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Full Length Research Paper

Participatory demonstration and evaluation of drought tolerant maize technologies in Daro Lebu, Hawi Gudina and Boke Districts of West Hararghe Zone, Oromia National Regional State, Ethiopia

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Abstract

Limited access to improved maize seed, late delivery of the available inputs, drought, insects-pests, lack of agronomics management and diseases are the major challenges facing maize production in Ethiopia. The experiment was conducted with the objective to demonstrate and evaluate the drought-tolerant maize varieties under farmers' conditions. One kebele from each district, seven farmers, and two farmer Training Centers were used for demonstration and evaluation of maize varieties. Yield, farmers' preference, number of participants in training and field day, cost of inputs, and benefits gained were major types of data collected using group discussion, observation, and counting. The collected data were analyzed using descriptive and inferential statistics, direct matrix and Garret ranking techniques, and partial budget analysis. The field day, training, advisory services, and supervision were conducted for the farmers with the integration of development agents and experts. MH-140 maize variety was high yielder, preferred by the farmers, and economically profitable than over MH-130 and local check varieties in the study area. Farmers were also preferred MH-130 variety in terms of early maturity than other varieties. Therefore, it recommended that both maize varieties (MH-130 and MH-140) for further scaling up in similar agro-ecologies thereby government organizations, non-governmental organizations, and private sectors engaged in agriculture in general and in maize production in particular.

Keywords: Maize, demonstration, participatory, drought, improved varieties, evaluation.

INTRODUCTION

Maize (*Zea mays*), also called corn, is believed to have originated in central Mexico 7000 years ago from a wild grass, and Native Americans transformed maize into a better source of food (Ranum et al., 2014). The inhabitants of several indigenous tribes in Central America and Mexico brought the plant to other regions of Latin America, the Caribbean, and then to the United States and Canada. European explorers took maize to Europe and later traders took maize to Asia and Africa. In Ethiopia, maize production has a recent history. It was probably introduced to this country from Kenya during the 17th Century (Marco et al., 2014).

It is estimated that in 2018, the total world production of maize was 1,147,621,938 tones (FAOSTAT, 2020), with the United States, China, and Brazil harvesting 34%, 22%, and 7.2% of the total production of maize, respectively. In large parts of Sub-Saharan Africa, maize is the principal staple crop covering a total of over 38 million hectares. Maize accounts for 30% of the total area under cereal production in this region, 19% in

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West Africa, 61% in Central Africa, 29% in Eastern Africa, and 65% in Southern Africa excluding South Africa (Cairns et al., 2013; FAOSTAT, 2020). Ethiopia is the second largest maize producer in Africa next to South Africa and high average productivity as compared to Africa and low productivity compared to the world average (Dagne, 2016). In Ethiopia, 10.2 million hectares (80.71%) of land has covered by cereal crops in the 2017/18 year (CSA, 2018). Out of this, the area covered by the maize crop was accounts 2.1million hectares, which is next to *Teff* crop accounted that 3 million hectares. However, in terms of its production and the number of producers maize ranked first next to *Teff* which accounted 84 million quintals and 10.6 million in number, respectively.

In the country, four regions namely Oromia, Amhara, SNNP, and Tigray were the major maize producers in the 2017/18 production *Meher* season (CSA, 2018). The Oromia region was the first in maize production that accounted 4.9 million producers, 1.15 million hectares and 46.8 million quintals of the yield obtained this year. In West Hararghe zone, maize is the second crop produced next to sorghum in the area in 2016/17 year. According to CSA (2017), the result indicated that 39,807.63ha covered by the crop and 919,626.81Qt of the yield obtained from 589,968 maize producers in the area by 2016/17 cropping season.

Maize contains about 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 Kcal/100g (Ignjatovic-Micic et al., 2015), as compared to rice and wheat, but has lower protein content. Maize provides many of the B vitamins and essential minerals along with fiber but lacks some other nutrients, such as vitamin B_{12} and vitamin C, and a poor source of calcium, folate, and iron (Ranum et al., 2014). Approximately 88% of maize produced in Ethiopia is consumed as food, both as green and dry grain (Tsedeke et al., 2015). Maize is consumed as *Injera*, Porridge, Bread, and *Nefro*. In addition to this, it is used to prepare local alcoholic drinks known as *Telia* and *Arekie* (MoANR, 2016). The leaf and stalk are used for animal feed and the dried stalk and cob are used for fuel. It is also used as industrial raw material, serving as starch, a sweetener for soft drinks, an input for ethanol fuel production, and oil extraction (Tsedeke et al., 2015; MoANR, 2016).

In sub-Saharan Africa, maize is predominantly grown in smallholder farming systems under rainfed conditions with limited inputs. Low yields in this region are largely associated with drought stress, low soil fertility, weeds, pests, diseases, low input availability, low input use, and inappropriate seeds (Ahmed et al., 2017; Santpoort, 2020). The annual maize yield loss of about 15% is attributed to drought in sub-Saharan Africa. Limited access to the improved maize seed, late delivery of the available inputs, drought, insects-pests, lack agronomics managements, and diseases are the major challenges in maize production in Ethiopia (Michael et al., 2020; van Dijk et al., 2020). Similarly, in West Hararghe zone drought, limited access to newly released improved early maturing maize varieties, and insect-pests were the majors' constraints observed in the area. The survey result indicated in drought-prone maize growing areas of Ethiopia, Kenya, Tanzania, and Uganda, early maturity was the second most desired attribute of maize varieties after yield potential (Erenstein et al., 2011).

