Tigray Agricultural Research Institute
Agricultural Growth Program-II

Pre-extension Demonstration of Agricultural Technologies

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May 2020
Mekelle, Tigray, Ethiopia

Tigray Agricultural Research Institute
Agricultural Growth Program-II

AGRICULTURAL GROWTH PROGRAM

Pre-extension Demonstration of Agricultural Technologies

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The research tasks are not also being done without the great demand of farmers to adopt new agricultural technologies and practices; there for our gratitude as institute and the AGP program would like to acknowledge the workaholic farmers that have been working with the program. Eventually, the collaborative TARI management staff and TARI/AGP-II coordination staff are among those who need to be appreciated and acknowledged for their unreserved technical and financial monitoring, evaluation and support.

Forward

Agricultural growth program have been implemented through identifying and prioritizing commodities for food security, climate smart and excess production for commercialization and source material for an industry which would be as a great role in supporting the transformation agenda of the country. For this reason, the government of Ethiopia designed an agricultural growth program one and two to support both the research and extension in five components. The research component deal on technology generation/adaptation, technology demonstration, technology multiplication and human and physical capacity building. Since the launching period in 2016 the institute have generated/adapted and demonstrated several technologies to the public extension. This 2019 publication consists of the completed research activity done by the AGP-II mandate centers that could be as a source of information and evidence to support our agriculture to improve production and productivity and it will also be as a resource for further scientific studies and developmental works.

The extension will also use as evidence and guide for further scale up and package implementation in supporting the farmers. As a research we recommend every stakeholder who would like to support the agriculture should start with assessing and having information on what have been done and written in the major commodities of the region so that the duplication of resource could be minimized and the technical efficiency of support could also be improved using the justification given by agricultural researchers.

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Preface

Agricultural growth program has been implemented since 2015; and have successfully released about 22 technologies through generation/adaptation research activities. Most of the technologies have also been demonstrated to the public extension through FREGs established. As the third component of the research to produce 3000 pre-basic seed, it is achieved and disseminated to beneficiaries in the region. In this completed proceeding, technologies generated/adapted and pre-demonstrated are compiled in the intention for the extension to adopt them and have evidence on the advantage of the research done so far in improving the production and productivity of the selected mandate commodities of AGP-II. This publication will also be useful as a baseline and reference for further studies and related projects. I would like to convey my message to the research institute, extension bodies and stakeholders who are working on improving the production and productivity of the commodities included in this document; to begin with assessing what is done and to take the recommendations given by the researchers to popularize the findings. No matter how AGP-II exists or not, the bureau of agriculture and the institute need to take the outputs into considerations for further planning and policy arrangements. I would also like to congratulate to every farmer of the AGP-II mandate districts, TARI researcher, expert and DAs for their unreserved contribution for the successful implementation and completion of these research outputs.

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Contents

1. Crop Technologies

1.1. On-Farm Demonstration of Glyphosate Application on Improved Orobanche Tolerant Faba Bean Variety for Orobanche Control: The Case of Ofla District, Southern Tigray

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Abstract

Broomrape (Orobanche crenata) infestation is the main constraint of fababean production in the highland areas of southern Tigray, and it can cause up to 100% yield loss. Though, using Orobanche tolerant Hashenge variety is an option to increase production of fababean in areas where Orobanche weed infestation is very high, the application of a very little amount of glyphosate on the Orobanche tolerant Hashenge variety was significantly decreased the Orobanche weed, and increase grain yield of the crop. Therefore, the on-farm demonstration of glyphosate application was conducted in Ofla district during 2019. Practical training on the method of glyphosate application was given to experts and participant farmers. Yield data was collected from four locations which have a plot size of 100 m^2 each. The collected data was analyzed using SPSS version 20 software and presented descriptively. In addition, partial budget analysis was carried out between the treatments. The result of the analysis shows, an average grain yield of 11.30 qt/ha and 7.30 qt/ha, was harvested from the glyphosate treated and untreated, respectively. The partial budget analysis result also shows that glyphosate treated Hashenge variety has better advantage than non-treated Hashenge variety. Hence, it should better if glyphosate application for the variety Hashenge is applied as a supportive package to increase the production of the variety and decreased the seed bank of the Orobanche weed in the hot spot areas of Ofla district.

Keywords: Broomrape, Farmers' perception, Glyphosate, Herbicide,

Introduction

Faba bean (*Vicia faba L.*) is originates in the Far East and is one of the earliest domesticated legume crops after chickpea and pea (Tafere et al 2012). Faba bean is one of the best crops among the grain legume (Singh et al 2013). Similarly, faba bean is one of the major pulse crops grown in the highlands (1800–3000 m.a.s.l.) of Ethiopia (Temesgen and Aemiro 2012; Tafere et al 2012). Ethiopia is the second largest producers of faba bean in the world, next to China (Biruk, 2009). However, the national productivity of faba bean in the country is still very low. The national average yield under smallholder farmers' is 2.05 t/ha and in Tigray region, the average productivity is about 1.64 t/ha, which is lower than the national average (CSA 2018).

Pulses in general can play a 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 beans are highly nutritious because of their high protein content. They are 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 is a high value crop that fetches high income to farmers. Besides, it is an important rotation crop which farmers are using to restore the fertility of their land/plots (Crépon et al 2010 and Negash et al 2015). In the southern zone of Tigray, particularly in highland districts faba bean is dominantly grown crop next to wheat and barley (SZDCO 2018). The crop is widely used for food in different forms like *sprouted bean* and *green pod* alone and stews *(whot)* with other mixtures (Kidane and Brhane, 2018).

In addition, farmers commonly used faba bean as crop rotation with cereal crops like wheat and barley for soil fertility improvement as well as disease and insect pest break. However, despite of its multiple importance recently the production of faba bean hs been very low due to different biological factors such as diseases. Broomrape (*Orobanche crenata*) is one of the most seriously limiting factors for faba bean production, particularly in northern Ethiopia, including the study area. Broomrape (*Orobanche Crenata*) is commonest in the Mediterranean countries, the Middle East and East Africa (Ethiopia), while other species have a wider distribution (Perez-de-Luque et al 2010). *O. 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; 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). Recently, 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 Amhara Region (Mekonnen et al 2017). This problem is also the same in the southern Tigray in general and Ofla district in particular.

In South Tigray, the history of Orobanche weed go back to 33 years, which has been seen in 1985 in Ofla district at one kebelle called Adigollo (Teklay et al 2013). The distribution of the weed is increasing at alarming speed from some localized areas to almost throughout the whole southern zone of the region (Teklay et al 2013). Nowadays, the distribution of the weed increases from one district to four and from one kebelle to thirteen keblles and, its incidence varies from <10% up to 100% as well as the yield loss was estimated to reach 0 to 99.2% depending the level of infestation (Tsehaye 2017). Contrary to normal weeds, most of the damage to the host is done before the parasitic weed emerges above the soil.

Thus, control methods should focus on reducing soil seed bank and interfere with the parasite's early developmental stages (Muller-Stover et al 2005). Hence, an integrated approach has to be advised to alleviate the problem that is challenging faba bean production and household food, income and nutrition security. Integrated control of broomrape weeds means to combine and to integrate different preventive measures and control instruments into the given farming system (Muller-Stover et al 2005). In southern Tigray, part of the solution improved Orobanche tolerant Hashenge variety was promoted to Orobanche infested areas of Ofla district and farmers harvested an average grain yield of 20 and 45 qt/ha at farmers field (Kidane and Brhane 2018). However, only use of Orobanche tolerant variety can't avoid the problem of faba bean production. Studies indicated that Glyphosate is one of the herbicides that are currently in use for broomrape control (Eizenberg et al 2006).

The effect of glyphosate on O. crenata naturally infested soils of faba bean in south Tigray was evaluated by Alamata Research center. The result of the study shows the variety Hashenge treated with glyphosate was shown a yield advantage of 9.30% and significantly decreases the number of orobanche per meter square over the untreated one (Unpublished data AARC 2017). Therefore, this study is initiated to demonstrate the glyphosate application in combination with the improved Hashenge variety as a package to farmers in the Orobache infested areas of Ofla district with the objectives to Demonstrate the efficacy of glyphosate in faba bean to control Orobanche; Evaluate the perceptions of farmers towards the efficacy of herbicide and Evaluate the yield advantage gained due to the practice over the local practice

Methodology

Description of the Study Area

The present research was carried out in Ofla district of southern Tigray, Ethiopia. Ofla district is located at 12°31’N latitude and 39°33’E longitude. The altitude varies between 1700-2800 m.a.s.l. The annual rainfall varies from 450mm to 800mm during keremt and 18mm to 250 mm during Belg season. Wheat, barley, field pea, faba bean and lentil the dominant crops grown in Ofla district. Wheat and barley are the major sources of daily foodstuffs (OoARD 2018). About 42% of the area is high land, 29% of the area of the district is categorized on the *weynadega* (mid land) agro ecology and 29% of it is on the kola (low land) agro ecology. The experiment was carried out in the Orobanche hot spot areas of Ofla district in Adigolle kebelle (Fig 1).

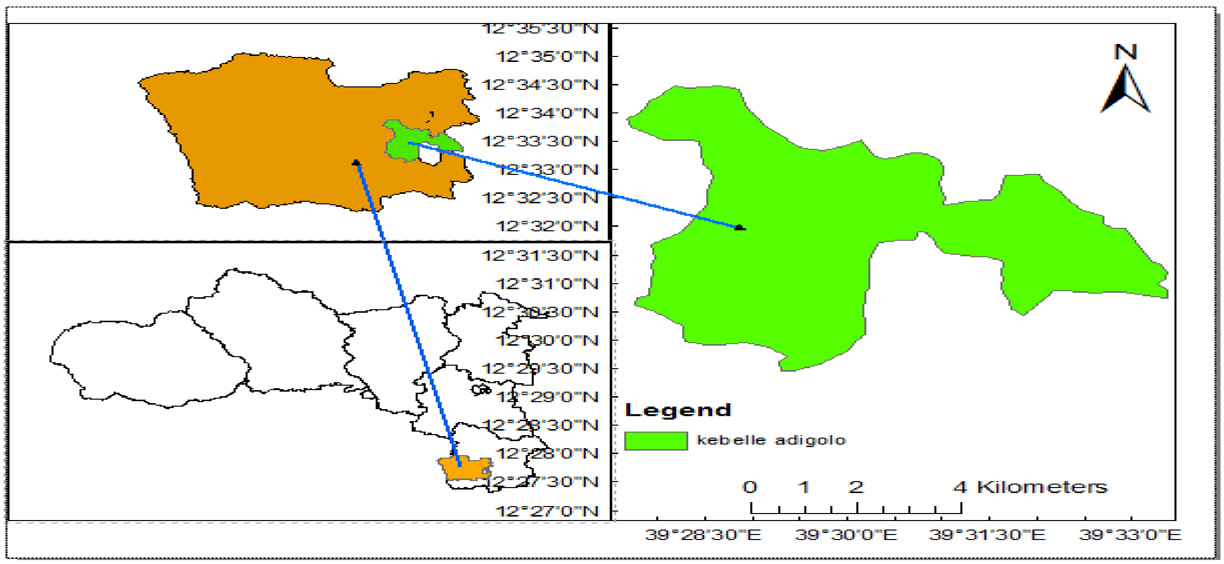

Fig 1. Map of the study area

Selection of kebelle, farmers and approaches used

The selection of the kebelle was done based on history of Orobanche infestation. Adigollo kebelle was one the host spot area for Orobanche weed. Then after selection of the kebelle the inerested participant farmers were selected in collaboration with development agents of the respective kebelle. During 2018/19 production season the activity was implemented in a total of 31 interested farmers which have cluster farm lands were participated on glyphosate application. For the purpose of the demonstration of the practice and to collect the biological data four location with a plot size of 10*10 m for each glyphosate treated Hashenge variety and untreated Hashenge variety plots was used. The space between rows and plants was 40 & 10 cm, respectively. In addition, the space between plots was 1m. Glyphosate 48% SL was applied at a rate of 80 gram and 2 ml active ingredient per hectare and 100 M^2 respectively, for treated plot 2 times after 2 and 4 weeks after sowing. Practical training on the application of glyphosate was given to 3 experts and 24 farmers after 10 days of planting. Finally field days was conducted to promote the practice for development partners and farmers

Picture 2. showing some of the performed activities during the demonstration

Method of data collection and analysis

The data on grain yield of both Glyphosate treated and untreated of Hasenge variety was collected using total harvest of 100 m^2 area of land, and threshed manually. Grain yield was weighed using sensitive balance and converted to hectare bases. In addition, data related to Orobanche count and costs incurred and obtained the benefit of the practice was collected. Finally the collected data were analyzed using SPSS v. 20 software and presented descriptively.

