Vol. 13(1), pp. 1-9, January 2025
https://doi.org/10.14662/ijebm2024160

ISSN:2384-6151
https://www.academicresearchjournals.org/IJEBM/ijebm.html

International Journals of Economic and Business Management

Full Length Research

Yield Gap and Economics of Cluster Based Large Scale Demonstration of Food Barely Variety in Hula District, Sidama Region, Ethiopia

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Accepted 15 July 2024

The research was conducted in Hula district of Sidama region, Ethiopia. The district was selected purposively based on the potential of food barley production. The objective of this paper is to share the experiences and results of cluster based technology demonstrations in relation to technology and extension gaps of food barely varieties. From the district, two food barley potential villages were selected and farmers also selected based on land availability and farmers willingness. One food barely variety (HB-1307) was demonstrated along with its full-recommended packages in the study areas. Training was given to develop awareness to different participants at different stage on production practice of food barley technology. To demonstrate the food barley technology, a field day was organized by inviting different stakeholders (Farmers, DAs, Experts and Researchers). The variety (HB-1307) demonstrated at study area which was acceptable during field visit and field day by farmers due to its disease acid soil tolerance, seed color and size, plant biomass, grain yield and early maturity productivity after harvesting showed a high yield performance. The overall harvested mean yield of HB 1307 and the local farmer practice was 38 qt ha^{-1} and 22 qt ha^{-1}, respectively. Therefore, based on the results shown above HB1307 is the best performed variety in the study area.

Key words: food barely, large scale demonstration, Hula district, gaps, farmer preference

Citation: Alemnew, W. (2025). Yield Gap and Economics of Cluster Based Large Scale Demonstration of Food Barely Variety in Hula District, Sidama Region, Ethiopia. Inter. J. Econ. Bus. Manage. Vol. 13(1), pp. 1-9

INTRODUCTION

Among the top ten crops worldwide, barley ranks fourth in importance among cereal crops worldwide, behind rice, wheat, and maize (Akar et al., 2004 and Tilahun et al., 2017). Ethiopia's highlands are home to a significant barley crop. According to Kemelew and Alemayehu (2011), food barley is an emergency crop that may be grown in September to bridge the acute food crisis due to its early maturity. Traditionally, its grains are used to manufacture “Injera” and local brews for domestic consumptions and during festivals. These days, it goes through several value-added processes to create a variety of food items, including as bread, porridge, soup, powder, and roasted grains, that can be consumed.

The crop's lower productivity was caused by different factors. The main ones are pests, weed competition; inadequate agronomic and low crop management methods, limited demonstrated improved varieties (Tadesse and Derso, 2019). Furthermore, one option for smallholder farmers looking to improve their production but lacking access to desired improved variety seeds in barley growing agro-ecologies is the improved food barley technologies transfer activity (Tadesse and Derso, 2019). The adoption rate of improved technologies from research to farmers was very limited due to the scarcity of improved seed and weak linkage between research and agriculture office. The national and regional research systems in the nation have been undertaking a number of research activities on crop improvement and have been releasing numerous varieties in an effort to address the productivity problem in the study area.

Even though this variety is readily available, the majority of farmers in the district still lack access to it and continue to use native varieties, which are known for their extremely low yield and high disease susceptibility. Smallholder farmers are the main producers and consumers of food barley in the highland areas of the Sidama region, especially in the Hula district. Poor production yields in the region are mostly caused by a lack of better seed types, a poor utilization of improved variety, and a high prevalence of rust diseases linked to both biotic and edaphic variables. Farmers are more familiarized to using local variety in the region's current barley production system than they are to using better entire production packages, such as enhanced seed, agrochemicals, agronomic methods, and other production inputs.

The Holetta Agricultural Research Center released the six-rowed food type barley, HB 1307, in 2006 for use in mid- and high-altitude regions. It was a cross between a landrace line and exotic germplasm (Awra gebs-1 x IBON93/91). Tests conducted over the course of three years (2002–2004) demonstrated its advantages in terms of stability, wide adaption, and grain yield performance. Its physical grain quality is good, and it can withstand lodging, leaf rust, scald, and moderate resistance to net and spot blotch. It also yields a considerable amount of biomass.

It is reliable for comparable agro-ecologies taken into consideration in the study because of its variety, agronomic and qualitative attributes, and superior performance over the checks. Thus, in order to boost production and productivity, this study was conducted to demonstrate and disseminate enhanced food barley technology at cluster based large-scale demonstration approach by grouping farmers with full package application.

Objectives

1. To improve the production of improved food barley technology in the study area.
2. To identify the technology and extension gap of the study
3. To assess farmers' preferences about the improved food barley variety.

