TAS Trends in Agricultural Sciences

OPEN ACCESS

Cluster-Based Large-Scale Demonstration of Improved Maize (*Zea mays* L.) Technology in Sodo District, East Guraghe Zone, Central Ethiopia

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ABSTRACT

Background and Objective: Maize is a key crop in Ethiopia due to its nutritional and economic significance; however, national average yields remain significantly below both the global average and even the local potential of the Sodo District in East Gurage Zone. This study aimed to enhance maize production and productivity through a cluster-based large-scale demonstration of improved maize technology, targeting awareness creation and adoption among multiple stakeholders. **Materials and Methods:** A purposive sampling method was used to select the Sodo District and farmers were chosen based on cluster sampling and willingness to participate. The study employed a cluster-based design with 48 participating farmers. Gambela Kebele was selected for implementation and a farmer's research extension group was established. The program included theoretical and practical training sessions for host and non-host farmers, development agents and experts. Descriptive statistics ($p<0.05$), were used to analyze yield performance and perception data. **Results:** Training significantly improved participants' knowledge, skills and attitudes toward maize technology. Field days involving farmers, researchers, extension experts and decision-makers promoted visibility and knowledge exchange. The improved maize variety BH546 demonstrated good performance, with an average yield of 62.15 quintals per hectare, higher than the national and local averages. Farmers in the study area positively perceived the variety in terms of yield and adaptability. **Conclusion:** The demonstrated yield of BH546 exceeded both the national and district averages, indicating the variety's high potential. Wider dissemination through established extension systems, along with full agronomic packages, is recommended to scale up adoption and boost regional productivity.

KEYWORDS

Maize productivity, cluster-based demonstration, BH546 variety, farmer perception, extension system, sodo district

INTRODUCTION

Ethiopia is the fifth-largest producer of maize in Africa and smallholder farmers make up 94% of the crop production. The country produces white maize, the preferred type of maize in neighboring markets.

ISSN: 2957-9449 (Online)
ISSN: 2957-9430 (Print)
https://doi.org/10.17311/tas.2025.183.189

Received: 11 Apr. 2025
Accepted: 27 Jun. 2025
Published: 30 Sep. 2025

As the cheapest source of caloric intake in Ethiopia, providing 16.7% of per capita calorie intake nationally, maize is an important crop for overall food security[1]. In Ethiopia and is the single largest sub-sector within Ethiopia's agriculture, far exceeding all others in terms of its share in rural employment, agricultural land use, calorie intake and contribution to national income[2]. Maize (*Zea mays* L.) is used in the human diet in large parts of the world and it is an important feed component for livestock[2]. It is the most important crop in terms of both total national production and productivity and grows in all agro-ecologies, starting from lowland to 3700 m above sea level in the country[3]. In Ethiopia, maize is one of the most cereal crops cultivated on over 2.56 million hectares of land, accounting for 21.02% of the total grain crop area, with an annual production of 107.5 million tons, contributing about 32.79% of the total grain production[4]. Regarding the volume of production, it is placed in the first place while ranked second about area coverage. Similarly, 1.39 million tons of maize were produced from 0.35 million ha of land in Southern Ethiopia[4]. Comparatively, total annual maize production exceeds all other cereals in the area covered and several households involved, thus implying that maize is one of the priority food security crops in Ethiopia[4].

Despite its nutritional and economic values, the national average productivity is only 4.95 ton/ha, which is far below the world's average yields of 5.6 ton/ha[4]. The productivity of the crop in the study areas is even lower (4.95 ton/ha) than the national average yield[4]. Although some improved varieties were introduced to farmers in the area, they do not use them with their recommended agronomic practices and maize production and productivity were below their potential, even though there were maize potential agro-ecologies in the area. To tackle this production problem, a year before, Worabe Agricultural Research Center had done adaptation and demonstration trials on different improved midland maize varieties in Gurage, Zone and recommended to disseminate and demonstrate it in wider farmers' fields and other similar agro-ecological settings of both Zones. Despite the importance of maize as a principal food crop, its average yield in Ethiopia (3.6 ton/ha) is still lower than that of the world's average (5.6 ton/ha in 2016)[5]. A significant portion of this yield gap is attributable to biotic and abiotic stresses. The low productivity of maize is attributed to many factors like the frequent occurrence of drought, decline of soil fertility, poor agronomic practice, cease/limited use of fertilizer, insufficient technology generation and adoption, lack of credit facilities, poor seed quality, disease, insect pests and weeds[6]. Weak research-extension linkage is also a major bottleneck for the low awareness and adoption of improved agricultural technologies. For that creating various initiatives to strengthen the research-extension-farmer linkage is an important mechanism to be able to bridge the gap and on-farm demonstration of improved maize variety with associative inputs, including farmers' pieces of training are important to facilitate change in the behaviour of farmers and ultimately bring behavioural changes in favour of improved maize technology adoption and extension package[3]. Therefore, this cluster-based large-scale demonstration was conducted to improve maize productivity by creating awareness of the appropriate application of recommended maize packages and to evaluate farmers' feedback on technology, thereby ultimately enhancing the maize productivity improvement of smallholder farmers.

