Original Research Article||

Pre-Extension on-Farm Demonstration Trial of Maize in Heban Arsi and Sankura districts, southern Ethiopia

Alemayehu Zemede Lemma[1]*, Muluken Philipos, Getu Mitiku[1], Yuel Talew[1], Temesgen Gizaw[1] and Derese Teshome[2]

[1]*Wondo-Genet Agricultural Research Center, Wondo Genet, Ethiopia*

[2]*Ethiopian Institutes of Agricultural Research, Addis Ababa, Ethiopia*

Abstract

Maize is extensively cultivated by more than 9.3 million farmers in Ethiopia. However, its productivity of the crop is low due to limitation in using and dissemination of improved maize technologies. The objective of this study was to demonstrate the performance of improved maize technologies and estimating production cost and revenue of maize technologies in large scale cultivation at Sankura and Heban Arsi districts. In this study two new maize and one locally used varieties (as a check) were used with agronomic and crop protection packages in the 2019 cropping season. At Sankura, BH- 547 gave a higher mean grain yield and showed a 10.5 and 22.7 % grain yield advantage over BH-546 and BH-540 (local check), respectively. In contrast, BH-546 produced a higher grain yield and scored a 10.2 and 1.1 % advantage over BH-547 and BH-540 in the Heban Arsi district. Similarly, participating farmers of Sankura selected BH-547 based on the field performance. The BH-546 was preferred for large scale production by farmers at the Heban Arsi district. The average net benefit return of maize technology demonstration at Sankura was about 37,370.00 ETB. At Heban Arsi, the average net benefit return is estimated to be about 29,162.9 ETB. The study result revealed that the use of improved maize technology could increase maize productivity and profitability in the districts provided that farmers adopt the technology and implement following the demonstrations. Seed multiplication and distribution of BH-547 and BH-546 should be strengthened to satisfy the demand created among farmers of the districts.

Key words: Demonstration, maize, pre-extension

Original submission: May 1, 2022; **Revised submission**: August 12, 2022; **Published online**: October 23, 2022

***Corresponding author's address:** Alemayehu Zemede Lemma, Email: *alexzemede@gmail.com*
Authors: Muluken Philipos: *natinard.phillip1@gmail.com*; Getu Mitiku: *getumitikub@ymail.com*; Yuel Talew: *yueltalew@gmail.com*; Temesgen Gizaw: *temegizawgobena@gmail.com* and Derese Teshome: *derese06@yahoo.co.uk*

INTRODUCTION

Maize is a cereal crop which is cultivated widely throughout the world and has the highest production among all the cereals. It is an important staple food in many countries and is also used as animal feed and many industrial applications. The crop has tremendous genetic variability, which enables it to thrive in tropical, subtropical, and temperate climates (Hellin et al., 2012).

Maize is one of the most versatile crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as a queen of cereals because it has the highest genetic yield potential among the cereals. Maize is Ethiopia's leading cereal crop in terms of production with 6.2 million tons produced in 2014 by 9.3 million farmers across 2 million hectares of land (CSA, 2020). In terms of cultivated area, it is the second most widely cultivated crop next to tef. Ethiopian farmers grow maize, primarily for subsistence with 75% of all maize output consumed by farming households, making it a key crop for overall food security and for economic development in the country (CSA, 2020).

Despite its importance, maize productivity in Ethiopia has remained very low below the world average (5.57 t ha^{-1}) (FAO, 2020). The low productivity of maize is attributed to many factors like the frequent occurrence of drought, declining of soil fertility, poor agronomic practice, and cease/limited use of fertilizer, insufficient technology generation, and adoption, lack of credit facilities, poor seed quality, disease, insect pests, and weeds (Yami et al., 2020). In Ethiopia, maize improvement research has been conducted over years and so far about 73 improved varieties were developed by the national maize research program and officially released by the national variety release committee (MoALR, 2020). Thus, using improved maize technological packages increased the production and productivity of maize in Ethiopia.