Results and Discussion

Grain yield performance of the glyphosate application on faba bean

The grain yield of the glyphosate treated was higher than the untreated plot which is due to the application of the herbicide in reducing Orobanche weed. An average grain yield of 11.47 qt/ha, was harvested from glyphosate treated Hashenge variety, whereas 7.30 qt/ha was harvested from an untreated Hashenge variety. This indicates that the treated plot had 55% yield advantage than the untreated plot (Table 1). The result of the analysis indicated that the highest 2.46 and 29.33 *O. crenata* number per plant and per meter square respectively, was observed in untreated Hashenge variety while the lowest 1.27 and 19.66 was recorded on treated Hashenge variety.

Table 1. Comparison of glyphosate treated vs untreated Hashenge variety

Parameters	**Glyphosate**				Yield advantage **(%)**
	Treated		Untreated		
	Mean	Sd	Mean	Sd	
Grain yield qt/ha	11.47	11.16	7.30	4.63	55%
Orobanche per plant count	1.27	1.13	2.46	0.61	-48.37%
Orobanche number (count)/m^2	19.66	11.37	29.33	14.57	-32.97%

This implies that the practice can decreased 48.37 and 32.97% respectively, the Orobanche weed per plant and Orobanche weed per meter square, respectively (Table 1). This result has very important implications for decreasing the seed bank of Orobanche in the study area. As one plant of Orobanche weed is caused to increase more than 0.5 million seed of the weed (Joel et al 2007).

Farmers' evaluation on the effectiveness of glyphosate application

Based on the criteria mentioned by farmers in Table 2, farmers were reported that the performance of Hashenge treated with glyphosate has better than the field which was not applied by glyphosate which was sown in their adjacent field land. Additionally, they explained the Orobanche weed population and disease occurrence was low in the treated plot than the untreated.

Table 2. Evaluation of farmers for the treatments

Farmers' observation	Ranking of the treatments		Final selection
	Treated	Untreated	
Low *orobanche* count	1st	2nd	Treated plot was first selected
Higher yield	1st	2nd	
Early maturing	1st	1st	
Low disease affected	1st	2nd	
Better field performance	1st	2nd	
Total score	10	7	

N.B. treated=Hashenge + glyphosate and untreated means only Hashenge variety
Score = calculated by number of criteria ranked first is multiplied by 2 and number of criterieas ranked second also multiplied by 1.

Moreover, they expected higher grain yield from the treated plot than the untreated due to the better field performance of the faba bean in the treated plots. The treated plot was recorded higher total score than the untreated plot (Table 2). Hence, it is quite evidence that farmers in the area clearly shows the effect of glyphosate application on faba bean to boost production and decreased the Orobanche seed bank.

Picture 3. During evaluation of the demonstration plots

Partial budget analysis of the glyphosate application

Table 3. partial budget analysis

variable cost	Controlled	Treated
Cost of land preparation (Birr/ha)	400	400
Cost of seed (birr/ha)	4000	4000
Cost of fertilizer (birr/ha)	1000	1000
Cost of Bio fertilizer (birr/ha)	120	120
Cost of planting (birr/ha)	840	840
Cost of Glyphosate	00	400
Cost of labor to apply glyphosate	00	400
Cost of weeding (birr/ha)	1200	1200
Cost of harvesting and threshing (birr/ha)	840	840
TVC	**8400**	**9600**
Yield obtained (Qt/ha)	7.30	11.47
Selling price (birr/kg)	24	24
Total benefit (Birr)	**17520**	**27528**
Net benefit (Birr)	9120	17928
MRR (RATIO)	7.34	

The partial budget analysis which was expressed in hectare is shown in Table 3. The variable cost in treated plot occurred due to the cost of the glyphosate and cost of application for the practice. The marginal rate of return (MRR) in Table 3, shows greater than the minimum acceptable rate of return (100%). For every one Birr 1 investment in glyphosate (herbicide) application for improved Hashenge variety production there would be 7.34 Birr return based on the demonstration plot. This indicates that using integrated technologies like improved seed supported by additional packages (like glyphosate application) can bring additional benefit to the farming community in the areas which is infested by Orobanche weed.

Conclusion and Recommendations

From the yield analysis results the treated plot recorded a yield advantage of 55% over the untreated plot. The practice also decreased about 32% Orobanche weed count/m2 compared to the untreated. Moreover, farmers explained that the Orobanche weed population is low in the treated plots and the performance of Hashenge treated by glyphosate has better than the field which was not applied by glyphosate which was sown in their adjacent land. Furthermore, farmers confirmed that the glyphosate treated plot was selected first according to the farmers predetermined criteria. In conclusion, applications of glyphosate can significantly benefit to the farming community in the areas which is infested by Orobanche weed, as well as it can also contributed to decrease the Orobanche weed bank in the soil. Therefore, this is very important to promote the practice as supporting package to control and decreased the seed bank of Orobanche weed in the Orobanche weed infested areas of the study area. The glyphosate application should be promoted as supportive package with the improved Hashenge variety to larger areas and growers of the orobanche infested areas of southern Tigray. Glyphosate utilization should be supported by practical training, technical backstopping and safety as the herbicide can cause complete loss of the faba bean.

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1.2. Demonstration of BH-546 Drought Tolerant Hybrid Maize Variety at North Western Zone of Tigray

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Abstract

The demonstration trail was conducted at Laelay Adyabo, Medebay Zana and Tselemti of maize growing districts. It was conducted by selecting a total of five Kebelles. A total of 46 farmers was involved in the intervention. After giving training to the participanting farmers, DAs and experts, BH-546 maize seed variety were offered to the participant farmers. Each farmer have been planted a plot size of 20m*20m for each of the two varieties (BH-546 and the locally available maize variety). The result obtained shows, BH-546 maize variety was gave better yield than the local available maize variety at Tselemti district (BH-546, 43.44 ql/ha and 37.1 ql/ha from the local available). But in case of Medebay Zana and Laelay Adyabo districts BH-546 maize variety was given lower yield as compared to the local available maize variety (35.3 ql/ha BH-546 and 42.33 ql/ha the locally available maize variety at Laelay Adyabo and 32.83 ql/ha BH-546 and 35.2 ql/ha the other variety at Medebay Zana). The response of the farmers indicates that, at Tselemti district, BH-546 maize variety is preferred by the respondents in the attributes such as its cube, wind damage tolerance and its grain yield. The farmers at Laelay Adyabo and Medebay Zana districts were responded that as BH-546 maize variety is poorly preferred in most attributes of the commodity as compared to the other maize varieties. Especially the variety is less preferred in its late maturity, low cubing ability and low grain yield. Accordingly the variety is not going to popularize to other farmers and districts.

Key Words: yield, perception, productivity

Introduction

Maize (Zea mays L.,) is the third most important cereal crop in the world after rice and wheat. Total world area of maize production in 2012 was 176 million ha, while that of wheat was 216 million ha and rice was 184 million ha (FAOSTAT 2012). But in terms of production and productivity, the report of FAOSTAT (2008) indicated that in 2008 maize was the world's leading cereal crop with annual total production of 695 million tons and with productivity of 4.8 ton ha^{-1}. Based on the report from the Food and Agricultural Organization of the United Nations (FAO 2008), maize breeders were and still are very successful in improving maize grain yield and its productivity so as to increase; globally maize productivity increased from 1.9 tons ha^{-1} in 1960 to 5 tons ha^{-1} in 2008. According to FAO statistics (2008), the usage distribution of maize grain in 2008 consumption was 21% for human food, 72% for animal feed and 7% for industry. From 1995 to 2020, global and sub-Saharan Africa maize consumption is projected to increase by 50% and 93%, respectively. Helping farm families grow more is the smartest way to fight hunger and poverty. Maize is preferred for its high productivity and adaptability; it can be expected to feed the world population for the indefinite future through the improvement of genetic and agronomic practices. The sub humid agro ecology of mid-altitude ranging from 1500 m to 2000 m above sea level is considered to be the major maize growing zone in Ethiopia (Legesse Wolde et al 2012). The major maize growing regions of the country including the present study site, Bako, receives a fairly reliable average annual rainfall ranging from (1000–1500mm). However, productivity of maize in the country has remained low, with the estimated national average yield of 2.90 ton ha^{-1} compared to the world average yield of 5.1 ton ha^{-1} (FAOSTAT 2012). With this, Report of Mosisa Worku et al.(2011) during reviewed of 3rd maize national workshop stated low maize productivity in Ethiopia is associated with several constraints that hinder its production and productivity like lack of high yielding and stable improved genotypes, drought, reduction in soil fertility, inappropriate agronomic practices, low adoption of improved agricultural technologies including varieties by farming communities, soil erosion, foliar diseases, weeds (especially *striga*), inadequate food storage and preservation that result in significant commodity price fluctuation, and barriers to market access. Those factors might largely by attribute the country to be one of the least developed and food unsecured countries in the world for many years. Participatory variety selection on improved maize variety was conducted at Tselemti district. BH-547, MH-140, BH-546 and local maize varieties were used in the PVS. From these varieties BH-546 maize variety were given good yield which is about 5562 kg per hectare. Therefore, the objective of this study is to demonstrate BH-546 improved maize variety in the study area where the participatory variety selection was carried out. Therefore the objective of the study was to demonstrate BH-546 improved maize variety as compared to the locally growing maize variety and to assess the acceptability of the demonstrated improved maize variety in the study area

Methodology

Description of the study areas

The study was conducted in 2018/19 at Medebay Zana, Tselemti and Laelay Adyabo districts.

Laelay Adyabo district is located at 14^o 08N to14^o 69N and 37^o 89'E to 38^o 46'E and annual rainfall is 605-1370mm. Whereas Medebay Zana district is found at 13.68-14.33 ^{O}c Northing and 38.30-38.58^{O}c Easting and annual rainfall ranged from 600-900mm. Tselemti district is located at latitude and longitude of 13^o 05'N and 38^o 08' E, respectively, with an altitude ranging from 800-2870 meter above sea level. The district has an annual rain fall of 758mm to1100mm with mean daily temperature that ranges between 16$^o{}_C$ to 38$^o{}_C$ (OoARD 2016).

