}$) | SY (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| Farmers' practice | 310.9 | 87.9 | 6.736$^a$ | 51.56$^a$ | 10.74 | 2305$^{ab}$ | 8433$^b$ |
| Axial+2,4-D | 356.7 | 86.6 | 6.72$^{ab}$ | 50.1$^{ab}$ | 10.68 | 2575$^a$ | 8102$^b$ |
| Weedy check | 328.7 | 91.1 | 6.19$^b$ | 48.82$^b$ | 11.20 | 1819$^b$ | 9743$^a$ |
| LSD0.05 | ns | Ns | 0.41 | 1.79 | ns | 517.9 | 787.6 |
| SE+ | 22.42 | 1.72 | 0.18 | 0.78 | 0.31 | 224.6 | 341.54 |
| CV (%) | 10.7 | 3.1 | 4.3 | 2.4 | 4.5 | 15.9 | 6.2 |

*Note: ET = effective tillers per m$^2$; PH = plant height; SL= spike length; TSW= thousand seeds weight; BM= biomass yield; GY= grain yield; and SY= straw yield; ns=not statistically significant.*

### Weed density and efficiency of weed control treatments

Twenty-six weed species were recorded of, which 8 are grassy weeds and 18 are annual broadleaf weed species. The analysis of variance for the different weed control treatments showed significant differences in densities of grass and broadleaf weed species (Table 3). The mean comparison of treatments indicates that significantly lower weed densities per $m^2$ of grass and broadleaf weed species were observed on farmers' practice and Axial + 2,4-D treatments although they are not significantly different from each other.

The analysis of variance results for the three weed control treatments showed highly significantly different (p<0.001) effect on the weed control ratings (Table 4). The treatment means separation (Table 5) also showed that Axial + 2,4-D treatment was significantly higher in weed control rating (weed control efficiency) for grass weed species as compared to the farmers' practice although they are not significantly different for broadleaf weeds control ratings. The probable reason may be farmers had difficulties in differentiating some grass weed species from malt barley plants during hand weeding under the treatment of farmers' practice.

*Table 3. Mean values of weed densities in each weed control treatments*

| Treatment | GWD $m^{-2}$ | BGWD$m^{-2}$ | GWBM$m^{-2}$ | BWBM$m^{-2}$ |
|---|---|---|---|---|
| Farmers' practice | $70.2^a$ | $29.4^a$ | $67.66^a$ | $50.4^a$ |
| Axial+2,4-D | $36.6^a$ | $29.2^a$ | $33.22^a$ | $10.35^a$ |
| Weedy check | $124.6^b$ | $141.2^b$ | $169.96^b$ | $192.44^b$ |
| LSD0.05 | 43.06 | 67.7 | 75.45 | 121.76 |
| SE+ | 18.67 | 29.4 | 32.72 | 52.8 |

*Note: GWD=Grass weeds density; BWD=Broadleaf weeds density, GWBM= Grass weed fresh biomass; BWBM= Broad leaved weeds fresh biomass*

*Table 4. Analysis of variance of efficiency ratings of weed control treatments*

| Source of variation | d.f. | GWCR | BWCR | TWCR |
|---|---|---|---|---|
| Replication | 4 | 859.3 | 99.0 | 387.7 |
| Treatment | 2 | 8894.9 | 10597.4 | 8462.1 |
| Residual | 8 | 328.3 | 248.0 | 211.8 |
| P-value | | <.001 | <.001 | <.001 |

*Note: GWCR=grassy weeds control rating; BWCR= broad leaved weeds control rating; TWCR= total weeds control rating*

*Table 5. Comparison of weed control efficiency ratings of farmers' practice and Axial + 2,4-D weed control treatments*

| Source of variation | GWCR | BWCR | TWCR |
|---|---|---|---|
| Farmers' practice | $55.35^b$ | $72.87^a$ | $62.12^b$ |
| Axial+2,4-D | $82.8^a$ | $85.18^a$ | $77.78^a$ |
| LSD | 26.42 | 22.97 | 21.23 |
| SE+ | 11.46 | 9.96 | 9.2 |
| CV (%) | 36.8 | 10.9 | 24.4 |

*Note: GWCR=grassy weeds control rating; BWCR= broad leaved weeds control rating; TWCR= total weeds control rating*





## Effect of weed control on profitability of malt barley

The results of mean comparisons for the effects of weed control treatments on the total revenue and net benefit earnings from malt barley production showed statistically significant differences (Table 6). The highest total revenue and net benefit earnings were recorded in Axial + 2,4-D treatment, followed by farmers' practice.

*Table 6. Mean comparison of weed control treatments effects on revenue and net benefit earnings from malt barley production*

| Treatment | TR | NB |
|---|---|---|
| Farmers' practice | $31089^{ab}$ | 23589 |
| Axial+2,4-D | $32753^a$ | 30623 |
| Weedy check | $26255^b$ | 26255 |
| LSD | 4768.87 | 4768.87 |
| SE | 2068.02 | 2068.02 |
| CV (%) | 10.9 | 12.2 |

*Note: TR=total revenue (Birr $ha^{-1}$); NB= Net benefit (Birr $ha^{-1}$)*

# Conclusion and Recommendation

The results showed that sequential application of Axial and 2,4-D herbicides has better performance in improving grain yield and net benefits of malt barley production through effective control of grassy and broadleaf weed species. Therefore, it is suggested that this weed control technology be scaled up and out in barley growing areas of the test locations and similar areas.

# Acknowledgments

Grateful acknowledgment is also extended to Miruts Legesse and Birhane Hagos who supported during weed data collection.

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# Demonstrating Herbicides on Malt Barley in North Shewa Zone of Amhara Region

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## Introduction

There are many factors limiting barley production in Ethiopia including low yielding varieties, poor growing conditions, diseases and insect pests and crop-weed competition. A significant yield reduction has been reported due to weed infestation (Morishita and Thill 1988; Watson et al., 2006). Weeds compete with crop plants for various resources such as water and nutrients, resulting in low yields (Jarwar et al., 2005). By competing for light, water, space and nutrients, weeds can reduce crop yield and quality and can lead to billions of dollars in annual crop losses globally (Srinivasrao et al., 2014).

Several grass and broadleaf weeds infest the barley crop and may reduce yields of up to 48.9% depending on weed density and stage of the crop (Metwally et al., 2000). Under partial weed management, it is common to observe barley fields infested with grass weeds, causing yield losses of up to 60% in some barley growing areas of Ethiopia (Hailye et al., 1999). The highlands of North Shewa have suitable environmental condition for barley production. Barely is an important crop as food and malting for farmers covering 65, 380.84 ha. However, weed infestation has been one of the major constraints contributing to low productivity, which is about 2.22 t ha$^{-1}$ (CSA, 2017).

Weeds can be controlled through different management practices in barley fields. These include cultural, physical, chemical and integrated methods. Hand weeding is the most practiced weed control option in barley; however, it is labor intensive and therefore limits the production area (Dubey, 2014). Chemical control is the most common, efficient and economic method of control (Kebede et al., 2017). In many barley producing areas, barley fields are mostly treated with broadleaf herbicides. Currently, Derby 175 SC is a widely used herbicide for control of broadleaf weeds in barley by the farmers in North Shewa highlands and use of herbicide for the control of grass weeds is limited. The objective of this study was to demonstrate and create awareness of farmers on the efficacy of herbicides for the simultaneous control of grass and broadleaf weeds in malt barley production.

## Materials and Methods

### Study locations

An on-farm field experiments were conducted at Ankober and Basona-Worana districts (Figure 1). One of the testing sites at Ankober is located at an altitude of 3120 m with mean annual rainfall of 1793 mm and average minimum and maximum temperatures of 13 and 27 $^{o}$C, respectively. The altitude of a testing site at Basona-Worana was 2975 m with average annual rainfall of 897.8 mm and mean minimum and maximum temperatures of 6.1 and 19.7 $^{o}$C, respectively. The soil of the testing sites in both locations is Cambisols.





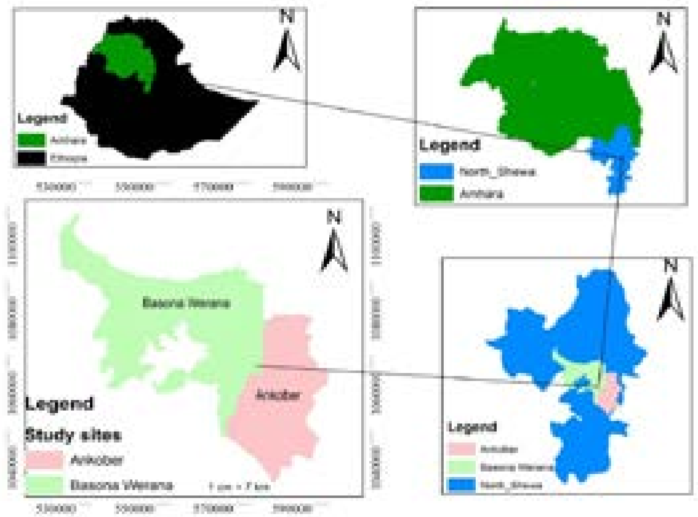


*Figure 1. Maps showing the locations of the experimental districts*

### Treatments and management practices

The trials were conducted using two treatments Axial® 045 EC [(Pinoxaden)+Derby 175 SC (flurasulam 75 G/L + flumetsulam 100 G/L)] and farmers practice [Derby 175 SC (flurasulam 75 G/L + flumetsulam 100 G/L)] on three sites in each district. Each farmer's field comprised all the treatments and was used as a replication. Malt barley variety Holker was the test crop and was planted broadcast in June 2016 at the seed rate of 100 kg ha$^{-1}$. Plot size of each treatment was 100 m$^2$. Harvesting was done in November 2016.

Both herbicides were applied at one time (40 days after planting) at the rate of one litter per hectare for each herbicide. All 46 kg of $P_2O_5$ and half of 41 kg N ha$^{-1}$ were applied at planting and the other half of 41 kg N ha$^{-1}$ was applied at tillering stage.

### Data collection and analysis

Data on type and numbers of weed before and after herbicide application and crop parameters like plant height, spike length, grain and straw yield, and TKW were collected using 1m$^2$ quadrant in each plot. Participatory approaches were implemented by involving farmers and extension workers to demonstrate and evaluate the effects of herbicides on the control of grass and broadleaf weeds in the study area. Data analysis was carried out using SAS software. Average yield of barley was adjusted downward by 10% for partial budget analysis (CIMMYT, 1988). Cost of herbicides, labor and spraying equipment were used as variable costs. The cost of Axial was 1250 Birr per litter and cost of Derby 175 SC was 3400 Birr per litter. Labor cost to spray one-hectare barley field was determined by man-day and was 200 Birr. The price of barley seed and straw was 12 and 2 Birr kg$^{-1}$, respectively, according to the local market.

# Results and Discussion

## Weed count and biomass

The trial failed at Ankober district due to hail damage and there will be no result reported here. The results of herbicide application effects on weed parameters at Bassona-Worana district are presented in Table 1. *Snowdenia polystachia*, *Gastridium phleoldes*, *Avena spp*, *Cyperus spp*. and *Setaria spp*, were among grass weeds found in barley fields. On the other hand, *Guizota scabra*, *Galium spp* and *Trifolium rupelfianum* were among broadleaf weeds observed in the barley fields. Weed counts of 93.65 and 65.41 plants m-2 were recorded from plots sprayed with Derby 175 SC alone and Axial® 045 EC + Derby 175 SC, respectively, after treatment application. Chhokar et al. (2008) also reported that herbicide Pinoxaden was highly effective against grass weeds of wheat and barley when applied 32-37 days after planting. Sareta et al. (2016) also stated that herbicide Pyroxsulam exhibited significant potential to control problematic grass (like *Setaria pumila*) and broadleaf (*Polygonum nepalense*) weeds of wheat when applied 30-35 days after germination.

The other weed parameter influenced by herbicide treatment is the weed biomass. The highest weed biomass of 15.32 t ha$^{-1}$ was harvested from plots sprayed with Derby 175 SC alone, while the lowest of 6.93 t ha$^{-1}$ was from Axial® 045 EC + Derby 175 SC sprayed plots. Moreover, application of Axial® 045 + Derby 175 SC was effective on decreasing weed count by 41.17% and biomass by 121.21% after herbicide application when compared to plots sprayed with Derby 175 SC alone. Chhokar et al. (2008) reported that post-planting application of Pinoxaden was found effective in decreasing barley and wheat weed density and biomass of grass weeds compared to weedy check (untreated).

## Yield and yield components

The results of herbicide application effects on yield and yield components of malt barley at Bassona-Worana district are presented in Table 1. The highest malt barley grain yield of 3.3 t ha$^{-1}$ and straw yield of 5.91 t ha$^{-1}$ were obtained from Axial® 045 EC+Derby 175 SC sprayed plots while Derby 175 SC alone sprayed plots gave grain yield of 2.31 t ha$^{-1}$ and straw yield of 3.67 t ha$^{-1}$. In agreement with this finding, Khan, et al. (2011) stated more dynamic weed control and increased grain yield of wheat where a combination of both broad and grass weed herbicides were sprayed. Axial® 045 EC + Derby 175 SC application was superior in weed control giving greater reductions in weed number and weights than application of Derby 175 SC alone.

*Table 1. Effects of herbicide treatments on weed parameters, yield and yield components of malt barley in 2016 main cropping season*

| Treatment | WCBT | WCAT | WB | PH | SL | TKW | SY | GY |
|---|---|---|---|---|---|---|---|---|
| Axial® 045 EC+Derby 175 SC | 181.33 | 65.41 | 6.93 | 80.82 | 5.98 | 39.60 | 5.91 | 3.67 |
| Derby 175 SC | 198.33 | 93.65 | 15.32 | 77.09 | 5.44 | 38.67 | 4.07 | 2.31 |
| Statistical significance | NS | * | * | NS | NS | NS | NS | * |

*Notes: NS = not statistically significant; * = statistically significant at 5%; WCBT = weed count before treatment per m$^2$; WCAT = weed count after treatment per m$^2$; WB = weed biomass (t ha$^{-1}$); PH = plant height (cm);SL = spike length (cm); TKW = thousand kernel weight (g);SY = straw yield (t ha$^{-1}$); and GY = grain yield (t ha$^{-1}$) of malt barley.*





## Partial budget analysis

Partial budget analysis showed the highest net benefit of 45,390 Birr ha$^{-1}$ was obtained from Axial® 045 EC + Derby 175 SC sprayed plots while Derby 175 SC sprayed plots gave net benefit of 28,700 Birr ha$^{-1}$ (Table 2). Marginal return of the combined application of Axial® 045 EC + Derby 175 SC herbicide for the control of broad leaf and grassy weeds in malt barley production was 1,335.2% as compared to application of Derby 175 SC alone, which controls broadleaf weeds. Hence, a 1335.2% marginal rate of return in switching from application of Derby 175 SC herbicide alone to Axial® 045 EC + Derby 175 SC implies that for each Birr invested in the application of Axial® 045 EC + Derby 175 SC, the producer can expect a return of Birr 13.35 after recovering the cost.

*Table 2. Partial budget analysis of herbicide weed management practices for malt barley production in 2016 cropping season*

| Herbicide | SY | ASY | GY | AGY | Total revenue (Birr) | Total variable cost (Birr) | Net benefit (Birr) | MRR (%) |
|---|---|---|---|---|---|---|---|---|
| Derby 175 SC | 4.08 | 3.67 | 2.31 | 2.08 | 32300 | 3600 | 28700 | - |
| Axial® 045 EC + Derby 175 SC | 5.91 | 5.32 | 3.67 | 3.30 | 50240 | 4850 | 45390 | 1335.2 |

*Notes: SY = straw yield (t ha$^{-1}$); ASY = adjusted straw yield (t ha$^{-1}$); GY = grain yield (t ha$^{-1}$); AGY = adjusted grain yield (t ha$^{-1}$); MRR = marginal rate of return; 1USD = 27.50 Birr*

## Farmers' perception

During the evaluation, 15 farmers (1 female) and 10 extension workers and researchers (3 female) participated. The evaluation criteria used were plant height, number of tillers, spike length of barley, and weed biomass. Consequently, farmers preferred Axial® 045 EC + Derby 175 SC application as it gave good weed control and higher grain yields.

# Lessons learned

Capacity building of farmers on the types and rates used as well as how and when to apply herbicides are essential to adopt herbicide weed management. There are demands to use herbicides against malt barley weeds to ensure grain quality. Timely access and timely application of herbicides were the main challenges.

# Conclusions and Recommendations

This study demonstrates that application of Axial® 045 EC + Derby 175 SC gave superior weed control and higher yield than Derby 175 SC alone for malt barley production. Farmers' preference also supported this finding. Thus, Axial® 045 EC + Derby 175 SC is recommended for broadleaf and grass weed control for wider scaling of malt barley production in the study locations and similar areas. Training of farmers about type of herbicides, time, rate and method of application is critical and need due attention.

## Acknowledgments

We thank Debre Birhan Agricultural Research Center for providing logistical support for conducting the study.

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# Demonstrating Post-Emergence Herbicides for Malt Barley Production in Bale Zone of Oromia Region

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## Introduction

Malt barley is a very sensitive crop to weed competition and suffers great yield and quality reduction due to competition (Stroud, 1989). Weeds impose serious problem to cereal production in Bale highlands, southeastern Ethiopia. Cereal production is hampered due to the aggressiveness of both grass and broad leaf weeds (Tessema et al., 1999). This might be due to multiple factors such as ineffective herbicides, which are currently in use; unavailability or inaccessibility of types of herbicides in sufficient quantity and at required time; shift in weed flora due to continuous mono-cropping of cereals; frequent use of one type of herbicide; and morphological similarity of weed species with the cereal crops (Tanner and Sahile, 1991). Verification and demonstration of newly introduced selective herbicides are very important for control of weeds. Axial 045 EC is a selective herbicide used to control most of the important annual grass species in small grain cereals such as wheat and barley. This herbicide is not demonstrated to the farmers for its efficacy in controlling grass weeds in malt barley. The objective of this study was to demonstrate post-emergence herbicide (Axial 045 EC) for its efficacy in controlling annual grass weeds in malt barley.

## Materials and Methods

### Study locations

The demonstration was conducted in Goba and Dinsho districts of Bale highlands. Goba has an altitude range of 1517 to 4378 m and annual rainfall range of 937 to 1342 mm. The maximum and minimum temperatures for Goba are 19.58 and 6.53°C, respectively. Dinsho has an altitude range of 2444 to 4250 m and has annual rainfall of range of 965 to1314 mm. Maximum and minimum temperature for Dinsho are 15.33 and 7.07°C, respectively. All testing sites were in the highlands with 2400-3000 m. Soil types of testing sites are more of Chromic Luvisols and Cambisols. Soil PH is 6.01- 6.82 for Dinsho.

### Treatments and design

The treatments consisted of 2,4-D; 2,4-D + Axial 045 EC; and weedy check. The demonstration was laid out as a single block consisting of three plots. The first plot was treated with 2,4-D, the second plot with 2,4-D + Axial 045EC and the third plot was weedy check. The size of each plot was 25 $m^2$. The test crop was improved malt barley variety IBON 174/03, broadcasted at the seed rate of 125 kg $ha^{-1}$. NPS fertilizer at the rate of 100 kg $ha^{-1}$ was applied at planting.

### Farmers' participation in herbicides demonstration

Fifty farmers at Goba and 42 farmers at Dinsho participated on evaluation and selection of the promising herbicides.

## Data collection and analysis

Weed composition controlled by herbicide application was recorded and quantified. Grain yield and socio-economic data were collected to analyze yield advantage and cost benefit of herbicide demonstration. Cost-benefit analysis was done as described by CIMMYT (1988). Yield advantage was calculated as follows:

$$\text{\% Yield increase over check} = \frac{\textit{Yield of treated plot - Yield of untreated plot}}{\textit{Yield of treated plot}} \text{ X 100\%}$$

# Results and Discussion

The results obtained from the two districts indicated that 2,4-D + Axial 045 EC application was the most effective against the broad leaves and grass weeds in malt barley. The weed community observed in the experimental fields comprised of both broad leaf and grass weeds. Out of the total weeds observed in the experimental fields, 67% were broad leaved while 33% grass weed species. Among broadleaf weed species Amaranthus hybridus, Chenopodium spp, Galensoga parviflora, Commelina benghlensis, Guizotia scabra and Anagalis spp were the most dominant. On the other hand, Avena fatua, Bromus pectinatus and Phalaris paradoxa were the most dominant grass weed species observed in the experimental plots at the time of treatment application. Herbicide 2,4-D controlled all the broadleaf weed species while Axial 045 EC controlled all grass weed species in malt barley at both Goba and Dinsho locations.

Grain yield advantage of herbicide treatments are presented in Table 1. Maximum grain yield of 2.72 t $ha^{-1}$ at Dinsho and 3.68 t $ha^{-1}$ at Goba was obtained from plots treated with 2,4-D + Axial 045 EC giving the respective grain yield advantage of 58.8% and 67.4% over the weedy checks. Plots treated with 2,4-D gave the second maximum grain yield of 2.16 and 2.48 t $ha^{-1}$ at Dinsho and Goba, respectively.

The cost-benefit analysis also revealed that plots treated with 2,4-D + Axial O45EC gave the maximum net benefit, the value-cost ratio being 2.56 and 3.58 at Dinsho and Goba, respectively (Table 2 and 3). Farmers participated on evaluation of demonstration (42 farmers at Dinsho and 50 farmers at Goba) selected 2,4-D + Axial O45EC as promising herbicides in improving productivity and grain quality by controlling weeds.

*Table 1. Grain yield and yield advantage of herbicidal weed control in malt barley*

| District | Treatment | Grain yield (t $ha^{-1}$) | % yield advantage over weedy check |
|---|---|---|---|
| Dinsho | 2,4-D | 2.160 | +48.15 |
| | 2,4-D + Axial 045 EC | 2.720 | +58.82 |
| | Weedy check | 1.120 | |
| Goba | 2,4-D | 2.480 | +51.61 |
| | 2,4-D + Axial 045 EC | 3.680 | +67.39 |
| | Weedy check | 1.200 | |





*Table 2. Cost-benefit analysis of herbicides demonstration in Dinsho*

| Treatment | Yield obtained (t $ha^{-1}$) | Sale price (Birr $kg^{-1}$) | TVC (Birr $ha^{-1}$) | TR (Birr $ha^{-1}$) | NB (TR-TVC) | VCR (NB÷TVC) |
|---|---|---|---|---|---|---|
| 2,4 - D | 2.16 | 12 | 7980 | 25920 | 17940 | 2.25 |
| 2,4-D + Axial 045 EC | 2.72 | 12 | 9160 | 32640 | 23480 | 2.56 |
| Weedy check | 1.12 | 12 | 6,828 | 13,440 | 6,612 | 0.97 |

Note: TVC = total variable cot; TR = total revenue; NB = net benefit; VCR = value cost ratio

*Table 3. Cost-benefit analysis of herbicides demonstration in Goba*

| Treatment | Yield obtained (t $ha^{-1}$) | Sale price (Birr $kg^{-1}$) | TVC (Birr $ha^{-1}$) | TR (Birr $ha^{-1}$) | NB (TR-TVC) | VCR (NB÷TVC) |
|---|---|---|---|---|---|---|
| 2,4 - D | 2.48 | 1200 | 8140 | 29760 | 21620 | 2.66 |
| 2,4-D + Axial 045 EC | 3.68 | 1200 | 9640 | 44160 | 34520 | 3.58 |
| Weedy check | 1.20 | 1200 | 6,980 | 14,400 | 7,420 | 1.06 |

Note: TVC=total variable cost; TR=total revenue; NB=net benefit; VCR= value cost ratio; one USD being equivalent to 27.35 BIRR, the average of official market price during 2018

# Conclusion and Recommendations

Demonstrations confirmed that application of 2,4-D + Axial 045 EC herbicides effectively controlled broadleaf and grassy weeds in malt barley and gave highest grain yield than application of 2,4-D alone and weedy check treatments in all test locations. Farmers also selected 2,4-D + Axial O45 EC as promising herbicides in controlling weeds in malt barley. These results suggest that application of 2,4-D + Axial O45 EC herbicide for the control of broadleaf and grass weeds in malt barley should further be scaled up and out for wider scale use. It is also suggested that the recently registered herbicide Axial-1, which controls both broadleaf and grassy weeds in one go be demonstrated in order to reduce the cost of application of 2,4-D + Axial O45 EC herbicide, which are two different herbicides being applied at different sequential time.

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# Evaluating Use of Multi-Crop Mobile Thresher by Seed Producer and Marketing Cooperatives

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## Introduction

Threshing is one of the most important farm activities, which are human labor and animal power intensive. One of the problems of threshing for crop in general and for cereals in particular is separating the grain from the head (Yisa et al., 1998), cleaning of grains from the straw and dusts and high labor requirements leading to inefficiency. Slight delay in threshing operation may lead to tremendous post-harvest losses and deteriorations of the quality of the grain or seed. Traditional threshing methods in Ethiopia include trampling of harvested crops with animals and manual beating for shelling the crop on hard slant surface. Transporting and heaping the harvested crops before threshing is costly, time consuming and causes losses during the process. Hand threshing and separation of grain is labor intensive and time consuming. Generally, traditional methods of threshing by live animals and human labor results not only in significant losses in quantity and quality of the produce but also time consuming and arduous (Negassa et al., 2011). Time is a very important factor in agricultural activities in line with operations of production activities in general and very crucial particularly for threshing activity. Now in some places a tractor is used in place of animals for treading harvested crops.

There are various types of threshers found in the world: multi crop thresher (MCT), paddy thresher, high-capacity multi-crop thresher, pigeon pea thresher, semi-axial flow multi crop thresher, groundnut thresher, sunflower thresher, single ear head thresher, and maize thresher. Among these threshers, multi crop threshers with medium and high capacity are the most available types in various parts of Ethiopia. In contrast to traditional methods, threshing using multi-crop threshers was found to be economic with several benefits (Tsegaye, 2015). These threshers can be used for various crops with little adjustments in cylinder speed and clearance between cylinder and concave. The MCMT can be used to thresh crops such as tef, wheat, barley, millet, mustard, pigeon pea and soybean with a simple adjustment in the engine throttle to adjust the speed of the threshing drum. This feature of the MCMT is very critical to utilize the capacity and profitable use of the thresher (Negassa, 2012). These threshers provide good quality seed and grain as well as finely crushed and chopped the straw, which would be more palatable animal feed.

The threshing capacity of MCMT ranged from 425 kg hour-1 of mustard to 2900 kg hour$^{-1}$ of maize. The MCMT provided by the ICARDA-USAID project to strengthen the capacity of seed producer cooperatives are assumed to be easy to move from place to place and provide clean seed without much loss and damage. During threshing, seed loss in terms of broken grain, un-threshed grain, blown grain, spilled grain is desired to be minimum. The study was conducted to assess farmers' reflection and feedbacks on the use and contribution of MCMTs and the efficiency, the gaps and challenges of using the machine in the study area.





## Materials and Methods

### Study locations

The selection of study locations was based on the location of target cooperatives, which are engaged in seed production, including farming system and other social attributes, which may directly or indirectly affect the adoption of the technology, suitability of the landscape for crop production especially the target crop like malt barley, and other major cereal crops such as wheat for contrast, productivity of the area, the infrastructure, maintenance services, supportive extension and linkage among actors, labor availability and its costs.

Six farmers' seed producer and marketing cooperatives that had access to use MCMT were selected purposively in 2018. The cooperatives are found in four districts of North Shewa Zone in Amhara Regional State. In all the cooperatives malt and food barely, wheat, faba bean, chickpea, tef, and lentil are considered as major crops grown by the farmers. All the cooperatives located within 20-65 km from DBARC. Member farmers of the cooperatives, who had grown malt barely in rainfed conditions were selected and a simple survey was administrated to assess the efficiency of threshing practices adopted for malt barely seed. The threshing for malt barley was in October to December 2018.

### Organizing trainings

During donation of MCMTs to seed producer cooperatives, practical training on operations of the machine, maintenance and management was provided to the operators, cooperative management leaders and extension workers.

### Data collection

Feedbacks were collected from the beneficiaries, operators, cooperative leaders and extension workers in group discussion and by asking key informants about suitability and threshing efficiency of the machine; quality of seed, grain and straw; and cost effectiveness as compared to the traditional methods. The quality and efficiency parameters for evaluation included the parameters of threshing and cleaning efficiency; seed damage and cost of operation were measured by taking samples in the threshing practices. Grain samples were collected from the machine threshing output to evaluate the quality of grain.

## Results and Discussion

### Training and experience sharing

Training was delivered twice for two consecutive years to introduce the machine parts and how it operates, safety rules of machine operation, and maintenance. The trainings were provided by the trained mechanics and experts. The participants were 47 in total (all male) from district agricultural experts, cooperatives management leaders and hired machine operators (Table 1). After first round of training, the trainees were left alone to run the threshing operation, all practices of handling the machine and identify the practical gaps. Second round training improved their confidence by solving identified gaps during practical operations.

*Table 1. Type and number of trainees on operations of the machine and maintenance*

| ***Participant*** | ***Number of trainees*** | | ***Total*** |
|---|---|---|---|
| | ***First round*** | ***Second round*** | |
| *Agricultural experts* | *3* | *4* | *7* |
| *Cooperative leaders* | *6* | *14* | *20* |
| *Hired operators* | *6* | *14* | *20* |
| *Total* | *15* | *32* | *47* |

## MCMT evaluation results

Group discussion with beneficiary farmers revealed that the traditional threshing method by manual beating and animal power is low in capacity, high threshing cost, time consuming and higher seed damage. Moreover, it requires winnowing manually to separate grains from straw and dusts. Farmers also said that threshing by tractor treading is time consuming and requires more space to handle the operation. These limitations of the traditional threshing practice and threshing by tractor treading made the farmers adopt the new MCMT, in view of increasing production area under malt barely crop. The MCMT has a rated capacity of threshing 300 and 500 kg grain per hour for wheat and barley with fuel consumption of one liter per hour. During this study, MCMT threshed 2 to 3 t of wheat and barley per eight hours' effective work for well-dried harvested crops, which would have required three working days with six animals and four man-days in the traditional threshing practice. The efficiency of MCMT depends on the moisture contents of the crop at harvest and the experience and skill of the operators. Fine chopping of straw by MCMT made it preferable than other harvesting machines, which have higher threshing capacity and speed but with long cut of straw. Finely chopped straw either alone or mixed with other livestock feed additives was easy to feed to livestock as it facilitates intake and make it palatable by different animals.

Although the MCMT price is lower than other threshing machines, it is still not affordable to individual subsistent farmers; thus, needs availability of service providing entity. It also needs access to road and plain topography for moving from place to place. Interview with key informants (farmers and experts) concurred on the increasing acceptance of MCMTs in the intervention areas and adjacent kebeles. The cooperatives also provided the machine renting services to the adjacent districts after completing threshing of the harvests in their mandate areas. This enables to generate additional income to the cooperatives and employment opportunity to the operators. The main reasons for choosing and adopting the MCMTs by the beneficiaries in the study locations were:

- Speed of threshing where the output of 4 hours threshing by MCMT used to take 3-4 days with traditional methods;
- Threshing labor cost is significantly reduced on which only three man-days per day are required on MCMT with equal output of the traditional method, which required 8-10 man-days;
- Threshing by MCMT enhances grain quality since there is no mixing with sand, soil, and animal urine and dung, which are the major grain quality reducing factors in the traditional method; and low grain damage during threshing, which is negligible (less than 1%);
- In terms of cost required to thresh 2 t of grain using MCMT costs 1,000 Birr while the traditional method costs 3,200 Birr;
- The crop loss during threshing process is highly reduced due to effective threshing, which reduces un-threshed seeds, broken seeds, produce eaten by animals, reduce losses in the threshing floors by the traditional threshing method; and
- The introduction of MCMT enables animals that would have been used for threshing to be allocated for more productive purposes such as produce marketable products like milk and meat generating income for farmers.

The MCMT helped the farmers to thresh the crops on time. It eliminates winnowing to separate the grain from the straw and dusts. It works in all environmental conditions such as windy, rainy days, and under shade. It reduces the post-harvest losses in general and losses caused by bad weather particularly due to delayed harvesting. Compared to the traditional methods, it saves labor, time and cost. It produces fine chaff by fine chopping of straw, which is highly preferable to feed alone or to mix with other feed additives for livestock feed.

## Challenges

Potential limitations in which farmers reflected for better use of the machine are listed as follows:

- The potential threshing capacity of MCMT per hour is low as compared to other types of threshers. The specification requiring four working hours per day till the first 50 hours is reached is very limiting, in addition to its low threshing capacity of eight hours per day;
- The spare part of the machine is not easily accessible, and it is laborious and difficult to move from place to place on the undulating lands; and
- The MCMT has no capacity of harvesting; it would have been better to have combined harvesting and threshing.

## Future directions and recommendations

Based on the farmers' feedbacks, continuous follow-ups, and field observations, the following are suggested for further improvement and scaling.

- Individual or organized service providers like cooperatives are required to be in place for wider use of MCMT by subsistent farmers through rental arrangements;
- The design features of MCMT may be adopted for threshing tef, faba bean, sorghum, chickpea and other crops; and
- Needs integration with the microfinance to facilitate credit system for increasing the accessibility of the MCMT for small group of farmers or individuals.