Different research centers released different technologies of maize, but farmers don't accept/know the released technologies because of poor Farmers-Extension-Researchers (FER) linkages and fear for newly released technologies. Demonstration is an efficient method to disseminate improved technologies and reach many farmers when they are conducted by farmers themselves on their farms (Bekele et al., 2022). Pre-extension of improved technology using lead farmers approaches would be effective to reach many farmers and disseminate recent technologies to end users. Once farmers are trained and well-oriented, it could be possible to pass the knowledge and skills on the improved technologies to their peers (Bekele et al., 2017). Based on the evidence and experiences by the government of Ethiopia (MoARC 2020), it is expected that the available maize technologies will be more productive and profitable than the local varieties used by farmers in the districts of Sanakura and Heban Arsi.

The purpose of this pre-extension demonstration trial was to assess productivity and profitability of the improved maize technologies in the farmers' fields of Sankura and Heban Arsi districts and thereby create opportunity for identification of suitable variety for further dissemination of maize technologies to large number of farmers.

MATERIALS AND METHODS

The Study Site

The study was conducted in 2019 in two of the major maize- growing woredas (districts), Heban Arsi of the West Arsi zone, Oromia region, and Sankura, in the Southern region of Ethiopia. These areas are among the major maize growing environments for farmers with the crop used to meet all livelihood needs. In the districts, maize and wheat accounts for the largest total average land allocation per farming households with almost all farmers grow the two crops in the major rainy seasons.

Selection and Packaging of Technologies

The full technological packages of maize used for on-farm demonstration included two improved maize varieties (BH-547 and BH-546) and BH-540 as local check together with maize production packages (seed rates, NPS and urea fertilizer, row planting with appropriate spacing) and crop protection recommendations. Selection of the vanities was made based on agro-ecological adaptations, grain yield potentials and their tolerance to major diseases. Recommended seed rates of the varieties and fertilizer were provided to each host farmer of the districts.

Implementation Procedures and Extension Communication Methods

Sites and Farmers Selection

Pre-extension on farm demonstration of maize was carried out in two villages with the participation of 7 and 5 farmers in the Heban Arsi and Sankura districts, respectively. The selection of sites and farmers was carried out by members of the technical committee together with district experts and development agents.

Training and Field Supervision

A total of 30 participants attended the training before the implementation of the activity in the selected woredas and kebeles. A training of trainers was given to development agents (DAs) and district experts on maize production and management techniques. In addition, the district and development agents provided practical training to the participant farmers during implementation. Furthermore, technical training manuals and printed extension materials have been prepared and distributed to development workers and district experts.

On-Farm Demonstration

The field demonstration was conducted in five farmer's fields in the Heban Arsi and Sankura districts from June 2019 to the end of November, both locations representing the mid altitude maize growing environments of the country. The demonstrations consisted of two new maize varieties (BH-546 and BH-547) being compared against an old maize variety (BH-540). Each variety was grown with a plot of 400 m^2 (with 75 cm between rows and 25 cm between plants). Recommended fertilizer rate and cultural practices of crop protection and managements were applied. During the demonstration, besides host farmers, a large number of farmers from the nearby villages visited the field plot and compared their practices.

Participatory Variety Selection

Participatory variety selection (PVS) is used as an approach to identify varieties preferred by farmers, and accelerate technology dissemination (Joshi and Witcombe, 1996; Mulatu and Belete, 2001; Mulatu and Zelleke, 2002; Goa and Ashamo, 2017; Adu et al., 2021). It provides an opportunity for farmers to identify and select materials of their interest screened under a demonstration plot. In the current demonstration, farmers were invited and instructed by the researchers and extension workers from each district office to evaluate the new varieties compared to the check they knew well and the evaluation was done two weeks before harvest. In the PVS, out of 22 and 27 participants, 5 and 6 were women in Sankura and Heban Arsi districts, respectively. Farmers were asked to rank the varieties and with their own criteria.

Field Days, Experience Sharing and Communication

Three field days were held in the implementing districts and a total of 235 participants (20 females and 215 males) were in attendance (Table1). The performance of the technologies was evaluated and communicated to different stakeholders such as farmers, experts, seed multipliers as well as districts and kebele administrators. The demonstration created an opportunity for a large number of farmers to visit the demonstration and experiences were shared among farmers of many villages. Extension materials and mass Media communications (Radio, Television and website) were used during the events to reach a large community stakeholders.

