Advances in Crop Science and Technology

ISSN: 2329-8863

Research Article

Participatory On-Farm Evaluation and Demonstration of Improved Lowland Maize Varieties in Southern Ethiopia

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Abstract

The Maize is one of the most important cereal crops in terms of area coverage, the volume of production, and its economic importance regarding food security in Ethiopia. Participatory on-farm demonstration and evaluation of lowland maize varieties were conducted with their full packages at Melokoza district and Basketo Special district, Southern Ethiopia. A gender-inclusive farmer research group (FRG) was formed in each kebele before the start of demonstration work. Capacity-building training was delivered to FRG members and extension agents on maize agronomic practices. A single plot design (side-to-side) was used on the 10m*10m size of the area for each variety (MH130 and MH140) on each selected farmer land and farmer training center (FTC). Participatory Rural Appraisal (PRA) tools such as pair-wise and direct matrix ranking methods were adopted during technology demonstration and evaluation. At physiological maturity, farmers' field day was organized and technology was promoted through using different media outlets. Averaged across locations, the grain yield of MH130 and MH140 varieties were 49.3 Qt ha-1 and 42.75 Qt ha^{-1}, respectively. The MH130 variety has a 22.1% higher economic benefit than the MH140. Moreover, MH130 was ranked first in terms of drought tolerance, yield, pest and disease resistance, earliness, seed size, plant height, and marketability. Therefore, MH130 was recommended for further scaling up in the study area and other similar agro-ecologies.

Keywords: Proliposomes; On-farm evaluation and demonstration; Farmers; Matrix-ranking; Preference criteria; Maize

Introduction

Feeding the mushrooming world population without affecting the ecosystem is the most important challenge of our time [1]. Global food production needs to double by 2050 to meet the escalating demand posed by population growth and increased demand for biofuels [2, 3]. According to [4], world cereal production is increased by 3.2-folds from 1961 to 2015. This is due mainly to the intensified use of chemical fertilizer, high yielding variety, pesticides, and irrigation water Although the green revolution that transformed Asian agriculture did not bring apparent impacts for African agriculture due to a couple of factors. Thus, the issue of food insecurity remains a hot policy agenda in the continent. The fertilizer use is undoubtedly low. It seldomly exceeds 20 kg ha^{-1}. The reason for the inadequate use of chemical fertilizer is related to the high cost of fertilizer and its inaccessibility and unavailability at the right time and place, a weak fertilizer market, limited access to credit and input services, and weak extension systems [5, 6].

Ethiopia is the second-most populous and land-locked country in Africa with a population size of above 110 million and food security is an enduring critical challenge. The agriculture sector is mainly dominated by smallholders who cultivate an average landholding of less than one hectare. Maize is among the important cereal crops in terms of area and volume of production and is used as food for man, feed for animals, and source of energy (bio-fuel) [7]. It ranks first in production and productivity and second in the area of production after Teff (*Eragrostis tef*) [8]. Because of its importance in terms of wide adaptation, total production, and productivity, maize has been selected as one of the high-priority crops to feed the increasing population of Ethiopia. Its productivity showed an increasing trend with time since the mid-1990s. This is due mainly to the wide adoption of improved seeds, improved access to extension services, and market information, to mention a few. Despite the importance of maize as a principal food crop, its national average yield is lower i.e., about 4 t ha-^{1} as compared to the world average of 5.82 t ha-^{1}. The data showed that the area coverage and total production of maize exceeded 2.2 million hectares and 9.6 million tons, respectively, while the productivity is about 4.2 t ha^{-1} by 2019 (Figure 1) [9]. Also, there is a wider gap between actual and potential maize yield [10].

