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On-farm demonstration and evaluation of improved lowland sorghum technologies in Daro Lebu and Boke districts of West Hararghe Zone, Oromia National Regional State, Ethiopia

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This experiment was conducted in Daro Lebu and Boke districts of West Harerghe Zone with the objectives of evaluating lowland sorghum varieties on farmer's field and creating linkage and networking among stakeholders. Three kebeles were selected purposively based on sorghum production potential; two kebeles from Daro Lebu and one kebele from Boke district. Five farmers and one farmer training center participated depending on their interest to the technology, managing the experiment, having appropriate land for the experiment and taking the risk at the time of failures. Two improved varieties namely, Ethiopian Sorghum Hybrid-1 and Chare with local checks were demonstrated and evaluated. The experiment was demonstrated on 100 m^2 demonstration plots, and DAP 100 kg/ha-with Urea (50 kg at the time of sowing and at growing stage) were applied to one demonstration plot with a seed rate of 10 kg/ha. Both quantitative and qualitative data were collected through observation, group discussion on field day and data recording sheet. Descriptive statistics, gross margin analysis and independent t-test were used to analyze collected data. Results indicated that Ethiopian Sorghum Hybrid-1 was ranked first in terms of yield, drought tolerant, biomass, early maturity, and seed colour and disease resistance. Independent t-test revealed that mean comparison of Ethiopian Sorghum Hybrid-1 and Chare along with local check were statically significant at 5% significant level on mean yield performance and had more economic advantage than local variety at the study area. Therefore, Ethiopian Sorghum Hybrid-1 and Chare varieties are recommended for further popularization and scaling up in study area and similar agro ecology.

Key words: Sorghum demonstration, evaluation, early maturity, marginal analysis, varieties.

INTRODUCTION

Sorghum is an important cereal crop used by humans as staple food grain in many semi-arid and tropical areas of the world (Belay, 2017). It is the 5th most important cereal crop in the world (FAOSTAT, 2013), the 3rd important cereal (after rice and wheat) in India and the 2nd major crop (after maize) across all agro ecologies in Africa. In West Africa, especially in Burkina Faso, Sorghum is the staple crop and produced in low-input cropping systems. Sorghum is a major food and nutritional security crop to more than 100 million people in Eastern horn of Africa, owing to its resilience to drought and other production constrains (Gudu et al., 2013).

The lives of millions of poor Ethiopians is depend on production of sorghum. It has tremendous uses for the Ethiopian farmer and no part of this plant is ignored. Besides being a major source of staple food, it serves as an important source of feed and fodder for animals. Sorghum exhibits a wide geographic and climatic adaptation. It also requires less water than most cereals; hence it offers great potential for supplementing food and feed resources. Sorghum grows in a wide range of agro-ecologies most importantly in the moisture stressed parts where other crops can least survive and food insecurity is rampant (Tekle and Zemach, 2014).

In Ethiopia, total land of Sorghum production under peasant holdings covers about 456,171.54/ha (CSA, 2017). The main sorghum producing regions are Oromia and Amhara, accounting for nearly 80% of the total production. The leading sorghum producing zones are East and West Hararge in Oromiya and North Gondar and North Shoa in Amhara. Two regions, Southern Nations, Nationalities, and Peoples' Region (SNNPR) and Tigray are relatively less important, contributing 11 and 4% of the national production, respectively. Ethiopia is the second largest producer of sorghum, after the Sudan (Demeke et al., 2013).

In moisture stress area the grain-filling stage was the most important constraint, followed by insect pests, particularly stalk borer. Although drought is largely unpredictable, the farmers dealt with frequent drought events by either growing a diverse set of traditional cultivars from different maturity types, shifting from late-maturing to early-maturing cultivars, or replacing sorghum with tef or chickpea (Beyene et al., 2016).

Sorghum is adapted to a wide range of environments, it is largely produced in the highlands, medium and lowland regions. Even though sorghum is dominantly grown in the zone, most smallholders' farmers use landrace variety of sorghum which results in low yield, susceptible to disease and take long period of time to harvest. Crop production in the study area totally depends on rainfall availability which is highly sensitive to climate change (Fekede et al., 2016). Based on practical problem of shortage of improved variety of sorghum and shortage of rain fall in the zone especially in low land areas, Mechara Agricultural Research Center have been conducting adaptation trail of improved lowland sorghum variety to select well adapted variety to agro-ecology of the area in previous cropping season. Therefore, this activity was initiated with objectives to demonstrate and evaluate improved low land sorghum technologies and create linkage among researcher, farmers, extension agents and other stakeholders.

