

POTATO-BARLEY DOUBLE CROPPING IN BIMODAL RAINFALL AREAS OF CENTRAL HIGHLANDS OF ETHIOPIA

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Abstract:

In Ethiopia, barley and potatoes are the most important food security crops. Despite their importance, these crops' production and productivity could be higher for several reasons. Potatoes and barley are growing alternatively in the study area year after year, and the area has the potential for bimodal rainfall distribution in the short and main seasons. The short-season rain is suitable for potatoes, and the primary season is for barley production. Double cropping was evaluated to grow those crops in a double cropping system in Belge and the primary season in 2014. Based on the result of the evaluation and farmers' interest in the activities, the pre-scaling up of the barley-potato double cropping system was done in 2015, and 6-tone potato and 0.75-tone malt barely seed were used on three hectares of farmers' land. Sample data were taken from double and comparable farmer's fields of single cropping systems to show the yield advantage of double cropping compared with a single production system. An average of 46.4 t/ha of potato and 3.6 t/ha of malt barley yield from double cropping and 3.2t/ha of malt barely from single cropping were obtained during the primary season. The net benefits of double cropping in monetary value were 197,244.36 Ethiopian Birr. To sustain and strengthen the seed production and marketing of potato and barely double cropping technologies, training, experience sharing, and supply of early-generation seed for cooperatives are recommended as intervention options for sustainable production.

Keywords: Double Cropping, Potato, Barley, Gross Benefits, and Net Farm Benefits.



INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the most important staple food crops in the highlands of Ethiopia. It is cultivated on about 1.13 million hectares of land, and the total annual grain production in 2009/10 stands at 1.78 million metric tons (CSA, 2019). Barley accounts for about 12.2 % of the total area from significant cereal crops and 11.5% of Ethiopia's annual cereal production. Although barley grows in all the regions, the major barley-producing regions include Oromia, Amhara, Tigray, and Southern Nations, Nationalities and Peoples Region (SNNPR), which account for 99.5% of the total annual production. Over the last 15 years, barley production has increased twofold, from 8.87 million tons in 1994 to about 17.5 million tons (FAOSTAT, 2010). Barley is cropped twice a year in the primary season, locally known as meher (June- October), and the short rainy season, locally known as belge (March-April). Barley is grown in diverse environments with an altitude range of 1500 to 3500 masl but is predominantly grown from 2000 to 3000 masl (Berhane et al., 1996). The total area covered by barley in the Amhara Region is about 388,113.19 hectares, with a total production of 5,905,028.22 tons, and its productivity was 1.52 ton/ha, which is below the national average, 1.75 ton/ha (CSA, 2020).

In Ethiopia, barely is the fifth most important crop after tef, maize, sorghum, and wheat. Barely is a dependable food source in the highlands, produced during the primary and short rainy seasons

and under residual moisture and irrigation water. It is used in different forms, such as bread, porridge, soup, roasted grain, and for preparing alcoholic and non-alcoholic drinks. Its straw is used for animal feed, thatching roofs, and bedding. However, production in Ethiopia, in general, and the Amhara Region in particular, is usually practiced with little or no external inputs and under low production costs, mainly in higher altitude or steep slopes, eroded lands, or moisture stress areas (Hailu & Van Leur, 1996).

Potato (*Solanum tuberosum*, L.) is the world's third most important food crop in overall production after rice and wheat. It is a food security crop (Devaux et al., 2014) in some countries, including Ethiopia. Ethiopia is one of the significant potato-producing countries in Sub-Saharan Africa, where potato is the fastest-growing food crop (Asrat, 2013). Potato production in Ethiopia has exponentially expanded from 30,000 ha about thirty years ago to 160,000 ha of land. Potato provides a vast opportunity and good prospects for value addition. It opens more expansive room for commercial investment in crucial value chains (Wustman et al., 2014). Potatoes play a vital role in developing countries because of their ability to provide nutritious food for the poor and hungry. The past few decades have dramatically increased potato production and demand in many developing countries (FAO, 2014).

Ethiopia has the highest potential for potato production of any country in Africa, with 70% of the 13.5m ha of arable land suitable for potato cultivation. It is estimated that 160,000 ha are now planted annually by approximately one million potato farmers (Haverkort et al., 2012). Cereal crops mainly dominate crop production in Ethiopia and the Amhara Region. Despite the significant potential contributions of horticultural crops, particularly root and tuber crops, for food security, income generation, and resource-base conservation, they have yet to be fully exploited and utilized (Gebremedhin et al., 2008). Potatoes are an essential food security and hunger reliever crop in the Amhara region and several other parts of the country because they mature earlier than most other crops when in critical need. In recent years, the production of this crop has expanded rapidly owing to the presence of improved technologies and the expansion of irrigation culture. Farmers who operate barely-based farming systems in the highlands of Ethiopia have very few alternative crops.