In Ethiopia, a total of 65 maize varieties were released from 1973-2016 for different agro-ecologies (MoANR, 2016). Out of released varieties, 11 varieties were recommending for low-moisture agro-ecologies of the countries to stand with yield losses by drought (Dagne, 2016). In order to solve the maize constraints in the study area, Mechara Agricultural Research center has been implementing a trial on evaluation of the adaptability of newly maize varieties in the area. A total of three newly released varieties (MH-140, MH-130, and MH-138), Melkassa-7 (standard check), and one local check were evaluated on two locations in the West Hararghe zone. Based on average result of the study, MH-130, MH-140 and Melkassa-7 selected in early maturity (101, 113 and 103) days and yield potential (27.9, 25.7 and 30.9) Qt/ha than others and recommended for further demonstration and promotion in moisture deficit area (McARC, 2016).

In lowland areas of West Hararghe Zone, it observed that farmers producing more sorghum due to not accessing lowland maize varieties, awareness gaps, and other factors. In research validation and scaling up process, participation of farmers in varietal choice has considerable value through demonstration of the technology under farmers' field for further adoption and utilization of the technology (Asfaw et al., 2018). Therefore, the study aims to demonstrate and evaluate the drought tolerant maize varieties under farmers' conditions thereby creating awareness and linkage among actors in the study area.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted in Daro Lebu, Boke and Hawi Gudina districts of West Hararghe Zone of Oromia National Regional State, Ethiopia. The districts were bounded to each other and the communities share their culture, knowledge and skills. The detail of the background of each district was presented in the following (Table 1).

Site and Farmer Selection

The experiment was conducted for one year in Daro Lebu, Hawi Gudina and Boke districts of West Hararghe zone. One *kebele* from each district selected purposively based on the production potential of maize and lowland areas with the collaboration of district agricultural office. Accordingly, Milikaye *kebele* from

Daro Lebu district, Kurkura *kebele* from Boke district, and Ibsa *kebele* from Hawi Gudina district were selected for executing the demonstration under farmers' conditions. Moreover, a total of seven (7) farmers and two Farmer Training Center (FTC) have participated in the experiment (Table 2). Farmers were selected based on gender balance, willingness to provide 352m^2 land for the trial, promise to manage the field continuously, interest to provide labour without any support, willingness to allocate the oxen with its materials, willingness to take the risk or failure and willingness to communicate the result for fellow farmers.

Research design

Two improved drought tolerant maize varieties namely MH130 and MH140 compared with a local check under farmer`s condition of the study area. A single plot design (side-to-side) was used on 10m*10m size of the area for each variety on each selected farmer land. A spacing of 75cm* 25cm between row and plant was used during sowing time. Fertilizers, 50kg of DAP at sowing, and 60 kg urea at planting and knee height stages were applied as per the recommended rate.

Description of Improved Maize Varieties

Both maize varieties were released recently for drought prone areas of the country. The varieties were released by Melkassa Agricultural Research Center operated under the Ethiopian Institute of Agricultural Research. The MH-140 was released in 2013 recommended for wet and dry mid altitudes whereas MH-130 was released in 2012 and recommended for dry areas (Table 3).

Approach used

Training was organized for the selected experimental farmers and respective DAs concerning drought tolerant maize production and management systems. Then, sowing was conducted jointly with researchers (extenstionists and cereal agronomist), farmers and extensions agents in each district. Close supervision and monitoring were undertaken through joint action of stakeholders. Finally, field day was organized for different stakeholders including farmers to create awareness, selection of performed varieties, and boost the dissemination of the varieties through farmers to farmers. Different extension materials such as leaflets and manuals of training were delivered to the farmers during the field day and training for the available farmers, extension agents, and agricultural office experts. Moreover, the outputs gained from the study were communicated on a field day program, mass media, and written materials.

Types of Data and Method of Data Collection

Both quantitative and qualitative data were collected from primary and secondary sources. The number of farmers participated in demonstration, training and field day, date of planting, maturity date, disease and insects effects, farmers' preferences and yield gained (Qt/ha) were the major types of data collected during demonstration process. Besides, types of advisory services gained by the farmers and frequency of (land preparation, supervision made, and weeding practices) were collected from experimental farmers and. Socio-economic profiles, demographic, crop profiles and climatic information were collected from research reports, district agricultural offices reports, internet and other written materials. The economic data like cost of inputs (seed, rent land, oxen per plough land per day, labour man per day per the activities, fertilizers and chemicals) and benefit gained (cost of the product/yield gained) were collected from the producers, extension agents and merchant in the area.

Data collection sheet was developed prior to executing the trails. During monitoring and evaluation, the researchers and development agents collected different types of data mentioned above on developed collection sheets as per scientific unit of measurements. The checklists were also developed for collecting the economic data and secondary data. The farmers' preferences and perceptions towards technologies were collected by establishing small groups in the field day program. The field day participants were divided into small groups from different disciplines (farmers, extension agents, experts and researchers), lead by the group leader, and recorded each individual farmer's preferences thereby visiting each variety on their plots at maturity stage.

