Tigray Agricultural Research Institute
Agricultural Growth Program-II

Pre-extension Demonstration of Agricultural Technologies

Proceedings of a Workshop, 09-15 November 2018, Capital Hotel, Wukro, Tigray, Ethiopia

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Acknowledgements

Tigray Agricultural Research Institute (TARI) have been contributing to the Program Development Objective (PDO) to increase agricultural productivity and commercialization of smallholder farmers targeted by the program and contributes to dietary diversity and consumption at household level. In achieving the PDO, TARI/AGP-II had approved a total 95 research activities in 2016, supported by the World Bank and to be implemented under technology generation, pre-extension demonstration and technology multiplication. The completed activities compiled here in this document are among the activities under pipeline up to the year 2016 and completed in 2017. These completed pre-extension demonstration and technology multiplication works were presented and reviewed in the workshop, with the full participation of all relevant stakeholders, on November 9-15, 2018 and those accepted in the workshop are now edited and complied in this proceeding.

These achievements are brought by the relentless efforts of the young and senior researchers, the collaboration of the support staff and the research centers of TARI, development agents, the farming community, administrative bodies of the respective AGP-II mandate districts and the beneficiary farmers from the 205 AGP-II mandate *kebelles;* which are delighted to work with us and they deserve a great honor and gratitude for their contribution.

Desalegn Emiru
Research Component Coordinator
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Forward

The AGP-II Research Component aims at adapting and or generating agricultural technologies, pre-extension demonstration of proven technologies, supplying and maintenance of source technologies. The technology adaptation, generation and pre-extension demonstration activities are envisaged to be implemented by taking into consideration principles of cross-cutting issues such as nutrition, gender and climate smart agriculture.

Cognizant of the importance of agricultural technologies, TARI has been undertaking s research in GTP-II period with the objective of adapting, generating and promoting agricultural technologies that enhance productivity and commercialization based on clustering , agroecology, and value chain approach and comprise the following strategy and approaches: Technology Adaptation: Introduction of appropriate technologies from local and abroad and adapt to Tigray condition ; technology generation: Development of own technologies; prescaling up and popularization of promising technologies; and multiplication and maintenance of source technologies.

This proceeding of demonstrated Proved technologies by TARI will serve as a reference for wider circulation and knowledge exchange among researchers, academicians, and development practitioners to fill gaps in technology promotion and popularization to accelerate agricultural productivity in Tigray and similar biophysical and socioeconomic setups.

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Preface

The government of Ethiopia have brought the Agricultural growth program intended to increase agricultural productivity and commercialization of smallholder farmers and contributes to dietary diversity and consumption at household level. The project would also contribute to the higher-level objectives of poverty reduction and climate change mitigation and adaptation through supporting climate smart agricultural initiatives. To this end, the Tigray region is working on the five components of the program; Public Agricultural Support Services, Agricultural Research, Smallholder Irrigation Development, Agriculture Marketing and Value Chains, Project Management, Capacity Development, and Monitoring and Evaluation.

Tigray Agricultural Research Institute is therefore working on generating/adapting technologies suited to the agro-ecologies of the region and demonstrating them in close collaboration with farmer research and extension groups. TARI also supplies source technologies by multiplying them in the mandate areas on farmers field, to address problems related to seed shortage and the like. As part of the agricultural growth program, TARI had a total of 95 activities in 2016/17. So far TARI has supplied basic and pre-basic seed types of different food and feed crops. Demonstration of generated or introduced technologies and their multiplication needs serious attention from the stakeholders working in the agricultural system. Particularly pre-extension demonstration and multiplication of technologies demands alignment with the technology disseminating strategies. Therefore, skill and financial capacity of seed producers need to be strengthened so that the source technologies demonstrated and multiplied from the research will reach to large part of the farming community and agricultural raw material demanding industries.

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1. Crop Technologies

1.1. Popularization of improved tef variety to enhance smallholder farmers tef productivity in Southern Zone of Tigray, Northern Ethiopia

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Abstract

The study was conducted in the lowlands of Southern zone of Tigray in 2015/16 and 2016/17 production seasons. The objectives of the study were to popularize improved tef variety (Boset) and to evaluate farmers' perception of Boset compared to the existing tef cultivar in Raya-Azebo and Raya-Alamata districts. A total of 45 interested farmers were purposively selected and they planted the improved tef variety in cluster. The improved tef variety, Boset performed well in Raya-Alamata district and has given the mean grain yield of 21.53 qt ha^{-1}. The existing cultivar has given mean grain yield of 11.3 qt ha^{-1}. The improved variety had given significantly higher grain yield than the existing tef cultivar. The yield difference between the improved variety and the local could have been from differences in agronomic practices, crop management and soil type. The improved tef variety (Boset) was also popularized in Raya-Azebo district and has given mean grain yield of 9.43 qt ha^{-1}. Majority of the respondents have liked the pre and post-harvest attributes of the improved tef variety compared to the existing cultivar. Therefore, office of agriculture and rural development of the respective districts should disseminate and scale-out Boset in the study areas and similar agro-ecologies. Besides, seed producer cooperatives or farmers group should sustainably multiply the seeds of Boset.

Keywords: Boset, tef, popularization, grain yield

Introduction

Tef (*Eragrostis tef (*Zucc.) Trotter)) originated in Ethiopia (Vavilov 1951) and it is one of the important cereal crops grown in diverse climatic and edaphic zones of the country. Like all other cereal crops, tef belongs to the Poaceae or Grass family and believed to be first domesticated by pre-semitic inhabitants in Ethiopia between 4000 and 1000 B.C (Alganesh 2013). This crop species is an allotetraploid, which is believed to have originated from *Eragrostis pilosa* (Endeshaw and Lester 1981). Tef is considered as native to Northern Ethiopia, although so far only five wild types or accessions were collected from only the lowlands in the North East and

South East Ethiopia (Tadesse 1975). The crop is relatively resistant to many biotic and abiotic stresses and can be grown under different agro-ecological conditions, ranging from lowland to highland areas. It can also be stored for many years without being seriously damaged by storage insect pests (Demeke and Di Marcantonio 2013).

Tef covers about 28% of the total cultivated area of cereals, and accounts for 21% of the total cereal production in the country (CSA 2010). Nationally, the area coverage of tef in 2016/2017 'Meher' production season was about 3,017,914.36 ha with an average national productivity of 16.64 kg ha^{-1} (CSA 2017). Tef grain is predominantly produced by smallholder farmers in the country, where about 62% of the population depend on it as staple (Assefa et al 2011). The crop constitutes about two-thirds of the dietary protein intake of most Ethiopians (Seyfu 1997). The grains are highly nutritious with about 9 to 11% protein content, which is slightly higher than sorghum, maize and oats (NRC 1996). Moreover, tef grains are gluten free, making them a valuable food source for human with celiac disease (Seyfu 1997).

Tef is largely produced for marketing purpose because of its premium price over other cereal crops. Tef seed marketing mainly depends on three general color grades (white, mixed and red). Consequently, the white-seeded tef is fetching the highest price than the two remaining grades. There are also important sub-grades within each grade such as 'Magna' (very white seed) which grows in East Shoa and is sold at a premium price (Demeke and Di Marcantonio 2013).

In the Tigray region, the major tef producing areas are the Central, some parts of North-Western and Southern zones particularly Raya-Azebo and Raya-Alamata districts. The area coverage of the crop in the region is about 167,584.33 ha with an average productivity of 14.38 qt ha^{-1}. Similarly, the area coverage for tef production in the southern zone of the region is estimated to be 44,036.04 ha with an average productivity of 13.97 qt ha^{-1} (CSA 2017).

Despite its economic importance, the productivity of the crop both at the national and regional level is low (CSA 2013). Poor agronomic practices and other constraints like water lodging, low modern input use, lack of high yielding cultivars and high post-harvest losses contribute to its lower productivity (Berhe et al 2011). Hence, the Ethiopian Agricultural Research System

(EARS) has carried out numerous research activities to overcome these problems and then to enhance tef productivity at the national level. In Tigray region, where the rainfall is erratic and unreliable, the productivity of the crop is low. The lowland area of the Southern zone of the region is frequently exposed to drought and moisture stress, which results in decline of tef productivity. For moisture stressed areas, an improved tef variety Boset is best adapted and Alamata Agricultural Research Center in collaboration with AGP-II project has introduced Boset to Raya-Azebo and Raya-Alamata districts. Therefore, the objectives of the study were to popularize improved tef variety Boset to farmers in the lowland districts of the Southern zones of Tigray and to assess their perception towards the improved tef variety by comparing it with the existing tef cultivars.

Materials and Methods

Description of the study Areas

The study was conducted in Raya Azebo and Raya Alamata districts. Both of the districts are located in the lowland of the Raya valley and with a potential for tef production. Raya Azebo district is located in southern zone of Tigray, about 122 kms south of Mekelle city, the capital city of Tigray regional state. Raya-Alamata District is located between 12.26^0 – 12.57^0 North latitude, and 39.24^0 –39.76^0 East longitude. Based on the secondary data obtained from office of agriculture and rural development (OoARD, 2016), about 25 % of the area in the district is categorized as highland (Dega) with the remaining 75% lowland (kola). The mean annual rainfall of the district is 650 millimeters (mm), which varies between 600 to 700 mm, and is unevenly distributed. The main rain season (*kiremti*) extends from June to September. The second rainy season known as the '*belg'* extends from February to April, where farmers mainly grow early maturing tef varieties and animal feed crops. The average annual temperature is 25^oc, and it ranges from 23 to 27^oc. Major crops grown in the area includes sorghum, tef and vegetable crops. Cattle and small ruminants (goats) also dominate the livestock production in the area. A map of the study areas is presented in figure 1.

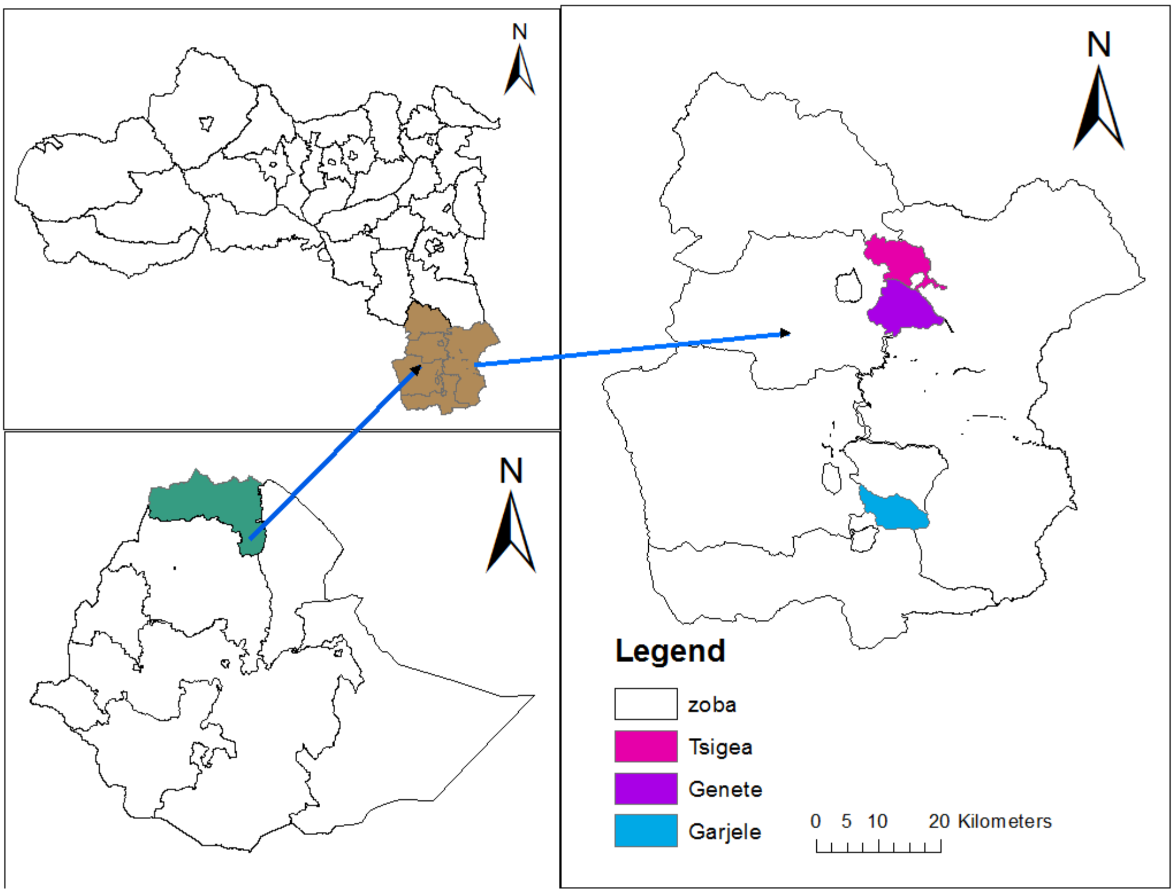

Figure 1. Map of the study site

Sampling technique and procedures

The study employed three-stage sampling method. First, Raya-Azebo and Raya-Alamata districts were purposely selected from Southern zone of Tigray based on their potential for tef and their being moisture stressed. Then three Tabia's, two from Raya-Azebo and one from Raya-Alamata, were randomly selected.. Finally, in close collaboration with offices of agriculture and rural development, 45 farmers (15 from each Tabia) were randomly selected based on the availability of resources and the criteria and objectives of AGP II project. Selection of beneficiary farmers was based whether his/her farmland is in the tef cluster sites and had at least 0.5 ha of farmland. The research center provided the improved tef variety (Boset) while the existing teft cultivar (Bine) was from farmers own stock. Before the implementation, practical training on the agronomic practices of the improved variety, and the ways of its implementation was delivered to participant farmers, experts and development agents. All management practices required for the tef crop were carried out by participant farmers with close follow-up of the researchers, experts and development agents.

Data collection methods

The primary data includes qualitative and quantitative data. The qualitative data (farmers' perception) were collected using structured and semi-structured interview while the quantitative data (grain yield) were measured from samples collected by the researchers. The grain yield data was collected using a 1 x 1 meter quadrant. The study also used 7 randomly selected beneficiary farmers to collect the pre and post-harvest attributes of the varieties both in the field and after harvesting. To collect pre-harvest perception data, farmers were asked to list the major tef selection criterion used from their own experience. After farmers had listed their selection criterions then they tried to evaluate and compare these two varieties (improved *vs* existing tef cultivar) based on the predetermined crop attributes already identified. In the evaluation process, farmers gave their own score (1-10) for each crop attributes. Post-harvest perception data were collected using a five level Likert scale, which includes very poor, poor, same, good and very good. Besides, secondary data was also reviewed from annual reports, proceeding and journals.

Data analysis

The study employed both descriptive and narrative to analyze the grain yield and farmers' perception on pre and post-harvest attributes of the improved tef variety by comparing with the existing tef cultivar.

Results and Discussion

Grain yield of the improved tef (Boset) *vs* existing tef cultivar (Bine)

During the 2016/17 production season, the improved tef variety (Boset) had well performed in Raya-Alamata district particularly at Tabia Kulu-Gizie-Lemelem, and the mean grain yield found was 21.53±1.47 qt ha^{-1}. A higher yield variation was also observed among participant farmers that planted the same variety, which ranges from 19.8 to 23.83-qt ha^{-1}. The yield difference might have been brought from the differences in implementation of agronomic practices, crop management and soil profile of each farmer's farmland. Hence, farmers who used the recommended fertilizer rate and improved agronomic practices have given better grain yield than those who used below the recommended fertilizer rate and the traditional agronomic practices. The mean grain yield obtained from the existing tef cultivar was 11.3±3.11 qt ha^{-1} with the minimum and maximum yield of 7.27 and 14.10 qt ha^{-1} , respectively. The improved variety has given significantly higher grain yield than the existing tef cultivar used in the area (Table 1).

Table 1**.** Mean grain yield obtained from improved tef variety vs existing cultivar (Bine)

Parameter	Treatments	Minimum	Maximum	Mean	SD	t-value
Grain yield	Boset	19.80	23.83	21.53	1.47	6.135***
(qt ha^{-1})	Bine	7.27	14.10	11.30	3.11	

Source: Survey data 2016

The improved tef variety (Boset) was also popularized in Raya-Azebo district particularly at Tabias Genete and Tsigea in 2015/16 production season, and the mean grain yield obtained was 9.43 qt ha^{-1}. The yield of Boset varied from 4 to 16 qt ha^{-1} among individual farmers.

Farmers' perception towards overall pre-harvest attributes of improved tef variety vs the existing cultivar

Analysis of farmers' perception result towards the improved and the existing tef cultivar showed a significant difference in the mean perception score for the listed attributes evaluated by farmers. However, farmers also mentioned that Boset had shown a shattering problem as compared to the existing cultivar but generally, the farmers have favored the improved variety for its pre-harvest traits as compared to the existing cultivar and the average mean score for Boset was significantly higher (6.71) than the existing cultivar (3.00) (Table 2).

Table 2**.** Farmers' perception on overall pre-harvest attributes of the improved tef variety vs the existing cultivar

Attributes	Existing cultivar (Bine)	Improved variety (Boset)
	Score	Score
Plant height	2	8
Earliness to maturity	2	8
Heading (spike length)	3	7
Color attractiveness	3	7
Drought resistance	3	7
Early germination	2	8
Shattering problem	6	4
Mean	3.00	6.71
SD	1.41	2.13
t-value	3.83***	

Source: Survey data 2017.

Farmers' Perception towards Pre and Post-harvest Attributes of the Improved Tef Variety vs Existing Cultivar

Majority of the respondent farmers evaluated Boset as good and very good based on the predetermined pre-harvest and post-harvest attributes compared to the existing cultivar. However, about 14.3% of the respondents have not favored the improved variety for its less disease tolerant and this implies it needs proper disease management. Moreover, the beneficiary farmers had favored the improved the variety for its earliness, attractive seed color, flour quality, food taste/*injera*, seed color, seed weight and marketability of the seeds (Table 2). In the analysis, flour quality refers to the suitability of the flour for food preparation and *injera* quality for its taste, preference, and ability to stay with its original color, softness of *injera* after baking and over time.

Table 3. Farmers' perception on pre- and post-harvest attributes of the improved tef variety (Boset) vs existing cultivar (Bine)

Attributes	Perception levels									
	Very poor		Poor		Same		Good		Very good	
	N	%	N	%	N	%	N	%	N	%
Early germination	-	-	-	-	-	-	2	28.6	5	71.4
Disease tolerance	-	-	1	14.3	-	-	2	28.6	4	57.1
Pest tolerance	-	-	-	-	-	-	4	57.14	3	0.43
Early maturity	-	-	-	-	-	-	4	42.9	3	57.1
Thresh ability	-	-	-	-	-	-	5	71.4	2	28.6
Straw palatability	-	-	-	-	-	-	4	42.9	3	57.1
Grain yield	-	-	-	-	-	-	5	71.4	2	28.6
Seed color	-	-	-	-	-	-	2	28.6	5	71.4
Seed weight	-	-	-	-	-	-	2	28.6	5	71.4
Marketability	-	-	-	-	-	-	1	14.3	6	85.7
Injera quality	-	-	-	-	-	-	2	28.6	5	71.4
Flour quality	-	-	-	-	-	-	2	28.6	5	71.4

Source: Survey data 2016.

Conclusion and Recommendation

The study showed that the improved tef variety (Boset) had shown better performance in grain yield and it was highly favored by the farming community in the pre-determined pre- and post-harvest attributes of the crop over Bine which is mainly produced in the study areas. Hence, office of agriculture and rural development of the respective districts should further disseminate and scale-out Boset to a large number of farmers in similar agro-ecologies. Seed producer cooperatives or organized farmers group should also be formed to continuously and consistently multiply and supply the seeds of this variety so that there is sustainable seed supply for Boset in the area.

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1.2. Pre-extension popularization of improved tef variety at tef growing districts of North Western Zone of Tigray Region

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Abstract

The demand for tef is increasing both locally and globally, given its health importance and the ever improving standard of living of the people in the region. Many endeavors were made by governmental and non-governmental bodies to enhance the production and productivity of tef.. Shire-Maitsebri Agricultural Research Centre (SMARC) is also entitled to undertake tef related research activities including introduction, adaptation, verification and demonstration of tef technologies. As a continuum of the the previous tef related activities, this pre-extension demonstration of improved tef variety was, therefore, initiated to enhance production and productivity of tef through popularizing a highly adaptable, high yielder and most preferred tef variety in selected tef growing districts of North Western zone of Tigray region. More specifically, it sought to popularize an improved tef variety to large number of farmers in the selected districts; and collect beneficiary farmers' perception on the popularized tef variety. A total of 348 farmers were included in the study. Both grain yield and farmers' response on the improved teff variety have been considered. The data collected were subjected to descriptive analysis. The average grain yield was 16.39 and 15.2 qt ha^{-1}, were obtained from Kora and Quncho tef varieties, respectively, in Tahtay Koraro district. Kora performed best with 7.8% yield advantage over Quncho. Similarly, the average grain yield was 14.19 q and 13.3 qt ha^{-1} respectively for Quncho and Kora tef varieties, respectively in Medebay Zana district. Kora still performed best with 6.69% yield advantage over Quncho. Farmers perception data collected also indicated that there no differences between Kora and Quncho. Therefore, Kora should be scaled-out to large farmers with research technically backing the extension.

Key words: Kora, Quncho, tef, Medebay-Zana, Tahtay-Koraro

Introduction

Tef [*Eragrostis teff* (zucc) Trotter] is cereal that belongs to the family Poaceae, The crop is indigenous to Ethiopia and has an amazing wealth of diversity (Seyfu 1991). Tef originated in Ethiopia and become known to the world. The crop has been introduced to South Africa and is being cultivated as a forage crop and recently it is cultivated as a cereal crop in northern Kenya (Seyfu 1997).

Tef is grown under diverse agro-climatic zones. Tef can grow from sea level to 2800 meters altitude with varying mean annual rainfall of 750-850 mm and mean temperature of 10 and 27^0c are suitable for tef cultivation (Seyfu 1997). Interestingly, tef can thrive well in both waterlogged as well as droughty conditions.

On a nutritional yardstick, tef on an average supplies around two third of the protein required in the daily diet of the population. It has high fiber content and highest iron content. Its straw is used as a feed to livestock and beside to this it has multiple other uses including acting as reinforcement for thatched roofs and mud bricks.

Tef is Ethiopia's most important staple crop and has the largest value in terms of both production and consumption in Ethiopia. The value of the commercial surplus of tef is second only to coffee (Minten et al 2013).

Despite its importance in Ethiopia, tef yields are low. In the production year 2016-2017, yields were 1.66 metric tons (mt) per hectare (ha), significantly lower than other cereals such as maize (3.67 mt/ha), sorghum and wheat (2.52 mt/ha and 2.67 mt/ha) (CSA 2017). Moreover, teff yields are low because of agronomic constraints like lodging, low modern input use, and high post-harvest losses (Fufa et al 2011). It would seem that because of its superior nutritional qualities, it is the preferred grain for making *injera*, its accessibility though is limited due to its high cost.

In Tigray specifically in North Western zone, the area under tef cultivation was increasing and currently occupies the largest hectarage among the midland cereals of the area. This was because tef grain and straw fetch a relatively high price in the market compared to other cereals.

The productivity of tef in North Western Tigray is relatively low as compared to the national average. Low usage of improved tef variety in the area could be one of the reasons for the low productivity of the tef. To alleviate this problem, improved tef varieties were tested at the Shire-Maytsebri Agricultural Research Center mandate areas. An extraordinary work was executed in the last five years on disseminating and scaling-out of the improved Quncho tef variety to large numbers of farmers. Demonstration of a new improved tef variety Kora was held in 2007/08 production season in the study area. Both the new and old (Kora and Quncho) have given good results except Kora performed well and have given better result in the water-logged areas. Therefore, the objective is study was to enhance production and productivity of tef through popularizing a high yielder tef variety in the selected tef growing districts of North Western zone of Tigray.

Materials and Methods

Description of the study area

The popularization of improved tef variety was undertaken at Tahtay-Koraro, and Medebay-zana districts of the North Western zone of the region. The rainfall of Medebay-Zana was 600-900mm and that of Tahtay-Koraro was 800-1000 mm (OoARD, 2016). The popularization of Kora was held at midland areas of the selected districts and this study was held in 2016 cropping season.

Sampling technique and sample size

A two stage sampling technique was employed to come up with the intervention areas and farmers those who participated in the popularization activity. In the first stage, four potential tef growing districts were selected. Then, six Kebelles, namely; Beles, Adigdad (Tahtay-Koraro), Hakfen, Adikemalik, Debrekerbe, Meshil (Medebay-Zana) were also purposively selected given their potential to grow teff. In the second stages, 348 farmers were purposively selected considering their willingness and ability to shoulder the popularization activity.

Table 1. Distribution of beneficiary farmers by districts, kebelles and gender.

