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Original Paper

Pre-extension Demonstration and Evaluation of Improved Food Barley Varieties in Chora and Gechi Districts of Buno Bedele Zone Southwestern Oromia, Ethiopia

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***Abstract*— The experiment was conducted with the objectives to evaluate yield performance and economic profitability, identify farmers' varietal selection criteria and to improve farmers` knowledge and skills towards improved food barley production and management practices. Based on barley production potential and road accessibility, five kebeles were selected and two improved barley varieties (Adoshe and HB 1307) were evaluated alongside local variety. The 100 m2 plot size was used for each variety and all the recommended agronomic practices were used. Data like grain yield, farmers' varietal selection criteria's, number of training and field day participants, cost incurred and profit obtained were collected where descriptive statistics, one way ANOVA, matrix raking and partial budget were used to analyze. Both list-wise deletion and single imputation methods were used to fix non-equal treatment as missed data over 14 demonstration sites. The descriptive result of list-wise deletion shows, the mean grain yield of 3,714, 3,979 and 1,949 kg ha-1 were obtained from Adoshe, HB1307 and local varieties respectively whereas the mean grain yield of 3,404, 3,979 and 1,969 kg ha-1 were obtained in their respective orders. The list-wise deletion and imputation method ANOVA among the yield of demonstrated barley varieties shows that there is statistically significant yield difference at (P<0.05) and (P<0.01) between the varieties respectively. The matrix raking shows Adoshe variety was preferred first by about 69 and 96 participants partaken on the training and field day respectively. The economic analysis result revealed that, the 3.55 ETB marginal rate of return by list-wise deletion and 3.51 ETB by imputation methods were obtained from HB1307 variety whereas, 3.1 ETB marginal rate of return by list-wise deletion and 2.51 ETB by imputation methods were obtained from Adoshe variety indicating that farmers can recover all the incurred costs and gain 3.55/3.51 and 3.10/2.51 ETB for every 1 ETB they invest when they use HB1307 and Adoshe varieties respectively. Therefore, HB1307 and Adoshe varieties were recommended for further scaling up in the study areas and similar agro ecologies.**

Keywords*— *Buno Bedele, Demonstration, Farmers, Food Barley, Participatory, Yield

I. INTRODUCTION

Barley (Hordeum vulgare L.) is one of the earliest cultivated crops and its cultivation started before 5000 years ago in Ethiopia [8]. Nowadays, Ethiopian farmers grow barley in various climatic and soil types with an elevation ranging from 1,400 to over 4,000m above sea level (m.a.s.l) [4]. Barley is the principal food for smallholder farmers and can be used as beverages and animal fodder. For instance, it can be used to make bread, porridge, soup, and roasted grain and for preparing alcoholic and non-alcoholic drinks. Furthermore barley straw can serve as animal feed, thatching roofs, and bedding [5].

Despite its great significance in the farming system of the country, barley production is constrained by many confounding factors. The major production limiting factors are poor soil fertility; soil acidity; insect pests like aphids and barely fly; leaf diseases such as scald, blotch, smuts, leaf rust; low-yielding varieties and inadequate agronomic practices [5]. The findings of Asfaw, et al. [3] revealed that, low farmers' adoption rate of modern inputs like fertilizer and improved varieties were also among the yield limiting parameters. According to Ababa [1] report, about 50% of barley grower farmers were used inorganic fertilizer at a rate of less than 100 kg ha^{-1} and only 0.6% of them use improved seed.

The findings of Rashid, et al. [11] also confirmed that less than 1% of barley growers were using improved food barley varieties mainly because of the inaccessibility of improved food barley varieties. The decision of farmers' to adopt the improved technologies largely depends on both the nature of the technology itself and the availability and accessibility of improved seeds [3]. Besides, agricultural technology development and verification processes were initiated and implemented solely by researchers' interest and therefore the end-user/farmers were merely passive observant. The traditional top-down technology development process which lacks the participation of the ultimate users, the farmers, is the major limiting factor.

Not only evaluating the different varieties solely from biological (crop productivity related parameters) aspects but also considering the social acceptability and economic

profitability enhance the farmers' adoption rate of the commodity. This experiment was, therefore intended to evaluate the yield performance and economic profitability of the demonstrated food barley varieties, identify farmers' food barley varietal selection criteria and to improve the targeted farmers` knowledge and skills towards improved food barley production and management practices.