METHODOLOGY

Description of the study area

Daro Lebu is one of the districts found under West Hararghe Zone. The capital town of the district Mechara is found at about 434 km South East of Addis Ababa. The district is situated between 7°52'10" and 8°42'30" N and 4°023'57" and 41°9'14" E at 08°35'589" North and 40°19'114" East (Abduselam, 2011). The district is characterized mostly by flat and undulating land features with altitude ranging from 1350 to 2450 m.a.s.l. Ambient temperature of the district ranges from 14 to 26°C, with average of 16°C and average annual rainfall of 963 mm/year. The pattern of rain fall is bimodal and its distribution is mostly uneven. Generally, there are two rainy seasons: the short rainy season '*Belg*' lasts from mid-February to April whereas the long rainy season '*kiremt*' is from June to September. The rainfall is erratic; onset is unpredictable, its distribution and amount are also quite irregular (Asfaw et al., 2016). Consequently, most *kebeles* frequently face shortage of rain; hence moisture stress is one of major production constraints in the district (DLWADO, 2015).

Boke is one of districts of West Hararghe zone known for coffee production. It is located at 391 km East of Addis Ababa and about 69 km south of Chiro, capital town of the zone. The district receives an average annual rainfall of 850 mm and average temperature is 20°C. It shares borders with Chiro district in the west and north, Oda Bultum district in the south and Mesala district in the East (Fekede et al., 2016). The district is found within 1300 to 2400 m above sea level (BDAO, 2013) (Figure 1).

Farmers and site selection

The activity was conducted for one year in Daro Lebu and Boke districts of West Harerghe zone (2013). Gadulo and Gudis *kebeles* from Daro Lebu (2015) as well as Dololo *kebele* from Boke district were purposively selected based on their sorghum production potential. Five farmers and one Farmer Training Center (FTC) were selected based on their interest to the technology, model farmers, managing the experiment and have appropriate land for the experiment (Table 1).

Experiment design

Two improved sorghum variety namely ESH-1 and Chare were demonstrated and evaluated with local variety. The experiment was demonstrated on 100 m^2 demonstration plots, and DAP 100 kg/ha and Urea (50 kg/ha at the time of sowing and growing stage) were applied with the seed rate of 10 kg/ha. Drilling sowing methods were applied in the row with fertilizer. The required management like weeding, thinning out and urea application at the growing stage were done by the farmers.

Data collection methods

Both quantitative and qualitative data were collected from farmers

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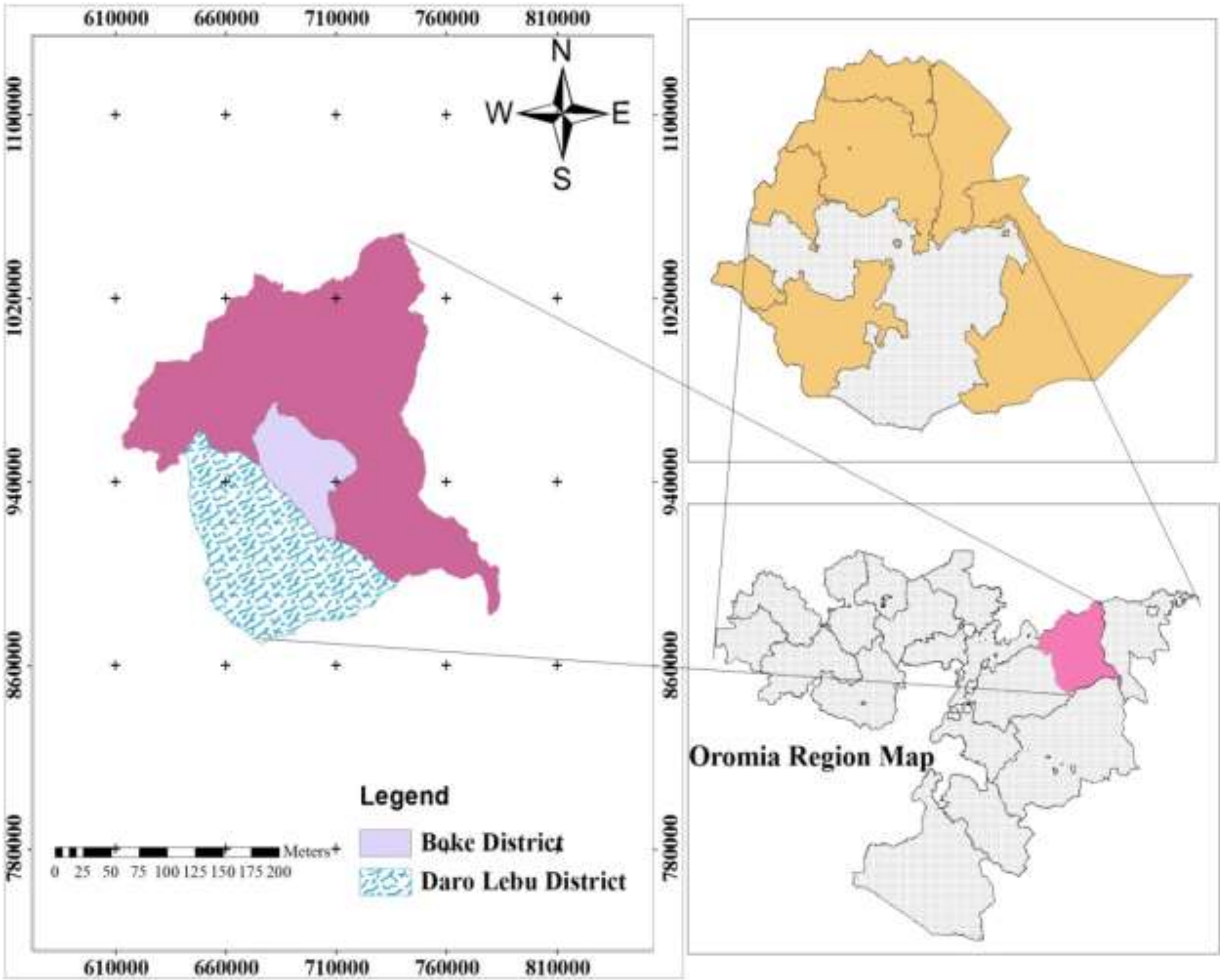