MATERIALS AND METHODS

Site and farmers' selection: The intervention was carried out in the Sodo District of the Eastern Guraghe Zone during the 2024/25 cropping season. From the district, one representative Kebele (Gambela) was selected purposively based on the production potential for maize. The selection of potential Kebeles was carried out in collaboration with development agents, researchers and experts. From the Gambela Kebele, 17 participant households were selected. Farmers were selected based on, availability and accessibility of land in the cluster. Gender issue was considered during farmer selection (from a total number 30% women and 70% males). Selection of farmers' research extension group (FREGs) members is based on farmers' willingness to be held as members, good history of compatibility with groups, genuineness and transparency to share innovations with other farmers were criteria used to select the hosting farmers. Consequently, one FREG having more than 15 members with the composition of men, women and youth farmers was established. Gender and youth balance in the Farmers Research Extension Group (FREG) unit was again strictly considered. Then, four representative hosting farmers from the FREG were selected. Farmers, research extension group members and other follower farmers are encouraged to participate in the physical activities from the beginning to the end of the demonstration activity. Finally, a total of 17 ha of land was covered in a cluster base at Gambela Kebele of Sodo District.

Implementation procedure: Before starting the activity, formal communication was made with Woreda experts and Kebele development agents. Before accomplishing the precondition, theoretical and on-farm practical training was organized to improve practical skill and attitude and create awareness on participant farmers, development agents, extension experts and researchers. After training farmers prepare their land together at cluster base by sharing experiences. The improved seed was delivered by Worabe Agricultural Research Center on time and fertilizer was prepared by farmers by themselves. The monitoring & evaluation was carried out at important stages with the cooperation of the Central Ethiopia Agricultural Research Institute, Worabe Agricultural Research Center and Woreda experts, Kebele development agents and farmers based on their arranged time. Further, management status of the cluster site was assessed and sequential data were collected. Further, field day and field visit were organized to demonstrate practices at large in the area. During field day and field visit, information dissemination methods such as mass medias (radio and TVs) and printed Medias (brochures & banners) were used for the information flow to the target and non-target population. The responsibility sharing of Worabe Agricultural Research Center was facilitating the logistics and inputs; Woreda experts and development agents were participated by giving the potential Kebele and clustered farmers together with researchers. Agricultural technology transfer and communication researchers participated by giving technical support, training to farmers, Das and Experts and taking feedback; Weed management by farmers; FREG members jointly with DAs of the respective Kebeles conducted periodic follow-up and support to farmers throughout the practices of land preparation to final harvesting.

Agronomic practices and inputs: Before sowing, farmers prepared their land appropriately and row planting of maize was done during the main season using the space between plants and rows (75×25 cm). The variety applied was BH-546, which is currently productive and high-yielding. The packages of technology used for the intervention were recommended seed rate of 25 kg/ha, DAP of 100 kg/ha, Urea 100 kg/ha (urea application after sowing date 35-45 days for the second time applied) and spacing (75×25 cm). Total area coverage was 17 ha.

Responsibility sharing and the way of follow-up: Based on the responsibility sharing example, Worabe Agricultural Research Center facilitates the logistics and inputs, organizes training and field day; district experts and development agents participated by giving the potential Kebele and clustered land together with researchers. Agricultural technology transfer and communication researchers participated by giving technical support, training, taking feedback and creating awareness among farmers, development agents and experts. Land preparation, planting, weed management, data collection and harvesting conducted in a participatory way (researchers, farmers and DAs).

Data collection: Grain yield data were collected through sampling of a (2×2m) using a quadrant five times per hectare by observing farmers' fields. The total number of farmers who participated in extension events such as training and field days was recorded by gender disaggregation. Feedback assessments on farmers' perceptions about the technology were also recorded.