Intervention District	Number of kebelles	Number of participants		
		Male	Female	Total
Tahtay-koraro	02	132	01	133
Medebay-zana	04	181	10	191
Total	06	313	11	324

Implementation procedure

Forming a multi-disciplinary team

To conduct the trial, a team comprising weed, agronomy, breeder, pathologists and socioeconomics and extension researchers was established. Team members were assigned responsibilities. Team was expected to deliver training to farmers, development agents (DAs), and experts to better align their assigned duties and responsibilities. Besides, the team was responsible for field day arrangements, coordination, follow up and technical backstopping. Farmers were expected to allocate land and cover the cost of production except cost of improved technologies. DAs of selected kebelles were responsible to play their role through paying a regular follow up to farmers, coordinating the farmers for the training, farmers' field days and reporting progress of work to the researchers and experts of respected intervention districts.

Farmers' selection criteria, plot size and management

Volunteer farmers who can provide their land for the study and are willing and able to provide feedbacks on the popularized tef technology were selected. Each farmer was then expected to avail a land, an area of 0.25 hectare. Seeds were drilled in rows with 20 cm spacing between rows. Farmers were also expected to manage their trials by themselves. Besides, selected farmers were expected to obey to the advice of the researchers so as to meet the objectives of the activity.

Training and input provision

Training

Training schedules were arranged and offered to farmers, experts and development agents of the host districts. The major areas of the training focused on.

- clearly explaining the objectives of the research
- record keeping
- methods of tef production with full package and
- on the unique traits of the improved tef varieties, Kora and Quncho, agronomic and disease management.

Input (tef seed)

Farmers who participated in the popularization were offered 3-5 kg of tef from each variety.

Data type, source, data collection and analysis

In this study, only primary data were collected and considered. The primary data include grain yield and farmers' perception on the improved tef variety. The grain yield was collected from 16 randomly selected farmers' fields. The data collected was analyzed using simple descriptive statistics like means and percentages. Farmer's response was collected from 20 randomly selected respondents. Likert scale with three scales (disagree, indifferent and agree) was used to gather farmers' response on important attributes of tef.

Results and Discussion

Grain yield comparison of improved Kora vs Quncho

Yield estimation was undertaken by taking sample from a plot area of 2 m x2 m from ten farmers' field. An average of 16.39 and 15.2 qt ha^{-1}, were obtained for Kora and Quncho varieties, respectively in Tahtay-koraro district. In Medebay-zana district, an average yield of 14.19 and 13.3 qt ha^{-1} were obtained for Kora and Quncho, respectively (Figure 1 and 2). There was 7.8 % and 6.69 % yield advantage of Kora tef variety over Quncho tef at Tahetay-Koraro and Medebay-Zana districts, respectively. The productivity of tef obtained in the study area is relatively low as compared to the national average 16.64 qt ha^{-1} (2017 CSA).

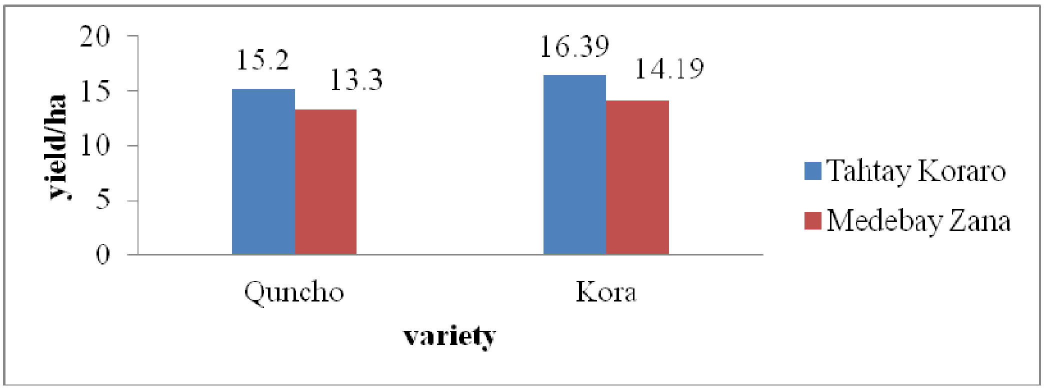

Figure 1. Grain yield compared between Quncho and Kora across locations.

Farmers' preferences for attributes of the varieties

Farmers' responses were collected on the important attributes of the tef varieties in Tahata-Koraro district. According to the respondents, Kora is better in tillers and less damaged by wind than Quncho. But Kora is late maturing and its straw is less palatable by animals compared to Quncho. Generally, out of 10 respondents, a score of 3.3, 3.8 and 2.9 were obtained for less preferred, no difference and Kora better preferred compared to Quncho on the described commodity attributes and most respondents agreed on no difference between Kora and Quncho (Table2).

Moreover, farmers' responses were collected on the important attributes of the tef variety in Medebay-Zana district. According to the respondents Kora is again better in tiller production and less damaged by wind than Quncho. However the variety is late maturing and its straw is less palatable to animals compared to Quncho tef. Out of 10 respondents a mean score of 3.5, 4.3 and 2.2 were obtained for Kora less preferred, no difference and Kora better preferred compared to Quncho, respectively, on the described commodity attributes. Most respondents though agreed on no difference between the Kora and Quncho (Table2).

Table 2. Farmers' perception on some important commodity attributes

S.N	Likert Scale Questions (Korra *vs* Quncho)	Level of agreement					
		Tahtay-Koraro			Medebay - Zana		
		1	2	3	1	2	3
1	Kora has better tillering capacity	2	1	7	3	3	4
2	Kora yields better biomass, for animal feed	5	2	3	2	5	3
3	Kora is drought tolerant	4	3	3	5	3	2
4	Kora matures earlier than the Quncho	5	4	1	6	2	2
5	Kora is less vulnerable to disease and pests	2	8	0	1	8	1
6	Kora is less susceptible to wind	1	2	7	2	1	7
7	Kora is preferred for its seed color in market	3	5	2	3	6	1
8	Injera made from korais tastier	1	9	0	5	5	0
9	Kora straw is more palatable to animal	6	2	2	6	4	0
10	Kora gives grain yield	4	2	4	2	6	2
Mean		3.3	3.8	2.9	3.5	4.3	2.2

NB. 1= Disagree, 2= Indifferent, 3=Agree

Figure 2. Farmers field day at Adigdad Kebelle, Tahatay-Koraro district

Conclusions and Recommendations

An average of 16.39 and 15.2 qt ha^{-1} were obtained for Kora and Quncho, respectively, in Tahtay-Koraro district and an average of 14.19 and 13.3 qt ha^{-1} were obtained from Kora and

Quncho, respectively, in Medebay-Zana district. Most farmers also perceived that as there is no difference between Kora and Quncho in the most important attributes. Considering the yield advantage however, the improved variety, Kora, has to be scaled-out to more number of farmers in the study areas (taken over by extension) while research has to be technically backthe extension process.

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1.3. Popularization of improved bread wheat variety at raya-alamata district, Southern Zone of Tigray, Northern Ethiopia

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Abstract

The study was conducted during 2016/17 production season at Raya-Alamata district particularly in two Tabia's namely Awkojira and Tsetsera. The objectives of the study were to popularize the improved bread wheat variety Kingbird and to evaluate farmers' perception towards the variety as compared to the existing wheat cultivar (Dashen). A total of 78 volunteer farmers were purposively selected and planted the improved bread wheat variety in cluster. The improved bread wheat variety well performed and shown significant difference in grain yield in both Tabia's compared with the existing wheat cultivar. Hence, the mean grain yield obtained from the improved variety were 40.38 and 52.65 qt ha^{-1} in Awkojira and Tsetsera, respectively while from the existing wheat cultivar gave 23.37 and 35 qt ha^{-1} at Awkojira and Tsetsera, respectively. King bird had also shown significant difference in grain yield between Tsetsera and Awkojira while the existing wheat cultivar had shown no significant difference between the sites which implied that the improved variety had better performance and fits to Tsetsera agro-ecology. Besides, the improved bread wheat variety was favored by the farming community for all the predetermined pre- and post-harvest attributes of the crop over the existing wheat cultivar. Therefore, office of agriculture and rural development of the respective districts should further disseminate and scale-out the improved bread wheat variety to farmers in similar agro-ecologies. Besides, Seed producer cooperatives or organized farmers group should continuously and consistently multiply this variety so that there is sustainable seed supply.

Keywords: Dashen, yield, Kingbird, popularization

Introduction

Wheat is one of the most important cultivated crops in the world with a world-wide production of 563.2 MT in 2002 alone (Roussel et al 2004). With the current rapid increase in world population, it is estimated that the global demand for wheat will increase by 40% before 2020 (Rajaram 2005). Therefore, developing a high yielding wheat variety is a priority objective in recent wheat breeding programs. Wheat breeders thus considered grain size as a major component of grain yield in wheat. Yet, larger seed grains are not only directly related to grain yield, but also have favorable effects on seed vigor and early growth, thereby promoting and stabilizing yielding ability. Large grain size was also an important trait selected during domestication and in modern wheat breeding (Botwright et al 2002; Peng et al 2003). Recently, snapshots of successful approaches such as breeding tolerance to acid soils, drought adaptation and disease resistance, illustrate how science and partnership have come together to solve tangible problems of resource-poor farmers (Reynolds and Borlaug 2006). As evidenced from many comparative studies, some of the most useful elements of that diversity have now been reintroduced in modern varieties through directed crossing with landraces and wild relatives of cereals (Smale et al 2002).

Wheat is one of the major cereal crops, and is an important food crop grown in Ethiopia. It has been selected as one of the country's target crops in the strategic goal to attaining national food self-sufficiency. The country is endowed with a wealth of genetic diversity, particularly for tetraploid-wheats. Bread wheat is mainly grown in the highlands of Ethiopia where the altitude ranges from 1900 to 3000 meters. Major wheat producer areas in the country include Arsi, Bale, Shewa, Illubabor, Western Harerghe, Sidamo, Tigray, Northern Gonder and Gojam (Bekele et al 2000).

Bread wheat (*Triticum aestivum* L.) is among the most important food crops, which is extensively grown throughout the dry areas in West Asia and North Africa (Su et al 2011). Modern hexaploid bread wheat originated by natural hybridization of tetraploid cultivated emmer wheat (*Triticum turgidum L. subsp. Dicoccum*). The evolution of hexaploid bread wheat is well understood by cytogenetic and molecular studies, but the intensity of the founder effect conferred by both polyploidisation incidents remains unclear. Hence, Ladizinsky (1985) hypothesized that a new population of hexaploid bread wheat was formed only once or very few times, thereby representing only a small fraction of variability present in the parental populations and resulting in a severe genetic bottleneck. To date, rising evidence suggest that hexaploid bread wheat is polyphyletic and first indications were given by restriction fragment length polymorphism (RFLP) (Dvorak et al. 1998): restriction site variation of low copy DNA (Talbert et al 1998) and simple sequence repeat (SSR) (Lelley et al 2000).

Farmers' participation in technology evaluation and recommendation, participatory research approach, should be employed widely to increase technology adoption (Getachew et al 2002). In the study area, wheat is one of the most important cereal crops that contributes the major share of that daily consumption of rural households in addition to being sources of cash income for many households. Farmers grow both improved varieties and local cultivars and often plant one variety year after a year. But most of the wheat particularly the bread wheat is susceptible to various diseases including rusts. Hence, Alamata Agricultural Research Center initiated an activity aimed at promoting and popularizing rust tolerant improved bread wheat variety to enhance the production and productivity of wheat in the study areas. Therefore, the objectives of the study were to popularize rust tolerant bread wheat variety known as Kingbird with its full package at farmers' field and to evaluate farmers' perception towards the improved variety by comparing it with existing wheat cultivar.

Materials and Methods

Description of the study areas

The study was conducted in Southern Zone of Tigray Regional State, Northern Ethiopia in 2016/17 cropping season. Raya-Alamata District is located between 12.26^0 – 12.57^0 North latitude, and 39.24^0 – 39.76^0 East longitude. A map of the study areas is presented in figure 1. Based on the secondary data obtained from office of agriculture and rural development (OoARD 2016), about 25 % of the area in the district is highland (Dega) and the remaining 75% is lowland (kola). The mean annual rainfall of the district is 650 millimeters (mm), which varies between 600 to 700 mm, and is characterized as temporally and unevenly distributed. The main rainy season known as the 'kiremt' extends from June to September and the second rainy season in the area known as the 'belg' season extends from February to April where farmers mainly grow early maturing tef and feed crops. The average annual temperature is 25^oc, and it ranges from 23 to 27^oc. Major crops grown in the area includes sorghum, tef and vegetables Cattle and small ruminants (goats) dominate the livestock production in the area.

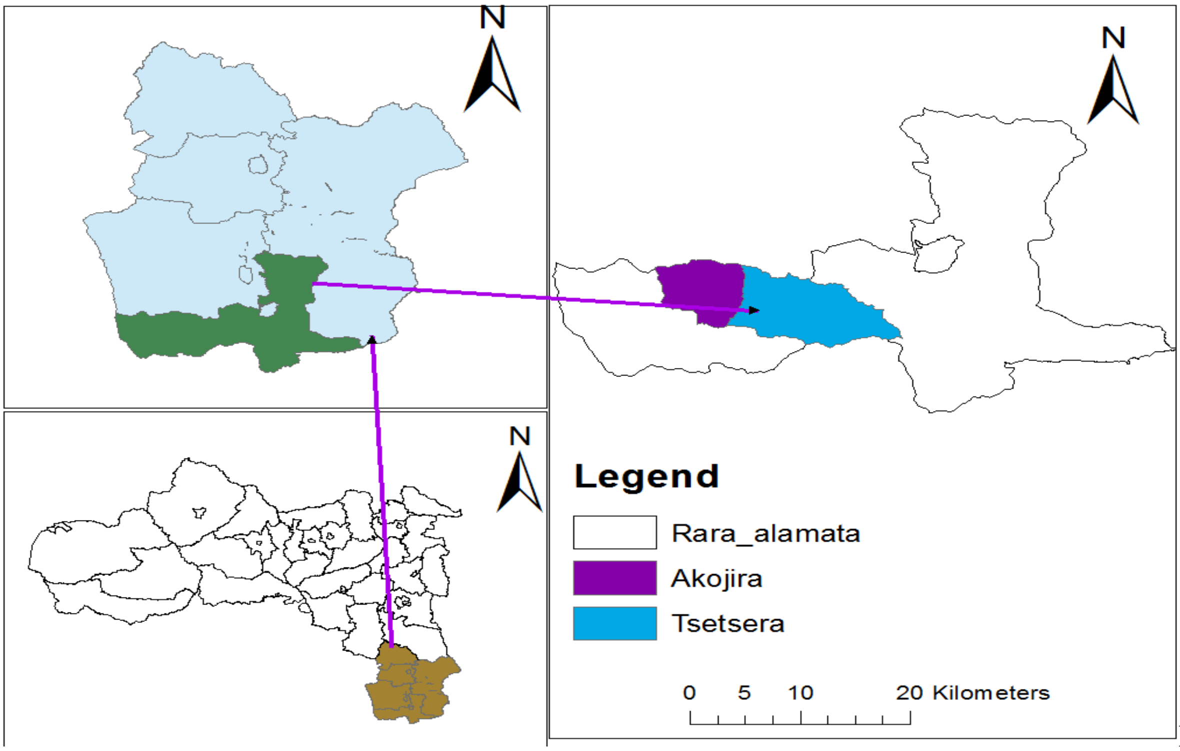

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Figure 1. Map of the study area

Sampling technique and procedures

The study employed three-stage sampling methods. First, Raya-Alamata district was purposely selected from Southern zone of Tigray region due to the fact that about 25% of the areas is highland, which is suitable for wheat production in the district. Despite this fact, Alamata Agricultural Research Center has never demonstrated proven agricultural technologies and best practices that could enhance smallholders' wheat production and productivity in the study area. Two Tabia's (Awkojira and Tsetsera) were then randomly selected and 78 farmers were randomly selected in collaboration with offices of agriculture taking into consideration availability of inputs and budget and also giving due emphasis to the criteria and objectives of AGP II project. The research center had provided rust tolerant improved bread wheat variety (King bird) and the farmers used the seeds of an existing wheat cultivar (Dashen) from their own stock. Before implementation of the activities, practical training on the agronomic practices of the improved variety and detailed procedures on the execution of the activities were given to participant farmers, experts and development agents. Then during the implementation, all management practices as per the recommendations for the crop were exercised by each participant farmer with close follow-up by the researchers, experts and development agents.

Data collection methods

This study used primary and secondary data. The primary data includes farmers' perceptions that were collected using structured and semi-structured interview and quantitative data like grain yield. The Grain yield was collected using a 1 x 1 meter quadrant. In the survey data collected, 19 randomly selected beneficiary farmers were used to collect the pre- and post-harvest attributes of the varieties both in field and after harvesting. In pre-harvest perception data collection, farmers were asked to list the major wheat selection criterions used from their own experience and they tried to evaluate and compare these two varieties (improved *vs* existing wheat cultivar) based on the predetermined crop attributes. In the evaluation process, farmers gave their own score (1-10) for each attribute used. While post-harvest perception data were collected using a five level Likert scale; very poor, poor, same, good and very good. Besides, secondary data were reviewed from annual reports, proceeding and journals.

Data analysis

The study employed descriptive and narrative analysis to analyze the grain yield and farmers' perception on pre- and post-harvest attributes of the improved and the existing bread wheat variety.

Results and Discussion

Grain yield of improved bread wheat variety (king bird) vs existing wheat cultivar (Dashin)

Kingbird performed well and has shown significant grain yield difference in both Tabia's (Awkojira and Tsetsera) compared with Dashen. The mean grain yield obtained from Kingbird was 40.38 and 52.65 qt ha^{-1}in Awkojira and Tsetsera, respectively while Dashen gave 23.37 and 35 qt ha^{-1} at Awkojira and Tsetsera, respectively (Table 1).

Table 1. Mean grain yield obtained from King bird compared with Dashin.

Parameter	Location	Treatments	Minimum	Maximum	Mean	SD	t-value
Grain yield (qt ha^{-1})	Akwojira	King bird	24.24	54.46	40.38	7.96	5.431***
		Dashin	22.5	24.24	23.37	1.23	
	Tsetsera	King bird	40.21	61.44	52.65	2.38	2.97*
		Dashin	26.91	43.09	35.00	8.09	

Source: Survey data 2016.

Kingbird gave shown significantly higher grain yield Tsetser than in Awkojira while Dashen show no significant difference (Table 2).This meant that the improved variety had better performance and fits well to the agro-ecology.

Table 2. Mean grain yield obtained across the locationsAwkojira and Tsetsera.

Parameter	Treatments	Location	Minimum	Maximum	Mean	SD	t-value
Grain yield (qt ha^{-1})	King bird	Akwojira	24.24	54.46	40.38	7.96	3.196***
		Tsetsera	40.21	61.44	52.65	2.38	
	Dashin	Akwojira	22.5	24.24	23.37	1.23	1.429
		Tsetsera	26.91	43.09	35.00	8.09	

Source: Survey data 2016.

Farmers' perception towards pre-harvest attributes of Kingbird vs Dashen

The farmers have favored almost all pre-determined pre-harvest attributes of Kingbird except plant height which recorded lower score than Dashen. Kingbird is highly preferred by the farmers and had highest mean score of 66.3 and 71.2 at Awkojira and Tsetsera Tabia's, respectively. Kingbird also scored higher values in terms of water logging capacity, tillering capacity and plant uniformity compared to Dashen. Kingbird had however scored a lower value in its plant height. This implied that the farmers were worried about the straw straw which is the main source of feed. Finally farmers ranked Kingbird first in the overall evaluation on the pre-determined attributes; hence the mean score for the Kingbird was significantly different and higher than Dashen.

Table 3. Farmers' perception on pre-harvest attributes of Kingbird and Dashen.

Attributes	Raya-Alamata District			
	Awkojira		Tsetsera	
	King bird	Dashin	King bird	Dashin
Plant height	40	60	40	60
Spike length	60	40	80	20
Tillering capacity	80	20	70	30
Color attractiveness	60	40	70	30
Plant uniformity	70	30	80	20
Earliness (maturity)	70	30	80	20
Drought tolerance	60	40	60	40
Water logging tolerance	90	10	90	10
Mean score	66.3	31.7	71.2	28.7
SD	15.0	15.0	15.5	15.5
t-value	4.31***		5.45***	

Note: The scores given for each attribute is out of 10 and was converted to 100.
Source: Survey data 2016.

Farmers' perception on post-harvest attributes of Kingbird and Dashen

Farmers' perception on the post-harvest traits of Kingbird were also evaluated by comparing with Dashen. Grain yield and straw suitability of straw as feed, marketability and its food preparation and taste preferences when prepared and consumed it in different recipes such as 'Injera' , bread, 'Kicha' and 'Kollo' were also compared. Hence, the survey result show that majority of the respondents had favored Kingbird for grain yield, seed marketability and food preparation and taste preferences. Some respondents however had less score straw palatability of Kingbird. Furthermore Kingbird was highly preferred than Dashen in different aspects of food preparation (powder and baking quality, food taste and food color and softness). In the highland s of the study areas wheat is commonly used for making kollo, himbasha and *injera*.

Table 4. Farmers' perception on post-harvest attributes of Kingbird and Dashen.

Attributes	Perception levels									
	Very poor		Poor		Same		Good		Very good	
	N	%	N	%	N	%	N	%	N	%
Grain yield	-	-	-	-	-	-	14	73.7	5	26.3
Easiness to thresh					3	15.8	9	47.4	7	36.8
Straw palatability	2	10.5	3	15.8	3	15.8	5	28.3	6	31.6
Market preference										
Seed color							9	47.4	10	52.6
Seed weight							9	47.4	10	52.6
Seed size					2	10.5	8	42.1	9	47.4
Premium price							6	31.6	13	68.4
Food preparation and taste preference										
Kicha (baking quality and taste)					1	5.3	12	63.2	6	31.6
Hinbasha (baking quality, taste, softness)					1	5.3	11	57.9	7	36.8
Injera (baking quality, taste, color and softness)					1	5.3	9	47.4	9	47.4
Kolo (taste, coarse and easiness to mill)					1	5.3	7	36.8	11	57.9

Source: Survey data 2016.

Conclusion and Recommendation

The study shows that the improved bread wheat variety King bird) had better performance in grain yield and it had also highly preferred by the farmers on the predetermined pre- and post-harvest attributes than Dashen. Besides, the improved variety is rust tolerant and improving the height of Kingbird could be an assignment for plant breeders in the future. For now, Kingbird is recommended that office of agriculture and rural development of the respective district should further disseminate and scale out the improved bread wheat variety to farmers in similar agro-ecologies. Seed producer cooperatives or organized farmers group should continuously and consistently multiply the seed so that there is sustainable supply.

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1.4. Popularization of improved malt barley varieties through contractual farming in Southern Tigray, Ethiopia

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Abstract

On-farm popularization of improved malt barley varieties through contractual farming was conducted in Ofla, Enda-Mehoni and Emba-Alaje districts of Southern Tigray, Ethiopia. The objectives were to popularize higher yielding varieties and evaluating the farmers' perception towards these varieties. To promote the varieties, three cooperatives made agreement with Raya Brewery. The cooperatives will produce the malt barley varieties and collect malt barley from producer farmers and sell them with a premium price of 20% over the local market price. Cluster farm lands were then selected in collaboration with development agents of the respective kebelles. A total of 286 farmers, with a total 84 ha participated. The result of the study showed that varieties EH-1847 and Sabini gave higher grain yield in Ayba and Hashenge kebelles, respectively. Besides, the varieties were highly preferred by the producer farmers in this kebelles. However, Sabini recorded lower grain yield and lower perception score in Mekan kebele than the local. The cooperatives collected less than 10% of the planned product that intend to supply Raya brewery. Therefore, the office of agriculture and rural development of Ofla and Emba-Alaje districts should continue scaling-up the malt barley varieties to the large number of growers and to implement contract farming strong integration and agreement of the parties is required before production.

Keywords. Malt barley, EH-1847, Sabini, perception, popularization

Introduction

Barley is believed to have been cultivated in Ethiopia as early as 3000BC (Hailu and Leur 1996). The country has suitable agro-ecological situations to produce malt-barley. Ethiopia accounts for about 25% of the total barley production in Africa, making it the second largest barley producer of the continent next to Morocco (FAO 2014). However, in Ethiopia, production of malt barley has a very short history and it was associated with the establishment St. George Brewery in the early twenties (Tadesse 2011).

Producing of malt-barley (*Hordeum distichon* L.) has a private benefit and societal profit (Getachew et al 2007). Malt-barley is one of the most important crops for food, feed, malt and income generation for many smallholder farmers in the highlands of Ethiopia including Tigray (Mulatu and Lakew 2011 and Feiten et al 2010). Out of the several uses, malt is the second most important and the main use for malt-barley is for commercial beer making, but malt- barley is also a desirable food source, notably for injera, porridge or roasted. It is also used for making local alcoholic beverages (Feiten et al 2010). Moreover, introduction of malt-barley varieties helped the local breweries to save significant foreign currency and raised farmers' income (Berhane et al 2016).

