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Enhancing sorghum yield through demonstration of improved sorghum varieties in Tanqua-Abergelle Wereda, Central Zone of Tigray, Ethiopia

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With the aim of improving food security through enhanced production and productivity of sorghum a demonstration of two improved sorghum varieties (Chare and Melkam) was conducted in two selected Kebelle (Shekha-Tekhli and Agbe) of Tanqua-Abergelle Wereda. A total of 100 farming households (88 male and 12 female) who are beneficiaries of the Productive Safety Net Program were purposively selected. Each farmer planted the improved varieties along with the local known as Merawi. A total of 2.5 quintals of seeds of both varieties was distributed to cover about 25 ha of land. The average grain yield obtained from the improved sorghum varieties (Chare, Melkam) and local sorghum variety (Merawi) was 47.6, 39.9 and 32.2 qt/ha, respectively. This indicated that the two improved varieties were about 47.8 and 23.9% more productive than the local variety in the same order. This will have significant contribution to the efforts towards ensuring food security and improving the livelihoods of poor farmers. In terms of monetary value, the beneficiary farmers would be able to generate an average gross income of 32,459.50, 27,681.00 and 22,305.50 Birr/ha from Chare, Melkam and local cultivar, respectively. Moreover, the improved verities were found to be early maturing and can best adapt to moisture stressed areas. Therefore, it is recommended that the office of agriculture and rural development of the wereda to further scale up the varieties to other areas to benefit quite significant number of farmers.

Key words: Farmer' perception, sorghum, improved varieties, demonstration, Tigray, Ethiopia.

INTRODUCTION

Sorghum is a staple crop in drought prone areas;-as it is drought tolerant worth promoting in view of effects of climate change and brings out large percentage of the people from poverty. Sorghum grows in a wide range of agro-ecological zones most importantly in the moisture stressed parts where other crops cannot survive and food insecurity is rampant (Asfaw, 2007). Globally, sorghum is the fifth most important staple food crop after wheat, rice, maize and barley (FAO, 2016). In Ethiopia, sorghum is grown in almost all regions occupying an estimated total

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land area of 1,854,710.93 ha of which 12.91% of land is in Tigray region (CSA, 2016). Sorghum in the study area is mainly grown under rain feed, where rainfall is erratic, low in amount and uneven in distribution. As a result, sorghum production has become highly unpredictable that leads into a chronic food shortage to the smallholder farmers.

The potential productivity of sorghum is reduced due to both abiotic and biotic stresses. Low soil fertility (nutrient deficiency) and drought were the main abiotic factors. Important biotic constraints include the parasitic weed; Striga (Striga species), foliar and panicle diseases and stem borers (Wortmann et al., 2006). Sorghum is utilized in different forms where the grain is used for human consumption and homemade beverages, leaves and stalks are commonly used as fodder for their animals. In the low land area of Tigray, farmers grow sorghum for human consumption in the form of food and homemade beverages.

In Tanqua Abergele Woreda, sorghum is one of the major food crops ranked first in its area coverage which accounts about 45.6% of the total cultivable land (TAWOoARD, 2013). However, the erratic and uneven distribution of rainfall is becoming a threat to produce late maturing local sorghum varieties. These local varieties are frequently exposed to moisture stress at flowering and grain filling stages of the crop which resulted in either low yield or total crop failure.

Scholars agree that technology demonstration is a critical means of technology evaluation and transfer. Demonstration experiment can be effective technique in fostering awareness due largely to their direct experimental nature which is beneficial to discovery learning (Leeuwis, 2004). As the demonstration is conducted on farm which is open to technology user and nonuser it gives room to extend the merit of the technology within the social system through social networks. Social networking is an important means of promoting technology adoption. Despite the effort of science and technology which has heavily influenced agricultural production system for decades, there are no as such promising changes in the life of target communities (Amanor, 1994). Researches targeting on solving agricultural problem were designed and implemented on station through academician's motivation. However, these research output did not address farmers' needs as the effectiveness of the technologies were measured through production and productivity which is not complemented with users' preference and working condition. Perception is how the smallholder farmers perceive the improved sorghum varieties (Melkam and Chare) from his/her point of view. Perception plays a vital role in shaping human practice (Leeuwis, 2004).