In Southern Ethiopia, maize is among the most important food crops. Its grain is consumed in different forms of food, while its stover is used as animal feed, fuel for cooking, organic fertilizer, and construction materials. However, its production and productivity are limited by several biotic and abiotic factors. The reason is soil quality deterioration due to inadequate fertilizer consumption and the use of low-yielding varieties [11]. The study conducted in South Ethiopia revealed that inherent soil fertility, limited access to improved agricultural inputs, pests and diseases, erratic rainfall, and poor field management practices are potential factors affecting crop production and productivity [12]. Involving farmers and incorporating their need and perception during technology design and development is the most important steps to enhance agricultural technology adoption and diffusion. Moreover, growing high-yielding and tolerant maize varieties are key to guaranteeing sustainable production and ensuring food security. Despite its suitable agro-climatic conditions, maize production and productivity in the Basketo special district and Gamo Gofa zones are markedly constrained by limited accessibility of improved agricultural technologies, particularly in lowland areas.

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Received: 3-Mar-2022, Manuscript No: acst-22-53285, **Editor assigned:** 6-Mar-2022, PreQC No: acst-22-53285 (PQ), **Reviewed:** 11-Mar-2022, QC No: acst-22-53285, **Revised:** 17-Mar-2022, Manuscript No: acst-22-53285 (R), **Published:** 25-Mar-2022, DOI: 10.4172/2329-8863.1000499

Citation: Yokamo S (2022) Participatory On-Farm Evaluation and Demonstration of Improved Lowland Maize Varieties in Southern Ethiopia. Adv Crop Sci Tech 10: 499.

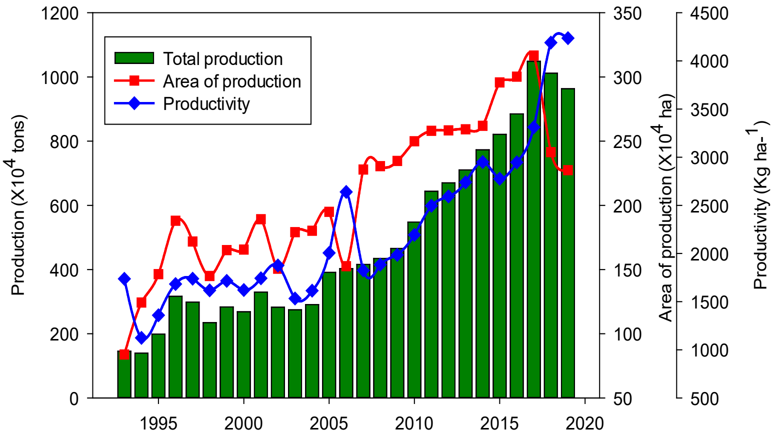

Figure 1: Maize yield (kg ha^{-1}), total production (x10^4 tons), and area coverage (x10^4 ha) in Ethiopia from 1993-2019. Adapted from the FAOSTAT database.

Therefore, drought-tolerant lowland maize varieties were demonstrated with the objectives of evaluating their productivity and profitability and farmers' preference for varietal attributes on selected farmer land and FTCs.

Material and methods

Description of the study area

Melokoza district is located in the southwestern part of Ethiopia in the Gofa zone of South Nation Nationalities and People Regional State region (SNNPR). It is located 661 km away from Addis Ababa. The altitude ranges from 505-2500 m.a.s.l. The district has 39 *kebeles* (37 rural and 2 peri-urban). According to the Melokoza office of Agriculture, the total population of the district is 152,502. Among these, 75,194 are male and 77,308 are female. The total household of the district is 28,936, of which 3077 are female-headed and 25,859 are male-headed. The mean annual precipitation is 1125 mm with a minimum and maximum of 750 and 1500 mm, respectively. Mean annual temperatures range from 15.1^{0}C and 27.5^{0}C. Maize, wheat, sorghum, teff, sesame, faba bean, common bean, banana, and coriander are among the widely grown crops for food and income generation.

Basketo special district is located in the southwestern part of Ethiopia adjacent to the Melokoza district in the SNNPR. It is located 626 km away from Addis Ababa. The altitude ranges from 780-2200 m.a.s.l. The mean annual precipitation and temperature are 1200 mm and 21^{0}C, respectively (unpublished, 2010). The district has three agro ecological zones; highland (1%), lowland (54%), and midland (45%). Similarly, Maize, wheat, barley, sorghum, teff, faba bean, sesame, common bean, banana, and coriander are among the widely grown crops for food and income generation.