Method of Data Analysis

Both qualitative and quantitative data analysis methods were employed to analyze the collected data. The quantitative data will be analyzed using mean, standard deviation, summation, range, and independent sample t-test. An independent sample t-test analysis was used to identify the mean yield difference between improved and local check maize varieties. The SPSS Ver. 20 was used to analyze numerical value of the collected data. Qualitative data were analyzed by using description, narration, interpretation, and argumentation. The yield advantage of improved maize technology over local/standard check is calculated in the following formula.

$$\text{Yield advantage \%} = \frac{\text{Yield of a new variety - Yield of local check}}{\text{Yield of local check}} \times 100 \quad (1)$$

Farmers' evaluation and selection criteria were identified through a participatory selection scheme using Garrets and direct matrix rankings techniques at maturity stage of the crop. First, farmers' have listed the selection criteria. Farmers were subject to rank the criterion based on their importance and long term of experiences own on crop production. Then, ranking of farmers criteria was conducted using Garret Ranking

Table 1. Description of the districts of the study area.

Characteristic	Descriptions		
	Hawi Gudina	**Daro Lebu**	**Boke**
Capital city	Bu'i	Mechara	Boke
Distance from zonal city (Chiro)	181KM	105KM	70KM
Distance from capital city (Finfine)	608KM	434KM	396KM
Borders	Daro Lebu district in North, Amigna district (Arsi Zone) in West, Burka Dintu District in East, and Belto district (Bale Zone) in South direction	Habro district in North, Shanen Kolu district (Arsi Zone) in South West, Boke district in East and Hawi Gudina in South direction	Habro ditrict in North, Daro Lebu district in South West, Oda Bultum district in North East, and Burka Dintu in South Direction
Number of kebeles	31	37	22
Altitude	1200-1800m.a.s.l	1350- 2450m.a.s.l	1100-1980m.a.s.l
Total area	304.120.8ha	132,356.9ha	123,188.06ha
Total cultivated land	30,419.9ha	29,838ha	31,150ha
Total maize lands	4500ha	6,525ha	7,250ha
Total maize producers	6845 in number	10,255 in number	11,255 in number
Latitude	8110º 35′ 33.311″N	8479º43′38.149″N	8526º42′28.947″N
Longitude	6185º8′8.841″E	5842º50′50.173″E	6118º1′13.416″E
Annual Temperature	27^{o}C-32^{o}C	14^{o}C-26^{o}C	18^{o}C-28^{o}C
Annual Rainfall	200-1500mm/year	Average= 963mm/year	600-800mm/year
Agro-ecologies	2% Highland, 3% Midlands, 95%Lowlands	44% mid-land, 56% lowlands	80% Midland, 20% Lowland
Soil type	Black and red soil	Black and clay soil	Black and red soil
Farming system	Crop (sorghum, maize, and wheat) and livestock (cattle, goat, camel, donkey, and sheep)	Crop (sorghum, maize, groundnut, coffee, *khat*, hot pepper,) and livestock (cattle, goat, camel, and donkey)	Crop (maize, sorghum, teff, coffee, *khat*) and livestock (cattle, goat, sheep, donkey, poultry, and camel)
Populations	Total= 142, 075 (70, 520male, 71, 545female)	Total=238, 117 (118, 945male,119,172female)	Total= 181, 242 (92, 064male, 89, 175female)

Source: WHZANRO, 2018.

Techniques. Garret's percentages were calculated by using the following formulae (Garrett and Woodworth, 1969).

Percent position= $100\frac{(Rij-0.5)}{Nj}$ ---(2)

Where,

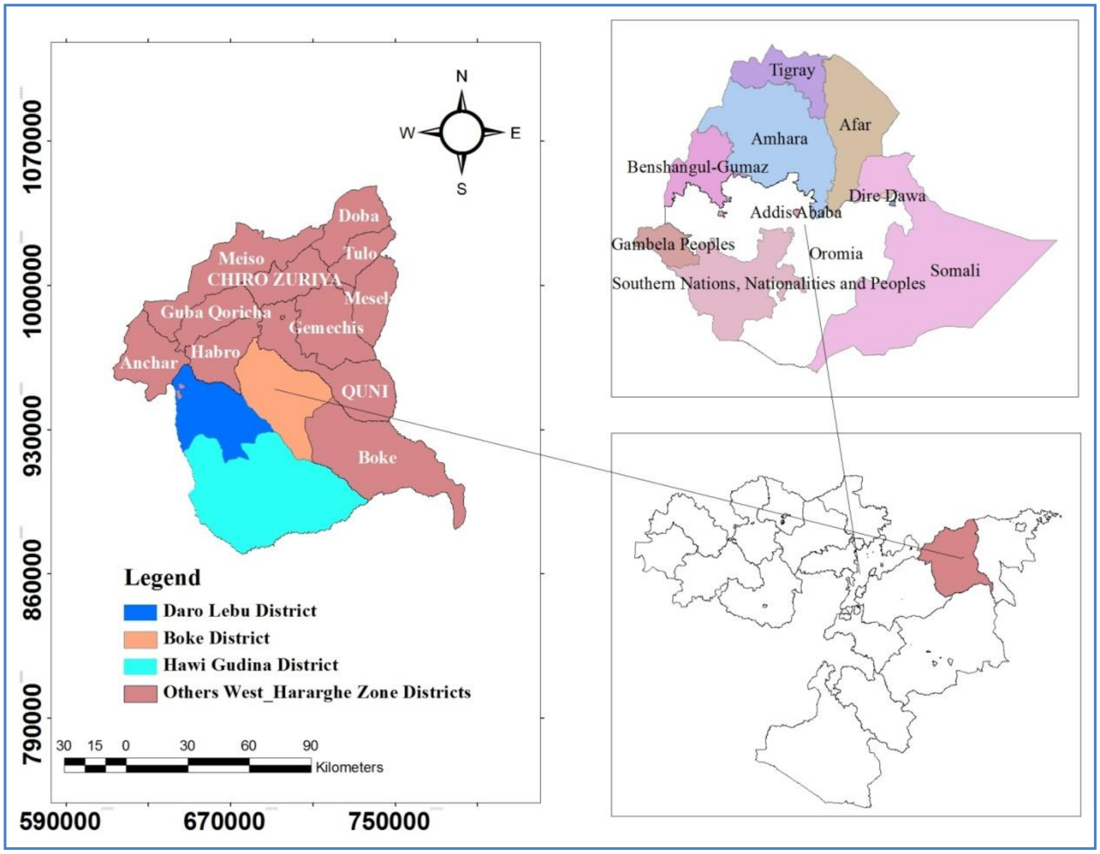
Rij= Rank is given for the ith items by the jth individual.