Understanding the problem, Abergelle Agricultural Research Center researchers have been conducting different research activities on-station and on-farmers' field to identify varieties and agronomic practices which have better adaptation under the agro-ecological conditions of it study areas. From the varietal evaluation and adaptation trials conducted on sorghum, Chare and Melkam were found to be high yielder and early maturing. The study was designed to test whether improved varieties (Chare and Melkam) has no significant difference in grain yield improvement, while farmers apply the technology at farm condition (H0). Hence, this study was initiated to enhance yield production and productivity through demonstration of improved sorghum varieties. The specific objective of the study seeks; to demonstrate the improved sorghum varieties (Chare and Melkam) in the economically marginalized smallholder farmers, to evaluate the performance of improved sorghum varieties (Chare and Melkam), and to collect farmers' perception about the improved sorghum varieties (Chare and Melkam) in the study area.

RESEARCH METHODOLOGY

The Wereda is located in central zone of Tigray 120 km away from Mekelle. It has area coverage of 122,500 ha with average holding of 1.0 ha per household (CSA, 2002). Agro-ecologically, the area is characterized as hot warm sub-moist low land (SMl-4b) with altitude below 1500 m.a.s.l. The annual rainfall and temperature is 350 to 700 mm and 24 to 41°C, respectively (Legesse, 1999). Mixed crop-livestock farming system is dominantly practiced in the Wereda. Crops such as sorghum, maize and pulses (cowpea, ground nut, sesame) are commonly grown. The Wereda is also known for its huge livestock resources particularly small-ruminants (TAWOoARD, 2013).

For the study, two kebelles (Shekha-Tekhli and Agbe) were purposively selected based on their accessibility and potential sorghum production. From both kebelles, a total of 100 productive safety net program (PSNP) beneficiary farmers (88 male and 12 female) were also purposively selected from both kebelles. Initially, farmers were trained about the varieties and improved agricultural practices namely about seed rate, fertilizer rate, planting dates and protection. Accordingly, they applied 10 kg/ha of seed rate along with 50 kg/ha Urea and 100 kg/ha DAP. Each farmer received 2.5 kg of seed to cover 0.25 ha of land improved sorghum variety along with local cultivar for comparison. In general, the beneficiary farmers hosted the intervention and apply all necessary management activities as per the recommendation. The woreda experts were involved in identifying the host farmers and conducted field supervision throughout the growing period. Similarly, training, technical backstopping, data collection and reporting were managed by researchers.

Both primary and secondary data were collected. The quantitative data (grain, cost and biomass yield) were collected using quadrant and qualitative data (farmers' perception) were collected from the beneficiaries using checklist. Additionally, data about the costs were collected by questioner and the profit data were collected from the grain and biomass yield estimated on January 2014 market price. Secondary data were also collected from different sources such as published (journals) and unpublished reports of the Wereda office of agriculture and Abergelle agricultural research center (AbARC). The quantitative data were analyzed using simple descriptive statistics such as mean, standard deviation (SD) and benefit cost ratio analysis. Additionally, the study employed paired T- test to see if the mean yield of improved sorghum varieties (Chare and Melkam) were significantly different