Figure 1. Map of study areas.
Source: Own design (2017).

Table 1. Experiment location, farmers participated and area covered in study area.

Districts name	*Kebeles*	No. of trail farmers	Area covered (m^2)
Daro Lebu	Gadulo	2	600
	Gudis	3	900
Boke	Dololo	1	300
Total		6	1800

Source: Own results (2017).

(qualitative data were collected on field day by group discussion on the performance of crop and quantitative data like yield of crop were collected on the from the participated farmers land) through observation group discussion on field day and data recording sheet.Data like farmer preference on disease and pest's resistance, early maturity, drought tolerance, grain color, biomass, and yield data were collected through the prepared data collection sheet/record sheet by organizing field day and observation on farmer's field.

Tools of data analysis

Descriptive statistics, gross margin analysis and independent t-test were used to analyze quantitative data. Farmer's preference was collected and analyzed by using simple ranking method in accordance with the given value (De Boef and Thijssen, 2007). The formula of ranking method used was specified as:

$$\text{Rank}=\Sigma^{N}/n \quad (1)$$

Table 2. Yield summary and mean comparison of sorghum varieties on farmer's field.

Varieties	Yield harvested in Qt/ha(N=6)							
	Min	Max	Mean	Std. deviation	t-value	Sig. (2-tailed)	yield difference from local	% yield increase over local check
ESH-1	0.30	43.30	20.9	15.13	7.426**	0.018	11.48	121.9
Chare	0.12	33.20	16.3	14.08	6.704**	0.022	6.88	73
Local	0.00	32.10	9.42	14.04			-	-

** indicates significant at 5% significant level
Source: Own results, 2017.

Where N is value given by group of farmers for each variety based on the selection criteria and n is number of selection criteria used by farmers.

Descriptive statistics

Descriptive statistics (mean of yield) were used to analyse the crop performance to evaluate yield gained from the experiment harvested from demonstration plot.

Gross margin analysis

Gross margin analysis is very useful and in a situation where fixed capital forms a negligible portion of production. It is the difference between gross income and the total variable costs (Mohammed et al., 2015). According to Ayinde et al. (2016), gross margin is expressed as:

$$GM = TR - TVC \qquad (2)$$

Where GM = gross margin, TR = total revenue, TVC = total variable cost

Average rate of returns (ARR) was also obtained. This was done by dividing total gross margin (GM) by the total cost of production per hectare.

RESULTS AND DISCUSSION

Crop performance on the farmer's field

The mean yield of ESH-1 and Chare were 20.9 and 16.3 Qt, with standard deviation of 15.13 and 14.08, respectively. Mean yield and standard deviation of the local variety were 9.42 and 14.04 in terms of Qt/ha (Table 2). The mean yield of local variety was less than both improved (ESH-1 and Chare) varieties due to intolerant behavior to drought. The result of independent statistical test indicated that there was statistical difference between the yields of improved ESH-1 and Chare varieties demonstrated on farmer's field at 5% significant level. But from the results of adaptation trial done on ESH-1 and Chare varieties at Mechara Agricultural Research Center, ESH -1 recorded mean yield of 38.67 and Chare recorded mean yield of 29.22 (Kinde et al., 2016). The difference in yield was observed due to presence of extreme drought in the study area in the last year.