Nj= Number of items ranked by the jth individual.

By using the scorecard prepared by Garret, the scores were allocated to the percentage values. Then for each factor, the scores of individual farmers are added together and divided by the total number of farmers for whom scores added. The mean scores for all the factors are ranked by arranging in descending order.

After ranking of the traits was conducting, they evaluated the maize varieties based on the listed criteria's thereby giving the score to the varieties. The scores were given to the variety (3= very good, 2= medium, and 3=poor) based on their importance. A direct matrix table was prepared by putting the varieties listed in the row and characteristics preferred by farmers in the column. During direct matrix ranking, farmers have given a rating of importance (a relative weight) of selection criterion (3= Very Important, 2= important and 1= Less Important) and rating of the performance of a variety for each trait of interest (selection criteria) was given based on their level of importance based on a common agreement of evaluators'. The score of each variety was multiplied by the relative weight of a given character to get the final result and then added with the results of other characters to determine the total score of a given variety. Scoring and ranking were done on consensus, and differences were resolved by discussion as indicated by (De Boef and Thijssen, 2006; Yalemtesfa, 2017*)*.

Cost-benefit analysis was conducted to analyze the benefits obtained from the demonstration trail and helps



Source: Own designed from GIS data, 2018

Fig. 1. Map of the study area.

to convince the end-users. The cost-benefit analysis of the maize demonstration viewed from a financial point. The economic benefit was analyzed through gross monetary advantage analysis. According to formula used by Sarker et al., (2013), the gross monetary advantage (GMA) was calculated by multiplying yields of the component crops by their respective current market price for the varieties of the maize yield and subtracting its total variable costs, then dividing its product to a total cost to obtain benefit-cost ratio (GMA).

GMA= [(Q*P)-TVC)]/TC……………………………………………………………………….. (2)

When Q is the output/yield gained, P is the current price of the crops and TVC is a total variable cost or, GM= TR-TVC, where GM (gross margin), TR (total revenue) and TVC (total variable cost) GMA (BCR) =TR/TC, when BCR, TR, and TC, benefit-cost ratio, total revenue and total cost of the project, respectively.

RESULT AND DISCUSSIONS

Extension services given to the farmers

The concept of extension services has changed over time. While technological transfer is still important, more emphasis is being placed on expanding the skills and knowledge of farmers (i.e., human capital development), enhancing rural livelihoods, achieving food security, and creating more efficient farmer-based organizations (Gerba, 2018; Guush et al., 2018). Blum et al. (2020) define agricultural extension services approaches as "a style of action embodying an extension philosophy which determines the direction and nature/style of various aspects (structure, leadership, methods, techniques, resources, and linkages) related to how extension and advisory services are provided." Some approaches include participatory approaches, demonstrations, fairs, mobile extensions, radio or televisions programs, farmer-to-farmer approaches, top-down or bottom-up approaches, the Training and Visit (T&V) approach, and group-based approaches. Accordingly, we were delivering the improved maize technologies, advisory services during site supervision, training, and field day to experimental farmers in the study area.

Improved technologies demonstrated on the farmers' field

A two improved lowland maize varieties were demonstrated with their full package of technologies on the farmers' field. MH (Melkassa Hybrid)-130 and MH-140 varieties were demonstrated on the experimental farmers' field on 10m*10m plot size along with the local check variety. The demonstration included agronomic practices such as spacing (75cm and 25cm between rows and plants), seed rate (25kg/ha), management practices (weeding, cultivating and others), land preparation, soil type and all others recommendation given to the varieties. The 0.25kg amounts of the seed rate were demonstrated on one plot size for one variety. A total of 6.75kg of seed was used to demonstrate all varieties on the farmer field. The 0.6kg of DAP and 0.5kg of UREA fertilizer rate was used to demonstrate on one plot size. A total of 16.2kg of DAP and 13.5kg of the UREA fertilizer rate were used to demonstrate on nine farmers field in three districts.