Data analysis: The collected data were organized, summarized and analyzed by using SPSS version 23.0 and the descriptive statistics ($p<0.05$), like minimum, maximum, mean and Standard Deviation (S D). were used. Besides, the perception data is also presented using a perception scoring and ranking method, like a Likert scale.

Awareness creation methods: Awareness was created through giving training for farmers, development agents, experts and researchers. Both theoretical and practical training were given. It was more focused on the agronomic importance of clusters and management practices of wheat technology. Field days play their great role in the demonstration of new technologies because they give the chance for farmers, Das and experts to share experience.

Thus, to demonstrate the technology, field days were arranged and invited farmers, DA, extension experts, leaders and researchers. The total number of participants training at the Sodo District (Table 1) was 75 (male 54 and female 21). The total number of field day participants at the Sodo District was 179 (male 114 and female 35) as shown in Table 1. The field day program included a visit to the fields, in-depth discussions about the activities and reflections from farmers and stakeholders regarding the performance of the BH546 variety with its packages.

The other awareness creation method was a field day, which was organized at the Sodo District with the help of the Worabe Agricultural Research Center and invited key stakeholders to enhance linkage and knowledge sharing among relevant actors.

Farmer's reflection and opinions during the field day: Improved variety BH546 showed promising performance in the study area. They said that the seed source for the next year is secured, which is a disease-resistant, marketable and on behave of their shared experiences. Farmers said that most of the time, maize is attacked by disease, but this year there is no disease attack; especially this year, most of the farmers have no maize even to eat, but we have more than home consumption. Last year, have a fear of risk, but we have learnt how, when and for what purpose we are producing maize. Before this demonstration, there was limited availability of improved maize varieties; yield decreased due to old varieties and there was gap in scientific Knowledge. Farmers have a limited awareness of cluster maize technology production. A cluster-based large-scale demonstration of maize technology can improve the seed shortage and food security of the farmers.

Not only farmers also other stakeholders gave positive response and feedback to the technology and its packages used. As farmers reported, the variety had potential in grain yield, disease resistance and its early maturity was selective. The district experts and DAs explained that this approach encourages research extension linkages to be strengthened. It paves the way to communicate with each other to exchange information from research to DA and farmers (even farmers with farmers).

RESULTS AND DISCUSSION

In this part, about the mean yield, farmers' perception about the technology in Sodo District was discussed as follows: Sample yield estimation was taken from sampled farmers and calculated. A sample was taken from 2×2m area (quadrant). Hence, the mean grain yield was presented in Table 2. As the results shown in Table 2, the mean grain yield of the BH546 variety was 6415 kg/ha in the Sodo District. The above results show the yield potentials of the variety in the study area. This finding is in line with the findings of Abate *et al.*[7], Hailemariam *et al.*[8], Orebo *et al.*[9], Simion *et al.*[10], Muluneh *et al.*[11], Hussain *et al.*[12] and Dembi *et al.*[13]. This means that the findings of the above authors on improved maize variety mean grain yields were near to this study. The mean grain yield of BH546 was recorded at the Sodo District, which was greater than the national average yield, the District's productivity and can produce beyond that BH546 variety in the study area performed uniformly at almost all the farmers' fields.

The mean grain yield of the maize variety (BH546) at the Sodo District in kg/ha. This is to make things clear to understand for reader. The minimum and maximum yields of the maize BH546 in Sodo District were 5225 and 7275 kg/ha, respectively. The mean grain yield of the BH546 variety was 6415 kg/ha as.

Table 1: Participants of awareness creation methods at the Sodo District

Awareness creation methods	Participants	Participants by gender category M	F	Total
Training	Farmers	43	19	62
	DAs	2	2	4
	Woreda experts	4	-	4
	Researchers	5	-	5
Total		54	21	75
Field day	Central Ethiopia Agricultural Research Center	12	-	12
	Central Ethiopia Regional State Agricultural Office	1	-	1
	Debub TV	2	-	2
	Extension expert from Eastern gurage zone	1	-	1
	Worabe Agricultural Research Center	17	-	17
	From Sodo Woreda Agricultural Office and Woreda Leader	5	-	5
	Sodo Woreda gov't media of communication	2	-	2
	DA	1	2	3
	Farmers	73	33	106
Total	114	35	149	

Table 2: Grain yield of maize at Sodo District in kg/ha

Participants	Grain yield of maize BH546 at Sodo District kg/ha
F1	59.15
F2	68.25
F3	65.75
F4	58.75
F5	52.25
F6	72.75
F7	71.55
F8	66.5
F9	69
F10	57.5
Minimum	5225.00
Maximum	7275.00
Mean	6415.00
Standard deviation	645.00

This implies that the variety BH546 performed well in the study area. The variation of the grain yield was observed across farmers due to the differences between farmers based on their knowledge, managements of their field, as their thinking and commitment differs. Some farmers know the sowing time very well; planting maize untimely can affect the grain yield of the maize. Even though the farmers' skill of production differs, the gap in the grain yield of this study was not as high. This means that there is no statistically significant difference between the yields. Therefore, for the cluster-based large-scale demonstration intervention, farmers should share experiences, team spirit, time and help each other's sowing at the same time to bring a near-uniform grain yield. These ways of working can help reduce the gaps between the farmers.