II. Materials and Methods

A. Description of the Study Locations

The study was conducted at Gechi and Cora districts (Fig. 1) of Buno Bedele zone in the 2022 main cropping season. Gechi district is bordered on the south by Didessa, on the east by the Jimma Zone, on the north by Bedele and on the east by the Didessa River which separates the district from the Jimma Zone. The site is located at 8°19'60.00" N (latitude) and 36°39'59.99" E (longitude) and 18km (11min') away from Bedele which is the chief town of Buno Bedele zone.

The district is divided in to three agro-ecological zones; namely, highland ('Dega'), midland ('Woinadega'), and lowland ('kola') areas with a proportion of 30.4, 45.7 and 23.9%, respectively. Annual precipitation ranges from 1500 to 2200 mm with 6 to 9 months of rainfall and daily temperature of the district varies from 12 to 35°C. Rainfall variability is an important determinant of rural-farming population of Gechi who practice rain fed agriculture. Coffee production is the dominant farming system in the district in which the major crops like maize, tef, sorghum, wheat and barley as well as horticultural crop production is practiced.

Chora district is located at the latitude of 8° 19′ 60″ N and longitude of 36° 14′ 60″ E. The district is bordered on the south by the Jimma zone, on the west by Yayo district, on the north by Dega district and on the east by Bedele district. The district is distanced about 36 km and 519 km from Bedele and Addis Ababa which are the capital twon/city of Buno Bedele zone and Ethiopia respectively. It has an elevation ranging from 1450–2300 m.a.s.l and characterized by the annual rainfall ranges between 1500 and 2200 mm, and daily mean temperature ranges between 9 C0 and 31 C0. The economy of the area is based on mixed farming system where crop production, livestock rearing, off and non-farm activities are practiced. The dominant crops produced in the areas are coffee, khat, tef, maize, wheat, barley and sorghum.

B. Site and Farmer Selection

Farmers' Research Group (FRG) approach was followed for the activity implementation as it facilitates best fit technology identification from their own perspectives next to learning with and from the farmers through experience sharing. Accordingly, six groups comprising about a total of 90 farmers were established by considering cross-cutting issues like a gender. Using the established FRGs as a reference point, ten trial farmers' fields and four Farmer' Training Center (FTC) were selected in collaboration with development agents based on farmers' willingness to participate in the activity and the representativeness of the FTCs.

C. Materials and Research Design

The on-farm demonstration and evaluation of different food barley varieties was done in 2022 main growing season. About two improved food barley varieties, namely Adoshe and HB 1307 were demonstrated alongside the local variety ('Torja') as experimental treatments. The experiment was laid out in a simple block design with 14 farmers' fields as a replication in two districts. The plot area was 10 m x 10 m for each variety. The seed rate of 125 kg ha^{-1} was planting by drilling seeds with spacing of 20 cm between rows. Phosphorous fertilizer (P_2O_5) was applied at the rate of 100 kg ha^{-1} at planting stage whereas about 150 kg ha^{-1} of urea was applied at vegetative stage. Weeding was done two times at the tillering and booting growth stage.