Training given

Training is one of the extension services delivered for the farmers to improve their knowledge, skill and attitudes on maize technologies. The training is delivering to the farmers at different stages before, during and after the implementation of the research projects (Bedru et al., 2009). The training was given to the farmers and other relevant stakeholders before the implementation of the demonstration on farmers' field. The training given to the participants on maize production, pre-harvest and post harvest management and extension methods for technology demonstration and communication for wider communities engaged on maize production.
Accordingly, 11 experimental farmers, 3 development agents, and 2 agricultural experts were participated on the training given by cereal breeder and extensionist researchers at Mechara town for two days. Two ways communication methods were applied during training delivery period for sharing their knowledge and experiences. The reason behind was the farmers have a lot of enriching knowledge and experiences on maize production throughout their life. The National Ethiopian Agricultural Extension System (NEAES) (2014) indicated that participatory extension system is the focus through jointly integrate farmers into groups, developments and agricultural professions through training farmers in different agricultural technologies. The training program helps the actors (farmers, extension agents, experts, and researchers) of the agriculture to link each other and know the same information on the research demonstration trails.

Advisory services given

In collaborative farmers' participatory research, the researchers and farmers jointly participated in the design, implementation and evaluation of the demonstration trail (Bedru et al., 2009). In the participatory research, researchers and development agents living in the area to serve the farmers were advising the experimental farmers during supervision of the maize demonstration trial. The researchers were supervising the demonstration trail four times (germination, flowering, maturity and threshing) per cropping season in both locations. The farmers were obtained advisory services on weeding practices, management, harvestings and storage mechanisms of the crop. The farmers, extension agents and researchers were jointly sowing the crop on farmers' field. After training was delivered, even there was a management gap observed among experimental farmers land.

Field day and awareness created

Field day is a kind of meeting whereby farmers, agri-business people and agricultural scientists and all stakeholders in agriculture discuss and interact fully with each other about agricultural practices (Akinsorotan, 2009; Blum et al., 2020). The importance of the field day is an opportunity for farmers to learn by seeing the performance of recommended practices adopted by other successful farmers. Farmers also discuss the pros and cons of the field day informally with their fellow farmers, extension workers, and subject matter specialists. Field day is an opportunity for the farmers to evaluate the technologies through their own criteria's. It can be two or three times in which the stages are at vegetative, flowering and maturity depending on crop type and nature produced (Bedru et al., 2009).
Accordingly, the field day was organizing at maturity stage of the maize crop in Daro Lebu and Boke districts on the selected farmers' field. A group of farmers, subject matter specialists, communication experts, researchers and other experts were involved in the program. Accordingly, 105 (83 Male, 22 Female) farmers, 4 (3 Male, 1 Female) extension agents and 33(28 Male, 5 Female) subject matter specialists were participating in the ceremony (Table 4). Field visit through facilitator, on-field technology selection, group discussion and general discussion were the major methods used in the program. The Bedru et al. (2009) indicated that defining purpose, planning, implementation and evaluation of the program is important in conducting field day on the farmers' field. In the program, farmers were selecting the maize varieties in different criteria for further production. Besides this, 120 leaflets on maize production were delivered to the participants of field day program in both locations to create awareness on improved maize technologies. Similarly, the findings of Blum et al. (2020) indicated that advisory tools include information and communication technologies (ICTs), printed materials (e.g. posters, brochure, and calendars), folk media (e.g. drama, puppet shows, songs, proverbs) and games, among others, are the instruments that support the implementation of advisory services.

Table 1. Number of farmers participated and an area used for maize demonstration in the study area.

District	*Kebeles*	Number of farmers and FTCs covered	Area covered (m^2)
Hawi Gudina	Ibsa	3*	1,056
Daro Lebu	Milikaye	3*	1,056
Boke	Kurkura	3	1,056
Total		**9**	**3,168**

*Indicates one FTC used from Hawi Gudina and Daro Lebu districts.

Table 2. Characteristics of improved maize varieties.

Varieties	Year of release	Rainfall (mm)	Altitude	Maturity days	Agro-ecology	Yield on research station (Qt/ha)	Other traits
MH-130	2012	600-1,000	1000-1750	120	Dry areas and mid-altitude	60-70	Hybrid, resistant to rust and blight
MH-140	2013	1000-1800	1000-1800	140	Wet and dry mid-altitudes	85-95	Hybrid, MSV and rust resistant

Source: MoANR, 2012 & 2013.

Table 3. Field day participants in Boke and Daro Lebu districts by gender and profession.

Locations (Districts)	Farmers					DAs			SMS			Total		
	Adult		Youth		Total	M	F	T	M	F	T	M	F	T
	M	F	M	F										
Daro Lebu	23	12	10	1	46	1	0	1	8	2	10	42	15	57
Boke	50	9	0	0	59	2	1	3	20	3	23	72	13	85
Total	73	21	10	1	105	3	1	4	28	5	33	114	28	142

Note: M-stands for male, F, stands for Female and T-stands for total, DAs- stands for Development agents and SMS-stands for subject matter specialists.
Source: Our results, 2017.

