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Participatory Demonstration and Evaluation of Open Pollinated Maize (*Zea mays L.)* Technologies for Mid-altitude Areas of Western Guji Zone, Southern Oromia, Ethiopia

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Abstract

This research activity was conducted in the West Guji zone, Abaya district for two consecutive years (2021 to 2023) to demonstrate and evaluate the productivity and profitability of the improved maize varieties, improve farmers' knowledge and skills, and enhance linkage among relevant stakeholders. Abaya district was selected purposively based on its potentiality for maize production with the district of agricultural office. The research activity was conducted on 10 farmers' fields, with 5 each at two kebeles, Bunnata and Guanga Badiya. Two improved OPV maize varieties (Kulani and Gibe-2) together with the standard local check were planted on a plot size of 10m * 10m (100m^2) located adjacently side to side. A recommended seed rate of 25 kg/ha, and spacing of 75 cm between rows and 25 cm between plants, and a fertilizer rate of 100 kg/ha NPS were used. All the agronomic practices were applied equally for the three maize varieties. Yield data was collected and the result indicated that Kulani gave a higher yield (32.4 qt/ha) followed by Gibe-2 (30.9 qt/a) while the lowest yield data was recorded from the local variety (18.7 qt/ha). In terms of the profitability of the demonstrated maize varieties, the financial analysis results show that participants farmers obtained a net profit of 94,891, 89,641, and 37,530 ETB per hectare from Kulani, Gibe-2 and local varieties, respectively, in one production season. Therefore, both the Kulani and Gibe-2 maize varieties were recommended for further scaling up in the Abaya district and areas with similar agroecologies.

Keywords

Demonstration, Evaluation, Profitability, Kulani, Gibe-2

1. Background and justification

Maize (*Zea mays L.)* is known as corn, belongs to the family *Poceaceae,* and is a versatile crop that adapts easily to a wide range of production environments [1, 2]. Maize is the third among cereals and the most important crop in the world in terms of growing area, production, and grain yield after wheat and rice [3] and it is an important basic crop of trade product and a recurring ingredient for millions of people in sub-Saharan Africa [4]. Maize is a multipurpose crop that acclimates effortlessly to a wide variety of production set of conditions. Maize occupies a crucial role in the world economy and is traded widely. Maize demand is proposed to increase by 50% worldwide and by 93% in sub-Saharan Africa between 1995 and 2020 [5].

Maize is one of the staple foods in Ethiopia, whose importance in consumption as well as production has significantly increased. In Ethiopia, among cereal crops maize ranks first and second in terms of the total grain production and area of production coverage, respectively [6]. Despite its importance and area coverage, the productivity of maize is still very low due to drought, declining of soil fertility, lack of improved seeds, poor agronomic practices, diseases, insect pests, and weeds [7]. As a result, there is a need to enhance maize production in Ethiopia in general and in the study area in particular.

1.1 Statement of the problem

In mid-highland altitude districts of West Guji Zone maize is one of the major staple food crops grown widely where local late-maturing varieties are dominant. In the area, maize production is still very low due to a lack of improved seeds, drought, disease and pest infection, weeds, and poor agronomic practices. Based on the above problems, the Yabello Pastoral and Dry Land Agriculture Research Center has undertaken an adaptation trail of different maize varieties in different districts of the West Guji Zone for two consecutive years, starting from 2015 to 2016. The result of adaption trials indicated that maize varieties, namely Kulani (5.63*t/ha)* and Gibe-2 (5.85*t/ha*) were highly preformed and high yielders on station and were recommended for Galana and Abaya respectively [8]. The study conducted so far by YPDARC was only emphasized on the station. Therefore, this specific activity is initiated to fill this research gap with the following objectives.

1.2 General objective

The overall objective of this study is to demonstrate and evaluate improved maize varieties in the selected district of West Guji Zone.

1.3 Specific objectives

The specific objectives of the study are:

- To evaluate the productivity and profitability of the improved maize varieties under farmers' conditions in the study area.
- To improve farmers' knowledge and skill of production and management of the improved maize varieties in the study area.