Nationally, there is a high demand for domestically produced malt-barley due to the increasing demand for beer (Rashid et al 2015; Berhane et al 2016). In Tigray region there is demand for malt-barley (Feiten et al 2010). Besides, the current capacity of Raya Beer factory is about 10,000 tons per year of malt-barley (Personal Communication 2016).

Although there is potential for production of malt-barley, malt barley in Ethiopia has not expanded to benefit most growers due to weak technology transfer, poor access to markets and unattractive price for malt-barley and are the main constraints for low productivity and limited expansion of malt-barley (Bayeh and Berhane 2011). In addition, lack of high quality seeds of improved varieties, limited number of malt-barley varieties meeting the requirement of farmers and industries are the main challenges of malt-barley varieties (Berhane et al 2016). Farmers and some agricultural officers believed that two-rowed barley is less yielding than six-rowed malt-barley varieties (Berhane et al 2016). Moreover, the productivity of barley is very low, which is about 1.8 ton/ha including both food and malting barley (CSA 2017).

Therefore, considering those facts promotion of different types of malt-barley varieties is a crucial issue to be done by different organization. In 2016/17 production season improved maltbarley varieties Sabni and Eh-1487 were demonstrated to 50 farmers. As a result, the varieties were adaptable and preferable by growers as well as the quality of the varieties fits with the standard set by Raya Brewery. Previous studies pointed-out that the quality of malt-barley production, processing and marketing had paid a greater degree of attention among farmers, traders, malting and brewing factories in Ethiopia (Tefera et al 2015). The concept of contract farming emerged in the 1980s, as a strategy for rural transformation in Africa (Watts et al 1988;

Bellemare 2012). The concept of contract farming in Tigray region in general and South Tigray (the study area) in particular is a recent one; it is expected to benefit the growers and stakeholders equally.

Hence, Alamata research center in collaboration with AGP II project has initiated popularization of improved malt-barley varieties in the form of contract farming in Ofla, Enda-mehoni and Emba-Alaje districts. This work can lead to further dissemination of the malt-barley and farmers' can benefit from this market oriented production system. There for, the objectives of the study were to popularize the improved malt barely varieties, assess farmers perception and strength the linkage between malt-barley growers and end users.

Materials and Methods

Area description

This activity was conducted in three districts namely; Ofla, Enda-Mehoni and Emba-Alaje. Ofla is located at 12^{o}31'N latitude and 39^{o}33'E longitude and an elevation of 2490 meters. Ofla is located about 620 km away from Addis Ababa (Capital city of Ethiopia) to the north and about 150 km to the south of Mekelle, capital of Tigray National Regional State. The annual rainfall of the district varies from 450 to 1200 mm during summer and 180-250 mm in the *belgi* r season (February to May). The mean annual temperature is 22^{o}c with minimum and maximum of 6^{o}c and 30^{o}c, respectively. About 42% of the area is *dega* (highland), 29% is categorized on the *weyna-degua* (midland) and 29% lies in the kola (low land) category. The important major crops grown in the district includes wheat, barley and faba bean. Dominantly soil classes are clay, silt, clay loam and sand (SZDCO 2016).

Enda-Mehoni district is located between 12.36 ^{o} -12.7 ^{o} north latitude and 39.18 ^{o} – 39.57 ^{o} east longitudes. About 65% of the area is highland (*dega*), 30% is categorized on the mid land (*weyna-degua)* and 5% lies in the kola (low land) category. The mean annual rainfall is 700 mm and with the range of 600 to 800 mm and it has bimodal nature. The average temperature of the district is also 10^{o}c and within the range of 8 to 12^{o}c. The major crops grown in Enda-mohoni include wheat, barley and faba bean. Dominant soil classes are clay, silt, clay loam and sand (SZDCO 2016).

Emba-Alaje district is also located between 1422710 and 1439170 north latitude and 530543 and 560142 east longitude, and lies at an altitude of 2350 meters. The mean annual rainfall of the district is 912 mm with mean daily temperature ranging between from 9-23^{0}c. The major crops grown in the district include wheat, barley and faba bean (Tesfay et al 2014).

The research was carried out in Enda-mehoni and Emba-Alaje districts, specifically at Ayba, Atsela and Emba-hasti kebelles, that atr located 102, 92 and 107 kms away from and south of Mekelle (capital city of Tigray) (Figure 1). These study areas were selected based on their potential for faba bean production and have experienced water-logging conditions.

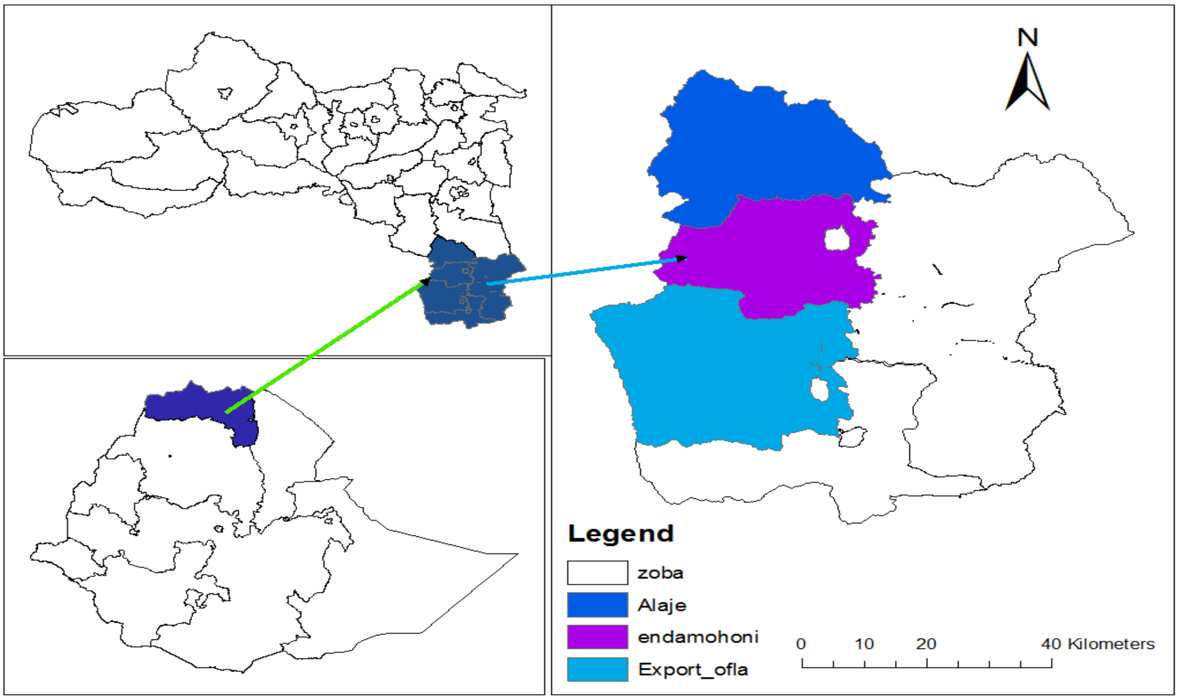

Figure 1. Map of the study areas

Selection of kebelles, farmers and approaches used

Three districts and one kebelle from each district were purposively selected. Practical and theoretical trainings related to the concept, advantages and disadvantages of contract farming, agronomics practices, disease and pest managements as well as the need of cluster based malt-barley production were delivered. In the first year, a total of 42 farmers, 6 kebelles and district experts were attending the training and in the second year a total of 248 farmer's 14 development agents, experts and 2 participants from the stakeholders were part in the training (Table 1).

Table 1. trained farmers, development agents and relevant stakeholder during the two years.

Year	Farmers		Experts and Das		Stakeholders		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
2016/17	34	8	4	2	0	0	38	10
2017/18	214	35	12	2	2	0	228	37
Total	248	43	16	4	2	0	266	47

Figure 2. Training participants at Hasenge kebele (left) and at Mekan kebelle (right)

Methodology used to promote the improved malt barley varieties

After the training, seeds of the two improved malt barley varieties were delivered to 50 beneficiary farmers (32 in Ofla woreda and Hashenge kebelle and 18 in Emba-Alaje, Ayba kebelle). Farmers in Hashenge received Sabini whereas farmers in Ayba tried EH-1847 because of it needs relatively high rainfall compared to Sabini. Farmer's preference towards these varieties was evaluated at field level and was appreciated by the farmers.

Then in 2017 three cooperatives made agreement with Raya brewery and produced the malt-barley and also collected the produced malt-barley seed from farmers and sold their products with a premium price of 20% over the local market price. 286 farmers produced malt-barley on an area of about 71.25 hectares.

Field days were conducted to promote and create demand on the varieties (Table2). This activity was supported by AGP II project as there was interest from the project side to disseminate malt-barley through contract farming with the three cooperatives in Southern zone of Tigray. Raya brewery and national projects like ATA became active partners in malt-barley promotion in the second year. In the two years project activity, a total of 275 individuals participated in the field days which represented different governmental and non-governmental institutions with the majority of the participants being farmers (Table 2).

Table 2. Summary of malt-barley field day participants.

Participants	1st year (2016)			2nd year (2017)			Grand total		
	M	F	Total	M	F	Total	M	F	Total
Farmers	18	18	4	71	19	90	89	37	126
Kebele DAs	6	5	11	17	7	24	23	12	35
District experts	4	4	8	9	-	9	13	4	17
District authorities	3	2	5	20	2	22	23	4	27
TARI	3	1	4	10	0	10	13	1	14
Researchers	10	2	12	26	1	27	36	3	39
Zone	-	-	-	5	-	5	5	-	5
ATA	-	-	-	2	-	2	2	-	2
AGP II	-	--		5	-	5	5	-	5
Africa RISING	-	-	-	1	-	1	1	-	5
Raya brewery	-	-	-	4	-	4	4	-	4
Grand total	44	32	76	170	29	197	214	61	275

Figure 3. Sabini at Hashenge (left) and EH-1847 at Ayba (right) during field days.

Data collection and analysis methods

The data on grain yield of the improved malty barley varieties were collected using a quadrat. The data were collected from randomly selected plots and replicated five times. A total of 5 quadrats were harvested from a single farmer and threshed manually. Grain yield was weighed using sensitive balance and converted to hectare. In addition, to collect farmers' perception on the varieties, a list of attributes was prepared together with the farmers and were asked to give the variety a score from 1-10 value for each attribute used to select the varieties. SPSS version 20 software was used to analyze the collected data. Descriptive statistics; like mean, minimum, maximum, standard deviation and inferential statistics like t-test was used to make comparison among the improved malt barley variety in different locations.

Results and discussion

Performance of the improved malt barley varieties at Ayba, Mekan and Hashenge kebelles

An average grain yield of 29.06 qt/ha was harvested from Sabini, which ranged from 17.66 qt/ha at Mekan to 34.76 qt/ha at Hashenge. As shown in table 3, the average grain yield of Sabini in Mekan was lower than at Hashege.

Figure 4. Raya brewery and Agricultural Transformation Agency representatives observing malt-barley fields.

A study by Muez et al. (2014) confirmed that the genotype Sabini was unstable in grain yield as compared the other malting varieties. On the other hand the variety EH-1847 recorded an average grain yield of 40.17 qt//ha, which ranged from 25 to 52.46 qt/ha (Table 3). From previous studies in Ethiopia, Eh-1847 recorded higher grain yield of about 44.20 qt/ha and had good malting quality and better agronomic performance (Wondimu and Berhane 2016).

Tabl 3. Average grain yield of the malt-barley varieties across locations.

Location	Variety name	Grain yield qt/ha				
		N	Mini	Maxi	Mean	Sd
Hashenege	Sabini	6	32.12	39.10	34.76	3.14
Mekan	Sabini	3	12.97	25.07	17.66	6.49
	Mean	9	12.97	39.10	29.06	9.47
Ayba	EH-1847	17	25	52.46	40.17	8.90

N= number farm plots sample data collected

Challenges faced by farmers during the contract farming exercise

Contract farming is a recent phenomenon in Tigray in general and south Tigray in particular. During the training the cooperatives agreed to supply 2400 qt of malt-barley to Raya brewery (Table 4) and Raya brewery agreedto purchase the produced malt barley with a premium price of

20% over the local market price of food barley. The price share was 15% to producers and 5% to cooperative members. However, the agreement was violated by the cooperatives organization. As indicated in table 4, the cooperatives have received Ethiopian Birr 290 from a single quintal that shows the cooperative is benefiting at the cost of the producer farmers. According the agreement, it was fair to if the produces sell their produce at about 1366 Ethiopian Birr/qt. However, the cooperatives did not follow the agreement accordingly. The researcher while conducting group discussion with producer farmers; the farmers are not interested to return the produced seed for the price of the malt-barley paid to the farmers is low even though the price paid by Raya brewery was fair. The cooperatives were only able to supply less than 10% of their malt-barley seed supply plan to the Raya Brewery (Table4).

Criticisms of contract farming often focus on the unequal power relationship between a company and farmers, the latter providing a form of cheap labor and the company passing over production risks to small-scale producers. There is great potential for trapping small-scale farmers to cycles of debt. Contracts create dependence by small farmers on the technology, credit, inputs and services provided by their contracting companies. Because contract farming mostly involves the use of intensive technologies in industrial agriculture, farmers may have to risk borrowing money to invest in agricultural production. They then may not earn enough money to cover their debts, a risk that is heightened when the contracting firm is the only buyer (FAO 2001).

Table 4. Amount of seed collected from producers and supplied to Raya brewery

Kebelle/cooperatives	Planned	Collected seed		Selling price (Birr/qt)			Based on the agreement (Birr/qt)	
	(qt)	(qt)	%	Coop from producers	Raya beer from coops	Coops received (Birr/qt)	Producer (15%)	Cooperative (5%)
Ayba	900	99	11	1150	1440	290	216	72
Mekan	750	33	4.4	1150	1440	290	216	72
Hasenge	750	62.8	8.3	1150	1440	290	216	72
Total	2400	194.3	7.9	1150	1440	290	216	72

Perception of farmers towards the improved malt barley varieties

The perception of farmers towards the improved malt barley varieties were evaluated through list of attributes taken from the farmers themselves according to their point of view. Accordingly, plant height, spike length, uniformly matured, easily thresh-able, seed weight, tillering capacity, logging resistance and early maturing were the parameters set by farmers to compare the varieties with existing barley varieties. However, the selection parameters were different from location to location and that was based on the farmers' preference. The result showed that the mean perception score of the Sabini was lower in makan than the existing local barley varieties whereas higher in Hashenge than the local barley varieties. The perception score of farmers in Mekan towards Sabini was twice lower than the local. This indicates that farmers are not interested by the variety by all parameters except early maturity. On the other hand, the variety EH-1847 recorded higher than the local. The result shows there is a highly significant difference in preference of the farmers between the local and improved malt barley varieties (Table5).

Table 5. Perception of beneficiary farmers on the improved malt barley varieties

Attributes	Ofla (Hahsenge)		Enda-mehoni (mekan)		Emba-alaje (Ayba)	
	Local	Sabini	Local	Sabini	Local	EH-1847
Plant height	4	6	7	3	2	8
Spike length	4	6	7	3	4	6
Uniformly matured	4	6	8	2	4	6
Easily treshable	2	8	7	3	-	-
Seed weight	-	-	7	3	-	-
Tillering capacity	3	7	5	5	4	6
Logging resistance	3	7	7	3	2	8
Early maturing	4	6	3	7	6	4
Mean	3.43	6.57	6.38	3.63	3.67	6.33
SD	0.78	0.78	1.60	1.60	1.50	1.50
T value	7.47***		3.44***		3.06**	

Source: Own survey, 2017

Conclusion and recommendation

The study concluded that EH-1847and Sabin varieties were showing higher grain yield and higher acceptance by the farmers compared to local cultivars in Ayba and Hashenge. EH-1847 however recorded higher yield than Sabini. Therefore, it can be concluded that the EH-1847 variety is best candidate for a higher productivity of malt barley in South Tigray.

Hence, this study recommended that the agriculture and rural development district office should disseminate the EH-1847 to the community and it is crucial to provide continuous support and follow-up to implement contract farming. Seed supply through organized seed producer cooperatives and organized farmers also need to go side by side the promotion.

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1.5. Pre-extension popularization of improved sorghum varieties at tahtay-adyabo and asgede-tsimbla districts of North Western Zone of Tigray, Ethiopia

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Abstract

In Tigray region many endeavors have been made by governmental and non-governmental bodies to enhance production and productivity of sorghum. The Shire-Maitsebri Agricultural Research Centre is mandated to undertake sorghum related researches and so far was doing several activities including introduction of germplasm, adaptation of released varieties and technologies, verification of new promising varieties and their demonstration.. As a follow up of the previously undertaken research works on sorghum, this research activity was, therefore, initiated to enhance production and productivity of sorghum by popularizing high yielding sorghum varieties in the selected sorghum growing districts of North Western zone of Tigray region. The districts and Kebelles were selected based on their potential for sorghum production and participant farmers were selected purposively given their willingness and ability to provide the required production costs. Both grain yield and farmers' response on the improved sorghum variety were considered. Data collected were subjected to descriptive data analysis. The average sorghum grain yield was 15.14 and 32.36 $qtha^1$ for local and Dekeba s, respectively in the Tahtay Adyabo district. Dekeba performed best with 113.74 % yield advantage, on average, over local cultivars. Besides An average of 38 and 21 t ha^{-1}, respectively, were obtained from Melkam and the local sorghum variety. There is 80.9% (17 qt yield advantage of Melkam over the local one at Asegede-Tsimbla district. More farmers witnessed that Dekeba and Melkam varieties have performed best as they are early maturing, drought tolerant and high yielding as compared the local one. Therefore Dekeba and Melkam have to be scaled-out to large farmers (taken over by extension) and research has to prepare a production manual with research technically backing extension.

Keywords. Dekeba, Melkam, Pre-extension Popularization, Asgede-Tsimbla, Tahtay-Adyabo

Introduction

Sorghum (*Sorghum bicolour* (L.) Moench) is a cultivated tropical cereal grass. Although not universally considered to have first been domesticated in North Africa, it was cultivated in the Nile or Ethiopian regions as recently as 1000 BC. It is the fifth most important staple food crop after wheat, rice, maize and barley (FAO 2012). The world average annual yield for sorghum was 1.37 tons per hectare in 2010.

Doggett (1988) confirms that sorghum was domesticated and originated in the northeast quadrant of Africa, most likely in the Ethiopian-Sudan border regions. The presence of wild and cultivated sorghums in Ethiopia reveals that Ethiopia is the primary centre of origin and centre of diversity (Mekibeb 2009). Sorghum is usually grown in arid and semi-arid parts of the tropics and sub-tropics where it is affected by drought during various growth stages (Amjad et al 2009). The crop is typically produced under adverse conditions such as low input use and marginal lands. It is well adapted to a wide range of precipitation and temperature levels and is produced from sea level to above 2000 meters altitude (Fetene 2011). Its drought tolerance and adaptation attributes have made it the favorite crop in drier and marginal areas.

In Africa, Sorghum is processed into a very wide variety of attractive and nutritious traditional foods, such as semi-leavened bread, couscous, dumplings and fermented and non-fermented porridges and forming the foundation of successful food and beverage industries. It is the grain of choice for brewing traditional African beers. Sorghum is also the grain of 21st century Africa. Sorghum is crucially important to food security in Africa as well as in Ethiopia as it is uniquely drought resistant from among the cereals and can withstand periods of high temperature.

In Africa even though the production of sorghum is increased year after year, the average yields remain below 1 tone/ha. This is because sorghum cultivation in Africa is still characterized by traditional farming practices; with low input use (no inorganic fertilizer or pesticides) and traditional varieties or landraces. Among others, seeds are critical determinants of agricultural productivity. Consequently, several improved crop varieties have been developed by the national and international research institutes and disseminated to the farmers through different programs and projects.

Ethiopian is often regarded as the centre of domestication of sorghum because of the greatest genetic diversity in the country for cultivated and wild forms (Fetene 2011). In Ethiopia, sorghum is ranked after tef, maize, and wheat both in area coverage and production (CSA 2017). Sorghum is grown in almost all regions of the country occupying an estimated total land area of 1.88 million ha (CSA 2017). There is large improvement in sorghum production driven by both land expansion and yield improvement. The major sorghum production regions of the country are Oromia at 39.5%, Amhara (35.8%), Tigray (13.5%), and Southern Nations and Nationalities People regions (5.2%).

The lowland areas of Ethiopia are characterized by high temperature and insufficient rainfall during the crop growing season. In most of these areas rainfall distribution is erratic and unreliable. North Western Zone of Tigray is one of the potential zones for sorghum production but rainfall is erratic and ceases early and there is lack of improved varieties. Due to such constraints sorghum yield in the study area remained low. To alleviate this problem different sorghum improved varieties were tested under the prevailing conditions of North Western Zone. During the demonstration, improved sorghum varieties like Dekeba and Melkam gave higher yields in the lowland areas of the zone. Besides these varieties are highly preferred in the study area due to their early maturity, tasty of its' injera' and preferred seed color in the market. Therefore, popularizing these higher yielder and preferred sorghum varieties to potential areas in the zone is essential to increase production and productivity of sorghum and to improve the livelihood of small scale farmers in the areas.

Materials and Methods

Description of the study area

The popularization of improved sorghum variety was undertaken at Asgede-Tsimbla and Tahtay-Adyabo districts of the North Western zone of the region. At Asgede Tsimbla popularization of Melkam was held at lowland part of the district. 45% of the district is midland and 55% is lowland. Asgede Tsimbla is found at the degree of 13.73-14.21 ^{o}c Northing and 37.59-38.31^{o}c Easting. The district has 25-35^{o}c of temperature and 500- 900 annual rainfall. Similarly at Tahtay-adyabo, popularization of Dekeba was conducted at lowland parts of the district. 87% of the district is midland and the remaining (94.13%) is lowland. The district is found at 14.05-14.89 °c Northing and 37.34-38.17 °c Easting. Temperature ranges from 38-40°c and 450- 550 mm annual rainfall (OoARD 2016).

Sampling technique and sample size

Tahtay-Adyabo and Asegede-Tsimbla districts were purposively selected for demonstration of Dekeba and Melkam in the 2007/08 production season as they are potential for sorghum production. The five Kebelles; Hitsats, Selam, Dedebit, Lemlem and Zban-Gedena were purposively selected given their potential for growing sorghum. Besides, 273 farmers were purposively selected based on their willingness and ability to shoulder the costs associated with popularization trial. Data on yield and farmers' responses on the popularized sorghum variety were collected given some important attributes. Perception data was collected from 14 farmers who were proportionately and randomly selected from the five intervention Kebelles.

Table 1. Distribution of beneficiary farmers by district, kebelle and sex.

Commodity	Intervention District	Number of Kebelles	Number of Participants		
			Male	Female	Total
Sorghum (Dekeba) Sorghum (Melkam)	Tahtay Adyabo	02	44	17	61
	Asgede Tsimbla	03	150	62	212
Total		05	194	79	273

Implementation procedure

Forming a multi-disciplinary team

To conduct the trial, a team comprising weed, agronomy, breeder, pathologists and socioeconomics and extension researchers were established with clear cut responsibilities for each member. Accordingly, the team delivered the required training to farmers, development agents (DAs), and experts to better align their duties and responsibilities. Besides, the team was responsible for field day arrangements, coordination, follow up and technical backstopping related supports. Farmers allocated their land and covered the cost of production except cost of improved technologies. DAs of selected Kebeles paying regular visits to make follow-up to farmers, coordinating the farmers for training and farmers' field days and reporting work progress to the researchers and experts of respected intervention districts. Farmers' training centers (FTCs) hosted the popularization trial and were playing a great role in bridging knowledge gaps, creating awareness, and speeding up the technology and information transfer among farmers.

Stakeholder analysis

Table2. Stakeholder responsibility Matrix (SRM)

Stakeholders	Responsibility
Researchers	- Technology provision - Capacity building - Technical backstopping - Follow-up - Data collection and analysis - Report writing
Farmers	- Host- allocating land - Implementing the activity - Evaluating technologies
Development Agents	- Farmers selection - Rapport building - Technical backstopping - Follow-up
District experts and management	- Rapport building - Follow-up
AGP-II t management	- Timely financial disbursement, and Monitoring & Evaluation
SMARC management	- Implementing the trial and Monitoring & Evaluation

The platform while demonstrating the proven agricultural technologies comprised of researchers, district experts, development agents (DAs), district and Keble administrators and farmers. Stakeholder analysis is an essential tool for developing a useful engagement plan. A common method of stakeholder analysis is a Stakeholder-Responsibility Matrix (SM). This is where stakeholders are plotted against two variables. These variables might be plotting the level of 'stake' in the outcomes of a project against 'resources' of the stakeholder. Another is the 'importance' of the stakeholder against the 'influence' of the stakeholder. The concept is the same, though the emphasis is slightly different. Yet, the engagement plan can be further developed using other variables; list of stakeholders against their respective responsibilities. Before undertaking this trial, the following engagement plan was developed and engaged (Table 2).