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# CHAPTER III

## MALT BARLEY SEED PRODUCTION

# Early Generation Seed Production of Malt Barley to Support the Seed System in Ethiopia

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## Introduction

Early generation seed (EGS) is the first and the most important part of the seed production system without it the seed production system will not sustain. EGS should not be confused with the large-scale certified seed multiplication and it has its own unique steps in the production process (Tripp, 1997). EGS includes breeder seed, pre-basic and basic seed productions (van Gastel et al., 1996). The quality and the amount of the EGS directly affect the quality seed production by the formal and the semi-informal seed system. The early generation seed production also includes the maintenance breeding to maintain the true to type of the released varieties (Atilaw et al., 2017; Bishaw and van Gastel, 2007). In Ethiopia early generation seed availability and quality is considered as one of the major constraints of the national seed sector (MoANR/ATA, 2013). The e national and the regional research institutes developing and releasing a variety are responsible to maintain produce and provide sufficient amount and quality source seed for the public or private seed enterprises or the seed producer cooperatives.

Kulumsa Agricultural Research Center (KARC) is responsible to develop, release and maintain improved varieties, multiply early generation seed of released varieties, demonstrate and popularize the released varieties to stakeholders in the seed value chain. KARC is also the major source of the EGS for malt barley in Arsi zone and the country at large. Every year, KARC produces the EGS using the main research center at Kulumsa and its sub centers (Bekoji and Kofele).

Barley covered about 150,000 ha in 2017/2018 meher cropping season in Arsi and West Arsi zones (CSA, 2018), which are the mandate areas of the KARC. Out of it, only 15% is covered by malt barley, which is equivalent to about 22,500 ha. To cover this land, it requires about 3,375 t of certified seed from the seed enterprise and the seed producer cooperatives. Consequently, for the seed enterprises to produce the 3,375 t of certified seed, they require about 253.1 t of basic seed. This in turn shows how much the breeder and pre-basic seeds are required from the breeders to satisfy this need. The same sequence of seed production steps should be implemented to produce a certified seed, which should be made available to barley producer smallholder farmers in the country. Therefore, the ICARDA- USAID malt barley seed production and scaling project in collaboration with Ethiopian Institute of Agricultural Research (EIAR) designed activities to enhance production and supply of EGS of newly released and adapted malt barley varieties in Arsi and the country at large.





## Materials and Methods

### Study locations

The EGS production activities were conducted with the financial support of ICARDA-USAID malt barley and faba bean seed and scaling project for the last three years from 2015/16 to 2017/18.

The EGS production was carried out by the barley improvement research program and farm unit of KARC at the main center (Kulumsa), and its sub-centers (Bekoji and Kofele). The altitude of KARC is 2200 m asl with geographic coordinate of 8°01' N latitude and 39°09' E longitude. KARC receives average annual rainfall of 830 mm, with the annual average maximum and minimum temperature of 23.2°C and 10°C, respectively. The Kulumsa area is mainly wheat producing zone with the mixed crop livestock production system as observed in most of the highlands of Arsi zone. The soil of the farm of the KARC is well drained light soil.

The altitude of Bekoji Research Sub-center is 2780 masl with the geographic coordinate of 7°53' N latitude and 39°25' E longitude. Bekoji receives the average annual rainfall of 1020 mm with an annual average maximum and minimum temperature of 20° and 8°C, respectively. It is dominated with mixed crop-livestock production system where barley and faba bean are the major crops followed by wheat. The soil of the sub-center is well drained light soil.

The altitude of Kofele Research Sub-center is 2620 masl with the geographic coordinate of 07°04'N latitude and 38°48' E longitude. It receives an average annual rainfall of about 1077 mm with an annual average maximum and minimum temperature of 18.3° and 2.3° C, respectively. The area dominantly produces barley and potato in the main season whereas horticultural crops are dominant in the belg season. Like other areas of the west Arsi zone, it is characterized by mixed crop livestock production system. The soil of the sub-center is more of relatively light Vertisols.

### Varieties and EGS production

The newly released and well adapted malt barley varieties were included in the project. These varieties were multiplied at Kulumsa Agricultural Research center main station (Kulusma), and in its sub centers (Bekoji and Kofele). The malt barley varieties included were Bahati, Beka, Bekoji-1, EH1847, Fanaka, HB1963, HB1964, Holker, and IBON 174/03. For the EGS seed production the following procedures were employed.

- Maintenance breeding: The breeder selected the true to type of about 1000 ears from each selected variety and planted each ear in one row in the succeeding year. Then the breeder evaluated each row thoroughly and eliminated the one not lookalike the original population. This served as the starting point for the breeder seed production and maintaining the true to type of the variety under consideration (Lavarack, 1994) and could be called as parental material or nucleus seed.

- Breeder seed production: The breeder seed is multiplied from the seed obtained from the maintenance breeding program and under the strict supervision of the breeder. Those rows with off type were eliminated and the true to type rows were harvested for each variety (van Gastel et al., 2002).
- Pre-basic and basic seed production: The pre-basic and basic seed production was carried out in collaboration with the KARC Farm Management Department under Technology Multiplication Directorate. In this process the seed research team inspected according to the quality standards set by the Ethiopian Seed Proclamation.

### Crop management

The land for seed production in the main campus of KARC and its sub-centers was selected based on the cropping history of the preceding year. The land used for EGS production of malt barley was the land covered with pulse and oilseed crops in the previous cropping season. This helps to maintain the true to type of the EGS produced. The farm was prepared using the standardized cultivation practice of the farm management department of the center. The seed rate of 85 kg $ha^{-1}$ for row planting was used for the pre-basic seed production with 100 kg $ha^{-1}$ DAP and 50 kg $ha^{-1}$ of urea where half of the urea was applied at planting and the remaining half after tillering of malt barley. Weeding was done by hand and herbicide application when necessary.

## Results and Discussions

### Breeder seed production

From 2015/16 to 2017/18, KARC produced a total of 23.78 t of breeder seed, of, which 11.64, 8.17 and 3.96 t were produced in 2015/16, 2016/17 and 2107/18, respectively (Table 1). To produce the breeder seed, the center allocated about 11.5 ha of land at KARC main station in Kulumsa, and sub-centers at Bekoji and Kofele (Table 1). Seeds of nine malt barley varieties were produced in the last three years. The varieties were selected based on productivity, acceptance by the farmers and period of release. The breeder seed produced was used to produce pre-basic seed at KARC and was also provided to the seed enterprises of the country and SPCs in the Oromia region (Tables 2 & 4). About 10.69 t of breeder seeds were distributed to more than 14 organizations (Tables 2 & 4), including seed enterprises, research centers/institutes and universities. The KARC not only produced and supplied seed for the Arsi and West Arsi zones of its mandate areas but also served as seed source for the whole country. Therefore, KARC contributes its part to the seed sector of the country in order to improve availability and accessibility of the improved malt barley varieties to the smallholder farmers.

### Pre-basic seed production

During 2015/16 to 2017/18, the pre-basic seed of eight malt barley varieties were produced on a total land area of 19.6 ha at Kulumsa and its sub-centers (Bekoji and Kofele) in collaboration with farm management unit of KARC. The total amount of pre-basic seed produced was 45.9 t (Table 3). In this category, most of the recently released





varieties were included such as Bhati, Bekoji-1, Fanaka, IBON 174/03, HB 1963, HB 1964, and EH1847. About 17.56 t of pre-basic seed were distributed to more than 13 organizations including seed enterprises, universities, research centers and seed producer cooperatives involved in the seed system of country (Table 4).

The breeder and pre-basic seed produced were distributed to more than 15 organizations participating in the national seed system (Table 2 and 4). Most of the recipient organizations are public seed enterprises, agricultural research centers/ institutes and universities working on demonstration of the improved malt barley technologies to farmers in their respective mandate areas to create awareness and demand for the technologies. In addition, the public seed enterprises and the seed producer cooperatives also contributed to further multiplication and availability of the improved malt barley seed to the farmers in the country.

During the early generation seed production of malt barley, the amount of seed produced varied across years. The major reason for this fluctuation is the unavailability of enough land for EGS production since the land allocation is from the leftover land from the research trials. This shows that the breeder could not use the full capacity to produce the required amount of EGS. In addition, the fertility of the land allocated for EGS production of malt barley in the sub-centers such as Bekoji and Kofele is usually marginal and poorly prepared since the land was the leftover after planting of the experimental plots.

Table 1. Breeder seed produced by KARC and its sub-centers

| Variety | 2015/16 | | 2016/17 | | 2017/18 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Area planted (ha) | Seed produced (kg) | Area planted (ha) | Seed produced (kg) | Area planted (ha) | Seed produced (kg) | Area planted (ha) | Seed produced (kg) |
| Bahati | 1 | 2550 | 0.4 | 1590 | 0.25 | 275 | 1.66 | 4419 |
| Beka | 0.1 | 150 | – | – | – | – | 0.1 | 150 |
| Bekoji-1 | 1.5 | 1780 | 0.1 | 248 | – | – | 1.64 | 2032 |
| EH1847 | 1.56 | 2370 | – | – | – | – | 1.56 | 2370 |
| Fanaka | 0.15 | 380 | 1 | 2230 | 0.25 | 360 | 1.4 | 2970 |
| HB1963 | – | – | – | – | 0.2 | 549 | 0.2 | 549 |
| HB1964 | – | – | – | – | 0.2 | 488 | 0.2 | 488 |
| Holker | 0.82 | 1030 | 0.3 | 791 | 0.25 | 693 | 1.34 | 2514 |
| IBON 174/03 | 1 | 3380 | 1.6 | 3310 | 0.75 | 1598 | 3.35 | 8288 |
| Total | 6.13 | 11640 | 3.42 | 8169 | 1.9 | 3963 | 11.5 | 23776 |

Table 2. Malt barley breeder seeds (kg) supplied by KARC to different stakeholders in 2015/16

| Variety | Initial stock | BDU | TMSR | ESE | Areka ARC | Adet ARC | Worabe ARC | Soil KARC | HARC | ICARDA | Hawassa ARC | DBARC | KARC Path | Balance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bahati | 1640 | | | 125 | | | | 1300 | | | 45 | | 128 | 42 |
| Bekoji-1 | 750 | 50 | 160 | 125 | | | | | 150 | | | | | 265 |
| EH1847 | 2366 | 50 | 170 | 625 | 112 | 50 | 60 | 100 | | 126 | 45 | 80 | 2 | 226 |
| Fanaka | 306 | | 100 | | | | | 200 | | | | | | 6 |
| IBON 174/03 | 3161 | 50 | 400 | 106 | 112 | 50 | 60 | 1923 | | 146 | 45 | | 130 | 139 |
| Total | 8223 | 150 | 830 | 981 | 224 | 100 | 120 | 3523 | 150 | 272 | 135 | 80 | 260 | 678 |

Note: BDU = Bahir Dar University; TMSR =Technology Multiplication and Seed Research of KARC; ESE = Ethiopian Seed Enterprise; ARC = Agricultural Research Center; HARC = Holetta ARC; DBARC = Debre Birhan ARC.





Table 3. Pre-basic seed produced by KARC and its sub-centers

| Variety | 2015/16 | | 2016/17 | | 2017/18 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Area (ha) | Seed produced (kg) | Area (ha) | Seed produced (kg) | Area (ha) | Seed produced (kg) | Area (ha) | Seed produced (kg) |
| Bahati | – | – | 0.5 | 1440 | 0.75 | 1395 | 1.25 | 2835 |
| Bekoji-1 | – | – | 0.8 | 1840 | 0.25 | 852 | 1.05 | 2692 |
| EH-1847 | – | – | 0.82 | 2502 | – | – | 0.82 | 2502 |
| Fanaka | – | – | – | – | 2.5 | 4260 | 2.5 | 4260 |
| HB 1963 | – | – | – | – | 0.25 | 544 | 0.25 | 544 |
| HB 1964 | – | – | – | – | 0.25 | 580 | 0.25 | 580 |
| IBON-174/03 | – | – | 4 | 11330 | 5.5 | 13310 | 9.5 | 24640 |
| Sabni | 4 | 7900 | | – | – | – | 4 | 7900 |
| Total | 4 | 7900 | 6.12 | 17112 | 9.5 | 20941 | 19.62 | 45953 |

Table 4. Malt barley breeder and pre-basic seeds (kg) supplied by KARC to different stakeholders in 2016/17

| Variety | Seed class | Initial stock | Hawassa University | TMSR | KARC Comp | Research & Ext | OSE | ESE | SARI | Worabe ARC | KARC | HARC | KARC | DBARC | Balance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bahati | Breeder | 2160 | | 60 | | | | 4 | | | | 1600 | | | 500 |
| | Pre-basic | 1340 | 300 | | | | 740 | | | | | | | | 300 |
| Bekoji-1 | Pre-basic | 1550 | | | | 900 | | | | | | 200 | 300 | 100 | 100 |
| EH1847 | Pre-basic | 2460 | 360 | | | 1300 | | | | | | | | | 800 |
| Fanaka | Breeder | 800 | | 200 | | 500 | | | | | | | | | 100 |
| | Pre-basic | 550 | | | | | | | | | | | 550 | | 0 |
| Holker | Pre-basic | 300 | | | | | | | | | | | 300 | | 0 |
| IBON 174/03 | Breeder | 780 | | 700 | | | 80 | | | | | | | | 0 |
| | Pre-basic | 13600 | 360 | | 500 | 1500 | 170 | | 500 | 30 | 1500 | 1800 | 6300 | 1000 | 1040 |
| Total | | 23550 | 1020 | 960 | 500 | 4200 | 990 | 4 | 500 | 30 | 1500 | 3600 | 7150 | 1100 | 2840 |

## Challenges

Shortage of land in KARC and its sub-centers is the major challenge for early generation seed production and supply. KARC is the sole provider of the early generation seed of malt barley in Oromia Region and the main source for the national seed system in Ethiopia. However, due to critical land shortage, it is not yet been possible to produce EGS in the required amount and quality to meet the demands of seed producer enterprises, cooperatives, unions and research institutions of the country.

## Future direction

The responsible government bodies should give serious attention to solve the problem of land shortage of agricultural research institutions both at federal and regional levels for increasing EGS production and supply in the country.

Strengthening cooperation among the stakeholders in the seed value chain is an important area in order to improve seed production and supply system in the country. A consultative forum for planning EGS production would be necessary.

Farmers, seed producer cooperatives and unions, seed enterprises, research institutions, NGOs and the Ministry of Agriculture should work together in order to improve the supply of quality seed of malt barley in the country.

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# Basic and Certified Seed Production of Malt Barley by Seed Producer Cooperatives

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## Introduction

While agriculture has remained the mainstay of economic growth and development in Ethiopia, majority of land area covered with food crops is with seeds obtained from sources other than the formal seed sector. The proportion of improved seed coverage was below 10% even for the major cereal crops. Of the total annual arable land coverage by major food crops, farm saved seed covers 96.5% and 3.5% is by improved seeds (Atilaw and Korbu, 2011). In recent years, however major progress has been made in supplying seeds of improved varieties of various crops. According to Bishaw and Atilaw (2016), over 105,100 t of seed were supplied from the formal sector in 2014, yet the major crops produced were wheat and maize contributing 64 and 19% of the formal seed supply, respectively, though both crops occupy about 13 and 17% of cultivated area in the same order. This implies that the seed supply from the formal sources is better for wheat and maize, yet economically important crops such as barley, pulses and oil crops receive limited attention from the formal seed sector. Even though there is a substantial increase in certified seed supply, there is a huge gap between supply and demand for malt barley. The informal seed system, farmers produced, and saved seeds are still the major source of seed for smallholder farmers. In very recent years, farmers' seed producer cooperatives are playing significant role in producing seeds of economically important crops like malt barley. Therefore, to enhance availability of malt barley seeds, farmers' seed producer cooperatives need to be supported in all possible ways to strengthen their capacity in seed production and marketing. The objective of this work was to study and document the achievements made and the challenges encountered in malt barley seed production by seed producer cooperatives in the highlands of Arsi.

## Materials and Methods

### Study locations

The study covered six districts in two zones i.e. five districts (Chole, Honkolo-Wabe, Lemu-Bilbilo, Munesa and Tiyo) in Arsi Zone and one district (Kore) in West Arsi Zone, which were involved in malt barley seed production during 2015/16-2017/18 cropping seasons. These areas are selected since they are known for their potential in malt barley production. They are situated in geographic coordinate of 07°43.645'-08°11.341'N latitude, and 038°66.489'-039°54.592'E longitude. These areas have altitude ranges from 2565 to 3084 m asl and receive an annual rainfall that ranges from 863.8 to 1089.9 mm. Further details, including temperature and soil type of each target kebele are presented in Table 1.

*Table 1. Geographic coordinates, altitudes, weather and soil types of target seed producer cooperatives in Arsi and West Arsi Zones*

| SPC | District | Latitude N | Longitude E | Altitude (masl) | Rainfall (mm) | Tmax | Tmin | Soil type |
|---|---|---|---|---|---|---|---|---|
| Moye-Gado | Chole | 08°14.104' | 039°55.304' | 3084 | 866.2 | 27.1 | 14.3 | Nitosols |
| Bila-Sokora | Chole | 08°11.341' | 039°54.592' | 2962 | 863.8 | 27.1 | 14.3 | Nitosols |
| Hundie-Gudina | Munesa | 07°31.494' | 038°59.696' | 2778 | 1025.7 | 22.5 | 10.0 | Luvisols |
| Tuka-Katara | Lemu-Bilbilo | 07°26.774' | 039°14.936' | 2928 | 1028.5 | 18.1 | 5.7 | Vertisols |
| Lemu-Dima | Lemu-Bilbilo | 07°34.572' | 039°16.536' | 2893 | 1049.6 | 19.6 | 8.3 | Luvisols |
| Lemu-Burkitu | Lemu-Bilbilo | 07°36.659' | 039°15.507' | 2734 | 1049.6 | 19.6 | 8.3 | Luvisols |
| Dheka-Dhera | Lemu-Bilbilo | 07°26.327' | 039°16.110' | 2981 | 1028.5 | 18.1 | 5.7 | Vertisols |
| Teji-Burkitu | Honkolo-Wabe | 07°25.301' | 039°24.491' | 2839 | 989.2 | 23.5 | 11.2 | Vertisols |
| Beriti | Tiyo | 07°50.545' | 039°11.808' | 2983 | 1025.7 | 22.5 | 10.0 | Luvisols |
| Dandi-Boru | Tiyo | 07°52.409' | 039°07.496' | 2565 | 1089.9 | 21.8 | 12.3 | Luvisols |
| Lelisa-Bole | Kore | 07°43.645' | 038°66.489' | 2805 | 1281.2 | 20.6 | 8.4 | Nitosols |

*Note: SPC is seed producers cooperative; Tmax and Tmin is maximum temperature and minimum temperature, respectively, in °C*

## Description of SPCs and member farmers

Initially the public private partnership (PPP) malt barley project started in 2010/11 cropping season and supported mainly by Asella Malt Factory and other four breweries (Saint George, Meta, Harar, and Bedele) had played a significant role for the initiation of the community-based seed multiplication not only for malt barley but also for other rotation crops like faba bean, field pea and oilseed crops. Later in 2013, an Integrated Seed Sector Development project supported by the Government of The Netherlands came into picture to strengthen the already established seed producer cooperatives and to scale-up the Local Seed Business (LSB) models to these cooperatives. During 2015/16-2017/18, ICARDA-USAID malt barley and faba bean seed production and scaling project played very significant role in supporting and strengthening these cooperatives in seed production and marketing of malt barley varieties. Thus, 11 seed producer cooperatives in six districts were involved in the malt barley seed production and marketing in 2015/16-2017/18. The number of member farmers in each cooperative ranged from 25-172 with a total number of 721 member farmers (72 females) (Table 2). The farmers in the proximity of the cooperatives, which were not member of seed producer cooperatives, were also involved in seed production activities of the project. These farmers were included because their farmlands are situated within the clusters of the farmlands of member farmers. Some farmers also benefited indirectly by purchasing the produced seeds from the cooperatives. The seeds produced by the non-member farmers were inspected together with the member farmers and the non-members obliged to pay commission to the cooperatives while their seeds were sold.



**CHAPTER III**: Malt barley seed production

*Table 2. Seed producer cooperatives participated in malt barley seed production in 2015/16-2017/18*

| Cooperative | Year established | Number of members | | | Remark |
|---|---|---|---|---|---|
| | | Male | Female | Total | |
| Lemu Dimma | 2011 | 144 | 28 | 172 | Licensed |
| Tuka katara | 2012 | 48 | 5 | 53 | Licensed |
| Deka Dera Cheleleka | 2014 | 61 | 4 | 65 | Licensed |
| Lemu Burkitu | 2011 | 88 | 1 | 89 | Licensed |
| Teji Burkitu | 2010 | 30 | 4 | 34 | Licensed |
| Hunde Gudina | 2012 | 38 | 3 | 41 | Licensed |
| Beriti | 2013 | 40 | 6 | 46 | Licensed |
| Abdi Boru | 2016 | 32 | 6 | 38 | Licensed |
| Bila sekora | 2012 | 35 | 0 | 35 | Licensed |
| Moye Gado | 2013 | 22 | 3 | 25 | Licensed |
| Lelisa Bole | 2012 | 111 | 12 | 123 | Licensed |
| Total | | 649 | 72 | 721 | |

## Training and field days

Various types of training were organized for farmers, development agents (DAs) and agricultural professionals working on the seed multiplication in the target districts and cooperatives. Training topics covered improved malt barley technologies, quality seed production practices, and seed business. Kulumsa Agricultural Research Center (KARC) in collaboration with the seed producer cooperatives themselves and other stakeholders, organized various field days each year to demonstrate new varieties and promote the seed production fields of the seed producer cooperatives.

## Crop management

The planting time of malt barley in the respective districts ranged from mid-June to late July depending on the on start of the rainfall. A seed rate of 100 kg ha$^{-1}$ for row planting, and 125 kg ha$^{-1}$ for broadcasting; fertilizer rates of 100 kg ha$^{-1}$ of DAP or NPS and 50 kg ha$^{-1}$ of urea were used by the majority of the member farmers in each cooperative. Few farmers used more seed or lower fertilizer rates than the recommendations. Majority of farmers used axial herbicide for controlling grass weeds and 2,4-D for controlling broad leaf weeds. Other recommended malt barley agronomic packages like proper land preparation, rouging, harvesting and threshing were applied by most farmers and technical supports were provided by team of researchers from KARC and experts from the respective districts where the seed producer cooperatives are situated.

## Seed quality control and certification

Asella Seed Quality Control and Certification Center (ASQCCC) was invited to inspect and approve the quality of the seeds produced by each cooperative. Besides controlling the quality of the seed produced, the laboratory participated in providing trainings to the cooperatives for the quality seed production.

## Data collection

Data on the amount of seed of various classes of malt barley varieties provided to the cooperatives, area covered by each variety and seed class, amount of seeds produced by the cooperatives by variety and seed class, seed marketing by the cooperatives and individual member farmers, seed field inspected and inspection results, the number of trainings and field days organized and the number of participants by gender were collected.

# Results and Discussions

## Seed supply

Each year, with the support of ICARDA-USAID faba bean-malt barley seed production and scaling project, significant amounts of initial seeds of demanded malt barley varieties were delivered to the seed producer cooperatives. Besides delivering initial seed, the center has played its role in facilitating linkage between the cooperatives and seed sources like seed enterprises and other non-governmental organizations (NGOs) so that these cooperatives get different classes of seeds and other supports. At the beginning of the project, in 2015/16 cropping season, all the cooperatives linked to the project obtained 29.4 t of seed (including 1.11 t pre-basic seed of five different varieties contributed by KARC) and planted on about 220 ha.

In 2016/17 cropping season, with the support of the project, the KARC has supplied 13.97 t of seed to nine seed producer cooperatives to cover 111.5 ha of land. Of, which 3.164 t (22.64%) was pre-basic seed of five varieties (Bahati, Bekoji-1, Fanaka, Holker and IBON 174/03), which was directly provided from the center; 10.0 t (71.6%) seed was Certified Seed 1 (certified seed first generation) of variety Traveler, which was purchased from Lemu Dima seed producer cooperative; and the remaining 0.806 t (5.8%) was basic seed of two malt barley varieties revolved from previous year.

Similarly, in the 2017/18 cropping season, with the same support of the project, 45.5 t of different classes of seeds of eight malt barley varieties was provided to 11 seed producer cooperatives to cover 364 ha of land with a seed rate of 125 kg ha$^{-1}$. However, the actual land covered was only 309.7 hectares since some farmers used higher seed rate than the recommendation. KARC was the source for 9.5 t pre-basic seed of six malt barley varieties (Bahati, Fanaka, HB1963, HB1964, Holker, and IBON 174/03), which accounted for 20.9% of total seed. Basic seed of 12.3 t (27.3% of total seed) of Fanaka and IBON 174/03 malt barley varieties, and 10.8 t of Certified seed 1 (23.7% of total seed) of Traveler variety were purchased from seed producer cooperatives, Oromia Seed Enterprise, and Heineken Brewery Share Company. The remaining 28.3% of the total seed used in 2017/18 cropping season was from revolving source of previous cropping season.

## Basic and certified seed production

Considering the limited seed production of malt barley varieties by public and private seed producers, this project has given due attention for basic and certified seed production by





locally established seed producer cooperatives. During the project period in 2015/16-2017/18 cropping seasons, a total of 325.81 t of basic seed of eight malt barley varieties was produced (Table 3). During the initial year of the project only 30.7 ton was produced from 9.3 ha of land but the production progressively increased both in area coverage and production, which reached 70.3 ha of land producing 192.1 t of basic seed in one year at the end of the project period, 2017/18. Malt barley variety IBON 174/03 was with the largest quantity of basic seed produced accounting 54.97% (179.1 t) of the total during the three years followed by Bahati and Fanaka accounting 19.33% (62.8 t) and 9.3% (30.4 t), respectively.

*Table 3. Amount of basic seed produced by seed producer cooperatives in 2015/16-2017/18*

| Variety | 2015/16 | | 2016/17 | | 2017/18 | | Average productivity (t ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| | Area planted (ha) | Seed produced (t) | Area planted (ha) | Seed produced (t) | Area planted (ha) | Seed produced (t) | |
| *Sabini* | 5.0 | 14.2 | | | | | 2.84 |
| *Bekoji-1* | 1.0 | 2.9 | | | | | 2.90 |
| *IBON 174* | 0.75 | 4.6 | 16.7 | 44.5 | 47.0 | 129.96 | 2.78 |
| *EH1847* | 0.5 | 1.6 | | | | | 3.20 |
| *Bahati* | 2.0 | 7.4 | 8.3 | 26.3 | 11.2 | 29.1 | 2.92 |
| *Fanaka* | | | 5.8 | 20.4 | 4.0 | 10.0 | 3.10 |
| *Holker* | | | 4.2 | 11.8 | 2.4 | 5.76 | 2.66 |
| *HB1963* | | | | | 4.5 | 13.99 | 3.11 |
| *HB1964* | | | | | 1.2 | 3.3 | 2.75 |
| *Total* | 9.3 | 30.7 | 35.0 | 103.0 | 70.3 | 1921.1 | |

Regarding certified seed production, the SPCs collectively produced 877.8 t on 319.9 ha of land (Table 4). Seeds of six malt barley varieties were produced but three of the varieties (Traveler, IBON 174/03 and Fanaka) accounted for 98.4% (863.5 t) of the total production-each of these three accounting 60.69% (532.7 t), 27.79% (243.9 t) and 9.9% (86.9 t), respectively.

*Table 4. Amount of certified seed produced by seed producer cooperatives in 2016/17-2017/18*

| Variety | 2016/17 | | 2017/18 | | Productivity (t ha$^{-1}$) |
|---|---|---|---|---|---|
| | Area planted (ha) | Seed produced (t) | Area planted (ha) | Seed produced (t) | |
| IBON 174/03 | 3.4 | 10.2 | 85.5 | 233.7 | 2.74 |
| Fanaka | 4.8 | 15.3 | 22.0 | 71.6 | 3.24 |
| Traveler | 68.7 | 186.1 | 131.0 | 346.6 | 2.67 |
| Sabini | 2.9 | 9.25 | | | 3.19 |
| Bekoji-1 | 1.0 | 3.2 | | | 3.20 |
| EH1847 | 0.625 | 1.8 | | | 2.88 |
| Total | 81.43 | 225.85 | 238.5 | 651.9 | |

## Seed certification

Seed certification is an integral part of quality seed production and any seed producer, company, cooperative or union is required to get certification after field inspection and laboratory seed testing by a certification agency. According to the Ethiopian Seed Proclamation No 782/2013, any person or organization who intends to engage in seed production shall have a certificate of competence. But during the project period none of the cooperatives involved in the seed production had the required certificate of competence. Therefore, these cooperatives had to be linked to an entity with the certificate of competence for their seeds to be certified, which otherwise would have been left uncertified. Therefore, in the 2016/17 cropping season with a request from KARC, the seed production fields of five seed producer cooperatives and one farmers' group were evaluated by ASQCCC.

A total of 75.98 ha was requested to be inspected out of, which 57.78 ha (76.04%) was assessed (Table 5). From the inspected fields 48.98 ha (84.77%) was accepted and the remaining 8.8 ha (15.23%) was rejected. In terms of seed production, about 182.32 t (79.99%) was accepted and 30.92 t (20.01%) was rejected. The major reasons for rejections were varietal mixture, noxious weeds and loose smut disease in the neighboring farmers' fields.

Similarly, in the 2017/18 cropping season, KARC requested ASQCCC for inspection and certification of malt barley seed production fields of 11 seed producer cooperatives. Nevertheless, the request did not get positive response for the simple reason that KARC is not able to collect the seeds produced by these cooperatives for further processing and storage to qualify storage inspection for issuing final certification. However, malt barley seed production fields of four cooperatives, which were linked to Galema Union during this cropping season were inspected by the ASQCCC based on the request from the union. Out of 77.15 ha of malt barley fields of five malt barley varieties (Table 6.) 76.2 ha (98.77%) were inspected. This high level of inspection performance was due to the proximity of the seed production fields, which were clustered and easily accessible.

From 76.2 ha of inspected fields, 67.35 ha (88.39%) was accepted; and the remaining 8.85 ha (11.61%) was rejected. In terms of production 207.7 t (91.78%) was accepted and 18.6 t (8.22%) was rejected. The percentage of rejections in both years particularly in some of the cooperatives is very low indicating that the cooperatives have relatively good technical and internal quality control capacity.





*Table 5. Malt barley seed production, inspection and certification in 2016/17cropping season*

| SPC | Variety | Seed class | Malt barley area (ha) | | | | Seed produced (t) | |
|---|---|---|---|---|---|---|---|---|
| | | | Planted | Inspected | Accepted | Rejected | Accepted | Rejected |
| Lemu-Dima | IBON 174/03 | Basic | 1.125 | 1.125 | 1.125 | 0.0 | 4.533 | 0.0 |
| | Fanaka | Basic | 1.0 | 1.0 | 1.0 | 0.0 | 3.90 | 0.0 |
| | Bahati | Basic | 1.4 | 1.4 | 1.4 | 0.0 | 4.62 | 0.0 |
| Tuka-Ketara | IBON 174/03 | Basic | 1.6 | 1.3 | 1.3 | 0.0 | 7.8 | 0.0 |
| | Fanaka | Basic | 3.4 | 2.8 | 2.8 | 0.0 | 10.64 | 0.0 |
| | Bahati | Basic | 1.6 | 0.25 | 0.25 | 0.0 | 1.35 | 0.0 |
| | Traveler | CS2 | 11.0 | 7.0 | 5.5 | 1.5 | 18.7 | 5.1 |
| | HB1963 | Basic | 0.25 | 0.25 | 0.25 | 0.0 | 1.35 | 0.0 |
| | Holker | Basic | 1.5 | 1.0 | 1.0 | 0.0 | 3.65 | 0.0 |
| Hunde- Gudina | IBON 174/03 | Basic | 6.25 | 4.25 | 3.0 | 1.25 | 13.42 | 5.495 |
| | Traveler | CS2 | 12.0 | 11.5 | 8.1 | 3.4 | 27.4 | 11.5 |
| Bila- Sekora | IBON 174/03 | Basic | 1.25 | 1.25 | 1.25 | 0.0 | 5.83 | 0.0 |
| | Fanaka | Basic | 0.4 | 0.4 | 0.4 | 0.0 | 1.76 | 0.0 |
| | Traveler | CS2 | 8.0 | 4.25 | 3.45 | 0.8 | 13.68 | 3.2 |
| Teji-Burkitu | IBON 174/03 | Basic | 1.6 | 1.6 | 1.6 | 0.0 | 6.08 | 0.0 |
| | Bahati | Basic | 1.2 | 1.2 | 1.2 | 0.0 | 4.92 | 0.0 |
| | Fanaka | Basic | 0.8 | 0.8 | 0.8 | 0.0 | 3.68 | 0.0 |
| | Traveler | CS2 | 9.6 | 8.9 | 8.65 | 0.25 | 28.65 | 0.825 |
| FG | Traveler | CS2 | 12.0 | 7.5 | 5.9 | 1.6 | 20.355 | 4.8 |
| | Total | | 75.975 | 57.775 | 48.975 | 8.8 | 182.318 | 30.92 |

*Note: SPC is seed producer cooperatives; FG is farmers' group; CS2 is certified seed 2*

*Table 6. Malt barley seed production, inspection and certification in 2017/18 cropping season*

| SPC | Variety | Seed class | Malt barley area (ha) | | | | Seed produced (t) | |
|---|---|---|---|---|---|---|---|---|
| | | | Planted | Inspected | Accepted | Rejected | Accepted | Rejected |
| Lemu-Dima | IBON 174/03 | Basic | 8.0 | 8.0 | 8.0 | 0.0 | 30.1 | 0.0 |
| | IBON 174/03 | C1 | 4.7 | 3.0 | 3.0 | 0.0 | 13.6 | 0.0 |
| | Fanaka | Basic | 1.3 | 1.3 | 1.3 | 0.0 | 3.4 | 0.0 |
| | HB1963 | Basic | 1.3 | 1.3 | 1.3 | 0.0 | 3.8 | 0.0 |
| | HB1964 | Basic | 0.5 | 0.5 | 0.5 | 0.0 | 2.1 | 0.0 |
| | Traveler | CS2 | 8.0 | 8.0 | 8.0 | 0.0 | 23.8 | 0.0 |
| Tuka-Ketara | IBON 174/03 | Basic | 8.0 | 8.0 | 8.0 | 0.0 | 22.01 | 0.0 |
| | IBON 174/03 | CS1 | 2.0 | 2.0 | 2.0 | 0.0 | 7.8 | 0.0 |
| | Fanaka | Basic | 1.6 | 1.6 | 1.6 | 0.0 | 4.2 | 0.0 |
| | HB1963 | Basic | 2.0 | 2.0 | 2.0 | 0.0 | 6.36 | 0.0 |
| | HB1964 | Basic | 0.35 | 0.35 | 0.35 | 0.0 | 1.2 | 0.0 |
| | Traveler | CS2 | 8.0 | 8.0 | 1.4 | 6.6 | 6.4 | 12.25 |
| Deka-Dera | IBON 174/03 | CS1 | 5.0 | 6.0 | 5.25 | 0.75 | 12.8 | 2.6 |
| | Fanaka | CS1 | 2.5 | 2.5 | 2.5 | 0.0 | 7.75 | 0.0 |
| | Traveler | CS2 | 4.0 | 4.0 | 4.0 | 0.0 | 11.2 | 0.0 |
| Teji-Burkitu | IBON 174/03 | Basic | 6.7 | 6.45 | 6.45 | 0.0 | 15.15 | 0.0 |
| | IBON 174/03 | CS1 | 6.0 | 6.0 | 5.5 | 0.5 | 12.85 | 1.6 |
| | HB1963 | Basic | 0.6 | 0.6 | 0.6 | 0.0 | 1.7 | 0.0 |
| | Traveler | CS2 | 6.6 | 6.6 | 5.6 | 1 | 21.48 | 2.15 |
| | Total | | 77.15 | 76.2 | 67.35 | 8.85 | 207.7 | 18.6 |

*Note: CS1=Certified seed 1; CS2=Certified seed 2*





## Seed marketing and farmer-to-farmer seed exchange

The main purpose of establishing local seed producer cooperatives initially was to alleviate the seed shortage of their respective localities. Later on, with strong support from various stakeholders and projects, the seeds they were producing were attracting demand by farmers and stakeholders from different corners of the country as the seeds were of high quality and of demanded varieties and were not produced in sufficient quantity by public or private seed enterprises.