2. Materials and methods

2.1 Description of the study area

Abaya district is located 365 Km from Addis Ababa to the south direction. Abaya is found at 6^0 $14'_N$ latitude and $30^0 10'_E$ longitude. The altitude of the district ranges from 1200-2060 masl. It has an estimated average annual rainfall of about 1223 mm and therefore the average annual temperature ranges from 16^0C–28^0C. It is bounded by regional states of Nations, Nationalities, and people of southern Ethiopia in the North and East, Lake Abaya to the West, and Galena district in the South. The sole two types of agro-climatic conditions of the district are the mid-highlands and lowlands. About 30% of the entire area of the district falls under mid-highlands. The remaining 70% falls under lowlands agro-climatic conditions. According to the soil map of Borena Zone, the soil units of Abaya district are calcaric and euricfluvi sols, euricnitosols, and chiromic and orthicluvis sols. Of these, the first two categories of soils (calcaric and euricfluvi sols) covered the largest part of the district. The main crops produced in the district were maize, barley, 'teff', sorghum, common bean, wheat, field pea, and fava bean [9].

2.2 Site and farmer selection

This research activity was carried out in the two kebeles of the Abaya district of West Guji Zone. Two potential maize-producing kebeles (Bunnata and Gaunga Badiya) were selected from the district purposively in collaboration with experts and development agents of the Abaya district agricultural office based on the potentiality for maize production and accessibility to road. From each kebele, one FRG (Farmers' Research Group) member considering gender consisting of 15 members was established at each kebele and FRG with a member of 15 (3 male trial farmers and 2 trial farmers) and 10 other farmers working with trial farmers. The selection criteria of members of FRG farmers were based on their interest in technology, willingness to manage and provide land for demonstration, sharing the knowledge for both participant and non-participant farmers, and the like.

2.3 Training

After selecting farmers, Participatory training composed of theoretical and practical sessions was given to the selected farmers by a multidisciplinary team of Yabello Pastoral and Dryland Agriculture researchers (Breeder, Agronomist, Economist, and extensionist) on the importance of technology, production, and management packages including fertilizers application, the appropriate amount of seed rate, distance between rows and plants and creating strong linkage among relevant stakeholders.