Farmers' selection criteria, plot size and management

Volunteer farmers who can provide their land and are willing and able to provide feedbacks on the popularized sorghum technology were selected. Each farmer was expected to avail a land with an area of 0.25 hectare. The sowing method employed was row sowing with 75 cm spacing between rows. Farmers were also expected to manage their trials by themselves. Besides, selected farmers were expected to obey the rules and regulations so that they can meet the set objectives of the activity.

Input provision

Training

Training schedules were arranged and offered to farmers, experts and DAs of host districts. The major areas of the training include.

- Objectives of the research activity
- Farmers Research Extension Group/ FREG concepts
- Record keeping
- Methods of sorghum production with full package and unique traits of the improved sorghum varieties, Dekeba and Melkam , agronomic and disease management.

Sorghum seed

Once the farmers who are expected to participate in the popularization trials were selected, they were offered with 3kg of sorghum which is Dekeba variety to Tahtay-Adyabo and Melkam variety to Asegede-Tsimbla districts.

Data type, source, data collection and analysis

For this study, only primary data was considered. The primary data include grain yield and farmers' response on the improved sorghum varieties. The data collected was analyzed using simple descriptive statistics specifically, mean and percentage. Likert scale with three scales (disagree, indifferent and agree) was used as a tool to collect the primary data on farmers' response.

Result and Discussion

Grain Yield

Sorghum grain yield comparison of local versus improved (Dekeba) sorghum varieties

Yield estimation was undertaken by taking sample from the plot area of 2 x2 m of the 7 farmers' field. An average yield of 32.36 and 15.14 qt ha^{-1}, respectively were obtained from Dekeba and Dagnew. There is 113.7% yield advantage of Dekeba over the local one at Tahtay-Adyabo district. Moreover, an average yield of 38 and 21 qt ha^{-1} were obtained from Melkam and local, respectively. There is 80.9% yield advantage of Melkam over the local one at Asegede-Tsimbla district.

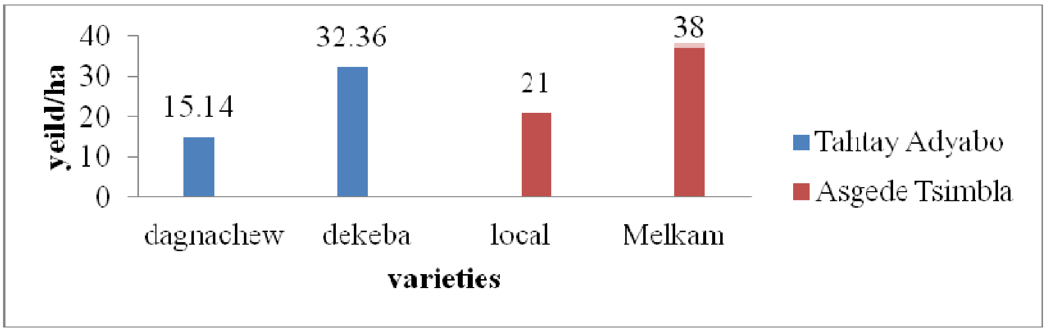

Fig. 1. Sorghum grain yield comparison among Dagnew, Melkam and Dekeba.

Generally the average productivity of Dekeba and Melkam was 35.18 qt ha^{-1} and was greater than the national (25.5 qt) and regional (28.06 qt/ha) productivity of sorghum (CSA 2017).

Farmers' preferences on the popularized sorghums' varieties

Farmers' perceptions about the improved varieties were collected on the important parameters.

Table1 3. . Farmers' preferences on Dekeba and melkam Sorghums'

s/n	Likert Scale Questions Improved versus local	Level of agreement					
		Dekeba (Tahtay-Adyabo)			Melkam (Asegede-Tsumbla)		
		1	2	3	1	2	3
1	better germination performance	1	5	1	1	4	2
2	better tillering capacity	5	0	2	5	0	2
3	yields better biomass, from animal feed perspective,	0	1	6	0	1	6
4	drought tolerant	0	1	6	0	1	6
5	matures earlier	0	0	7	0	0	7
6	less preferred by birds	4	1	2	4	2	1
7	less susceptible to wind	1	1	5	0	2	5
8	less vulnerable to disease & pests	0	0	7	0	2	5
9	preferred for its seed color in market	0	0	7	0	0	7
10	gives better grain yield	0	0	7	0	0	7
11	Enjera made from the improved variety is tastier	0	0	7	0	0	7
12	Stock of the variety is more palatable by animal	0	0	7	0	0	7
	Average	0.92	0.75	5.33			
	1=disagree, 2= indifference and 3= agree				0.833	1	5.16

Most of the respondents preferred Dekeba due to the following attributes: variety yields better biomass from animal feed perspective, drought tolerant, less susceptible for wind, matures earlier, less vulnerable to disease and pests, preferred for its seed color in market, better in its grain yield, *injera* made from the variety is tastier and stalk of the variety is more palatable to animal compared to local. But Dekeba is highly attacked by birds. Generally, out of the 7 respondents, more than 70% of them agreed that Dekeba variety is preferred for most attributes as compared to the local (Table 3).

Similarly, farmers' perceptions were collected on the important parameters for melkam.. Most of the respondents agreed that the variety is less susceptible to wind, less vulnerable to disease and pests, yields better biomass from animal feed perspective, drought tolerant, matures earlier, preferred for its seed color in market, suited for *injera* (tastier), gave higher grain yield and more palatable by animal as compared to local sorghum variety. Whereas the farmers were respond that the variety is less preferred as it is highly preferred to birds attack. Generally, out of the 7 respondents interviewed, more than 70% of them agreed that Melkam is preferred in most attributes compared to the local one (Table 3).

Moreover, field day participants appreciated both Melkam and Dekeba for their tasty *injera* and high demand by hotel owners and other customers. Farmers also said that these varieties enabled them to benefitt from their unproductive and water logged lands.

Figure 2. Field visit on Dekeba at Zban-Gedena kebelle.

Figure 3. Field performance of Dekeba at Lemlem Kebelle

Figure 4. Field performance of the improved sorghums on field of *Ayte* Hagos Gebrekrstos.

Conclusion and Recommendations

To enhance production and productivity of sorghum in the study area popularization of Melkam and Dekeba were attempted. The recorded yield advantages of Melkam and Dekeba were significantly higher than the local cultivar. Melkam and Dekeba gave higher yield as compared to the local sorghum varieties. Most farmers perceived that the improved sorghum verities are preferred when compared with the locals. Farmers forecasted significant improvements in their assets due to higher production of these varieties.

The office of agriculture and rural development of the District should further disseminate the varieties to large number of farmers and wider areas with similar agro-ecologies. To address issues related to improved seed access, linkages between researchers, government organization and NGOs should be strengthened.

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1.6. Pre-extension popularization of Setit-1 sesame variety at tahtay-adyabo and asgede-tsimbla Districts, North Western Zone of Tigray, Ethiopia

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Abstract

To enhance production and productivity of sesame, Shire-Maitsebri Agricultural Research Centre (SMARC) in collaboration with other research centers were conducting sesame research including adaptation of released technologies, verification of new varieties and demonstration of technologies. Follow up of the previously undertaken research; this research activity was initiated to enhance production and productivity of sesame through popularizing a high yielder sesame variety in selected sesame growing districts of North Western zone of Tigray region. A two stage sampling technique was employed to identify the intervention areas and farmers that participated in the popularization activity. Intervention districts and Kebelles were purposively selected given their potential to grow sesame. Similarly in the second stage, participant farmers were selected purposively considering their willingness and ability to allocate the required production costs. The study was held at two districts with 179 beneficiary farmers. Both grain yield and farmers' response on the improved variety were considered and the data collected were subjected to descriptive data analysis. The average sesame grain yield found was 4.74 and 6.49 qt ha^{-1} for local and Setit-1, respectively in Tahtay-Adyabo district. Setit-1 performed best with 36.92 % yield advantage over local cultivars. The average grain yield found was 3.12 and 5.98 qt ha^{-1} for local and Setit-1, respectively, in Asgede-Tsimbla district. Setit-1 still performed best with 91.67 % yield advantage over the local sesame cultivars. Most of the participant farmers have witnessed that Setit-1 have performed best as it matured early, was drought tolerant and gave higher yield in all intervention districts. Therefore, the improved variety, Setit-1, has to be scaled-out to large farmers and research has to technically back the extension.

Keywords: Setit-1, Popularization, Tahtay-Adyabo, Asgede-Tsimbla

Introduction

Sesame (*Sesamum indicum*) is one of the most versatile crops that can be grown in dry arid regions. Sesame is an important oil-seed crop. It is grown in Africa, Asia and parts of Latin America for its edible seeds which are also source of sesame oil. The semi-drying oil is of high quality and is used as a substitute for olive oil as a salad and cooking oil (Langham 2008).

Sesame has unique attributes that can fit to most cropping systems (Langham 2008). Sesame is grown in areas with annual rainfall of 625-1100 mm and temperature of 27°c. The crop is tolerant to drought, but not to water logging and excessive rainfall. Sesame is well adapted to a wide range of soils, but requires deep, well-drained, fertile sandy loams (Geremew et al 2012).

Ethiopia is known as the centre of origin and diversity for cultivated sesame. It is among the major cash crops by which Ethiopia is known at international markets (Sorsa 2009). Sesame is currently the country's principal export oilseed and is mainly raised by small scale farmers. There is huge potential to grow sesame seed in the country and high market demand at international levels (Sorsa 2009: Sluijer and Cecchi 2011).

Sesame market is a billion dollar industry in the world that supports the livelihoods of Millions of farmers (USAID 2010). World production of sesame seeds is estimated at 3 million tones, and is steadily growing currently. Next to coffee, sesame seed is the second largest agricultural export earner in Ethiopia, and is grown mainly for the export market (Aysheshm 2007: Alemu and Meijerink 2010) only about 5% is believed to be consumed locally (Aysheshm 2007).
In Ethiopia, sesame grows well in the semi-arid areas of Amhara, Tigray, Benshangul Gumuz, and Somali Regions. Lowlands of Oromiya and Southern Nations nationalities and Peoples Regions also grow significant amount of sesame (Geremew et al 2012).

Tigray is one of the highly sesame producing regions in Ethiopia. North western zone of Tigray has potential area for producing sesame and according to CSA (2017) of the total area cultivated under sesame in Tigray 16.69% of it (18,086.73ha) is found in North Western zone of Tigray.

Due to low usage of improved sesame seed, the production of sesame in the study area remained low. To alleviate such problems as well as to increase production and productivity of sesame, demonstration of Setit-1 and Humera-1 sesame varieties had been conducted in 2015 production season in North Western zone of Tigray. Setit-1 sesame variety gave better yield than Humera-1. Therefore, popularizing Setit-1 to more potential sesame producing farmers was crucial to increase production and productivity of sesame and to improve the livelihood of small scale farmers in the study areas.

Materials and Methods

Description of the study area

The popularization of Setit-1 improved sesame variety was undertaken at lowland areas of Asgede-Tsimbla and Tahtay-Adyabo districts of the North Western zone of the region. Asgede-Tsimbla is 45% midland and 55% lowland. The district is found at 13.73-14.21^{O}c Northing and 37.59-38.31^{O}c Easting. The district has temperature range of 25-35^{o}c of and annual rainfall of 500-900 mm. Tahtay-Adyabo district is 5.87% midland and the remaining is lowland. The district is located at 14.05-14.89 Northing and 37.34-38.17 ^{o}c Easting. It has temperature range of 38-40^{o}c of and annual rainfall of 450-550 mm (OoARD 2016).

Sampling technique and sample size

The study was conducted in Asgede-Tsimbla and Tahtay-Adyabo districts of North Western zone Tigray. The two districts were purposively selected as demonstration trials using improved sesame varieties of Setit-1 and Humera-1 had been conducted in the earlier production season at those districts and the districts have the potential for sesame production.

Table 1. Distribution of beneficiary farmers by district, kebelle and sex.

Intervention District	Number of Kebelles	Number of Participants		
		Male	Female	Total
Tahtay-Adyabo	02	71	16	87
Asgede-Tsimbla	02	88	04	92
	04	159	20	179

Four Kebelles; Selam, Dedebit, Lemlem and Ademeyti were purposively selected given their potential for sesame production. Besides, 179 farmers were purposively selected given their willingness and ability to shoulder the popularization work. Data on yield and farmers' response on the popularized sesame variety were collected. Perception data were collected from 20 farmers who were proportionately and randomly selected from the four Kebelles. The study was conducted in 2016 production season.

Implementation procedure

Forming a multi-disciplinary team

To conduct the trial, a team comprising weed, agronomy, breeder, pathologists, agricultural mechanization, and socioeconomics and extension researchers was established and members had clear-cut responsibilities. The team delivered the required training to farmers, development agents (DAs), and experts so as to better align their duties and responsibilities. Besides, the team took the responsibility for field day arrangements, coordination, follow up and technical backstopping related aspects. Farmers allocated land and covered the cost of production except cost of improved technologies. DAs made a regular follow-up to farmers, coordinated farmers training and farmers' field days and reported work progress to the researchers and experts of the districts. Farmers' training centers (FTCs) hosted the popularization trial as well, which played a great role in bridging knowledge gaps, creating awareness, and speeding up the technology and information transfer to farmers.

Farmer's selection criteria, plot size and management

A volunteer farmers who can provide their land and are willing and able to provide feedbacks on the popularized sesame technology was selected. Each farmer was expected to avail a land with an area of 0.25 hectare. The sowing method employed was row sowing with 40 cm spacing between rows. Farmers were also expected to manage their trials by themselves. Besides, selected farmers were expected to obey the rules and regulations that they are told to meet the set objectives of the activity.

Input provision

Training

Trainings were offered to farmers, experts and DAs of host districts. The major areas of the training focused on explaining the objectives of the research activity, farmers research extension group/FREG concepts, record keeping, methods of sesame production with full package and unique traits of the improved sesame variety, Setit-1, agronomic and disease management

Figure 1. Training held at Asgede Tsimbla-Maihanse; Techniques of sesame production

Figure 2. Training held at Tahtay-Adyabo on techniques of sesame production

Sesame seed

farmers selected to participate in the popularization trials were offered with 1kg seed of setit-1 sesame variety.

Data type, source, data collection and analysis

In this study only primary data were considered. The primary data include grain yield and farmers' response on the improved sesame variety. Grain yield was analyzed using simple descriptive statistics specifically, mean and percentage. Likert scale with three scales (disagree, indifferent and agree) was used to collect the primary data on farmers' response to the important commodity attributes.

Results and Discussion

Yield comparison of Improved Versus local Sesame Varieties by District

Yield was estimated by taking sample from plot area of 2 x 2 m on ten farmers' field. An average of yield of 6.49 and 4.74 qt ha^{-1} respectively were obtained from setit-1 and local variety of sesame (Figure 3) in Tahtay-Adyabo i.e. 36.92% yield advantage of sestet-1 over the local one. Furthermore, an average of 5.98 and 3.12 qt ha^{-1} were obtained from setit-1 and local, respectively at Asgede-Tsimbla which has 91.6% yield advantage over the local (Figure 3).

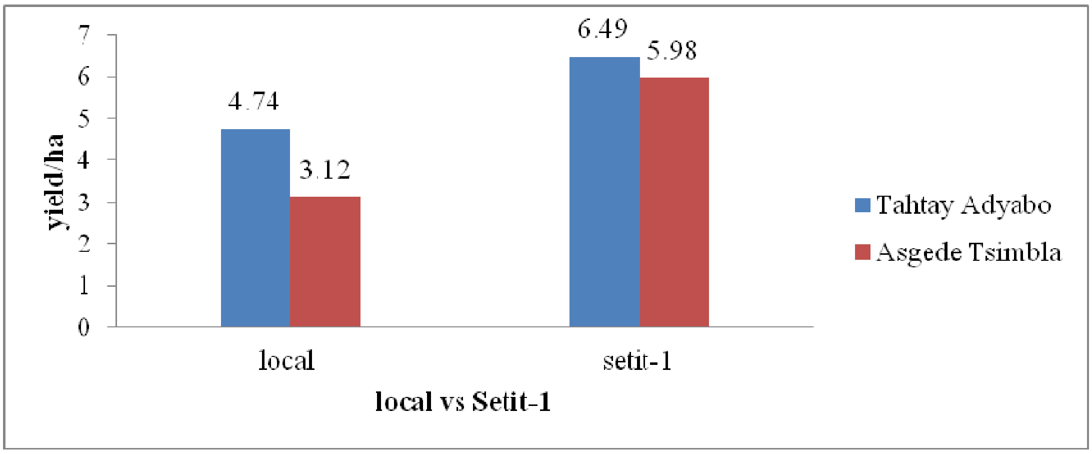

Figure 3. Sesame grain yield compared between local and Setit-1.

Farmers' preferences on the popularized sesame attribute

Farmers' responses were collected on the important attributes of the sesame variety in Tahtay-Adyabo. Most of the respondents preferred Setit-1for its higher number of capsules, early maturity, being less susceptible to wind, higher seed weight and higher yield than the local one. On average, 56.7% of the respondents agreed that setit-1 is preferable than the local one (Table 2).

Similarly farmers' responses were collected from Asgede-Tsimbla. Most of the respondents preferred Setit-1 for its higher number of capsule, early maturity, being less susceptible to wind, higher seed weight and higher yield than the local one. On average, 70% of the respondents agreed that setit-1is preferable than the local one (Table 2).

Table 2. Farmers' response on some selected sesame attributes

Likert scale (Setit-1 versus local)	Level of agreement					
	Tahtay-Adyabo			Asgede-Tsimbla		
	1	2	3	1	2	3
better germination performance	3	3	4	5	1	4
higher number of capsule	1	1	8	1	0	9
drought tolerant	1	3	6	0	4	6
matures earlier	0	4	6	0	0	10
less susceptible to wind	3	3	4	2	2	6
less vulnerable to disease and pests	2	3	5	1	3	6
preferred for its seed color in	0	7	3	1	6	3
has higher seed weight	0	2	8	0	1	9
high yielder	1	2	7	0	0	10
(1) Disagree (2) Indifferent (3) Agree	1.22	3.11	5.67	1.11	1.88	7.0

Figure 3. Setite-1 at different growth stages at Asgede-Tsimbla and Tahtay-Adyabo districts

Conclusions and Recommendations

Setit-1 improved sesame variety was popularized in Asegede-Tsimbla and Tahtay-Adyabo districts, in the 2016 cropping season. The results showed that Setit-1 gave higher gain yield over the local variety in all locations.

In addition, setit-1 was also promising in most perception parameters such as high yield, higher number of capsule, higher seed weight and earlier maturity. Generally most of the respondents agreed that setit-1 is preferable than the local one. Therefore, the improved variety, Setit-1, has to be scaled-out to large number of farmers in the study area (taken over by extension) while research keeps on technically backing the extension.

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1.7. Improving faba bean production of smallholder farmers' through onfarm popularization of *Orbanche crenata* tolerant variety in Ofla District, Southern Tigray, Ethiopia

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Abstract

Broomrape (*Orobanche crenata*) infestation is the main constraint of faba bean production in the highlands of Southern Tigray. It cancause up to 100% yield loss. Thus, using Orobanche tolerant variety is an option for areas with very high Orobanche infestation. Popularization of the improved Hashenge variety was therefore conducted for two years. The objectives were to popularize the Orobanche tolerant variety, Hashenge, and collect and analyze farmers' perception towards this variety compared to local cultivar. The seed of Hashenge and Bio-fertilizer was provided to 135 farmers and they planted their faba bean crop in clusters in the Ofla district (Adigolo and Hashenge kebeles). Yield data was collected from randomly selected farm lands of participant and non-participant farmers. The collected data was analyzed using SPSS 20. The study showed that an average grain yield of 2.0 and 4.53 t/ha was obtained fromfrom the local and Hashenge varieties, respectively, in the 2016/17 and 2017/18 production seasons. There was a significant difference in grain yield and perception score between the improved and local cultivars. Besides, the perception score towards the post-harvest attributes of Hashenge was better compared to the local cultivars. However, about 40% did not prefer its food taste particularly when prepared as *wot* and 60% of the respondents said that Hashenge is not as early as the local in maturity. As majority of the farmers preferred Hashenge, it is better if the agriculture and rural development district office disseminate Hashenge to areas infested by Orobanche weed to boost the production of faba bean in the community. It should only be promoted in area where Orobanche infestation is a critical problem. Moreover, it needs special care on the seed system as seeds of Hashenge should not be taken out of the Orobanche infested areas.

Keywords: popularization, Hashenge, Orobanche, tolerance

Introduction

Pulses play significant role in improving smallholders' food security, as an affordable source of protein. Pulses make up approximately 15% of the average Ethiopian diet. They can also have an income benefit for smallholders, both in terms of diversification and because they yield a higher gross margin than cereals (IFPRI 2010). Out of pulses, faba bean is highly nutritious because of their high protein content. Faba bean is a good source of food with a valuable and cheap source of protein, starch, cellulose and minerals (Haciseferogullari et al 2003; Karkanis et al 2018). It also fetches high income to farmers. Besides, it is an important rotation crop which farmers are using to restore the fertility of their lplot of land (Crépon et al 2010: Negash et al 2015).

Faba bean (*Vicia faba* L.) originated in the Far East and is one of the earliest domesticated legumes crops after chickpea and pea (Tafere et al 2012) and is one of the best among the grain legume (Singh et al 2013). Similarly, it is one of the major pulses grown in the highlands (1800–3000 meters alltitude) of Ethiopia (Temesgen and Aemiro 2012, and Tafere et al 2012). Ethiopia is the second largest producer of faba bean in the world, next to China (Biruk 2009). However, the national productivity is still very low. According to CSA (2017), the national average yield of faba bean under smallholder farmers' is 2.05 t/ha and the average productivity is about 1.64 t/ha in the Tigray region, which is lower than the national average.

In the study area, faba bean is widely used as sprouted bean,green pod and stews (*wot*) with other mixtures. In addition, farmers commonly plant it in rotation with wheat and barley for soil fertility improvement as well as disease and insect pest suppression. The price of faba bean is higher than cereals. However, recently the production of faba bean is decreasing due to different diseases. Broomrape (*Orobanche crenata*) is one of the most seriously limiting factor for faba bean production.

Broomrape is common in the Mediterranean countries, Middle East and East Africa (Ethiopia), while other species have a much wider distribution (Perez-de-Luque et al 2010). *Orobanche crenata* is important in Ethiopia where it infests many legume crops, particularly faba bean, field pea, chickpea, lentil and dekoko (*Pisum sativum* var. *abyssinicum*) (Rezene and Gerba 2003, Rubiales et al 2006 and Teklay et al 2013). The parasite causes up to 100% yield loss in faba bean and field pea (Rezene and Gerba 2003: ICARDA 2006: Teklay et al 2013). In the highly infested areas, farmers are avoiding growing food legumes, resulting in substantial reductions to cultivated areas and to food legume production (Besufikad et al 1999). The complete faba bean yield loss by this weed forced farmers to replace faba bean by cereal crops in South and North Wollo zone of the Amhara Region (Mekonnen et al 2017).

In South Tigray, the history of Orobanche weed goes back to 33 years which has been seen in 1985 in Ofla district at one kebelle called Adigollo (Teklay et al 2013). The spread of the weed in Tigray region is alarming. It started in a small kebelle and is now distributed throughout the whole Southern zone of the region (Teklayetal 2013b). All districts of southern Tigray and thirteen kebelles are now infested. The incidence varies from <10% up to 100%. Yield loss was estimated to reach up to 99.2% depending on the level of infestation in the zone (Tsehaye 2017).

Therefore, Alamata Agricultural Research Center in collaboration with ICARDA worked to identify high yielding and Orobanche tolerant faba bean varieties for about five years. As a result, the center identified and released one Orobanch tolerant faba bean variety (Hashenge) at National level called (AARC 2014). Hence, this study was initiated to boost the production of faba bean through on-farm popularization of the Hashenge on farmers' field and then evaluate farmers' perception towards the variety in Ofla district, South Tigray, Ethiopia. Thus, the objectives of the study are to popularize the variety in Orobanche infested area and collect farmers' perception on the variety.

Materials and Methods

Description of the study area

The activity was carried out in Ofla district, Tigray, Ethiopia, located at 12°31'N latitude and 39°33'E longitude and an elevation of 2490 meters Ofla is located about 620 km far from Addis Ababa to the North and about 150 km South of Mekelle, capital city of Tigray National Regional State. The annual rainfall of the district varies from 450 to 1200 mm during summer (June to September) and 180-250 mm during winter season (February to May). The mean annual temperature is 22°c with minimum and maximum temperature of 6°c and 30°c, respectively. About 42% of the area is *dega* (highland), 29% *weyna-degua* (midland) and 29% is on the *kola* (low land) category. The major crops grown in the district includes wheat, barley and faba bean. Dominant soil classes are clay, silt, clay loam and sand (SZDCO 2016).