Data collected on 287.5t and 468.2 t of seed produced by six and nine of the 12 cooperatives in 2016/17 and 2017/18 cropping season, respectively, indicate that about 73.54% of the total seed produced is used for seed purpose (Tables 7 and 8). About 99.84 t (13.21%) of the seed was sold to Asella malt factory for malting purpose; 100.14 t (13.25%) of the seed was either consumed at home or sold on market as grain.

Seed marketing was done either through cooperatives or individually by member farmers. A total of 318.22 t (57.26%) of seed was marketed through cooperatives to various customers. These cooperatives sold their seeds to agricultural research centers such as Holetta, Debre Birhan, Sekota, and Kulumsa; to NGOs such as Self-help Africa, ICARDA-Africa Rising and others; to other cooperatives and unions and individual farmers. The seeds sold to various research centers, NGOs and unions were distributed to various seed producer groups and farmers in their respective target regions/districts for further seed multiplication or malt production.

Significant amount of seed was also distributed by individual member farmers either through direct sale or through bartering. Through bartering, malt barley seed was mainly exchanged with either wheat or food barley or other malt barley varieties and the exchange ratio was one to one. Seed distribution through sale by individual farmers is presented below.

A total of 176.67 t of seed, which is 31.79% of the total seed sale in the two years was distributed by individual farmers. Of this, 171.19 t of seed (96.9%) was directly sold and the remaining 5.48 t (3.1%) was bartered with other crops. These individual member farmers sold or exchanged their seeds with other farmers within their kebeles or beyond as well as within their district or beyond. A total of 447 male and 9 female farmers from eight different districts and 85 different kebeles purchased or exchanged the seed from these member farmers in 2016/17 cropping season (Table 7). Similarly, a total of 753 male and 29 female farmers from ten different districts and 142 kebeles purchased or exchanged the seed in the 2017/18 cropping season (Table 8).

The seed price ranged from 950 to 2000 Birr in 2016/17 cropping season whereas it ranged from 1000 to 2300 Birr in 2017/18 cropping season per 100 kg seed and the lowest price was when the seed was sold immediately after harvest and/or during harvesting period while the highest price was when the seed was sold during planting time. The maximum barley grain price was 1100 and 1300 Birr per 100 kg in 2016/17 and 2017/18 cropping season, respectively. Up to 60% price increment between harvesting and planting time was also reported by FAO (2010). The seed prices were also higher when farmers took seeds on loans.

Table 7. Seed marketing and farmer-to-farmer seed exchange by SPCs in 2016/17

| SPC | Variety | Seed marketed, seed saved and home consumed by individual farmers* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Exchanged seed (t) | | Direct beneficiary farmers | | Seed sold by cooperatives (t) | Used as own seed source (t) | Seed sold as malt grain to AMF (t) | Seed sold as grain to others (t) | Seed used for home consumption (t) |
| | | Bartering | Sale | M | F | | | | | |
| Bila- Sekora | IBON 174/03 | 0.10 | 2.92 | 39 | 1 | 0.0 | 0.4 | 0.0 | 0.0 | 0.4 |
| | Traveler | 0.225 | 4.32 | 41 | 1 | 0.0 | 1.71 | 8.74 | 0.0 | 3.45 |
| | Bekoji-1 | 0.2 | 0.6 | 8 | 0 | 0.0 | 0.35 | 1.0 | 0.1 | 1.05 |
| | Fanaka | 0.0 | 1.03 | 8 | 0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Hunde- Gudina | IBON 174/03 | 0.2 | 6.1 | 45 | 0 | 9.408 | 2.431 | 0.0 | 0.48 | 0.46 |
| | Traveler | 0.0 | 1.3 | 8 | 0 | 1.1 | 1.7 | 11.2 | 1.0 | 5.1 |
| Lemu-Dima | IBON 174/03 | 0.05 | 1.3 | 11 | 2 | 4.7 | 0.5 | 0.0 | 0.0 | 0.0 |
| | Fanaka | 0.0 | 0.7 | 5 | 1 | 0.668 | 0.15 | 0.0 | 0.0 | 0.0 |
| | Bahati | 0.0 | 0.4 | 2 | 0 | 0.45 | 0.2 | 0.0 | 0.0 | 0.4 |
| | Traveler | 0.0 | 0.0 | 0 | 0 | 103.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Teji- Burkitu | Traveler | 0.4 | 5.75 | 37 | 2 | 10.0 | 2.6 | 0.0 | 0.2 | 1.65 |
| | IBON 174/03 | 0.1 | 1.25 | 10 | 0 | 0.4 | 0.55 | 0.0 | 0.0 | 0.35 |
| | Fanaka | 0.0 | 0.9 | 10 | 0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Moye- Gado | Traveler | 0.0 | 9.85 | 100 | 0 | 0.0 | 2.205 | 0.8 | 0.0 | 0.8 |
| | IBON 174/03 | 0.0 | 3.4 | 33 | 0 | 1.8 | 0.2 | 0.0 | 0.0 | 0.0 |
| | Bahati | 0.0 | 1.05 | 12 | 0 | 0.0 | 0.35 | 0.0 | 0.0 | 0.8 |
| Tuka- Ketara | IBON 174/03 | 0.0 | 2.92 | 14 | 0 | 5.595 | 0.825 | 0.0 | 0.0 | 0.0 |
| | Fanaka | 0.0 | 2.3 | 14 | 1 | 7.0 | 0.85 | 0.0 | 0.0 | 0.0 |
| | HB1963 | 0.0 | 0.0 | 0 | 0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Traveler | 0.0 | 5.75 | 32 | 0 | 6.4 | 3.45 | 12.2 | 2.7 | 3.2 |
| | Holker | 0.0 | 1.3 | 9 | 1 | 2.8 | 0.5 | 1.0 | 0.0 | 0.4 |
| | Bahati | 0.2 | 1.15 | 9 | 0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 |
| Total | | 1.475 | 1.475 | 447 | 9 | 154.721 | 19.571 | 34.94 | 4.48 | 18.06 |

*Note: *Individual farmers' sale price of seed varied from 950 to 1625 Birr per 100 kg while sale price of cooperatives ranged from 1100 to 2000 Birr per 100 kg seed (seed sold by individual member farmers of SPCs was either excess of submission to the SPCs or not submitted to the SPCs); SPC= seed producer cooperatives; AMF= Asella malt factory; M = male; F = female*





Table 8. Seed marketing and farmer-to-farmer seed exchange by SPCs in 2017/18

| SPC | Variety | Seed marketing, seed reserve and home consumption by individual farmers* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Exchanged seed (t) | | Direct beneficiary farmers | | Seed sold by cooperatives (t) | Used as own seed source (t) | Seed sold as malt grain to AMF (t) | Seed sold as grain to others (t) | Seed used for home consumption (t) |
| | | Bartering | Sale | M | F | | | | | |
| Bila Sekora | IBON 174/03 | 0.5 | 13.8 | 104 | 4 | 23.9 | 4.114 | 0.0 | 0.0 | 5.0 |
| | Fanaka | 0.2 | 0.6 | 7 | 0 | 5.4 | 1.3 | 0.4 | 0.0 | 6.2 |
| | Traveler | 0.3 | 3.0 | 26 | 0 | 0.0 | 1.175 | 6.4 | 1.0 | 8.1 |
| Teji Burkitu | IBON 174/03 | 0.5 | 5.0 | 34 | 1 | 9.6 | 1.65 | 0.7 | 0.0 | 0.0 |
| | Traveler | 0.4 | 3.8 | 29 | 0 | 8.5 | 1.425 | 0.6 | 0.0 | 2.4 |
| Deka Dera | IBON 174/03 | 0.0 | 7.0 | 30 | 2 | 9.5 | 2.934 | 0.0 | 0.0 | 1.2 |
| | Traveler | 0.0 | 4.4 | 20 | 0 | 1.6 | 1.1 | 4.9 | 0.0 | 0.7 |
| | Fanaka | 0.0 | 1.0 | 7 | 1 | 6.0 | 0.3 | 0.0 | 0.0 | 0.3 |
| Lemu Dima | IBON 174/03 | 0.5 | 9.4 | 55 | 1 | 21.5 | 2.75 | 0.0 | 0.0 | 1.7 |
| | Fanaka | 0.0 | 0.0 | 0 | 0 | 1.5 | 0 | 0.0 | 0.0 | 0.0 |
| | Traveler | 0.2 | 1.3 | 7 | 1 | 10.8 | 0.55 | 12.7 | 0.0 | 1.9 |
| | HB1963 | 0.0 | 0.0 | | | 3.1 | 0 | 0.0 | 0.0 | 0.0 |
| | HB1964 | 0.1 | 1.3 | 11 | 0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Lemu Burkiu | IBON 174/03 | 0.3 | 12.3 | 76 | 4 | 0.0 | 4.082 | 0.0 | 0.0 | 4.1 |
| | Fanaka | 0.0 | 2.0 | 20 | 0 | 0.0 | 0.875 | 0.0 | 1.6 | 3.4 |
| | Traveler | 0.0 | 0.2 | 2 | 0 | 0.0 | 0.8 | 5.7 | 0.0 | 2.1 |
| Hunde Gudina | IBON 174/03 | 0.6 | 28.5 | 109 | 5 | 21.0 | 7.295 | 0.0 | 3.8 | 6.6 |
| | Traveler | 0.0 | 0.0 | | | 0.0 | 1.3 | 3.9 | 1.0 | 10.4 |
| | HB1963 | 0.0 | 1.1 | 8 | 0 | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 |
| Moye Gado | IBON 174/03 | 0.2 | 11.4 | 130 | 6 | 12.7 | 4.1 | 0.6 | 0.0 | 2.1 |
| | Fanaka | 0.0 | 2.0 | 9 | 1 | 0.0 | 0.87 | 0.0 | 0.8 | 0.0 |
| | Traveler | 0.0 | 0.3 | 3 | 0 | 0.0 | 0.7 | 20.4 | 0.0 | 0.0 |
| Tuka Ketar | IBON 174/03 | 0.0 | 1.5 | 11 | 0 | 18.3 | 0.85 | 0.0 | 0.0 | 0.0 |
| | Fanaka | 0.0 | 0.2 | 2 | 0 | 1.9 | 0.0 | 0.9 | 0.0 | 0.0 |
| | Traveler | 0.0 | 2.7 | 9 | 1 | 2.7 | 0.57 | 6.5 | 1.2 | 0.9 |
| | HB1963 | 0.0 | 0.7 | 5 | 0 | 4.7 | 0.4 | 0.0 | 0.0 | 0.0 |
| Beriti | IBON 174/03 | 0.4 | 2.2 | 24 | 1 | 0.0 | 0.575 | 0.0 | 0.8 | 0.0 |
| | Fanaka | 0.0 | 1.0 | 11 | 1 | 0.0 | 0.86 | 0.0 | 0.0 | 0.7 |
| | Traveler | 0.0 | 0.5 | 4 | 0 | 0.0 | 0.24 | 1.3 | 1.7 | 1.2 |
| Total | | 4.0 | 116.9 | 753 | 29 | 163.5 | 41.3 | 64.9 | 11.8 | 65.8 |

*Note: Abbreviations are as indicated under Table 7; *individual farmers' sale price of seed varied from 1200 to 2200 Birr per 100 kg while that of cooperatives ranged from 1535 to 2300 Birr per 100 kg seed*

## Trainings and field days

Various trainings and field days were organized during the last three years with support of the project to achieve the project outputs. The themes of the trainings were seed production and management of malt barley, which was delivered before planting to make aware the farmers on the necessary requirements for seed production and to help them to take appropriate measures ahead of time about seed production to meet quality standards so that the produced seed will not be rejected at the end of the day; training on pre and post-harvest management, which was delivered at maturity stages to maintain the purity of the seed produced both in the field and during storage; and seed/farm entrepreneurship training, which was delivered to executive committee members of each cooperative, district level cooperative officers and auditors who are working with the seed producer cooperatives. The aim of this training was to strengthen the managerial and organizational skills and structures of the cooperatives. In general, 1659 participants were involved in all the three trainings delivered during the three years from 2015/16-2017/18 (Table 9). Trainees were 1301 farmers (126 females) and 358 staff members (51 females) of partners and stakeholders including zone and district level experts of agricultural extension, kebele level development agents, heads and experts of cooperatives. In addition to the above trainings, a total of 1095 participants (141 females) also got different trainings from different stakeholders directly or indirectly linked to the project in the year 2017/18 (data not shown in Table 9).

*Table 9. Type and number of training participants in 2015/16-2017/18*

| Participant | 2015/16 | | 2016/17 | | 2017/18 | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| Farmers | 82 | 6 | 844 | 99 | 249 | 21 |
| Experts and development agents | 34 | 11 | 128 | 24 | 35 | 10 |
| Junior researchers | | | 38 | 1 | 32 | 4 |
| Experts & heads of cooperatives | | | 40 | 1 | | |
| Total | 116 | 17 | 1050 | 125 | 316 | 35 |

To demonstrate new varieties and promote the seed production of the SPCs, KARC in collaboration with the cooperatives and other stakeholders organized several field days. The field days contributed in creating a better image of the SPCs in the presence of potential customers and authorities such as the bureau of agriculture and cooperative promotion agency, seed enterprises, quarantine, and seed quality certification laboratories. A total of 1968 participants attended the field days organized during 2015/16-2017/18 cropping seasons (Table 10). The participants were 1490 farmers (156 females) and 478 staff members (51 females) of different organizations indicated above.





*Table 10. Type and number of field day participants*

| Participant | 2015/16 | | 2016/17 | | 2017/18 | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| Farmers | 210 | 34 | 551 | 83 | 573 | 39 |
| Experts & development agents | 53 | 1 | 104 | 16 | 70 | 8 |
| Researchers | | | 36 | 2 | 49 | 11 |
| Others | | | 72 | 7 | 43 | 6 |
| Total | 263 | 35 | 763 | 108 | 735 | 64 |

*Note: Others include heads and experts of bureau of agriculture and cooperative promotion agency, seed enterprises, quarantine and seed quality certification laboratories*

## Challenges

Some of the major challenges in the production of basic seed and certified seed of malt barley by the SPCs in the project period include:

**Shortage of initial seed:** The initial seeds of the recently released varieties were not available in any of the public seed producers. Besides, the seed that were available on the hands of KARC or other research centers particularly in the first year of the project was not available in required quantity due to the fact that the research centers had no enough land for EGS production

**Field clustering:** There were many fields of non-member farmers in between the fields of cooperative member farmers that made the field clustering difficult. This further makes seed field inspection and quality control activities difficult and time consuming for both internal and external bodies.

**Seed quality control and certification:** For the seed fields to be quality controlled and certified, the SPCs need to have certificate of competence (COC) for seed production. But all these cooperatives had no COC and were not able to certify their produced seeds by the responsible regulatory body with their own request; and they were forced to depend on others with COC for seed certification.

**Seed storage facilities:** Only one of the cooperatives had standard seed store, but the rest either had sub-standard seed stores with small capacity or did not have any seed store. Thus, they were forced to save their seeds individually at members' home, which in turn led to deterioration of the quality of seeds produced.

**Harvesting and seed cleaning:** Harvesting and seed cleaning are important steps in the seed production and have significant effects on seed quality. Most of the cooperatives were harvesting and cleaning manually and they usually don't treat and label their seeds, the intervention suggested by all the stakeholders in the seed value chain to improve the quality of the seeds produced by the cooperatives.

**Weak integration of malt barley value chain:** The weak integration among different stakeholders in the seed value chain leads to inappropriate use of the produced seeds. For example, large portion of the seeds produced by different cooperatives were sold to Asella Malt Factory for malting purpose instead of using it as seed for further malt grain production in the farmers' fields. Besides, different stakeholders said some potential areas lack seed for malt grain production, but high amount of seeds to low potential areas.

## Future directions

Improved seed is a key input for our agricultural development, but there is huge gap in the supply and demand chain. Due attention must be given to strengthen the capacity of SPCs to produce high quality and sufficient quantity seed of the demanded varieties at least to narrow the gap between demand and supply. The SPCs are well equipped with technical skills and are able to produce quality seeds at least at field condition as proved in this project since most of the fields inspected by ASQCCC were accepted.

Most of the cooperatives are not able to further clean, treat and store the seed produced to the expected high-quality standards. Hence, the seed value chain actors particularly for malt barley must integrate themselves, intervene and act on their responsibilities to strengthen the seed producer cooperatives to the required standard levels. Those cooperatives that fulfill the basic standards for seed production also need to be supported in getting COC in the shortest possible time or need to be linked to seed cooperative unions in their proximity to get their seed production be inspected and certified.

Besides, access to initial seed is a major problem for these cooperatives, strategies must be devised for research centers and others responsible for early generation seed production to have enough and suitable farmlands for the production of the required quantity and quality of early generation seed.

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# Community-based Malt Barley Basic-seed Multiplication and Promotion in Koga Irrigation Scheme in Amhara Region

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## Introduction

Seed is a key input for improving crop productivity and production (Beyene, 2010). It is one of the most economic and efficient inputs to agricultural development (FAO, 2006; Atilaw, 2010). However, there has been limited use of improved seeds by most farmers in Ethiopia (CSA, 2010). Availability of and access to good quality EGS at the right time and place has been one of the major constraints in the seed value chain in Ethiopia (Bishaw and Atilaw, 2016). Usually farmers get limited access to quality seed of improved varieties through technology transfer and pre-scaling mechanisms of the research centers. This is usually followed by community-based seed production and distribution initiatives by farmer groups and cooperatives (Desalegn et al., 2012).

Community-based seed production is part of the informal seed system that offers many opportunities for improving the seed security of small-scale farmers since it is built on farmers' knowledge and capacities. Seed supply through the informal sector in Ethiopia is estimated to be 80–90% (Bishaw et al., 2008). Seed production follows all the necessary procedures of seed certification where farmers are registered and fields are inspected for certified seed production (Teddie and Grace, 2010).

During the last few years, promotion of the two improved malt barley varieties (EH1847 and IBON 174/03) by Adet Agricultural Research Center (AdARC) in cooperation with the agriculture extension offices at the grassroots levels resulted in increasing demand of EGS by the public seed enterprise, cooperatives, unions and different projects. This huge gap in demand and supply of EGS was beyond the capacity of AdARC, which critically lacks land for seed multiplication. Therefore, community-based EGS multiplication with the participation of different stakeholders and farmers at Koga Irrigation Scheme was initiated; and linkages among the possible actors on seed multiplication and promotion of malt barley technologies strengthened.

## Materials and Methods

### Study locations

In 2017/18 offseason, community-based EGS seed multiplication activities were conducted in Kudmi and Kolela kebeles, on the farmers' fields at Koga Irrigation Scheme (KIS) in Mecha district of West Gojam Zone in Amhara Regional State. Mecha district is located at 11°10′ to 11°40′N latitude and 37°02′ to 37°17′E longitude with an average altitude of 1901 masl. The districts receive an annual rainfall of 1200-1500 mm, which is uni-modal with good distribution between May and October for meher season production. Moreover, the district has a large irrigated area and plain topography in KIS. The area has 13°C and 35°C minimum and maximum temperature, respectively. The dominant soil types in the district are Nitosols (93%), brown mixed soil (4%) and Vertisols (3%). Crop-livestock mixed farming is the dominant production system where maize, finger millet, tef, wheat, pulses, barley and horticultural crops are widely produced.

The command area of KIS is found in the geographic coordinates of 11°10' to 11°22'N latitude and 37°02' to 37°17'E longitude with the average altitude of 1960 masl in the Tana Basin and suitable temperatures for year-round cropping of the area. The dominant soil type of the irrigation command area is Nitosols. The irrigation area covers 7,000 ha of smallholder farmers for agricultural production during dry season to improve food security and livelihood of about 12,000 households (McCartney and Awulachew, 2007).

## Partnerships

Linkage among stakeholders is vital for successful seed production and technology promotion at wider scale. The roles and responsibilities of each partner was established as indicated below.

### Adet Agricultural Research Center (AdARC)

Its main responsibilities were to establish effective and efficient coordination and collaboration among stakeholders to ensure a smooth flow of information and knowledge transfer about malt barley seed multiplication among partners and stakeholders for future wider multiplication and dissemination. Some of major responsibilities included:

- Supply inputs such as seed of improved malt barley varieties;
- Organize trainings to farmers, DAs and experts/administrative leaders;
- Provide technical support, organized joint monitoring and evaluation of farmers' fields;
- Play leading role in establishing and strengthening farmer-to-farmer experience sharing; and
- Organize field inspection and laboratory testing and facilitated market linkage and price setting assessments.

### Farmers

The responsibilities of seed multiplier farmers were well defined in the memorandum of understanding and included:

- Provide own fertilizer, labor and land for malt barley seed multiplication as well as irrigation water based on barley water requirement;
- Participate in planning, implementation and evaluation of activities by themselves and with other farmers and experts;
- Participate in group discussion for sharing their indigenous knowledge and experiences;
- Meet seed quality standards such as isolation distance, rotation, timely weeding, rouging of seed fields, harvesting, threshing, and proper storage;





- Participate in data collection providing appropriate information or feedback about improved malt barley and seed multiplication; and
- Involve in price setting of malt barley seed after harvest.

### Office of agriculture (woreda to kebele level)

Office of agriculture is the main responsible government organization in the seed multiplication and distribution process. Some of the main responsibilities included:

- Facilitate activities and clustering of farmlands based on farmer's willingness;
- Facilitate information sharing among farmers, participate in organizing training and field day events;
- Participate in the joint monitoring and evaluation of seed multiplication and other events; and
- Mobilize farmers for problem identification and evaluation during implementation of EGS and technology promotion.

### Koga Irrigation Project

Main responsibilities of the irrigation scheme included:

- Ensure economic and proper use of irrigation water according to the recommendations;
- Mobilize farmers in water user association and set irrigation schedule to farmers for irrigating their crop based on size of their land area and crop water requirement;
- Participate in the joint training and field day events, monitoring and evaluation; and
- Participate in market linkages of farmers and unions and price setting assessments.

### Koga irrigation users' unions

The main responsibilities of unions were:

- Distribution of seed and collection of produce from seed cooperatives; and
- Ensure provision of Birr 22 profit margin per 100 kg seed to cooperatives, which collects seed from individual farmers by paying 15% premium price on top of grain market price.

### Andinet, Bered Gefera and Kudmi seed multiplication and marketing cooperatives

The major responsibilities were encouraging farmers produce quality seed and to improve their marketing system and linkages between farmers and other actors. They were also involved in seed distribution, price setting, harvesting of the seed from the field, storage management and efficient marketing coordination.

### Amhara Seed and Other Inputs Quality Control and Quarantine Agency

The agency conducted field inspection and laboratory testing to ensure seed quality standards and certification according to the national standards of Ethiopia established in 2010 and according to revised seed proclamation No.782/2013.

## Amhara Seed Enterprise (ASE)

ASE conducted seed cleaning, bagging, labeling, and laboratory testing with the collaboration of external seed quality control agency and ensured seed marketing to the unions.

## International Center for Agricultural Research in the Dry Areas (ICARDA)

ICARDA provided training of trainers, funding, technical backstopping, and monitoring and evaluation.

## Selecting and training farmers

Seed multiplication sites (seed multiplier farmers) were selected with close collaboration and discussion with agricultural extension agents of Koga irrigation scheme and farmers themselves. Although many farmers were interested, only those farmers with adjacent lands to form clusters were selected. A total of 575 kg pre-basic seed of IBON 174/03 and EH 1847 malt barley varieties were delivered to Koga irrigation project kebele facilitators who distributed the seed to beneficiary farmers for planting on 4.85 ha of land. Before planting, training was organized for farmers and facilitators to have common understanding on the implementation process and crop management, and to address the knowledge and skill gap of malt barley seed production.

## Preparing and managing seedbed

The seed multiplication field was ploughed 3-5 times with oxen plow before planting. Planting was done manually at the seed rate of 125 kg ha$^{-1}$ in rows with 20 cm spacing. Recommended fertilizer rates of 121 kg ha$^{-1}$ NPS and 100 kg ha$^{-1}$ urea were applied. The whole amount of NPS fertilizer was applied at planting time while urea was applied in two splits, half at planting and the other half was top dressed after one month of planting. Sowing date was in 4-6 December 2017. Furrows in 40 cm spacing were used for irrigating the field. Crop watering was done at every 9-14 days' interval, depending on the access to water reservoir. Some farmers used double row sowing method after, which 40cm wide furrow was made for irrigation while others used the same 40cm wide furrow for planting and irrigation (Figure 1). Manual hand weeding was done twice. Dimethoate at the rate of one gram per hectare was diluted in 125 liter of water and sprayed to control aphids. Twice rouging was done to remove off types and make sure that pure seed is harvested. Crop harvesting was done manually by sickle from 2–5 April 2018 with the follow up of unions and researchers.

*Figure 1. Double row planted irrigation furrows (left) and single row planted furrows (right) (emerged plants on top of furrows)*





## Field days

At crop maturity stage, field days were organized to facilitate experience sharing, linkage among stakeholders, technology promotion and evaluate the overall performance of the seed production and promotion.

## Data collection

Qualitative and quantitative yield related, and social data were collected. Yield data were collected after harvest and social data (farmers' and experts' opinion or feedbacks) were collected during field monitoring and evaluation at vegetative and maturity stage of malt barley varieties, including field day events. Structured interview, farmers' group discussion and individual farmer interview were used as a major social data collection approach. Thus, farmers' perception and feedbacks were collected from 15 host farmers and 3 kebele facilitators.

## Data analysis

Data were analyzed using simple descriptive statistics (such as mean, maximum, minimum, standard deviation, and percentage) and Kiker scale. Social data (farmers' and experts' opinion or feedbacks) were qualitatively described and classified by themes and contents.

# Results and Discussion

## Training

Training was provided to 25 farmers and 6 experts from KIS and Abay Watershed Management Project, and KIS user union. The training included malt barley seed production technology and standards, agronomic practices/production packages, disease and pest managements, irrigation methods, market linkage, access and opportunities as well as each actor roles and responsibilities. During this event, computer power point presentations in Amharic language, leaflets, posters, and audio visuals were used as training materials for additional capacity building on malt barley seed production.

## Field days

Field day is an event on, which an area containing successful farming practice is open for people to visit and learn (JICA, 2015). Field day is an extension approach mostly used to create wider demand for other farmers and stakeholders on the technology under evaluation at the field. In cognizant of this, field days were organized for 85 farmers and 53 staff of stakeholders such as woreda and zone administrative authorities and experts, Amhara Region Agricultural Research Institute, KIS, Abay Watershed Management, Amhara Seed Enterprise, Bahir Dar University, Amhara Seed Quality Control and Quarantine Agency, Koga Irrigation Users Union, Guna Seed Multiplication and Marketing Union, three Primary Seed Producer and Marketing Cooperatives, and Amhara Mass Media. Amhara Mass Media promoted the irrigated seed production and the field day events by broadcasting on Amhara television and radio programs.

*Figure 2. Participants visiting, discussing and sharing experiences on irrigated seed production of malt barley varieties at Koga in 2017/18*

Field day participants, including farmers, were very much impressed by the performance of the irrigated malt barley seed production. Farmers ranked variety IBON 174/03 first followed by EH1847 although they preferred both for further production at wider scale. Participants from Koga Irrigation Project, Guna Seed Multiplication and Marketing Union, and Amhara Seed Enterprise also said that both varieties (IBON 174/03 and EH1847) have better tillering capacity, spike length, and uniform maturity. They suggested to support farmers as a source of early generation seed and promotion of the varieties to reach more farmers.

Amhara Seed Enterprise indicated that early generation seeds of malt barley varieties had been purchased from other regions; thus, suggested that AdARC should continue to fill early generation seed multiplication; especially pre-basic and basic gap by working in collaboration with farmers and other stakeholders. It was also suggested that KIS stakeholders' platform should be organized for the proper management and use of technologies, sustainable technology promotion and seed multiplication.

## Yield

Yield data (Tables 1 and 2) and farmers' evaluation (Tables 3 and 4) are presented below to show performance of malt barley varieties in the irrigated production system at KIS.

Productivity of malt barley variety IBON 174/03 ranged from 2.82 to 4.62 t ha$^{-1}$ on 14 farmers' fields with the average productivity of 3.48 t ha$^{-1}$ while that of EH1847 ranged from 2.93 to 4.26 t ha$^{-1}$ on four farmers' fields with the average productivity of 3.40 t ha$^{-1}$ (Table 2). The productivity of the two malt barley varieties under irrigation is much higher than the average productivity of barley reported by CSA (2017) in Amhara Region. Productivity variation within each variety in this irrigated scheme was also high due to variations in timely availability of irrigation water and management practices in each farmer's field. Optimal availability and irrigation method are expected to highly improve productivity of these malt barley varieties under KIS.





*Table 1. Planted land areas and produced basic seed yield in 2017/18*

| Variety | Kebele | Number of farmers | Planted land area (ha) | Seed produced (t) |
|---|---|---|---|---|
| IBON 174/03 | Kudmi | 3 | 0.482 | 1.763 |
| | Kolela | 11 | 2.263 | 7.646 |
| EH1847 | Kolela | 4 | 1.105 | 3.761 |
| Total | | 18 | 4.850 | 13.170 |

*Table 2. Productivity of malt barley varieties (kg ha$^{-1}$) under irrigation in Koga irrigation scheme in 2017/18*

| Variety | Kebele | N | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|---|---|
| IBON 174/03 | Kudmi | 3 | 3575 | 3855 | 3715 | 1.4 |
| | Kolela | 11 | 2818 | 4617 | 3415 | 5.65 |
| EH1847 | Kolela | 4 | 2931 | 4260 | 3396 | |

The average Likert Scale measure of farmers' perception on malt barley varieties indicated that 47.0% and 52.1% of 13 farmers, respectively, expressed strongly positive and positive agreements in rating the performance of varieties in terms of the nine traits listed in Table 3. Generalizations of farmers' perception about the technology acceptability parameters through Likert scale measurements indicated that the average score for individual 9 traits of malt barley varieties ranged from 4.07-4.84 (Table 4), implying that farmers and other actors have good perception on the acceptability of the technologies since the minimum score required is 3.51. Average score of 2.51-3.50 indicates that the respondents have no confidence while score of less than 2.50 means the respondents have no good perception on the technology.

To satisfy farmers' interest and malt barley grain demand of the value chain, linkage and communication between stakeholders are important for enhancing early generation seed production and promotion of malt barley technologies in Koga irrigation command areas and beyond.