Materials and Methods

Description of the study area

The study was carried out over the course of two years in the Hula area of Ethiopia's Sidama region. Within the Sidama Regional Administration is the district of Hula. The district is located 370 kilometers south of Addis Ababa and 93.4 kilometers southeast of Hawassa. The district is dominated by the Highland agro ecological zone (72%), with the midland making up the remaining 28% (HDAO 2021). With an average yearly temperature of 10 to 15°C and an annual rainfall of 1200 to 1800 mm, the Hula district has a wet, cool temperate climate. Enset (Ensete ventricosum), potatoes (Solanum tuberosum), bread wheat (Triticum aestivum L.), barley (Hordeum vulgare), and cabbage (Brassica carinata) are the most often produced crops in this district (SZPEDD, 2010). Hula is located close to the communities of Bursa and Dugo and is 2,653 meters above sea level elevation.

Site and farmer selection

The study area was selected by using purposive sampling method based on its suitability for the variety, accessibility for supervision, and potential for producing food barley. Two exemplary potential demonstration sites were also purposively chosen from the district based on accessibility and barley production potential. Four farmer research groups (FRG) unit was formed and 64 host farmers were benefited in the demonstration. Other farmers were arranged as follower farmers under the host farmers to exchange experience and get knowledge on the variety and production package of food barely.

The site and farmer selection processes were conducted jointly with development agents (DAs) and district agriculture experts. The farmers were selected based on willingness to be held as cluster/farmer research members, accessibility for supervision of activities, good history of compatibility with cluster farming, and willingness to share innovations with other farmers. Four model representative trial hosting farmers were chosen from each FRG unit, with the remaining farmers serving as participant units. In addition, the trial/experimenting farmers were chosen based on several factors, including having enough land available for the demonstration; being close to roads to increase the likelihood of receiving visits from other farmers; having a track record of managing experimental plots successfully in the past or being devoted to trust trials; and being honest and open in their explanation of the technology to others. Following the creation of the FRGs, experts, DAs, and farmers were invited to a theoretical training session.

Activity implementation and field design

A total of sixty four host farmers received training from a multidisciplinary team of researchers from the Wondogenet Agricultural Research Center (WgARC). Practical trainings also provided to farmer research group members, Development agents and district experts on the following subjects such as:

- Purpose and way of practice of FRG
- cluster farming approach
- Agronomic practices of food barely
- Post-harvest management and barley storage facilities.

The land was properly plowed and made ready for planting of barely. One food barley variety (HB-1307)with local check was demonstrated on adjacent lands with a minimum of 0.25ha for each host farmer. All the necessary recommended agronomic practices were equally applied to all of the plots. For food barley, the spacing of 20 to 30 cm between rows was used. The recommended seed rate of 120 kg ha^{-1} is used by drilling in the prepared rows. Shallow planting of 5cm depth was employed in the presence of ample soil moisture. The recommended fertilizer rate of NPS 100 kg ha^{-1} was also applied at the sowing/planting time of the crop.

For joint monitoring and evaluation, the demonstration sites were supervised at monthly intervals to check the status and to identify gaps. At the maturity stage of the crop, a participatory variety evaluation platform was arranged that was attended by the experimenting farmers, FRG members, follower farmers, researchers from WgARC, and district agricultural experts. Important implementation tools like Continued supervision of the field, conducting training for knowledge sharing, and development of training materials like leaflets and field day were conducted to implement and achieve the objectives of the study.

Data collection and analysis

Appropriate data collection methods like direct field observations/measurements and focused group discussions were employed to collect both qualitative and quantitative data. The data was analyzed by using descriptive statistics and ranking techniques to administered and used to rank the variety traits in order of their importance.

Variety preference

Growers cultivate cultivars that meet their end-use requirements, are dependable in their region, and function well under their unique management circumstances (Pena et al., 2002). A farmer is unlikely to accept a variety if it does not match these requirements (Negatu and Parikh, 1999; Dahl et al., 2001). A variety's acceptability may differ greatly based on the farmer's location, socioeconomic status, end-use objectives, gender, etc. Thus, it is improbable that a single "super" variety will be embraced by all farmers (and this would be bad for plant breeders as well). Few variants ever reach the status of "widely adopted," as it can take up to 15 or 20 years (Ceccarelli, 2012). This may be partly explained by a breeding process that ignores variety performance or usage adaptability in inadequate soil and management conditions, which are realities for most small-holder farmers.