Site and beneficiary farmers selection

The demonstration work was conducted in Agricultural Growth Program-II (AGP-II) beneficiary areas of the Basketo Special and Melokoza districts. Two Kebeles (peasant association) from each district (a total of four kebeles) were purposively selected such as Angla-3 and Angla-4 from the Basketo special district and Salaysh-1 and Salaysh-3 from Melokoza district based on its potential of maize production. In each operational Kebele, farmer research group (FRG) was established, which includes 30% of women households. Sixteen farmers were selected to conduct the demonstration work on their field in collaboration with researchers, extension agents, and FRG members by taking into consideration the farmers' interests and motivation, land ownership, and other important socio-economic aspects. The host farmers, FRG members, and extension personnel were delivered capacity-building training on maize agronomic practices. A two-way communication approach was followed during the delivery of training for sharing their knowledge and experiences.

Planting materials and field design

All the necessary inputs were delivered to the farmers from Arbaminch Agricultural Research Center (seed, fertilizer, etc.). Two lowland varieties of maize (MH130 and MH140) were used for this demonstration work with the recommended fertilizer rate of 100 kg ha^{-1} NPSB and 100 kg ha^{-1} UREA. All the NPSB is applied during planting time as basal fertilizer, whereas one-third of the area was applied during planting and the remaining two-thirds at the knee height stage. A single plot design (side-to-side) was used on the 10m*10m size of the area for each variety at each selected farmer land and FTC. Planting was done within the same week by keeping a spacing of 75cm*25cm between row and plant.

Description of the varieties

Both varieties (MH130 and MH140) were released by Melkassa Agricultural Research Center in 2012 and 2013, respectively. The MH130 was recommended for dry areas and MH140 was recommended for wet and dry mid-altitudes [13]. The yield potential (research station) of MH130 and MH140 were 6-7 t ha^{-1} and 8.5 to 9.5 t ha^{-1}, respectively.

Technology evaluation methods and data collection

FRG members, model farmers, and other farmers who reside in the communities were invited to visit the demonstration plot and evaluate the crop performance at the different plant growth stages. PRA tools such as pair-wise ranking and direct matrix ranking were adopted for the evaluation and ranking of important maize attributes by farmers.

Data collection

Both quantitative and qualitative data were collected from primary and secondary sources. Structured field assessment, checklist, and focused group discussion methods were adopted to collect all the relevant data. At physiological maturity, maize is harvested from whole plots and grain yield was measured after drying at an optimum moisture level. The direct cost-benefit analysis was calculated by summing all the costs and gains during the demonstration period.

Net benefit = total gain – total cost (1)

Data analysis

An independent t-test was employed to check the statistical differences between varieties. The collected data were subjected to SPSS version 22.0 and illustration figures were drawn using sigma plot version 12.5.

Results and discussion

Grain yield

The result of the grain yield revealed that there was statistical variation among varieties (Figure 2). Overall, the average grain yield was 49.3 Qt ha^{-1} for MH130 and 42.75 Qt ha^{-1} for MH140 variety. Specifically, MH130 could increase grain yield by 21.3%, 11.8%, 12.3%, 14.3% at Angla-3, Angla-4, Salayish-1, and Salaysh-3 sites over MH140 variety, respectively. Averaged across four locations, MH130 could increase grain yield by 15.4% over the MH140 variety. The observed significant difference among varieties may be related to genetic variation. In line with the present finding, [14] reported that MH130 yields about 6.55 t ha^{-1}, which was significantly higher than MH140 (50.02 Qt ha^{-1}) and MHQ138 (50.8 Qt ha^{-1}) in Southern Oromia. In contrast with our results, [15] reported that MH140 variety could give a significantly higher yield over MH130 variety in two different locations. [13] Seconded that MH140 produced a higher grain yield (34.6 Qt ha^{-1}) than MH130 (27.06 Qt ha^{-1}) in the West Hararghe Zone. However, both MH130 and MH140 varieties were suggested for further scaling up due to their better performance in south Ethiopia [16].