*Table 3. Likert Scale measure values of farmers' perception on technologies*

| Selected traits of tested varieties | | Farmers' response options and ratings | | | | |
|---|---|---|---|---|---|---|
| | | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
| Seed quality and purity is good | N | 3 | 9 | 1 | | |
| | % | 23.08 | 69.23 | 7.69 | | |
| Varieties have better tillering capacity | N | 9 | 4 | | | |
| | % | 69.23 | 30.77 | | | |
| Vegetative performance is very good | N | 6 | 7 | | | |
| | % | 46.16 | 53.84 | | | |
| Seed setting performance is good | N | 7 | 6 | | | |
| | % | 53.84 | 46.16 | | | |
| Varieties are disease resistant | N | 2 | 11 | | | |
| | % | 15.39 | 84.61 | | | |
| Varieties are less lodging | N | 11 | 2 | | | |
| | % | 84.61 | 15.39 | | | |
| Varieties maturity time is suitable to the irrigated area | N | 9 | 4 | | | |
| | % | 69.23 | 30.77 | | | |
| Varieties Have Higher Plant Height & Panicle Length | N | 3 | 10 | | | |
| | % | 23.08 | 76.92 | | | |
| Varieties have higher productivity | N | 5 | 8 | | | |
| | % | 38.46 | 61.54 | | | |

*Table 4. Sum and average of scores for Likert scale measure of farmers' perception*

| Selected traits of tested varieties | Sum of scores | Average scores |
|---|---|---|
| Seed quality and purity is good | 53 | 4.07 |
| Varieties have better tillering capacity | 61 | 4.69 |
| Vegetative performance is very good | 58 | 4.46 |
| Seed setting performance is good | 59 | 4.54 |
| Varieties are disease resistant | 54 | 4.15 |
| Varieties are less lodging | 63 | 4.84 |
| Varieties maturity time is suitable to irrigated area | 61 | 4.69 |
| Varieties have higher plant height & panicle length | 55 | 4.23 |
| Varieties have higher productivity | 57 | 4.38 |
| Average | 57.89 | 4.45 |



**CHAPTER III**: Malt barley seed production

## Lessons learned

- Off season seed production using irrigation and community-based seed production is a very promising approach for narrowing EGS production and supply gaps;
- Community-based EGS production is also important approach to alleviate land scarcity of the national agricultural research system;
- Capacity building of individual farmer and cooperatives are priority areas of intervention for successful community-based EGS production; and
- Strong linkage of actors in malt barley seed production is required and should be priority intervention area for successful planning and implementation in the value chain.

## Conclusions and Recommendations

Off-season EGS production under irrigation and community-based seed production showed higher productivity and acceptability of tested malt barley varieties, which attracted participant stakeholders for strengthening linkage among actors in seed value chain for enhancing production and scaling up/out. The experiences also suggest that capacity building of individual farmer and cooperatives are priority areas of intervention for successful community-based EGS production. Strong linkage of actors in malt barley seed production is required and should be priority intervention areas for successful planning and implementation in the value chain.

## Acknowledgments

AdARC is acknowledged for providing logistical supports and following up of implementation of the activity. Great thanks go to farmers, Koga Irrigation Project and Koga Irrigation Union for their support and interesting participation in implementing the seed multiplication and promotion. We would like to sincerely thank all those who contributed for successful completion of this seed multiplication and promotion.

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**CHAPTER III**: Malt barley seed production

# Malt Barley Seed Supply and Production in North Gonder Zone of Amhara Region

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## Introduction

Apart from biotic and abiotic factors, limited adoption of improved barley production technologies contributed to low productivity and production of malt barley in Ethiopia (Mulatu and Lakew 2011). Cognizant of this, the Gonder Agricultural Research Center (GARC) executed adaptation trials of released malt barley varieties such as Bahati, EH1847, IBON 174/03, and Traveler in 2014 and found them adapted to the area and recommended them for commercial production. A farmer participatory variety selection and demonstration resulted in the selection of IBON 174/03 by farmers for wider scale production. However, the adoption was not satisfactory for the basic reason that the seed supply was very limiting. Therefore, there was no sufficient malt barley production and marketing although there are customers in the area, the Gonder Malt Factory (GMF). The demand of malt barley by GMF has not yet satisfied and it has been importing malt from abroad since the domestic production is much below the demand in the country.

The seed shortage might be attributed to the existence of recently introduced and commonly known as "boren" weed (***Chrysanthemum segatum***). This discouraged seed producer farmers due to rejection since the weed has been declared as noxious weed or quarantine pest. The other reason might be high demand for malt barley by malt factories, which collect all malt barley production as grain for malt, which hinders farmer-to-farmer seed exchange to expand malt barley production. The ICARDA-USAID malt barley and faba bean seed production and scaling project in collaboration with GARC during 2015-2017 initiated malt barley seed production and scaling activities in the highlands of North Gonder in order to improve access to quality seed of improved varieties with better productivity and quality attributes, increase malt barley production and improve livelihood of farmers.

## Materials and Methods

### Study locations

Dabat, Debark, and Wogera were malt barley producing districts in North Gonder Administrative Zone where the study was conducted in 2015/16-2017/18. The agroecology of these three districts is generally known as highland (dega), which has altitudes above 2500 m. GARC has one research station each at Dabat and Debark districts where field experiments and early generation seed multiplications were executed.

Dabat station is located at latitude of 12.93178 N and longitude of 37.74412 E with the altitude of 2628 m, receiving the average annual rainfall of 758 mm most of, which falling between April and September having peaks in July and August. Average temperature is 16.60c and the soil type is Cambisols.

Debark station is located at latitude of 13.13166N and longitude of 37.899121E with the altitude of 2885 m, receiving the average annual rainfall of 974 mm most of, which falling between April and September and having peaks in July and August. The temperature ranges from 8.6 0c to 19.8 0c and the soil type is Cambisols.

According to zonal office of agriculture annual report in 2016 main cropping season, about 62% of malt barley production in North Gonder Zone is produced in Dabat, Debark and Wogera districts. The dominant crops being produced in the highlands in descending order in terms of area are wheat, barley, and faba bean. Barley is produced during the main long rainy season (meher) and the short rainy season (belg) in these areas as sole crop or mixed cropping with other crops like wheat, faba bean and field pea. Malt barley, however, is produced in sole cropping usually in meher season.

## Approaches

Malt barley varieties such as Bahati, EH1847, IBON 174/03, and Traveler were found adapted to Dabat, Debark, and Wogera in 2014, prior to the launching of the ICARDA-USAID malt barley and faba bean seed production and scaling project. Malt barley variety IBON 174/03 was found superior in its yield and was preferred by farmers for further seed multiplication and malt grain production in barley producing highlands of North Gonder Zone. Based on these results, IBON 174/03 was multiplied and distributed during the last three years, 2015/16-2017/18, with the support of the project.

Early generation seed multiplication by the GARC and community-based seed multiplication with farmers were implemented to ensure farmers get access to the quality seed of best performing varieties and hence boost malt barley production in the target districts. Using this internal and external seed sources, further scaling was done, training and field days were organized. Some details of activities are presented below.

## Early generation seed multiplication

Early generation seed (breeder and pre-basic) malt barley was multiplied at the two stations located at Dabat and Debark. The seed multiplication fields on the stations passed through close monitoring and the seeds produced form the fields were distributed for seed producing farmers and cooperatives. The land areas of the stations were not enough to produce the required amount of seed; thus, additional breeder, pre-basic and basic seed were purchased through the project from external sources like Holetta Agricultural Research Center.

Malt barley varieties included in early generation seed production were EH1847, and IBON 174/03, but EH1847 was not preferred by farmers for community-based seed multiplication due to its inferior performance compared to IBON 174/03 in the areas. Therefore, IBON 174/03 was multiplied every year from 2015-2017 whereas EH1847 was multiplied only in 2016 cropping season.





## Community-based seed multiplication

IBON 174/03 was multiplied on farmers' fields at Dabat, Debark and Wogera districts in cluster approach. Prior to communication with farmers, discussions were made about the activities with office of agriculture in the three districts. Having created awareness about the seed multiplication activities, we shared the responsibilities on different activities. Clusters were selected based on accessibility to road for close follow-ups. Farmers willing to multiply seeds were selected and identified by the development agents and agricultural experts of respective kebeles based on availability of farmland in the selected cluster, willingness, capacity to use all recommended production packages and membership of seed production cooperatives. The source seeds were provided by GARC.

## Crop management

Field preparation and planting were done according to the production packages and management with close follow up of GARC and development agents of respective kebeles. The seed rate used for seed multiplication fields was 100 kg $ha^{-1}$. Sowing dates were from early to mid-June and harvesting was done in late October to early November. All agronomic practices were executed as per the recommendations of GARC and 121 kg $ha^{-1}$ NPS fertilizer at planting and 100 kg $ha^{-1}$ urea fertilizer with split applications at planting and booting stages were used.

## Monitoring and certification

Farmers willing for seed multiplication were registered and received malt barley seeds based on the area of their farmland allotted for malt barley seed production. The farmers who received the seeds agreed to return the amount of the seed they received in kind after harvesting their produce. Agricultural experts, development agents and researchers individually and/or jointly undertook the follow-up. The district office of agriculture assigned responsible person for supervision and monitoring the activities. Gonder Quarantine Office did the field inspection and laboratory seed testing for seed certification.

# Achievements

## Trainings and field days

Having selected farmers for seed multiplication, all the farmers in the cluster participated in the training of malt barley seed production. The training areas were techniques and procedures of malt barley seed production, pest management, soil fertility management, safe use of pesticides, and seed marketing. Development agents at kebele level also provided on-field practical training to farmers at different crop growth stages. A total of 553 farmers (27 females) and 74 others staff members (21 females), including agricultural experts of zonal and district agricultural offices, development agents and junior researchers were trained during 2016-2018 (Table 1).

Field days on malt barley seed production and management were organized every year and different stakeholders, farmers, cooperatives, agricultural experts at zonal and district levels, and researchers were invited and attended. These field days enhanced seed distribution by creating awareness and by letting farmers witness the benefit they got by using the improved malt barley technologies and the quality seeds. During the field days, experiences were also shared on seed multiplication using cluster approach and on farm management activities. Discussions were also held on how to utilize the seed produced to expand malt barley production in the districts. Participants also discussed the challenges and opportunities on malt barley seed production to learn from past events and to indicate the ways to establish sustainable seed production and marketing system. Most of the field days were organized by kebele level development agents to enhance awareness and experience sharing among farmers; and create demand and enhance farmer-to-farmer seed exchange. Thus, a total of 1111 farmers (92 females) and 266 other staff members (43 females) attended the field days, which include zonal and district level agricultural experts, kebele level development agents, cooperatives, farmers' cooperatives unions, researchers of international, national and regional research centers, media organizations, sectorial actors in malt barley value chain (Table 1).

*Table 1. Trainings and field day participants during 2016-2018 cropping seasons*

| Category of participants | Training participants | | | Field day participants | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total |
| Farmers | 526 | 27 | 553 | 1019 | 92 | 1111 |
| Others | 53 | 21 | 74 | 223 | 43 | 266 |

*Note: Others for the training include district and zonal experts, kebele development agents, and junior researchers; others for the field days include stakeholders of different governmental and non-governmental organizations.*

# Seed production

## Early generation seed production

GARC took the responsibility for breeder and pre-basic seed production. The amount of cleaned breeder and pre-basic seed produced and ready for distribution is indicated in Table 2. This includes 0.23 t of breeder seed and 2.28 t of pre-basic seed. Given the overall shortfall of early generation seed in the country such decentralized production approach for varieties released by the federal research system needs to be sustained by the regional agricultural research institutes.

*Table 2. Early generation malt barley seed production during 2015-2017 cropping seasons*

| Seed class | Variety | 2015 | | 2016 | | 2017 | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | Area (ha) | Seed produced (t) | Area (ha) | Seed produced (t) | Area (ha) | Seed produced (t) | Area (ha) | Seed produced (t) |
| Breeder seed | EH1847 | 0 | 0 | 0.01 | 0.03 | 0 | 0 | 0.01 | 0.03 |
| | IBON 174/03 | 0.02 | 0.05 | 0.01 | 0.02 | 0.04 | 0.13 | 0.07 | 0.20 |
| Total | | 0.02 | 0.05 | 0.02 | 0.05 | 0.04 | 0.13 | 0.08 | 0.23 |
| Pre-basic seed | EH 1847 | 0 | 0 | 0.04 | 0.14 | 0 | 0 | 0.04 | 0.14 |
| | IBON 174/03 | 0.14 | 0.35 | 0.2 | 0.68 | 0.44 | 1.13 | 0.78 | 2.15 |
| Total | | 0.14 | 0.35 | 0.24 | 0.82 | 0.44 | 1.13 | 0.82 | 2.28 |





## Community-based seed production

About 39.3 t of basic seed and 104.6 t of certified seed were produced by 65 farmers (3 females) in 2016-2017 using community-based seed production system (Table 3). The basic seed was produced to augment the shortage of land on the GARC stations and for further multiplication by the communities or formal sector entity. The certified seed was produced for marketing by the communities. However, all the seed produced were not utilized as seeds. The challenge here is farmers were not able to get approval to sell seeds out of the production area because of Boren weed (*Chrysanthemum segatum*), which is considered as quarantine weed. Most of the seeds were sold as grain for malt factories and other beneficiaries whereas some were used as a seed only in the production districts. This is not only a disappointment for farmers, but also require further strategies on how to address the seed issue in the districts.

*Table 3. Community-based malt barley seed productions in 2016-2017 main cropping seasons*

| Seed class | Variety | 2016 | | 2017 | | Total | |
|---|---|---|---|---|---|---|---|
| | | Area (ha) | Seed produced (t) | Area (ha) | Seed produced (t) | Area (ha) | Seed produced (t) |
| Basic | IBON 174/03 | 5 | 12.5 | 8 | 26.8 | 13 | 39.3 |
| CS1 | IBON 174/04 | 25 | 71.125 | 10 | 33.5 | 35 | 104.625 |
| Total | | 30 | 83.625 | 18 | 60.3 | 48 | 143.925 |

*Note: CS1 = certified seed first generation*

Using CBSP and external sources during 2016-2018 cropping seasons, 6.8 t seed of IBON 174/03 variety was distributed to 41 farmers although the number of beneficiary farmers in 2016 and 2017 were not recorded (Table 4).

*Table 4. Seed distribution for seed producing farmers in Dabat, Debark and Wogera districts*

| Year | Variety | Seed class | Amount (t) | Area covered (ha) | Participants | |
|---|---|---|---|---|---|---|
| | | | | | Male | Female |
| 2016 | IBON 174/03 | Basic | 2.5 | 25 | – | – |
| 2017 | IBON 174/03 | Basic | 2.5 | 25 | – | – |
| 2018 | IBON 174/03 | Basic | 0.8 | 8 | 21 | 0 |
| 2018 | IBON 174/03 | Basic | 1 | 10 | 20 | 1 |
| Total | | | 6.8 | 68 | 41 | 1 |

## Farmer-to-farmer seed exchange

During 2016-2018, more than 10 t seed of IBON 174/03 was disseminated informally in a farmer-to-farmer seed exchange scheme (Table 5). In this predominantly established cultural system of seed exchange, 294 farmers got access to the improved malt barley seed.

*Table 5. Farmer-to-farmer malt barley seed exchange at Dabat, Debark and Wogera districts*

| District | Variety | Seed exchanged (t) | Number of farmers | |
|---|---|---|---|---|
| | | | Male | Female |
| Dabat, Debark, Wogera | IBON 174/03 | 10.904 | 260 | 34 |
| Total | | 10.904 | 260 | 34 |

## Monitoring and certification

Efforts were made to let farmers get certificates for the seeds they have produced. However, due to heavy infestation of boren weed (*Chrysanthemum segatum*) in Debark and Dabat districts it was impossible to get approval. Gonder Quarantine Office has declared that, giving certificates for seed produced in boren weed infested areas is banned to control distribution of the weed from one location to other locations with seeds. Hence, GARC in cooperation with agricultural extension and cooperatives collected the produced seeds from farmers and sold it back to farmers to be used only in the two districts, Dabat and Debark. The seeds produced at Wogera were certified because there was no boren weed infestation in this district.

# Challenges and opportunities

## Challenges

The GARC research stations at Dabat and Debark have very small land, not more than 2.5 ha, to execute research and to multiply seeds. This is a major challenge in malt barley seed production particularly sufficient quantity of early generation seed of different crops.

The existence of a noxious weed, boren, is the biggest challenge for seed production and establishing seed producer cooperatives in the districts.

Many farmers are subsistent producers and cannot hold the seeds they produced until the next planting season to sell as seeds. Rather they sell the seeds as grains or seeds for anyone who comes to buy soon after production.

The inability of farmers to implement all the recommended agronomic practices like weeding, fertilizer usage, and pest management made the productivity lower than that of the on-station production.

The financial and storage capacity of the multipurpose or seed producer cooperatives was also very limited so that they cannot facilitate seed production as expected.

## Opportunities

North Gonder Zone is the third largest producer zone, which has about 41,000 ha of land covered with barley (CSA, 2017). The area is potentially very suitable for malt barley production where a grain yield of more than 4 t $ha^{-1}$ was attained in research fields. Farmers can achieve higher productivity provided they apply the recommended packages for malt barley production.





The GMF creates market opportunity for malt barley grain producing farmers since it is situated very close to the production areas. Currently, GMF imports its malt requirement from abroad because local production does not meet its annual requirement.

Despite the challenges, the agro-ecological suitability for malt barley production, the demand of malt factories and breweries for malt are opportunities, which can sustain malt barley seed and grain production in the area.

# Conclusions and Recommendations

On-station EGS production and on-farm CBSM significantly improved availability and timely access of improved seed of malt barley to farmers in the highlands of North Gonder. However, land shortage for EGS production by GARC, and limited availability and high interest rate of credit services to cooperatives are serious bottlenecks for further expansion of improved seed production. Therefore, strengthening capacity of research centers, seed producer cooperatives and farmers are very important intervention areas to improve seed supply in order to improve productivity and production of malt barley. The ever-increasing demand of malt factories and breweries, the suitable agro-ecological conditions of the highlands of North Gonder Zone are good opportunities to expand the scale of malt barley production.

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# Community-based Malt Barley Seed Production in Alicho Wuriro and Gumer Districts in Siltie and Gurage Zones

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## Introduction

The Southern Nations Nationalities and People's Regional State (SNNPRS) contributes 7.22 and 6.5% of area coverage and production of barley, respectively, to the nation with average productivity of 1.72 t ha$^{-1}$ (CSA 2015), which is lower than the potential 6 t ha$^{-1}$ yield of the crop (Hasan, 2014). Although agro-ecologies in the southern highlands of Ethiopia are suitable for malt barley production, lack of high yielding cultivars and poor crop management practices are contributing to low productivity. Farmers in Alicho Wuriro and Gumer districts lack access to high yielding malt barley varieties for maximizing their production, which consecutively increase their incomes and improve their livelihoods. Therefore, this activity was initiated to enhance seed production and supply of improved malt barley varieties through CBSP under farmers' condition.

## Materials and Methods

### Study locations

On-station early generation seed (EGS) production and CBSP schemes were conducted in Alicho Wuriro and Gumer districts during the main cropping season of 2015-2017. The altitude of the Alicho Wuriro district ranges between 2,453 and 2,984 meter above sea level (m asl). One of the testing sites in Alicho Wuriro district is located at 7°58'N latitude and 37°29'E longitude with the annual rainfall of 825 mm and average temperature of 13.26°C. The altitude of the Gumer district ranges between 2450 and 2825 m asl with the average annual rainfall of 1,015.1 mm, and average annual temperature of 14.45°C. One of the testing sites in Gumer district is located at 7°54'N latitude and 38°04'E longitude.

The dominant soil type is loam in texture for Alicho Wuriro and clay loam for Gumer; both soils are naturally well drained and suitable for malt barley production. Food barley, enset and faba bean are the dominant and staple food crops grown in both study locations.

### Selecting sites and farmers

Site and kebele selections were done based on potential production in a participatory mode with the district agricultural office and experts working on barley production. Similarly, farmer's selection was done with collaboration of agricultural office experts, kebele administration and development agents by considering different selection criteria.





### Source seed, planting and crop management

Seed of improved malt barley varieties were sold to participant farmers with full technical support and advice. This activity was carried out using improved malt barley varieties, EH1847, Holker and IBON 174/03, which were planted during mid-July each year at the seed rate of 125 kg ha$^{-1}$ by hand in rows spaced 20 cm apart in well prepared large field. Fertilizer rates of 121 kg NPS ha$^{-1}$ was applied once during planting time whereas 50 kg urea ha$^{-1}$ each was applied in split at planting and tillering in equal amounts. Weeding, and other crop management practices were done as required. Harvesting was done manually at the start of October when the crop maturity was attained, and the grain yield was adjusted to 12.5 % moisture content for data measurement.

### Capacity building and follow-ups

Training on seed production and crop management practices was provided to farmers soon after selection of sites and farmers. In addition, an individual contact extension approach was used, where researchers and technical assistants provided advice, counseling, supervision at the household level and organized farmer-to-farmer seed exchange. Field inspection was conducted by Wolkite Seed Quality Inspection and Control Laboratory on clustered fields for seed production during the seasons. Finally, field days were organized to create awareness, demand and market opportunity for the CBSP scheme.

## Results and Discussions

### Training and field days

Soon after selection of seed production sites and participant farmers, training was provided for 586 participants (168 females) consisting of farmers (348 males and 159 females), development agents and experts (70 males and 9 females) at Alicho Wuriro and Gumer districts in the three consecutive years of the project. The training covered malt barley production technologies, diseases and weed control, post-harvest loss and introduction of improved storage bags like PICS (Purdue Improved Crops Storage) to strengthen the skills and awareness. Practical training during field inspection on seed inspection and certification was also provided by Wolkite Seed Inspection Laboratory experts to ensure quality seed production, which meet the standards.

Field days were organized after heading of malt barley varieties for participants to observe and evaluate the performance of varieties under farm conditions at Alicho Wuriro and Gumer districts. All field management issues, production challenges and future directions were discussed and agreed during the field days. A total of 2,035 participants (828 females) attended the field day comprising farmers, researchers, zonal agricultural and natural resource department and districts' experts, development agents and media experts (Table 1). The field days also enhanced experience sharing among farmers. According to the farmers, almost all malt barley varieties have been well accepted. During the field visits, farmers showed an interest to produce early maturing and high yielding malt barley varieties as source of income and asked for a strengthening of linkages with breweries.

Table 1. Participants of field days in 2015-2017 at Alicho Wuriro and Gumer districts

| District | Zonal and district administration and agricultural experts | | Farmers | | |
|---|---|---|---|---|---|
| | Male | Female | Male | Female | Total |
| Alicho Wuriro | 72 | 54 | 545 | 354 | 1025 |
| Gumer | 84 | 60 | 506 | 360 | 1010 |
| Total | 156 | 114 | 1051 | 714 | 2035 |

## On-station breeder and pre-basic seed production

On-station breeder and pre-basic seed production for sourcing community-based seed production is one of the important activities of the project implemented in 2015-2017 (Table 2). A total of 2.71 ha and 2.86 ha, respectively, were planted producing 8.68 and 9.55 t of breeder and pre-basic seed. On-station land and nucleus seed shortage were the major limiting factors to produce matching amount of source seed for supplying the CBSP scheme.

Table 2. Breeder and pre-basic seed production of malt barley varieties in 2015-2017

| District | Variety | Area planted (ha) | | Seed produced (t) | |
|---|---|---|---|---|---|
| | | Breeder | Pre-basic | Breeder | Pre-basic |
| Alicho Wuriro | EH1847 | 0.85 | 1.05 | 2.80 | 3.31 |
| | Holker | 0.00 | 0.25 | 0.00 | 0.65 |
| | IBON 174/03 | 0.88 | 0.25 | 2.85 | 1.00 |
| Gumer | EH1847 | 0.47 | 1.05 | 1.50 | 3.88 |
| | Holker | 0.00 | 0.13 | 0.00 | 0.30 |
| | IBON 174/03 | 0.51 | 0.13 | 1.53 | 0.41 |
| Total | | 2.71 | 2.86 | 8.68 | 9.55 |

## Community-based seed production (CBSP)

Community-based seed production was organized in Alicho Wuriro and Gumer of the Siltie and Gurage Zones, respectively. Number of farmers participated, and amount of seed produced each year in each district are presented in (Table 3). A large number of farmers (94 males and 30 females at Alicho Wuriro, and 68 males and 35 females at Gumer district) participated in this activity because previous demonstrations of EH1847, Holker and IBON 174/03 varieties and promotion with field days at both districts had created a great demand for the seed. In both districts, the variety IBON 174/03 performed better in participant farmers' fields. Higher average seed yield of 3.30 t ha$^{-1}$ for the variety IBON 174/03 was obtained in Gumer by farmers who had participated in the community-based seed production, while lowest mean seed yield of 2.43 t ha$^{-1}$ for variety Holker was obtained at Alicho Wuriro. Area coverage and total seed produced from improved malt barley varieties was 39.50 ha and 107.80 t, respectively at both districts in 2015-2017.





From a total production, 36.65 t of seed were exchanged through farmer-to-farmer seed exchange for production during cropping season and the rest were used as a grain in the two districts. Generally, the mean yield of the variety in both districts was more than the other neighboring farmers. Farmers perceived that the EH1847 and IBON 174/03 varieties gave a better yield because these varieties have high grain filling capacity and resistance to lodging. As the performances of these varieties have been consistent between districts and among farmers, they are suggested to go through the extension system for large-scale production.

Table 3. Basic seed production of malt barley and participant farmers in CBSP in 2015-2017

| District | Variety | Area planted (ha) | Seed produced (t) | Productivity (t ha$^{-1}$) | Producer farmers | |
|---|---|---|---|---|---|---|
| | | | | | Male | Female |
| Alicho Wuriro | EH1847 | 4.5 | 14.3 | 3.18 | 94 | 30 |
| | Holker | 23.5 | 57.0 | 2.43 | | |
| Gumer | EH1847 | 5.5 | 16.7 | 3.04 | 68 | 38 |
| | IBON 174/03 | 6.0 | 19.8 | 3.30 | | |
| Total | | 39.5 | 107.8 | 2.73 | 162 | 65 |

## Challenges

The main challenges faced during seed production in two districts were seed shortage of improved malt barley varieties, stem rust and shoot fly on Holker variety, soil acidity and seed mechanical mixture at farmer level.

Even though the agroecology of the study locations has high potential, lack of farmers' awareness to produce malt barley, lack of full package technology adoption was also challenging to improve productivity and production.

## Conclusions and Recommendations

CBSP was proved to be feasible with strong technical backstopping from agricultural research centers through supplying quality early generation seed and training to enhance farmer's skills and awareness; commitment of agricultural extension staff at different levels down to development agents at kebeles; and the support of seed inspection and certification laboratories for practical training and monitoring in maintaining seed quality standards.

Among the three varieties used in CBSP, EH1847 and IBON 174/03 varieties were preferred by farmers in terms of high productivity and resistance to lodging under farmers' conditions in Alicho Wuriro and Gumer districts. Therefore, these varieties and the associated production packages are suggested to be supported by wider scaling to improve productivity and production; and to create sustainable demand and CBSP in the two districts and similar areas.

## Acknowledgments

Logistical support of South Agricultural Research Institute and Worabe Agricultural Research Center is highly appreciated. Farmers' critical evaluation and feed backs were valuable guides for our future endeavors.

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**CHAPTER III**: Malt barley seed production

# Popularization and Community-based Seed Production of Malt Barley in Amhara Region

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## Introduction

Ethiopia is a major producer of barley where both food barley and malt barley are grown in the country. The share of malt barley production is quite low (10-15%) compared to food barley despite favorable environment and potential market opportunity (ever increasing malt factories and breweries) for increased production of high-quality malting barley (Lakew et al., 2016; Bekele et al., 2005). Currently there are 11 breweries with the annual malt barely demand of 118,000 t (Gessesse, 2017). There are more on the pipeline for establishment. Ethiopia, which is endowed with good weather for production of malt barley is forced to spend the hard currency for importing around 60% malt to meet the demand of the breweries. Amhara Region has potential highland areas that are suitable for quality malt barley production both under rainfed conditions in main long rainy season and under irrigated condition during the short rainy seasons. However, malt barley production has not been expanded and productivity at farm level has remained low in the region due to various factors such as unavailability of quality malt barley varieties and associated technologies, poor agronomic practices of farmers, weak linkage among stakeholders, inadequate technology transfer, limited access to markets and unattractive malt barley price as well as weak seed system.

Seed is the most important agricultural input for increasing crop productivity and production and improved livelihoods of farming communities. However, the formal seed system of Ethiopia for example, the federal Ethiopia Seed Enterprise and the regional Amhara Seed Enterprise mainly focused on wheat and hybrid maize with limited attention to seed of other cereals (barley, tef, and sorghum), grain legumes and oilseeds. Alternative approaches such as such decentralized farmer-based seed production and marketing by the intermediate sector (cooperatives, farmer groups, communities) can provide farmers with seed at the right time, place and reasonable price augmenting the formal seed system in Ethiopia.

To alleviate these problems, the Adet Agricultural Research Center (AdARC) in collaboration with the national research system has developed improved malt barley technologies (varieties with full production packages). Moreover, adaptation and demonstration of these improved malt barley technologies were also conducted at Estie, Farta, Guagusa Shikudad and Lay Gaynt districts of Awi and South Gonder Zones of Amhara Region of Ethiopia.

With the financial and technical support of ICARDA-USAID Project it also created demand for the malt barley technologies. The objectives were to create demand through popularization and pre-scaling up of malt barley technologies; create and strengthen linkage among the possible actors of malt barley production; and enhance malt barley technology multiplication and dissemination. This paper presents the achievements, lessons learnt, challenges encountered, gaps identified, and future research and development interventions.

# Materials and Methods

## Study locations

Through the support of ICARDA-USAID malt barley and faba bean seed production and scaling project, the malt barley pre-scaling up activity was conducted during two consecutive years (2016/17-2017/18 cropping seasons) at Estie, Farta, Guagusa Shikudad, and Lay Gaynt in Awi and South Gonder Zones in Amhara Region of Ethiopia. The descriptions of the intervention districts are given below.

Estie is located at 11°37'-11°63'N latitude, and 38°06'-38°4'E longitude with an altitude of 1,446 to 3,320 masl. The annual rainfall ranges from 1,300 to 1,500 mm while the temperature varies from 8°C to 25°C (EWAO 2016). The rainy season is unimodal, which is from May to the end of November though the peak rainfall occurs in July and August. Nitosols is the dominant soil type across the district. Tef, barley, wheat, faba bean and field pea are major crops being grown.

One of the test locations in Farta district is located at 11°51′N latitude, and 38°1′E longitude with an average elevation of 2,706 m asl. The annual rainfall of the district ranged from 1,250 and 1,599 mm with the average minimum temperature of 9°C and maximum temperature of 25°C (FWAO 2016). The rainfall pattern of the areas is unimodal with erratic distribution, and effective rainy period extending from June to October. Nitosols is the dominant soil type. The most widely grown annual crops in the highlands are barley, potato, tef, wheat, triticale, faba bean, and field pea.

Guagusa Shikudad is located at 11°91'-11°92'N latitude, and 38°61'-38°87'E longitude with an altitude ranging from 2562 to 2718 m asl. The district receives annual rainfall of more than 1,140 mm with annual average temperature of 10 to 25°C (GSAO 2016). The area has a unimodal rainfall pattern with erratic distribution, and the rainy months extend from March to the end of November, but peak rainfall occurs during the months of July and August. The district has high potential for irrigated crop production and famers produce irrigated crops including malt barley. The dominant soil type is Nitosols. Barley, potato, maize, field pea and faba bean are the major crops being grown. Irrigated malt barley production in the district is being main source of malt barley grain for malt factories.

Lay Gayint is located at 11°32'-12°16'N latitude, and 38°12'-38°19'E longitude with the altitude ranging from 1,500-4,235 m asl. The rainfall pattern is bimodal with erratic distribution, the main rainy season being from June to September while the short rainy season (belg) is from February/March to May. The dominant soil type is brown (LGWAO, 2016). Potato, barley, tef, wheat, triticale, faba bean and field pea are the dominant crops being grown in the highlands with 2,400-2800 m asl where our sites were selected.





## Farmers' selection and field clustering

Selection of participant farmers and clustering fields was done with close collaboration and discussion with agricultural extension agents and farmers themselves. About 459 voluntary host farmers (78 females) were selected based on their willingness and interest to participate in the pre-scaling up activity. Farmers who are volunteers to conduct the activity were selected after awareness was created and district agricultural experts and researchers made the mobilization. As much as possible, host farmers' land was clustered for improving efficiency of monitoring and evaluation, exchange of feedbacks and experiences, seed field inspection, and showcase impact in scale. Land size allocated to malt barley production by individual member farmers of the cluster ranged from 0.15 to 0.5 ha.

## Technology packages

Improved malt barley varieties, EH1847, IBON 174/03 and Sabini, were used for the pre-scaling up activity in the intervention areas. A seed rate of 125 kg $ha^{-1}$ with fertilizer rate of 121 kg $ha^{-1}$ DAP (Di-ammonium Phosphate) or NPS (Nitrogen-Phosphorous-Sulfur) were applied during planting while 40 kg $ha^{-1}$ urea was applied after 30 days of planting during the first-hand weeding. Seeds were drilled in rows spaced 20 cm.

## Technology scaling approaches

Malt barley technology scaling approaches used include establishment of Innovation Platforms (IPs); trainings for capacity building; partnership arrangement and share of responsibilities; joint planning, implementation, monitoring and evaluation; enhance community-based seed production system; and creation of market linkage with cooperatives (unions). The details of each are presented below.