Technology gap, extension gap and technology index

The discrepancy between the yield of farmers' practices and the demonstration yield is known as the extension gap. We must train and equip partner farmers to use the enhanced agricultural production technology in order to close the extension gap. Greater extension gaps are a sign of modern technology' poor uptake. The result of discrepancies between prospective yield and demonstrated yield is the technology gap. The techniques employed by Yadav et al. (2004) were utilized to calculate the technological index, extension gaps, and technology gaps.

Extension gap = Demonstration yield-Farmer yield
Technology gap = Potential yield-Demonstration yield
Technology index = Potential yield − Demonstration yield × 100/ Potential yield

Partial budget analyses

Using formulas and symbols, this section describes the formal logic of partial budget analysis. Although this discussion of the subject may be too technical for some readers, it is important to cover the material to ensure that the technique is applied correctly. The following term abbreviations are used to make economic topics and relationships easier to express:
NI = net income
TR = total return
TC = total costs
FC = fixed costs
VC = variable costs = A change in any of the above, for example
A NI = change in net income,
R = rate of return
NI = TR – TC-- (4.1)
Total returns (TR) correspond to the value of harvested yield.

Total costs (TC): include the costs of all inputs, such as seed, fertilizer, pesticides, labor and capital. For purposes of PBA, total costs can be separated into two groups: fixed costs (FC) and variable costs (VC):
TC = FC + VC -- (4.2)

Fixed costs (FC): When a new technology is compared against a farmer's present technology, fixed costs (FC) are those that do not vary between the two technologies. For example, in an experiment that compared different seed qualities (as the example), costs for fertilizer, tillage and weeding are the same.

N.B: in case of technology demonstration fixed cost (land) is not used as a cost

Variable costs (vc): on the other hand, are those that do vary between the technologies being evaluated. The variable costs are those associated with the two technologies being evaluated (seed cost and capital cost). Combining formulae 4.1 and 4.2 results in the following:
NI = TR- (FC + VC) --- (4.3)

Change in net income (ANI). In deciding whether or not to adopt a new technology, a farmer wants to know if it will increase his net income. The increase of change in net income (ANI) is the difference between the change in total returns (ATR) and the change in fixed costs (AFC) and variable costs (AVC), according to formula 4.3:
ANI = ATR - (AFC + AVC). -- (4.4)
Fixed costs are, by definition, the same for both technologies: AFC = 0.
Thus formula 4.4 can be simplified to:
ANI = ATR - AVC. --- (4.5)
By application of a new technology a farmer expects an increase in net income.

Rate of return (R): In addition to change in net income, another criterion, the rate of return (R) is useful for evaluating the economics of adopting a new technology. R measures the increase in net income (ANI) which is generated by each additional unit of expenditure (AVC):
R = ANI/AVC -- (4.6)

Stated differently, R is the net return on additional money invested in a new technology relative to the farmer's current setup. It is not required to compute the rate of return (R) if the new technology is less expensive than the farmer's current technology. In the event that the alternative technology is more expensive, the rate of return (R) needs to be greater than that of alternative potential investments and high enough to offset adoption-related risks. Generally speaking, until a new technology has a minimum rate of return (R) of 1.0, we are not hopeful about its adoption.

Results and Discussion

Training, field days, and experience sharing

District-wide extension activities drew 325 participants in total 260 men and 65 women during the events (Table 1).

Large-scale demonstration plot field performance was assessed and shared with a variety of stakeholders, including researchers, agricultural office specialists, and farmers (both host and non-host). In addition to this, a sizable number of farmers visited the expansive demonstration plot and exchanged experiences with farmers from various communities. Extension materials and mass media (radio, and television) were utilized to reach a wide audience with better Barely technology packages. The farmers who are capacitated through regular trainings, best practice field visits and exchange of experiences were fastening the adoption of technologies.

Table 1: Number of participants attended on extension events

Training participants **(#325)**	Extension Events			
	Training		Field day	
	Male	Female	Male	Female
Farmers	82	18	105	24
Experts from office of agriculture	26	12	28	8
Researchers	5	-	14	3
Total	**113**	**30**	**147**	**35**

Source: own computation, 2022

Farmer's variety traits preference

The participant beneficiaries of enhanced agricultural technologies have strong preferences that reflect their likes and dislikes. They will exchange out less desired good traits or characteristics for more favored ones as a result of these preferences. Therefore, it is crucial to determine the quality of a given variety the intended end users want to see taken into account in plant breeding programs by interviewing them. Because it will save time and resources while promoting and disseminating the chosen variety, in addition to being quickly adopted (Dan, 2012). 42 different stakeholders, from which 34 were farmers, 5 were agriculture experts (DAs, supervisors), and 3 were researchers who engaged in the process of focus group discussion and preference evaluation at the crop green and maturity stage. Farmers' selection criteria were used to evaluate the variety when the crop reached at maturity stage.