Table 1. Number of participants attending the field days and experience sharing visit at the districts

Districts	Field day participants									
	Farmers		Experts		Researchers		Administration personnel		Total	
	F	M	F	M	F	M	F	M	F	M
Heban Arsi	5	65	2	12	1	4	-	2	8	81
Sankura	2	55	3	8	1	4	-	2	6	69
Total	11	168	6	31	3	12	-	4	14	150

Sampling, Data Collection and Management

Both physical and cost data were collected from farmers and local markets. Random sampling was used to collect representative data on grain, biomass and cobs yield. Labor and input application costs (seed, fertilizer, and insecticides) were taken from on-farm demonstrations. Data were summarized using descriptive statistics such as means, ranges, and percentages.

TECHNOLOGICAL ACHIEVEMENTS

Productivity Under on Farm Demonstration Conditions

In the Sankura district, BH-547 gave the highest grain yield followed by BH-546 with the BH-540 as the local check performing the least. BH-547 had 10.5 and 22.7 % yield advantages over BH-546 and BH-540 (Table 2). Similar reports were presented by (Yokamo and Okya, 2018) on grain yield and net benefit using maize technology demonstration where BH-547 performed better than other varieties in participatory pre-extension demonstration conducted in south Ethiopia.

Table 2. Estimated mean and ranges of grain, biomass and cob yield of maize varieties tested at farmer's fields of Sankura in 2019.

Variety	Grain yield (t ha^{-1})		Biomass yield (t ha^{-1})		Cobs yield (t ha^{-1})	
	Mean	Range	Mean	Range	Mean	Range
BH-540	3.8	3.4 - 4.7	5.8	5.5 -7.0	0.86	0.82-1.2
BH-547	5.0	4.4 -5.6	7.5	6.5-8.4	1.17	1.1-1.4
BH-546	4.5	4.2-5.0	6.7	6.3-7.6	0.99	1.1-1.3
Mean	4.4	4-5.1	6.6	6.1-7.3	1.0	1.1-1.3

In contrast, under drought-prone environment of the Heban Arsi district, BH-546 stood best in performance and other attributes. It showed a 10.52 and 8.1% yield advantages over BH-547 and BH-540, respectively (Table 3). Although the performance of the BH-547 and BH-546 were found promising compared to BH-540 (local check), their performances were comparable to the national maize average yield (4 t ha^{-1}) (CSA, 2020), the average grain yield obtained at both districts was generally low. These could be due to terminal drought associated with late planting in both districts. The average biomass yield recorded was 6.6 and 5.5 t ha^{-1} and varied from 6.1 to 7.3 and between 5 to 6.3 t ha^{-1} at Sankura and Heban Arsi sites, respectively. On average, the yield of maize cobs was 22.7 and 22.5% of the grain yield at Sankura and Heban Arsi in respective order (Tables 2 and 3). Massimo et al. (2016) reported that cobs yield contributed, on average 18.7% of the grain yield of maize.

Table 3. Estimated mean and ranges of grain, biomass, and cob yield of maize varieties tested at farmer's fields in Heban Arsi, 2019.

Varieties	Grain Yield (t ha^{-1})		Dry biomass yield (t ha^{-1})		Cob yield (t ha^{-1})	
	Mean	Range	Mean	Range	Mean	Range
BH-540	3.7	3.4-4.0	5.7	5.1-6.2	0.83	0.85 -1
BH-547	3.4	2.9 -4.1	5.1	4.4-6.3	0.77	0.73-1
BH-546	3.8	3.6-4.3	5.8	5.5-6.5	0.86	0.9-1.2
Mean	3.6	3.3-4.1	5.5	5-6.3	0.81	0.83-1.1

Cost-Benefit Analysis

The maize technology demonstration has generated a net benefit estimated to about ETB 37,370 and 29,162.9 per hectares with input costs estimated to be almost Birr 15,450 and 14,950 in Sankra and Heban Arsi districts, respectively (Table 4). The average gross benefit of grain yield was about 83%. On average cobs yield contributed the lowest benefit (1.8%). The two highest production average costs were labor (60.2%) and fertilizer (32.9%) in both districts. The result of the demonstration revealed a 2.4 and 1.95% benefit-cost ratio in Sankura and Heban Arsi districts, respectively. A similar analysis for tef was by Bekele et al. (2022) indicating that a benefit-cost ratio of 1.5 is highly profitable and attractive in seed business-oriented method. Hence, the technologies are profitable and farmers' household income would be increased, if the new maize technologies are adopted and utilized on large scale in the study areas and elsewhere with similar ecologies and market situations.