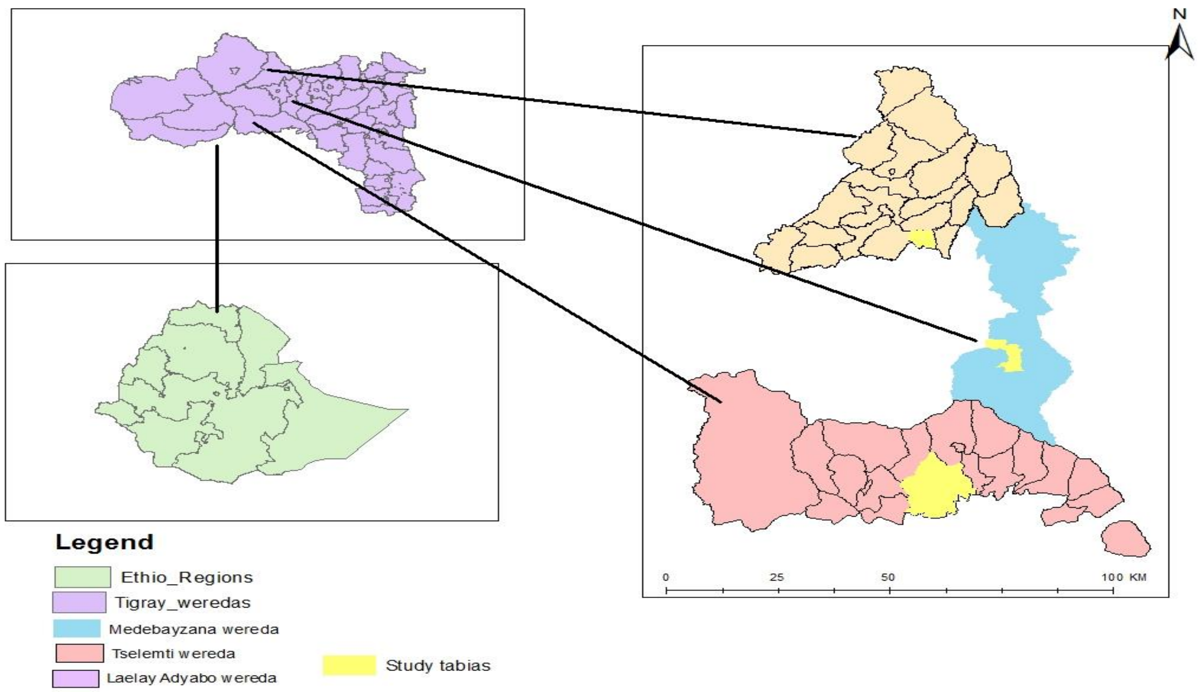

Figure 1. Map of the study area

Beneficiary selection

A total of 46 farmers were involved during the intervention based on their interest. Training was given to the farmers, development agent and experts. Improved seed of BH-546 maize variety was offered to each participant farmers and compared with the locally available maize variety.

Data collection and method of data analysis

Grain yield and farmers perception data were taken from the sample respondents. The collected data were analyzed using the descriptive statistics.

Results and discussion

Grain yield was taken from the plot area of 1m*1m from 11 randomly selected farmers and The results are depicted here in the table.

Table 1. Yield obtained from the demonstrated Maize variety (n=11)

SN	District	Variety	Min (ql/ha)	Max (ql/ha)	Mean (ql/ha)	Std. Dev.	P-value	Yield increment in (%)
1	Tselemti	BH-546	37.33	56.50	43.44	7.811	0.140	17.08
		Local	32.15	41.11	37.10	3.730		
2	L/Adyabo	BH-546	31.0	41.20	35.30	5.284	0.154	-16.6
		Local	38.0	47.00	42.33	4.509		
	M/Zana	BH-546	30.5	35.00	32.83	2.254	0.232	-6.73
		Local	33.24	36.91	35.20	1.847		

The demonstrated BH-546 maize variety was gave better yield at yield as compared with the local/ the standard check maize variety at Tselemti district (which is 17.08% yield increment). However, the variety (BH-546 maize) gave lower yield than the local variety both at Laelay Adyabo and Medebay Zana districts.

Figure 2. Demonstrated BH-546 Maize Varity at Tselemti district, 2018

Figure 3. Demonstrated BH-546 Maize Varity at Laelay Adyabo district, 2018

Figure 4. Demonstrated BH-546 Maize Varity at Medebay Zana district, 2018

Table 2. Farmers' response on attributes of Maize variety Gibe-3 Maize variety versus locally grown Maize varieties at Tselemti, L/Adyabo and M/Zana districts

SN	Attributes	Tselemti Farmers response(%)			L/Adyabo Farmers response(%)			M/Zana Farmers response(%)		
		Poor	No change	Good	Poor	No change	Good	Poor	No change	Good
1	Germination performance	0	100	0	0	100	0	25	75	0
2	Cubing ability	0	40	60	75	25	0	75	25	0
3	Yielding biomass, from animal feed perspective	20	60	20	0	75	25	0	100	0
4	Early maturity	60	40	0	75	25	0	50	50	0
5	Drought tolerance	20	80	0	25	75	0	0	100	0
6	Wind damage tolerance	0	0	100	0	75	25	0	100	0
7	Diseases and insect pests tolerance	0	100	0	0	100	0	0	100	0
8	Seed color preference	0	60	40	25	75	0	25	75	0
9	Seed size	0	100	0	25	75	0	25	75	0
10	Its test in Injera or other forms	20	80	0	0	100	0	0	100	0
11	Grain yield	0	20	80	75	25	0	75	25	0

The farmers at Tselemti were preferred BH-546 maize variety in the attributes of its cube, wind damage tolerance and its grain yield. But the variety is less preferred its late maturity. But at L/Adyabo and Tselemti districts the variety (BH-546) maize is less preferred in most attributes of the commodity as compared with the other locally available maize varieties. Particularly the variety is less preferred in attributes such as in late maturity, low cubing ability and low grain yield (table 2).

Conclusion and Recommendation

The demonstrated BH-546 maize variety result shows that the variety was gave better yield, only at Tselemti district as compared to the other locally grown maize varieties. But the improved variety (BH-546) was gave lower yield at Medebay Zana and Laelay Adyabo districts as compared with the other variety. Besides, farmers preferred BH-546 maize variety in some of the commodity attributes at Tselemti district. But the variety is less preferred by farmers at Laelay Adyabo and Medebay Zana districts. Though BH-546 Maize variety is gave better relatively yield as compared to the other local maize variety it is not recommended to popularize the variety.

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1.3. Demonstration of Gibe-3 Maize Variety at North Western zone of Tigray

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Abstract
The demonstration trail of Gibe-3 maize variety was conducted at Laelay Adyabo, Medebay Zana and Tselemti districts of maize growing districts. It was conducted by selecting three Kebelles from Tselemti, one Kebelle from Laelay Adyabo and one Kebelle from Medebay Zana district. A total of 57 farmers were involved in the intervention. After giving training to the participant farmers, DAs and experts, Gibe-3 maize seed variety were offered to participant farmers. Each farmer have been planted a plot size of 20m*20m for each of the two varieties (Gibe-3 and the local available maize variety). The result obtained shows, Gibe-3 maize variety was gave slightly better yield than the local available maize variety at Tselemti and Laelay Adyabo districts (Gibe-3, 43.87 ql/ha and 36.42 ql/ha the local available at Tselemti and 32.62 ql/ha Gibe-3 and 30.2 ql/ha the local at L/Adyabo district). But in case of Medebay Zana district Gibe-3 maize variety were given lower yield as compared to the local available maize variety (Gibe-3 maize variety gave 26.86 ql/ha and 37.05 ql/ha from the local available maize variety). The farmers perception result also shows that, the farmers preferred Gibe-3 maize variety in most of the commodity attributes at Tselemti and L/Adyabo districts. But the variety is less preferred as compared to the local grown maize variety at M/Zana district. It is recommended to be popularized Gibe-3 maize variety to large farmers of Tselemti and Laelay Adyabo districts by multiplying the required amount of seed.

Key Words: farmers' perception, yield, productivity

Introduction

Maize occupies an important position in the world economy and trade as a food, feed and industrial grain crop. Maize accounts for 15-56% of the total daily calories of people in developing countries, and is currently produced on nearly 100 million hectares in 125 developing countries and is among the three most widely grown crops in 75 of those countries (FAOSTAT 2010). Maize is one of the most important cereal crops in Ethiopia, ranking second in area coverage after tef and first in total production (CSA 2013).

Though Ethiopia has a great potential, the agriculture sector is not in a position to feed the ever increasing population of the country and most of the districts in the country are food insecure and people are depend on food aid. This situation calls for improving the productivity of the sector.

Accordingly, the government of Ethiopia is committed to achieve food security and reduce poverty in line with the UN Millennium Development Goals and has developed a strategy called "Plan for Accelerated and Sustained Development to End Poverty (PASDEP)". The strategy for food security in the country requires introduction of appropriate agricultural technologies. Among the target commodities that have received due emphasis in promotion of agricultural production, maize is one of the crops, which have given top priority for introduction and expansion by the government so as to ensure food security in the country. Considering this to improve productivity and production of maize different efforts were held in Tigray specifically in Northwestern zone of Tigray.

Shire-Maytsebri Agricultural Research Center had conducted adaptation trail on the improved maize varieties namely Gibe-2, Gibe-3, Gutto, Melkasa-2, BLSyn 2006 CIM COMP F3comparing with local variety for the last two years. Of these varieties Gibe-3 maize variety were given high yield which is up to 7076 k.g/ha as compared to the other varieties. Therefore it is important to demonstrate this high yielder maize variety in the area in the farmers' field. Accordingly, the objectives are to demonstrate Gibe-3 improved maize variety as compared to the locally growing maize variety and to assess the acceptability of the demonstrated improved maize variety in the study area.

Methodology

Description of the study areas

The study was conducted in 2018/19 at Medebay Zana, Tselemti and Laelay Adyabo districts.
Laelay Adyabo district is located at 14^o 08N to14^o 69N and 37^o 89'E to 38^o 46'E and annual rainfall is 605-1370mm. Whereas Medebay Zana district is found at 13.68-14.33 ^{O}c Northing and 38.30-38.58^{O}c Easting and annual rainfall ranged from 600-900mm. Tselemti district is located at latitude and longitude of 13^o 05'N and 38^o 08' E, respectively, with an altitude ranging from 800-2870 meter above sea level. The district has an annual rain fall of 758mm to1100mm with mean daily temperature that ranges between 16$^o{}_C$ to 38$^o{}_C$ (OoARD 2016).

Beneficiary selection

A total of 57 farmers were involved during the intervention based on their interest. Training was given to the farmers, development agent and experts. Improved seed of Gibe-3 maize variety was offered to each participant farmers and compared with the locally available maize variety.

Data collection and method of data analysis

Grain yield and farmers perception data were taken from the sample respondents. The collected data were analyzed using the descriptive statistics.

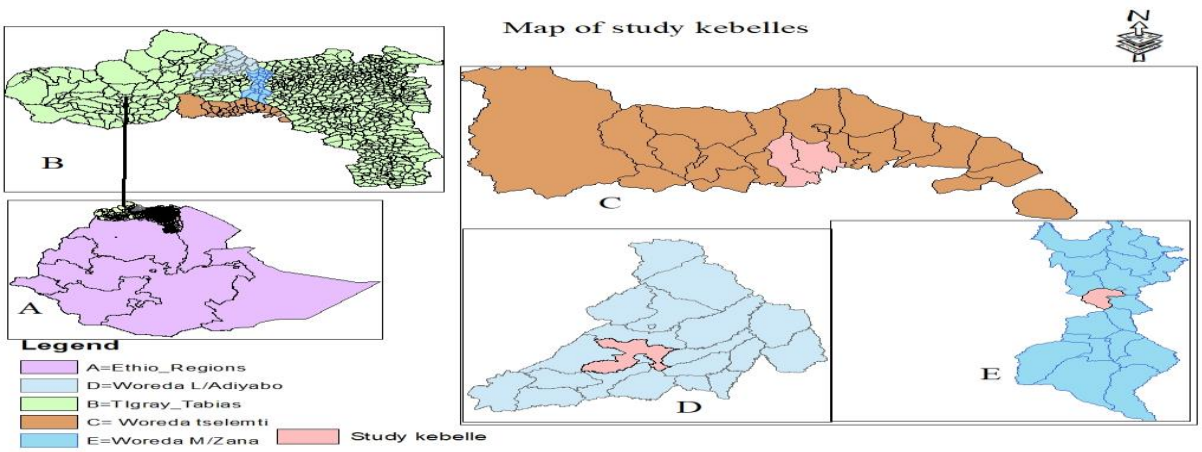

Figure 1. Map of the study area

Results and Discussion

Table 1. Yield obtained from Gibe-3 Maize variety (n=16)

SN	District	Variety	Min (ql/ha)	Max (ql/ha)	Mean (ql/ha)	Std.Dev.	P-value	Yield increment in (%)
1	Tselemti	Gibe-3	35.60	52.02	43.87	5.455	0.011	20.4
		Local	21.22	45.61	36.42	7.175		
2	L/Adyabo	Gibe-3	28.50	37.25	32.62	4.396	0.558	8.01
		Local	26.10	35.60	30.20	4.881		
	M/Zana	Gibe-3	22.05	31.33	26.86	4.649	0.074	-27.2
		Local	31.04	42.32	37.05	5.676		

Gibe-3 Maize variety has gave better yield than the locally grown maize variety at L/Adyabo district. It also scored a significant yield as compared to the locally planted maize variety at Tselemti district. On the other hand it gave significantly lower yield than the local one at M/Zana district.