Farmers' perceptions about the technology: Farmers have a broad knowledge base; they lack control treatment for comparison and statistical tools to test the hypothesis and perception about demonstrated variety was consulted based on the desired criteria by themselves. Farmers appreciated different stakeholders who supported them during the work carried out and said that support from other crops, NRM and Livestock parts for the future. The way the cluster demonstration was very effective in popularizing the new technology in an observable way. The main farmers' feedback and interesting thing is that working in clusters helps as making team spirit in their work as well as thinking. One of the special characteristics of the BH546 variety was clothing the cob to protect the rain entrance. Due to this, the cluster working helped them to help each other and learning each other in the field as shown below (Table 3). According to farmers' perspectives, all farmers strongly agree on early maturity, good disease

Table 3: Farmers' perception regarding the CBLSD of maize technology at Sodo District

	Responses (Sodo District N=17, Variety =BH546)					
Items	Strongly agree	Agree	Disagree	Strongly disagree	Mean score	Rank
Grain yield	17	0	0	0	4.00	1st
Early maturity	12	5	0	0	2.82	6th
Seed per cobe	13	4	0	0	3.05	5th
Disease tolerance	14	3	0	0	3.29	4th
Lodging resistance clothing the rain	11	5	1	0	2.58	7th
Enterance to the cobe	16	1			3.76	2nd
Marketability	15	2	0	0	3.52	3rd

resistance, good quality market demand and good grain yields (perception score of 4 = strongly agree, 3 = agree, 2 = disagree and 1 = strongly disagree). Farmers' perceptions regarding the cluster-based large-scale demonstration of maize technology were positive perception as shown below (Table 3). Theoretical and practical training for farmers was given to create awareness and which increased the acceptance levels of farmers. The only challenge was the differences in the adoption levels and which were reduced by creating awareness among the farmers.

Experts stated that the improved maize variety showed a high yield and that the better practice assisted farmers in increasing the production of maize in the area. Early planting of maize enabled the farmers to produce twice per year means the cluster is free for chick pea. The demands about the technology already created, so expanding the technology to other possible districts and Kebeles is very simple. Researchers also suggested that strengthening the linkage between the institutional and farmers' sides is very important to sustain the technology in the future.

Farmers, DAs, experts and researchers learn from each other. From farmers, the researcher gets the traditional knowledge b/c farmers are more experienced (e.g, time of sowing). Also, researcher supports by sharing scientific knowledge. Farmers learned the importance of cluster, agronomic practices for the production of improved maize technology. Farmers learned about the amount of input utilized per hectare and the spacing between plants and rows. Furthermore, they learnt about the general techniques of land preparation and harvesting, as well as the study area's planting and harvesting times. Following these processes, the lessons learned from the demonstration were successful, as evidenced by the high output.

CONCLUSION

The BH546 maize variety demonstrated superior performance across farmers' fields in the Sodo District, surpassing both national and local yield averages. Farmers responded positively to the technology, indicating strong potential for adoption. Institutional collaboration among research centers, unions, experts and extension agents is essential for sustaining and scaling this success. Strengthened technical support and seed multiplication by unions are critical to ensure accessibility. Therefore, BH546 is recommended for wider adoption in Sodo and similar agro-ecological zones to boost maize production.

SIGNIFICANCE STATEMENT

This study identified the improved maize variety 'BH546' and its associated production package as top-performing under cluster-based demonstration, which could be beneficial for enhancing maize productivity in the study area and similar agroecological zones. This study will assist researchers in uncovering critical areas of variety adaptability and technology dissemination that have remained unexplored by many. Consequently, a new theory on sustainable crop intensification in clustered farming systems may be developed.

ACKNOWLEDGMENT
I would like to acknowledge the contributions to our design and testing of cluster based large scale demonstration of maize technology by the help of the agricultural technology transfer and communication department researchers, Sodo District extension experts, development agents and farmers.

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