## Multidisciplinary team of researchers

A multidisciplinary team of researchers consisting of economists, research-extensionist, seed specialists, breeders, agronomists, and crop protection specialists was established from the implementing research center for providing technical backstopping, training, field monitoring and evaluation, and feedback data collection.

## Innovation platforms (IPs) and linkage

Innovation platforms (IPs) that comprise AdARC, office of agriculture from region to kebele level, farmers' primary cooperatives and unions, seed enterprises and malt factories and breweries were established and made functional from planning through evaluating the all activities by using regular meetings, field days and workshops. This chain of activities of IPs enhances linkages among partners for sustainability in production and marketing of malt barley.

# Partnerships

Memorandum of understanding (MoU) on the roles and responsibilities of each actor was signed among AdARC, office of agriculture, malt factory and farmers' cooperative union. Focal persons from district and kebele offices of agriculture were assigned in each intervention district for enhancing easy communication; smooth functioning of the activities and data collection. The details of the roles and responsibilities are presented below.

Adet Agricultural Research Center (AdARC): The major roles and responsibilities of AdARC was coordination and facilitation of all activities; delivery of initial seed of improved variety; organizing training, field days and IPs meetings/workshops; arranging and facilitating joint monitoring and evaluation events with stakeholders; and write quarterly and annual reports. These roles and responsibilities helped AdARC to build effective and efficient coordination and collaboration among stakeholders to ensure a smooth flow of information and knowledge about the technologies among stakeholders for future wider dissemination and sustainability.

**Farmers:** Farmers are ultimate users of any technology generated and transferred; and are core and primary stakeholders in malt barley technology pre-scaling up activity. The major roles and responsibilities of farmers were providing their own labor and land for the whole implementation of the activity on the ground; and participate in planning, implementation and evaluation of activities with researchers, experts and officials.

**Office of Agriculture (Regional, Zonal, district and kebele level):** The office of agriculture is responsible government organization for technology dissemination and transfer. The main roles and responsibilities of the office were facilitating selection of target location and farmers; mobilizing farmers for technology evaluation, training and field day events; participate in the joint monitoring and evaluation events; and seriously following up and ensuring the implementation of activities by farmers. Development agents were also responsible for tracking farmer-to-farmer seed exchange.

**Farmers' cooperatives union:** The main roles and responsibilities of farmers' cooperatives union were timely purchase and supply of seed, fertilizer and agro-chemicals to farmers through sale; and facilitating malt barley seed and grain marketing through agreements signed between farmers and the cooperatives union.

Zonal plant quarantine offices: Apart from inspection services in the field and in storage, the experts provided in-house and practical on-field training to farmers about seed quality standards and how to produce quality seed.

**Gonder Malt Factory:** The main role of Gonder Malt Factory was purchasing malt barley grain for malt purpose based upon previous agreement held with famers in collaboration with farmers' cooperative union.

**International Center for Agricultural Research in the Dry Areas (ICARDA):** The main roles and responsibilities of ICARDA in implementing the malt barley pre-scaling up activity were provision of funding; delivering initial technologies like seeds; participate in the joint field monitoring and evaluation events; organizing training of trainer's workshops, and annual review and planning meetings; and writing quarterly and annual reports.

## Community-based seed multiplication (CBSM) schemes

In addition to popularization of malt barley technologies, the CBSM scheme was implemented to make seed available locally for own use and/or sell for surrounding farmers' or any organization. Malt barley pre-scaling up activity was done on farmers' field who were members of farmers' seed producers and marketing cooperatives organized by cooperative agency for easy implementation of community-based seed production activity, especially seed marketing.

## Tracking farmer-to-farmer seed exchange

Das recorded farmer-to-farmer seed exchange  in each kebele every year in order to use the information for planning the subsequent seed production scale and to assess farmers' technology demand and dissemination for future research and development efforts.

## Data collection

Qualitative and quantitative yield related and social data were collected. Yield data were collected after harvest by taking quadrat plot sampling technique (three quadrat samples per field, each quadrat being 1 $m^2$) and using survey by preparing checklists. Farmers' preference and overall performance of the technology was collected by check list from participant famers who implemented the pre-scaling up activity. Some of social data were collected during monitoring and evaluation (M&E), experience sharing and field day events as well as during innovation platform and joint planning meetings. Direct field observations; individual participant farmers' interview using checklists; focus group discussion; and key informants interview approaches were also used to collect data.

## Data analysis

Data were analyzed using simple descriptive statistics and social data (farmers' and experts' opinion/feedbacks) were simply qualitatively described and classified by themes and contents. Likert scale measurement technique was used to analyse farmers' and experts' perception.

# Results and Discussions

## Early generation seed production

Early generation seed (EGS) of different seed classes was multiplied and used for maintenance, further seed multiplication and pre-scaling up activity. The seed production was carried out on-station under rainfed and irrigated conditions with close follow up of researchers. Fifty-three tons of EGS (1.55 t breeder, 8.95 t pre-basic and 42.5 basic seed) of improved malt barley varieties was produced on 27.04 ha of land and used for multiplication and pre-scaling up purposes throughout the intervention periods (Table 1). Most of basic seed was produced on farmers' fields (cooperative union member farmers' fields) after they got pre-basic seed from AdARC.

*Table 1. Early generation malt barley seed production during 2015-2017*

| Variety | Seed class | Area planted (ha) | Seed produced (t) |
|---|---|---|---|
| EH1847, Holker, IBON 174/03, Sabini | Breeder seed | 1.544 | 1.552 |
| EH1847, IBON 174/03, Sabini | Pre-basic seed | 4.25 | 8.95 |
| EH1847, IBON 174/03 | Basic seed | 21.25 | 42.5 |

# Popularization and on-farm seed production

## Capacity building

Multidisciplinary team of researchers from AdARC gave theoretical and practical (on-job) trainings to farmers and experts. This was done to improve positive impact on the sustainability and adoption of the technology under pre-scaling up. A total of 601 farmers (105 females) and 52 experts (12 females) were trained to fill their gaps on knowledge, skill and attitude for better accomplishment of pre-scaling up activities (Table 2). Trainings covered malt barley production agronomy; disease and pests control options; seed production, marketing and post-harvest handling techniques; and extension tools. Computer power point presentations in Amharic language and training materials such as leaflets, posters, and audio visuals were used.

Simple evaluation of the training event by checklist indicated that 90%, 85% and 95% of participants rated the training as "good" in "methodology", "logistics" and "contents", respectively. The positive effect of the training was also observed on farmers' field performance during monitoring and evaluation trips, which confirmed that famers and experts tried their best to implement the pre-scaling up activity according to the knowledge and skill they obtained from the training.

*Table 2. Number of participants trained in malt barley technologies at Estie, Farta, Guagusa Shikudad and Lay Gaynt districts during 2016-2017*

| Year | Number of farmers | | Number of experts | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| 2016/17 | 223 | 62 | 17 | 6 |
| 2017/18 | 273 | 43 | 23 | 6 |

A one-day sensitization workshop was held every year among partners before the implementation of the pre-scaling up activity in each intervention district on awareness issues like implementation approach, review and planning, share of roles and responsibilities, data collection methods, and identifying opportunities, challenges, and the way forward. Participants were heads, researchers, experts and farmers from different organizations that are members of the innovation platform.

## Input delivery and beneficiary farmers

About 13.1 t of pre-basic, basic and/or certified seeds of EH1847, IBON 174/03 and Sabini varieties were provided to 459 smallholder farmers who planted on 122.35 ha of land and produced 240.6 t of seed during the project period from 2015 to 2017 cropping season at Estie, Farta, Guagusa Shikudad, and Lay Gaynt (Table 3). Every year the seed produced by farmers was used as seed source for their own use, and other farmers through sale or farmer-to-farmer seed exchange. Most of the malt barley seed produced was delivered to the Guna farmers' seed producers and marketing cooperatives based on agreement that it would be sold to users. Based on the agreement, the initial seed provided to the farmers by the AdARC for the pre-scaling up activity was collected as revolving seed by district and





kebele agriculture offices after harvest for providing to other farmers in the next production season. This revolving seed scheme helped a greater number of farmers participate in the technology promotion and dissemination process.

*Table 3. Amount of malt barley seed provided and produced by farmers in Estie, Farta, Guagusa Shikudad and Lay Gaynt districts in 2015/16-2017/18*

| Year | Seed provided to farmers (t) | Number of direct beneficiary farmers | Area planted (ha) | Seed produced (t) |
|---|---|---|---|---|
| 2015/16 | 0.40 | 20 | 3.0 | 7.6 |
| 2016/17 | 3.20 | 52 | 24.35 | 52.4 |
| 2017/18 | 9.50 | 387 | 95.0 | 180.6 |
| Total | 13.10 | 459 | 122.35 | 240.6 |

## Joint planning, implementing,monitoring and evaluation

A team of researchers, agricultural extension experts (regional, zonal, and district levels), development agents at kebele level, farmers' cooperatives union experts, and farmers jointly monitored and evaluated the implementation of the planned malt barley pre-scaling up activity at least two times in the production season or year. Application of agronomic packages and seed production techniques like rouging by farmers and any challenges and constraints were assessed and solutions were suggested during monitoring and evaluation field visits according to roles and responsibilities of each actor in the team. Moreover, researchers and district level agricultural extension experts frequently visited fields to ensure smooth implementation. Review and planning forums also helped joint review of achievements and provide recommendations for planning the implementation of the next season seed production and pre-scaling up activities.

## Field days and mass media

Ten field days were organized in collaboration with district and kebele level agriculture offices and representatives of participant farmers to show the performance of malt barley technologies, share experience and create wider demand. Accordingly, 460 farmers (59 females) and 95 experts (21 females) attended the field day events in the intervention districts (Table 4). Experts said that efforts made on seed multiplication process follow up, market linkage creation with seed agencies and breweries, and capacity building activities were done as planned and played major role for implementation of the activities. The field day was broadcasted by Amhara Television and Radio programs, which helped us reach large audience for awareness and demand creation especially on the importance of malt barley production as source of income for smallholder farmers and as raw materials for malt factories and breweries. Additional extension materials such as banners, posters, leaflets, and production manuals about malt barley production and marketing were used during field day events for wider technology adoption and dissemination enhancement.

Table 4. Field days organized and number of participants on malt barley on-farm seed production through technologies pre-scaling up in 2016-2017 across target districts

| Year | Number of farmers | | Number of experts | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| 2016 | 123 | 31 | 56 | 17 |
| 2017 | 278 | 28 | 18 | 4 |
| Total | 401 | 59 | 74 | 21 |

## Yield performance of varieties

The improved malt barley varieties EH1847, IBON 174/03 and Sabini performed very well on farmers' field condition at all intervention districts: Estie, Farta, Guagusa Shikudad, and Lay Gaynt (Table 5). The malt barley productivity at Estie, Farta, and Lay Gaynt districts are better than the national (2.04 t ha$^{-1}$) and regional (1.83 t ha$^{-1}$) average productivity. Malt barley productivity in all target districts was by far better than the average productivity at South Gonder Zone (1.67 t ha$^{-1}$) and Awi Zone (1.54 t ha$^{-1}$). Comparison with these zones was purposely done since Estie, Fata, and Lay Gaynt are found in South Gonder Zone while Guagusa Shikudad is found in Awi Zone.

According to our personal communication with farmers and experts, and practical field observations, productivity of improved malt barley varieties in pre-scaling up activities was by far higher than the yield of farmers' old malt barley variety (Holker) and local food barley varieties. This indicates that there are favorable environmental conditions and willing farmers to expand malt barely seed and grain production so long as quality seeds are timely available with affordable price for planting and premium price of produced seed and grain are ensured by seed agencies, malt factories and breweries.

Table 5. Productivity of malt barley varieties and target districts in seed production through pre-scaling up in 2016–2017

| District | Productivity of districts (t ha$^{-1}$) | | | Average productivity of varieties (t ha$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Average | EH1847 | IBON 174/03 | Sabini |
| Estie | 1.80 | 3.20 | 2.64 | 2.57 | 2.71 | - |
| Farta | 1.60 | 3.00 | 2.28 | 2.54 | 2.37 | 1.93 |
| Guagusa Shikudad | 1.40 | 2.00 | 1.70 | 1.75 | 2.02 | 1.33 |
| Lay Gaynt | 2.20 | 4.80 | 3.24 | 3.34 | 3.55 | 2.84 |

Table 6. National, regional and zonal productivity of malt barley in 2015/16–2016/17

| Year | Average grain yield (t ha$^{-1}$) | | | |
|---|---|---|---|---|
| | Ethiopia | Amhara Region | South Gonder Zone | Awi Zone |
| 2015/16 | 1.97 | 1.78 | 1.63 | 1.51 |
| 2016/17 | 2.11 | 1.88 | 1.71 | 1.57 |
| Mean | 2.04 | 1.83 | 1.67 | 1.54 |

Source: CSA, 2017; Authors' data calculations





## Farmer-to-farmer seed exchange and marketing

Awareness creations through training and field days enhanced farmer-to-farmer seed exchange. Most of the malt barley seed produced by farmers in the pre-scaling up activity was supplied to farmers' cooperative union for seed purpose and was sold to malt factories. The remaining seed was sold to farmers through farmer-to-farmer seed exchange (Table 7). The malt barley seed produced by participant farmers and transferred to surrounding farmers through farmer-to-farmer seed dissemination was tracked to know the destination for technology diffusion and adoption purposes. The data collected and researchers own observations revealed that there was high seed transfer among farmers. This is one of the advantages of community-based seed production scheme that made seed locally available with relatively low cost and at required quantity and enabling farmers to use the seed with full confidence. Accordingly, a total of about 30.4 t seed of improved malt barley varieties (EH1847, IBON 174/03 and Sabini) was revolved and exchanged among 783 farmers in 2015/16-2017/18 (Table 7). To summarize, about 47.7 t seed of improved malt barley varieties was inspected and approved and sold for seed purpose in the four target districts in 2015/16-2017/18.

Table 7. Seed exchange among farmers through farmer-to-farmer and revolving seed schemes of malt barley pre-scaling up during 2015-2017

| Method of seed dissemination | Seed provided (t) | Area planted (ha) | Direct beneficiary farmers |
|---|---|---|---|
| Revolving seed fund | 11.80 | 118 | 458 |
| Farmer-to-farmer exchange | 18.60 | 149 | 325 |

## Technology assessment by farmers and experts

Researchers and farmers listed some criteria such as germination and field establishment, tillering capacity, vegetative growth, lodging and disease tolerance, early maturity, and yield potential of the varieties to measure farmers' perception and attitudes on the technology. The comparison using Likert scale was made between the recently introduced improved malt barley varieties produced in the pre-scaling up, and the old malt barley variety (Holker) already used by farmers (Table 8). Most beneficiary farmers stated that the popularized malt barley varieties were found superior over the earlier known variety, Holker. Likert scale result showed that 91%, 68.2%, 50% and 91% of the respondents strongly agreed on good germination and field establishment, better tillering capacity, good vegetative growth and better lodging tolerance of the new malt barley varieties, respectively, compared to already existing variety, Holker. Moreover, 75% and 25% of the respondents strongly agreed and agreed on superiority of the new varieties in yield over Holker.

*Table 8. Likert scale result of farmer's perception and attitude on malt barley technologies in 2017/18*

| Questions/criteria presented to respondents | Respondents' response on each category (%) | | | | | |
|---|---|---|---|---|---|---|
| | SDA | DA | ND | A | SA | AS |
| Germination performance of seed delivered was good | | 4.5 | | 4.5 | 91 | 4.55 |
| Tillering capacity of varieties was better than earlier known variety | | 4.5 | | 27.3 | 68.2 | 3.84 |
| Vegetative growth performance of varieties was good | | 4.5 | 4.5 | 41 | 50 | 4.82 |
| Varieties are resistant to lodging | | | | 9 | 91 | 4.59 |
| Seed setting potential of varieties was good | | | 4.5 | 22.7 | 72.7 | 4.37 |
| Varieties were diseases tolerant | | | | 36.4 | 63.6 | 4.91 |
| Varieties were frost tolerant | | | 9.1 | 4.5 | 86.4 | 4.68 |
| Varieties were early maturing than the earlier known variety | | 9.1 | | 4.5 | 86.4 | 4.64 |
| Seed color of varieties is good & acceptable by the community | | 13.6 | 13.6 | 27.3 | 45.5 | 4.77 |
| Varietal characters like plant height & panicle length acceptable compared to earlier known variety | | | | 36.4 | 63.6 | 4.68 |
| Productivity of varieties is better compared to earlier known variety | | | | 25 | 75 | 4.05 |

*Note: SA=Strongly Agree, A=Agree, ND =Not decided, DA=Disagree, SDA=Strongly Disagree, AS = Average scores. Sum score = frequency of SA*5 + frequency of A*4 + frequency of ND*3+Frequency of DA*2 + frequency of SDA*1. Average Score = sum score divided by total sample size (22 in this case). Moreover, if the average score is usually greater than 3.51, it means, farmers have good perception on malt barley technologies.*

Farmers said that, we used to believe the productivity of food barley is better than malt barley and give more emphasis for food barley. Moreover, we used to say that since there is weak market linkage for malt barley, we still produce food barley in large quantities than the malt one. However, since the introduction of improved malt barley varieties by the research center, we see that, the productivity of those varieties is much higher than the one we are producing (Holker) and even they are better than the local food barley varieties under production.

The result of the farmers' need assessment shows that EH1847 and IBON 174/03 improved malt barley varieties are highly preferred for their high tillering capacity, good grain filling, uniform in maturity and high grain yield. Sabini variety is less preferred by farmers due to its low biomass (straw) yield and its early maturity before the rainfall ceases make harvesting difficult and may cause quality deterioration in the highland areas of Estie, Farta, and Lay Gaynt where the rainy season is long. However, the early maturing Sabini malt barley variety is highly preferred by farmers for production in irrigated areas in Guagusa Shikudad and Mecha districts for double or triple cropping systems.

Experts and officials appreciated the performance of improved malt barley varieties and their uniformity under farmers' field management conditions during field days and monitoring and evaluation events. They witnessed that the improved malt barley varieties performed very well than the old variety under production (Holker). They added that, linkage among stakeholders should be more strengthened for input-output marketing (improved seed and





malt barley grain for malt factories). Experts and officials said that since the demand for malt is continue increasing over time and the country is importing malt from abroad, there should be further intervention (backstopping) in technical and material support (capacity building, introduction of new varieties and inputs) from the research center for sustainability purpose. Generally, seed and malt quality, marketing and sustainability related issues were the major areas of discussion.

# Challenges and Lessons Learned

## Challenges

The challenges in conducting the technology multiplication and pre-scaling up activities were:

- Shortage of initial seed of improved varieties for the pre-scaling up activity especially in the first year of intervention;
- Difficulty in clustering fields for the pre-scaling up activity since farmers were not sure of the market for malt barley production especially in the first year of intervention;
- All host farmers did not apply all the recommended agronomic practices (low or high seed rate, inconsistence time and frequency of weeding, lack of proper seed roughing and site inspection, low quality produce); and
- High running cost of the innovation platforms and relatively weak linkage among stakeholders

## Lessons learned

- Knowledge transfer methods like training, field days and technology evaluation played key roles in technology demand creation and dissemination activity; and
- Working with stakeholders in joint planning, implementation and monitoring brings accountability, share of roles and responsibilities, minimizes time and costs, which all in all lead to success and sustainability of the results of the technology multiplication and pre-scaling up activities.

# Conclusions and Recommendations

## Conclusions

EH1847 and IBON 174/03 improved malt barley varieties performed very well under farmers' field conditions and farmers' management than the older variety (Holker) being in wider production. These two improved malt barley varieties got wider acceptance by farmers, agricultural experts and Gonder Malt Factory. Sabini improved malt barley variety is early maturing and not suitable for long rainy season of highland areas whereas it is highly preferred for irrigated production system to fit in double or triple cropping systems. Varieties EH1847 and IBON 174/03 are also preferred for their higher productivity in the irrigated production system; they are also early maturing than wheat under irrigation.

We have learned that the concerted effort of actors in malt barley production and marketing value chain is very important to ensure wider scale malt barley production, marketing and sustainability.

Trainings, awareness creation, monitoring and evaluations, stakeholders' meetings and field day events are important interventions to strengthen capacity of farmers and agricultural extension experts.

## Recommendations

- Good practices developed in malt barley production through the pre-scaling up activity should be popularized to a wider scale into other similar potential areas to reach more farmers (vertical and horizontal scaling out) by office of agriculture in collaboration with farmers' seed cooperatives unions and Gonder Malt Factory;
- Seed enterprises and other governmental and nongovernmental organizations, which engaged should multiply the seed of malt barley varieties to satisfy the demand of farmers;
- Further training or capacity building, package development (renewal based on new findings), seed renewal at least every 3 to 4 years should be done in collaboration with office of agriculture; and
- Early generation seed supply from the agricultural research centers and multiplication by community-based seed producer cooperatives through capacity development and technology supply should be maintained if seeds are to be timely available to farmers at affordable price.

## Acknowledgments

ARARI, AdARC in leading the implementation of the activity; ICARDA malt barley and faba bean seed production and scaling project in financing the activity, capacity building, and monitoring and evaluation; agricultural offices in mobilization and implementation; farmers' cooperatives unions for facilitating input-output marketing; quarantine office for conducting seed quality inspection; agricultural development agents in overall implementation of the activity; and farmers in willingness to test and manage the technology are all highly acknowledged in the whole implementation process of the malt barley technologies multiplication and pre-scaling up activities.

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# Promoting Community-based Seed Multiplication in the Central Highlands of Oromia Region

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## Introduction

In the barley-based farming systems of the central highlands, smallholder farmers have very few alternative crops. One source of income could be growing malting barley, which has dependable local buyers in the country (Mulatu and Lakew, 2011). The availability of good quality barley seed is one of the key constraints of the farmers in the highlands of Ethiopia. Seed is the most basic input for agriculture and a sustainable seed system is fundamental to ensure the production and supply of high-quality seeds at affordable prices to the farming communities. However, the availability of the formal sector is not sufficient to meet local farmers' requirements. This is mainly due to the limited capacity of the existing national and regional seed enterprises of the country and/or absence of enough private/community seed multipliers. In most cases, these organizations were unable to operate efficiently. In addition, they concentrated on a few crops such as hybrid maize for, which there was high seed demand and profit.

On the other hand, the informal sectors include farmers who produce seed of improved crop varieties and this seed system accounts for 80–90% of the seed used by smallholder farmers through farm saved seed or from other informal sources (Bishaw et al., 2008). However, the distributed seeds are not able to satisfy farmers' seed demand, quality, and variety preference. Therefore, promoting a community-based seed system is crucial for farmers to get quality seed and minimize the existing improved seed shortage in the country. With this understanding, promotion of community-based seed multiplication had been initiated by the ICARDA-USAID malt barley and faba bean seed production and scaling project. The objectives are to improve availability and access to improved seeds of malt barley varieties at a reasonable price and appropriate time; create awareness and demand for malt barley seed production and malt barley technologies; and increase the amount of production and fill the gap of quality malt barley demand by the local brewers through the supply of improved seeds to large scale producers.

## Materials and Methods

The CBSM activity was conducted from 2015 to 2017 with locally organized seed producers at Dufa kebele in Wolmera district. During the three years, 100 farmers (18 females) were organized and participated in seed production. The CBSM scheme was organized by a team composed of breeders and seed technologist with a leading role by the extension group. The team made a series of consultation meetings and discussions with the respective district agricultural offices prior to the implementation of the CBSM Scheme. The stepwise methodologies are discussed in the following steps.

## Site selection

The barley and highland pulses research team first identified the potential sites that met the critical requirements for CBSM. The two most important criteria for a good CBSM site include the location and accessibility. The test location, Dufa kebele is in Wolmera district of West Shewa Zone of Oromia Region. The proximity of the site to the center is very convenient to provide technical support and nurture the CBSM group into a viable small-scale seed producer cooperative. The geographic coordinate of one of the fields in Dufa is 09°03'N latitude and 38°30'E longitude. The soil type of the kebele is light brown-reddish soil characterized as Nitosols. The altitude of the CBSM sites ranges between 2400 and 2650 m. The length of the growing period ranges from 4 and 6 months with an average annual rainfall and a mean temperature of 1134 mm and 15.9°C, respectively. Farmers practice a mixed crop-livestock production system. Cereals (barley and wheat), highland pulses (faba bean and field pea) are the most important food grains mainly cultivated in the district, including Dufa.

## Selecting the communities

Once the site was identified, a detailed consultation meeting was organized with the communities. The consultation meeting was facilitated by the district office of agriculture with full support from the barley team of the Holetta Agricultural Research Center (HARC). One of the underlying requirements for CBSM was that the target communities of the site must be willing to participate in group activities and interested in seed production and marketing. Once the target community and participant farmers identified, a detailed seed production plan was developed in cooperation with the district office of agriculture. All other technical supports were provided by the barley research team of HARC.

## Organizing trainings and field days

Training of extension staff, DAs, and farmers engaged in CBSM was very critical. At least two trainings were provided at HARC and CBSM site. The first training was organized before planting of barley, where all the concept of CBSM and barley production techniques were explained. The second training was organized during the crop growing period to demonstrate the techniques of field and crop management, rouging off-types, and management of quality seed production. In the three years CBSM activity, field days were organized every year at district and kebele levels to create awareness on technology availability, suitability, and market opportunity.

## Seed sources and crop management

To start the CBSM scheme, high quality basic seeds of improved varieties produced under the strict supervision of the HARC were provided to the CBSM farmers. Following the high demand for quality malt barley seeds, two dominantly grown malt barley varieties with good malting quality attributes, namely Holker and IBON 174/03, were promoted for rapid seed multiplication. The basic seeds were supplied in a revolving seed basis to the CBSM groups where they pay back the seed in kind for scaling purposes by the office of agriculture. The





varieties were sown in rows from mid- to end- June at a seed rate of 125 kg $ha^{-1}$. Fertilizer was applied at a rate of 120/50 kg $ha^{-1}$ of NPS/urea. Insect pests and diseases were not a serious problem during the cropping seasons. However, grass weeds such as wild oat were problems and were controlled by applying a grass weed killer herbicide, Axial-1 at a rate of one liter per hectare. Harvesting time ranged from mid-October to the end of November depending on the maturity period of the varieties and the location. Malt barley variety IBON 174/03 was relatively earlier than Holker in maturity.

## Monitoring and evaluation

A team of researchers and agricultural extension experts in the district were actively involved in follow up and inspection of each seed multiplication fields to ensure standards of quality seed production. The necessary data were collected at different stages for the desired actions. The regional regulatory body was invited to assess the quality of seed and approve for further sale and distribution by CBSM. Accordingly, the Ambo regulatory body inspected the CBSM field at different crop growth stages and finally, seed samples were taken for germination and purity test, and plots that fulfilled the desired standards were accepted as Certified Seed 1.

# Results and Discussions

## Trainings and field days

Trainings are one of the prominent inputs to speed up the adoption of high yielding crop varieties and their agronomic practices. Over the last three years, a series of trainings were organized and provided to 100 farmers (18 females) and 205 participants (39 females) representing agricultural experts and development agents, members of the district administration, cooperatives, and regional regulatory bodies on the following thematic areas:

- Experiences of integrated seed system development (ISSD);
- Local seed business: Organization of seed producer cooperatives and organizational management;
- Available malt barley technologies and management practices;
- Soil fertility and acid soil management;
- Crop disease management practices;
- Entomological pest management;
- Weed management options;
- Community-based seed multiplication;
- Quality declared seed production;
- Seed business skills; and
- Seed quality and regulatory aspects

Field day is an event in, which proven technologies are demonstrated on large-scale areas and open for farmers and users to visit and learn. Such purposeful field days create demand for technologies, encourage farmers to buy the technologies being demonstrated and improve adoption (Maina and Gowland-Mwangi, 2014; Asmelash, 2014). During the last three years, field days were organized at district and kebele levels for a total of 307 participants (43 females) representing zonal and district administrators, bureau of agriculture officers and experts, development agents, regulatory bodies, and farmers to create awareness on availability, suitability and market opportunity of malt barley technologies. It was also a good opportunity to get feedback from farmers and other stakeholders about the technology and CBSM seed production scheme for further improvement of both the technology and the CBSM scheme.

## Seed provision and production

The amount of seeds provided and planted, the number of farmers involved, and the land area covered by improved malt barley varieties are shown in Table 1. From 2015 to 2017 cropping season, a total of 184 farmers (42 females) were involved in the CBSM Scheme. A total of 10.6 t of basic seeds were provided in kind through the support of ICARDA-USAID seed production and scaling project (revolving seed system) from HARC. Malt barley varieties, namely Holker and IBON 174/03 were multiplied on a total of 84.9 ha of land.

The total amount of seed produced, and the productivity of the varieties are indicated in Table 2. The mean seed yield obtained during the three years (2015-2017) ranged from 0.8 to 2.4 t $ha^{-1}$. As shown in Table 2, the mean seed yield in 2016 was relatively lower than that of 2015 and 2017 due to the occurrence of frost at the grain filling period. In total, over the last three years, about 152.36 t of quality seed was produced through the CBSM scheme. Interestingly, out of the 67.15 t produced in 2017, about 47.74 t of seed approved by the RRB inspection and was certified for use as seed.

*Table 1. Amount of seed provided, area planted and participant farmers in CBSM*

| Year | Variety | Number of farmers participated | | | Quantity of seed provided (t) | Area planted (ha) | Area inspected and approved by RRB |
|---|---|---|---|---|---|---|---|
| | | Male | Female | Total | | | |
| 2015 | Holker | 20 | 4 | 24 | 1.1 | 8.8 | – |
| 2016 | Holker | 70 | 16 | 86 | 5.7 | 45.7 | – |
| 2017 | IBON 174/03 | 52 | 22 | 74 | 3.8 | 30.4 | 21.6 |
| Total | | 142 | 42 | 184 | 10.6 | 84.9 | 21.6 |

*Note: RRB = Regional Regulatory Body.*

*Table 2. Performance of malt barley varieties and seed produced*

| Production year | Variety | Total seed produced (t) | Yield range (t) | Mean yield (t $ha^{-1}$) |
|---|---|---|---|---|
| 2015 | Holker | 16.66 | 0.8-1.94 | 1.89 |
| 2016 | Holker | 68.55 | 1.0-2.0 | 1.50 |
| 2017 | IBON 174/03 | 67.15 | 1.2-2.4 | 2.21 |
| Total | | 152.36 | | |





# Challenges and lessons learned

## Challenges

The following were the major challenges encountered during the implementation of CBSM Scheme:

- Capacity development both technical and institutional is crucial if a CBSM should thrive and sustainably address the demand for seed. Farmers and extension workers need to be equipped with all the necessary knowledge and skill to produce quality seed. Thus, organizing the CBSM scheme into more organized cooperatives and unions with the basic infrastructures such as storage facilities, cleaning machinery, and technical assistance is crucial and needs the participation of all stakeholders to increase the capacity of farmers to deal with the marketing of seeds;
- Some farmers were observed managing the seed multiplication plots not differently from the normal grain production plots resulted in the rejection of plots from the scheme during the seed inspection;
- Unless there is a significantly differentiated price between seed and grain, it may force seed-producing farmers to lose interest in seed production. There must be a price reward for producing quality seed; and
- Unpredictable natural stresses leading to low yield and low crop performance due to excess rain, high disease pressure, and frost occurrence at the grain filling stage, especially in 2016 cropping season.

## Lessons learned

Some of the key lessons learned from the CBSM initiative are briefly discussed below:

**A willing community:** The first step is to sensitize the farmers on the concept of CBSM and find out their interest in taking up seed production as a potential farm enterprise. The selection of farmers to form a CBSM group is very important for the success of the group. If only poor farmers with limited landholding are selected, they may not be able to produce seed, as whatever they produce may be just enough for their consumption.

Access to improved technologies: Smallholder farmers who practice CBSM have much faster access to quality seed, new improved varieties, and other production technologies, which enhances their production.

**Site selection and clustering:** The Selection of CBSM site is critical for its success. The site should be preferably near the road as it facilitates regular monitoring, seed collection, and delivery of inputs. The site should be with good isolation to avoid field contamination during harvesting. The CBSM site should be in a central or accessible area so that other farmers can see the seed production and it can be used for demonstration and promotion to other farmers.

**Monitoring:** Regular monitoring and inspection by an experienced person with good knowledge of malt barley seed production is necessary for successful and good quality seed production. The bureau of agriculture, cooperative bureau, and extension officer of the area needs to devote their time to nurture the CBSM group.

**Training on seed production and crop management:** CBSM farmers are expected to produce good quality seed and hence should master the art and skills of seed production. Farmers should be trained in field management, crop production and protection techniques, quality seed production, and post-harvest handling.

**Supply of source seed:** For seed production, the CBSM groups should be assured of high-quality source seed. As the CBSM become seed producers, the channel for obtaining basic seeds has also been defined and put in place in the national seed production scheme. The CBSM groups who are the seed producers should access new source seed annually to multiply and produce high seed quality. Technically, the seed of highly self-pollinated crops like barley should be recycled for a maximum of three seasons without significant yield loss, which could be used as a source for QDS production where generation control is not required.

**Cleaning, packaging, and marketing:** The packaging of seed, quality control, and marketing are important issues for the CBSM groups to promote their produce for a stable market. The assurance of quality is very important and hence the involvement of the regional regulatory body for quality control should be strengthened.