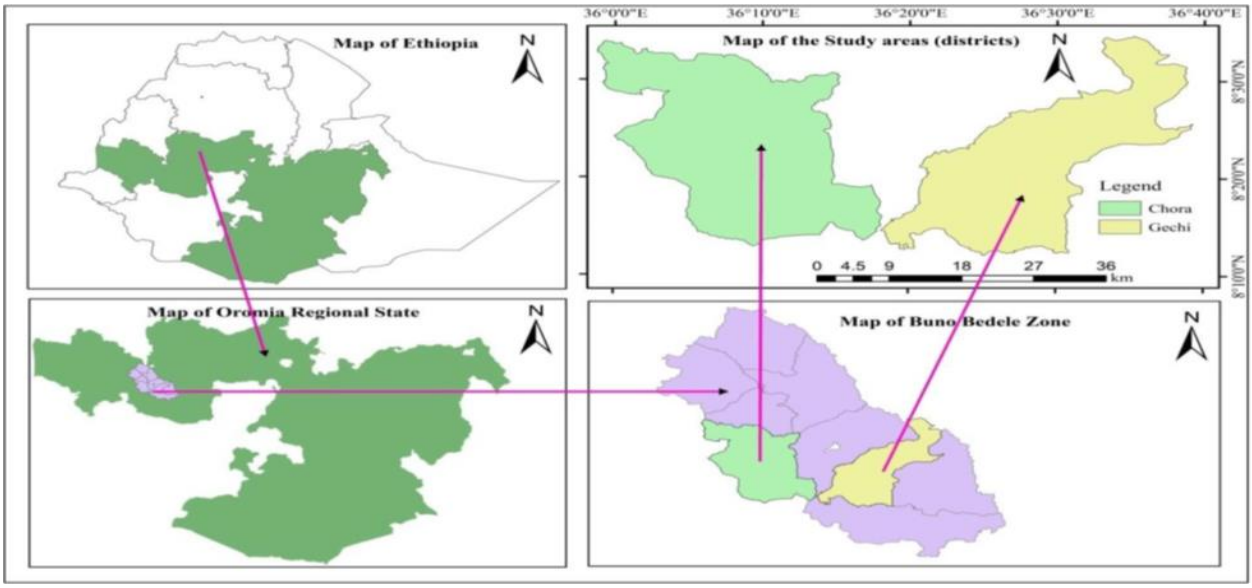

Fig. 1. Map of the Study Area

D. Technology Promotion Approaches

Different technology promotion approaches were used to facilitate further scaling of improved food barley varieties through awareness creation. Training and field-day are the commonly used technology promotion approaches with the intension of creating awareness and access to the wider stakeholders. Accordingly, the training was provided for development agents, subject matter specialists (SMS) and farmers on food barley varietal evaluation criteria, yield advantage over the local and its management practice whereas, field day was organized at crop maturity stage for further awareness creation and dissemination.

E. Data Collected and Method of Analysis

Both quantitative and qualitative data were collected. The collected quantitative data like yield and number of participants on the training and field day whereas qualitative data such as farmers perception towards the improved food barley varieties through participatory varietal selection, trainee and field-day participant ideas were subjected to analysis using SPSS software version 20. The result was discussed using mean and standard that presented in the form of tables.

III. Results and Discussion.

A. Yield Performance

The following table (Table I) shows the yield performance of the demonstrated barley varieties across 4 farmers' fields by list-wise deletion and 14 farmers' fields using single imputation methods. Dou to the seed scarcity of improved barley (HB 1307) variety that replicated across 4 farmers' fields, the yield performance of two improved varieties (Adoshe and HB 1307) and local variety was analyzed using missed data handling methods for HB 1307 variety that was not replicated across 14 farmers' field as that of Adoshe and Torja.

The two important missed data handling methods are list-wise deletion which is ignoring the observation with missing values and single imputation which is very important in small scale and huge data analysis through maintaining the completeness in a dataset. Accordingly, the descriptive result of list-wise deletion revealed that, the mean grain yield of 3,714±10.367, 3,979±3.674 and 1,949±2.682 kg ha^{-1} were obtained from Adoshe, HB 1307 and local varieties respectively. The list-wise deletion analysis of variance among the yield of demonstrated barley varieties shows that there is statistically significant yield difference at ($P<0.05$) between the varieties (Tables II). By using Equation (1), the computed yield advantage also shows that HB 1307 and Adoshe variety had the greater yield advantage of 104% and 91% respectively over the local (Torja) variety.

However, deleting a large number of observations with missing values causes a significant loss of information [13]. It also decreases the statistical power and efficiency of the data [7]. Hence, single imputation of replacing the mean attribute was employed for the completeness of the treatment data. The result of demonstrated barley yield through single imputation shown that, the mean grain yield of 3,404±8.606, 3,979±1.765 and 1,969±4.562 kg ha^{-1} were obtained from Adoshe, HB 1307 and local varieties respectively. The single imputation analysis of variance among the yield of demonstrated barley varieties shows that there is statistically significant yield difference at ($P<0.01$) between the varieties (Tables 2). The computed yield advantage also confirmed the HB 1307 and Adoshe variety had the greater yield advantage of 102% and 73% respectively over the local (Torja) variety (Tables 3).

TABLE I. Yield Performance Of The Demonstrated Food Barley Varieties In Qt Ha^{-1}.