Descriptive analysis result

Yield gained and its advantage over local check

The yield of the demonstration trial was harvested only from five farmers in Boke and Daro Lebu districts due to extreme drought prevail in Hawi Gudina districts and germination problem in one farmers field in Daro Lebu district. The result of Table 5 revealed that the average yield obtained from the improved maize varieties accounted that 34.6 Qt/ha for MH-140, 27.06 Qt/ha for MH-130 and 17.67 Qt/ha for Local check. The highest yield was recorded from MH-140 and followed by MH-130 and local check varieties. There was a high mean difference yield obtained between improved and local check varieties. Our findings indicated it was above zonal average yield of 2016/17 year that accounted 23.10 Qt/ha (CSA, 2017). Similarly, the findings of Mieso (2017) indicated that the highest yield was recorded from MH-140 over MH-130 varieties in Abaya district, Southern Ethiopia. Contrary to our findings, the result of Natol et al. (2018) indicated that the highest yield recorded from MH-130 over MH-140 variety in Dugda Dawa district, Southern Oromia, Ethiopia.

Yield gained against earlier recommendations

Before the technology was demonstrated on the farmers field, the adaptation and verification trial were conducted on research station and sub-stations. In 2014-2015, the adaptation trial was conducted in three locations (Mieso, Daro Lebu at Mechara research station and Daro Lebu at Milikaye kebele). The result obtained on Table 6 the MH-130 variety gained during the adaptation and demonstration stage is near to each other. However, the MH-140 yield obtained from demonstration stage higher than adaptation study increased by 7.1 Qt/ha. However, the potential of the maize varieties by the released organizations were 60-70 Qt/ha for MH-130 and 85-95 Qt/ha for MH-140 variety. Under research-managed trial, all package of the technology were applied as per recommendation domain. However, farmers managed trial controlled by the farmers themselves and create a gap to apply all

Table 4. The mean yield of improved maize technologies and its yield advantage in both locations.

Varieties	Yield (Qt/ha) (N=5)				Mean difference over check (Qt/ha)	Yield advantage over check (%)
	Min.	Max.	Mean	Std. Dev.		
MH-130	9.97	40.69	27.06	12.24	9.39	68.9%
MH-140	6.99	50.48	34.6	11.18	16.93	95.8%
Local check	3.28	34.91	17.67	13.63	0	0

Source: Our results, 2017.

Table 5. The mean yield difference of improved maize technologies at different stages.

Varieties	Mean yield gained (Qt/ha)		
	Released center	Adaptation stage	Demonstration stage
MH-130	60-70	27.9	27.06
MH-140	85-95	27.5	34.6

Source: Our computation, 2017.

required package of technologies as per recommended rate.

Independent sample t-test result

The independent sample t-test was employed to identify the statistical difference of the yield among the varieties and locations. The independent sample t-test result in Table 7 indicated there was no significant difference between MH-130 and local varieties as well as MH-130 and MH-140 varieties in terms of yield per hectare. Nevertheless, there was a significant difference between MH-140 and local check varieties in terms of the yield per hectare in the study area. In other ways, the independent sample t-test result revealed that there was no significant difference between Daro Lebu and Boke districts in terms of overall yield of the varieties. Even though, statistical non-significant between two locations, the highest yield (30.46 Qt/ha) of maize was recorded in Daro Lebu and increased over Boke district by 3.1 Qt per hectare. The difference occurred due to high management given for the variety by Daro Lebu district experimental farmers.

Farmers' preferences

Farmers' preferences are the most important type of data that cannot be missed in improved agricultural technologies demonstrations under farmers' circumstances. The rationale behind to use farmers preferences as part of demonstration is due to the fact that the objectives of researchers usually yield maximization may differ from objectives of farmers like market, quality, household utilization and results from conventional research process takes a long time to reach to the farmers (Yalemtesfa, 2017). Accordingly, the farmers' preferences data on improved maize technologies were collected at maturity stage of the crop through organizing field day. The data were collected at both farmer's field and Farmer Training Center (FTC) of Milikaye kebele in Daro Lebu district. Both women and men participated on field day for technology evaluation and selection at farmer's field 29 (Male 25, Female 4) and FTC 25 (Male 21, Female 3). The reason was four farmers missed their participation while moving from farmer's field to FTC on field day ceremony.

On the farmers field, the maize variety selection criteria's were listed by the farmers and ranking was conducted the criteria in a group ways. The result of Garret ranking techniques on Table 8 depicted that high yielder, early maturity, head size, drought tolerance and seed size were the major criteria ranked by the farmers from first to fifth based on the importance for evaluating maize varieties in the study area. Similarly, Natol et al. (2018) findings indicted that yield, early maturity, drought tolerance, seed size, seed color, disease resistance, and plant height as major criteria that farmers used in evaluating maize varieties. The study of Abera et al. (2013) finds out yield, disease and insect resistance, and lodging resistance as major criteria used in maize technology evaluation and selections by West Ethiopia farmers.

According to the relevance ranking criteria, the direct matrix ranking was conducted to select best maize varieties used for further production by the farmers. The relative weight of the selection criteria was given by the farmers based on the level of importance (3= very important, 2=important and 1=Less important). That means farmers were also identified and gave the rank for the best criteria on Table 8 below. The scores were also given to the varieties the depending on the criteria (Table 9). The result of direct matrix ranking indicated that MH-130 ranked first next to MH-140 and local check varieties in terms of all criteria's except early maturity and biomass/plant height for livestock forages on farmer's field. The total weighted score of farmer's field maize varieties selection accounted that 62 for

Table 6. The independent sample t-test result on mean yield of improved maize varieties in both locations.