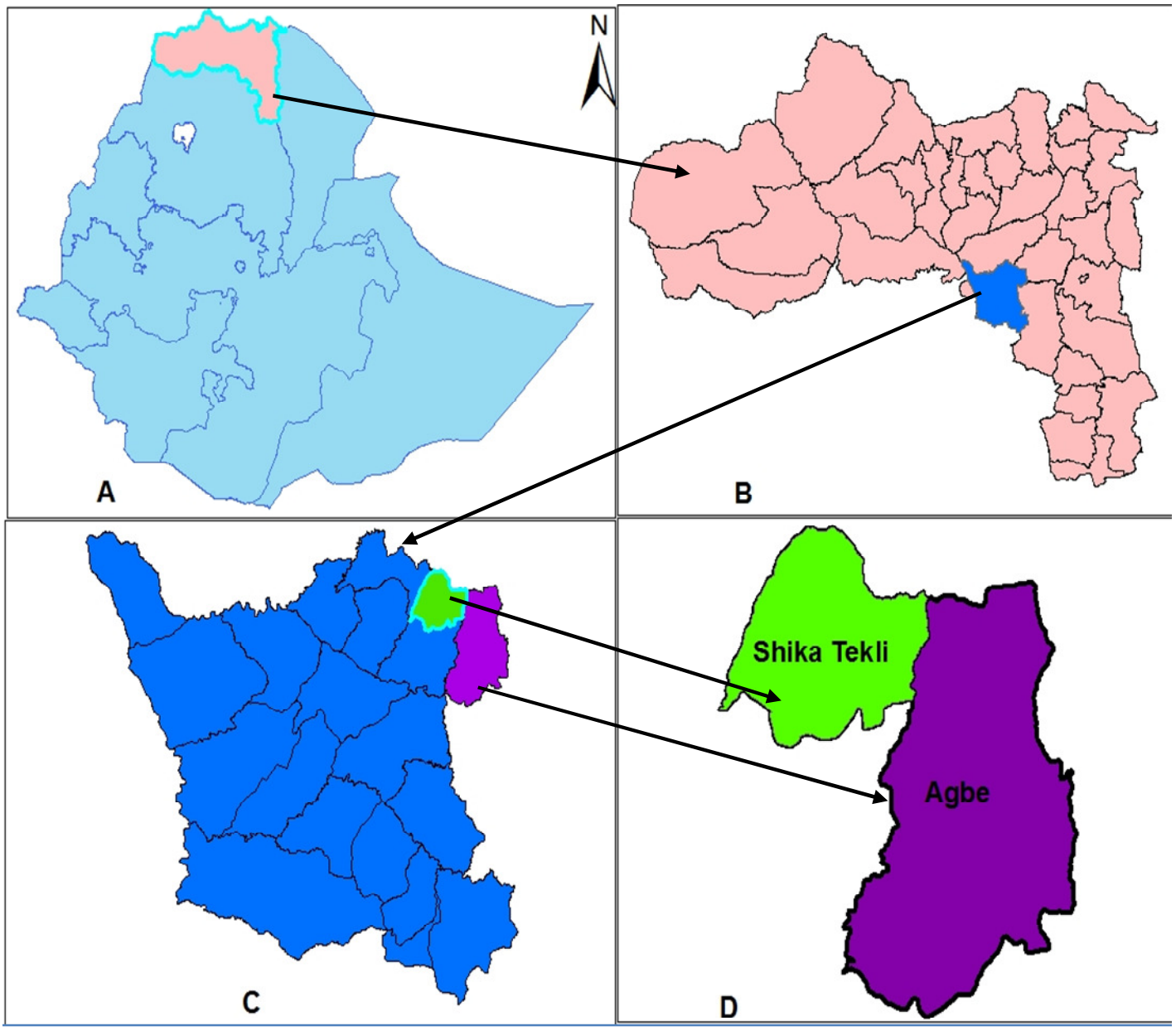

Figure 1. Map of the study area (A refers to Ethiopia, B refers to Tigray Region, C refers to Tanqua-Abergelle and D refers to study kebelle).

from the local cultivar. To analyze farmers' perception, the study used percentage and narrative analysis (Figure 1).

RESULTS AND DISCUSSION

Grain and straw yield of the varieties

Production comparison between the two improved varieties (Chare, Melkam) and one local cultivar known as 'Merawi' was made. The local cultivar 'Merawi' was selected because it is the cultivar most commonly grown in the study area. The result obtained from the improved sorghum varieties as well as the local cultivar in the study areas are described in Table 1.