To facilitate the evaluation and selection process, first, the participants were divided into small, manageable groups; one group had ten members, including a group leader and a secretary. The enumerators received a brief orientation at each demonstration site, explaining how to organize the data they had collected, how to have a group discussion and come to a consensus, how to carefully assess each variety by taking into account each criterion and using a rating scale, and how to integrate the researchers' criteria to their criteria to choose the demonstrated varieties in order of their importance. Finally, the evaluators were instructed to report through their group leader at the end. Every variety was assessed concerning the criteria, which were arranged according to the weights assigned to each attribute. The evaluation's result was shown to the assessors after the process and discussion (FGD) was made on the way ahead. The variety selected, accordingly, will be recommended for further scaling up.

Table 2: FRG member preferences and ranking towards the demonstrated barley variety

No	Food barley variety	Selection criteria						Rank
		GSC	B	DR	GY	EM	Overall	
1	HB-1307	5	5	4	4	4	22	1st
2	(EH-1493) Locally recycled Variety	3	2	2	3	4	14	2nd

GSC = Grain size and color, B = Biomass, DR = Disease resistance, GY = Grain Yield, EM = Early maturity; **Scores**: - 1= Very poor 2= Poor 3 = Good 4 = Very good 5 = Excellent

Participatory evaluation of the variety traits by the farmers is another important part of this study. Hence farmers evaluated technology by setting their own criteria, and shown their own way of selecting a variety for their localities. Accordingly different stakeholders (farmers, researchers and agricultural experts) participated on participatory evaluation and selection. Thus a total of 42 participants involved on the selection process at maturity stage. During the assessment farmers were assisted to list their own selection criteria which may help them to identify best varieties that can fit their demand. These traits include tillering capacity, disease and pest tolerance, early maturity, seed size, lodging tolerance and seed color. Accordingly, farmer's ranked disease and pest tolerance trait and seed size and seed color also ranked 2nd and 3rd respectively (table-3). Therefore, based on objectively measured traits and farmers preferences; breeders focus on the traits of disease and pest tolerance, seed size and color at the time of breeding process.

Table 3: Pair wise ranking result to rank variety traits in order of importance

N.O	Traits	A	B	C	D	E	F	Score	rank
1	Disease and pest tolerance(A)		A	A	A	A	A	5	1
2	Seed size (B)			B	B	B	B	4	2
3	Seed color (C)				C	C	C	3	3
4	Tillering capacity (D)					D	D	2	4
5	Lodging (E)						E	1	5
6	Early maturity (F)							0	6

On-farm performance of food barley variety

Despite the inevitable variability in performance between the demonstrated and farmer practices, the yield performance of the HB-1307 variety was still promising. The overall harvested mean yield of HB-1307 and the locally recycled variety was 38 qt ha^{-1} and 22 qt ha^{-1}, respectively. Therefore, the yield advantage of HB-1307 food barely variety has a 72.72% yield advantage over the farmer's practice. This may be due to using improved full production packages such as improved seed, chemicals, right time of sowing, seed treatment, row planting, weed management, and time-to-time technical guidance followed as compared to farmer's practice.

Yield advantage (%) = $\frac{\text{Demonstrated veriety Yield} - \text{Loca check variety Yield}}{\text{Local check Yield}} X\ 100$

Yield advantage % for HB-1307 = **38qt/ha – 22qt/ha * 100/22qt/ha = 72.72 %**

Therefore, HB 1307 has 72.72 % yield advantage over the EH-1493 locally recycled variety

Technology Gap, Extension gap, and technology index

The technology gap, extension gap and technology index were computed by using the following formulae

Technology gap = Potential yield- Demonstrations yield.

2. Extension gap = Demonstrations Yield-Farmers practice yield.

3. Technology Index = $\frac{\text{Potential Yield} - \text{Demonstratio Yield}}{\text{Potenial Yield}} X\ 100$

Extension gap: District-wide extension activities drew 325 participants in total 260 men and 65 women during the events (Table 1). Large-scale demonstration plot field performance was assessed and shared with a variety of stakeholders, including researchers, agricultural office specialists, and farmers (both host and non-host). In addition to this, a sizable number of farmers visited the expansive demonstration plot and exchanged experiences with farmers from various communities. Extension materials and mass media (internet, radio, and television) were utilized to reach a wide audience with better Barely technology packages.