## Conclusions and Recommendations

The CBSM has been proven as a viable alternative seed production scheme for making improved seeds available to farmers interested in malt barley production. It involves the organization of interested farmers or a community into a seed producer group. CBSM is efficient and a sustainable seed production model for smallholder malt barley growing farmers, especially when the formal sector cannot meet the need of the farmers. CBSM groups have the prospects of being developed into a small-scale seed enterprise in the future, which can produce and supply quality seed at the farm level. The CBSM groups can be a sustainable seed enterprise, as the demand for quality malt barley grain will continue to rise. At present, farmer's seed replacement rate is very low and expected to increase due to awareness of the advantages of using high-quality seed. The interest of farmers in Wolmera district is increasing from time to time to use improved varieties. This is an opportunity for seed producers to sale seed of their improved varieties. And this situation promises a viable seed business of the CBSM groups.

After three years of the program, farmers in the CBSM are familiar with seed production techniques and committed to grow seeds of improved varieties as a commercial crop. Thus, the support of the research institutes, bureau of agriculture, the regional regulatory bodies, bureau of cooperatives, the formal seed sector, and the extension system is vital to strengthen the CBSM scheme and transform them into cooperatives for the production and marketing of high-quality seed.





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# Profitability of Community-based Seed Production of Malt Barley in Northwestern Amhara Region

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## Introduction

Seed systems can be either formal or informal sector. Formal seed systems generally consist of agricultural research institutions, public and private sector companies producing and marketing seed, and regulatory agencies responsible for seed quantity control and certification. The informal seed system consists of large number of farmers who produce both traditional and improved varieties, market their own production and take care of their own research needs (Setimela and Kosina, 2006). The private sector tends to concentrate on producing seeds of hybrid varieties that are profitable and difficult to keep from harvest by farmers, while seed of self-pollinated crops is considered less profitable (David and Sperling, 1999; Rubyogo et al., 2010) are less attractive for private sector. Moreover, the public sector lacks the capacity to produce seed in sufficient quantities. Thus, in Ethiopia, the formal seed sector focuses mainly on hybrid maize and some cereal crops like bread wheat and tef.

The role of the informal sector in seed production and distribution is widely recognized (Sperling and Cooper, 2003; Aw-Hassan et al., 2008). The informal sector distributes seed through many ways that range from seed-to-seed exchange, gifts, payment for labor or cash sale. Empirical evidences indicate that farmer-to-farmer seed marketing has gained importance as a means of seed exchange in sub-Saharan Africa as economies develop and farmers are increasingly using markets to meet their seed needs (Aw-Hassan et al., 2008; Sperling and McGuire, 2010). Limited availability and access to quality seed is often regarded as one of the main obstacles for increasing productivity and production levels (Katungi et al., 2011) as improved varieties coupled with use of inputs and associated technologies determine crop productivity within the farming systems (Tesfaw, 2015).

Therefore, Adet Agricultural Research Center (AdARC) promoted the community-based seed production and marketing of malt barley in order to increase seed access and boost production by smallholder farmers in Amhara Region of Ethiopia. The effectiveness of community or farmer-based seed production in bulking and marketing new crop varieties will depend on the financial profitability (Srinivas et al., 2010). Although community-based seed production and marketing was and is being promoted as a means of accelerating the diffusion of new varieties and to create seed access, the profitability of community-based seed production of malt barley has not been evaluated based on farmers' condition. Hence, this study was conducted to assess the costs and benefits of community-based seed production of malt barley in Amhara Region.





## Materials and Methods

### Study locations

Malt barley community-based seed production and marketing system had been promoted at Lay Gayint, Farta, Guagusa Shikudad and Estie districts where profitability analysis of the system was studied in 2018. Descriptions of the study districts are given below.

**Lay Gayint:** is located between 11°32' and 12°16'N latitude and 38°12' and 38°19'E longitude with an altitude ranging from 1500 to 4235 meters above sea level (m asl) even though most of malt barley production was between 2500-3000 m asl. It receives the annual average rainfall of 1020 mm with the annual average minimum and maximum temperatures of 6.9 and 21.9OC, respectively. The rainfall pattern is bimodal with erratic distribution and the main rainy season (meher) is long that occurs between June and September while the short rainy season (belg) occurs between March and May. Agro-ecologically, the district is 45.35% highland, 39.43% midland, 12.5% lowland and 2.72% alpine (wurch). The soil is 55% brown, 15% red, 15% black, 10% grey (%) and 5% others in color (LGWAO, 2016). Potato, barley, tef, wheat, triticale, faba bean and field pea are the dominant crops being grown while sorghum and linseed are also being produced in small amount. Malt barley is produced both for malt factories raw material supply through producers' cooperatives and local consumption as fried grain, enjera, local beer preparation and for market.

**Farta:** One of the study locations in the district is located at 11°51′N latitude and 38°1′E longitude with an average elevation of 2,706 m asl. Agroecology of the district is 25% lowland, 45% midland and 30% highland, which receives annual rainfall of 1250–1599 mm with the annual average minimum and maximum temperatures of 9OC and 25OC, respectively (FWAO, 2016). The rainfall pattern of the areas is uni-modal with erratic distribution and effective rainy period extends from June to October. Nitosols is the dominant soil type. The most grown annual crops are barley, potato, tef, wheat, triticale, faba bean and field pea while maize, linseed, chickpea, and finger millet are minor crops.

**Guagusa Shikudad:** One of the testing sites in the district is located between 11°91' and 11°92'N latitude and 38°61' and 38°87'E longitude with the altitude ranging from 2562 to 2718 m asl. Agroecology of the district is 70% midland (Woinadega) and 30% high land (Dega), receiving annual rainfall of 1140-3572 mm with the annual average minimum and maximum temperatures of 10OC and 25OC, respectively (GSAO, 2016). The area has a uni-modal rainfall pattern with erratic distribution and the rainy months extend from March to the end of November, but peak rainfall occurs during the months of July and August. The district has high potential for irrigation production and famers are currently producing crops including malt barley under irrigation using both traditional river diversion and constructed small-scale irrigation scheme. Nitosols is the dominant soil type. Barley, potato, maize, field pea and faba bean are the major crops being produced by farmers. Under the irrigated production system, the district is being main source of malt barley grain for malt factories.

**Estie:** It is located between of 11°37' and 11°63'N latitude and 38°06' and 38°4'E longitude with an average altitude of 2615 m. The agroecology of the district is 6% lowland, 27% midland and 66% highland. The annual rainfall ranges from 1300–1500 mm with the annual average minimum and maximum temperatures of 80C and 250C, respectively (EWAO, 2016). The rainy season extends from May to the end of November though the peak rainfall occurs during July and August. Nitosols is the dominant soil type.

## Data collection and analysis

Direct field observation, individual host farmers' interview using checklists, focused group discussion (FGD) and key informants interview (KII) were some of the methods of data collection in this community-based seed production cost-benefit analysis study. Qualitative and quantitative yield related, and social data were collected on host farmers who participated in community-based malt barley seed production through face-to-face interview. Yield data were collected after harvest by taking three quadrants' samples per field (one quadrant being 1 $m^2$) on 45 malt barley fields, and social data using survey by preparing checklists on 459 host farmers who participated in seed production. Detailed information was collected on all the variable production costs incurred from land preparation to harvesting and post-harvest handling as well as materials used in seed production. Market prices for malt barley seed selling were collected from farmers, traders and marketplaces. Cost of fixed assets was not considered since fixed assets are shared among many crops being produced by a farmer.

Data were analyzed using simple descriptive statistics such as mean, maximum and minimum. Social data were qualitatively described and classified by themes and contents. All the input, output and production cost data collected were used in the calculation of the net margins or profit (defined as the residual after variable production costs are deducted from the total revenue of seed production). Enterprise budgeting method was followed, and net returns analysis was used to determine the profitability level of community-based seed production.

To determine the cost and returns of malt barley community-based seed production, the gross margin (GM) analysis was employed. The gross margin is the difference between the total revenue (TR) and the average total variable cost (TVC). The total revenue is the product of malt barley seed/grain quantity $ha^{-1}$ and its price. The total cost is given by sum of the total fixed cost (TFC) and the TVC (Katungi et al., 2011).

Gross margin analysis could be mathematically described as:

$$GM = GR - TVR \quad \ldots\ldots .1$$

Where GM = Gross Margin BIRR/ha; GR = Average Gross Return/ha; and TVC= Total Variable Costs (Birr $ha^{-1}$).

Benefit-cost ratio (BCR) was used to determine the profitability of the community-based seed production as stated below:

$$Benefit\text{ - }Cost\ Ratio = \frac{Total\ Revenue\ (TR)}{Total\ Cost\ (TC)} \quad \ldots\ldots .2$$

If BCR > 1, then the total revenue is greater than the total cost; if BCR = 1 then the total revenue is equal to the total cost; and if BCR < 1 then the revenue is less than the total cost.



**CHAPTER III**: Malt barley seed production

## Inputs

Malt barley varieties IBON 174/03, EH1847 and Sabini were used for the community-based seed production in the intervention areas. A seed rate of 125 kg $ha^{-1}$ with fertilizer rate of 121 kg $ha^{-1}$ DAPS or NPS and 40 kg $ha^{-1}$ urea were used. All DAP or NPS was applied during planting while urea was applied after 30 days of planting (during 1st weeding). Planting was done by drilling in rows spaced apart in 20 cm.

# Results and Discussion

## Costs of community-based malt barley seed production

The major variable costs of community-based seed production at smallholder farmers' level could primarily be divided into inputs (materials) and field operational costs. The average total variable costs of malt barley community-based seed production were 16,638.80 Birr $ha^{-1}$ (Table 1). Average input (material) costs accounted about 31.7% while field operation costs accounted about 68.3% of the average total cost.

Since most of the farmers use family labor in production, monetary value of wage rate that prevailed in the locality was included to the man-days spent by the family to account for the cost of labor. Out of average total variable cost, seed constitutes the third major input cost component (16.15%) while land preparation (plowing) takes the largest among operational costs (23%) followed by weed control (16.83%). Next to land preparation, weeding, threshing and harvesting are major operational cost components in their order of importance.

*Table 1. Variable costs of community-based malt barley seed production in 2017/18*

| Inputs/type of field operation | Measurement unit | Units required $ha^{-1}$ | Unit cost (Birr) | Total cost (Birr $ha^{-1}$) | % of total cost |
|---|---|---|---|---|---|
| Cost of inputs/materials | | | | 5,278.80 | 31.73 |
| Seed | kg | 125.00 | 21.50 | 2,687.50 | 16.15 |
| Fertilizer: DAP | kg | 121.00 | 14.60 | 1,766.60 | 10.62 |
| Urea | kg | 40.00 | 14.12 | 564.80 | 3.39 |
| Bags/Sacks | Number | 25.99 | 10.00 | 259.90 | 1.56 |
| Cost of field operation | | | | 11,360.00 | 68.27 |
| Land preparation (plowing) | Man days | 18 | 215.00 | 3,870.00 | 23.26 |
| Planting | Man days | 12 | 60.00 | 720.00 | 4.33 |
| Fertilizer application | Man days | 2 | 60.00 | 120.00 | 0.72 |
| Weeding | Man days | 40 | 70.00 | 2,800.00 | 16.83 |
| Rouging | Man days | 4 | 70.00 | 280.00 | 1.68 |
| Harvesting and piling | Man days | 22 | 70.00 | 1,540.00 | 9.26 |
| Threshing | Man days | 24 | 70.00 | 1,680.00 | 10.10 |
| Bagging and transporting | Man days | 5 | 70.00 | 350.00 | 2.10 |
| Average total variable cost | | | | 16,638.80 | 100.00 |

*Source: Farm level survey and crop cut sample data, 2018*
*Note: Average official exchange rate of one USD was equivalent to 27.67 Birr in 2018*

## Revenue from community-based malt barley seed production

Revenue from community-based malt barley seed production mainly comes from seed and straw yield. The average malt barley seed and straw yields obtained were 2549 kg ha$^{-1}$ and 38 bundles ha$^{-1}$, respectively (Table 2). The national and regional barley grain yields were 2039 and 1831 kg ha$^{-1}$, respectively (CSA, 2017). The selling price was recorded immediately after harvest at farm gate, which was 21.5 Birr kg$^{-1}$ seed, and 180 Birr bundle$^{-1}$ straw (one bundle being 80 kg).

Revenue from community-based seed production was computed as the total value of seed and straw yields so that farmers who engaged in malt barley community-based seed production earned a mean gross return of 61,643.5 Birr ha$^{-1}$ (54,803.5 Birr from seed yield and 6,840 Birr from straw yield) (Table 2).

*Table 2. Average seed and straw yield, unit price and revenue of malt barley community-based seed production in 2017/18*

| Variable description | Unit | Total yield obtained | Unit price (Birr*) | Total revenue (Birr) |
|---|---|---|---|---|
| Harvested average seed yield | kg ha$^{-1}$ | 2549.00 | 21.50 | 54,803.50 |
| Harvested average straw yield | Bundle ha$^{-1}$ | 38.00 | 180.00 | 6,840.00 |
| Total revenue (Birr) | | | | 61,643.50 |

*Source: Farm level survey and crop cut sample data, 2018*
*Note: one bundle of straw is equivalent to 80 kg; average official exchange rate of one USD was equivalent to 27.67 Birr in 2018*

## Profitability of community-based malt barley seed production

Gross margin computed as average total revenue less average total variable cost showed that a gross return of 45,004.70 Birr ha$^{-1}$ (73% of the total revenue) with a high benefit-cost ration value of 3.71 was earned from malt barley community-based seed production (Table 3). All these profitability measure results indicate that farmers' community-based seed production of malt barley is profitable enterprise, which is in agreement with the findings of Katungi et al. (2011) for common bean in Kenya and Chivatsi et al. (2002) for open pollinated maize in western Kenya.

*Table 3. Costs and returns from community-based malt barley seed production in 2017/18*

| Variable description | Value |
|---|---|
| (1) Total revenue (Birr ha$^{-1}$) | 61,643.50 |
| (2) Average total variable cost (Birr ha$^{-1}$) | 16,638.80 |
| Profitability measures | |
| (3) Gross Return (Birr ha$^{-1}$): (1)-(2) | 45,004.70 |
| Profit margin/ha (%): (3)/ (1) *100 | 73% |
| Benefit-cost ratio (BCR): (1)/ (2) | 3.71 |

*Source: Farm level survey and crop cut sample data, 2018*
*Note: Average official exchange rate of one USD was equivalent to 27.67 Birr in 2018*





## Sensitivity analysis

Agricultural production is unpredictable due to risk and uncertainties that could happen under natural environment. Therefore, simulation may help to minimize those risk and uncertainties in many cases and the sensitivity analysis was also done for malt barley community-based seed production enterprise (Table 4). The sensitivity analysis result shows that the enterprise was likely to be sensitive to yield and price fluctuations. A reduction in seed price or yield by 20% equally reduced the profitability of malt barley community seed production enterprise by 6.74%. A 50% reduction in yield reduced the profitability by 26.98% while a 50% reduction in yield coupled with 20% increment in TVC reduced profitability by 37.78%. However, the business of community-based malt barley seed production was found to be profitable over these risk scenarios unless extraordinary conditions happen.

*Table 4. Sensitivity analysis of profitability of community-based malt barley seed production in 2017/18*

| Item description | Original values | 20% decrease in price | 20% decrease in yield | 20% decrease in yield + 20% increase TVC | 50% decrease in yield | 50% decrease in yield + 20% increase in TVC |
|---|---|---|---|---|---|---|
| (1) Total revenue (Birr ha$^{-1}$) | 61,643.50 | 49,314.80 | 49,314.80 | 49,314.80 | 30,821.75 | 30,821.75 |
| (2) Total variable cost | | | | | | |
| (Birr ha$^{-1}$) | 16,638.80 | 16,638.80 | 16,638.80 | 19,966.56 | 16,638.80 | 19,966.56 |
| Profitability measures | | | | | | |
| (3) Gross Return (Birr ha$^{-1}$): (1)-(2) | 45,004.70 | 32,676.00 | 32,676.00 | 29,348.24 | 14,182.95 | 10,855.19 |
| Profit margin ha$^{-1}$ (%): (3)/ (1) *100 | 73.00 | 66.26 | 66.26 | 59.51 | 46.02 | 35.22 |
| Benefit-cost ratio: (1)/ (2) | 3.71 | 2.96 | 2.96 | 2.47 | 1.85 | 1.54 |

*Source: Farm level survey and crop cut sample data, 2018*
*Note: Average official exchange rate of one USD was equivalent to 27.67 Birr in 2018*

# Conclusions and Recommendations

Results of this study indicated that community-based malt barley seed production by smallholder farmers is a promising and profitable business enterprise in the study locations even under the existing low productivity and/or low-price scenarios.

In general, the study suggests that community-based seed production of malt barley can be replicated in similar areas by grouping and empowering farmers to meet seed demands of improved varieties in the country since formal seed enterprises or agencies are not yet fully engaged and convinced with the profitability mainly due to erratic demands, and the level of bulk production and aggregation problems.

To improve success and sustainability, capacity building of farmers in skill and knowledge building trainings in seed production and management, timely supply of initial seeds of improved varieties, timely support in seed quality control and certification are required. Strong market linkages among malt barley producers and cooperatives as well as government seed producer enterprises are also required for success and sustainability.

## Acknowledgments
AdARC for leading the implementation of the activity, Farmers Cooperatives Union for facilitating input-output marketing, quarantine office for conducting seed quality inspection, development agents for overall implementation of the activity, and farmers for hosting the activities and providing information in the profitability evaluation process are highly acknowledged.

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CHAPTER III: Malt barley seed production

# Profitability of Malt Barley Basic-seed Production and Marketing Cooperatives in North Shewa of Amhara Region

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## Introduction

Quality seed is one of the most economic and efficient inputs for agricultural development (FAO 2006). Use of quality seed can increase the yield potential of the crop by significant folds. Access to quality seed is crucial in improving farm household food security in agrarian nations particularly in sub-Saharan Africa (SSA), including Ethiopia. The low crop productivity in SSA including Ethiopia is due to a limited use of seeds of improved varieties by smallholder farmers. The supply of certified seed of grain crops in Ethiopia is estimated to be about 10% of the annual seed planted (Bernard et al., 2010). Farmers' access to seeds of adapted varieties of modern or landrace to their agro-ecologies is critical in increasing food production (Feder et al., 1985). The advent of the Ethiopia's new economic development plan, the first Growth and Transformation Plan (GTP1), initiated farmers to participate in seed production. This on-farm seed production and marketing program brought advantages to smallholder farmers to participate in seed production, which may also create opportunity for strengthening the overall seed system of the country (Alemu 2011; Sahlu et al., 2008).

For small-scale farmers, the development of a sustainable community-based seed production and marketing is essential to improve their food security, especially in conditions where their seed stocks are severely affected. Therefore, farmer-based malt barley seed production and marketing system is an alternative new approach being undertaken for the purpose of introducing and disseminating new malt barley varieties. The actors that have interest include government institutions, public seed enterprises, international research institutes, public research institutes, local processors, small traders, farmers' cooperatives, farmers' cooperatives unions, malt factories, and seed and grain producer farmers. In this process the inputs and products flowing through the system adds values. Therefore, this study was conducted for evaluating the contribution and profitability of farm level seed production and marketing activities and to assess the market opportunities and challenges of malt barley seed production in North Shewa.

## Materials and Methods

### Study locations

This study was conducted on Mush Seed Production and Marketing Cooperative in Bassona-Worana district, situated at about 30 km from Debre Birhan on the way to Dessie. The activity was implemented for three consecutive years (2015-2017) in areas, which are suitable for malt barley production and with farmers who were interested and experienced in the production and marketing of malt barley. The study location represents typical barley growing highland areas with the altitude of 2800-3140 m asl. The soil type is light with brown color. The geographic coordinates of the surrounding areas lie between 9°38'17" and 9°49'55"N latitude and 39°32'1" to 39°45'38"E longitude. According to the long-term data of 5 to 10 years, the area receives an annual rainfall of 1003.1-1635.9 mm with the annual average minimum (6.2-7.6°C) and maximum (17.5-19.6°C) temperatures (Unpublished data, DBARC). Farmers have established proper crop rotation system in a cluster base, which is suitable for quality seed production.

## Approaches

Major participants in this activity were researchers, farmers' extension workers and Mush Seed Producer and Marketing Cooperative (MSPMC). Member farmers received trainings about quality seed production and management, post-harvest handling of the seed and opportunities of participating in seed production and marketing activities. Debre Birhan Agricultural Research Center (DBARC), through the support of ICARDA-USAID seed production and scaling project, delivered malt barley source seed to the cooperative. The cooperative and offices of agriculture were responsible to motivate farmers to cluster fields, distribution of seed to cooperative member farmers and monitor the seed production fields. The office of agriculture and the research center were also responsible for facilitating marketing linkages, in addition to field monitoring and capacity building trainings. Dessie Plant Seed and Agriculture Inputs Quality Control and Quarantine Authority Branch Office supported the cooperative in field inspection and provision of trainings on seed production and certification standards (Table 1).

Farmers planted the malt barley varieties at seed rate varying from 100 to 125 kg $ha^{-1}$ depending on the soil fertility to avoid lodging. The planting dates were in early to mid-June depending on the rainfall distribution. Farmers applied urea and NPSB fertilizers based on the recommendation. NPSB contains 37% phosphate, 17% Nitrogen, 7% Sulphur and 0.5% Boron. Weeds were managed using herbicides and hand weeding. Broad leaf weeds were controlled using chemicals immediately after third week of planting time. Farmers harvested malt barley starting from second week of October.

## Model seed production and marketing cooperative

The model was applied by establishing the seed production and marketing cooperative at community level. Access to appropriate technologies and facilities enabled the cooperative to plan and handle seed production operations from planting to harvesting, cleaning, marketing and distribution. The CSPM model has three major components, namely; community organization and the operational and administrative establishment; multiplication and dissemination of appropriate varieties and technologies; and market linkage and financial management.





*Table 1. Field and seed standards for barely seed certification*

| **Characteristics** | **Seed class** | | |
|---|---|---|---|
| | **Pre-basic** | **Basic** | **Certified-1** |
| *Field standards* | | | |
| *Rotation (minimum number of year)* | 2 | 1 | 1 |
| *Isolation distance (minimum in meters)* | 5 | 3 | 3 |
| *Off types and other cultivars (maximum %)* | 0.03 | 0.05 | 0.1 |
| *Seed standards* | | | |
| *Pure seed (minimum %)* | 98 | 98 | 97 |
| *Other crop seed (maximum %)* | 0.03 | 0.05 | 0.1 |
| *Weed seed (maximum %)* | NS | 0.01 | 0.02 |
| *Disease infected seed (maximum %)* | NS | 0.02 | 0.03 |
| *Inert matter (maximum %)* | 1 | 2 | 2 |
| *Germination rate (minimum %)* | 90 | 90 | 85 |
| *Seed moisture content (maximum %)* | 12.5 | 12.5 | 12.5 |

*Source: Ethiopian Standards Agency 2015*
*Note: N.S = not specified*

## Profitability analysis

The profitability of seed production and marketing cooperative was analyzed using cost benefit analysis techniques of deducting seed production costs from seed marketing revenues. All the cost items incurred related to seed production were listed and all revenues received related to seed marketing were also registered. The net benefit was calculated by deducting total costs from the gross benefits (Equation 1):

$$\text{Net benefit} = \text{Total gross benefit} - \text{Total production costs} \qquad (1)$$

# Results and Discussions

## Capacity building and awareness creation

Training was provided to create awareness and improve skills of farmers and extension workers about quality seed production. Eight-six farmers (21 females) and 7 extension workers (3 females) attended the trainings. Field days were also organized for different stakeholders to draw lessons on the approaches we followed and get feedbacks about the intervention. One-hundred and fifteen farmers (30 females), and 45 experts and other stakeholders (13 females) participated in the field days. Market linkage was facilitated, and farmers' motivation was improved during the field days to produce and supply quality seed in the future.

## Field inspection and market linkage

To ensure quality seed production, the seed fields were inspected by internal and external regulatory agency at the field level. The cooperative and the district office of agriculture together with the DBARC invited the external regulatory agency, the Dessie Plant, Seed and Agriculture Inputs Quality Control and Quarantine Authority. The Amhara Seed Enterprise and Seed Unions as well as farmers purchased the seed produced each year for both seed and grain production purpose. Most of the seed produced was used in formal sector after it was inspected and accepted by the internal and external seed regulatory agency.

In this approach more than 34.7 t of basic seed was produced and used for seed and grain. More than 12 t of basic seed of recently introduced malt barley variety IBON 174/03 was supplied by the producers and sold to different organizations. Most of the seed was used by the formal sector such as the Amhara Seed Enterprise, cooperatives and research centers. This seed production and marketing cooperative benefited the producer farmers with the alternative access to new varieties, market opportunities and training in seed production and marketing skills.

Farmers in the area were also convinced to use the quality seed and acquired it locally instead of buying it from external sources. This intervention helps to access seeds of different malt barley varieties. Hence, an increasing number of farmers got highly productive quality seed of improved varieties at the required amount, at the right time and at reasonable market price. Farmers got seeds of malt barley varieties in different ways through direct purchase, exchange and as a gift from the producer farmers.

## Seed production and marketing

Many actors were involved in seed production and marketing activities in the intervention areas. The main actors were seed producer and marketing cooperatives, DBARC, Amhara Seed Enterprise, Gonder Malt Factory, Dashen Brewery, BGI Ethiopia, Global Malt Service (GMS) Ethiopia, and farmers' cooperatives unions. The Amhara Seed Enterprise participated in both input supply and output marketing of malt barely. Tegulet Seed Union, Dashen Brewery and BGI Ethiopia, GMS Ethiopia and Gonder Malt Factory involved in malt barely seed supply and output marketing activities. All these encouraged the participant farmers in seed production and marketing of malt barley.

## Profitability of seed production

Thirty hectares of land was used for malt barley seed production and marketing purposes using a cluster approach for three different varieties. These malt barley varieties are Bekoji-1, IBON 174/03, and Sabini; each planted on 5.0, 17.5, and 8.0 ha, respectively (Table 2).

*Table 2. Area allocated and seed used for malt barley seed production*

| Variety | Area allocated (ha) | Seed rate (kg ha$^{-1}$) | Total seed used (kg) | Seed cost (Birr kg-1) | Total seed cost (Birr) |
|---|---|---|---|---|---|
| Bekoji-1 | 5.0 | 100 | 500 | 16 | 8000 |
| IBON 174/03 | 17.5 | 100 | 1700 | 16 | 27200 |
| Sabini | 8.0 | 100 | 800 | 16 | 12800 |



CHAPTER III: Malt barley seed production

The farm gate price of seed and straw was set immediately after harvest. The seed and straw prices for both varieties were similar and was 15 Birr kg$^{-1}$ and 80 Birr per bundle (one bundle on average is 45 kg), respectively. The total production cost and field operation of malt barley seed production and marketing activities are presented in Table 3.

*Table 3. Variable costs of malt barley seed production*

| Field operation | | Unit | Quantity | Unit cost (Birr) | Total cost (Birr per 30.5 ha) |
|---|---|---|---|---|---|
| Land preparation | First plowing | man/days | 120 | 400 | 48000 |
| | Second | man/days | 120 | 400 | 48000 |
| | Planting | man/days | 130 | 400 | 52000 |
| Fertilizers | DAP fertilizer | T | 3 | 12450 | 37350 |
| | Urea fertilizer | T | 5 | 11500 | 57500 |
| Seeds | Seed cost | T | 3 | 16000 | 48000 |
| Labor | Fertilizer application | man/days | 10 | 100 | 1000 |
| Weed control | Hand weeding, first | man/days | 180 | 100 | 18000 |
| | Hand weeding, second | man/days | 120 | 100 | 12000 |
| | Herbicide 2,4-D | Litter | 30 | 120 | 3600 |
| | Herbicide application (labor) | man/days | 10 | 150 | 1500 |
| Rouging | Labor | man/days | 30 | 60 | 1800 |
| Harvesting | Labor | man/days | 200 | 120 | 24000 |
| Transporting bundle | Labor | man/days | 90 | 100 | 9000 |
| Threshing | Labor | man/days | 60 | 120 | 7200 |
| Bagging | Bags | number | 870 | 10 | 8700 |
| Total | | | | | 393,850 |

The seed production and marketing of malt barley was evaluated by the seed inspection and certification laboratory. Bekoji-1 was rejected due to seed mixture and weed management problems of the farmers. Sabini gave higher seed yield than other varieties. IBON 174/03 variety was planted in large areas in 2017 production year and farmers preferred it due to its early maturity and well adaptability in the production areas (Table 4).

*Table 4. Seed production and productivity of malt barley varieties in 2017*

| Variety | Area planted (ha) | Area inspected (ha) | Area approved (ha) | Area rejected (ha) | Seed yield (t ha$^{-1}$) | Straw yield (Bundle ha$^{-1}$) | Total seed Production (t) | Straw production (Bundles) |
|---|---|---|---|---|---|---|---|---|
| Bekoji-1 | 5 | 5 | 0 | 5* | 2.8 | 7 | 14 | 32 |
| IBON 174/03 | 17.5 | 17 | 17 | 0 | 2.8 | 5.00 | 47 | 156 |
| Sabini | 8 | 8 | 8 | 0 | 3.0 | 5.00 | 24 | 56 |

Note: *Rejected due to seed mixture and weed problems; one bundle = 45 kg

The cost benefit analysis of the malt barley seeds production and marketing benefited the community by provision of new opportunities in seed businesses. The cooperative made a gross income of US$ 117,607 from malt barley seed production whereas the total cost was US$ 29,730 with a net income of US$ 87,337 (Table 5). The results showed a net income of US$ 2,911 $ha^{-1}$ obtained from the seed business (Table 5).

*Table 5. Cost benefit analysis of malt barley seed production and marketing on 30.5 ha in 2017*

| *Description* | *Value* |
|---|---|
| *Total seed production (t)* | *71* |
| *Total straw production (t)* | *198* |
| *Total rejected seed/grain production (t)* | *14* |
| *Average price of cleaned seed (USD $t^{-1}$)* | *1,111* |
| *Average price of grain (rejected seed), USD $t^{-1}$* | *889* |
| *Average price of straw (USD $t^{-1}$)* | *130* |
| ***Gross income*** | |
| *Income from sale of seed (USD)* | *78,881* |
| *Income from rejected seed (USD)* | *12,446* |
| *Income from sale of straw (USD)* | *25,740* |
| *Total gross income (USD)* | *117,067* |
| ***Gross costs (USD)*** | |
| *Total variable cost* | *29,174* |
| *Total fixed costs* | *556* |
| *Total production cost (USD)* | *29,730* |
| *Total net income (USD)* | *87,337* |
| *Net Income (USD $ha^{-1}$)* | *2,911* |

*Note: One US$ was equivalent to 13.5 Birr in the official exchange market during the study period*

# Experiences of farmers in seed production and marketing

## Seed as a business

Almost 80% of the seed produced by farmers were accepted during quality assurance and the produced seed was disseminated to other producer farmers. This showed a good market opportunity for seed business. Purchase of improved seed by farmers in Africa, except in a small number of countries, is infrequent. Based on a survey of seed sales and adoption rate in 2007, estimated use of certified seed of hybrid maize ranged from 5% in Angola to 80% in Zimbabwe (Langyintuo et al., 2008). Compared with the certified seed use observed in 1997, a decline was noted in Angola, Zambia and Zimbabwe but there was an increase in Ethiopia, Kenya, Malawi, Mozambique, Tanzania, and Uganda . Since the use of improved seed is at such a low level in most countries, there is the apparent potential for the growth of the seed industry in Africa.





According to our study, farmers understood that seed production and marketing activity by itself was a new business opportunity. Such awareness encouraged us of bringing farmers together and establishing the cooperatives. Currently farmers sell malt barley seed to different organizations for up to 14,000 Birr $t^{-1}$. The idea of seed as business was introduced in the locality and farmers gained income and experience from seed and grain business (Table 5).

## Partnership with stakeholders

Quality seed is one of the most economic and efficient inputs to agricultural development (FAO 2006). Availability of, access to and use of quality seed remain a major problem. Alternative approaches of seed production and marketing involving farmers is one of the options. However, apart from economic viability and profitability there is a need for creating partnership by linking them with different stakeholders (Bishaw and Niane, 2015). Many stakeholders play important roles to provide solution for farmer's seed related problems. We were working with zonal and district administrations, office of agriculture, seed regulatory agencies, cooperatives and communication offices on activities such as annual planning, mobilizing and organizing farmers, monitoring and evaluation, establishing the cooperative and providing technical support and regular supervision.

Development agents and local leaders were also directly involved in site selection, organizing and mobilizing farmers and continuously monitoring and evaluating the seed producers. Dessie Plant, Seed and Agriculture Inputs Quality Control and Quarantine Authority, universities in the vicinity, district level cooperative unions, Tegulet Seed Union at zonal level, and Africa Rising project were also our major implementing partners. This will ensure sustainability of local seed production and marketing.

## Strengthening seed production and marketing cooperatives (SPMCs)

The Ethiopian seed system includes both formal and informal systems sometimes called local or farmers seed system, which operates simultaneously in the country. There is, however, a fact that the formal system is the original source of improved seeds in the informal system. The formal seed sector is a source of improved varieties and source of early generation seed including breeder, pre-basic and basic seeds of new varieties obtained from national agricultural research systems including higher learning institutions, i.e., universities, faculties of agriculture. However, the commercial seed sector supplies less than 10% of the country's annual seed demand. Almost all public and private sectors, work particularly on wheat and maize, which is more than 90% of the formal seed supply (Thudi et al., 2014; Bishaw and Atilaw, 2016).