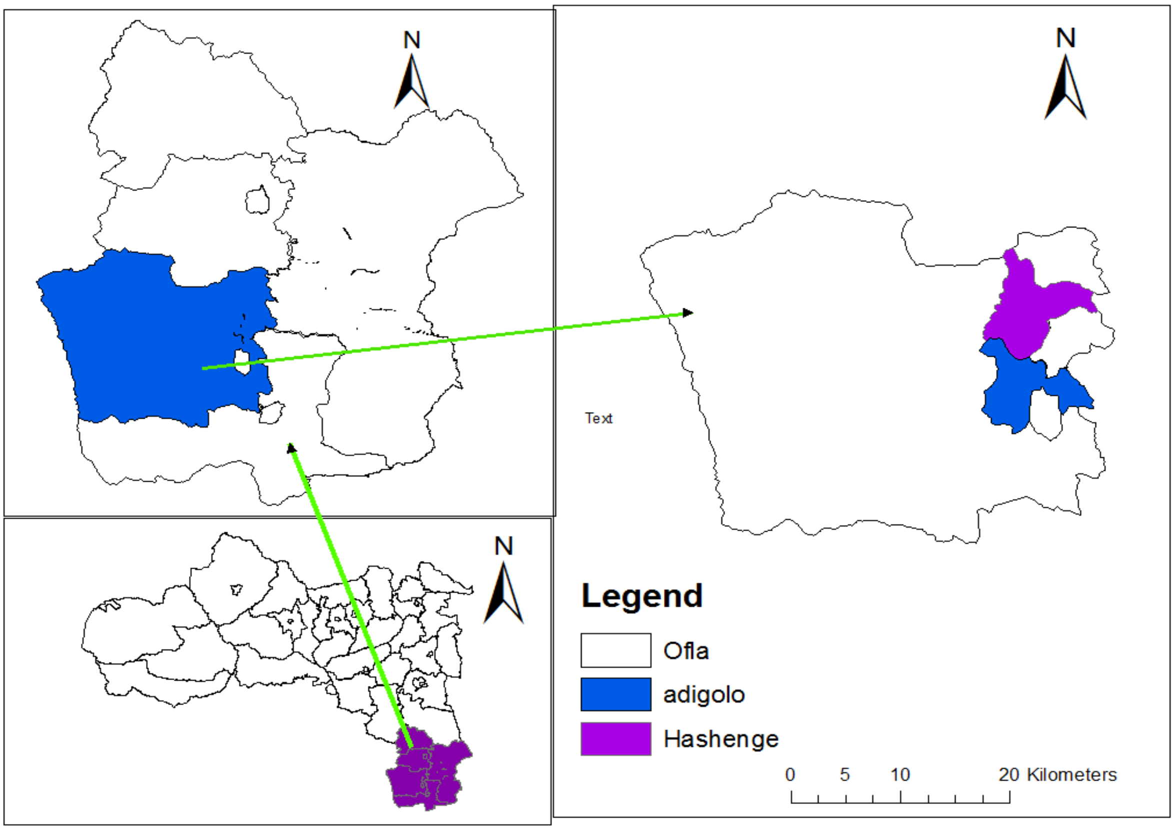

Figure 1. Map of the study areas

Selection of kebelles, farmers and approaches used

Ofla district is an orobanche infested areas where the incidence ranges from 71 to 100% (Tsehaye 2017). During first year, in 2016/17 production season, the activity was conducted only in Adigollo kebelle whereas in the second year it popularization continued supported by the Agiricultural Growth Program phase two in both Adigollo and Hashege kebelles of Ofla district. The selection of kebelles and farmers was done based on the history of orobanche infestation of the fields and farmers interest to participate. Practical and theoretical trainings were given to 118 farmers, 12 kebelle and district experts on agronomic practices, disease and pest management aspects (Table1). In the second year practical training on the application of bio-fertilizer was included. After delivering the practical training to farmers and experts an agreement was reached with the participants to plant the variety in row and apply bio-fertilizer.

During the popularization, seeds of Hashenge were given to 21 interested farmers in cluster at Adigolo kebelle, and 114 individual farmers in Adigolo and Hashenge kebelles in 2017/18 production season. During the two years, a total of 145 farmers participated and about 33.75 hectares of land was covered with the improved faba bean variety. All participants also applied bio-fertilizer in 2017/18 production season.

Filed days were organized to promote the variety while it was in the field for two consecutive years. During the field days 29 stakeholders, 141 researchers and experts, and 229 farmers participated. The feedback of the participants was positive and they highly appreciated the concerted effort of Alamata Agricultural research center and the stakeholders. Farmers appreciated the performance of Hashenge in the orobanche infested areas. Farmers told the field day participants' that faba bean production was almost stopped due to orobanche infestation in the area and they indicate their interest to plant this variety year after a year in the infested areas (Table2).

Figure 2. Partial view of participants during practical training on bio-fertilizer application

Table 1. Farmers and experts training during two year popularization activity.

Years	Farmers		Experts		Total	
	Male	Female	Male	Female	Male	Female
2016/17	17	6	4	2	21	8
2017/18	85	10	5	1	90	11
Total	102	16	9	3	111	19

Table 2. Field day participants during the two years project activity.

Year	Farmers		Experts and researchers		Stalk holders		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
2016/17	130	24	67	6	8	2	205	32
2017/18	70	5	60	8	16	3	146	16
Total	200	29	127	14	24	5	351	48

Figure 3 field day participants observing the performance of Hashenge.

Data collection and analysis methods

The data was collected using 1 x1 meter quadrat from randomly selected farm lands and were replicated five times. Grain yield was weighed using sensitive balance and converted to hectare.

In addition, to get farmers' perception on the varieties, a list of attributes was used and farmers were given a score from 0-10 value for each attributes used to select the varieties. In addition, perception level of participant farmers was collected through Likert scale for the list of varieties attributes. Descriptive statistics like mean, percentage, and inferential statistics like t-test was used to make comparison among the local and Hashenge .

Results and Discussion

On-farm performed activities and field management of farmers

The variety Hashenge was planted in Orobanche infested areas of Ofla district at Adigollo and Hashenge kebelles. During 2017 production season the researchers and experts supervised the farm plots of participant farmers whether they planted the variety in row and applied bio-fertilizer or not at field level. Finally they approved that all participants implemented based on the agreement made during the training. Moreover, researchers observed an interesting experience from the farmers that they protected the bio-fertilizer from sun light using umbrella (Figure 4B).

Figure 4. The farmer mixing the bio-fertilizer with the seed in his field (A), temporary shed used by farmers to protect bio-fertilizer from sun light (B)

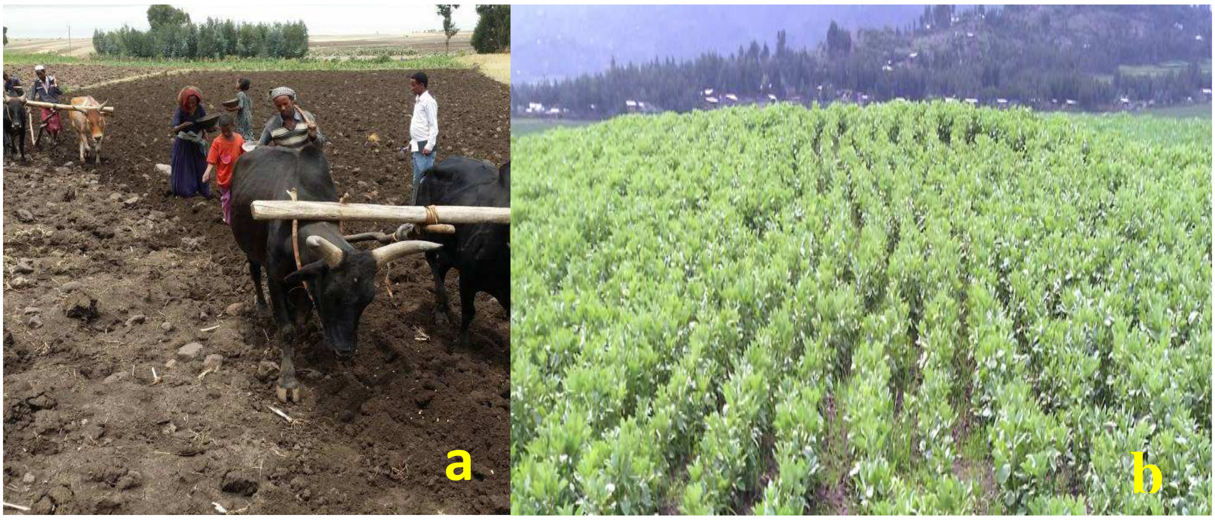

Figure 5. Farmers planting Hashenge in rows (a), performance of the row planted faba bean at farmers' field (b)

Grain yield performance of Hashenge variety

The result of the first year shows, an average grain yield of 2.0 t//ha with a range of 1.2 to 3.0 t/ha was harvested from Hashenge in Adigollo kebelle (Table3). This is a significant improvement in the yield of faba bean when compared to the regional average of 1.64 t/ha (CSA 2017). The grain yield from farmer's field was low compared to what is obtained in research station which ranges from 3.5-5.0 t/ha (Teklay et al 2013). In the first year, Hashenge showed high yield variation among participant farmers due to the difference in agronomic practices and other inputs likes inorganic fertilizer and Bio-fertilizer applied out by individual farmers. Additionally, farmers reported that frost during maturity was the main reason for the relatively low yield of Hashenge in 2016/17. Participant farmers highly appreciated Hashenge for its tolerance of Orobanche compared to local cultivars.

In the 2017/18 production season, an average grain yield of 4.53 t/ha, with a maximum and minimum of 5.03 and 3.53 t/ha, respectively, were harvested from Hashenge. On the other hand, an average grain yield of 1.2 t/ha with a range of 1.6 to 2.3 t/ha was harvested from local cultivars in the adjacent farm lands. This result shows there is a highly significant difference between the local and Hashenge at $p<0.001$ (Table 3). This indicates that participant farmers got more than two fold higher grain yield than farmers who planted local cultivars. Visiting farmers in the field day were highly impressed by the performance of Hashenge and its tolerance to Orobanche.

Table 3. Grain yield of Hashenge compared to local cultivar.

Variety	Location	N	Grain yield t/ha				t value	Yield advantage over local	Production year
			Mini	Maxi	Mean	SD		%	
Hashenge	Adigolo	10	1.2.	3.00	2.01	0.57		26.89	2016/17
Hashenge	Adigolo& hashenge	15	3.53	5.03	4.53	0.41	4.79***	186.65	2017/18
Local	Adigolo& hashenge	7	1.2	2.59	1.58	0.49			

Perceptions of participant farmers towards Hashenge compared to local cultivars

No one farmer perceived Hashenge very poor level related to 12 attributes. As indicated in table 4, majority of the respondents reported that Hashenge was preferred for its germination, pod per plant, tillering capacity, disease/insect resistance, seed per pod, biomass, grain yield, marketability and seed color compared to existing local cultivars. However, 60% respondents perceived that the variety is not early as compared to local cultivars of faba bean in the area. In addition, 40% of respondents perceived the taste of ''wot'' from Hashnge not tasty as the local varieties (Table 4). On the other hand, Hashenge was highly preferred by farmers for consumption in the form of "sprouted" compared to local and was tasty. Consequently the market price of Hashenge is higher than the local due to its seed size. Hashenge is highly preferred than the existing faba bean varieties by local beverage producers (Endasewa). The local beverage producers preferred Hashenge because of the seed size is large and it is uniform than the local cultivars. In addition, the variety has almost 100% germination compared to local (Table 4).

Table 4. Farmers' perception towards Hashenge.

Characteristics	Perception level									
	Very poor		Poor		Neutral		Good		Very good	
Germination	-	-	-		-	-	2	20	8	80
Earliness	-	-	6	60	1	10	-	-	3	30
Pod per plant	-	-	-	-	-	-	2	20	8	80
Tillering capacity	-	-	-	-	-	-	3	30	7	70
Disease/insect tolerant (orobanche)	-	-	1	10	1	10	5	50	3	30
Seed per pod	-	-	-	-	-	-	4	40	6	60
Biomass yield	-	-	-	-	-	-	3	30	7	70
Grain yield	-	-	-	-	-	-	4	40	6	60
Seed size	-	-	-	-	-	-	1	10	9	90
Food taste (Tsebhi)	-	-	4	40	-	-	2	20	4	40
Marketability (Bukilti…)	-	-	-	-	-	-	4	40	6	60
Seed color	-	-	-	-	-	-	2	20	8	80

Perceptions of participant farmers towards Hashenge compared to local cultivars

The variety was implemented in two kebelles of Ofla district. Hence farmer's perception towards the Hashenge variety was evaluated through preparing nine variety attributes taken from farmers. Plant height, pod per plant, tiller capacity, water logging tolerance, number of seed per pod, earliness to set pods, earliness to mature, disease/pest resistance and grain yield were the parameters. The result shows the mean score for the local was lower than HashengeI in both locations. Further, the result indicated that Hashenge recorded higher in eight parameters in Hashege kebelle and seven parameters in Adigollo kebeles compared to local. Farmers perceived that Hashenge is late maturing and it is not early to set pods compared to the local cultivar. The final analysis however showed that there is highly significant difference in grain yield and perception score between the local and Hashenge (Table 5).

Farmers also observed that there was lower Orobanche pressure on Hashenge compared to the local in their adjacent fields. Participant farmers also gave higher score for Hashenge compare to the local (Table 5). Similarly, Teklay et al. (2013), conducted an experiment on orobanche hot spot area of Ofla district for two years (2011-2012) and found out lower Orobanche pressure on Hashenge (genotype ILB4358).

Table 5. Perception of farmers on pre-harvest traits of Hashenge variety

Variety attributes	Score from 10			
	Hashenge kebelle		Adigolo kebelle	
	Local	Hashenge	Local	Hashenge
Plant height	3	7	2	8
Pod per plant	3	7	3	7
Tiller capacity	4	6	2	8
Water logging	3	7	3	7
Seed per pod	3	7	4	6
Earliness to set pods	4	6	6	4
Early maturing	6	4	6	4
Disease/pest/Orobanche tolerance	3	7	3	7
Grain yield	2	8	2	8
Mean	3.44	6.55	3.44	6.55
SD	1.13	1.13	1.58	1.58
t value	5.45***		4.15***	

***, significant at 1% probability level.

As indicated in (Table 6), the majority (> 80%) of respondent's perceived hashenge positively for all parameters compared to local. The farmers highly appreciated the color, seed weight and they reported that the variety was preferred for Bukulti and Tiktiko by the local beverage producer (endasewa's) due to its large size and taste. As Crepon et al. (2010), reported faba bean seed size is an important trait in determining market and consumption forms. Large-seeded varieties are widely used for food, either as a fresh green vegetable or (dehulled) dry seeds. However, less than half of the respondents perceived that the Hashenge does not make tasty tsebhi (*wot*) when compared to the local for its Tsebhi taste (Table 6).

Table 6. Perception of farmers on post-harvest traits of Hashenge.

Variety attributes	Perception level									
	Very poor		Poor		Same		Good		Very good	
	N	%	N	%	N	%	N	%	N	%
Seed color	-		-	-	-	-	12	44.4	15	55.6
Seed weight	1	3.7	0	0	2	7.4	11	40.7	13	48.1
Seed size	-	-	-	-	-	---	10	37	17	63
Straw palatability	3	11.1	0	0	3	11.1	8	29.6	11	48.1
Grain market preference	-	-	1	3.7	-	-	12	44.4	14	51.9
Bukulti/tiktiko preference	-	-	-	-	-	-	10	37	17	63
Bukilti/tiktiko taste	-	-	-	-	-	-	9	33.3	18	66.7
Tsebhi(whot) taste	5	18.5	6	22.2	9	33.3	5	18.5	2	7.4

Conclusion and recommendation

The study concluded that the Hashenge variety was showing higher grain yield and high preference by the farmers compared to local cultivars as well as social acceptance. Infact Hashenge had a yield advantage of 26.89 and 186.65% in first and second year of popularization, respectively, i.e. farmers that planted Hashenge got more than two-fold yield than those that planted the local. Therefore, it can be concluded that planting Hashenge is one of the best options to boost production and productivity of faba bean in the orobanche infested areas of Southern Tigray, Ethiopia.

This study therefore recommended that it is better if the agriculture and rural development district office disseminate Hashenge to areas infested by Orobanche to boost the production of faba bean in the highlands of Southern zone of Tigray only.

To further address the challenges of Orobanche infestation in the Southern zone of Tigray, the research partners should focus on enhancing the capacity of smallholder farmers vigorously. It is better to develop a special seed system for the area so as to ensure seed security and curb further distribution of the weed in the community and beyond. To increase the agricultural productivity, researchers and extension experts should take efforts to demonstrate and promote improved agricultural technologies and market oriented commodities for faba bean.

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2. Mechanization Technologies

2.1. Demonstration of improved small scale tomato paste processing technology

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Abstract

Mekelle Agricultural Mechanization and Rural Energy Research Center (MAMRERC) conducted a research on preparation of different products from tomato such as tomato paste, ketchup, Jelly and Jam. Physico-chemical properties and microbial properties (bacteria, yeast and mould) were studied for the products prepared. Microbial examination revealed that the product is still safe to consume after 6 months of preparation at farmers level. The main objective of this project was to demonstrate wholesome and low cost processed tomato paste as an alternative for consumers by elongating the shelf life of tomatoes for several months and to benefit farmers, entrepreneurs and small scale processors. The activity was implemented in two potential tomato producing woreda's. 40 female farmers were included in the project. Economic and perception data was collected and analyzed descriptively. In terms of trial ability of the technology is well evaluated and it is found that the technology is much satisfactory. In terms of relative advantage, the descriptive statistics and economic analysis revealed the new technique of preparation of tomato paste had an overall economic advantage. Moreover, the perception of women participants which confirms the relative advantages of the new technique as it is very effective and efficient in minimizing the post-harvest losses of tomato. It was perceived that the technology is much more advantageous and acceptable. Hence, there is a need to scale-out the technology for farmers, entrepreneurs, cooperatives and other relevant actors by strengthening their awareness on the technology.

Key words: demonstration, perception, post-harvest loss, shelf life, tomato paste,

Introduction

Tomato (*Lycopersicon esculentum*) is a popular and highly consumed vegetable worldwide. In Ethiopia as in many other countries, it is commonly used for consumption as fresh or cooked dishes and for processing in to several products such as paste, puree, ketchup, sauce or juice. Aside from its economic value, tomatoes and tomato products are vital to human nutrition, being rich sources of folate, vitamin C, potassium and more importantly carotinoids (pro-vitamin A and anti-oxidant activity), the most abundant of which is lycopene followed by beta-carotene, gamma-carotene and phytoene. Other nutritional substances in tomatoes include vitamin E, trace elements, flavonoids, phytosterols and several water soluble vitamins (Beecher 1998).

There are different processing methods for tomato. In this case, simple and low-cost techniques of tomato paste processing will be focused to fit with the overall requirements and capacity of poor farmers, processors and small-scale entrepreneurs. Tomato paste is a concentrated tomato containing a minimum 24% of soluble natural dry matter or a soluble solids content of 24°Brix using a refracto-meter. But in the rural areas where refracto-meter is not available, the desired soluble solids content can be determined by experience observing the viscosity of the product. For example, if the end-point is 24°B, the tomato paste is sticky on a teaspoon and flows slowly on the paper.

Mekelle Agricultural Mechanization and Rural Energy Research Center (MAMRERC 2016) conducted research on preparation of different products such as tomato paste, ketchup, jelly and Jam. Physico-chemical properties: total soluble solids (TSS), acidity, ascorbic acid content (AAC) and microbial properties (bacteria, yeast and mould) were studied for the products prepared. Microbial examination revealed that the product is safe to consume after 6 months. Hence, further demonstration and promotion of this minimally processed tomato paste preparation technique was quite pertinent.

During peak production period, oversupply of fresh tomatoes in the market can be observed and price is much lower than during lean periods. Vegetable processing is a new vision for farmers because market supply and price of fresh produce are very erratic. Fresh produce has very short shelf life and if farmers process their produce, their income can be sustained while supplying diverse products to the market. Additionally, vegetable processing can reduce imports and if products have competitive quality, this can open-up export opportunities. Such export market can stimulate agricultural activities. All of these can create more employment opportunities particularly in rural areas which is good to the economy. Based on this, the present study was initiated to demonstrate wholesome and low cost processed tomato paste as an alternative for consumers to prolong the shelf life of tomatoes for several months and to benefit farmers, entrepreneurs and small scale processors to generate income.

Materials and Methods

Description of the study area

The activity was undertaken in two potential tomato production woredas. 40 female farmers and local traders were included in the project and inclusion was based on their willingness and capability to manage technical requirements.

Data collection

Red-ripe, un-bruised and high quality tomatoes were used for the demonstration on making tomato paste which was bought from growers in the local area. Additional materials used include fresh ripened tomatoes (120kg), teaspoon, jar (glass bottle), cape, polyethylene tube, filler, wood and stove, pulper (sharp knife), sieve (stainless) or cotton sack, salt, pectin, washing pail or basin, towel and spices.

Researchers, respective woreda staffs of the office of agriculture and rural development, and participants jointly managed the activities. Data on perception of the farmers towards the technologies was collected using ranking, scoring and other parameters. Relevant marketing data pertinent to the technology was also collected. The data was analysed using descriptive statistics.

Procedures followed during processing

Step 1 Pre-processing: Tomatoes at optimum quality (red-ripe stage but firm) and free of defects (insect or disease damage, physical injuries) were selected.

Step 2 Blanching and peeling: In order to soften the skin for easy peeling and inactivate the enzymes, particularly catalase and peroxidase blanching was done for 5-10 minutes at controlled temperature in boiling water and cooled in cold water for 5-10 minutes.

Step 3 Seed separation and crushing: The fruits were sliced into half and the seeds were scooped out using a teaspoon, because seeds could impart bitter taste to the paste.

Step 4 Concentrating or Cooking: Cooking was done for several hours until enough water was removed to produce a thick red concentrate.

Step 5 Pasteurization or sterilization: To destroy of bacteria and fungi and their enzymes, sample containers were dipped in boiled water for 20-minute.

Storage period of the processed paste was evaluated in 2, 4, 6 and 8 months by visual appearance, external appearance and examining the microbial load.

Results and Discussions

Characteristics of tomato paste

There are different processing methods for tomato. In this case a simple and low-cost technique of tomato paste processing was focused so as to fit it with the overall requirements and capacity of poor farmers, processors and entrepreneurs. Tomato paste is a concentrated tomato containing a minimum 24% of soluble natural dry matter or a soluble solids content of 24°Brix using a refract meter. But, in the rural areas where refracto-meter is not available, the desired soluble solids content can be determined by experience observing the viscosity of the product. For example, if the end-point is 24°B, the tomato paste is sticky on the teaspoon and flows slowly on the paper (MAMRECRC 2008).

Tomato paste will help farmers to ensure that the products can be stored for personal consumption or later sale. Tomato paste is easy to handle and can come in various amounts. Any farmer who has tomato paste in his home can use or preserved tomato all year round and is free to decide when to bring his/her product/ harvest to use or market.

The high acceptance of tomato paste is due to the following reasons

- It is easy to prepare and handle

- Hygiene is improved
- Quality tomato is preserved
- Very inexpensive
- Makes work easier for women
- Tomato paste are kept safe
- Adaptable to the needs of small farmers
- Offers marketing advantages during time of scarcity and prevent post-harvest losses

Trial-ability of the technology

The value of trials is that they reduce uncertainty about the innovation and develops skills in applying the innovation (Pannell et al 1999). According to Pannell et al (1999), nine characteristics of innovations that affect an innovations' trial ability were used to evaluate the method of preparation of tomato paste and the tomato paste itself. And the technology is evaluated by researcher, experts and farmers accordingly. The following are characteristics of a highly trial able innovation:

1. Highly divisible or trial able: Tomato paste might be made in different amounts. Based on the interest of the household, the technology could be prepared in different amount. Thus the technology is easily trial able in small scale at any time and place.

2. Strongly observable results: Tomato paste has a short response lag time between using the innovation and seeing results. It takes no time to observe the result just in three months: farmers can evaluate the technology after they carefully prepared the innovation.

3. Complexity: tomato paste is very simple technology. It needs some training to understand how to prepare and use tomato paste. Moreover it is easy to handle and requires only small space. Thus this technology has low or no complexity to understand and to use it by end users.

4. Cost*:* To prepare tomato paste only few cost are needed. This cost may include cost of tomato, cost of material for preparation such as fuel and labor. In terms of its relative advantage this cost is relatively low considering the high post-harvest loss due to lack of proper preservation. Thus, farmers may need to incur this cost to benefit more.

5. *Low risk of failure of the trial:* If properly prepared as per the manual**,** this technology has less risk of failure. However, if there is no proper preparation and the containers are not clean and free enough from any contamination, the technology has a great risk of failure, Moreover, if container is not closed properly and air enters to the container, there may be total loss.

6. *Innovation similar to normal practice**:* Almost all users and producers of tomato have not used any method of preservation mechanism. As a result there is a great tomato post-harvest loss. Tomato paste adopted and developed by researchers is simple to prepare and is very effective to prevent post-harvest loss. With simple training, users can handle the tomato paste preparing method. Users also need additional skill or special training to identify the different cause and signs of spoilage for better preservation.