Organization of field day

Farmers' field day was organized at the maize physiological maturity stage in all locations and different stakeholders participated in the field day. Furthermore, a constructive discussion was held between farmers, researchers, and other officials before, during, and after the demonstration program. Different media outlets were used to promote technologies.

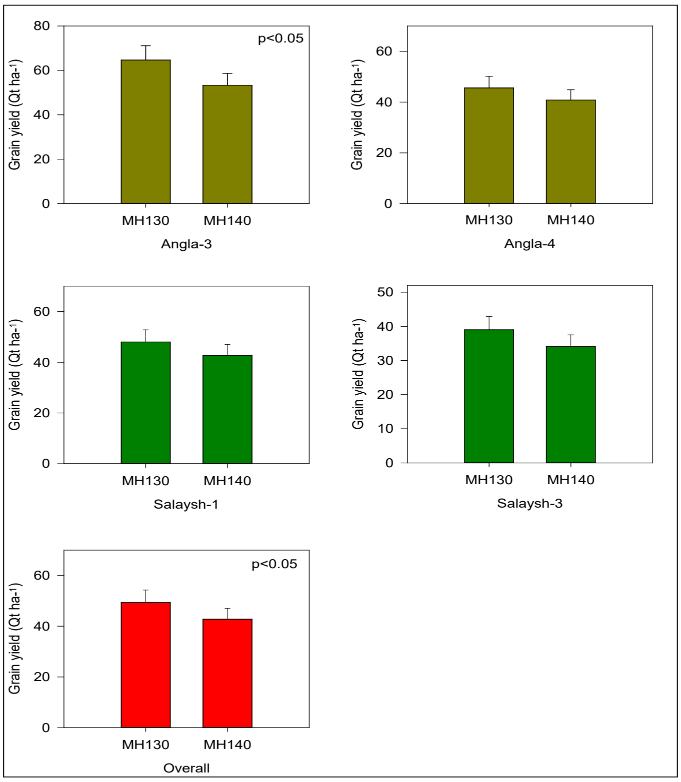

Figure 2: Maize grain yield at Basketo special and Melokoza districts in 2017/18. (*Note*: Qt ha^{-1} is quintal per hectare; 1 Qt = 100 kg).

Variety evaluation and selection

Technology generation and varietal improvement are adopted as the main national strategies for food security and agricultural growth [17]. Participating farmers in the varietal selection process are important to get the right feedback on the performance of variety and deepen its adoption [18]. In the present study, variety preference by farmers depending on different criteria is one of the important parts. Farmers were actively participated and observed the performance of each variety during the demonstration. Before the beginning of pair-wise ranking, participant farmers from each Kebele were asked to set the most important selection criteria regarding maize traits. The selection criteria were based on an extensive discussion and agreement by farmers themselves and researchers have recorded each criterion. Accordingly, yield, drought tolerance, pest and disease tolerance, early maturity (earliness), seed size, plant height, and marketability were identified as the potential criteria. Then, the pair-wise ranking was employed to rank each criterion based on its importance (Table 1). Accordingly, drought tolerance, yield, earliness, and disease and pest resistance were ranked by farmers as the major important criteria. From this result, it was observed that the farmers' selection criteria are beyond yield and more farmers preferred drought tolerance (DT) over yield. Therefore, the aforementioned criteria were important for researchers and breeders to incorporate the need and perceptions of farmers during technology design and development, which thereby enhances technology adoption and diffusion. [17] Reported that participating farmers in the breeding of crop varieties for low-resource farmers is highly important to promote the uptake of technologies.

After defining the important selection criteria, farmers were compared and ranked each variety for individual traits considered important by them. The rating performance was scored from 5 to 1 (5 being the highest score representing excellent, 4, very good; 3, good; 2, poor; and 1, very poor). Overall, the MH130 variety was selected as the best variety over MH140 by farmers at all kebeles (Table 2). In line with this finding, [14] reported that MH130 followed by MHQ138 were selected by farmers on average across various criteria in Southern Ethiopia. The present study area is highly affected by erratic rainfall and therefore, farmers prefer MH130 due to its earliness over MH140 and they gave the name for this variety "*Fetino Derash Ziriya*" meaning "fast-paced variety".