Figure 2. Demonstrated Gibe-3 maize variety at Mr. Werash G/mariam, Serako Kebelle, Tselemti district, 2018

Figure 3: Demonstrated Gibe-3 maize variety at Mr Hagos field, Hakfen Kebelle, Medebayzana district, 2018

Table 2. Farmers' response on attributes of Maize variety Gibe-3 Maize variety versus locally grown Maize varieties at Tselemti, L/Adyabo and M/Zana districts

SN	Attributes	Tselemti Farmers' response (%)			L/Adyabo Farmers response(%)			M/Zana Farmers response(%)		
		Poor	No change	Good	Poor	No change	Good	Poor	No change	Good
1	Germination performance	0	100	0	0	100	0	40	6 0	0
2	Cubing ability	20	20	60	0	40	60	80	20	0
3	Yielding biomass,	0	80	20	0	80	20	0	80	20
4	Early maturity	0	90	10	20	80	0	0	100	0
5	Drought tolerance	0	100	0	20	80	0	0	100	0
6	Wind tolerance	0	60	40	0	40	60	20	80	0
7	Diseases and insect pests tolerance	0	100	0	0	100	0	0	100	0
8	Seed color preference	0	80	20	0	80	20	20	80	0
9	Seed size	30	70	0	20	60	40	40	60	0
10	Its test in Injera or other forms	20	60	20	0	80	20	20	80	0
11	Grain yield	20	20	60	0	40	60	60	20	20

As the result from farmers response at Tselemti and Laelay Adyabo, indicates farmers were preferred Gibe-3 Maize variety in the attributes of its cubing ability, less damaged by wind and its grain yield. Generally most of the farmers are interested with the variety and they are planned to plant in a larger area. But the variety is less preferred in its late maturity. While the variety (Gibe-3) was less preferred by most of the respondents in most of the commodity attributes at Medebay Zana district (table2).

Conclusion and Recommendation

The demonstrated trail result shows that, the variety was given better yield at Tselemti and Laelay Adyabo districts as compared to the locally grown maize variety. But Gibe-3 maize variety gave lower yield than the local grown maize variety at Medebay Zana district. The farmers perception result also shows that, the farmers preferred Gibe-3 maize variety in most of the commodity attributes at Tselemti and L/Adyabo districts. But the variety is less preferred as compared to the local grown maize variety at M/Zana district. Hence, it is recommended to be popularized Gibe-3 maize variety to large farmers of Tselemti and Laelay Adyabo districts.

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1.4. Demonstration of Setit-2 Sesame Verity at Tahtay Adyabo and Asgede Tsimbla Districts, North Western Zone of Tigray Region

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Abstract

The trail was conducted at Tahtay Adyabo and Asgede Tsimbla districts of sesame growing districts. It was conducted by selecting two Kebelles per district. A total of 57 farmers were involved in the intervention. After giving training to the participant farmers and experts, Setit-1 and Setit-2 seed were offered to participant farmers. Each farmer have been planted a plot size of 20m*20m for each of the two varieties. The descriptive result shows, Setit-2 has given slightly better yield at both districts. Setit-2 has given an average yield of 5.92 ql/ha and 6.6 ql/ha respectively at A/Tsimbla and T/Adyabo districts, whereas Setit-1 sesame variety has given an average yield of 5.18 ql/ha and 6.28 ql/ha respectively at same districts. Most of the farmers were perceived as the two varieties are similar in most of the mentioned commodity attributes. But farmers preferred Setit-2 sesame variety in its earliness to mature, capsule and yield. Therefore it is recommended, that Setit-2 sesame variety has to be popularized to large farmers of the areas.

Key Words: farmers' perception, yield, productivity

Introduction

Sesame (Sesamum indicum L.) belongs to the family of Pedaliaceae. Sesame was cultivated and domesticated on the Indian subcontinent during Harrapan and Anatolian eras (Bedigian and Van der Maesen 2003). It is one of the most versatile crops that can be grown in dry arid regions. Sesame is an important oil-seed crop. It was a major oilseed crop in the ancient world due to its easiness of extraction, great stability, and resistance to drought. It has unique attributes that can fit most cropping systems. Sesame is considered to have both nutritional and medicinal values. The seeds are used either decorticated or whole in sweets such as sesame bars and halva, in baked products, or milled to get high-grade edible oil or tahini, an oily paste (Bedigian 2004). Next to coffee, sesame is the second largest agricultural export earner for Ethiopia, involving a number of smallholder farmers in its production throughout the nation (CSA 2016). For instance, in 2015 sesame accounts 12.7% of the total exportable agricultural commodity of the country (United Nations 2018). In Ethiopia, sesame grows well in the semiarid areas of Amhara, Tigray, Benshangul Gumuz and Somali Regions. Lowlands of Oromiya and Southern Nations nationalities and Peoples Regions also grow a significant amount (Geremew et. al 2012). Tigray is one of among the highly sesame producing regions in the country. North western zone of Tigray has potential area for producing sesame and is one of among the sesame producing zones in the region. From 2.5 million hectare cultivated area of the zone, more than 14% was covered with sesame crop in 2017 cropping season (WOoARD 2017). To increase production and productivity of sesame in the study area, different researches was conducted on sesame crop. Continuation of this, demonstration of Setit-2 sesame variety had been conducted on the potential sesame producing districts of the zone. Accordingly the objectives are to demonstrate Setit-2 sesame variety, to farmers in comparison with Setit-1 and to collect acceptability of the demonstrated improved sesame variety.

Methodology

Description of the study area

The study was conducted in Tahtay Adyabo and Asgede Tsimbla districts of north western zone of Tigray. Tahtay Adyabo is located at the degree of 14.05-14.89 ^{o}c Northing and 37.34-38.17 ^{o}c Easting. The district has 38-40^{o}c of temperature and 450mm-550mm annual rainfall. 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 500mm-900mm annual rainfall.

Farmers and site selection

The research activity was conducted for one year at and Tahtay Adyabo and Asgede Tsimbla districts of north western Tigray. Lemlem and Adiaser Kebelles from Tahtay Adyabo and Selam and Dedebit Kebelles from Asgede Tsimbla district was purposively selected based on their potentiality on producing sesame. A total of 57 were participated in the intervention based on their interest for conducting the trail. Setit-2 sesame variety was demonstrated to evaluate in comparison with setit-1 sesame variety. It was demonstrated on the plot area of 20mx20m. Row sowing methods were applied with 10 cm between plant and 40 cm between rows. All the required management practices were applied by the participant farmers.

Data collection and analysis

Quantitatively data on grain yield was collected from the farmers' field. Qualitative data were collected from the farmers' perspective on the traits of sesame using likert scale questions. Descriptive statistics like mean, percentage and t-test were used to analyze the data.

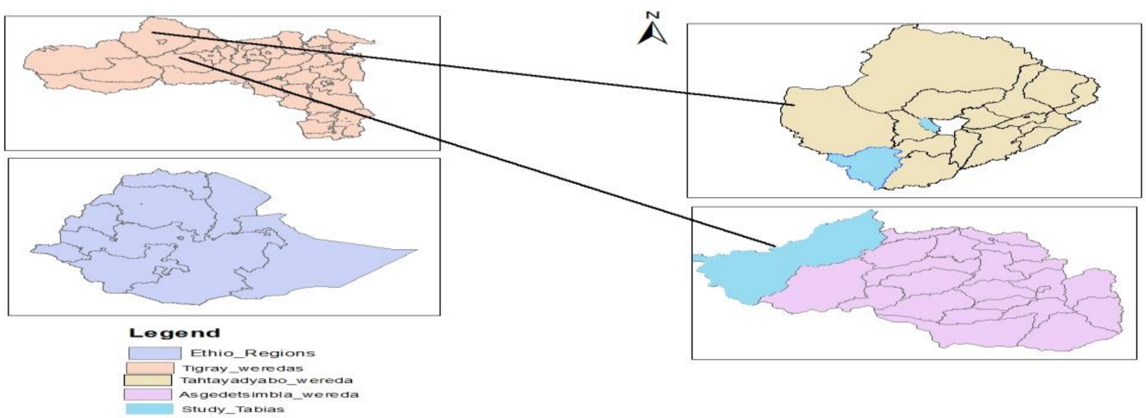

Figure 1. Map of the study areas

Results and Discussion

Table 1. Grain yield of the demonstrated Setit-2 sesame

SN	District	Variety	Min (Ql/ha)	Max (Ql/ha)	Mean (Ql/ha)	Std.Dev.	P-value	Yield increment in%
1	Tahtay Adyabo	Setit-2	3.58	9.00	5.92	1.709	0.401	14.28
		Setit-1	3.25	7.45	5.18	1.458		
2	A/Tsimbla	Setit-2	5.65	8.5	6.60	0.992	0.537	5.09
		Setit-1	5.30	7.59	6.28	0.890		

As shown in table 1 Setiti-2 has gave slightly better yield as compared to Setit-1 in two of the districts. Setit-2 sesame variety has given 14.28% and 5.09% yield advantage over Setit-1 sesame variety respectively at Tahtay Adyabo and Asgede Tsimbla districts. However the average yield obtained in the area is still below the average national productivity, which is 6.9quintal per ha (CSA 2018).

Farmers' perception

Farmers point of view on the demonstrated new sesame variety were taken. The perception were collected on the commodity attributes of germination performance, early maturity, capsule, drought tolerance, shattering, insects damage, diseases damage, wind damage, color preference, seed weight and grain yield. 10 farmers from Tahtay Adyabo and 10 farmers from Asgede Tsimbla district were randomly selected from the total participants for interviewing. Farmers was informed to compare Setit-2 and Setit-1 sesame varieties on the mentioned attributes, by using three levels; good, no change and poor. If setit-2 is better than setit-1 sesame variety on the mentioned attributes use good; if setiti-2 is lower on the mentioned attribute use poor and if the two varieties have no any difference on the mentioned attributes use no change.

Figure 2. During training session at Asgede Tsimbla district, 2018

Figure 3. During planting of the demonstrated setit-2 sesame at Asgede Tsimbla district, 2018

Figure 4.During planting and at vegetative stage of the demonstrated Setit-2 sesame variety on Lichi Redda farm at Tahtay Adyabo district, 2018

Figure 5. During different stages of the crop on Wahid Tesfay and G/Slasie Belay farmers field at A/Tsimbla district, 2018

Figure 6. TARI's and Center monitoring and evaluation teams visiting the demonstrated Stiti-2 sesame variety at T/Adyabo and A/Tsimbla districts August, 2018

Figure 7. During field day at Tahtay Adyabo and Asgede Tsimbla districts from left to right side

Table 2. Farmers' response on attributes of Sesame, Setit-2 versus Setiet-1 varieties (n=20) at Tahtay Adyabo and Asgede Tsimbla district

SN	Attributes	T/Adyabo Farmers response			Asgede Tsimbla Farmers response		
		Poor Percentage	No change Percentage	Good Percentage	Poor Percentage	No change Percentage	Good Percentage
1	Germination performance	0	100	0	0	100	0
2	Early maturity	0	40	60	0	40	60
3	Capsule number	10	50	40	10	30	60
4	Drought tolerance	20	60	20	0	100	0
5	Shattering tolerance	0	100	0	0	100	0
6	Wind damage tolerance	10	70	20	10	60	30
7	Diseases tolerance	0	70	30	10	60	30
8	Insects tolerance	0	100	0	0	100	0
9	Color preference	0	100	0	0	60	40
10	Seed weight	0	100	0	0	60	40
11	Grain yield	10	70	20	40	40	50

Farmers preferred Setit-2 sesame variety in the attributes of early maturity, capsule number and in its yield as compared to Setit-1 sesame variety. Most of the respondents are planned to use both of the variety for the coming production season.

Satisfaction and continuity of using the technology

Farmers are satisfied on the demonstrated Setit-2 sesame variety. 80% farmers and 100% of the farmers at T/Adyabo district were satisfied with the technology and planned to use the variety on the technology.