The ever-increasing human population and grazing animals (often of poor quality) overburden the highland environment. Food security in such environments is thus increasingly becoming a daunting task (Bayeh & Stefania, 2006). The factors constraining the increased production of barely in different production systems have been identified and documented (Chilot et al., 1998). The most important abiotic stresses include low soil fertility, low pH, poor drainage, frost, and drought. The critical biotic stress includes diseases, such as scald, net blotch, spot blotch, and rusts, which can reduce yield up to 67%, and insect pests, such as aphids and barely shoot fly, which can cause yield losses of 79% and 56% respectively. Potato production during the belg season as a rotational crop was done in the past production season to break the following of farmland and increase productivity barely through soil fertility improvement.

During the demonstration phase, Potato was planted in the 2014 belg season on farmers' fields, resulting in significant benefits for farmers in the highland bimodal rain fail areas, which gave on average 46 t/ha marketable tuber yield. The second crop, food barley, was sown in the primary season on the same plots of land on which potato was produced. Total benefits of a single farm, both on belge and main season activities, indicated that farmers benefited from potato and barley double-cropping production in a single year with an average of 183,868.2 Birr/ha per year. Farmers' feedback showed they are pleased to see such a successful potato-barley double-cropping production system that has never been experienced before. High demand was created for potatoes in the Belgian season and food and malt barley in the primary season.

The result showed that Pre-scale up of potato-barley double cropping, with improved variety of malt barley or food barley of HB-1307 on well-drained fertile lands with low risk of frost based on farmers interest or food barley Basso variety combined with Broad Bed Furrow (BBF) on water logging and frost risk areas having relative low level of soil fertility. Based on these findings and recommendations generated from the previous demonstration activity, large-scale technology transfer activity was done to benefit smallholder farmers using different approaches. This activity was done to increase the productivity of smallholder farmers through double cropping, maximize the potential of short-season rainfall with high-potential potatoes, and make suitable precursor crops for barley.

Objectives.

1. To create a broader demand for potato-barley double cropping technologies,
2. To create and strengthen linkage among the possible actors in potato-barley double cropping technologies and
3. To enhance technology multiplication and dissemination system.

METHODS

The activity was done at Tarmaber Wereda, which has the potential for bimodal rainfall distribution with the cooperation of Woreda and Kebele agricultural experts. The approaches used during the implementation of the activities were established by a multidisciplinary team of researchers, extension workers, and farmers' groups. Establishing a multidisciplinary team comprised of researchers, extension workers, and farmers groups was one approach used during the implementation of the pre-scaling-up activity. The training was organized for interested farmers and agricultural experts, both participating and non-participants. The training focused on improved production systems of potato and barley based on technologies characters and their agronomic practices and concepts, and the importance and benefits of potato barley double cropping in bimodal rainfall areas. Gera potato variety was delivered to the selected farmers during the belge season of 2015 on seed repayment bases, and then malt was barely planted on the potato-harvested farmland. Researchers, extension workers, and farmer groups practiced continuous monitoring and evaluation. Finally, field days were organized in Belge, and the main seasons comprised farmers, researchers, project donors, extension workers, and other stakeholders. Farmers' and other stakeholders' feedback and opinions during field day were collected.

RESULT AND DISCUSSION

Training and Technology Delivery. Before supplying the seed, training was given to farmers and experts about the overall activities and the benefits of potato barely double cropping compared with following practice observations in their location and potato and barely production package for 112 participant farmers and experts. About 6 tones of improved potato seed of Gerra variety was delivered in belge season, and 0.8 tone malt barely Bekoji-1 variety was distributed during the primary production season of 2015 for a total of 186 (12 female) farmers on 3 hectares of land. To produce seeds of improved potato varieties in their locality, a farmer's seed producer and marketing cooperative was established, and the Wereda Office of Agriculture was convinced of this success and then committed to construct a Difused Lidght Storage (DLS) potato seed storage structure. The cooperative collected all the produce of last belge season potato tuber seed and stored it in the DLS for sale and next year's seed purpose.

Field Days. Field days were held by inviting various stakeholders to promote and raise knowledge about the production of potatoes and potato-barely double cropping. A total of 442 (96 female) farmers, specialists, and other stakeholders attended the field day event. Farmers reflected

their interest in producing potato and barley as a double cropping system in one production period. Potatoes are a potential rotational crop for barley and help with food security. High demand was created for potato production.

Moreover, the performance of barely after potato production shows the highest yield difference. Farmers explained that land fallowing during the primary season was optional since it reduced total production improvement. Potato-barley double cropping reduces weed and other related problems caused by the following of farmland.