Combination of variety/locations	Mean yield (Qt/ha)			t-value
	Mean	Std. Dev.	Std. Error	
MH-130	27.03	12.24	5.47	-1.021[ns]
MH-140	34.60	11.18	4.99	
MH-140	34.60	11.18	4.99	2.147*
Local	17.68	13.63	6.09	
MH-130	27.03	12.24	5.47	1.142[ns]
Local	17.68	13.63	6.09	
Daro Lebu district (N=2)	30.46	15.84	6.47	0.936[ns]
Boke district (N=3)	27.36	11.96	3.99	

Note: * indicates that significant at 10% level and ns- indicate non-significant
Source: Our computation, 2017.

Table 7. The result of Garret ranking techniques in maize varieties selection criteria.

Criteria	Rank Value (N=29)										Average score	Rank
	1	2	3	4	5	6	7	8	9	10		
HY	23	4	2	0	0	0	0	0	0	0	79.03	1
EM	4	14	5	6	0	0	0	0	0	0	67.97	2
HS	0	5	13	10	0	1	0	0	0	0	61.97	3
DT	2	4	5	2	12	4	0	0	0	0	58.31	4
SS	0	2	2	10	11	1	3	0	0	0	54.79	5
IPR	0	0	0	1	3	12	8	5	0	0	44.93	6
SC	0	0	2	0	3	7	5	8	3	1	42.21	7
DiR	0	0	0	0	0	4	10	10	5	0	38.52	8
GL	0	0	0	0	0	0	3	6	14	6	29.62	9
BT	0	0	0	0	0	0	0	0	7	22	20.66	10

Note: HY-High yield, EM-Early Maturity, HS- Head Size, DT-Drought Tolerance, SS- Seed Size, IPR-Insect Pest resistance, SC-Seed Color, DiR-Disease Resistance, GL-Good for Livestock Forage, BT- Bear Tip cover
Source: Our computation, 2017.

MH-130, 44 for MH-140 and 28 for local check varieties. Contrary to this, on FTC field the farmers shifted their ideas on varieties selection due to the performance of crop different from farmers' field. Accordingly, farmers were rank MH-140 as first next to MH-130 and local check varieties in terms all criteria's except early maturity. Finally, farmers have accepted both varieties (MH-140 in terms all criteria except early maturity and disease reaction and MH-130 in terms of early maturity and disease resistance) for further production in their area. The findings of Natol et al. (2018) indicated that MH-130 variety is more preferred than MH-140 by the farmers in the area. Conducting on-farm research on different locations and farmers' field helps us to obtain reliable, representative and accurate research results.

Cost-benefit analysis result

The cost-benefit analysis of the research project from its financial point of view was used to evaluate the technology to be financially feasible or not in the area. In agricultural projects, the cost of inputs required to execute the project was collected from both locations in the study area. The cost of inputs (seed, fertilizers, labor from sowing to threshing at different stages of production, insecticides, and plough cost) and the product cost (yield) were collected based on the data obtained from the farmers, merchants and experts in the area. As known, maize is the food secure crop and farmers in the area are not produced for the market. Even though, analyzing the benefit-cost is required to convince the farmers whether economical advantages or not in improved maize technologies production. In the areas, farmers produce maize on their farmlands through their labor and other social capital systems. The result on Table 10 indicated that the highest cost of inputs incurred on improved maize technologies due to the cost of improved seed higher than local seed cost.

The result of Table 11 indicated that the highest gross margin/net benefit and total revenue were obtained from MH-140 variety that accounted 8050.5 birr and 22, 490 birr in a hectare of the land at production period, respectively. Next to this, MH-130 and Local check varieties gross margin/net benefit and total revenue were accounted that 3169 birr and -3256 birr, and 17,608.5birr and 10,166 birr from a hectare of the land, respectively. The benefit-cost ratio was accounted that 40.99%, 16.14% and -17.48% for MH-140, MH-130 and local check varieties respectively. Therefore, farmers are profitable if engaging in producing improved maize varieties than local check varieties and sold at production period (from October to February) in the study area.

Most of the time farmers were more profitable if sold their product during non-production season than at production season. The result of Table 11 &12 also

Table 8. The result of direct matrix ranking of maize varieties selected by the farmers.

Criteria	Relative weight	Variety Score in Farmers Field (N=29)						Variety Score in Farmer Training Center (N=25)					
		MH-130		Local		MH-140		MH-130		Local		MH-140	
		Score (N)	Weight score	Score (N)	Weight score	Score (N)	Weight score	Score (N)	Weight score	Score (N)	Weight score	Score (N)	Weight score
HS	3	3(25)	9	1(28)	3	2(25)	6	2(24)	6	1(25)	3	3(23)	9
SC	2	3(16)	6	1(29)	2	2(16)	4	2(22)	4	1(29)	2	3(22)	6
SS	2	3(17)	6	1(28)	2	2(16)	4	2(23)	4	1(25)	2	3(22)	6
HY	3	3(25)	9	1(29)	3	2(25)	6	2(24)	6	1(24)	3	3(23)	9
EM	3	2(22)	6	3(26)	9	1(22)	3	2(14)	6	3(13)	9	1(11)	3
DR	3	3(17)	9	1(24)	3	2(13)	6	2(13)	6	1(21)	3	3(11)	9
IPR	2	3(15)	6	1(27)	2	3(14)	6	2(16)	4	1(22)	2	3(18)	6
GL	1	2(25)	2	1(26)	1	3(23)	3	2(25)	2	1(25)	1	3(25)	3
DiR	2	3(17)	6	1(27)	2	2(15)	4	3(14)	6	1(22)	2	2(13)	4
BT	1	3(15)	3	1(24)	1	2(13)	2	2(13)	2	1(19)	1	3(11)	3
Total weight score	22		62		28		44		46		28		58
Average weight score			2.82		1.27		2		2.09		1.27		2.64
Rank			1		3		2		2		3		1