The average net benefit among maize varieties showed that BH-547 and BH-546) showed 11.7 and 10.3% higher profit than BH-540 (Table 5). Benefit-cost ratio for maize varieties was found higher than one suggesting that farmers in the districts of Heben Arsi and Sankura would generate modest benefit while using improved maize varieties.

Table 4. Cost-benefit summaries for maize technology demonstration carried out at Sankura and Heban Arsi districts

Items	Sankura	Heban Arsi
Grain yield (ETB/ha)	44,000.00	36,720.00
Dry biomass yield (ETB/ha)	7920.00	6600.00
Cobs yield (ETB/ha)	900.00	792.9
Gross Benefit	52,820	44112.90
Seed cost (ETB/ha)	550	550
Fertilizer cost (ETB/ha)	5000	5000
Chemical cost (ETB)	500	500
Cost of labor (ETB/ha)	9400	8900
Total variable cost (ETB)	15450	14950
Net benefit (ETB)	37,370.00	29,162.9
Benefit-cost ratio	2.4	1.95

Table 5. Cost-benefit summaries for maize technology demonstration carried out among maize varieties

Items	BH-547	BH-546	BH-540
Grain yield (ETB/ha)	42,062.6	41561.8	37555.9
Dry biomass yield (ETB/ha)	7498.3	7438.8	6843.7
Cobs yield (ETB/ha)	897.30	856.4	786.3
Gross Benefit	50,458.2	49,857	45185,9
Seed cost (ETB/ha)	550	550	550
Fertilizer cost (ETB/ha)	5000	5000	5000
Chemical cost (ETB)	500	500	500
Cost of labor (ETB/ha)	9150	9150	9150
Total variable cost (ETB)	15,200	15,200	15,200
Net benefit (ETB)	35,258.2	34657	29985.9
Benefit cost ratio	2.32	2.28	1.97

Farmer's Variety Selection

Evaluation and assessment for maize technology demonstration were held by farmers of both Heban Arsi and Sankura districts at grain filling stages. Farmers who participated in the evaluation identified varieties adapted to their environment based on the traits of interest. Accordingly, out of 22 farmers (2 females and 20 males) who participated in the evaluation and selection of varieties at Sankura, 90.9% of them selected BH-547. In contrast, more than half of the participant farmers preferred BH-546 and BH-547 was the second choice by farmers of the Heban Arsi district. Farmers participating in variety selection preferred BH-547 over BH-546 and BH-540 for their bigger cob size, good husk cover, high yielding, and better reaction to known diseases of the area. The majority of the farmers who participated in the evaluation in Heban Arsi selected BH-546 for good husk cover, double cobing, rachis thickness, grain filling, earliness, and tolerance to diseases. Bad husk cover, susceptibility to major diseases, and lodging were among the major reasons for farmers to reject BH-540, the most popular hybrids adapted to the same agro-ecology in the Heban Arsi district. Similar findings were reported by Muluneh et al. (2020), where BH-547 and BH-546 were among the most preferred varieties selected by farmers of Hawassa district, Southern region of Ethiopia in participatory variety evaluation and selection trials held among 12 maize hybrid varieties.

CONCLUSIONS

The pre-extension demonstration proved that improved maize technology was found more productive and profitable in the districts of Heben Arsi and Sankura, although the benefits varied among farmers and between different varieties. In general, participating farmers of Sankura identified BH-547 based on the field performance whereas BH-546 was preferred to further large- scale production by farmers of the Heban Arsi district. Seed multiplication and distribution of BH-547 and BH-546 should be strengthened to take the technologies to larger number of farmers and satisfy the demand created by during the on farm demonstration trials held in the districts.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

ACKNOWLEDGEMENT

The authors would like to thank the Ethiopian Institute of Agricultural Research and Agricultural Growth Program II (AGP II) for financial support. They also appreciate the facilitation by the Wondo Genet Agricultural Research Center. Authors also express their gratitude to the farmer's for their active engagement and proper management for the farms.