7. *Strong linkage between the landholder's practices and the problem being addressed**:* Lack of tomato preservation is one of the main constraints in tomato utilization. Some study shows that about 92 % post-harvest loss happens in tomato and it remains unmarketable or is sold at low price. The new technology tomato paste helps to address such problems by preserving for long time and offers marketing advantages during time of surplus production. Therefore this technology is effective to solve real problems of tomato post-harvest losses.

Table 1. Evaluating the characteristics tomato paste

Trail ability Characteristics of Tomato paste	Number of respondents	Yes (%)	No (%)	Remark
Highly divisible/easily triable	400	95%	5%	
Strongly observable results	400	100%	0%	
A short response lag time	400	92%	8%	
Low complexity	400	78%	22%	
Low cost	400	100%	0%	Relatively
Low risk of failure of the trial	400	5%	95%	
Well implemented trial	400	80%	20%	
Innovation similar to normal practice	400	20%	80%	Not but simple
Strong linkage between farmer practices (and thus innovation) and the problem being addressed	400	90%	10%	
Gender neutral	400	100%	0%	

Source: MAMRERC (2016)

8. Gender aspect of the technology: day-to-day management of food preparation is undertaken by women, often with assistance from their female children. Therefore this technology is intended to solve women problems in their daily activities. Once they prepare the tomato paste, they can use for long time and no need to prepare tomatoes for daily cooking.

9. Sensory attributes of tomato paste: Sensory properties, indicative of the quality parameters for tomato paste samples, were measured to quantify the extent of the characteristics difference between tomato paste and fresh one.

Five trend panelists were used for the pretest. A five point hedonic scale was used to determine the organoleptic attributes and acceptability of the complementary food. The number "5" represented 'like very much, '1' represented 'dislike very much'. The observations and suggestions made by the trend panelists were used to improve the preparation of the tomato paste processing.

A total of 20 mothers were selected for the sensory evaluation. They were selected randomly from the mothers who have tomato paste. These mothers voluntarily accepted to participate after thorough discussion and interview and the result shown in the table below.

Table 2. Indicates sensory attributes of tomato paste: Sensory evaluation

Frequency(20)	like	Like (%)	Dislike (%)
Colour	4.55	91	9
Smell	4.3	86	14
Taste	4.2	84	16
consistency	3.2	64	36
Over all acceptance	4.2	84	16

Source: MAMRRC 2016.

Perception of farmers on attributes of prepared tomato paste

Time saving: The work is entirely performed by female member of the household. The day to day activity was no considered as a job even though it consumes much of their time. This new technique helps women to save much of their time and they could spend their time in other activities. In terms of time saving the result shows that the new technique save 80 % of the time they spent in their day to day activities.

Safety and comfort of tomato paste: a great care is needed in preparation of the tomato paste. It needs proper hygiene and personal sanitation otherwise a problem may be created in the health of the users. If, however, the new preparation of tomato paste is properly managed no problem is encountered. Besides the technology is used by cooking thus the paste is safe and healthy to use after several months.

Suitability in small scale: all participant farmers perceive that this tomato paste is very suitable to prepare in different amounts and can use it at any time in their home. If someone has the ability to afford large amount, he/she can prepare and use it all the year round.

Perception of farmers on cost of preparation of tomato paste: with the current price fluctuation in tomato, tomato paste is a good technology to stabilize the market. At lean time the price of fresh tomato is unaffordable to consumers and at peak production, the price will be very low which cause discomfort and great loss to the producers.

Table3. Perceptions on of tomato paste attributes

Parameters relative advantage	% (yes)	Remark
1. The expected profitability of the innovation	100	
3. low cost or profitability of the practice the innovation would replace	100	high
4. low adjustment costs involved in adopting the innovation	75	No cost
5. No effect on the riskiness of production/outcome	50	
6. No negative effect on other components of the farming system	100	
7. No negative effect on the family lifestyle	100	
8. Compatible with a farmers' existing technologies, practices and resources	100	
9. The innovation's compatibility with existing beliefs and values	100	
11. The innovation's low complexity	70	

Source: MAMRERC 2016.

The innovation's effect on the family lifestyle: Preparation of Tomato paste is introduced to decrease post-harvest loss and to stabilize market. The implementation has no any negative effect in the family life style, rather it supports and can be managed by female members of the family.

The innovation's compatibility with the beneficiaries' existing technologies, practices and resources: The preparation of tomato paste has minimum deviation from the existing practices. It needs simple training and some additional skill to manage the new technology. All the participant farmers perceive that the new technique of preparation of tomato paste has no compatibility problem with existing beliefs and values. Moreover the technology is aimed to prevent post-harvest losses which are more supportive to the government policies especially in the prevention of post-harvest loss and market stabilization.

Partial budget analysis

Tomato paste can fit to different sizes. In the analysis 30 kg of tomato was taken for one month to feed five persons per day. The main advantage of the new technique is decrease post-harvest losses of tomato: by preparing tomato paste and preserving tomato in low price season for use in the high price season.

Partial budget analysis result revealed that the new technique of preparation of tomato paste has very small cost and better return as compared to the normal practices i.e. the new technique was 5.93 times more efficient.

Table 3. Partial budget analysis of preparation of tomato paste

Parameters		*Traditional* technique t=x P=5	New technique t=x P=5	*Traditional* technique t= y P=30	New technique t=x P=30	Estimated value
Price of tomato= 5	5	5*30=150	5*30=150	30*30=900	5*30=150	Lobour=120 per 480
Fuel cost	7	7*30=210	7*5=35	7*30=210	7*5=35	
Time taken	min	10*3*30=900	120	10*3*30=900	120	
Cost time in birr/min	120/day	225	30	225	30	
Total cost		585	215	1335	215	
Net benefit						
MRR						

Source: MAMRERC 2016

Total cost from traditional technique= 1335 to prepare given amount of tomato

Total cost from traditional technique= 215 to prepare given amount of tomato

Efficiency = 1335/225*100=593.33%; i.e. the new technique is 5.9 times more cost efficient than the traditional one

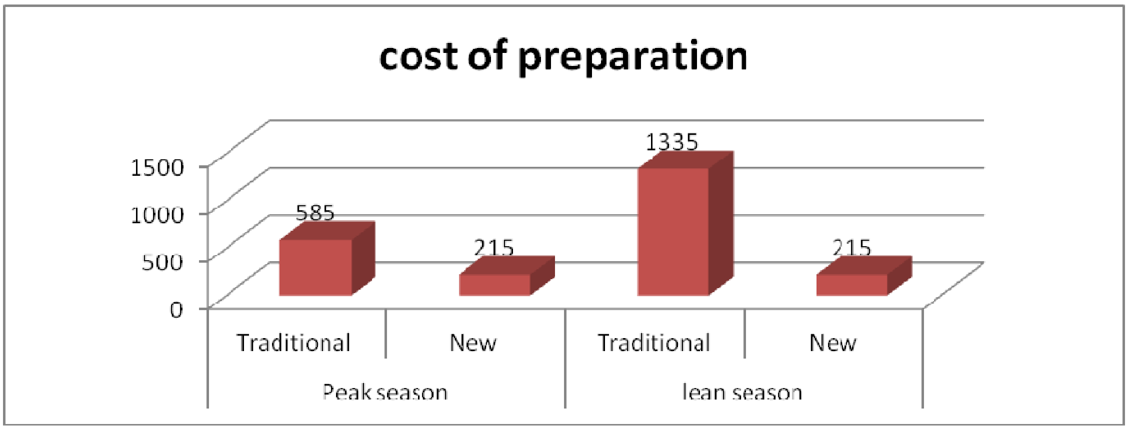

Figure 1.Cost of preparation of tomato paste (Source: MAMRERC 2009)

Conclusions and Recommendations

Since value addition and product diversification has paramount importance in the present market scenario, more diversified products from tomato like tomato paste have much more relevance as a method of preservation and post-harvest loss prevention. The developed product was retained original fruit flavor and was safe for consumption. Development of such nutritional products using pilot scale facilities not only reduce the postharvest losses but also impart value to less appreciated vegetables. Moreover, it makes for greater food security and offers marketing advantages during time of scarcity. It decreased the post-harvest loss of tomato through preservation and will also result in equitable distribution of food and income for rural households. Producer can sale and use the tomato paste at any time of the year.

Therefore, preparing of such products will provide ample avenues for employment in the rural masses by way of setting small scale processing units. To reduce uncertainty about the innovation and develops skills in applying the innovation, trial ability of the preparation of tomato paste was evaluated by stakeholders such as researchers, experts, health works and end users: farmers. The characteristics of the tomato paste were evaluated including how easily a farmer can learn about an innovation's, its performance and management.

In Terms of trial-ability, different factors such as highly divisible/easily trial able, strongly observable results, a short response lag time, the effectiveness in the problem being addressed and other factors of the preparation of tomato paste was well evaluated and it is found that the technology is much satisfactory. Therefore it was demonstrated and popularized in the farmer's field level for further evaluation.

In terms of relative advantage, the technology is deeply evaluated by farmers. It was perceived that the technology for preparation of tomato paste is much more advantageous and the study showed it has overall relative advantage over the traditional. According to the results of this evaluation, almost all stakeholders are well aware of its trail-ability and its relative advantage over the existing practices. In general the method of preparation of tomato paste in terms of economic, social, environmental, cultural and personal was found to be acceptable technology.

Since this practice is very acceptable by women farmers and users at peak production period we recommend scaling-up to other areas. But great care and continuous training and supervision is needed on how to prepare and store it in order to enhance the wider adoption of this product in the rural community.

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2.2. Popularization of engine operated maize sheller to selected maize growers of Tigray Region, Ethiopia

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Abstract

Maize production has increased in the last few years in Tigray region and in the country. Despite the increase, there are still many problems in the production systems that are not solved. Amongst them, method of shelling is the first. The traditional methods of shelling include (rubbing the cob together, fringe by hand finger, beating the cobs using sickle or by pestle and animal tramping). These methods are labor intensive, time consuming, cause damage and loss of grains. In order to solve the problems, the research center modified and improves the Bako model engine operated maize sheller which has the capacity to shell more than6 ton $h^{-1}$and with 98.9 % efficiency. The overall objective of this research is to enhance productivity of small scale farmers through popularization of effective and efficient use of engine operated maize sheller. The improved engine operated maize sheller had a higher advantage in labor and time saving over the traditional one. The partial budget analysis also indicated that engine operated maize sheller is economically feasible than the traditional one; hence for every 1 ETB invested in the improved engine operated maize sheller; the return was 5.51 Ethiopian Birr (ETB). Because of the current socio-economic problems, the small scale farmers could not adopt the engine maize sheller but they can own it in group. To resolve this challenge, researchers need to think of its size and may be make it suitable to small holder farmers. It might also be possible to manufacture and popularize the engine operated maize sheller so as to benefit the large scale producers and cooperatives.

Keywords: Engine operated maize Sheller, partial budget analysis, popularization

Introduction

Agriculture is arguably the most important vehicle for realizing economic development, creating employment and reducing poverty in Africa. In the Eastern and Central Africa (ECA) sub-region, agriculture accounts for about 43% of the gross domestic product (GDP) and for over 60% of exports. About 70% of the population and nearly 90% of the poor work in agriculture where they depend for increased agricultural productivity to lift them out of poverty (Odame et al 2013).

In Ethiopia maize is the most important cereal crop both in terms of production and area coverage. From 9 million farmers, 70% of the total farmers produced about 6 million tons of maize on two million hectares of land. The farmers grow maize mostly for subsistence: 75 % of all maize produced consumed by the farming households (CSA 2012). Maize plays a major role in the livelihood and food security of most smallholder farmers in Ethiopia. It is grown in most parts of the country with different productivity potentials. For many years, maize in Ethiopia has been the first in production and second (next to tef) in area of cropped land (Legese et al 2010). In the 2015/16 production year alone, Ethiopia produced 3.89 million tons of maize on 1.77 million ha of land. This gives an average productivity of 2.2 tons/ha, which is the highest of all cereal crops produced in the same year (CSA 2012).

In Africa, maize has become a staple food crop that is known to the poorest family. It is used in various forms to alleviate hunger, and such forms include pap or 'ogi', maize flour, and etc. It is because of the important place of maize that it's processing and preservation to an optimum condition must be analyzed (Pavasiya et al 2018). The major steps involved in the processing of maize are harvesting, drying, de-husking, shelling, storing, and milling. For the rural farmers to maximize profit from their maize, appropriate technology that suites their needs must be used. The processing of agricultural products like maize into quality forms not only prolongs the useful life of these products, but also increases the net profit farmers make from mechanization technologies. One of the most important processing operations done to bring out the quality of maize is shelling or threshing of maize (Oriaku et al 2014).

Improved agricultural technologies are widely recognized as the key means of addressing the causes of low productivity. Over the past decade, research institutions have generated numerous technologies, innovations and management practices in maize production that are effective in addressing most of these factors. However, many of these technologies have not been widely adopted by the intended users, especially smallholder farmers. To help resolve this challenge, Mekelle Agricultural Mechanization and Rural Energy Research Center (MAMRERC) had adopted effective and efficient engine operated maize Sheller from Bako Agricultural Research Center for maize shelling. The Sheller had the capacity to shell more than 5-6 ton ha^{-1} with 98.9 % efficiency (MAMRERC 2012).

Traditionally farmers have experienced some methods of shelling maize, which includes rubbing the cob of corn together, fraying by engine finger and beating the cobs by using stick and use of oxen. Those methods do not support large-scale shelling of maize and especially for seeds and commercial purposes. In order to overcome the above mentioned problems, the research center verified and demonstrated the engine operated maize Sheller to over 120 farmers; hence, the technology was highly demanded especially by large scale farmers. Therefore, the overall objective of this research was to enhance productivity of small scale farmers through popularization of effective and efficient use of engine operated maize Sheller while the specific objectives were to save time and work load, enhance knowledge and skill of the farmers to adopt and to speed up the technology dissemination rate in a wider area and more farmers.

Materials and Methods

Description of the study area

This popularization was conducted in 2017/2018 production season in Tigray Regional State which is located in the northern escarpment of Ethiopia between 360-400 E longitude and 12.50-150 N latitude. The research was conducted in the Agricultural Growth Program (AGP-II) target districts; Medebay-Zana and Laelay-Adiabo and this work particularly focused on two Tabia's.

Sampling technique and procedures

Rapid assessment, community meeting and group discussion was held for the selection of the specific target groups. In collaboration with Office of Agriculture and Rural Development (OoARD), representative sites and 142 maize producer farmers were selected purposively based on their interest to participate in popularization of engine operated maize Sheller. Before conducting the research, farmers and development Agents (DAs) were trained. Training was both theorey and practical. Researchers demonstrated the technology to be popularized (engine operated maize Sheller) and showed them how to operate the machine and how to shell maize cobs and adjust the machine. The engine operated maize Sheller had the capacity to shell to more than 5-6 ton ha^{-1} and with 98.9 % efficiency (Figure 1).

Figure 1. Engine-driven Bako type maize Sheller

Data collection methods

The study was based on primary and secondary data. The primary data includes qualitative and quantitative collected from 30 participant farmers. The qualitative data (farmers' perception and performance of the engine operated maize Sheller) were collected using structured and semi-structured interview while the quantitative data (economic data of the engine operated maize Sheller versus traditional shelling practices) were collected using checklist. Besides, desk studies, expert consultations and focus group discussion with key informants were heldusing checklists. Secondary data was reviewed from annual reports, proceeding, journals and Universal Resource Locator (URL).

Data analysis

The descriptive methods of data analysis were used for quantitative data while narrative methods of data analysis were used for qualitative ones.

Results and Discussion

Trail-ability characteristics of engine operated maize sheller

Trial-ability of the engine operated maize sheller: is defined broadly as how easily a farmer can learn about an innovation's performance and management. Based on the idea of trial-ability, 9 characteristics of innovations that affect an innovations' trial-ability is used to evaluate the technology and the technology is evaluated by experts and farmers (Table 1).

Table 1. Participatory evaluation on the characteristics of engine operated maize sheller

Trail ability characteristics	Number of respondents	Yes (%)	No (%)	Remark
Highly divisible/easily friable	142	95%	5%	
Strongly observable results	142	100%	0%	
A short response lag time	142	92%	8%	
Low complexity	142	78%	22%	
Low cost	142	7%	93%	relatively
Low risk of failure of the trial	142	100%	0%	
Well implemented trial	142	100%	0%	
Innovation similar to normal practice	142	4%	96%	new
Strong linkage between the landholder's practices (and thus innovation) and the problem being addressed	142	92%	8%	

Source: Survey result 2017.

Highly divisible or trial able: The engine operated maize Sheller cannot be trialed in part or on a small scale. Thus the technology is huge and only used as it is and this make the technology difficult to adopt by users. However farmers can see the performance of the technology with small amount of produce.

Strongly observable results: Engine operated maize sheller has a short response lag time between using the innovation and seeing results. It takes no time to observe the result just in few minutes and farmers can evaluate the technology.

***Complexity*: ** Engine operated type maize sheller is complex technology. It needs special training to understand how to operate or use. Thus this technology has complexity to use it. However, nowadays most farmers are well aware of engine water pumps and the operation of the engine operated maize Sheller is as the same as the other engine-operated machines around. Thus, many farmers can operate the machine easily.

Cost: The investment cost of this technology may range from 48,035-52,000 ETB. Moreover, it has adjustment cost and transportation costs. However, in terms of its advantage for service providers, it is profitable.

Low risk of failure of the trial: Engine operated maize sheller has low risk of failure. With proper service, it can operate without any maintenance for long time. If it implemented well, it provides the intended service effectively and efficiently.

***Innovation similar to normal practice*: ** Farmer does not have any special equipment for shelling so researchers developed simple engine operated maize sheller. Users therefore need new and detail knowledge and skill or special training to operate it.

Strong linkage between the landholder's practices (and thus innovation) and the problem being addressed: Traditionally farmers have experienced some methods of shelling maize, which includes rubbing the cob of corn together, fraying by finger, and beating the cobs by using stick. These methods of shelling are not effective and efficient. In Addition they cause hand and finger injury and other health problems. Thus engine operated maize sheller was developed to address such problems. Therefore this technology is effective and efficient to solve the existing problems. Moreover, this technology has no spillover effect in solving the problem being addressed.

Farmer's perception on relative advantage of the engine operated maize sheller vs traditional maize shelling practices

The expected use or profitability of engine type operated maize Sheller: Engine maize sheller is huge capacity technology. Depending on the moisture availability of the maize to be shelled, the engine can shell up to 40 kg per hour. Since farmers had a great expectation of usefulness or profitability of this engine maize sheller. However they were also thought of the cost of the technology and its availability in their local area. The economic advantage of the technology could be measured in terms of labor cost and time saving.

Profitability of engine maize sheller: Whatever cost was to be incurred due to the new implement it needed to be recovered immediately in terms of the advantages that farmers got through the use of the new implement. These may have been in terms of labor, time saving or seed quality when we come to engine maize sheller. The engine operated maize sheller is found to be more effective and efficient than manual or traditional maize shelling practices. A local perception by farmers with respect to economic feasibility of the technology was collected and we found out that it has economic advantage. However, the farmers did not favor the technology because its investment and adjustment costs are unaffordable.

Time saving**:** Farmers tried to evaluate the engine operated maize sheller with the existing shelling practices. All participants (100%) replied that the engine maize sheller takes less time than traditional practices for a given amount of maize which is incomparable.

Labor saving**:** When comparing with traditional practices which require more labor to shell a given amount, the engine operated maize sheller requires minimum labor up to four to work efficiently. Within short period time large amount of maize could be shelled by the improved maize sheller whereas the traditional maize shelling practices required more number of labors to shell the same amount of maize which is tiresome.

Brakeage**:** Almost (90%) of the participants agreed that the machine have a minimum breakage than shelling by oxen and hitting by stick. Thus the traditional practice decrease the quality of maize and consumer do not prefer as they think the maize shelled by traditional practice breakage is due to pest's damage. Hence, reduces the market price of the broken maize and some time it may not be sold at market.

Cost**:** When comparing with traditional practices, the engine operated maize Sheller has small cost per 100 kg. The total cost incurred to shell 100 kg of maize was only 5.51 ETB while for manual shelling incurred 240 ETB to shell 100 kg of maize. However, the farmers (100%) perceived that engine operated maize Sheller has required huge investment cost which is unaffordable by small scale farmers. Hence, farmers were failed to adopt this technology due to its high cost and socio-economic problems.

Safety and comfort**:** All the respondent farmers (100 %) replied that the technologies were found better in term of safety and comfort comparing with traditional hand fringe, using oxen and hitting with stick. As the traditional practices have effects on hand/finger/ brushing, tiresome, and scratching of their bottom hand while improved maize sheller technology causes no injuries. Oxen bottom foot is also damaged during large amount of maize shelling.

Suitability in small-scale**:** All the respondent farmers perceived that this engine type maize sheller is not compatible with their farm condition. It was not suitable to use especially for small-scale farmers. Due to poor rural infrastructure, it is very difficult to transport the machine from one farmer to another.

The profitability of the practice the innovation would replace: Though the traditional practices do not have direct cost, they cause health problems such as finger injury and more dust. The new technology, engine type maize sheller, however involves small cost which is negligible. The perceptions of farmers were found in line with the economic verification trail result conducted by the research center. Hence, the partial budget analysis indicated that engine operated maize Sheller is economically more feasible than the traditional one i.e., for every 1 ETB invested in the improved engine operated maize Sheller, the return was 5.51 ETB (MAMRERC 2017).

Table 2. Profitability of engine operated maize Sheller

Parameters	Engine operated maize Sheller		Remark
	Cost per day		
Capacity per day	8*4000	32000 kg	Depending on the type of the maize
Investment cost	48000	48000	
Depreciation cost	10 year	13.15	4800
Maintenance cost		250	
Fuel cost	3.5*20*8	560	
Labor cost per day	200*4	800	
Lubricant cost	1*40	140	
Total cost required		1763.15	
Cost require to shell 100 kg of maize		5.51 ETB[1]	

[1], Ethiopian Birr (ETB)
Source: MAMRERC 2017.

The innovation's effect on -family lifestyle: The implement has no any negative effect in the family life style rather it supports and can be used by any member of the family including men, and women after they acquired the basic knowledge and skill.

The innovation's compatibility with a landholder's existing technologies, practices and resources: The engine operated maize Sheller has no compatibility problem with existing beliefs and values. Moreover the technology is produced by governmental institution which is devoted and more supportive to the government policies. However, this technology has economic of scale problem. Therefore, farmers or users need to form group to solve the problem of economic of scale. Even though engine operated maize sheller has a great relative advantage, it has some problems with compatibility to the existing socio-economic problem of the farmers.

The innovation's low complexity: The engine operated maize sheller is not simple enough for farmers to adjust and operate it easily. It needs special knowledge and skill. However, simple training could be enough to operate and manage it. The result indicated that in terms of simplicity of engine operated maize sheller, (62%) of the respondent perceived that the farm implement is suitable to operate and manage it.

Table 3. Attributes of innovations that affect adoption: Relative advantage of engine operated maize sheller

Attributes	Perception	% (Yes)	Remark
The expected use/profitability of the innovation	High	100	
Profitability of the practice the innovation would replace	Increase quality Save time	0 100	
Costs involved in adopting the innovation	High investment cost	100	Price =about 48000
	Have adjustment costs	100	
Effect on the riskiness of production/outcome	Low breakage	85	Compared with use of stick and oxen
Effect on other components of the farming system	Negative effect	0	
Effect on the family lifestyle	Negative effect	0	More supportive
Compatible with a farmers' existing technologies, practices and resources	Compatible	0	Large scale only
The innovation's compatibility with existing beliefs and values	Compatible		
The innovation's complexity	Low	0	Need skill

Source: Survey result 2017.

Conclusion and Recommendation

Improved agricultural implements or technologies are widely recognized as the key to address low productivity of labor, time saving and produce quality maize seeds. The survey results indicated that, almost all stakeholders were aware on its trail-ability and relative advantage over the existing practices. In general, the engine operated maize sheller technology, was economically feasible and favored by most farmers. Its acceptability was also very high by extension experts, administrators and large scale farmers. However, it needs huge investment cost and has economic scalability problem; hence this technology was not compatible to small scale farmers. However, for service providers, this technology is very profitable. Therefore, it is recommended that:

- there is a need to scale out the technology for potential and large scale farmers and cooperatives.

- Further effort is required by agricultural development actors to raise farmers' awareness about the existing technology to satisfy the entire large scale and small scale maize producers.
- Increase farmers' access to extension services has great need for large scale maize producers in Tigray region.
- More training must be given to small and medium enterprises who are involved in manufacturing of the technology to produce simple, quality and affordable engine operated maize sheller. However, the research center is responsible in controlling quality of the technology.