As it is described in Table 1, an average grain yield of 47.60 and 39.90 ql/ha were obtained from the improved sorghum varieties Chare and Melkam, respectively while the average grain yield obtained from the local cultivar 'Merawi' was 32.20 ql/ha. The result of the study indicated in (Table 1) shows both the improved sorghum varieties (Chare and Melakm) have statically significant (at > 5%) grain yield increment over the local sorghum cultivar with yield increment of 15.40ql/ha (47.8%) and 7.70 ql/ha (23.9%) over the local cultivar (Figure 2).

In the dry season shortage of animal feed is also one of

Table 1. Mean grain and straw yield of improved varieties vs. local cultivar in areas.

Variety	Minimum (kg/ha)	Maximum (kg/ha)	Mean (kg/ha)	Yield advantage from local t %	SD	T-value	Sig
Chare	4300.00	5200.00	4760.00	47.8	2.75	19.67	0.000***
Melkam	3010.00	4740.00	3990.00	23.9	4.71	6.89	0.000***
Merawi (local)	2800.00	3750.00	3220.00	-	2.46		

Source: Computed from field data taken in quadrant from 1 m^2 plot size (2014).

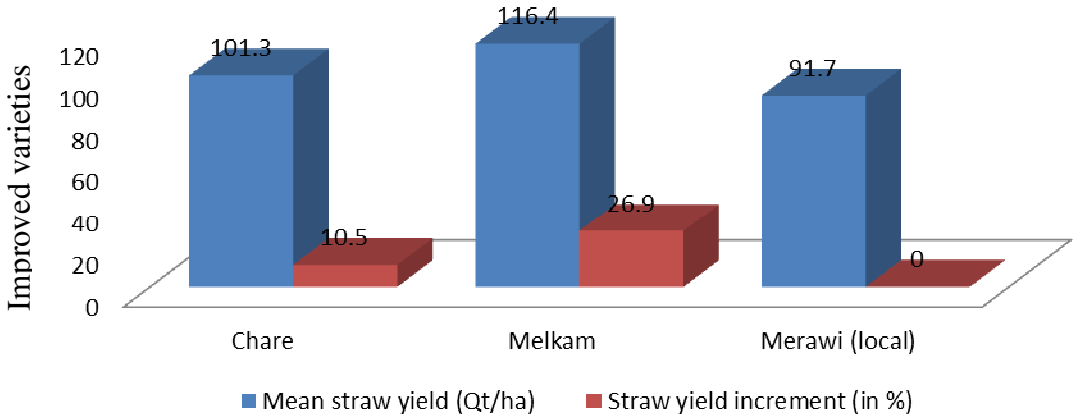

Figure 2. Mean of straw yield of improved varieties vs. local cultivar in qt ha^{-1}.

Table 2. Benefit cost ratio of the improved sorghum varieties vs. local cultivar.

Variety	Total variable cost (Birr)	yield (Qt/ha)		Income (Birr/ha)		Gross income (Birr/ha)	Net income (Birr/ha)	Benefit Cost Ratio (GI/C)
		Grain	Straw	Grain	Straw			
Chare	13,777.00	47.6	101.3	30,940.00	1,519.50	32,459.50	18,682.50	2.36
Melkam	13,777.00	39.9	116.4	25,935.00	1,746.00	27,681.00	13,904.00	2.01
Merawi (Local)	13,777.00	32.2	91.7	20,930.00	1,375.50	22,305.50	8,528.50	1.62

Source: Computed from field data taken in quadrant and estimated price in the nearby market (2014).

the critical problems of farmers. In this regard, compared to the improved varieties the local cultivars are lower in their bio-mass yield. The result indicated that the straw yield obtained from Chare and Melkam was 10130.00 and 11640.00 kg/ha, respectively while the biomass yield the local is 9170.00 kg/ha. This implied that the improved varieties give additional straw yield, about 10.5% (Chare) and 26.9% (Melkam) higher compared to the local cultivar (*Merawi*).