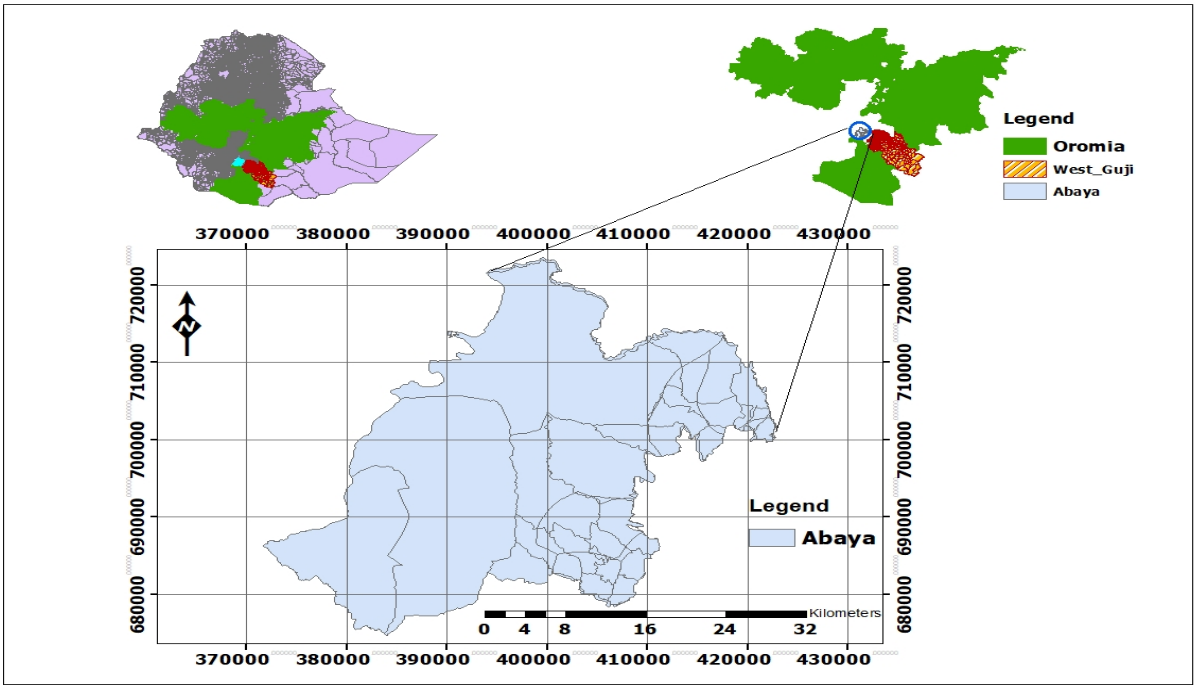

Figure 1. Map of the study area.

2.4 Research design

Two improved maize varieties, Kulani and Gibe-2 with one standard local variety, replication-replicate across five trial farmers per kebeles. Accordingly, Kulani and Gibe-2 with one standard local variety were planted on a plot size of 10m x 10m (100m^2) of land on each of the 10 farmer's fields. A seed rate of 25kg/ha and 100kg NPS/ha was used with a line spacing of 75cm and 25cm between plants and rows respectively. All agronomic management practices were equally applied for both improved and local varieties. Accordingly, a total of 30 farmers were reached through this demonstration.

2.5 Technology evaluation and demonstration methods/techniques

The evaluation and demonstration of the trials were implemented on farmers‟ fields to create awareness about the maize varieties. The evaluation and demonstration of the trials followed the method demonstration approach by involving Farmers' Research Extension Groups (FREGs), development agents, and experts at the different growth stages of the crop. The research activity was jointly monitored and evaluated by FREGs, researchers, experts, and development agents.

2.6 Monitoring and evaluation methods

The research activity was monitored and evaluated jointly by researchers from Yabello Pastoral and Dryland Agriculture Research Center and Development Agents (DAs), Subject Matter Specialists (SMS) from the Abaya district Agricultural Office, and selected model farmers on which research activity was conducted. The DAs see and monitor the activity day to day since they are nearer to the farmers' jurisdiction and also give technical assistance to the farmers. Joint monitoring and evaluation of the activities were conducted among the participating farmers of the districts based on the necessities and requirements. As a result, DAs, SMSs, and researchers offered advice based on the practical problem observed on the trial sites.

2.7 Data collected and method of collection

The types of data collected included yield data, changes in the level of knowledge and skill of farmers, the total number of farmers who participated in extension events: training, field visits, and field days, and stakeholder participation. Appropriate data collection methods (preparing checklists, Focus Group discussions, personal observation, field days,) were employed to collect both qualitative and quantitative data.

2.8 Method of data analysis

Farmer's preference was analyzed qualitatively and agronomic data was analyzed using SPSS version 20. Quantitative data was summarized using simple descriptive statistics (Mean, Frequency, and Percentage) and SPSS software version 20 while the qualitative data collected using group discussion and key informant interviews, field observation, and oral histories was analyzed using narrative explanation. Simple financial analysis was used to evaluate whether the technology was financially feasible or not in the study area and to analyze the costs incurred and the net benefit gained from the production of each variety and location used for the demonstration using Excel and presented by table. Moreover, a simple knowledge test was also used to compare agro pastoralists' knowledge levels before and after the demonstration period related to the newly introduced maize varieties. One-way ANOVA was employed to analyze whether there is a statistically significant mean difference in yield (qt/ha) or not among the three demonstrated OPVs (Kulani and Gibe-2) and standard local check maize varieties.