Technology gap and its index: It is indisputable that numerous factors played a role in the discrepancy between the potential yields of the variety obtained during on-farm demonstrations on farmers' fields and those acquired on-station under the breeder's supervision. This gap was caused by a number of causes, including variations in the soil's fertility, unpredictability on larger plots, follow-up and less regular inspection of the on-farm study, and weather variations. A smaller technological divide indicated that a given crop type was more adaptable.

Using the above-mentioned formulas, the observed technology gap and technology index of the food barley variety under investigation (BH-1307) were determined. The outcomes are shown in table 4 below. The aforementioned data indicates that BH-1307's mean technology index is 24%. The food barley variety BH-1307 has a comparable mean yield gap yield performance when compared to the farmer's practice of 12 qt/ha during the presentation. Table 1's technology index (24%) shows how feasible it is to use evolving technology in a farmer's field. The more technologically feasible something is, the lower the technology index value. This demonstrates the viability of producing the food barley variety (HB-1307) in the research area. The highest value of the technology index was index's value indicated greater technology feasibility. It shows the efficacy of good performance of relevant interventions or technologies demonstrated in farmer's field.

Tabel 4: BH-1307 barley variety yield, technology gap, and technology index in Hula district

Variety	Yield (Qt/ha)				Technology Gap	Extension Gap	Technology index (%)
	Poten tial	Demonstration	Farmer practice	Yield advantage (%)			
HB-1307	50	38	22	72.72	12	16	24

Partial budget analysis

Researchers and extension agents use partial budget analysis to help them choose which technologies to use for farmers. When deciding whether or not to adopt new technology, partial budget analysis can be used to determine how profitable the technology is. Budgeting promotes practical decision-making by helping management think ahead of time. A net benefit of approximately ETB 80,700 and 50,900 per hectare has been gained on demonstration and local practice respectively (Table 5).

The demonstration's benefit showed that the benefit-cost ratios for the local practice and the demonstration were 1.6% and 2.4%, respectively. It suggests that if farmers adopt and use the technology in a number of shown ways and appropriately implement production packages, their family income will rise and the technologies are profitable.

Table-5: Cost-benefit analysis summary for food barely technology demonstration

N.O	Items	Demonstration	Local practice
1	**Gross benefit (A+B)**	**139,000**	**81,500**
A	Grain yield (ETB/ha)	133,000	77,000
B	Biomass yield	6,000	4,500
2	**Variable cost (C+D+E+F)**	**58,300**	**30,600**
C	Seed cost (ETB/ha)	7,200	10,800
D	Fertilizer cost (ETB/ha)	17,700	11,800
E	Chemical cost (ETB)	8,400	1,500
F	Cost of labor (ETB/ha)	25,000	6,500
3	**Net benefit (ETB) (1-2)**	**80,700**	**50,900**
4	**Rate of return (3/2)**	2.4	1.6

Source: own data computation, 2020

Lessons Learned

Large-scale on-farm demonstrations allow farmers and researchers to share knowledge in a way that is mutually beneficial. During the study, farmers were able to witness HB-1307's actual performance. In order to increase the production and productivity of the food barely, the research team was subjected to a collective variety evaluation and received comments for future research projects. For the purpose of transferring the innovations, the study team's contacts with specialists, DAs, farmers, and other stakeholders were reinforced. Improved knowledge and proficiency in barley crop management were attained by farmers. Improved barley varieties that suit their local socioeconomic, cultural, and ecological circumstances were also given to them.

Conclusions and Recommendations

The evaluators determined that the most often used selection criteria in the region for choosing the top-performing variety or varieties were seed size and color, disease resistance, biomass, and grain yield. Although there will always be differences in performance amongst farmers' techniques, the HB-1307 food barley variety showed encouraging yield performance.

Technical advice and support are provided to smallholder farmers so they can increase barley productivity and get the required outcomes. Nowadays, farmers' groups are thought to be the smallest association of farmers. Thus, establishing and bolstering FRGs/FREGs is one of the extension techniques that put the farmer at the center of agricultural research, technology promotion, and dissemination. HB 1307 variety was selected, and it was suggested that they pre-scale up activities on a larger plot (at least 0.5 hectares per trial farmer) in order to promote popularity. Stakeholder relationships must be strengthened in order to achieve the aim. Widespread application of the most recent production methods combined with enhanced high-yielding variety will eventually reverse this extension gap trend. Farmers are able to abandon their customs thanks to the use of contemporary technologies.

Acknowledgements

The Hula Agricultural Office workers, farmers, administrators, and Wondogenet Agricultural Research Center will all get recognition.

Conflicts of Interest: The authors of this paper declare that they have no conflicts of interest with regard to its publication.

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