Benefit cost ratio of the improved varieties Vs local cultivar

Given the prevailing market price, benefit cost ratio was computed from grain and straw yield on hectare basis. In terms of monetary value, the beneficiary farmers were able to generate an average gross income of 32,459.50, 27,681.00 and 22,305.50 Birr/ha from Chare, Melkam and local cultivar, respectively (Table 2). There is no difference in management practices to all and hence the total variable costs are similar. The average net income farmers could generate per hectare was 18,682.50, 13,904.00 and 8,528.50 Birr/ha, in the same order. This implied that farmers could earn an additional net income of 10,154.00 and 5,375.50 Birr/ha from Chare and Melkam, respectively. The benefit cost ratio of Chare, Melkam and local cultivar was 2.36, 2.01 and 1.62, respectively. In other words, farmers can generate 2.36, 2.01 and 1.62 Birr benefit from Chare, Melkam and local

Figure 3. Performance of Chare and Melkam at heading stage in Tanqau Abergelle Wereda.

Table 3. Farmers' perception on attributes of improved sorghum variety versus local cultivar.

Parameter	Farmers response											
	Melkam Vs Local						Chare Vs Local					
	Lower (%)		No change		Higher		Lower (%)		No change		Higher	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Early maturity	0	0	1	6.67	14	9.33	0	0	2	13.33	13	86.67
Drought resistance	0	0	0	0	15	100	0	0	0	0	15	100
Disease resistance	2	13.33	12	80	1	6.67	5	33.34	8	83.33	2	13.33
Pests resistance	3	20.00	12	80.00	0	0	1	6.67	14	93.33	0	0
Grain yield	0	0	2	13.33	13	86.67	0	0	0	0	15	100
Straw yield	0	0	3	20.00	12	80.00	0	0	2	13.33	13	86.67
Seed uniformity	0	0	0	0	15	100	0	0	0	0	15	100
Seed color	0	0	8	53.33	7	46.67	10	66.67	5	33.33	0	0
Taste of food (Enjera)	0	0	5	33.33	10	66.67	5	33.33	6	40.00	4	26.67
Marketability	0	0	6	40.00	9	60	0	0	5	33.33	10	66.67
Straw palatability	2	13.33	10	66.67	3	20.00	6	40.00	8	53.33	1	6.67
Over all acceptance	0	0	0	0	15	100	0	0	0	0	15	100

Source: Own computation from survey data (2014); Freq refers frequency.

cultivar for 1 Birr investment cost of production. The cost benefit ratio indicates growing all verities of sorghum is financially profitable, however producing improved sorghum varieties has great contribution in capitalizing the return of producers'. This implies that with ever increasing human population while the size of the cultivated land remains constant, improving production and productivity of a given land using improved crop varieties could be the best solution as far as improving household food security status is concerned (Figure 3).

Farmers' perception on attributes of improved sorghum variety

The improved sorghum varieties merits and demerits were assessed from farmers' point of view. Table 3 demonstrates the perception of farmers based on the parameters listed in deciding a variety is acceptable in replacing the existing local cultivar. The participant farmers perceive the technology as a favor in its' drought resistant, early maturity, and grain and straw yield.

Additionally, the technology beneficiary criticizes the technology negatively in its' poor disease resistance and low palatability of the straw. The data collected from the sampled technology users response is similar with the data collected from non-technology user field day participant farmers and agricultural knowledge workers in the varieties early maturity and have good performance in field level. Both the target beneficiaries as well as participants of the field days perceived that the improved varieties (Chare and Melkam) were better in yield, early to maturity and drought tolerant. Additionally, the participant farmers perceive that improved sorghum variety especially Chare is lower in straw palatability and its color when compared with local cultivar.

CONCLUSIONS AND RECOMMENDATIONS

From the demonstration intervention, it can be concluded that there are wider possibilities to greatly support the government efforts toward enhancing food security and livelihoods of poor households. As in the case of the two improved sorghum varieties (Melkam and Chare), increasing productivity of a given crop commodity by about 23% and 48%, which have a quite significant implication on improving household food security. Therefore, the study points out the following recommendations:

(1) There should be reliable seed supply both in quality and quantity of both varieties so as to ensure sustainable seed supply system and fulfill the farmers demand.
(2) Considering the erratic and unrealizable climatic conditions, further research efforts to generate drought tolerant sorghum varieties are very essential.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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