2.9 Yield advantage

The yield advantage of improved maize varieties over commercial varieties was calculated using the formula suggested by [10] technology gap and technology index as follows:

$$Yield\ advantage\ of\ new\ variety = \frac{\text{Yield of new variety} - \text{Yield of commercial variety}}{\text{Yield of commercial variety}} \times 100$$

3. Results and discussion

3.1 Yield performance of the demonstrated varieties

Table 1 presents the yield performance of the demonstrated varieties (Kulani, Gibe-2, and local) across the kebeles. Accordingly, the yield performances of Kulani, Gibe-2, and local standard check varieties were 32.4, 30.9, and 18.7 qt/ha respectively.

The result of one-way ANOVA revealed that there are statistically significant mean differences (F (2), 27) among the three demonstrated OPV maize varieties (Table 2). Moreover, Tukey's HSD post hoc multiple comparison tests showed that Kulani and Gibe-2 had significantly higher ($p < 0.05$) mean yield (qt/ha) compared to the local variety, while no significant difference ($p > 0.05$) was observed between Kulani and Gibe-2 (Table 1). As a result, Kulani gave the highest yield followed by Gibe-2 while the local variety gave a lower yield compared to both improved maize varieties. This study is consistent with the findings of [11] and [12] who found that improved varieties were significantly higher yielders compared to local checks.

On the other hand, the yield performances of the demonstrated improved OPV maize (Kulani and Gibe-2) varieties were below the adaptation trial yields (Figure 2). This might be justified by the drought that occurred at the time of the demonstration.

Table 1. Performances of the demonstrated OPV maize varieties across kebeles

Varieties	N	Mean	Minimum	Maximum
Kulani	10	32.4±3.41**a**	26.5	37.0
Gibe-2	10	30.9±2.64**a**	25.8	34.2
Local	10	18.7±1.46**b**	16.0	21.0
P-value		0.001		

Key: Mean with different superscript letters along the column were significantly different ($p<0.05$). Source: Own computation, 2023

Table 2. One Way ANOVA's results of the demonstrated OPV maize varieties

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1121.361	2	560.680	81.165	0.001
Within Groups	186.513	27	6.908		
Total	1307.874	29			

Source: Own computation data, 2023

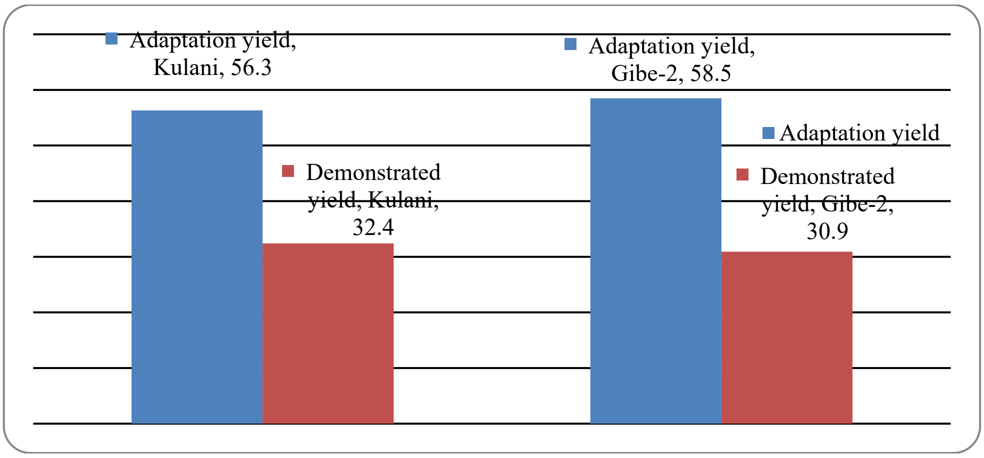

Figure 2. Yield performances of the demonstrated OPV varieties versus adaptation yield.

3.2 Yield advantage of the two OPV maize varieties over the local check

The calculated technology index percentage of yield advantage of the two OPV (Kulani and Gibe-2) maize varieties showed that they have 73.3 and 65.2% yield advantage over the local variety, respectively (Table 3). This study is similar to the previous findings of [11] and [12] who reported that an improved maize variety had more yield advantage over the local check.