REFERENCES

Adu, G.B., Badu-Apraku, B., Akromah, R., Amegbor, I.K., Adogoba, D.S., Haruna, A., Manigben, K.A., Aboyadana, P.A. and Wiredu, A.N. 2021. Trait profile of maize varieties preferred by farmers and value chain actors in northern Ghana. Agronomy for sustainable development, 41(4): 1-15. [Scholar Google]

Bekele, A., S. Chanyalew, T. Damte, K. Assefa and Tadele Z. 2017. Lead Farmers Approach in Disseminating Improved Tef Production Technologies. Ethiop. J. Agric. Sci., 27(1): 25-36. [Scholar Google]

Bekele, A., S. Chanyalew, T. Damte, N. Husien, W. Kebede, K.Tolossa, Y. Genet, K. Assefa, D. Nigussie, D. Klauser and Tadele Z. 2022. Seed–Business Oriented Demonstration Trials: An Efficient Option to Promote Tef (Eragrostis tef) Varieties. Ethiop. J. Agric. Sci., 32(1): 125-138. [Scholar Google]

CSA (Central Statistical Agency). 2020. Report on area and production of major crops for private peasant holdings (Meher Season). Statistical Bulletin 578, Agricultural sample survey volume V, Addis Ababa, Ethiopia.

Goa, Y. and Ashamo, M. 2017. Participatory approaches for varietal improvement, its significances and challenges in Ethiopia and some other Countries: A Review. International Journal of Research Studies in Science, Engineering and Technology [IJRSSET], 4(1): 25-40. [Scholar Google]

World Food and Agriculture Organization (FAO). 2020- Statistical Year book 2020. Rome.

Hellin J., B. Shiferaw, E. Jill, Cairns, M. Reynolds, Ivan Ortiz-Monasterio, M. Banziger, Kai Sonder and Rovere R. 2012. Climate change and food security in the developing world: Potential of maize and wheat research to expand options for adaptation and mitigation. Journal of Development and Agricultural Economics, 4(12): 311-321. [Scholar Google]

Joshi, A. and Witcombe, J. R. 1996. Farmer participatory crop improvement. 2. Participatory varietal selection, a case study in India. Experimental Agriculture, 32: 461–477. [Scholar Google]

Massimo Blandino, Claudio Fabbri, Mariangela Soldano, Carlo Ferrero and Amedeo Reyneri. 2016. The use of cobs, a by-product of maize grain, for energy production in anaerobic digestion .Italian Journal of Agronomy, 11(3): 195-198. [Scholar Google]

MoALR (Ministry of Agriculture and Livestock Resource). 2020., Plant Variety Release, Protection and Seed Quality Control Directorate, Crop Variety Register, Issue No.23, Addis Ababa, Ethiopia.

Mulatu, E. and Belete K. 2001. Participatory variety selection in lowland sorghum in eastern Ethiopia: impact on adoption and genetic diversity. Experimental Agriculture, 37: 211–229. [Scholar Google]

Mulatu, E. and Zelleke H. 2002. Farmers' highland maize (Zea mays L.) selection criteria: Implication for maize breeding for the Hararghe highlands of eastern Ethiopia. Euphytica, 127: 11–30. [Scholar Google]

Muluneh G.S. Admassu and Zemede A. 2020. Participatory maize hybrid evaluation for different cropping systems in the central rift valley in Ethiopia. Journal of Plant Breeding and Crop Science, 12(14): 269-274. [Scholar Google]

Yami M., F. Meyer, and Hassan R. 2020. The impact of production shocks on maize markets in Ethiopia: Agricultural and Food Economics at http;//doi.org/10.1186/s40100-020-0153-5. [Scholar Google]

Yokamo, S. and Okya E. 2018. Participatory Pre-Extension Demonstration of Maize (Zea Mays L.) Varieties with its Full Packages in South Ethiopia. Adv Crop Sci. Tech., 6(2): 342. [Scholar Google]