Figure 1. Potato and barley are grown on the same field in short and main rainy seasons, respectively

Yield Advantage. The sample yield was used by sampling both from potato-barely double-cropping and non-double-cropping farms of malt barely(Holker) crop fields. The result shows a relatively good yield difference between the two sample yields of 3.8 and 3.6 t/ha of barley from potato barley double-cropping and barley single-cropping fields, respectively.

Table 1. Yields of barley and Potato in double cropping and fallow cropping system

Crop	Potato		Barley	
	Yield(t/ha		Yield component	Yield(kg)/ha
Marketable	4.642		Grain	3.82
Non-marketable	0.5		Straw	8.2
Single cropping of barley			Grain	3.6
			Straw	5.87

Benefit-Cost analysis of potato barley double cropping system.

Belig Season Farm Benefits. The gross marketable yield of potato tuber averaged over ten farmers' sites was 46427 kg/ha. Its adjusted yield was estimated to be 41784.3kg/ha. The gross benefit of potato (adjusted yield*average price) calculated was 208921.5 Birr/ha estimated with the price of 5 Birr/kg of tuber at Mezezo market during harvest in June 2015.

At the time of production, the total cost (TC) for producing potatoes, including the costs of seed, fertilizer, and labor, was estimated to be 37820 Birr/ha.

$$[TC=32,000 \text{ for seed}+4,320 \text{ for fertilizer} +1,500 \text{ for labor}] = 37,820\text{Birr/ha}$$

The Net benefit of potato production during immediate harvest resulted in 171,100.00 Birr/ha. (Gross Benefir (GB) -TC = 208,921.5-37820= 171,100 Birr/ha)

Meher Season Barley Production. During the primary production season, the potato areas were covered by the malt barley variety of Bekoji immediately after the harvest of potatoes planted in the short rainy season. The result of the primary season activity was evaluated as a gross yield of 3808 kg/ha malt barley grain from ten farmlands on average. The Adjusted yield was calculated as Gross yield (GY)-(10%GY)=3769.92kg/ha. The Total Cost(TC) per hectare of Seed (1875), Chemical cost (140), and fertilizer cost(2,000) was 4,015 Birr/ha.

Gross Benefit (GB) and Net Benefit(NB). The gross benefit was adjusted and multiplied by the current market price of 8 birrs (3769.92*8), which generated benefits of 30,159.36 birr/ha. Based on this, the field production net benefit (NB= GB-TC) resulted in 26,144.36 Birr/ha from grain in the area during harvest in December 2015.

Total benefits of a single farm area on both belg and main season activities indicated that benefits of potato barley double-cropping production system in a single year generated a total of 197,244.36 Birr/ha per year. Compared with the single crop production system in the area of 24,785Birr/ha within a year, the new approach generated 172,459.36Birr over the standard practice. Barley production using a double cropping system has a yield advantage of 5% per unit of land compared to the single and following annual production system.

Challenges.

1. Variability of soil fertility status and rainfall distribution in the area,
2. Lodging problems of early food barley variety of Basso on fertile and drained land limited its potential as farmers' interest relaid on it,
3. Farmland fragmentation and difficulty in clustering,
4. The high seed rate of potatoes leads to a scarcity of seed tubers,
5. Low input utilization of farmers for the production of barley and

CONCLUSION

Promoting potato-barley double cropping in bimodal rainfall areas of North Shoa resulted in high financial and yield advantages for the smallholder farmers. This system would have similar advantages in agroecologies similar to other potential areas. Basso's improved food barley variety, which is short maturing, should be replaced with a relatively long maturing HB-1307 food barley variety for the primary season production to reduce yield losses due to looking effects. Well-drained fertile lands with a low risk of frost based on farmers' interest should be selected for future scaling-up activities. Basso variety combined with BBF on water logging and frost risk areas with relatively low soil fertility levels should be done for future promotion. The result presentation event to show the advantages of double cropping and the use of innovative farmers to break the season following is essential.

Since potato is a food security crop in the high-potential area of North Shoa, wider popularization and dissemination should be done by government and non-governmental practitioners. The rotation of potatoes with barely a significant yield differs from non-rotated farmland. The double-cropped land has a yield advantage of about 2 Quintals per hectare, which differs from the non-double-cropped land regarding barley productivity only. In the highland area of North Shoa, which was highly affected by frost, the only crop was barely any potato, so potato, as a rotational crop, should be used for both crop rotation and food security purposes.

Therefore, it is important to sustain the seed system and improve the livelihood of rural farmers. We should strengthen farmers' seed production and marketing cooperatives for potatoes and sustainably provide early-generation seeds for cooperatives.

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