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2.3. Increasing chicken productivity through improved housing system: demonstration of poultry cage in Tigray

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Abstract

Mekelle Agricultural Mechanization and Rural Energy Research Center (MAMRERC) developed an improved the modern poultry cage which is simple, closed, manageable and relatively cheap technology which was verified during the participatory evaluation. The overall objective of the project was to improve productivity of poultry by introducing improved chicken houses. Hence this kind of cage is necessary to demonstrate and further evaluate so as to benefit small-scale farmers. Representative site and farmers were selected and training was given to 143 farmers and Development Agents. The demonstration of improved poultry cage was conducted on 12 hosts across 4 districts. Economic data and farmers' perception were collected. Descriptive statistics was used for analyzing quantitative data. Perception data collected across all the demonstration sites indicated that the improved poultry cage had higher advantage over the traditional as per the perception of farmers. The partial budget analysis comparing with traditional poultry cages with the improved one also shows that one birr additional investment in the improved poultry cage will provide 3.53, 6.04 and 9.12 birr gain in 15, 21 and 42 chicken holding cages, respectively. In addition the technology is economizes land; it is the house which can assist chickens indoor because it provides all necessary living facilities to chickens. Most of the farmers interviewed perceived that improved poultry cage was suitable and have great relative advantage. It was, thus, recommended that further popularizing and scaling-out of the improved poultry cage is quite pertinent.

Key words: Demonstration, chicken, Poultry Cage

Introduction

Poultry is important source of animal protein. The contribution of poultry production towards alleviation of the problem of malnutrition has remained negligible. Backyard poultry is an integral component of nearly all-rural and many urban households providing valuable protein through a low input system. In most developing countries women and children are generally in charge of the poultry husbandry. The fast turnover, small investment cost and size of the animals make poultry keeping one of the most suitable options in villages of Ethiopia (FAO 2010).

Keeping poultry makes a substantial contribution to household food security throughout the developing world. It helps diversify incomes and provides quality food, energy, fertilizer and a renewable asset. Despite of those economic advantages, there is no standard poultry house in our region. Chickens are living with human all over the night otherwise they might be attacked by predators (FAO 2010).

Lack of housing is one of the constraints of the smallholder poultry production systems (Tsegay et al 2017). In some African countries, a large proportion of village poultry mortality is accounted to nocturnal predators because of lack of proper housing (Alem 2014). Some research works also indicated that the mortality of scavenging birds reduced by improved housing. For instance, in the Gambia livestock improvement program, which included improved poultry housing, it resulted in lower chick mortality (19%) relative to that observed in Ethiopia (66%) and Tanzania (33%), where no housing improvements were made (Kitalyi 1998).

Mekelle Agricultural Mechanization and Rural Energy Research Center (MAMRERC 2017) developed an improved the modern poultry cage which is simple, close, manageable and relatively inexpensive technology which was verified during the participatory evaluation. According to MAMRERC (2017), it was found to be promising in solving the above mention problems which farmers face in poultry production. It was demanded especially by women farmers. Therefore, the objective of this study was to demonstrate modern poultry cage, which was proved to protect chickens against disease and predators, decreasing mortality rate and potential to enhance family income by selling surplus eggs and chickens.

Materials and Methods

Description of the study area

The demonstration activities were carried out in Tigray Regional State which is located in the Northern escarpment of Ethiopia between 360-400 E longitude and 12.50-150N latitude. The activity was done in AGP-II target areas in the four districtswhich were Enda-Moheni in Southern zone as well as Asigede-Tsinbila, Medebay-zana and Laelay-Adiyabo in North West zone of Tigray. The study was initiated to demonstrate the importance of improved poultry cage as compared to locally available cage or no cage.

Selection of participant farmers

Rapid assessment, community meeting and group discussion was done for the selection of the specific target groups. Model farmers involved in poultry production were included in demonstration of the modern poultry cage. Maximum effort was made to ensure the involvement of women farmers and thirty two female households participated in the demonstration.

Training was organized to orient farmers, development agents and district agricultural office experts about the technical and related matters of the demonstration to be executed. In line with the methodology described, a number of activities were conducted in the implementation process. The selected target farmers carefully observed and evaluated the improved poultry cage technology.

Type of data and method of data collection

The required secondary and primary information were collected by using major data collection techniques including desk review, survey and quantitative study methods.
The collected data includes mortality rate, labor requirement and farmers' perception on the characteristics which was suitable and relative advantage. At the same time before intervention, baseline information about the target area was collected.

Data analysis

To compare research data with the perception of farmers on the ground, descriptive statistics (frequency, percentage, mean, SD) for quantitative and narration for qualitative data was used for analysis.

Results and Discussion

Village backyard poultry production system

Village or backyard poultry production system is one of the three systems of poultry production in Tigray**.** Village poultry is kept with minimal input of resources and is considered by most smallholders as supplementary to the main livelihood activities. The birds scavenge to feed and are rarely provided except for kitchen leftovers, although supplementation with cheap grains or leftovers from the keepers' own grain production does occur. Sheds, if provided, are made of local materials. Poultry keepers lose many birds as a result of diseases and predators, but little attention is paid to the health and protection of birds. The birds are mainly indigenous sometimes mixed with foreign breeds. The productivity of village poultry is low as a result of the above characteristics, but the little output obtained from keeping poultry contributes to household income and provides access to high-quality protein, which is generally in short supply.

Poultry population and the average number of chickens per household (flock size) are estimated at 7.2 in Tigray regional state, the values of which are above that of the national average of 4.1 (Solomon 2013). Most of the birds kept under the backyard system belong to indigenous poultry. The backyard poultry production systems are not business oriented rather destined for satisfying the various needs of farm households.

The poultry are kept in close proximity to the humans. Mostly indigenous chickens are kept although some hybrid and exotic breeds may be kept under this system (Nzietcheung 2008). The few exotic breeds kept under this system are those provided by the government extension programs. The size and composition of flocks kept by households vary from year to year owing to various reasons such as mortality from diseases, agricultural activities and household income needs. Mortality in local birds results mainly from disease and predators as well.

Although many other factors such as accidents and theft result to in poultry loss but high chicken mortality has always occurred at time of disease outbreak and predators. A study in central

Tigray showed that hatchability was high but eventually they left with two or three birds reach maturity (Alem 2014).

Predators are the major causes of year round losses of chickens in Tigray. The most common predators mentioned by the farmers are wild cat, dogs, hawk, genet, snake and fox in their order of importance. Although all those predators were mentioned by the farmers as main causes of chicken loss, their order of importance varies with season (Alem 2014).

According to Alem (2014), the average survival rate of chicks was 61.95% in lowland and 69.4% in midlands. Average mortality of chickens was 10 per year and it was significantly higher. Relatively local chickens have better performance (Alem 2014).

Characteristics of modern poultry cage

Modern Poultry cage is the house which can assist chickens indoor. It provides all necessary living facilities to chickens. It is simple, close, and manageable and relatively cheaper technology which was verified during the participatory evaluation. The modern poultry cage was found to be highly promising and demanded specially by women farmers. Therefore, this kind of cage is necessary to manufacture and further demonstrate to benefit small-scale farmers.

Trial-ability is defined broadly as how easily a farmer can learn about an innovation's performance and management. Besides how easy it is to establish a physical trial, this depends on how easy it is to understand what the trial tells you about the innovation, which depends in part on how complex the issues involved are. The value of trials is that they reduce uncertainty about the innovation and develops skills in applying the innovation. That is, they contribute to both stages of the learning process the authors identify earlier: decision making; and skills development (Pannell et al 2006). Based on Pannell et al (2006), eight characteristics of innovations that affect an innovations' trial-ability were used to evaluate the technology and the technology is evaluated by researchers, experts and farmers accordingly. The following are characteristics of a highly trial-able innovation which were used to evaluate the modern poultry cage:

1. Highly divisible or trial-able: Modern poultry cage might be made in different size. Based on the interest and socioeconomic back ground of the household, the technology is available at any size. Thus the technology is easily trial-able in small-scale at any time and place.

2. Strongly observable results: Modern poultry cage has a short response lag time between using the innovation and seeing results. It takes no time to observe the result or merits just in few months' i.e., farmers can evaluate the technology.

3. Complexity: Modern poultry cage is very simple technology. No need of special training to understand how to operate or use. Moreover it is easy to handle and requires only small space. Thus this technology has low or no complexity to understand and to use it.

4. Cost: The initial investment cost of modern poultry cage technology is relatively high from the current statue of the households in Tigray especially woman. The initial cost may range from 110 -130,148-166 and 185-222 US dollar for the capacities of holding 15, 21 and 42 chickens, respectively. In terms of its medium and long term advantage this cost is relatively low with the consideration of highly expected mortality due to lack of proper housing. Thus, poultry producer may need to incur this cost to benefit more in the near future.

5. Low risk of failure of the trial: Modern poultry cage has no risk of failure. It can operate with simple maintenance for more than 15 years. If it is implemented well, it could be managed any time and place by any member of the household, men and women.

6. Innovation similar to normal practice: Chickens are living with human all over the night unless otherwise they are attacked by predators. Some farmers try to separate and build traditional houses; however, these traditional houses are not safe and not provide complete services for the given chickens. Modern Poultry cage which was developed by researchers is simple and manageable. It could be operated with all members of the household. Thus farmers do not need any additional skill or special training to operate it.

7. Strong linkage between the landholder's practices and the problem being addressed: Lack of housing is one of the constraints of the smallholder poultry production systems. A study in livestock improvement program showed that chick mortality in Ethiopia was 66 %, without any housing improvements (Kitalyi 1998). Thus modern poultry cage was developed to address such problems. Therefore, this technology is effective to solve such poultry production problem. Besides this technology has no any spillover effect while solving the problem.

8. Gender aspect of the technology: Despite all the regional differences in smallholder poultry production, one observation seems to remain the same, whether talking of smallholder households in Africa, Asia or Latin America, namely the day-to-day management of poultry is undertaken by women, often with assistance from their children, whereas, men may assist in the construction of housing (night shelters for the animals). Women and children are, as a general rule, the ones who feed and water the birds, clean the housing and apply treatments (Mathias 2006: Tadelle et al 2003: FAO 2010).

Table 1: Evaluation of the characteristics of modern poultry cage

Characteristics	Response	Remark
1. Highly divisible/easily manageable	yes	Different capacity
2. Strongly observable results	yes	
3. A short response lag time	yes	In months
4. Low complexity	yes	To use
5. Low cost	no	Relatively
6. Low risk of failure of the trial	yes	
7. Well implemented trial	yes	
8. Innovation similar to normal practice	yes	
9. Strong linkage between the landholder's practices (and thus innovation) and the problem being addressed	yes	
10. Gender sensitive	yes	

Poultry are kept at the homestead. Poultry keeping is, thus, an activity that the women can undertake without having to leave the household, where they will usually be occupied by domestic duties such as cooking, cleaning and caring for children. As such, they do not have to allocate a lot of extra time to manage the poultry (the daily cleaning of the poultry house, feeding, etc.), thus, this improved poultry cage is directly intended to help women and their children as they are directly involved in poultry production and it makes work easier for women and children.

Perception of farmers on attributes of the modern poultry cage

An innovation's perceived relative advantage is the decisive factor determining the ultimate level of adoption of most innovations in the long run' (Pannell et al 2006).The implement had to perform satisfactorily the job it was intended for. The advantage that it gives the farmers has to be in line with the identified problems. In addition to the economic advantage, the modern poultry cage has the following relative advantages as perceived by participants: Easy to handle or manage specially for women and children, more safe for chicken, easily manageable for hygiene, less space requirement, relatively inexpensive, more adaptable to the needs of small farmers, makes for greater food security and offers marketing advantages during time of scarcity. And this advantage makes the technology more popular.

Time and Labor saving: Even though many farmers do not seem to spent much time and labor in managing backyard poultry production**,** still indirectly they spent considerable time and labor in keeping their chickens from predators and the chicken themselves create many problems in the daily activities of the farm. Thus the modern poultry cage gives them a great advantage in avoiding the damage on the chicken and caused by chickens themselves.

Safety and comfort of modern poultry cage: 100 % of the participants said the cage is better in terms of safety and comfort comparing with no cage and the traditional poultry houses which causes great poultry loss. Although many other factors such as accidents and theft cause poultry loss, high chicken mortality occurred at time of disease outbreak and due to predators and this cage secures chickens from such threats.

Makes for greater food security and Offers marketing advantages during time of scarcity: Improving the productivity of village chicken through improved managements including proper housing will result in increasing opportunities of equitable distribution of food and income for the households of rural areas of Tigray. Farmers can sale their chicken at any time and at fair price because their chicken are often kept safe.

Suitability in small scale: All of the participant farmers perceive that this improved poultry cage is very suitable to use at any place in their back yard with different chicken holding capacity based on their interest. If someone has the ability to afford large size, he/she can use effectively where as those who has and need small size they could use the small ones. Thus, the improved poultry cage technology is adaptable to the needs of small farmers.

Hygiene aspect of modern poultry cage: Village or backyard poultry production system is characterized by a low input (scavenging is almost the only source of diet), low input of veterinary services, minimal level of bio-security, high off -take rates and high levels of mortality. Lack of housing is one of the constraints of the smallholder poultry production systems as a result every waste material is exposed and this cause hygiene problem for both the chickens as well their owners. Moreover the poultry are kept in close proximity to humans. To solve the existing problem which is associated with poultry production, introduction of this newly developed poultry cage is crucial one as it is closely managed and one of the main advantages the improved poultry cage to keep both the chickens and human healthy and this advantage was perceived well by all participants.

Perception of farmers on cost of modern poultry cage: With their current income and consciousness level, farmers perceive that the initial investment cost of modern poultry cage technology is relatively high particularly for woman. Even though the technology is effective in solving many of the problems associated with backyard poultry production and resulted better economic advantage in medium and long term, the initial cost which ranges from 3000-3500, 4000-4500 and 6000-7500 birr for the holding capacities of 15, 21 and 42, respectively, seems unaffordable as the perception of farmers indicates. Considerable number of farmers however showed great interest to own the technology.

Table 2. Perception in the attributes of Modern poultry cage: Relative Advantage

Parameters Relative Advantage	% (yes)	Remark
1. The expected profitability of the innovation	100	
3. Low cost or profitability of the practice the innovation would replace	90	high
4. Low adjustment costs involved in adopting the innovation	25	No cost
5. No effect on the riskiness of production/outcome	98	
6. No negative effect on other components of the farming system	100	
7. No negative effect on the family lifestyle	100	
8. Compatible with farmers' existing technologies, practices and resources	100	
9. The innovation’s compatibility with existing beliefs and values	100	
10. The innovation’s perceived environmental credibility	100	
11. The innovation’s low complexity	100	

Source:(MAMRERC 2017.

The innovation’s effect on the family lifestyle: Improved poultry cage is introduced to decrease mortality rate and increase the production and productivity of chicken. The technology has no any negative effect in the family life style rather it is supportive and can be used and managed by any member of the family including men and women.

Innovation’s compatibility with existing household technologies, practices and resources: The technology needed to resemble the traditional implement as much as possible. The modern poultry cage has minimum deviation from the existing practices. It needs no more additional skill to manage. Thus farmers do not face any difficulty, orientation and simple training being enough. All the participant farmers perceive that the modern poultry cage has no compatibility problem with existing beliefs and values. Moreover the technology is produced by governmental Institutes which is loyal and it is more supportive to the government policies.

Partial budget analysis of improved poultry cage

Improved poultry cage could be made with different chicken holding capacities. Partial budget analysis was therefore done for the 15, 21 and 42 poultry cages and the result shows that introduction of improved poultry cage has better return than the tradition practices.

Table 3. Partial budget analysis of poultry cage with holding capacity of 15 chickens

Cost	No cage	Traditional night cage	Modern cage Capacity(15/cage)	Price
Investment cost	0	240	3500	
Depression cost	0	80	350	Per year
Maintenance cost	0	0	25	
Transportation cost	0	20	50	
Total cost per year	0	100	425	
Survival rate (%)	50	60	98	
Benefit				
Number chicken in the given year	7.5	9.0	14.7	
Income from sell in birr	900	1080	1314	120 birr
Income from egg	1200	1440	2352	2 birr
Total income	2100	2520	3666	
Net benefit	2100	2420	3241	
MRR		4.2	3.53	3.68

- MRR21 =2520-2100/100-0=204/100=4.2
- MRR32=3666-2520/425-100=3.53
- MRR31=3666-2100/425-0 =3.68

Table 3. Partial budget analysis of poultry cage with the capacity of 21 chickens

Cost	No cage	Traditional night cage	Improve cage	Price
Investment cost	0	330	4500	
Depression cost	0	110	450	Per year
Maintenance cost	0	50	50	
Transportation cost	0	50	80	
Total cost per year	0	210	580	
Survival rate(%) estimated	50	60	98	
Number chicken in the given year	11.5	12.6	20.58	
Income from sell of chickens in birr	1380	1512	2469.6	120 birr
Income from egg	1840	2016	3292.8	
Total income	3220	3528	5762.4	
Net benefit	3220	3318	5182.4	
MRR		1.47	6.04	4.38

- MRR21 =3528-3220/210-0 =1.47
- MRR32=5762.6-3528/580-210 =6.04
- MRR31=5762.6-3220/580-0 =4.38

Table 4: Poultry cage with the capacity of 42 birds per cage

Cost	No cage	Traditional night cage	Modern cage	Price
Investment cost	0	660	7500	
Depresciation cost	0	220	750	Per year
Maintenance cost	0	150	100	
Transportation cost	0	150	160	
Total cost per year	0	520	1010	
Survival rate (%)	50	60	98	
Benefit				
Number chicken in the given year	21	25.2	41.16	
Income from sell in birr	2520	3024	4939.2	120 birr
Income from egg	3360	4032	6585.6	2
Total income	5880	7056	11524.8	
Net benefit				
MRR		2.26	9.12	5.59

Source: MAMRERC, 2017

- MRR21 =7056-5880/520-0=2.26
- MRR32=11524.8-7056/1010-520 =9.12
- MRR31=11524.8-5880/1010-0 =5.59

Marginal rate of return: the marginal net benefit (i.e., the change in net benefits) divided by the marginal cost (i.e., the change in costs), expressed as a percentage.

- This partial analysis shows that one birr addition investment in the improved poultry cage will provide 3.68, 4.38 and 5.59 birr gain from 15, 21 and 42 chicken capacity cages, respectively, as compared with no cage. Thus the use of this improved poultry cage with different chicken holding capacities is economically profitable.

- The partial budget analysis comparing with traditional poultry cages also shows that one birr additional investment in the improved poultry cage will provide 3.53, 6.04 and 9.12 birr gain in 15, 21 and 42 chicken holding capacity cages, respectively. Thus, the use of this improved poultry cage with different chicken holding capacities is economically profitable.

Conclusion and Recommendation

Results from the demonstration sites indicated that the improved poultry cage had higher advantage over the traditional. The partial budget analysis comparing with tradition poultry cages also showed that one birr addition investment in the improved poultry cage will bring 3.53, 6.04 and 9.12 birr gain in 15, 21 and 42 chicken holding capacity cages, respectively. In addition the technology is beneficial in terms of land economy as the chickens are kept in door (cage) which provides all necessary living facilities to chickens. Most of the farmers interviewed also perceived that the improved poultry cage was suitable and have great relative advantages. Therefore, it is recommended for further popularization and scaling-out widely to beneficiaries.

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3. Livestock Technologies

3.1. Demonstration of improved feed trough for efficient utilization of crop residue: The case of Southern zone of Tigray Region

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Abstract

The availability of feed resources is one of the most important factors that determine the productivity of livestock. Additionally, farmers are not efficiently utilizing the crop residues and wastage happens during feeding their livestock. Therefore, demonstration of improved feed trough at small-scale farmers to reduce wastage of crop residues or other biomass and thereby evaluating awareness of farmers towards improved feed trough at household level was conducted at four districts (Raya Alamata, Enda-Mohoni, Ofla and Raya Azebo) of southern Tigray. A total of 61 improved feed trough technologies were constructed, and data like amount of feed consumed and residue and farmers perception were collected from 29 randomly selected respondents. The collected data was analyzed using descriptive statistics. The result of the study pointed out that majority (72.4%) of the respondents have constructed single faced feed trough whereas the remaining 27.6% had double faced feed trough. Farmers reported that single faced feed trough is easy to construct than double faced type. Majority of (86.2%) of the respondents in the traditional feeding fed three times a day, while nearly 65.5% of the total respondents used a once a time offered for two days to restrict on the quantities of feed given to their animals per day in the improved feed trough. This indicates that, traditional feed trough needs more labor and time than the improved feed trough in terms of method of restriction quantities of feed offered per day for animals. The average values of Tef straw, wheat straw, sorghum stover, hay and concentrate offered (kg/day/head) in both types was not significantly different. However, the average values of Tef straw, wheat straw and sorghum stover (kg/day/head) of feed refusal at both feed troughs was significantly different ((p=0.02, 0.0001 and 0.001), respectively. The study concludes that the wastage of feed from improved feed trough was lower, it is economical to use as it to reduce wastage of feed compared with traditional feed trough. Therefore, it is economical to popularization the improved feed trough for efficient utilization of crop residue or other feeds at small-scale farmers by concerned governmental and non-governmental organizations in Southern Tigray region, Ethiopia.

Keywords: Crop residue, feed trough, perception, feed utilization, southern Tigray

Introduction

The availability of feed resources and the nutritional quality of the available feeds are the most important factors that determine the productivity of livestock. Livestock production throughout the world is dependent on a variety feed resources. Worldwide, there are more than 560 different types of feed resources derived from herbaceous forages, trees and shrubs, food crop residues, food crop green feeds, food crop roots and tubers, concentrates and agro-industrial by-products, mineral supplements, and others (ILRI 2006). In Ethiopia, such feed resources support different livestock production systems that are part of the mixed subsistence farming. Livestock production in Tigray, as in many parts of Ethiopia, is traditional and generally dependent on crop residues, natural grazing/browsing, hay from indigenous grass, and agro-industrial (Yayneshet 2010).

Solomon (2004) noted that crop-residues accounted for 74.15% of the total annual feed supply which was the major source of feed starting from harvesting of food crops to the wet periods during which time feed from grazing areas is inadequate. Crop residue is one of the abundantly produced feed resources which accounts to 63.8% of the total feed resources and its usage was highly hampered by alternative uses, failure to store properly to use during time of feed scarcity and not improving its quality by different techniques (Melaku et al 2003). Livestock, therefore, depend on the straw from cereal crops, especially during dry periods when there are limited feed supplies from grazing lands. Similarly, in most intensively cultivated areas, crop residues and aftermath grazing accounts for about 60 to70% of the basal diet, particularly, wheat straw is the dominant feed in wheat-based farming system (Seyoum et al 2001). Straws from tef, barley and wheat form the largest component of livestock diet in the medium and highland areas, while maize, sorghum and millet Stover's constitute larger proportion of livestock feed in lower to medium altitudes (Alemayehu 1985).

Ruminants are major asset for rural households throughout the country in general and Tigray region in particular. The regions have crop-livestock mixed farming system. Hillsides and sloppy areas dominate most of the area in the region. Farmland is often short and then the small-scale farmers are forced to cover this small farmland using crops to fulfill their food requirements. Inadequate feed supply, both in terms of quantity and quality, is the major constraint affecting livestock production in Ethiopia. Feed scarcity is indicated as a factor responsible for the lower reproductive and growth performance of animals especially during the dry season (Legesse 2008).

Crop residue is becoming the major feed source of animals in southern Tigray. Tef, wheat and barley straw are the most popular ruminant feeds in the majority of Tigray particularly during the dry season. The most important components of the crop residues are the leaves and stems that remain after the grain is harvested. The actual quantities of crop residues available for livestock feeding is reduced by the costs of collection, transport, storage and processing, seasonal availability, other alternative uses and wastage (Nigatu 2016). Additionally, farmers also practice poor management and not efficiently utilizing the crop residue. Recent study in Ethiopia showed that use of feed trough and storage shed saves 30-50% of feed biomass that would be wasted during storage and feeding at household level. It also showed that 10-20% of labor requirement for feeding is reduced due to use of feed trough (Melkamu et al 2017). Therefore, the present study was initiated to demonstrate improved feed trough technology developed with the aim of reducing wastage of feed biomass in small scale farmers and to evaluate farmers' perception on the efficiency of the feed trough to reduce wastage as compare to local management practices.

Materials and Methods

Description of the study area

The demonstration trial was conducted in four districts of the southern zone of Tigray, namely, Raya Alamata and Raya Azebo from the lowland and Enda-Mohoni and Ofla from the highlands (Figure 1). Southern zone of Tigray is located at 660 km North of Addis Ababa, the capital city of Ethiopia and 120 km South of Mekele, capital city of the Tigray regional state. It is located at $12^0$15' and 13^0 41' North latitude and 38^o59'and 39^o54' East longitude, constituting an area of about 9,446 km^2. Major crop such as sorghum, tef, maize, wheat, barley, bean, linseed, onion, paper, cabbage, fruits are grown in the study areas. The zone has a high potential for livestock production where farmers are engaged mainly in cattle, shoat and honey bee productions. Livestock and crop husbandry plays a considerable role in subsistence farming of Southern

Tigray. The major livestock types in the districts are cattle, sheep, goats and poultry. Though the dominant cattle breeds are the local Harmo breeds in the lowlands districts, farmers in these areas also use some newly introduced cross/exotic breeds such as Begait and Holstein-Friesian. Similarly, sheep breeds are mainly local Ille breeds in the lowland and common highland sheep in the highlands (AGP I 2016).