Table 3. Farmers level of satisfaction on the technology and plan to use the variety for next season.

SN	Woredas	Satisfied with the technology		Planned to continue using the variety in (%)	
		Yes	No	Yes	No
1	Asgede Tsimbla	80	20	80	20
2	Tahtay Adyabo	100	-	100	-

Conclusion and Recommendation

Demonstration of Setit-2 sesame variety was conducted at Tahtay Adyabo and Asgede Tsimbla districts. The main objective was to demonstrate and familiarize the improved sesame variety to farmers in the area. On average basis, Setit-2 sesame variety was gave slightly better yield, as compared to Setit-1 sesame variety at both of A/Tsimbla and T/Adyabo districts. Though respondents prefer Setit-2 sesame variety in some of the commodity attributes, but most of the farmers were perceived as Setit-2 and Setit-1 sesame varieties have no more difference on the mentioned commodity attributes. Generally, the participant farmers were responded that as they are interested for continuing using this new sesame variety for the coming season though there is no more difference in yield. Hence, it is recommended to be popularized Setit-2 sesame variety to large farmers of the area.

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1.5. Demonstration of Improved Soybean Varieties at Tselemti and Tahtay Adyabo Districts of North Western Zone Tigray

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Abstract

To familiarize and introduce soybean commodity in north western Tigray, Ethiopia demonstration of improved soybean varieties were conducted in 2018/19. The trail was conducted at Tahtay Adyabo and Tselemti districts that have a potential for growing the soybean. It was conducted by selecting two Kebelles from Tselemti district and one Kebelle from Tahtay Adyabo district. A total of 35 farmers were involved in the intervention. The necessary training was given to the participant farmers and experts. Following this improved seed of Awassa-95 and Gizo varieties at Tahtay Adyabo districts, and Wegayen and Gizo seed at Tselemti district were offered to participant farmers. Each farmer have been planted a plot size of 20m*10m for each of the two varieties. The descriptive result shows, Awassa-95 soybean variety has given significantly higher yield at Tahtay Adyabo as compared to Gizo variety. The variety was gave an average yield of 10.67 quintal/ha and 5.7 quintal/ha respectively Awassa-95 and Gizo. At Tselemti district Wegayen variety was gave 12.31 quintal/ha and 10.52 quintal /ha of Gizo variety. This shows that Gizo variety gave better yield as compared to Wegayen variety at Tselemti district. Farmers perception result also show that most farmers perceived as Awassa-95 soybean variety has given more important in some commodity attributes as compared to Gizo variety at Tahtay Adyabo district. While Gizo soybean variety is preferred in some commodity attributes as compared to Wegayen variety at Tselemti district. Based on the result it is recommended to be popularize Awassa-95 soybean variety at Tahtay Adyabo and Gizo at Tselemti district.

Key Words: farmers' perception, yield, productivity

Introduction

Soybean (*Glycine max*) is one of the most important food plants of the world and seems to be growing in importance as industrial and multipurpose crop. Soybean is a drought tolerant crop that requires warm climates and is suitable for low to medium altitudes (Urgessa 2015). Moreover, soybean is the primary source of edible oil globally with the highest gross output of vegetable oil among the cultivated crops with total cultivated area of 117.7 million ha and total production of 308.4 million tons (FAOSTAT 2015). Soybean is a stable food of great nutritional value. It is an important global crop, providing oil and protein. Soybean plant has tawny or grey-color pubescence on the stems, leaves and pods.

In Ethiopia, soybean is a multipurpose most nutritionally rich crop as its dry seed contains the highest protein and oil content. Thus, production of soybean in Ethiopia is very essential to overcome malnutrition and partially compensate the expensive source of animal proteins and as a source of income for smallholder farmers. Production of this crop is indispensable in the country to enrich the staple cereal based food with sufficient and high-quality protein (Mekonnen and Kaleb 2014). Since its introduction in Ethiopia in the early 1950s soybean has become one of the most important lowland grain legumes in the country that is highly adapted to diverse agro ecological conditions including areas of marginal to the production of most of other crops.

The main soybean producing areas are in the western part of the country, in Oromia and Benshangul Gumuz, and, to a lesser extent, in the Amhara region. In recent years given the wide range of health benefits of soybean and the country started exporting the crop, production and area cultivated under soybean in the country has increased trend. For example in area coverage it increased from 26,000 ha in 2013/14 to 38,072 ha in 2017/18 and in production it raised from 490,000 quintal in 2013/14 to 864,678 quintals in 2017/18. Though Tigray region have potential areas for growing the soybean but cultivation of the crop is not yet started as reported by (CSA 2018). So to introduce the crop to north western Tigray, Shire-Maitsebri Agricultural Research Center is conducting many research activities. The continuation of this demonstration of the improved soybean varieties were held at Tselemti and Tahtay Adyabo districts of north western Tigray. Therefore, the objectives are to demonstrate the improved soybean varieties in the study area and to assess acceptability of improved soybean varieties by the farmers.

Methodology

Description of the study area

The study was conducted in Tahtay Adyabo and Tselemti districts of north western zone of Tigray. Tahtay Adyabo is located at the degree of 14.05-14.89 ^{o}c Northing and 37.34-38.17 ^{o}c Easting. The district has 38-40^{o}c of temperature and 450mm-550mm annual rainfall. Likewise, Tselemti district is located in the altitude ranges from 800-2870 meter above sea level, and latitude and longitude of 13^{o}05'N and 38^{o} 08' E, respectively. The mean maximum and minimum temperature are 38$^{o}_{c}$ and 16$^{o}_{c}$ respectively and the area receives annual rainfall of 758-1100mm.

Farmers and site selection

The research activity was conducted for one year at Tselemti and Tahtay Adyabo districts of north western Tigray. Medhanalem and Wuhdet Kebelles from Tselemti district and Lemlem Kebelle from Tahtay Adyabo district was purposively selected based on their potentiality for soybean production. A total of 35 farmers which is 23 from Tselemti and 12 farmers from Tahtay Adyabo district were participated in the intervention based on their interest for conducting the trail. Two improved varieties Wegayen and Gizo in Tselemti, and Gizo and Awasa-95 soybean varieties in Tahtay Adyabo district was demonstrated on 20m x 10m (200m^2) area. In the demonstration trail 100 NPS /DAP kg/ha at the time of planting was applied with recommended seed rate. Row sowing methods were applied with 10 cm between plant and 60 cm between rows. All the required management practices were conducted by each of the participant farmers.

Data collection and analysis

Quantitatively data on grain yield was collected from the farmers field. Qualitative data were collected from the farmers' perspective on the traits of the improved soybean varieties using likert scale questions. Descriptive statistics like mean, percentage and t-test were used to analyze the data.

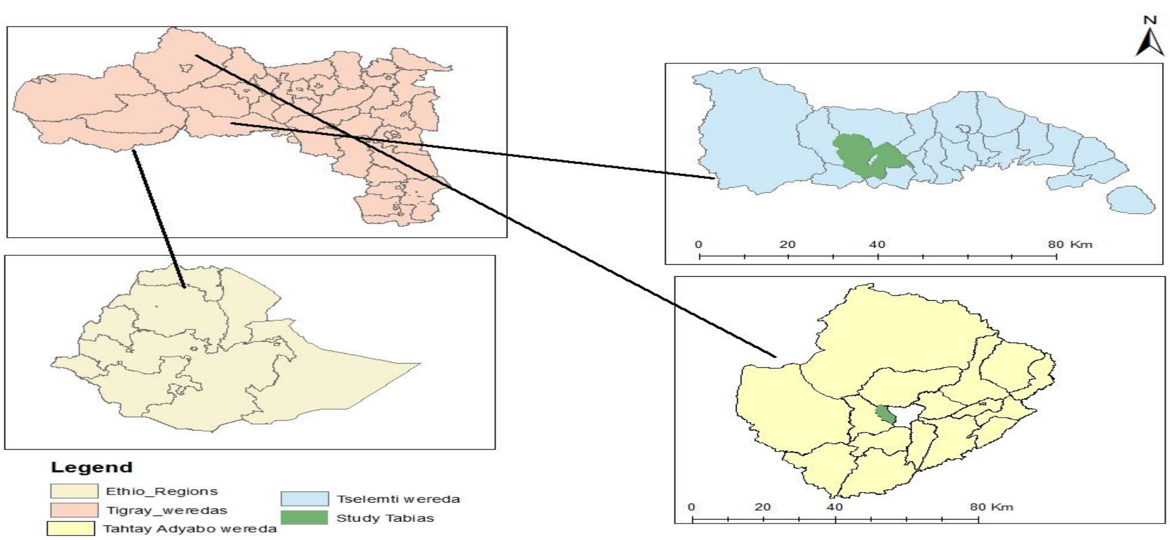

Figure 1. Map of the study area

Results and Discussion

Table 1. Yield obtained from improved soybean Varieties (n=9)

SN	District	Variety	Min (Ql/ha)	Max (Ql/ha)	Mean (Ql/ha)	Std. Dev.	P-value	Yield increment in (%)
1	Tselemti	Wegayen	5.20	13.81	10.52	3.953	0.489	17.01
		Gizo	6.33	16.5	12.31	3.879		
2	T/Adyabo	Gizo	3.78	7.10	5.70	1.460	0.004	87.19
		Awassa-95	8.20	12.00	10.67	1.692		

Gizo variety gave better yield as compared to Wegayen at Tselemti district (which is 17.01% yield increment). On the other side in Tahtay Adyabo district Awassa-95, gave significantly higher yield than Gizo soybean variety (i.e. Awassa-95 variety gave 87.19% yield increment over Gizo variety). Though the productivity of the soybean obtained in the area is below the national which is 22.7 ql/ha, but the yield gained in the area is promising result (CSA, 2018).

Farmers' preference

The response of the farmers on the demonstrated improved soybean varieties was collected from 18 randomly selected farmers. Attributes such as germination performance, higher number of capsule, early maturity, drought tolerance, diseases tolerance, insect tolerance, its taste, seed weight and grain yield was used to compare the improved soybean varieties. Three levels good, no change and poor was used to compare the attributes for the varieties. If the two varieties are equal on the mentioned attribute the tick on no change, if the improved variety is better on the specified attribute than the other variety tick on good and if the improved variety is less preferred on the specified attribute tick on poor.

Table 2. Farmers' response on attributes of soybean, Awassa-95 versus Gizo soybean varieties (n=8) at Tahtay Adyabo district

SN	Attributes	Farmers response		
		Poor (%)	No change (%)	Good (%)
1	Germination performance	0	100	0
2	Early maturity	0	0	100
3	Capsule number	0	25	75
4	Drought tolerance	0	0	100
5	Diseases tolerance	0	75	25
6	Insect tolerance		75	25
7	Its taste in stew or other forms	0	75	25
8	Seed weight	0	100	0
9	Grain yield	0	0	100

As indicated in table 2 farmers were preferred Awassa-95 soybean variety than Gizo variety in some important attributes mainly in the attributes of early maturity, drought tolerance, capsule number and its yield.

Figure 2. Farmers conducted the demonstration of improved soybean varieties (W/ro Shwaynesh Redda and Gebru Redda) at Tahtay Adyabo district, 2018

Figure 3. Farmers field day on the demonstrated soybean varieties at Tahtay Adyabo district, 2018

Figure 4. Farmers field day on the demonstrated soybean varieties at Tselemti district, 2018

Table 3. Farmers' response on attributes of Wegayen versus Gizo soybean varieties (n=10) at Tselemti district

SN	Attributes	Farmers response		
		Poor (%)	No change (%)	Good (%)
1	Germination performance	0	100	0
2	Early maturity	60	40	0
3	Capsule number	80	20	0
4	Drought tolerance	0	100	0
5	Diseases tolerance	0	100	0
6	Insects tolerance	0	100	0
7	Its taste in stew or other forms	0	100	0
8	Seed weight	10	90	0
9	Grain yield	90	10	0

Gizo variety is preferred by the respondents in the parameters of early maturity, capsule number and its yield as compared to Wegayen variety.