For crops such as barley, the role of formal sector remains insignificant for many years although recent trends continue to change. Most of the seed demand including barley is fulfilled by the informal sector, which was estimated to be 80-90% (Thijssen et al., 2008). Farmer-to-farmer seed exchange systems are short, simple and less externally regulated and are particularly important in serving the needs of smallholder farmers who use own-saved seed from the previous harvest and/or seed accessed from friends, relatives and local markets. Therefore, to expand the area coverage of improved seed and market participation of smallholder farmers, establishing farmer seed producer and marketing cooperative is the feasible way. During our study period, two seed producer and marketing cooperative were strengthened to ensure sustainability of the seed supply system at local levels. Training was organized and delivered for cooperative committee members and experts about quality seed production, cooperative management skills, business plan development, the benefit of seed business, and strengthening themselves. Strengthening the capacity and linkages among major stakeholders of malt barley seed system such as the seed grower associations, unions, individual farmers, research centers, malt factories, breweries, is essential.

## Integrating seed production and technology diffusion

The function of seed production and marketing cooperative is multi-purpose: seed production, market promotion and technology diffusion. First, the cooperatives produced quality seed where field inspections were conducted by regulatory agencies each year and approved. The seed produced was sold by seed cooperatives and/or public seed enterprises to farmers. This will ensure the availability, access and use of quality seed by farmers. Second, the seed production fields were used for market promotion. Farmers were invited to visit the seed production fields and get firsthand information and experiences on the benefits of improved varieties. This will create awareness and demand for improved varieties and quality seed. Third, the seed production and marketing activities were used as a technology shopping for diffusion. Farmers can access the seed produced through direct cash purchase or farmer-to-farmer seed exchange with the cooperatives ensuring technology diffusion.

## Farmer-to-farmer seed exchange

The informal seed system played a key role in farmer-to-farmer seed exchange through, which the new technology could spread over potential areas. In Ethiopia, 60-70% of seed used by smallholder farmers is saved on-farm and exchanged among farmers, and the remaining 20-30% is borrowed or purchased locally (Thijssen et al., 2008). The informal seed system (either self-saved seed or farmer-to-farmer seed exchange) accounts for 90% of the seed used by smallholder farmers (Belay, 2004).

Most farmers are dependent on informal system probably this is because of the reason that farmers expressed it is relatively cheaper and readily available in the farmers' villages just at the time when seed is needed fulfilling the requirements and ensuring quality, availability, accessibility and affordability. During the project implementation years more than 36 ha of land was covered with seed of improved malt barley through farmer-to-farmer seed exchange reaching 58 farmers (12 females) who were indirect beneficiaries of the seed access (Unpublished annual report of district offices of agriculture in 2016).

## Role of SPMCs for technology diffusion and improving seed system

The seed production and marketing cooperatives established in intervention areas help to facilitate the adoption of improved agricultural technologies and market linkages for the formal seed system through seed producer and marketing cooperatives, seed union and public enterprise. Farmers' attitudes and opinions towards the introduced malt barley varieties and seed production and marketing were improved due to experiences of local seed business activities. Rapid assessments of the approach indicated that farmers, and other stakeholders' perception on the improved technologies and seed production activities confirmed the suitability of the approaches for ensuring easy access to seeds and improving crop productivity and production.





# Opportunities and challenges of SPMC

## Opportunities

- The growing demand for malt barley seed and grain production due to the expansion of malt factories and breweries in the country;
- Government's support to malt barley production and cluster-based farming for bulk production and aggregation to facilitate collection, transportation and marketing;
- Support of malt barley production by different actors and introduction of new malt barley varieties; and
- Availability of more seed experts at zone and district levels and other actors supporting local seed production and marketing.

## Challenges

- Cooperatives lack their own brand and packaging, labeling and other postharvest handling;
- Harvesting and storage problems in maintaining seed quality;
- Reluctance of farmers delivering all seed produced (divert malt barely seed for consumption) and as a result all inspected and produced seed not available for sale;
- Lack of contractual farming experience and limited contract enforcement in case of default;
- Low seed price of malt barley compared with grain market as per farmers' perception; and
- Capacity and financial constraints to strengthen seed producer cooperative with seed cleaning machines and mini-seed testing laboratories.

# Conclusions and Recommendations

## Conclusions

Farm level seed production and marketing is a new opportunity for farmers to participate in seed production and marketing at farm level to enhance the quality and quantity of seed supply at a community level and beyond. The involvement of many actors in malt barley production and marketing help access to trainings for interested farmers and farmer groups, and this improved the knowledge and skills of the participant farmers. This opportunity improved farmer's skills for easy management of diseases, pests and other crop protection activities as well as for inspection of the crop in the field to produce quality seed.

Community-based seed production enabled farmers have better bargaining power to get higher income from the seed produced than grain. Seed production as a business by cooperative or at community level was proved to be feasible with the net income of 2,911US$ ha$^{-1}$. This new approach increased area coverage of malt barley through better access to seed at the required time and quantity and at a relatively cheaper price as compared to other seed sources from the formal system. Our work shows that cooperative based seed production and marketing system could be one of the options for building a vibrant seed supply system.

## Recommendations

Establishing and strengthening seed production and marketing cooperatives through technical backstopping, providing training, experience sharing, post-harvest handling, marketing and business management skills are important issues to be addressed. Other issues, which need attention for strengthening the community-based seed multiplication of malt barely may include:

- Clustering fields involving more farmers in seed production and linking them with markets and distribution system needs attention;
- Implementing formal seed quality assurance to certify the seed of out-grower farmers and farmers' groups or associations to enter and compete in the formal seed marketing system particularly the zonal seed cooperative union or regional public seed enterprise;
- Promoting the success stories of community-based seed production and scaling to other areas to improve productivity and increase production;
- Integration, profitability and partnership and linkages among actors involved in malt barley production and marketing activities through platform approach may ensure sustainability; and
- Formal registration and legalization of seed production and marketing cooperative as a legal entity for similar areas.

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# Profitability of Malt Barley Seed Producer Cooperatives in Arsi Zone, Southeastern Ethiopia

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## Introduction

Barley is the major crop in the highlands of Ethiopia with huge economic importance. The demand for malt barley grain as raw material for malt factories and breweries will continue increasing with the expansion of beer industry. With the construction of new malt factories and breweries, the malt barley production became an important commodity for the malt barley producing farmers. The annual malt barley demand by the existing breweries in the year 2011/12 was projected to be over 67,510 t with an increasing trend. However, Asella and Gonder malt factories supplied only about 35% of the demand to the existing breweries and the remaining balance was fulfilled through import. Currently there are 11 breweries with the annual malt barely demand of 118,000 t (Gessesse, 2017). To satisfy the increasing demand, farmers should get quality seed of improved malt barley varieties with sufficient quantity. This can only be achieved through inclusion of the informal seed system. For the informal seed system to play an active role in the seed system and to continue play its role in the future, it should be profitable and sustainable.

Despite recent positive developments leading to productivity gains in smallholder agriculture, average yields remain low, and the progress needs to be sustained. Both biotic and abiotic factors including suboptimal agricultural management practices and inadequate provision of inputs such as seeds and fertilizers are largely impeding crop productivity. The formal seed production system is very limited in its capacity to supply enough seed to smallholder farmers, the current capacity being able to address about 10% of the national seed demand. Moreover, seed from the formal seed systems is expensive and not timely available to smallholder farmers. The importance of the informal seed system in improving the seed availability in the required amount, quality, time and affordable price to smallholder farmers was described by different authors (Bishaw et al., 2008; Alemu 2011; Altaye and Hussien 2013). Therefore, with the support of ICARDA-USAID malt-barley and faba bean seed production and scaling project and other collaborative organizations, Kulumsa Agricultural Research Center (KARC) established about 12 local seed producer cooperatives (SPCs) in Arsi Zone in order to enhance malt barley and faba bean seed production and supply in the national seed system.

The SPCs are assumed to be sustainable if they are feasible and profitable as a business entity. As compared to grain production, seed production demands more knowledge, skill, and resources such as inputs and crop management (harvesting, threshing, cleaning and storage facilities) in order to satisfy seed standards, set by the Ethiopian seed regulatory agency. All these inputs incur cost and the profitability of the seed producer is not only affected by the



**CHAPTER III**: Malt barley seed production

known factors controlled by the farmers but also by the prices set by different actors in the seed production value chain. Experiences elsewhere on the community-based bean seed multiplication enterprises in Ethiopia showed a gross margin profitability of US$ 792 ha$^{-1}$, besides its easy accessibility to the farmers (Tebeka et al., 2017). Similarly, the results from the wheat contractual seed production in Amhara region showed a profitability of US$ 514 ha$^{-1}$, which is reasonably encouraging (Tsegaye, 2012). Therefore, this study was designed to study the profitability of malt barley SPCs, which were established in Arsi Zone.

## Materials and Methods

### Description of seed producer cooperatives

The study was conducted in 2015/16-2017/18 cropping seasons of malt barley on four SPCs established by KARC in Arsi Zone of Oromia Region. The geographical locations (Table 1) of the SPCs participated in the study and farming system descriptions of the area are presented below.

The four SPCs included in seed production profitability study are in the major malt barley producing areas in Arsi Zone. A mixed crop livestock farming system dominates in Lemu Dima, Teji Burkitu, and Tuka Ketara SPCs, barley and potato being the major crops (Challa, et al., 2019). The Hunde Gudina SPC is dominated by wheat-tef based production system, in addition to producing malt barley and faba bean.Faba bean is important break crop for cereal crops like malt barley in the four cooperatives.

*Table 1. The geographical descriptions of SPCs participated in the study*

| Name of SPC | Latitude N | Longitude E | Altitude (masl) | Annual total rainfall (mm) | Average annual maximum temperature (°C) | Average annual minimum temperature (°C) | Soil type |
|---|---|---|---|---|---|---|---|
| Lemu Dima | 07°34.57′ | 039°16.54′ | 2893 | 1049.6 | 19.6 | 8.3 | Luvisols |
| Hundie Gudina | 07°31.49′ | 038°59.70′ | 2778 | 1025.7 | 22.5 | 10.0 | Luvisols |
| Tuka katara | 07°26.77′ | 039°14.94′ | 2928 | 1028.5 | 18.1 | 5.7 | Vertisols |
| Teji Burkitu | 07°25.30′ | 039°24.49′ | 2839 | 989.2 | 23.5 | 11.2 | Vertisols |

### Data collection

To estimate the profitability (net benefit) of each SPCs, the following data were recorded.

- Gender disaggregated data on the number of member farmers of each SPC;
- The total land occupied by each malt barley varieties in the respective SPC;
- The average farm-gate price of the seed and straw produced;
- All other associated costs incurred to produce the malt barley seed in each SPC;
- Total revenue was estimated by multiplying the average farm-gate price with the total seed and straw production; and
- The net benefit was estimated by subtracting the total cost incurred from the total revenue.

# Results and Discussion

## Seed producer cooperatives (SPCs)

The year of establishment and gender disaggregated membership of target SPCs are presented in Table 2. Although Teji-Burkitu SPC was established earlier than the other SPCs, its member farmers are the lowest with 34 farmers (4 females), while Lemu-Dima SPC, which was established in 2011 has the highest number of member farmers of 172 (28 females). The number of member farmers may have effect on scale and total net benefit (Tables 3) since land holding size of the SPC is directly associated with the number of member farmers who have individual right for direct access to landholding. With the support of ICARDA-USAID malt barley and faba bean seed production and scaling project during 2015/16-2017/18, the four SPCs produced malt barley in rotation with faba bean to maintain soil fertility and health in the highlands of Arsi Zone where barely and faba bean are major crops.

*Table 2. The number of member farmers and target seed producer cooperatives during 2015/16-2017/18 cropping seasons*

| SPC | District | Year of establishment | Member farmers | | |
|---|---|---|---|---|---|
| | | | Male | Female | Total |
| Lemu Dima | Lemu Bilbilo | 2011 | 144 | 28 | 172 |
| Hunde Gudina | Munisa | 2012 | 38 | 3 | 41 |
| Tuka Ketara | Lemu Bilbilo | 2012 | 48 | 5 | 53 |
| Teji Burkitu | Honkolo Wabe | 2010 | 30 | 4 | 34 |

## Profitability of SPCs in seed production

The summary of malt barley seed produced, productivity and profitability are presented in Table 3. Total production area during 2015/16-2017/18 of malt barley varieties across the four SPCs was 53.89, 9.95, 4.83, 0.25, 2.29 and 1.22 ha of land for Traveler, IBON 174/03, Fanaka, HB1963, Holker and Bahati malt barley varieties, respectively. Lemu-Dima SPC had the highest land area of 37.70 ha for malt barley seed production, but the productivity was the lowest, being about 3.0 t ha$^{-1}$ while productivity of Hunde-Gudina SPC having the third largest land area of 10.59 ha was the highest, being 3.82 t ha$^{-1}$. The respective productivity of seed production in Tuka-Ketara and Teji-Burkitu SPCs was 3.58 and 3.53 t ha$^{-1}$ on the corresponding land area of 17.25 and 6.88 ha. Even though seed price was not the same among SPCs (16.00-16.41Birr kg-1 seed), profitability was the highest for the SPC having the highest productivity. Thus, Hunde-Gudina, Tuka-Ketara, Teji-Burkitu and Lemu-Dima with the respective productivity of 3.82, 3.58, 3.53 and 3.00 t ha$^{-1}$ obtained the corresponding net benefit of 48,703.03, 44,423.00, 39,036.86, and 33,900.22 Birr ha$^{-1}$. However, Lemu-Dima with the highest production area of 37.7 ha obtained the highest total net benefit of 1,277,699.41 Birr, and Teji-Burkitu with the lowest production land area of 6.88 ha obtained the lowest total net benefit of 268,573.59 Birr.





The widely produced malt barley variety Traveler, on 53.89 ha, had the lowest profitability of 33,169.68 Birr ha$^{-1}$ on 34.82 ha of land in Lemu-Dima while the highest profitability was 59,033.43 Birr ha$^{-1}$ on 7.37 ha of land in Tuka-Ketara. The second widely produced malt barley variety IBON 174/03, on a total of 9.95 ha of land, had the lowest profitability of 22,095.80 Birr ha$^{-1}$ on 1.13 ha of land in Teji-Burkitu while the highest profitability of 61,368.28 Birr ha$^{-1}$ on 4.27 ha of land in Hunde-Gudina. The productivity of variety determined profitability. Productivity of Bahati, Fanaka, HB1963, Holker, IBON 174/03 and Traveler was 2.62-2.63, 3.18, 2.63, 2.62-2.63, 2.35-4.47, and 2.98-4.57 t ha$^{-1}$ across SPCs, respectively. This study revealed that productivity level of malt barley varieties and SPCs had the highest influence in determining profitability of malt barley seed production. Therefore, along with the selection of productive malt barley variety, farmers are required to do all the necessary agronomic practices, including rotation with legume crops such as faba bean, according to the agricultural production package recommendations in order to increase productivity for improving profitability per unit area.

*Table 3. Profitability analysis of malt barley seed production by SPCs during 2015/16-2017/18 cropping seasons*

| Cooperative | Variety | Planted area (ha) | Total seed produced (t) | Total straw produced (Bundle) | Total cost (Birr) | Total revenue (Birr) | Total net benefit (Birr) | Profitability (net benefit Birr $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| Hunde Gudina | IBON 174/03 | 4.27 | 19.08 | 21.33 | 65302.81 | 327061.23 | 261758.42 | 61368.28 |
| | Traveler | 6.33 | 21.40 | 18.98 | 108898.29 | 363392.00 | 254493.71 | 40219.52 |
| Total | | 10.59 | 40.48 | 40.31 | 174201.10 | 690453.2 | 516252.13 | 48703.03 |
| Lemu Dima | IBON 174/03 | 1.74 | 6.55 | 10.45 | 28238.55 | 115337.30 | 87098.74 | 50031.91 |
| | Fanaka | 0.58 | 1.52 | 3.48 | 9414.86 | 27579.47 | 18164.61 | 31296.08 |
| | Bahati | 0.55 | 1.45 | 3.33 | 8993.11 | 26344.03 | 17350.91 | 31296.08 |
| | Traveler | 34.82 | 103.60 | 139.20 | 648448.94 | 1803534.0 | 1155085.15 | 33169.68 |
| Total | | 37.70 | 113.12 | 156.50 | 695095.47 | 1972794.9 | 1277699.4 | 33900.22 |
| Teji Burkitu | Traveler | 5.37 | 20.60 | 21.48 | 106797.15 | 340341.15 | 233544.00 | 43485.83 |
| | IBON 174/03 | 1.13 | 2.65 | 9.03 | 21984.00 | 46912.87 | 24928.87 | 22095.80 |
| | Fanaka | 0.38 | 1.00 | 3.05 | 7423.09 | 17523.81 | 10100.72 | 26514.40 |
| Total | | 6.88 | 24.25 | 33.56 | 136204.24 | 404777.8 | 268573.60 | 39036.86 |
| Tuka Ketar | IBON 174/03 | 2.81 | 9.34 | 22.47 | 47813.58 | 164487.59 | 116674.01 | 41542.94 |
| | Fanaka | 3.87 | 10.15 | 30.93 | 65828.07 | 182010.91 | 116182.85 | 30047.29 |
| | HB1963 | 0.25 | 0.80 | 2.01 | 4282.89 | 14132.93 | 9850.04 | 39153.89 |
| | Traveler | 7.37 | 33.70 | 29.50 | 132384.96 | 567708.07 | 435323.11 | 59033.43 |
| | Holker | 2.29 | 6.00 | 18.29 | 38913.14 | 107592.66 | 68679.51 | 30047.29 |
| | Bahati | 0.67 | 1.75 | 5.33 | 11349.67 | 31381.19 | 20031.53 | 30047.29 |
| Total | | 17.25 | 617.40 | 108.53 | 300572.30 | 1067313.34 | 766741.04 | 44423.00 |





## Conclusions

This study proved that seed production as a business by SPCs in Arsi Zone is profitable. Profitability for malt barley seed production ranged from 33,900.22 to 48,703.03 Birr $ha^{-1}$ among the study target four SPCs during 2015/16-2017/18. Both productivity and seed price affected profitability.

Rotation of malt barley with faba bean has also been a good opportunity to improve productivity through improving soil fertility and health and sustainability in the highlands where crop diversity is limited. Therefore, along with the selection of productive malt barley varieties, farmers are required to apply all the necessary agronomic practices according to the agricultural production package recommendations in order to increase productivity for improving profitability per unit area.

It was also an educational experience to know that SPC with small number of member farmers was weak in bargaining power to fix price because of its small-scale production and small landholding size and hence obtained the lowest profitability regardless of its better productivity.

This study suggests that improving productivity of varieties and crop management practices may further improve profitability of SPCs. The size of SPCs is also important requirement to increase the scale of production based on land area (since member farmers own the land), which largely influences price bargaining power and eventually profitability.

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# CHAPTER IV

## MALT BARLEY TECHNOLOGY MULTIPLICATION AND SCALING





# Scaling up Malt Barley Technologies in North Shewa Zone of Amhara Region

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## Introduction

In Ethiopia, barely covers 959,273.36 ha with a national productivity of 2.11 t $ha^{-1}$ (CSA, 2017). The Amhara Region is the second largest barley producer in the country, covering 323,655.73 ha with a productivity of 1.88 t $ha^{-1}$. North Shewa is one of the largest barley- growing areas in Amhara Region having an increasing trend in area coverage over time (CSA, 2017). In North Shewa, barley covered 65,380.84 ha (being the first in the region) with the average productivity of 2.22 t $ha^{-1}$, which is higher than the national and regional average.

There are experiences in sustainable transfer of promising technologies (Pretty et al., 2011). This helped farmers to have a chance to enhance productivity and market participations (Altieri et al., 2012). Transfer of malt barley technologies can benefit the farmers to have a chance on access to improved seed and knowledge. Scaling up in this context means expanding and sustaining of successful practices of improved agricultural technologies in different places over time to reach a greater number of users. This brings more quality benefits to more people over a wider geographical area, more quickly, more equitably, and more permanently. Participatory approaches convince and motivate the farmers to change their attitudes towards on the new technology furthermore initiate them to involve in the out-reach program (Pretty et al., 2003).

However, malt barley has been a recent introduction in North Shewa Zone. Most farmers are not aware of malt barley improved technologies and grain quality requirements. Malt barley is economically important agricultural commodity, which brings a new opportunity to farmers in producing and marketing as a cash crop. Therefore, pre-scaling up of malt barley improved varieties with their production packages was conducted to improve malt barley productivity and production, to create awareness and demand through capacity building and partnership linkage in the value chain.

## Methodology

### Study locations

The activities were conducted at Angolela-Tera, Asagirt, Bassona Worana, and Tarmaber districts of North Shewa Zone of Amhara Region during 2016/17-2017/18. These districts are among the major potential areas suitable for malt barley production. The altitude of target locations in the districts ranged from 2750 to 3069 m asl receiving annual rainfall of 950-1200 mm. Geographic coordinate location of some of the sites in Asagirt district ranged from 9°19.82' to 9°20.45'N latitude, and 39°29.31' to 39°30.31'E longitude; sites in Bassona Worana district ranged from 9°41.46' to 9°47.52'N latitude, and 39°32.11' to 39°40.56'E longitude; sites in Tarmaber ranged from 9°40.33' to 9°49.48'N latitude and 39°31.73' to 39°45.16'E longitude for rainfed and supplementary irrigation during off-season; and the irrigation seed production site in Angolela-Tera district was at 9°31.56'N latitude and 39°28.22'E longitude. The major soil type is brown in color. Barley, wheat and faba bean are the major crops being produced in the study locations.

## Approaches

Every year, a workshop was organized with the heads of agricultural offices, experts, cooperative promotion agency, cooperatives unions, NGOs and private sectors to create awareness, share responsibility, resource mobilization, develop common understanding, review and planning. This was followed by signing Memorandum of Understanding (MoU) according to shared responsibilities through the facilitation of zonal agriculture office. The shared responsibilities included organizing trainings and field days, and seed dissemination by Debre Birhan Agricultural Research Center (DBARC) in cooperation with agricultural development offices; selection of farmers and sites, and follow up of land preparation by kebele development agents; seed quality control in the production fields and during storage by zonal plant quarantine and inspection office; joint field monitoring and evaluation by researchers from DBARC, agricultural extension experts of the districts and kebele development agents; and market linkage with seed enterprise and cooperatives unions. Activity details of each actor is presented in the subsequent sections under approaches, and results and discussions.

## Input delivery and technical support

Before seed delivery, participant farmers, district agricultural experts, and kebele development agents were trained about the importance of malt barley production, improved varieties and management practices, and marketing. Different media such as brochures and production manual or leaflets were provided to the trainees. The seeds of malt barely varieties Bekoji-1, Holker and IBON 174/03 were provided to the selected farmers in revolving seed scheme where they pay back the amount received in kind. The recommended seed rate, fertilizer rate and other agronomic practice were carried out on time by farmers with the help of development agents and researchers. Broadcast seed rate was 100 kg $ha^{-1}$, and sowing time was from mid to the end of June every year. Weed management practices were applied using different herbicides and hand weeding with proper crop rotation practices.

## Participatory field monitoring, evaluation and inspection

Starting from clustering of fields to planting of the crop, continuous field monitoring and evaluation were done by researchers, district agricultural extension experts and kebele development agents. Emphasis was given to monitoring the timely application of crop management practices by farmers. Seed production fields through scaling up activities were inspected by Dessie Seed Laboratory and Quarantine Office during flowering and





grain filling stages of the crop. Finally, field days were organized in cooperation with district and kebele agricultural extension offices.

# Results and Discussions

## Capacity building

A total of 405 farmers (67 females) and 48 staff of extension (11 females) including agricultural experts and development agents were trained (Table 1). The training focused on the improved malt barley varieties and production packages, seed quality, field inspection, marketing opportunities for both seed and grain of malt barely. Training was also given for leaders of the cooperatives and district level seed experts on technical aspects of quality seed production, field level seed quality control and Ethiopian seed standards, and management aspects of business plan preparation, marketing, and cooperatives internal control system.

Theoretical and practical training was also given to cooperatives leaders and district experts on the safe use, operation and proper utilization of multi-crop mobile threshers, which were donated by ICARDA-USAID faba bean-malt barley seed production and scaling project.

*Table 1. Training participants in 20116/17-2017/18*

| Farmer | | Agricultural expert | | Total | |
|---|---|---|---|---|---|
| Male | Female | Male | Female | Male | Female |
| 338 | 67 | 37 | 11 | 375 | 78 |

## Seed provision

Malt barely varieties Bekoji-1, Holker, IBON 174/03 and Sabini were provided to participant farmers in the revolving seed scheme. The seeds of the varieties were planted by organizing and preparing clustered fields with proper crop rotation. A total of 10.35 t of malt barely seed were provided to 277 direct beneficiary farmers (27 females), each farmer representing a farm household, planting 91.2 ha of land. These efforts motivated farmers to produce quality malt barley seed and/or grain (Table 2). This will contribute to the very limited formal sector certified seed supply of grain crops in Ethiopia, which was estimated to cover about 10% of the annual seed demand (Spielman et al., 2010). Farmers' access to seed of adapted modern varieties or local landraces adapted to their agro-ecologies is critical in increasing food production (Feder, 1980).

*Table 2. Amount of seed provided, area planted and number of beneficiary farm households*

| Malt barley varieties | Seed (t) | Planted area (ha) | Number of beneficiary farm households | |
|---|---|---|---|---|
| | | | Male | Female |
| Sabini | 1.2 | 10.2 | 25 | 3 |
| IBON 174/03 | 4.2 | 40.2 | 115 | 13 |
| Holker | 3.35 | 30.3 | 80 | 8 |
| Bekoji-1 | 1.6 | 10.5 | 30 | 3 |
| Total | 10.35 | 91.2 | 250 | 27 |

## Field days and feedback assessment

Different stakeholders including the farmers participated in the evaluation of the performance of malt barley varieties in the field. The fields were monitored by multidisciplinary team of researchers in the implementation periods (Figure 1). Field days were organized in different districts inviting stakeholders to create demand for the newly introduced technologies of malt barley. During the field days, discussions were done between farmers and stakeholders about the performance of the technologies, and farmers crop management problems and seed maintenance system. A total of 456 (86 females) farmers and stakeholders participated in the field days (Table 3). Participants in field days included farmers, agricultural extension experts from zone, district and kebele agriculture offices, seed producing cooperatives union, Debre Birhan University, breweries, malt factories, Africa RISING Project representatives, Global Malt Service (GMS) and ICARDA.

*Figure 1. Malt barley performance, field days and field monitoring activities*



**CHAPTER IV**: Malt barley technology multiplication and scaling

*Table 3. Field day participants*

| Farmer | | Stakeholder | | Total | |
|---|---|---|---|---|---|
| Male | Female | Male | Female | Male | Female |
| 319 | 70 | 51 | 16 | 370 | 86 |

## Farmers' reflection during field days

Some farmers like the malt barley varieties for preparing different food items for home consumption. Farmers were not convinced of the productivity of malt barley compared with food barley to expand malt barely production. Farmers used to believe that two-rowed malt barley varieties are lower yielding than six-row food barley varieties. They also used to believe that market price of the crop is still unsatisfactory. However, the conclusion is higher tillering efficiency, longer spikes and larger seed sizes of malt barley improve productivity and fetch higher price. To be competitive and have higher price, farmers are advised to expand production area and aggregate the produce to attract malt factories, which prefer bulk production and aggregation to reduce cost of grain collection time and transportation.

## Stakeholders' feedback about the technologies

Many of the stakeholders appreciated the efforts made to provide different alternative varieties for different intervention areas. The discussions in the field days suggested to use Bekoji-1 for Tarmaber areas; IBON 174/03 for frost prone areas; Holker for areas with early planting (usually in late May) in order to avoid frost, which is a major problem for late maturing varieties in high altitude areas; and Sabini for irrigated areas to fit in double or triple cropping system.

## Field inspection and market linkages

In order to strengthen the seed system, seed production fields were inspected each year by Dessie Seed Inspection Laboratory. The Amhara Seed Enterprise and farmers' cooperatives unions as well as the malt factories collected the seed and grain produced each year for seed and malt purposes, respectively. Most of the produced seed was used in formal seed system after the seed was inspected and accepted by the regulatory agency. More than 218.8 t were produced and used for seed and grain purpose. Particularly in 2017 production year, more than 9.2 t seed of IBON 174/03 malt barley variety was used in formal seed system by Amhara Seed Enterprise, farmers' cooperatives unions, cooperatives and research centers. Such type of stakeholders' linkage should further be strengthened to keep the system working and be sustainable.

## Challenges

Waterlogging due to high rainfall in 2016 and selection of sites with waterlogging background reduced productivity. Farmer's knowledge on the background of the land would be indispensable to avoid waterlogging sites in future endeavors.

Clustering of fields was important eye-catching approach to show the performance of the improved technology without being scattered in different fields where other crops may interfere and disturb the impression. However, it takes years to align clustering to match with crop rotation.

Farmers were not able to apply full package of malt barley production; especially weeding was not done timely or in some cases no weed control at all.

Mechanical admixture of seeds during harvesting, threshing and storage was also a challenge for the supply of quality seed and grain of malt barley to users.

# Conclusions and Recommendations

## Conclusions

This scaling up work proved that there are higher yielding malt barley varieties, which can replace the low yielding and the old malt barely variety, Holker, in the highlands of North Shewa. Although few farmers are still doubting the productivity of two-row malt barley varieties compared to six-row food barley varieties, it is a big achievement that most farmers are willing to expand production of the newly introduced high yielding malt barley varieties, which have plump and bold seed and may fetch relatively higher market price. As a result, most of the 218.8 t of seed produced was used in formal seed system after the seed was inspected and approved by the regulatory agency. Particularly in 2017 cropping season, more than 9.2 t seed of IBON 174/03 malt barley variety was used in formal seed system by Amhara Seed Enterprise, farmers' cooperatives unions, cooperatives and research centers.

Improving productivity has been a serious challenge since farmers were not able to apply full package of malt barley production; especially weeding was not done timely or in some cases no weed control at all.

Mechanical admixture of seed during harvesting, threshing and storage was also a challenge for the farming community.

## Recommendations

Capacity building of existing seed producer and marketing cooperatives through training and experience sharing on technical aspects of malt barley seed and grain production (field inspection, harvesting, storage, postharvest handling), marketing and business management should be a continuous endeavor to maintain sustainability.

Timely supply of effective herbicides and other inputs, and affordability of full package production inputs through access to credit services, and providing capacity building such as trainings and seed production facilities are important priority areas for future work.

Further strengthening and maintaining sustainability of stakeholders' linkage, which was created should receive attention by the agricultural extension offices while expanding malt barley production in wider scales.





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# Scaling up of Malt Barley in South Wollo Zone of Amhara Region

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## Introduction

Early generation seed production constitutes the maintenance breeding of improved variety and regular multiplication and supply of high-quality breeder, pre- basic or basic seed for large-scale certified seed producers (Hogge, 1998). In large-scale seed production, several factors may reduce the genetic purity, physical and health quality of the seed due to a progressive increase in the quantity of contaminants. Generally, three types of contamination are recognized: genetic contamination, due to cross pollination; mechanical contamination, due to physical admixture; and pathological contamination, due to increased infection and transmission of seed-borne and air-borne diseases (Atilaw et al., 2012). Therefore, continuous supply of early generation seed is required to overcome these problems. Sirinka Agricultural Research Center (SrARC) carried out participatory variety selection of malt barley varieties Bahati, Bekoji-1, EH1847, Holker, IBON 174/03, and Sabini at Dessie Zuria, Legambo, Wadilla, and Wereilu districts in 2015. According to farmers' preference, IBON 174/03 was selected for further seed multiplication and scaling up activity. Since the formal seed system is very weak in Ethiopia, research centers have been largely producing early generation seed of malt barley to supply the wider scale informal seed system through organizing community-based seed production (CBSP) scheme, which has been reported to be a successful approach. Therefore, early generation seed production and scaling up activities were initiated to enhance seed production and supply of improved malt barley variety IBON 174/03 through CBSP under farmers' condition and scaling up for improving productivity and production in the highlands of South Wollo Zone.

## Approaches

### Study locations

The highlands of South Wollo are the major barley growing areas, which have high potential for large-scale production and supply of malt barley grain to malt industries in the Amhara region. The smallholder farmers are sole producers and are dependent on barley for their economic livelihoods. Although the agroecology is very suitable for quality malt barley production, lack of high yielding varieties and poor crop management practices are mainly contributing to low productivity. Therefore, early generation seed production by agricultural research system, and community-based seed production and scaling up of improved malt barley variety IBON 174/03 was conducted by farmers during 2015-2017 in Legambo and Wereilu districts in the highlands of South Wollo Zone where barley and faba bean production dominates.





The testing sites in the two districts are in 11°54'50" to 11°82'71"N latitude, and 48°90'70" to 51°06'56"E longitude with the altitude of 2700-2850 m asl. These areas receive annual rainfall of 700-1000 mm and have the average annual minimum and maximum temperature of 11°C and 25°C, respectively. The soil is dominantly well drained Lithosols with the slope of 5-10 degrees.

### Selecting sites and farmers

Districts, kebeles and farmers were selected in consultation with zonal, district and kebele agricultural experts, kebele administration and development agents. Major selection criteria were production potential of the districts and kebeles. During site selection, farmers' willingness to cluster their fields, previous crop history of the land and crop rotation were considered for quality seed production to avoid admixtures, disease, insect pest, and weed buildups. Thus, Legambo and Wereilu districts were selected for community-based seed production (CBSP) and scaling up activities. Legambo district was also used for early generation seed production in the main rainy season and in the off-season under irrigation.