Profitability analysis

The direct cost-benefit analysis result revealed that MH130 variety has higher economic benefits over MH140 variety (i.e., 18,420 ETB for MH130 and 15, 083 ETB for MH140 variety) (Table 3). This implies that producing MH130 has 22.1% higher economic benefits over the MH140 variety. However, the cost of technology is among the major determining factors affecting technology adoption and diffusion. Farmers do not insist on adopting technologies that are expensive and riskier even if the technology is important. Therefore, developing cost-effective technology that has higher economic gains is highly important to boost technology adoption and diffusion and thereby food security.

Conclusion

Maize is one of the most important strategic crops for food

Table 1: Pair-wise ranking of selection criteria.

Selection criteria	YD	DT	PDT	EM	SS	HP	M	Frequency	Rank
YD	*	DT	Yd	Yd	Yd	Yd	Yd	5	2nd
DT		*	DT	DT	DT	DT	DT	6	1st
PDT			*	EM	PDT	PDT	PDT	3	3rd
EM				*	SS	EM	EM	3	3rd
SS					*	SS	M	2	4th
HP						*	HP	1	5th
M							*	1	5th
Note: YD=yield, DT= drought tolerance, PDT=pest and disease tolerance, EM= earliness, SS= seed size, HP= plant height, M=marketability									

Table 2: Ranking and scoring of maize variety by farmers at four kebeles.

Variety	Location												Overall rank
	Angla-4			Angla-3			Salayish-1			Salayish-3			
	TS	MS	Rank	TS	MS	Rank	TS	MS	Rank	TS	MS	Rank	
MH130	53	3.53	1	57	4.75	1	48	3	1	51	4.25	1	1
MH140	31	2.1	2	37	3.1	2	39	2.44	2	25	2.1	2	2
Where TS and MS represent total and mean scores, respectively													

Table 3: Direct cost benefit analysis.

S.N	Items/ type		Quantity /unit price	MH130	MH140
1	**Average yield**	kg		4930	4275
	Adjusted yield (-ve 10%)			4437	3847.5
	Grain yield	ETB	1 kg = 6 ETB	26,622	23,085
	Maize stalk	ETB		300	500
	Total gain in ETB (A)			***26,922***	***23,585***
2	**Fertilizer costs in kg**	NPS	100 kg	1450	1450
		Urea	100 kg	1202	1202
		Total	200 kg	*2652*	*2652*
	Seed cost	25*2=50 kg	37 ETB	1850	1850
	Land preparation	ha	ETB	1000	1000
	Labor costs per day	Sowing	”	500	500
		Weeding	”	1000	1000
		Fertilizer application	”	500	500
		Harvesting	”	500	500
	Transporting Cost			500	500
	Total costs in ETB (B)			***8502***	***8502***
3	***Net Benefit (A-B)***			***18,420***	***15,083***
Note*:* ETB= Ethiopian birr					

security in Ethiopia. Overall, the result revealed that MH130 could significantly increase grain yield over MH140 variety in study areas. Across all locations, MH130 increased mean grain yield by 15.4% over the MH140 variety. Drought tolerance, yield, earliness, and pest and disease tolerance were selected as the most important criteria in maize production. In addition to its yield advantage over the MH140 variety, MH130 was ranked first by farmers depending on different preference criteria. Therefore, MH130 variety was recommended for further scaling up in the study area and other similar agro-ecologies.

Acknowledgment

The author would like to thank South Agricultural Research Institute (SARI), Arbaminch Agricultural Research Center, and Agricultural Growth Program-II (AGP II) for funding research. Sincere appreciation to kebeles extension agents for their sincere support during site and farmers' selection, FRG formation, and follow-ups.

Conflict of interest

None

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