Conclusion and Recommendation

Demonstration trail of improved soybean varieties was conducted at Tselemti and Tahtay Adyabo districts. On average basis, Gizo variety gave higher yield as compared to Wegayen soybean variety at Tselemti district. But at Tahtay Adyabo district, Awassa-95 was gave higher yield than Gizo variety. Most farmers perceived that Awassa-95 soybean variety has given more important in some commodity attributes as compared to Gizo variety at T/Adyabo district. While Gizo soybean variety is preferred in some commodity attributes as compared to Wegayen variety at Tselemti district. Therefore, the improved variety, Gizo soybean variety, at Tselemti district and Awassa-95 soybean variety at Tahtay Adyabo district has to be popularized to large farmers of the area, after conducting the demonstration trail on utilization of the soybean in different recipes.

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2. Livestock Technologies

2.1. Improving the Productivity of Pasture Land through Demonstration of Forage Over Sowing: The Case of Ayba pasture land, southern Tigray.

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Abstract

The study was undertaken in Emba Alaje District, Ayba Kebele to demonstrate the improvement in forage yield on pasture over sown with adapted legume forage. The design was single plot design and the treatments were conventional farmers practice and pasture land over sown with vicia sativa. The study was carried out in a single plot design and a total of 60 quadrats of 0.5 × 0.5 m^2 size were used for herbaceous vegetation data and analyzed by t-test equal variances using R-software. Over sowing pasture land by forage legumes increased dry matter yield significantly as compared to the farmers' practice. The higher dry matter yield was recorded for pasture land over sown with vicia sativa (3.43 ton/ha). On average, the pasture land over sown with vicia sativa was 17.06% more productive than farmers' practice (2.93 ton/ha). The relative proportion of grass and legumes reached highest and significantly affected by over sowing. Vicia sativa over sown also increased the basal cover of herbaceous (2.28) compared to farmers' practice (1.47). Results of the financial analysis also indicated that over sowing the pasture with vicia sativa was found to be cost effective than the conventional farmers' practice in terms of the the net return. Therefore, based on the finding of the study it is highly recommended that the concerned governmental and nongovernmental organization should gave emphasis to promote vicia sativa over sown for rehabilitation of degraded pasture land of southern Tigray region, Ethiopia.

Key word: Species composition, forage yield, perception, basal cover, vicia sativa

Introduction

Natural pasture and crop residues are poor in quality and provide inadequate protein, energy, vitamins and minerals (Daniel 1990). Thus, the existing feed resources do not meet the nutrient requirements for growth and reproduction of animals. It is therefore one of the major constraints to livestock productivity. Pasture management can provide significant benefits including improved forage yields, lower feed costs and improve livestock performance (Abadi 2017). In order to increase the availability of feed resources, pasture land management practice need to be improved. More sustainable management of the land can be achieved through improved agricultural management, such as over sowing with Nitrogen fixing legumes (Nebi 2018).

Legumes provide many benefits to as pasture system and do not need any nitrogen fertilization. They improve the seasonal distribution of forage dry matter by boosting summer production and they improve protein levels and overall digestibility of the forage. If a pasture mainly composes of unproductive native grasses, there may be a benefit of introducing improved legume species and varieties (Alemayehu 2002). Over sowing is the simplest among forage development strategies and can be undertaken at very low cost. It involves broadcasting or sowing improved forage species into common grazing lands, native pastures and degraded areas without any cultivation or other inputs (Alemayehu 2002).

Over sowing natural pastures with adapted exotic legume species improved the dry matter yield and species composition than untreated natural pasture land. Over sowing adapted legume species for rehabilitation of degraded pasture land is one of the best solution to the grazing lands in the high lands of Ethiopia to improve the quality and quantity of natural pasture. Over sowing of *Vicia sativa* pasture had higher biomass yield and it is economical to use it for improving degraded pasture lands (Tesfay et al 2017). Studies show that the average dry matter yield for pasture land over sown with *Vicia sativa* (3.96 t/ha) and *Vicia dayscarpa* (3.12 t/ha) in the South Tigray (Tesfay et al 2017). However, there were no demonstration of legume over sowing on degraded pasture land before this study in the study area. Therefore, the objective of this study was to demonstrate adapted legume species for over sowing degraded natural pasture land as well as to assess the perception of farmers on over sowing forage legume species in improving the productivity of degraded pasture land.

Materials and Methods

Study area

The study will be conducted at the highland of Northern Ethiopia, Southern Zone of Tigray, Emba Alaje district, Ayba Kebele (Figure 1). The elevation of the area is 2350 m with annual average rainfall of 912 mm and mean daily temperature ranging between 9–23ºC. The rainfall pattern is bi-modal with the belg rain (short rains) occurring March to May and the meher, which is the main season, rain lasting from June to September. Major crops such as sorghum (*Sorghum bicolor*), Teff (*Eragrostis teff*), Maize (*Zea mays*), wheat (*Triticum spp*.), barley (Hordeum vulgare L.), Faba bean (Vicia faba), field pea (*Pisum sativum*), linseed (*Linum usitatissimum*), onion (*Allium cepa L*.), pepper (*Piper nigrum*), cabbage (*Brassica oleracea*), fruits are grown in the study area (Girmay et al 2014). Natural pasture is the major feed source in the area.

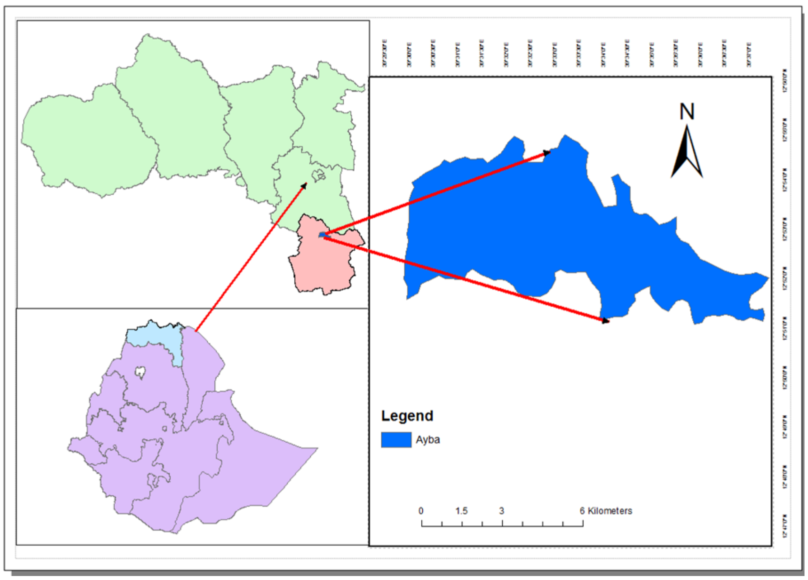

Figure 1. Map of study area (Ayba Kebele)

Implementation of legume over sowing demonstration

After selecting the interested farmers, practical and theoretical training was provided to district experts, development agents and land less youth which enabled them to develop skill on the general management practice of pasture land. A total of 100 land less youth were participated and a total of 0.5ha were covered by *Vicia sativa* over sown. Participant farmers had prepared their own pasture land, which are used as inputs for the demonstration of the over sowing and the Agricultural Growth Program (AGP) project was provided the raw materials like vetch seed.

Study design and measurements

The study design was single plot design. The treatments for the study were farmer's practice and vetch over sowing. The treatment varieties was selected based on previous adaptability to the area and potential to enrich the quality of the forage herbage. The amount of vetch seed rate that are used in the experiment was 30kg (Alley method) and 15kg (strip method) per ha. The size of experimental plot was 100 m^2 (10m x 10m). Over sowing was performed on the onset of the main season rain. The plots were managed for four months which is the rainy period. After sowing the plots were left to grow naturally without any intervention except protection from external disturbances such as human and animal interference.

Data collected included biomass yield, perception data, pasture botanical composition (percentage) and dry matter yield. For determination of dry matter yield, forage samples was harvested at the end of the day (104 days for vetch over sowing and 60 days for farmer's practice). Farmers' practice is a method of grazing livestock on a specific unit of land, where the animals have continuous, unrestricted access to the rangeland for a period of the year (referred to as growing season continuous grazing) (Vallentine 2001). An area were closed to livestock and protected by guards and bylaws against grazing and cutting during the wet season (two months) and grazed by livestock after two months. The protection from grazing is short-term and livestock are allowed to graze the enclosures when forage from the surrounding rangelands starts to decline (Verdoodt et al 2010).

Figure 2. Before over sowing (left side) and after over sowing (right side)

Forage sampling procedures

A sixty (two land use system×30 quadrates) 1m × 1m quadrat were placed randomly in every plot. Botanical compositions percentages and total dry matter yield were determined by harvesting from three times laid quadrates of size 1m x 1m from each plot randomly at its 50% flowering stage, at a height of 5cm near the ground. After harvesting, the total fresh weight of the forage sample from each quadrats was measured immediately for biomass yield determination using a sensitive balance. Sub-samples representing 10% of the whole forage samples harvested from the treatments were taken for determination of dry matter yield.

Dry matter yield

The dry matter yield of each quadrats was determined by drying a representative sample in an air dry for partial dry matter determination. The dry matter yield of each quadrats was converted to tons per hectare after drying. Dry matter production was calculated through the values of green production and dry weight percentage. Dry matter percentage = dry weight / fresh weight x100. The dry matter production (ton/ha) was calculated as (10 x TotFW x (DWss /HA x FWss)) (Tarawali et al., 1995). Where, TotFW = Total fresh weight, DWss = reweight subsample, FWss = Fresh weight subsamples and HA = Harvesting area.

Basal cover

In each quadrat the basal cover or area (the area occupied at the intersections of the plant-soil interface) of the living plant parts were estimated. Basal estimation has done by clipping for clear observation, accordingly plants basal covers in the quadrats were cut, to facilitate visual estimation of basal cover of living plant parts. The basal cover rating of the quadrats was considered ‘excellent’ when completely filled (>75%), “good” when partially filled (60-74%), “poor” when 50-69% filled, “very poor” when <50% filled.

Farmers’ perception

Farmers’ perception were collected from randomly selected 45 participant farmers through group discussion to compare the improved technology (legumes over sowing) and farmers’ practice.

Financial analysis

The comparative analysis included the variable costs and benefits for the calculation. Net return was calculated to determine the profitability of *Vicia sativa* over sowing following Upton formula (Upton, 1979). The gross field benefit per day was calculated by dividing the final sell of the biomass. 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). The cost was calculated based on cost needed for the different activities and in puts used for the application. However, the cost of harvesting and transporting ripe hay from pasture was not calculated.

Statistical analyses

Data collected from herbaceous vegetation composition, species diversity, and aboveground biomass were analyzed by t-test with equal variances to determine if there were significant differences between means of the various herbaceous characteristics with respect to different land management practice using R-software version 3.3.3 (The R Core Team 2018). Significant differences were declared at $p \leq 0.05$. Farmer's perception was collected through participatory rural appraisal approach using group discussion and data were analyzed using SPSS version 20 and means comparison was tested using t-test of Independent Samples Test with Levene's Test for Equality of Variances.

Result and Discussion

Botanical composition

Natural pastures are composed of grasses, legumes, sedges and other heterogeneous plants in various families, which could be herbaceous or woody forms (McIllroy 1972). Pasture component species, grasses, existing legumes and others were significantly different ($p<0.001$) among all the treatments and higher results of grass composition were obtained for untreated pasture (69.4%), followed by *Vicia sativa* sown pasture (53.27%). The composition of treatments in the demonstration site for *Vicia sativa* was 20.4% (Table 1). These findings suggest that grass legume mixtures offer a great potential for increased production (Nyfeler et al 2009; Finn et al 2013; Lüscher et al 2014). The composition of *Vicia sativa* and *Vicia dayscarpa* in the pasture land sown with *Vicia sativa* and *Vicia dayscarpa* was 39.3% and 33.3%, respectively (Tesfay et al 2017). Grass–legume mixtures (over sowing) have the potential to increase productivity, herbage nutritive value and resource efficiency (Peyraud et al 2009). Over seeding forage legumes into existing pasture may help to reduce forage deficit on small and resource-limited small farms (Bartholomew 2005; Bartholomew and Williams 2010). Forage legumes generally have higher nutritive value than grass species, and therefore, growing grasses and legumes in mixtures can improve herbage nutritive value compared with grass monocultures (Zemenchik et al 2002).