Note: relative weight of the criteria's give by the farmers, 3=Very important, 2= Important and 3=Less important and the score given to the varieties by the farmers, 3=Very good, 2=medium and 1=poor
Source: Our results, 2017.

Table 9. Cost of the inputs used for maize production on farmers field

Varieties	Average cost of inputs (Birr per ha)						TVC	TC
	Fertilizers	Seed	Insecticide	Plough	Labor	Rent land		
MH-130	1244.5	1200	275	6400	5320	5200	14,439.5	19,639.5
MH-140	1244.5	1200	275	6400	5320	5200	14,439.5	19,639.5
Local	1244.5	182.5	275	6400	5320	5200	13,422	18,622

Note: TVC=Total Variable Cost and TC= Total Cost
Source: Our computation results, 2017.

Table 10. The benefit obtained from improved maize during production period.

Variety	Quantity (Qt/ha)	Average Price (Birr/Qt)	TR	TVC	TC	GM	GMA/BCR
MH-130	27.09	650	17,608.5	14.439.5	19,639.5	3169	0.1614
MH-140	34.6	650	22,490	14,439.5	19,639.5	8050.5	0.4099
Local	17.68	575	10,166	13,422	18,622	-3256	-0.1748

Note: TR-Total revenue, TVC-Total variable cost, GM- Gross Margin, GMA (Gross Margin Advantage/Benefit Cost Ratio)
Source: Our results, 2017.

revealed that the net benefit obtained from MH-140 increased from 8,050.5 birr to 19,960.5 birr and gained a difference of 11,910 birr from a hectare of land in the study area. Similarly, the profit obtained MH-130 and local check varieties increased by 9, 281.5 birr and 5,546, respectively.

Table 11. The benefit obtained from improved maize during non-production period.

Variety	Quantity (Qt/ha)	Average price (Birr/Qt)	TR	TVC	TC	GM	GMA/BCR
MH-130	27.09	1,000	27,090	14,639.5	19,839.5	12,450.5	0.6276
MH-140	34.6	1,000	34,600	14,639.5	19,839.5	19,960.5	1.0061
Local	17.68	9,00	15,912	13,622	18,822	2290	0.1217

Source: Our results, 2017.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The experiment was conducted in Daro Lebu, Boke and Hawi Gudina districts of West Hararghe zone. Three kebeles and on nine locations (farmers field and FTC) were addressed through the demonstration trail. Training, supervision of the field, and field day was organized for the farmers, development agents and experts found in the district.

Two improved and one local check varieties were demonstrated and evaluated on both the farmers' field and FTC with its full package of technologies. Different agricultural extension services (training, demonstration, advising farmers, field day and improved technologies) were delivered for the farmers in the study area. Accordingly, 15 and 142 participants have participated in both training and field day program. The highest average yield was recorded from MH-140 (34.6 Qt/ha), followed by MH-130 (27.03 Qt/ha) and local check (17.68 Qt/ha) in the study area.

The independent sample-test result indicated that there was a significant difference between MH-140 and local check varieties at a 10% significance level. The result of Garret ranking techniques depicted that high yield; early maturity and head size was the major top three selection mostly preferred by the farmers in evaluating maize technologies. On the other hand, the direct matrix ranking was employed to rank farmers preferences towards best-performed variety. Accordingly, MH-140 variety was ranked first by the farmers in terms of all criteria's except early maturity and disease resistance compared to both MH-130 and local check varieties. Due to different characters and think as a solution for their problems, farmers preferred both improved maize varieties for further production in their area.

The partial budget analysis employed to identify the benefit and cost incurred in maize production. Due to high yield and preferable in the market, MH-140 variety was more profitable than other varieties. The net benefit obtained from MH-140 both at production and non-production season was accounted that 8,050.5 and 19,960.5 birrs respectively.

RECOMMENDATIONS

Based on the findings and conclusion obtained, the following recommendations have been giving on maize technology for the responsible bodies.

- The farmers should store their product and sell at the time supply of the product reduced in the area.
- It should be better to multiply the improved maize technology in our center for further scaling up in recommended area.
- It is better to include farmers' preferences in agricultural technology and innovation evaluation process in participatory ways.
- It should be recommended to scale up both varieties especially MH-130 variety in shortage of rainfall area for the end-users.
- The agricultural offices, university/research affairs office and non-governmental organizations should give attention for the technology promotion and benefit the farmers thereby conducting demonstration and scale up both on Farmer Training Center and on-farmers field for further production.
- The unions and seed enterprises should request the research institution recommendation to multiply adapted and accepted improved agricultural technologies by the farmers in reducing the seed shortage in the area.

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