List-wise deletion (a)					
Barley varieties	N	Minimum	Maximum	Mean	Std. Deviation
Adosh	4	2,400	4,700	3,714	10.367
HB1307	4	3,500	4,300	3,979	3.674
Torja	4	1,600	2,200	1,949	2.682
Single Imputation (b)					
Adoshe	14	1,700	4,700	3,404	8.606
HB1307	14	35	43	3,979	1.765
Torja_local	14	11	28	1,969	4.562

Source: Own computation, 2022

TABLE II. Analysis Of Variance For Yield Of The Demonstrated Barley Varieties

List-wise deletion (a)					
Yield	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	974.662	2	487.331	11.408	.003
Within Groups	384.481	9	42.720		
Imputation (b)					
Between Groups	1560.358	1	1560.358	22.993	.000
Within Groups	2714.531	40	67.863		

$$\text{Yield advantage \%} = \frac{Yield\ advantage\ of\ improved\ variety - Yield\ advantage\ of\ local\ variety}{Yield\ advantage\ of\ local\ variety}\ x\ 100$$

TABLE III. THE YIELD ADVANTAGE OF IMPROVED BARLEY VARIETIES OVER THE LOCAL ONE

List-wise deletion (a)			
Barley varieties	Mean yield (kg ha^{-1})	Yield difference (kg ha^{-1})	Yield advantage over the local variety (%)
Adoshe	3,714	1,765	91
HB1307	3,979	2,030	104
Torja (local variety)	1,949		
Imputation (b)			
Adoshe	3,404	1,435	73
HB1307	3,979	2,010	102
Torja (local variety)	1,969		

Source: Own computation, 2022

TABLE IV. FARMERS' BARLEY VARIETAL SELECTION ASSESSMENT BY SIMPLE SCORE RANKING (1-5)

Criteria	Adoshe	HB 1307	Torja
Lodging resistance	4	4	4
Yield performance	5	5	2
Spike length	5	4	3
Seed size	5	4	3
Diseases tolerance	5	4	2
Overall score	**24**	**21**	**14**
Mean score	**4.8**	**4.2**	**2.8**
Rank	**I**	**II**	**III**

Source: Experiment data result and own computation, 2022

TABLE V. TRAINING PARTICIPANTS

District	Participant categories	Male	Female	Total
Dabo Hana	Farmers	49	7	56
	Das	4	4	8
	Other Stakeholders	3	2	5
	Total	**56**	**13**	69

Source: Data result and own computation, 2022

TABLE VI. FIELD DAY PARTICIPANTS

Participants	Male	Female	Total
Farmers	66	13	79
Das	4	5	9
District agricultural expertise	6	2	8
Total	**76**	**20**	96

Source: Data result and own computation, 2022

B. Participatory Varietal Selection and Evaluation

Participatory varietal selection (PVS) and evaluation criteria is about linking indigenous knowledge where farmers set selection criteria based on their experience know-how and scientific knowledge where the researchers set some yield and yield related attributes. PVS values the researchers' and farmers' knowledge equally and underlines the complementary nature of both pools of knowledge in both generating and using technologies. Rapid and efficient transfer of advanced knowledge to the farmer and the potential for improved information benefit both farmers and society [2, 12]. Additionally, studies show that participating in agricultural extension programmes has positive economic gains for farmers [6, 9]. Hence, farmers are recognized as innovators and experimenters rather than as passive end-users of the technologies.

Accordingly, before varietal selection and evaluation process, all farmer research group (FRG) members including experiment hosting farmers were facilitated to set their priority selection criteria. Consequently, yield performance, spike length, seed size, lodging and diseases tolerance were identified as the most important varietal selection criteria. Using the liker scale of 1-5, 1 being very poor, 2 was poor, 3 was good, 4 was very good and 5 was being excellent, the varieties were ranked from the viewpoints of farmers varietal selection criteria.

The participatory farmers' varietal selection assessment result on Table 4 showed that Adoshe variety was preferred first

by fulfilling farmers own varietal selection criteria's whereas HB 1307 and Torja varieties got the second and third rank respectively. The reasons why farmers' preferred Adoshe variety were attributed to its lodging resistance, the highest spike length, high yield, seed size and diseases tolerance compared with other varieties. Hence, participatory farmers' varietal selection assessment (social aspect) result was matched with the biological result recommended during adaptation trial where Adoshe variety was recommended for further scaling up whereas HB 1307 variety was the leading in terms of yield performance.

C. Participatory Varietal Selection and Evaluation

Training

Training is an organized procedure which brings about a semi-permanent change in the areas of skills, knowledge, and attitudes towards specific job. Consequently, training was provided to different categories of participants (ie. farmers, development agents and woreda agricultural experts) on the full-package based production of improved food barley and the importance of farmer based varietal selection. Hence, a total of 69 (56 male and 13 female) participants were participated on the training (Table 5).