Table 1. The effect of over sowing legume forage on species composition.

Treatments	Species composition (%)			
	Grass	Natural legume	*Vicia sativa*	Forbs
Farmers' practice	69.3	9.3	*	21.4
Vicia sativa	53.3	18.6	20.4	7.7
P value	<0.001	<0.001		<0.001

* Absence

Figure 2. Pasture land with sativa over sown (left side) and farmers' practice (right side)

Dry matter yield

The annual dry matter yield of the natural pasture was significantly affected by legume over sowing. The higher yield was recorded on pasture land over sown with *Vicia sativa* (3.43 ton/ha) and 17.06% higher than that of the adjacent farmer's practice. The result was similar with Tesfay et al (2017), in Southern Tigray, observed increased dry matter production of a natural pasture over sown with *Vicia sativa* (3.96 ton/ha). Other authors have reported increased in pasture production when suitable pasture legumes were successfully incorporated (Walker 1969; Stobbs 1969 and Lwoga 1983). There were significant variations in total fresh biomass yield of the natural pasture with the over sowing and farmers' practice (P<0.001) (Table 2).

Aboveground biomass of herbaceous species were higher in the over sowing area than farmers' practice (19.03 and 10.29 ton/ha, respectively). The mean aboveground biomass yield measured in over sowing was 84.94% higher than that of the adjacent farmer's practice. The results indicated that over sowing legume species like *Vicia sativa* for pasture plots resulted in increased biomass production in comparison with non over sowing (farmer's practice). Cropping mixtures/

Over sowing could be a promising strategy for sustainable increase (Loreau and Hector 2001; Loreau et al 2001). Cardinale et al (2007) found that over sowing, on average, achieved a yield benefit of +77% compared with the average monoculture. The yield advantage of the average mixture (over sowing) was 18%, when compared with the mean yielding monoculture (Finn et al 2013). Over sowing had a highly significant effect on the pasture land yield (Kirwan et al 2007; Finn et al 2013; Sturludottir et al 2013).

Table 2. Fresh biomass, basal cover and dry matter yield ton/ha (Mean) of legume over sowing and adjacent farmers' practice pasture land

Land use system	N	Fresh biomass	dry matter percentage	DMY	Percent cover/basal cover
Over sowing	30	19.03	81.14	3.43	2.28
Farmers' practice	30	10.15	72.40	2.93	1.47
P value		<0.001	<0.001	0.01	<0.001

N= Number of quadrats

There was a highly significant difference ($p < 0.001$) in the dry matter percentage of herbaceous plants between legume over sowing plot and farmers' practice plot. The over sown plot had higher dry matter percentage than the farmers' practice plot (Table 1). The basal cover was significantly increased by treatment application ($P<0.001$) relative to the farmers' practice plot (Table 1). The highest mean basal cover (2.28) was recorded in plots treated with over sowing legume, while the lower (1.47) was observed under farmers' practice plot. Therefore, the present study confirmed that over sowing legume species would promote re-vegetation of various herbaceous species that might lead to higher basal cover.

Figure 1. Over sowing legume species (*Vicia sativa*)

Farmers' perception

Farmer's selection criteria on pasture land for pasture land rehabilitation purpose are shown in Table 3. Based on farmers selection criteria, over sown pasture had significantly (P=0.05) mean score over farmers' pasture land on production performance (Table 3). However, the farmers perceived negatively on the cost effective and simplicity of the technology when to compared with theirs practice (farmers' practice). Beside this, farmers were perceived positively on *Vicia sativa* over sowing in terms of amount of hay yield increment, forage quality enhancement, species compositions increment and basal cover enhancement (Table 3). Generally, the community had interest to rehabilitate their pasture land through *Vicia sativa* over sowing after they seen the pasture land productivity. Hence, it is quit evidence that farmers in the Ayba kebelle clearly shows the effect of *Vicia sativa* over sowing on pasture land to boost production and productivity of the degraded pasture land. Therefore, this positive observation of farmers on the application of *Vicia sativa* over sowing on pasture land has an implication for further scaling up of the practice in the whole pasture land Ayba kebelle and beyond in other kebelles in the district.

Table 3. Farmers' perception towards *Vicia sativa* over sown

Parameters	Farmers' practice	*Vicia sativa* over sown	P- value	t-value
Amount of hay yield increased	1	5		
Forage quality enhanced	1	5		
Soil fertility improved	1	5		
Cost effectiveness	4	1		
Simplicity to apply	4	1		
Species compositions increased	1	5		
Basal cover enhanced	1	5		
Total score	13	27		
Mean	1.86	3.86	0.05	-2.17

NB: 1.Very poor 2. Poor 3. Good 4. Very good 5. Excellent

Figure 2. Farmers' practice (right side) and pasture land with sativa over sown (left side)

Financial analysis

Vicia sativa over sowing to pasture land costs about ETB 1900 per hectare while the conventional practice had no any cost of production as indicated below (Table 4). Although legume over sown forage production has cost implication, it yielded a higher dry mass harvested from this production method which also resulted in higher net benefit (ETB 24010). Legume over sown pasture land had shown about 50.92% additional net benefits over the conventional practice. Over sowing of the natural pasture with legume species increased biomass production, it is economical to apply these as degraded land improving legume species (Tesfay et al 2017).

Table 4. Partial cost benefit analysis

Variable costs	Legume over sowing (T1)	Conventional practice (T2)
Cost of seed (ETB/Qt)	900	0
Cost of labour (ETB)	1000	0
Total variable cost (TVC) (ETB)	1900	0
Yield of dry mass or hay (ton/ha)	3.43	2.93
Price of hay (ETB/ton)	7000	5000
Total return from sale of hay (ETB)	24010	14650
Net return obtained (ETB)	22110	14650
ΔTVC	1900	
ΔNR	7460	
Advantage over the technology in %	50.92	

ΔNR = change in net return; ΔTVC = change in total variable cost

Conclusion and Recommendation

Over sowing natural pastures with adapted exotic legume species improved the dry matter yield and species composition than untreated natural pasture land. Over sowing adapted legume species for rehabilitation of degraded pasture land is one of the best solution to the pasture lands in the high lands of Ethiopia to improve the quality and quantity of natural pasture. Over sowing of *Vicia sativa* pasture had higher biomass yield and it is economical to use it for improving degraded pasture lands.

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2.2. Improving Productivity of Pasture Land through Demonstration of Manure Application: The Case of Ayba Pasture Land, Alaje District, Southern Tigray

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Abstract

The study was conducted in Ayba kebelle, Emba Alaje district located in southern zone of Tigray region from June to October 2019 with the objective to demonstrate manure application in improving the productivity of degraded natural pasture land and to assess farmers' perception towards the technology. The study was carried out in a single plot design and a total of 60 quadrats of 0.5 × 0.5 m^2 size were used for herbaceous vegetation data and analyzed by t-test equal variances using R-software. Manure application increased total dry matter yield by 32.08% from 2.93 to 3.87 ton/ha. Grasses and legumes species composition were dominant in manure application, while the farmers' plot was dominated by forbs. The Shannon diversity index of the herbaceous species was 1.99 and 1.73 in manure application and farmers' practice, respectively ($P<0.001$). Herbaceous species of basal area was significantly higher in the manure application than farmers' practice ($P<0.001$). The observation of farmers on manure application on pasture land clearly identified its effect on degraded pasture land enhancement. Moreover, manure application on degraded pasture land was found to be cost-effective with more dry matter yield. In conclusion, manure application resulted in high dry matter yield, improved grass-legume species composition and contribute to achieve more income for smallholder livestock producers in the highlands of South Tigray. In addition, farmers have positive observation on the application of manure on pasture land. Therefore, further scaling up of manure application in the whole pasture land at Ayba and beyond in other similar pasture lands in the district is recommended.

Key word: Diversity, dry matter, perception, species composition, land cover

Introduction

Grazing resources in pasture land which have significant contribution as animal feeds are being deteriorated due to high population pressure, land degradation and conversion of grazing lands into arable lands (Yayneshet 2010; Endale et al 2017). Pasture management can provide significant benefits including improved forage yields, lower feed costs and improve livestock performance (Abadi 2017). In order to increase the availability of feed resources, pasture land management practice need to be improved. More sustainable management of the land can be achieved through improved agricultural management, such as over sowing with nitrogen fixing legumes, addition of fertilizers and recycling of nutrients and soil erosion control. Direct addition of nutrients can be done through mineral fertilizer or organic inputs such as manure and compost through a combination of both nutrient sources. Organic inputs are potential sources of plant nutrients and have beneficial effects on soil fertility of degraded grazing land (Nebi 2018).

Livestock manure is an organic fertilizer that plays a key role in chemical and biological soil functions of intensively cropping fields under sustainable and environmentally harmonized herbage production. Prompt management of manure application should be a top priority for increasing herbage production in grassland agriculture to prevent environmental pollution. Since manure has a high concentration of organic matter, its application as a fertilizer helps decelerate depletion of organic matter in arable land, especially when there is a high frequency of heavy erosion (Larney et al 2000). It also increases the soil levels of the macro-elements such as nitrogen (N), phosphorus (P), and potassium (K) as well as micronutrients (Schmidt et al., 2000), improves soil physical properties (Benbi et al 1998), enhances DM yield and improves the crude protein concentration of herbages (Pieterse and Rethman 2002; Tessema et al 2003; Wadi et al 2004).. Manure contain 1.69%, 0.48%, 1.20%, 1.45%, 0.63% and 0.19% of N, P, Ca, K, Mg and Na, respectively (Asmare et al 2015). Moreover, manure helps in maintaining carbon, nitrogen ratio in the soil, increases soil fertility and productivity, improve the physical, chemical and biological properties, structure and texture, increases water holding capacity of the soil, minimizing the evaporation losses of moisture from the soil and reduce soil erosion (Salahin et al 2011).

Mugerwa et al (2008) reported that manured plots showed higher dry matter production, species wealth, percentage cover, and drastic changes in botanical composition than that of non-manure plots. Milton (1994) suggested that an optimistic management approach, which includes manure application and stock withdrawal (fencing off animals) from overgrazed areas, could optimize the restoration potential of degraded pasture lands). However, there were limited practise of manure application on degraded pasture land in the study area. Therefore, the objectives of the present study were to demonstrate manure application and their role in improving the productivity of degraded pasture land as well as to assess the perception of farmers towards manure application and its role in enhancing the productivity of their pasture land.

Materials and Methods

Study area

The study was conducted in Ayba kebele, Emba Alaje District, the highland of Southern Zone of Tigray, northern Ethiopia (Figure 1). The elevation of the area is 2350 m a.s.l. with annual average rainfall of 912 mm and mean daily temperature ranging between 9-23ºC. The rainfall pattern is bi-modal with the "Belg" rain (short rains) occurring in March to May and the "Meher", which is the main season, rain lasting from June to September. Major crops include sorghum (Sorghum bicolor), teff (*Eragrostis teff*), maize (*Zea mays*), wheat (*Triticum spp.),* barley (*Hordeum vulgare L.),* faba bean (*Vicia faba*), field pea (*Pisum sativum*) and linseed (*Linum usitatissimum*). (Girmay et al 2014). Natural pasture is the major feed source in the area.