Table 3. Yield advantage of the two OPV (Kulani and Gibe-2) maize (in %) over the local variety

Demonstrated varieties	Yield obtained (Qt/ha)	Yield advantage over local variety (%)
Kulani	32.4	73.3
Gibe-2	30.9	65.2
Local	18.7	-

Source: Own computation, 2023

3.3 Financial analysis of the demonstrated improved maize varieties

Table 4. Financial analysis of demonstrated OPV maize and local at Abaya district (2023)

Parameters	Varieties		
	Kulani	Gibe-2	Local
Yield qt/ha (Y)	32.4	30.9	18.7
Price(P) per quintal	3,500	3,500	3,000
Total Revenue (TR)=TR=Y*P	**113,400**	**108,150**	**56,100**
Variable costs			
Seed cost	3,439	3,439	3,500
Fertilizer cost	2,470	2,470	2,470
Herbicide cost	600	600	600
Labor (weeding, harvesting, and threshing) costs	8,000	8,000	8,000
Total Variable costs (TVC)	**14,509**	**14,509**	**14,570**
Fixed Costs			
Cost of Lands	4,000	4,000	4,000
Total Fixed Costs (TFC)	**4,000**	**4,000**	**4,000**
Total Cost (TC) =TVC+TFC	18,509	18,509	18,570
Gross Margin (GM) = TR - TVC	98,891	93,641	41,530
Profit=GM-TFC	**94,891**	**89,641**	**37,530**

Source: Own computation data, 2023

Production costs and return from improved OPV maize production were calculated by deducting total cost from total revenue. The production cost included variable costs (seed cost, labor cost, fertilizer, and herbicide costs) and Fixed costs (cost of land). The calculations were done by converting all the parameters per hectare. The final selling price used was the farm gate selling price during the harvest season. Accordingly, in terms of the profitability of the demonstrated maize varieties, the financial analysis result shows that participant farmers obtained a net profit of 94,891, 89,641, and 37,530 ETB per hectare from Kulani, Gibe-2 and local varieties, respectively, in one production season (Table 4). Therefore, the study suggests that using these two improved maize varieties (Kulani and Gibe-2) would increase their production and be economically profitable in the future. This study confirmed the previous findings of [11] who found that an improved maize variety was economically profitable for farmers compared to the commercial variety.

3.4 Capacity building

3.4.1 Training

Table 5 presents the number of agriculture experts, Development agents, farmers, and other participants who attended training on maize production and management before starting the research activity. A total of 41 participants: 19 and 22 attended the training in the 2021 and 2022 cropping seasons. Out of the total participants, female participants accounted for 34.15% while the remaining 65.85% were male participants.

Table 5. Types of the profession and number of participants who attended training on maize production across the year (2021 to 2022)

Stakeholders	Years						Grand Total
	2013			2014			
	Male	Female	Sub-total	Male	Female	Sub-total	
Experts	2	1	**3**	3	1	**4**	7
Development Agents (DA's)	2	1	**3**	2	2	**4**	7
Farmers	7	3	**10**	7	3	**10**	20
Others	2	1	**3**	2	2	**4**	7
Total	13	6	**19**	14	8	**22**	**41**

3.5 Farmers' feedback on demonstrated maize varieties

Farmers have their own criteria to select a certain variety based on their long farming experience. At the time of harvest, farmers were allowed to set their criteria after having know-how about the varieties. The criteria set by farmers were early maturity, yield, disease tolerance, seed color, taste, and seed size. Though Kulani was higher than Gibe-2, based on the criteria they set, farmers selected Gibe-2 for its early maturity, disease tolerance, seed color, and seed size and recommended further scaling up. Kulani was ranked second based on their criteria.