### Organizing trainings and field days

After selection of willing farmers, training was organized mainly to train farmers and development agents on the improved malt barley technologies, quality seed production and marketing, and on the economic importance of malt barley for the individual farmer as a source of income and for the country and for the region. The Seed Quarantine and Certification Laboratory provided in-house and on-field practical trainings on seed quality standards and on how to produce it in the field and in storage.

Field days were organized after heading growth stage of malt barley for participant farmers, agricultural experts and authorities from zonal, district and kebele development agents, researchers, quarantine and inspection laboratories, malt factories, and farmers' multipurpose cooperatives and unions to create awareness and demand, exchange experience, enhance farmer-to-farmer seed exchange and create market opportunities.

### Crop management

Rainfed seed production and scaling up activities were planted in early July every year while that of irrigation planting was in February for early generation seed production. A broadcast seed rate of 100 kg ha$^{-1}$ was used for malt barley variety IBON 174/03. At the time of sowing, 100/50 kg ha$^{-1}$ of DAP/urea was applied while additional 50 kg ha$^{-1}$ urea fertilizer was applied at the tillering stage in order to reach the recommended fertilizer application rate of 41/46 kg ha$^{-1}$ of N/$P_2O_5$. The seed production fields were weeded by hand one to two times starting 25-30 days after emergence of malt barley. No diseases and pest infestation occurred through the growing period. All clustered farmers tried to rogue out the off types. All field monitoring and evaluations from planting to harvesting were done by district agricultural experts, researchers from SrARC, and development agents at kebele levels. Field inspection and certifications were also carried out by staff from plant quarantine and certification laboratory at Dessie. Finally, harvesting was done in late October every year for rainfed production, and in late May for irrigated early generation seed production activities.

# Achievements

## Training and field days

A total of 164 participants, of which 32 farmers (8 females), 132 staff members (15 females) of agricultural extension experts at district level, development agents and junior researchers were trained by SrARC researchers in collaboration with ICARDA. Moreover, DAs in each target kebeles also trained 1614 farmers (308 females). The training topics included improved malt barley technology packages (about improved varieties, agronomic practices, and pest control including diseases, insect pests and weeds full package) for improving productivity and production, malt grain quality traits and their requirements, quality seed production and inspection procedures, post-harvest handling, and creating market opportunities and linkages.

Development agents provided practical on-field trainings by comparing the performance of improved malt barley technologies and farmers' traditional production technologies. After heading to maturity stage of malt barley, field days were also organized by SrARC and zonal office of agriculture in collaboration with district and kebele agricultural offices. Most of the field days were organized by development agents at kebele level, which enabled 2,737 farmers (698 females) share experiences among themselves, create demand and enhance farmer-to-farmer seed exchange.

SrARC and district level authorities organize one high level field day event every year where they invited different stakeholders such as zonal and district level sectoral experts and staff of finance institutions, malt factories and breweries, farmers' cooperatives and unions, research institutions, universities, and plant quarantine and certification laboratories, in addition to farmers' representatives in order to create awareness on the performance of improved malt barley technologies, seed production and scaling ups, malt grain and seed quality standards; share experience on alleviating challenges such as input and credit availability and affordability; and create market opportunities and linkage. At this level of the field days, 1,114 staff members (197 females) and 773 farmers (291 females) participated.

## Seed production and scaling up

Seed production and scaling up of malt barley variety IBON 174/03 in Legambo and Wereilu districts in 2015-2017 are presented in Table 1. The seed of malt barley variety IBON 174/03, identified in participatory variety selection, was planted in Legambo district on 0.2 ha of land and produced 0.6 t in 2015. This 0.6 t of seed was again planted on irrigated land area of 6 ha in 2016 and produced 17.5 t of basic seed. Out of this, only 12.2 t of pure quality seed was distributed to 229 farmers (23 females) for planting in the main rainy season of 2016 for CBSP in Legambo and Wereilu districts, which planted 118 ha of land for certified seed production and scaling up. A total of 424 ha of land was covered with the participation of 1065 farmers (114 females) who produced 1,279.94 t of certified/quality seed in 2016-2017, including revolving seed and farmer-to-farmer seed exchange schemes. On average, the grain yield productivity achieved was more than 2.8 t ha$^{-1}$, which is by far better than the average barley productivity of 1.7 t ha$^{-1}$ recorded in Amhara Region (CSA 2015).





Quality assurance and inspection on grain samples collected from scaling up productions by Amhara Seed Inspection and Quarantine Laboratory revealed that all samples show starch content of 58-65%, protein content of 8.5-12.4%, and thousands seed weight of 35-47 g, which meet high grain quality standards for brewery industry. Both germination capacity and germination energy were above 97% for all collected samples. These results suggest that the study locations are highly suitable for standard quality grain production of malt barley.

Therefore, around 80 t of seed was sold to Lay Gaynt district in South Gonder Zone; 100 t sold to Meket and Wadilla districts in North Wollo Zone for irrigated malt barley production in 2018. Gonder Malt Factory also purchased 100 t clean quality grain for malt purpose.

Every year, excess seed was retained by producers as seed source for their own, exchanged with other farmers for seed, sold for food, and for revolving seed for next season production. Most of the malt barley seed was exchanged with wheat in one to one ratio since the bold malt barley grain was preferable to prepare soup and other dishes for consumption during fasting in the study locations.

*Table 1. Malt barley seed production and scaling up in Legambo and Wereilu districts during 2015-2017*

| Activity | Area planted (ha) | Seed produced (t) | Number of farmers | | Year | Remarks |
|---|---|---|---|---|---|---|
| | | | Male | Female | | |
| Pre-basic seed production | 0.2 | 0.6 | – | – | 2015 | |
| Basic seed production | 6 | 17.5 | – | – | 2016 | Irrigated |
| Certified seed production and scaling up | 196 | 630.14 | 436 | 47 | 2016-2017 | 78 ha from revolving seed |
| Scaling up through farmer-to-farmer seed exchange | 228 | 649.8 | 515 | 67 | 2017 | |
| Total | 430.2 | 1298 | 951 | 114 | | |

# Opportunities and challenges

## Opportunities

- There is huge opportunity to improve malt barley productivity as compared to the average productivity of 1.7 t ha$^{-1}$ recorded in Amhara Region;
- The ever-increasing demands of breweries and malt factories, which have not yet met even 50% of the demands in Ethiopia are huge opportunities to expand malt barley production; and
- Analysis of grain samples collected from producer farmers showed that the physical and biological environments are suitable for malt barley production in the highlands of South Wollo.

## Challenges

- Most farmers are not applying full production packages for improving malt barley productivity and production;

- Timely availability and access of production inputs such as herbicides and fertilizer are major constraints;
- Some inputs particularly fertilizers and herbicides are expensive and are not affordable to smallholder farmers; and seed if it is purchased from centrally located seed enterprises; and
- Seed marketing system is not yet well established.

## Conclusion and Recommendation

Our seed production and scaling up work proved that quality seed and grain production of malt barley by smallholder farmers in the highlands of South Wollo is highly feasible. But it requires strong support and follow up by agricultural extension services, seed certification units, timely supply of inputs, affordable credits, and creation of sustainable market opportunities and linkages just to name the major ones.

Further scaling up of the malt barley variety IBON 174/03 should continue with the support of the concerted efforts of the different stakeholders in the value chain.

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# Scaling up Malt Barley Technologies in North Gonder Zone of Amhara Region

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## Introduction

The expansion of malt factories and breweries in Ethiopia created higher malt demand in the country (Amsalu and Mansingh, 2015). The Gonder Malt Factory located in North Gonder Zone has not yet been able to satisfy its demand of malt barley grain although the North Gonder Zone is one of the potential barley-producing areas in the country. The main technical and socio-economic constraints such as biotic and abiotic stresses, lack of quality seed of improved varieties, working capital, timely supply and access to inputs; and marketing problems limited malt barley productivity and production in Ethiopia (Begna, 2014).

Research centers released adapted, high yielding and quality malt barely varieties in order to satisfy the growing malt demand at the country level. However, only few of them are currently under production. Holker was the only malt barley variety produced and sold by growers in the highland area of North Gonder Zone. Farmers reported that the productivity of the Holker, an old malt barley variety released in 1970s, has been decreasing over the years. The Gonder Agricultural Research Center (GARC) conducted malt barley adaptation and agronomic trails and recommended IBON 174/03 variety. The new malt variety IBON 174/03 had better grain yield than Holker variety. The adoption of new crop management practices is often the key to maintaining a profitable agricultural operation. Technology transfer is a multi-level process of communication involving a variety of senders and receivers of ideas and materials. Therefore, this research intervention was initiated to popularize the IBON 174/03 variety with the recommended practices to boost malt barley productivity and production in the study locations.

## Methodology

### Study locations

The pre-scaling up work on the improved malt barley variety, IBON 174/03, was conducted at Debark and Wogera districts of North Gonder Zone during 2015/16-2016/17. The altitude of Wogera district ranges from 1500 to 3040 m asl although the altitudes of the study locations for our scaling up activities were more than 2600 masl. The districts receive an annual rainfall of 400-1000 mm, increasing with increasing altitude. Most study locations in the target districts have altitudes of more than 2850 meters above sea level. The rainy months extend from June to the end of September. However, most of the rainfall is received during the months of July and August. The soil type in both districts is well drained Cambisols. Barley, wheat, faba bean and field pea are the major crops grown in the target districts.

# Technology transfer approach

## Partnerships

Innovation platform (IP) was established at zonal level after training on the concepts of IP in 2015/2016. The IP had 20 members, which were constituted from different organizations. Major malt barley value chain problems were identified and discussed. Finally, roles and responsibilities were divided among members. Agreements were reached to create synergy on malt barley pre-scaling up activities such as input supply, organizing trainings and field days, market linkages, planning, monitoring, evaluation, ground level implementations including selection of sites and farmers, and clustering of fields. Stakeholders who participated in the monitoring field visits were heads of zonal agricultural offices, zonal office heads of cooperatives, Gonder Malt Factory, different NGOs, district agricultural offices, district office heads of cooperatives, GARC and participant farmers.

## Clustering fields

Clustering fields is an approach of aggregating fragmented plots into bigger fields. Clustered fields are advantageous for many reasons especially for seed production to avoid contamination from mechanical admixtures and outcrosses; easy access for monitoring and evaluations since the approach reduces time and travel costs; easy to organize practical field trainings and field days as it brings many small plots into one large scale contiguous field for sharing experiences and impressions; and easy to supply inputs and collect produces. With this understanding, many fragmented adjacent farmers' plots were brought into one large cluster being covered by one improved malt barley variety in each target site of target districts.

## Technology package

The technology packages promoted were improved malt barley variety IBON 174/03, and the improved agronomic practices such as seed rate, fertilizer rate, weeding, pest management and post-harvest management. The fertilizer rates applied were 120 kg $ha^{-1}$ NPS fertilizer and 100 kg $ha^{-1}$ urea fertilizer. All NPS fertilizer was applied at planting, and urea was applied 1/3rd at planting, 1/3rd after 45 days after planting, and 1/3rd at booting growth stage of malt barley. Row planting seed rate of 85 kg $ha^{-1}$ was used with spacing of 40 cm apart between rows. Planting was done in late June. Manual hand weeding was done twice: the first weeding 30-35 days after planting while the second weeding 40-45 days after planting. Harvesting was done in November.

## Selecting participants and capacity building

The planned activity first discussed with offices of agriculture of both districts. Intervention kebeles and the land required were determined together with office of agriculture. After willing farmers were identified, agreements were made according to the planned activities. Trainings on malt barley production and management were organized and delivered to the participant farmers and agricultural extension experts at district and kebele levels. To create awareness and demand, and collect feedbacks on the technology packages, field days were organized at crop maturity stage in both districts. During the field day, participant farmers, non-participant farmers, and other stakeholders were invited.



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## Data collection

Sample yield was collected using quadrant to estimate the productivity of the variety. Simple descriptive statistics was used to describe the results. Farmers (host, non-participant farmers) and stakeholder's opinion were collected and narrated. Farmers' feedback on malt barley production and marketing was assessed by using focus group discussion (FGD).

# Results and Discussions

## Training and field days

Trainings were organized in both 2015/16 and 2016/17 cropping seasons at Debark and Dabat districts to create awareness and build the knowledge and skills of participant farmers and agricultural experts. The trainings were provided on crop management, pest and diseases identification and control. During the training, 175 farmers (13 females) and 34 other stakeholders (9 females) participated (Table 1).

*Table 1. Number of trained participants in 2015/16-2016/17 cropping seasons*

| Kebele | Farmer | | District and kebele experts | | Junior researchers | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| Kino | 41 | 1 | 5 | 2 | | |
| Mekara | 26 | 7 | 6 | 2 | | |
| Gomia | 15 | 0 | 3 | 1 | | |
| Mikara | 80 | 5 | 7 | 4 | 4 | 0 |
| Total | 162 | 13 | 21 | 9 | 4 | 0 |

Two field days were organized to promote the new malt barley variety, IBON 174/03, and the production packages, to collect feedbacks from participants and to discuss about further scaling out of the technology. A total of 582 farmers (41 females), 70 experts and development agents (20 females), and 35 researchers (2 females) participated in the field days at maturity stage of malt barley (Table 2). Participants compared malt barley variety IBON 174/03 with the old malt barley variety Holker using different traits. They concluded that IBON 174/03 variety was better than Holker variety in terms of grain yield, tillering capacity, high biomass yield for animal feed, disease resistance, spike length, and lodging tolerance.

*Table 2. Field day participants at Debark, Debark and Wogera districts in 2015/16- 2016/17*

| Category of participants | Field day participants | | Total |
|---|---|---|---|
| | Male | Female | |
| Farmers | 521 | 41 | 582 |
| Zonal and district level experts, and kebele DAs | 50 | 20 | 70 |
| Researchers | 33 | 2 | 35 |
| Total | 604 | 63 | 687 |

## Productivity and production

The pre-scaling up was started in 2015/16 on 5.5 ha of land with fields of 12 farmers at Wogera district. In the second year in 2016/17, about 90 farmers participated and 25 ha was planted with IBON 174/03 malt barley variety at Debark district. In the two years 30.5 ha of land was covered with the participation of 102 farmers who produced 86.77 t of malt barley seed/grain.

Sample yield, which was randomly collected from 10% of the participant farmers in 2016/17 in order to estimate productivity revealed that grain yield productivity across farmers' fields ranged from 1.93 to 3.7 t $ha^{-1}$ (Table 3). This yield difference was most likely due to differences in farmers' crop management practices and variations in soil fertility. The mean average yield recorded from all sites was 2.85 t $ha^{-1}$, giving sampling-based yield estimate of 86.77 t 30.5 ha of land planted during 2015/16-2016/17 cropping seasons. The yield data showed that the overall sampled mean grain yield of IBON 174/03 variety under the recommended agronomic practices was better than the traditional barley production in the area. According to CSA (2017) meher season area and crop production report, the national and North Gonder Zone average productivity was the same, about 2.10 t $ha^{-1}$, which is lower than the average productivity of 2.85 t $ha^{-1}$ of IBON 174/03 malt barley variety.

*Table 3. Grain yield of IBON 174/03 malt barley variety grown on sampled farmers' fields in Debark district7*

| Farmers' fields | Grain yield productivity of sampled fields (t $ha^{-1}$) |
|---|---|
| 1 | 3.225 |
| 2 | 3.4333 |
| 3 | 2.7583 |
| 4 | 3.6833 |
| 5 | 3.700 |
| 6 | 2.775 |
| 7 | 2.0583 |
| 8 | 1.925 |
| 9 | 2.7917 |
| 10 | 2.100 |
| Mean | 2.845 |





## Seed inspection

Gonder Seed Quarantine and Inspection Office inspected the quality of malt barley seed production at Wogera district in 2015/2016 cropping season. Although the producer farmers fulfilled majority of the seed quality standards, the production clusters were rejected due to the invasive weed, locally called boren (*Chrysanthemum segatum*). Therefore, the malt barley seed produced was not sold as a seed for other locations, but farmers used the seed for themselves, exchanged with each other and sold the remaining as a grain for Gonder Malt Factory.

## Farmers' feedbacks

The main purpose of the FGD was to assess malt barley production and marketing status in North Gonder Zone. The following feedbacks through FGD were obtained from 11 participant farmers (2 females) who have experience and knowledge about malt barley production in Dabat and Debark.

Malt barley is mainly produced as rainfed crop while about 1% of farmers are producing under irrigation although the area has irrigation potential in the two districts. Irrigation is mainly used for vegetable crop production. There is no commercial/mechanized farm in the area. Out of the total barley production area, malt barley covers about 25% in the two districts. Although new varieties such as IBON 174/03 are being introduced and being scaled up, most farmers still produce Holker malt barley variety. Farmers use 130 kg $ha^{-1}$ seed rate with the application of 100 kg $ha^{-1}$ NPS fertilizer and 110 kg $ha^{-1}$ urea fertilizer for malt barley production. Only 3% of malt producing farmers are using blended fertilizer to produce malt barley.

According to participant farmers, weed is a series problem in malt barley production. Malt barley fields need to be weeded at least four times to minimize yield loss due to weed. The most common weeds competing malt barley plants are locally called boren, muja, ginchi, wajima and ashekit. About 99% of farmers use hand weeding to remove these weeds while only 1% of growers apply 2,4-D chemicals once in the growing periods for controlling these weeds. Among other expected pests, insect pests are not yet a problem.

Regarding to marketing and utilization of malt barley, farmers in the study area produce malt barley for two reasons i.e. to generate income to meet the household cash demands and for home consumption. About 70% of malt barley production is for market while the rest 20% is allocated for home consumption and 10% is saved and used as a seed for next cropping season. For home consumption, malt barley grain is prepared mainly in the form of injera, kollo, beso, and tella. The only market agent that farmers use to sell their malt barley produce is the primary farmers' cooperative in their locality. Gonder Malt Factory is the only large-scale malt barley buyer in the area. It buys malt grain through Debark union based on a contractual agreement. Debark Union, on the other hand, makes a contractual agreement with the primary cooperative near to the producers. The union operates in four districts: Dabat, Debark, Beyeda and Janamora. Currently, the union comprises 12 farmers' cooperatives, which collect malt barley grain from individual farmers.

## Conclusions and Recommendations

The pre-scaling up and assessments of farmers and stakeholders showed that the recent improved malt barley variety, IBON 174/03, is adapted, acceptable and high yielder. IBON 174/03 variety was also better in terms of tillering capacity producing high biomass yield, which is required for animal feed, disease resistance, spike length, and lodging tolerance. Therefore, it is recommended that IBON 174/03 malt barley variety should be scaled out further to increase productivity and production in the target districts and similar areas in order to improve livelihoods of farmers, and meet malt grain demands of malt factories and breweries. Concerted effort of stakeholders in malt barley production value chain should be maintained and strengthened to ensure sustainability of market-oriented malt barley production.

## Acknowledgments

Authors sincerely acknowledge ICARDA-USAID faba bean-malt barley seed production and scaling project for providing financial and capacity building supports; and GARC for providing logistical supports.

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# Scaling up Malt Barley Technologies in Central Highlands of Ethiopia

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## Introduction

The gap between domestic supply and demand indicates an opportunity to increase local production and substitute imports through a huge untapped potential of malt barley production in the country. Malt imports have grown tremendously reaching over 75,000 t in 2017 covering about 70% of total annual demand and costing the country 41.5 million US$ (ERCA, 2017). There is a huge domestic market for malt of reasonable quality if many farmers can commit part of their barley area to malt barley production in the highlands of Ethiopia. However, the question is how to involve farmers in the production of quality grain in the potential highland areas.

Many farmers are traditionally good producers of food barley, but not quite accustomed to the quality standards of malting barley. An innovative strategy for overcoming some of these difficulties involves the provision of small packs of seed of new and highly demanded malt barley varieties. The strategy attempts to bridge the gap between demand and supply of quality grain through the provision of potential and promising malt barley varieties identified from the previous demonstration trials and multiplied in the CBSM scheme through small pack out approach. The aim is promoting and scaling out new and proven malt barley technologies in the potential malt barley growing areas of the central highlands and thereby improving productivity and production under smallholder farmers' conditions.

## Methodology

### Study locations

The small seed pack distribution was carried out for three consecutive years (2015-2017) in four districts (Degem, Jeldu, Kersa-Malema, and Wolmera) in three zones of Oromia Region. The four districts were selected in consultation with the respective district bureau of agriculture considering the potential of malt barley production. The target districts are characterized as barley-based crop-livestock farming system with an altitude range of 2400-2800 m asl and the amount of rainfall ranges from 900 to 1200 mm. The major soil types of the target districts are characterized as Nitosols. Barley, wheat, faba bean, and potato are the major crops grown across the districts.

### Selecting sites and farmers

Sites in each district and consequently farmers were selected based on their exposure to the improved malt barley technologies in previous demonstrations. District agricultural extension experts and kebele agricultural extension development agents played an active role in the selection of sites and farmers.

### Organizing trainings and field days

After identifying target sites and participating farmers, the following activities, were undertaken for the effective implementation of the scaling out activities.

- Training of trainers of the respective district experts and development agents (DAs);
- Packaging and distribution of improved malt barley technologies;
- Joint monitoring and evaluation at different crop growth stages in order to evaluate crop performance, identify problems, and device corrective measures, and provide technical backstopping to district experts and development agents of the respective districts; and
- Organizing field days at representative and model scaling up sites

### Crop management

Three malt barley varieties, namely Bekoje-1, Holker, and IBON 174/03 were used in the scaling up activity. Planting was done in mid-June at a seed rate of 125 kg ha$^{-1}$. Fertilizer was applied according to the recommended rate of 120/50 kg ha$^{-1}$ of NPS/urea. Insect pests and disease were not the major problems, but grass weeds such as wild oat, which was a major problem was controlled by the application of Axial-1 at a rate of one liter per hectare.

## Results and Discussions

### Seed production and distribution

Based on the revolving scheme, 25 kg seed of each improved malt barley variety, sufficient to plant a quarter of a hectare was provided to each participating farmer. The arrangement was that the seed supplied would be returned in kind after production and then distributed to surrounding farmers with the help of the respective district office of agriculture for next season production. In three years, 5.15 t of certified seed of malt barley varieties were distributed to 148 farmers (9 females) and planted on 31.5 ha of land in the four districts (Table 1).

During the three years, 54.98 t of seed yield was obtained from 31.5 ha, with an average productivity of 1.75 t ha$^{-1}$, averaged over varieties and districts (Table 1). Productivity of malt barley varieties Bekoji-1, Holker, and IBON 174/03 grown on the respective area of 3.34, 18.06, and 10.11 ha was 2.69, 1.49, and 1.88 t ha$^{-1}$, respectively. Although Bekoji-1 was higher in productivity, it was not tested in relatively wider scale as compared to Holker and IBON 174/03. Therefore, in most of the districts, farmers confirmed that variety IBON 174/03 was the best performing variety because of its earliness, yield potential, and wider adaptation. On the other hand, variety Holker showed inconsistent performance across target districts. The low yield of Holker was due to poor adaptation to the area as it requires a long growing period. In addition, end season moisture stress and frost also contributed to





the low yield of Holker. Waterlogging was also a yield-reducing problem in some sites, which affected the performance of both Holker and IBON 174/03. Generally, productivity of the malt barley varieties in the pre-scaling up was low since some farmers were very reluctant to apply the required packages of malt barley production.

*Table 1. Planted land area, produced seed and number of farmers benefited from promotion of malt barley technologies in four districts during 2015-2017*

| District | Year | Varieties | Amount Provided seed (t) | Area planted (ha) | Seed produced (t) | Number of direct beneficiary farmers | |
|---|---|---|---|---|---|---|---|
| | | | | | | Male | Female |
| Degem, Jeldu, Wolmera | 2015 | Holker | 1.401 | 7.695 | 10.11 | 36 | 2 |
| Jeldu, Kersa-Malima, Wolmera | 2016 | Bekoji-1 | 0.694 | 3.34 | 8.98 | 37 | 0 |
| | | Holker | 0.230 | 1.25 | 1.95 | | |
| | | IBON 174/03 | 0.298 | 1.2 | 3.05 | | |
| Wolmera | 2017 | Holker | 1.529 | 9.11 | 14.91 | 66 | 7 |
| | | IBON 174/03 | 0.995 | 8.91 | 15.98 | | |
| Total | | | 5.147 | 31.505 | 54.98 | 139 | 9 |

## Trainings and field days

### Trainings

In-house and on-field trainings on techniques of malt barley production are very crucial to improve the knowledge and skill of smallholder farmers for improving productivity and quality of malting barley. In line with this, different efforts have been exerted to build the capacity of farmers, DAs, district agricultural experts, and other relevant actors. The major training areas were about quality grain production. Particularly, the training focused on:

- Use of inputs (type, quantity required and application methods);
- Malt barley pests and control methods (weeds, diseases, insect pests);
- Production of quality malt barley seed and grain (from site selection to post harvest handling) and marketing; and
- Importance of crop rotation for sustainable malt barley production.

During the three years, the trainings were given at the various levels involved a total of 430 participants, consisting of farmers, agricultural experts, development agents, experts of quarantine and seed quality laboratories, heads and experts of cooperatives (Table 2).

*Table 2. Number of training participants across target districts from 2015/16 to 2017/18*

| Year | Type of trainees | Number of participants | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| 2015/16 | Farmers | 85 | 10 | 95 |
| | Others | 56 | 16 | 72 |
| 2016/17 | Farmers | 67 | 5 | 72 |
| | Others | 44 | 10 | 54 |
| 2017/18 | Farmers | 70 | 7 | 77 |
| | Others | 46 | 14 | 60 |
| Total | | 368 | 62 | 430 |

*Note. Others include agricultural experts, development agents, experts of quarantine and seed quality laboratories, heads and experts of cooperatives*

## Field days

Field days were organized by the Holetta Agricultural Research Center (HARC) in order to get feedback on the new malt barley varieties and technologies, and creating awareness on introduced technologies and thereby improve the technical knowledge and skills of farmers, DAs and district experts. Overall, 577 participants (78 females) attended different field days organized at district and kebele sites (Table 3). The participants included zonal and district administration heads, zonal heads and experts of agricultural development offices, district heads and experts of agricultural development offices, administration heads of kebeles, kebele development agents, heads and experts of quarantine and seed quality laboratories, farmers and researchers.

*Table 3. Number of participants of field days organized in target districts during 2015/16-2017/18*

| Year | Type of trainees | Number of participants | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| 2015/16 | Farmers | 93 | 10 | 103 |
| | Others | 139 | 16 | 155 |
| 2016/17 | Farmers | 76 | 8 | 84 |
| | Others | 114 | 17 | 131 |
| 2017/18 | Farmers | 31 | 11 | 42 |
| | Others | 46 | 16 | 62 |
| Total | | 499 | 78 | 577 |

During the field days, participants discussed the merits and demerits of the technologies and future directions. In all the field days, the major issues raised and discussed include:



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- Strengthening of the extension system and farmers participation in a more organized form;
- Market linkage, particularly linking the produce with the agro- industry (malt factories and breweries);
- Source seed availability and sustainability, particularly ensuring a continuous supply of improved seeds of different classes (breeder to certified seeds);
- Strengthening linkages among the research centers, public seed enterprises, cooperatives, and unions;
- Seed certification – Involvement and integration of the regulatory agency in the farmer-based seed production and marketing; and
- Strengthening of farmers' cooperatives and unions for a continuous supply of quality malt barley grain.

# Challenges and Lessons Learned

## Challenges

The major challenges encountered during the implementation of scaling of malt barley technologies are described briefly below.

**Site and farmer selection:** Selected sites and farmers for implementing pre-scaling up of malt barley technologies were not appropriate in some cases. Some of the fields were sloppy with poor soil fertility and waterlogging problems. Some farmers were also very reluctant to apply the required packages for grain production and management. Thus, care should be taken in site and farmers selection in future endeavors.

**Weak participation of development agents:** In most cases, DAs were engaged with other non-agricultural activities and their involvement in the technology promotion/ scaling up is very limited. In addition, the turnover of district experts and DAs is very high. Therefore, a clear assignment of DAs and retention mechanism should be designed.

**Management of weeds, disease and insect pests:** It has been observed that there was weak follow-up and control of grass weeds, shoot fly, and leaf diseases such as scald and net blotch that contributed to yield reduction in some scaling up sites.

**Poor agronomic practice:** Low or partial application of recommended packages possibly contributes to low malt barley productivity. Malt barley fields in some sites were not properly prepared, fertilized, rotated with pulses or oil crops, weeded, and rouged out from mixed crops and varieties. Continuous follow-up and training by all concerned actors and mainly by the district agricultural offices and DAS should be strengthened Most of the farmers did not follow row planting even if they believed that row planting is advantageous over broadcasting. Farmers said, row planting takes more time and labor than broadcasting and hence this can delay planting time. Thus, effective small-scale row planter should be identified and made available to farmers.

**Shortage of improved malt barley seeds:** The limited availability of early generation and certified seed of malt barley is the bottleneck to malt barley production. Thus, production and provision of quality improved malt barley seed should get due consideration.

**Institutional factors:** Poor linkage between producers, cooperatives, unions, and agro-industries on marketing of malt barley produce needs special attention for improvement.

## Lessons learned

Several lessons have been learned from the malt barley pre-scaling up activities. These lessons are critical for scaling out of malt barley technologies to new areas for sustainable malt barley grain production. It involves the organization of interested farmers or a community into quality malt barley growers. Farmers should be trained on the skills of quality malt barley production and provided with good start-up quality certified seed. Some of the key lessons learned are largely attributed to the following factors:

**Training:** Training on quality malt barley production is very vital. Farmers, DAs, and district experts should be trained and acquainted with the concept of malt barley technology scaling for sustainable quality malt grain production.

**Partnership of stakeholders:** Strong partnerships are required among research, offices of agricultural development, district administration, and seed enterprises. This should be strengthened for effective joint planning, monitoring and evaluation, quality grain production, and marketing. Moreover, engagement of the industry both the malt factories and breweries in the large-scale malt barley grain production is important to enhance the supply and marketing of quality malt barley grain.

**Commitment from farmers:** Farmers awareness and commitment are very crucial to implement the technical recommendations of the improved malt barley technologies. Framers should consider agriculture as a business and engage in a more competitive and quality malt grain production.

# Conclusions and Recommendations

Efforts to enhance malt barley production have been initiated by the ICARDA-USAID malt barley and faba bean seed production and scaling project. To this effect, three malting barley varieties, namely Bekoji-1, Holker, and IBON 174/03 were promoted through small seed pack approach to increase the productivity and production of malt barley in the target districts. Among the three varieties pre-scaled up during the three years, IBON 174/03 received wider acceptance by participant farmers for its high productivity, good malting quality traits, and early maturity. Thus, it is recommended for large-scale production in the potential areas of the central highlands with more than 2300 masl. This will substantially increase the income and improve the livelihoods of the farming communities. The scaling up initiative has enhanced access to improved malt barley technologies, improving farmers' skill, knowledge, and attitude on quality malt barley grain production.





On the other hand, proper site and farmer selection, weak commitment of actors in implementing the activities in all stages, weak market linkages, and shortage of improved seed were the challenges confronted during the implementation. Thus, strengthening the linkage among relevant stakeholders and widely extending the scaling out of proven malt barley technologies in a well-organized approach requires due considerations in the future to satisfy the increasing malt barley demand in Ethiopia.

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This Book is the outcome of the collaborative endeavors of diverse stakeholders addressing the challenges of seed systems and scaling of malt barley production in Ethiopia. It is the first of two forthcoming books, which focuses on malt barley. Ethiopia is one of the major Vavilovian centers of origin for many agricultural crops and a center of diversity for crops like barley. Generally, both food (six-row) and malt (two-row) barley are cultivated in the country. Traditionally six-row barley is predominantly grown as major food security crop in the extreme highlands where alternative cereals are absent or limited. It can also be used for preparation of local beverages such as tella (local beer) and areke (local spirit). Malt barley based on two-row is a recent introduction to meet the domestic malt demand of growing malt factories and breweries. The country has been significantly deficient in meeting the ever-increasing malt barley demand of local breweries from domestic production where the net import bill for malt barley continues to increase and projected to reach as high as US$420 million by 2025. Given the favorable environment and available improved malty barley technologies, farmers can cost-effectively grow malt barley to meet the rapidly growing domestic demand reducing import and improve their livelihoods through increased income.

The Book with its title "Deployment of Malt Barley Technologies in Ethiopia-Achievements and Lessons Learned" provides a synthesis of the research for development and rich experience gained in scaling of malt barley technologies through effective partnership with broad range of stakeholders including the federal Ministry of Agriculture and regional Bureaus of Agriculture, the federal and regional agricultural research institutes, the federal and regional public seed enterprises, seed producer cooperatives or farmer seed producer groups, the International Center for Agricultural Research in the Dry Areas (ICARDA), and ultimately malt barley farmers. Many of the contributors to this volume provide sound evidence in favor of diversified interventions with due focus on mechanisms for institutionalizing the research approaches to ensure sustainability in addressing the challenges of domestic malt barley production and with the potential for export. The experiences and knowledge gained are put in context aimed at decision-makers, not only in Ethiopia but in other developing countries for wider application and spill overs. The Book provides useful insights to policy makers, researchers, students, development practitioners and donors involved in international development for generating and moving technologies out to the farmers' fields.

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ISBN 9780929127545

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