TABLE VII. ECONOMIC ANALYSIS OF THE DEMONSTRATED BARLEY VARIETIES

List-wise deletion (a)			
Parameters	Barley varieties		
	Adoshe	HB 1307	Torja
Yield kg/ha (Y)	3,714	3,979	1,949
Sale Price ETB/kg (P)	35	35	35
Total Revenue (TR=YxP)	129,990	139,265	68,215
Variable costs			
Seed cost (ETB/kg)	50	50	48
TVC	50	50	48
Net benefits (NB = TR-TVC)	129,940	139,215	68,167
Marginal rate of return (MRR = ΔTR/ΔTVC)	3.10	3.55	
Single Imputation (b)			
Yield kg/ha (Y)	3,404	3,979	1,969
Sale Price ETB/kg (P)	35	35	35
Total Revenue (TR=YxP)	119,140	139,265	68,915
Variable costs			
Seed cost (ETB/kg)	50	50	48
TVC	50	50	48
Net benefits (NB = TR-TVC)	119,090	139,215	68,867
Marginal rate of return (MRR = ΔTR/ΔTVC)	2.51	3.51	

Source: Data result and own computation, 2022

Field Day

Field day is another means of technology promotion events that organized at technology maturity stage to facilitate wider demand and high adoption rate toward the technology next to stakeholders' linkage improvement. As a result, field day was organized at food barley maturity stage by Extension Research Team of Bedele Agricultural Research Center where FRG members, other neighbor farmers, development agents, Chora and Gechi districts agricultural expertise were participated. A total of 96 (76 male and 20 female) participants were participated on the field-day (Table 6).

D. Participatory Varietal Selection and Evaluation

Economic analysis was performed to examine the economic feasibility of the treatments. Partial budget and marginal analyses were used. Partial budget is used to calculate the total costs that vary and the net benefits for each treatment of an experiment whereas marginal analyses is about just how the net benefits from an investment increase as the amount invested increases. The marginal rate of return (MRR) should be compared to a minimum acceptable rate of return (MARR) which is100% in order to select the high yielder variety [10].

Accordingly, it was the cost of seed that vary within the treatment. The seed cost of Adoshe, HB 1307 and Torja were 50, 50 and 48 ETB kg^{-1} respectively. As elsewhere the cost of improved seed is not equivalent to the local one during planting time. The cost of other production practices like, cost of land, labor cost for land preparation, fertilizers cost, weed control and yield transportation cost were assumed insignificant among the barley varieties or remain the same. The average farm gate price of barley grain yield was 35 ETB kg^{-1}.

As indicated on Table 7, the economic analysis result revealed that, the highest net benefit was obtained from HB 1307 variety with 3.55 and 3.51 marginal rate of return in list-wise deletion and imputation methods of missed data handling respectively followed by Adoshe variety. Since the marginal rate of return was greater than that of minimum acceptable rate

of return the farmers can recover all the incurred costs and gain 3.55/3.51 and 3.10/2.51 ETB for every 1 ETB they invest when they use HB 1307 and Adoshe varieties respectively.

IV. Conclusion and recommendations

A. Conclusion

The two improved food barley varieties (HB 1307 and Adoshe) were demonstrated and evaluated alongside with one local variety which is Torja. The highest mean grain yield was obtained from HB 1307 variety followed by Adoshe with statistically significant yield difference between the varieties. The economic analysis result revealed that, nearly equal marginal rate of return was obtained from HB 1307 and Adoshe varieties in which farmers can recover all the incurred costs and gain at most equivalent ETB for every 1 ETB they invest when they use HB 1307 and Adoshe varieties. In addition, Adoshe variety was preferred by fulfilling farmers own varietal selection criteria's like lodging resistance, the highest spike length, high yield, seed size and diseases tolerance compared with other varieties.

B. Recommendation

Adoshe was preferred by the farmers and other stakeholders on different technology promotion events whereas HB 1307 variety was still the leading in terms of yield performance and economic profitability. Therefore, the researchers are enforced to conclude that, both HB 1307 and Adoshe varieties were recommended for further scaling up in the study areas and similar agro ecologies.

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Declaration of competing interest

The authors declare that there are no conflicts of interest regarding the publication of this research activity.

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