Table 6. Rank of demonstrated maize varieties based on farmers' criterion

No	Crop varieties	Rank	Reasons
1	Gibe-2	1st	Early maturity, High yielder than local, Disease tolerant, seed color, taste, and seed size
2	Kulani	2nd	High yielder compared to both Gibe-2 and local, Seed pod
2	Local	3rd	Low yielder, late maturity, and susceptible to disease, small seed size

Source: Own data computation, 2022

Table 7. Pair ranking results to rank the variety traits in order of their importance

Code no	traits	Yield	Disease tolerant	Maturity	Seed size	Seed color	Taste	Frequency	Percentage (%)	Rank
1	Yield		1	3	1	1	1	4	23.5	2nd
2	Disease tolerant			3	2	2	2	4	23.5	2nd
3	Maturity				3	3	3	5	29.4	1st
4	Seed Size					5	5	2	11.8	3th
5	Seed color						6	1	5.9	4th
6	Taste							1	5.9	4th
	Total							17	100.0	

Source: Own data computation, 2022

3.6 Knowledge level before and after the demonstration

The knowledge level and skills of experimental farmers on the production of demonstrated OPV maize varieties before conducting the demonstration and after implementation were measured and compared. For this research purpose, simple yes or no questions were designed and farmers were asked to rate their level of knowledge before and after the demonstration period. All 8 (eight) surveyed farmers were subjected to the same questions on both occasions. The questions were asked during the training period before starting the experimental demonstration and after the completion of the experiment.

Based on the result of the survey, before the experiment only 37.5, 12.5, 25 and 37.5 % of farmers had information, knew the importance, knew the recommended spacing between plants and rows, seed and fertilizer rate per hectare, and knew the weeding frequency, full package agronomic practices, pre and post harvesting management regarding the demonstrated OPV (Kulani and Gibe-2) maize varieties, respectively. However, after the research demonstration intervention 87.5, 100, 75 and 62.5% of participating farmers responded as they had information, knew the importance, knew the recommended spacing between plants and rows, seed and fertilizer rate per hectare, and knew weeding frequency, full package agronomic practices, pre and post harvesting management regarding the demonstrated technologies due to their participation on the training of maize production from the start of the research activity to harvesting and threshing. Significance changes in the level of knowledge and skills could justified by the fact that theoretical and practical training for farmers and their active participation in result demonstration. This result is in line with the findings of [12, 13].

Table 8. Farmers' knowledge and skill before and after demonstration (N-8)

Statement	Before demonstration		After demonstration	
	Yes (%)	No (%)	Yes (%)	No (%)
Had information about improved OPV maize varieties	3(37.5)	5(62.5)	7(87.5)	1(12.5)
Know about the importance of OPV maize varieties	1(12.5)	7(87.5)	8(100)	0 (0)
Know the recommended spacing between plants and rows, seed and fertilizer rate per hectare	2(25)	6(75)	6(75)	2 (25)
Know weeding frequency, full package agronomic practices, seed preferences, pre and post-harvesting management	3(37.5)	5(62.5)	7(87.5)	1 (12.5)

Key: Numbers outside and inside the brackets indicate the number and percentage of participating farmers and their responses, respectively.

Source: Own survey result, 2022-2023

4. Conclusion and recommendations

The demonstration of two OPV-Open Pollinated maize (Kulani and Gibe-2) and one local variety were conducted at the Abaya district of the west Guji zone for two consecutive years (2021 to 2023) to evaluate the productivity and profitability and identify the best-performing maize and enhance farmers' knowledge and skill on the application of new technologies. The result of the study showed that Kulani (30.4 qt/ha) and Gibe-2 (30.9 qt/ha) were significantly high yielders compared to the local check maize variety (18.7 qt/ha) for the lowest yield was recorded. Though Kulani was a relatively high yielder than Gibe-2, Gibe-2 was preferred first for its early maturity, disease tolerance, seed size color, and taste. The knowledge and skills of farmers were enhanced through training and extension visits. In terms of profitability, the financial analysis result indicated that a net benefit of 94,891, 89,641, and 37,530 ETB/ha would be obtained from Kulani, Gibe-2, and the local standard check maize varieties respectively. Therefore, the study recommends *Kulani and Gibe-2* for pre-scaling in the Abaya district in particular and other similar agroecologies in general.

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