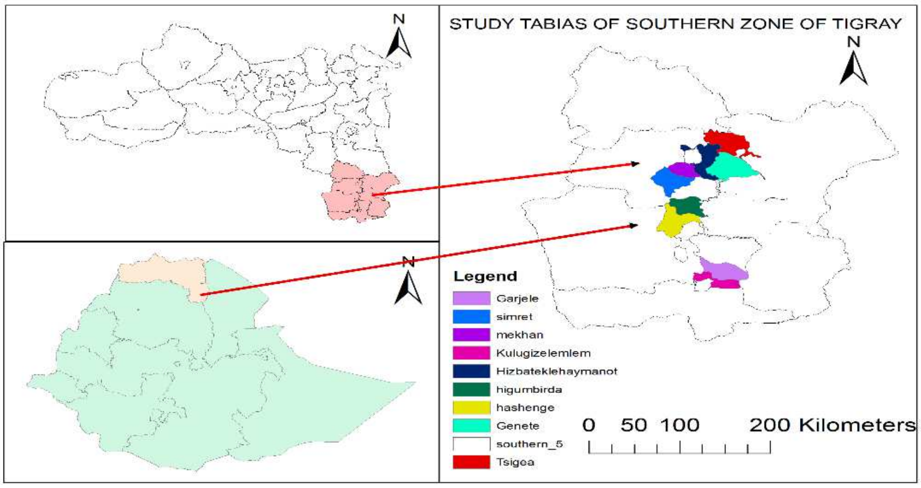

Figure 6. Map of study area (location of Kebeles).

Selection of target kebeles and farmers

Nine representative kebeles from both agro-ecologies was selected purposively. During demonstration 5 selected highland kebeles (two from Ofla and three from Enda-Mehoni), and 4 lowland kebeles (two from Raya Alamata and two from Raya Azebo) were purposively included from both agro-ecologies. A total of 61 interested farmers were selected purposively from nine kebeles. Finally, a total of 61 improved feed troughs were constructed at farmers and 7 feed trough at farmer training center in both agro-ecologies in 2018 (Table 1).

Preparation and introduction of improved feed trough

After identifying the farmers, practical and theoretical trainings were provided to the district experts, development agents and farmers. The training enabled them to develop skill on the general management practices of feed resources. Improved model feed trough was constructed in the farmers compound that keep mainly dairy cattle and which are ready and prepared to provide locally available materials such as *Eucalyptus* poles for the trough construction. The feed trough can be single or double faced and was constructed to serve for 3-6 animals at a time.

Table 7. Number of beneficiaries and respondents that participated in the demonstration

Agro ecology	District	Kebele	Farmers participated	FTC	Respondents sampled
Highland	Ofla	Hasehenge	5	1	2
		Hugumbirda	10	1	6
	Maichew	Mekan	10	1	6
		H/teklehymanot	5	1	2
		Smret	10	1	5
Lowland	Raya-Azebo	Genete	6	-	2
		Tsgae	5	-	-
	Raya-Alamata	Garjale	5	1	3
		kulgezie-lemelem	5	1	3
Total	4	9	61	7	29

It was constructed 40 cm high above ground, and 50-70 centimeter width, 160 cm length, 20-25 centimeter high from the floor of the trough and 80-90 cm high-from the floor of the trough to the roof. The trough has roofed shade to protect from rain and sun, and have straw storage within it (Figure 2).

Figure 7. Single faced improved feed trough at small-scale farmers.

Participant farmers had prepared their own local materials such as land and *Eucalyptus* poles, which are used as inputs for the construction of the feed trough. The Agricultural Growth Program (AGP) project provided the industrial materials like corrugated iron sheet (6 iron sheet/feed troughs), nails and covered the labor costs incurred for carpenters.

Measurements and method of data collection

Both qualitative and quantitative data were collected from randomly selected 29 participant farmers. The collected data were like farmer's perception, economic profitability and feed offered and refused to compare to the improved and local feed trough were collected.

Method of data analysis

The collected data was analyzed using SPSS version 20 and presented using tables, charts and percentages. Independent t test using R software was used to make statistical comparison between the improved and local feeding system.

Partial budget analysis

Partial budget analysis, dominance analysis and marginal rate of return were calculated to determine the profitability of improved feed trough according to the procedure of Upton (1979). The economic analysis included the variable costs and benefits. The gross field benefit per day was calculated by dividing the final sale of the fed refusal. Net Return (NR) or net benefit was calculated as the amount of money left when total variable costs (TVC) are subtracted from total returns or gross field benefit (TR):

$NR = TR - TVC$

The change in net income (ΔNR) was computed as the difference between the change in total return (ΔTR) and the change in total variable costs from the control (ΔTVC):

$\Delta NR = \Delta TR - \Delta TVC$

The marginal rate of return (MRR), which measures the increase in net income (ΔNI) in relation with each additional unit of expenditure (ΔTVC) expressed as a percentage: $MRR = \Delta NR / \Delta TVC$.

Results and Discussion

Demographic characteristics of participant farmers and livestock holding composition

The proportions of male and female headed households were 72.4% and 27.6%, respectively. Majority (93%) of the respondents had attended primary level of education while the remaining 7% were found to be illiterate (did not attend school). Moreover, more than half (89.7%) of the respondents were found to be married while the remaining 10.3% were widowed. All of the respondents (100%) practiced mixed farming system as a means of the farmers' livelihoods. The diversification of agricultural practice supports the farmers to mitigate the risk of single occupation. Number of animals owned by the respondents was presented in Figure 3. The dominantly practiced livestock production indicated in the bar graphs were poultry followed by sheep and oxen.

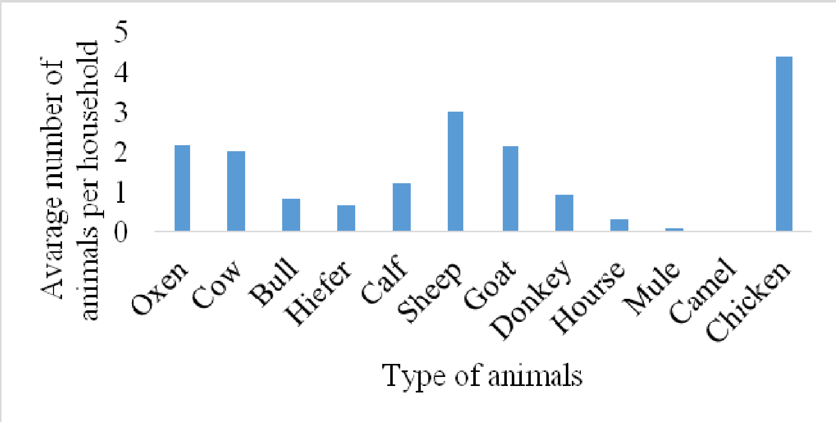

Figure 8. Average number of animals owned per household

Availability of feed resources and method of feeding before participating in demonstration

Feed resources available for livestock in all agro ecologies identified were crop residue, grazing land, crop after math, grass hay, weed, improved forage and concentrate feed. Farmers used crop residue (100%), grass hay (86.2%) and crop aftermath (100%) in the study area (Table 2). The major feed resources to livestock in Ethiopia as in other tropical and sub-tropical regions include natural pasture, crop residue, agro-industrial by-products, stubble grazing and browse species which are used at the site of production or conserved for use during seasons of shortage (Abdirahin et al, 2015).

Table 2. Available feed resources in the target households.

Type of feed resource	HHC[b] (N[a]=29)	Percent
Grass hay	25	86.2
Grazing land	29	100
Improved forage	3	10.3
Crop aftermath	29	100
Concentrate feed	2	6.8
Crop residue	29	100
Weed	22	75.8

[a]N= number of respondents, [b]HHC= house hold count

In the mixed farming systems of the Ethiopian, crop residues provide on average about 50% of the total feed source for ruminant livestock (Ahmed et al 2010). The contributions of crop residues reach-up to 80% during the dry seasons of the year (Adugna 2007). Crop residue is the major livestock feed in Tigray (Getnet and Ledin 2000; Gizaw et al 2017). The critical feed shortage was recorded in the period of February up to May in the study area. In this season, the contribution of crop residue was high compared to the other feed resources followed by crop aftermath and grass hay in the study area. Conserving crop residues and sending animals to the areas with better feed availability are the main coping mechanisms used against critical feed shortage.

The majority (76%) of the farmers used traditional feed trough (made up of stone or wood) and 20.7% used traditional feed trough (made up of cement or plastic) to fed their animals (fFgure 4). As shown in figure 5, feeding animals in traditional ground trough easily exposed the crop residue to rainfall, poultry/birds scavenge, the animals can also urinate or put their dung on it, soil and dung was easily mixed with the straw and much straw was observed wasted.

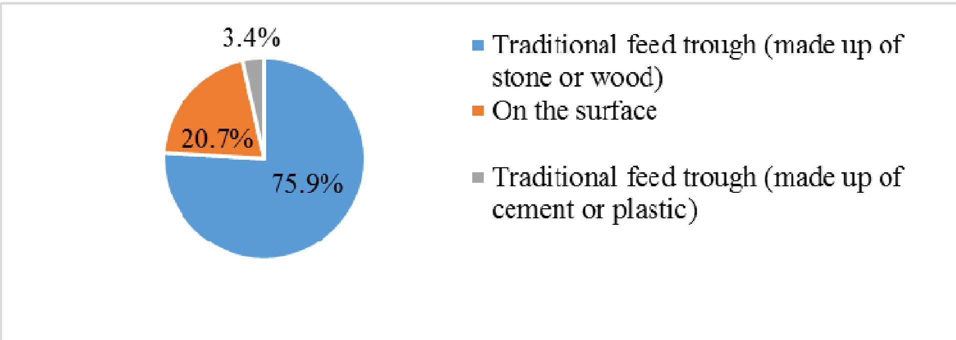

Figure 9. Method of feeding before feed trough demonstration

Figure 10. Traditional feed trough in the study area (left= Simret and right =Mekan Kebele)

The majority (72.4%) of the participant farmers constructed single faced feed trough whereas the remaining 27.6% of participants used double faced feed trough. The main reasons pointed out by participant farmers for selecting single faced type of feed trough than double type of feed trough in study area were based on suitability and easiness to construct. The majority of the respondents (75.9%) and (24.1%) indicated that tethering only, and continuous grazing and tethering, respectively, were the common feeding systems in the study area. The average number of animals fed by improved feed trough in the study area was different from respondent to respondent. As indicated in (Figure 6), 69% of the respondent notified that the average number of animals feeding by improved feed trough is 3-4. About 44.84% and 34.48 % of the respondents indicated that milking cow (cross) and milking cow (local), respectively are type of animals fed by the improved feed trough in the study area. 20.68% of the respondents used the feed trough for fattening oxen.

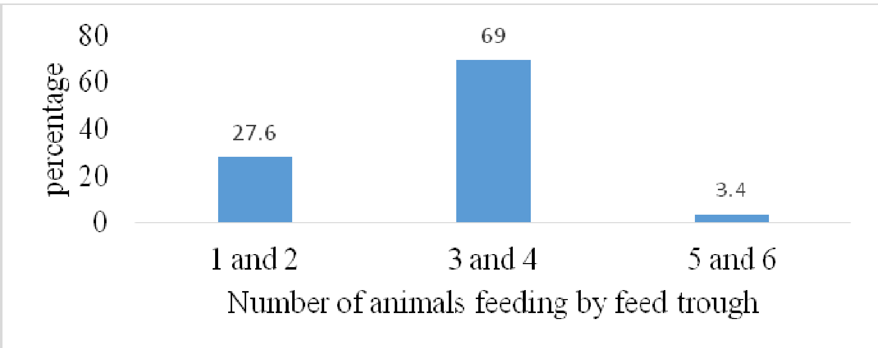

Figure 11. Average number of animal's fed by improved feed trough.

More than half of the respondents (55.2%) have modified their feed trough, however, 13 (44.8%) of the farmers did not modify their feed trough. In addition, 24(82.8%) of the respondent reported that, they need to modify their feed trough for the future. According to the respondents, sealing the ground by cement or soil, sealing by cement or soil both the two sides and ground, increased size and construct as house form were the main methods of feed trough modification. Based on animals consumption, offered once for two days, offered once for four days, offered once for one day, offered once for one week and not control are the methods that used to restrict quantities of feed offered per day for animals in the study area. More than half the respondent (86.2) in the traditional feed trough, the method of restriction quantities of feed offered per day for animals was based on animal consumption (three times a day). However, 65.5% of the respondents offered once for two days (Figure 7). This indicates that, traditional feed trough needs more labor and time than improved feed trough in terms of method of restriction quantities of feed offered per day for animals. This implies that using of improved feed trough can save time spent to feeding animals than the traditional method.

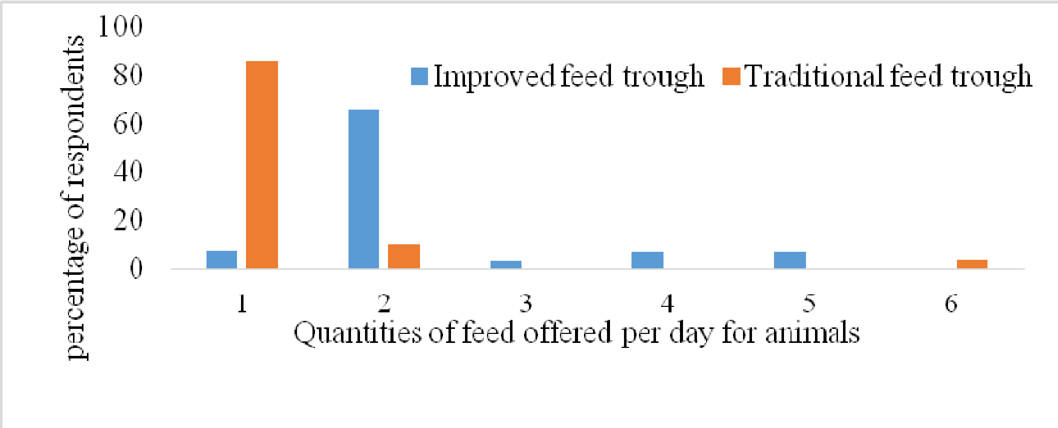

Figure 12. Method of restriction quantities of feed offered per day for animals (1=Based on animals consumed (three times a day), 2= given once for two days, 3=given once for four days, 4=given once for one day, 5=given once for weeks, 6=Not control)

Comparison of amount of feed refusal at both feed troughs

The feed refusal comparison for the two feed troughs across different feed sources was summarised in Table 4.The average quantity of Tef straw offered both in the improved and traditional feed troughs in the study areas was 12.76 and 13.83 kg/day/3-4 animals, respectively. This value indicated that, the mean value of Tef straw offered for animals per day was not significantly different ($p<0.05$). However, the average values of Tef straw refusal was 0.97 and 4.42 kg/day/3-4 animals for improved feed trough and traditional feed trough, respectively. This value indicated that, the mean value of Tef straw refusal for animals per day was significantly different and it was higher at traditional feed trough ($p<0.05$). The mean of sorghum stover refusal from animals was 1.68 and 8.10 kg/day/3-4 animals for improved feed trough and traditional feed trough, respectively and has highly significantly difference between the feed troughs (Table 3). The result of the study pointed out that all types of feed haveshown higher refusal in traditional feed trough than improved feed trough which implied that using of improved feed trough can avoid feed wastage significantly.

Table 3. Mean of fed offered and refusal in both feed troughs (kg/day/3-4 animals)

Type of feed	Amount of FO		p-value	Amount of FR		p-value
	IFT	TFT		IFT	TFT	
Tef straw	12.76	13.83	0.81	0.97	4.42	0.02
Wheat straw	25.72	30.17	0.48	2.76	11.56	0.0001
Sorghum Stover	16.25	17.58	0.78	1.68	8.10	0.001
Hay	12.07	11.63	0.90	0.38	2.32	0.002
Concentrate	2.56	2.48	0.94	0	0.05	0.17

FO = amount of feed offered, FR = amount of feed refusal, IFT= improved feed trough, TFT= traditional feed trough, Df =degree of freedom

Feed intake

There was highly significant difference (p<0.05) among feed troughs on daily feed intake of Tef straw, wheat straw and sorghum Stover.

Table 4. Mean of fed intake (kg/day/3-4 animals), percentage of fed intake and wastage of ffed in percentage in both feed troughs

Type of feed resource	Amount of FI		p-value	Amount of FI%		p-value	Amount of W%		p-value
	IFT	TFT		IFT	TFT		IFT	TFT	
Tef straw (N=16)	22.8	18.2	0.03	94	69	<0.001	6	31	<0.001
Wheat straw (N=21)	31.7	26.5	0.01	89	64	<0.001	11	36	<0.001
Sorghum Stover (N=16)	26.4	17.2	<0.001	88.2	56.6	<0.001	11.8	43.4	<0.001
Hay (N=16)	21.3	16.9	0.04	97.3	78.5	<0.001	2.7	21.5	<0.001
Concentrate (N=9)	8.3	7.1	0.5	100	98.1	0.2	0	1.9	0.2
Mean	12.7	9.8	0.009	93.3	71.1	0.007	6.7	28.9	0.01

N = number of sample (respondents), FI = fed intake, FI% = fed intake in percentage, W% = amount of fed wastage in percentage, IFT= improved feed trough, TFT = traditional feed trough

In line with this animals fed by improved feed trough had higher total dry matter intake (12.7 kg/day/3-4 animals) compared to animals fed by local feed trough (Table 4). In addition, there was highly significant difference ($p<0.05$) among feed troughs on wastage of feed in percentage of Tef straw, wheat straw and sorghum Stover. The low wastage of feed was recorded on improved feed trough as compare the traditional one (Table 4). The advantage of improved feed trough over traditional feed trough in terms of wastage of feed in percentage was 26.58%.

Perception of participant farmers towards the feed troughs

All of the respondents (100%) observed feed refusal is high in traditional. However, the farmers perceived negatively the cost efficiency of improved feed trough as 62% of the respondent had poor level of perception on cost of improved feed trough compared with traditional feed trough (Figure 8).

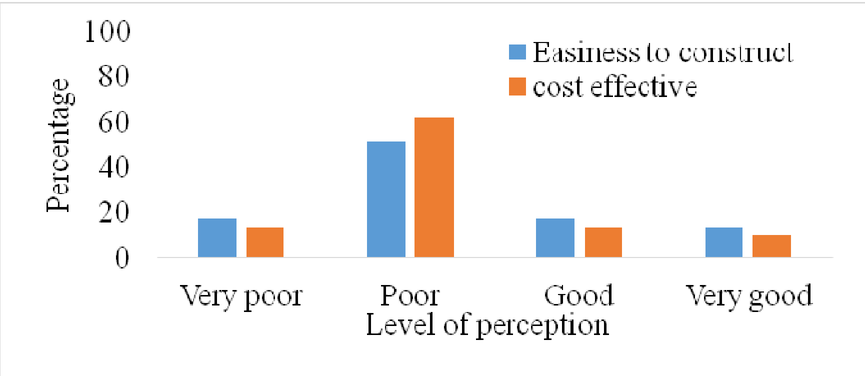

Figure 13.Ffarmers perception of the improved vs traditional feed trough.

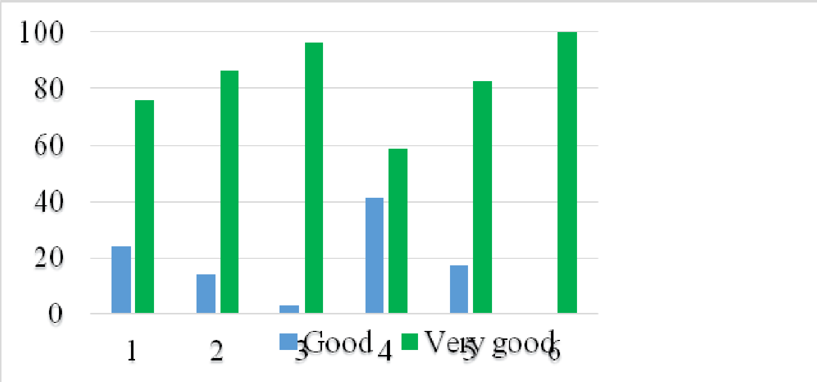

Figure 14. Advantage of improved feed trough over traditional feed trough (1=shed for animals, 2=shed for fed, 3=minimized fed wastage, 4=animal feed competition, 5= comfortable for animals and 6=straw storage within it)

Level of satisfaction and perception of adopting on their own cost

The levels of satisfaction being participated in feed-trough demonstration were as shown in figure 10. More than half (69%) of the respondents were highly satisfied in their participation. Around 96.6% of the respondents reported that they will adopt the improved feed trough technologies on their own cost. Moreover, the rest (3.4%) of the respondent did not agree to adopt the technologies in their own cost in the future.

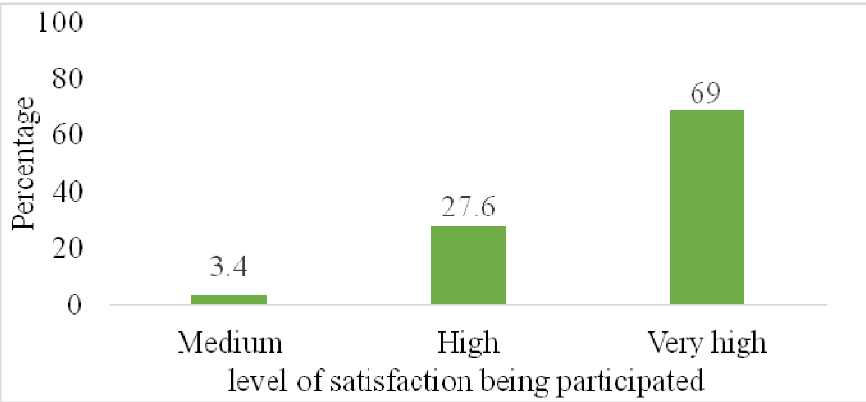

Figure 10. participant level of satisfaction with the technology.

Cost benefit analysis (Partial budget analysis)

It is assumed that one Tropical Livestock Unit (TLU) will have 250 kg live body weight and the daily DM requirement for maintenance is about 6.25kg and annual feed requirement is also 2281.25 kg (Jahnke and Jahnke 1982). The average number of animals fed by improved feed trough is 3-4. From the TLU feed balance concept, the annual fed requirement to 3-4 animals also 6843.75-9125kg. In the study area the average price of one kg of crop residue in 2016/2017 was 5.60 ETB. The total feed requirement when converted in ETB is 51100 (9125*5.60). The amount of feed refusal or wastage in percentage at improved feed trough and traditional fed trough was 6.7 and 28.9, respectively. From the annual feed requirements (9125kg), the amount of wastage was 611.38 and 2637.13 kg at improved fed trough and traditional fed trough, respectively. Feed refused was also converted to price (cost). The variable cost was calculated based on cost needed for the different activities and inputs used for the construction. However, the cost of *Eucalyptus* pole was not calculated. According to the analysis, wastage of feed from improved feed trough is low; it is economical to use it for wastage of feed as compared with traditional feed trough. This means that for every one birr additional cost of wastage of feed there is 8.82 ETB return for improved feed trough (Table 5).

Table 5. Partial budget analysis (price unit= ETB)

Inputs used	Type of technologies					
	Improved approach			Traditional		
	Quantity	Unit price	Total price	Quantity	Unit price	Total price
Corrugated iron sheet	6	200	1200	0	0	0
Nails (kg)	0.5	100	50	0	0	0
Labour	1	200	200	0	0	0
TVC			1450			0
Fed wastage (kg)	611.38	5.60	3423.72	2637.13	5.60	14,767.92
TR			3423.72			14,767.92
NR			1973.72			14,767.92
ΔTR			-12,794.2			-
ΔTVC			1450			-
MRR ratio			-8.82			-
MR (%)			-882.35			-

TVC = total variable cost; TR = Total return; NR = net return; ΔTR = change in total return; ΔTVC = change in total variable cost; MRR = marginal rate of return

Conclusion and recommendations

Previously farmers fed their animal in traditional feed trough mostly on ground based that is constructed by stone or wooden materials. This method of feeding leads to easily expose the crop residue to rainfall, the animals can also urinate or put their dung on it, soil and dung was easily mixed with the straw and much straw was wasted. Consequently, farmers and their children were also busy to protect wastage of feed during feeding of their animals. Therefore, this study is conducted to demonstrate improved feed trough in Southern Tigray, so as to reduce the feed wastage. During demonstration a total of 61 small- scale farmers and 7 farmers training Center participated. The study pointed out that the majority of participant farmers were interested to use single faced feed trough than the double faced. The study also showed that all types of feed were highly refused traditional feed trough. This implies that using of improved feed trough can significantly save the wastage of feed in the area. In addition, farmers perceived that the improved feed trough is comfortable, reduced competition; serve as feeding and temporary storage. Therefore, based on the finding of the study it is highly recommended that the concerned governmental and non-governmental organization should gave emphasis to promote the improved feed trough for efficient utilization of crop residue at small-scale farmers of Southern Tigray region, Ethiopia.

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