The result of the findings depicts that the demonstrated and evaluated improved varieties have high grain yield (ESH-1 43.3 Qt/ha and Chare 33.20 Qt/ha) whereas local has grain yield of 32.10 Qt/ha. Yield increases in percentage of improved variety of ESH-1 and Chare over local check were 121.9 and 73%, respectively. Yield difference pertining to poor tolerance of local variety to drought variety is already debated. It may be concluded here that adaptation of improved variety were more productive than local variety with the same area and management.

Capacity building and experiment evaluation

Training was given for awareness creation at Daro Lebu district (Gadulo and Gudis *kebeles*) before implementing the activity. Thus, eight farmers (seven male and one female) and three development agents (1 female and 2 male) participated in the training session from Daro Lebu district (Gudis and Gadulo *kebeles*). Field day was organized at two *kebeles* of Daro Lebu district to create awareness for participants. Accordingly, thirty-eight (38) male and ten (10) female households participated in mini field day organized at Daro Lebu district (Gudis and Gadulo *kebeles*) (Figure 2). Experts and DA's were also partaken with farmers for evaluation of the experiment. For variety selection on field, researcher divided farmers into three groups with combination of development agents and experts (subject matter specialists). The group of farmers and development agents led by subject matter specialists (SMS) were put in their own criteria to evaluate the technology by observing on field. Each group gave its own value to the experiment on each demonstration plot. As discussed in Table 3, the values given by each group of farmers were summarized and the average value ranked by participants.

From the result revealed as tabulated in Table 3, farmers, development agents and experts selected ESH-1 and Chare variety as 1st and 2nd with all average values given by farmers.

Figure 2. Group discussion on mini field day at Gudis *kebele*.

Table 3. Participants preference of the variety selection on field day.

Variety	Selection criteria's (score out of five)									
	HS	SC	Bms	EM	DsR	DrR	SG	PH	TS	Rank
ESH-1	4.6	4.8	3	3.6	4	4.4	3	3	30.4	1
Chare	3.8	3.6	2.8	4.2	4	4	3.2	3.6	29.2	2
Local	2.25	1.6	4.2	2	3	1.4	4.75	3.6	22.8	3

5=Excellent, 4=very good, 3=good, 2=fair, 1=poor; HS=Head Size, SC=Sead Color, Bms=Biomass, EM=Early Maturity, DsR=Disease Resistance, DrR=Drought Resistance, SG=Stay Green, PH= Plant height and TS=Total score
Source: Own results (2016).

Table 4. Gross margin of sorghum demonstration per *kebeles*

Variety	Yield (Qt/ha)	market price of output Qt/Birr	Fertilizer cost in ETB	Seed cost in ETB	Labor cost in ETB	TVC	TR(P*Q)	GM (profit)	Return to investment
ESH-1	20.9	1000	5450	900	7500	13850	20,900	7,050	0.51
Chare	16.3	1000	5450	900	7500	13850	16,300	2,450	0.18
Local	9.42	1000	5450	600	7500	13550	9,420	-4,130	-0.3

Source: Own result (2017).

Cost-benefit analysis result

The result shows that highest profit and returns were gained from ESH-1 and Chare varieties. ESH-1 variety gave a profit of 7,050 Birr/ha (seven thousand and fifty birr) and highest returns to investment of 51%. From Chare variety 2,450 birr/ha profit and 18% returns to investment were gained. Negative profit was recorded from local variety (Table 4) due to low yield gained from local variety in condition of drought prevalence in the study area. Thus, the findings summarized that using improved seed were economically profitable than local variety at study area.

CONCLUSION AND RECOMMENDATIONS

Generally, from the demonstrated variety, ESH-1 and

Chare varieties were selected as first and with all average values given by farmers. From the result of the study there was yield advantage of ESH-1 over Chare variety and local check. Study unveiled huge yield difference between improved varieties and local check due to difference in drought resistivity between improved and local variety. There was also statistical difference between the yield of improved (ESH-1) and Chare varieties at 5% significance level. From the result of study, ESH-1 and Chare have more economic profit than local variety. Therefore, ESH-1 is recommended for further scaling up in study area and similar agro ecology. It is required to popularize through clustering, and farmer to farmer linkage is required to disseminate this technology widely in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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