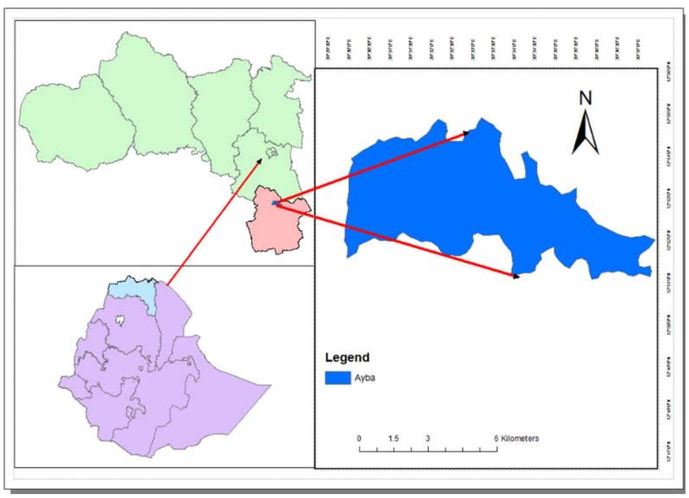

Figure 1. Map of study area (Ayba Kebele)

Site selection and management

The area selected for demonstration had been previously used as a common pasture land for many years. Later on, it was given for landless youth. A relatively flat field with less slop gradient variability was selected and demarcating before the execution of the experiment. The treatments (manure application and farmers' practice) were selected. Farmers' practice is a method of grazing livestock on a specific unit of land, where the animals have continuous, unrestricted access to the rangeland for a period of the year (referred to as growing season continuous grazing) (Vallentine 2001). An area were closed to livestock and protected by guards and bylaws against grazing and cutting during the wet season (two months) and grazed by livestock after two months. The protection from grazing is short-term and livestock are allowed to graze the enclosures when forage from the surrounding rangelands starts to decline (Verdoodt et al 2010).

Selection of farmers and manure application

After selecting the interested farmers, practical and theoretical training was provided to district experts, development agents and land less youth which enabled them to develop skill on the general management practice of pasture land. A total of 40 land less youth were participated and a total of 0.5ha were covered by manure application. Manure application was demonstrated in the interested land less youth that keep mainly dairy cattle. Participant farmers had prepared their own pasture land, which are used as inputs for the demonstration of the manure application and the Agricultural Growth Program (AGP) project was provided the raw materials like manure.

Figure 2. Manure top dressing

Study design and measurements

The study design was single plot design. The treatments for the study were farmers' practice and manure application. The amount of manure used in the experiment was 5ton per ha. The size of experimental plot was 100 m^2 (10m x 10m). Data collected included biomass yield, pasture botanical composition, dry matter yield, species diversity, ground cover/basal cover and farmers' perception. For determination of species composition, forage samples was harvested at the end of the day (104 days for manure application and 60 days for farmers' practice).

Forage sampling procedures

Sixty samples (30 in each of the two land use systems) were taken to determine botanical compositions and total dry matter yield by harvesting at its 50% flowering stage, at a height of 5cm from the ground. Samples were taken by using 0.5cm × 0.5cm size quadrat. After harvesting, the total fresh weight of the forage sample from each plot was measured immediately for biomass yield determination using a sensitive balance. Furthermore, all species were listed, recorded and identified based on their leaf and stem structure and floristic (flowering) characteristics of each botanical component. The average height of five random sampled plants in each plot was measured in centimeter from the ground surface to the top of the main stem at maturity (then the average was taken) (Figure 3). Identification of the species was undertaken with the assistance of farmers from the local community. The nomenclature was done following the procedures of Fromann and Persson (1974) and Edwards et al (2000). Herbaceous species were categorized into four palatability classes, as highly palatable (decreasers), palatable, less palatable (increasers), and unpalatable (invaders) based on the opinion of livestock owners.

Figure 3. Botanical compositions counting and plant height measuring

Dry matter yield

The dry matter yield of each plot was determined by air drying the representative samples for partial dry matter determination. The dry matter yield of each plot was converted to tons per hectare after drying. Dry matter production was calculated through the values of green production and dry weight percentage. Dry matter percentage = (dry weight/fresh weight) x100. The dry matter production (ton/ha) was calculated as (10 x TotFW x (DWss /HA x FWss))

(Tarawali et al 1995). Where, TotFW = Total fresh weight, DWss = reweight subsample, FWss = Fresh weight subsamples and HA = Harvesting area.

Basal cover

In each quadrat the basal cover or area (the area occupied at the intersections of the plant-soil interface) of the living plant parts were estimated. Basal estimation has done by clipping for clear observation, accordingly plants basal covers in the plot were cut, to facilitate visual estimation of basal cover of living plant parts. The basal cover rating of the plot was considered as 'excellent' when completely filled (>75%), "good" when partially filled (60-74%), "poor" when 50-69% filled, "very poor" when <50% filled.

Herbaceous species diversity

Herbaceous species diversity was measured for individual land use of each quadrat and calculating an index based on the number of species and their abundance. The herbaceous species richness, alpha diversity and Simpson index were calculated by Magurran (1988) and Efron and Tibshirani (1993) formula. Shannon diversity index calculated by Kent and Coker (1992) formula:

$H = -\sum_{i=1}^{s} Pi \ln(Pi)$ Where: H= Shannon diversity indices, S= the number of species, Pi=proportion of individual species and InPi=log proportion of individual species

Species evenness/equitability (E) calculated as follows:

$\text{Equitability (evenness)} = \frac{H}{H\ max}$ Where H= Shannon diversity indices, S= the number of species, Hmax = is the maximum level of diversity possible within a given population, which equals lnS (ln number of species).

Sorensen's coefficient of similarity

Herbaceous vegetation heterogeneity was calculated from the *Beta* component of diversity, which was estimated by using the Sørensen similarity index between all pairs of 0.25m^2 quadrats. This index ranges from zero (when the two compared sets are dissimilar and have not species in common) to one (in cases of complete similarity). In consequence, the higher this similarity coefficient, the lower the *Beta*-diversity or the species composition heterogeneity of the pasture stand. All similarity indices represent variations over two parameters: species composition in each of two sites and the species shared between the two sites (Novotny and Weiblen 2005). The widely used Sørensen similarity index (Magurran 2004) measures similarity in species composition for two sites, A and B, by the equation

$Sc = \left(\frac{2C}{A+B}\right) x100$ Where, Sc = Sorensen's similarity index, A = number of species in manure application site, B = number of species in the farmers' site, C = the number of species common in the manure application and in the farmers' pasture land.

Farmers' perception

Farmers' perception were collected from randomly selected 45 participant farmers (25 beneficiary and 20 non-beneficiary farmers) through group discussion to compare the improved technology (manure application) and farmers' practice.

Financial analysis

Comparative analysis was calculated to determine the profitability of manure application following Upton formula (Upton 1979). The comparative analysis were undertaken based on grass biomass yields. Selling of pasture harvested from protected or pastures grown on the borderline of the farm land is well known in the study districts. The cost was calculated based on cost needed for the different activities and in puts used for the application. However, the cost of harvesting and transporting ripe hay from pasture was not calculated. The comparative analysis included the variable costs (costs of manure and manure application) and benefits for the calculation. The gross field benefit per day was calculated by dividing the final sell of the biomass. Net Return (NR) or net benefit was calculated as the amount of money left when total variable costs (TVC) are subtracted from total returns (TR).

Statistical analyses

Data collected from herbaceous vegetation composition, species diversity, and aboveground biomass were analyzed by t-test with equal variances to determine if there were significant differences between means of the various herbaceous characteristics with respect to different land management practices using R-software version 3.3.3 (The R Core Team 2018). Significant differences were declared at $p \leq 0.05$. Farmer's perception was collected through participatory rural appraisal approach using group discussion and data were analyzed using SPSS version 20 and means comparison was tested using t-test of Independent Samples Test with Levene's Test for Equality of Variances.

Results and Discussions

Effect of manure application on the botanical composition of herbaceous species

Species composition of pasture lands was observed to be diverse in the field study and the result obtained for species type and their composition is indicated in Table 1. A total of 16 herbaceous species were identified in the farmers' practice site, of which 8 were grasses, three were herbaceous legumes and six were forbs. Among the identified species, annuals and perennials consisted of 8 (50%) and 8 (50%), respectively. Moreover, 5 species were highly palatable, 2 species medium palatable and 6 species less palatable to ruminant animals. On the other hand, 23 herbaceous species were identified in the manure application site. The functional group distribution of these species were 13 grass, 5 legumes, and 5 forbs. Different species composition was dominant in the plot fertilized with cattle manure (Girma et al 2003).

The effects of manure applications on ratios of botanical composition (legume, grass, and other plants) were found to be different. The number of individual perennial grasses and legumes were higher at manure application than farmers' practice in the study area (Figure 4). The higher composition of the perennial grasses may imply the potential productive nature of the pasture land for livestock production (Amaha 2006). Similar results were reported by De-Val and Crawley (2005) indicating that in well managed areas highly desirable perennial grasses were found to be abundant. Livestock herbivory can cause shifts in plant species composition by replacing highly palatable grasses with unpalatable species (Rutherford et al 2012). Aydın and Uzun (2008) reported that the effects of manure applications on ratios of legume and grass in botanical composition were found to be significant.

The present result suggests that the main reason for a low number of grass species in farmers' practice pasture land is the high grazing intensity and no fertilizer application. Hence, heavy grazing tends to reduce the presence of palatable species and consequently become dominated by other herbaceous plant or bushes (De Haan et al 1997). Ayana (1999) reported that species composition could depend on pasture management (intervention) and livestock population. Selective grazing of palatable herbaceous plants by livestock enhances the growth of annuals and unpalatable herbaceous plants (Skarpe 1992) resulting in the decline of palatable species (Fensham et al 2010; Tessema et al 2011).

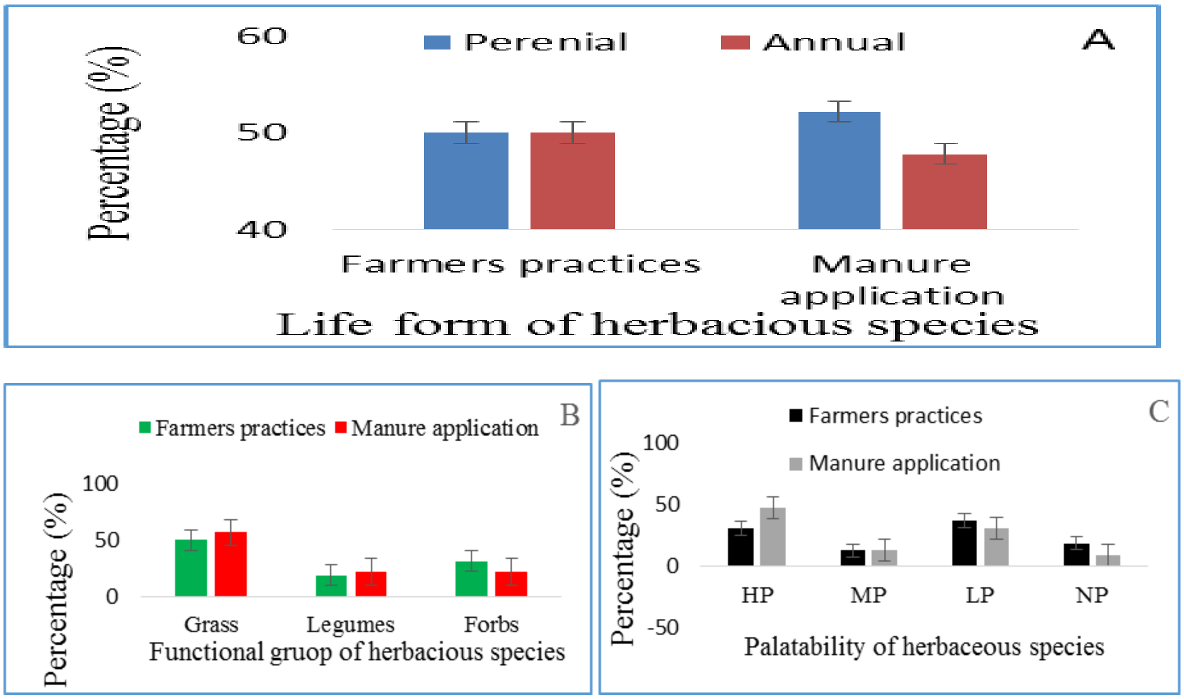

Figure 4. Functional group (B), palatability (C) and life form (A) of proportion herbaceous species in the two land use system (HP=high palatable, LP= less palatable, MP= medium palatable, NP=non palatable).

The forb herbaceous species proportion in the farmers' practice site was higher than in the manure application site (Figure 4). The farmers' practice site was highly dominated by forbs, this is in line with prior studies (e.g., Sternberg et al 2000; Mphinyane et al 2008 and Kgosikoma 2011) reporting that herbaceous plants are highly responsive to grazing pressure. The increase in forbs in pasture lands threatens livestock production because encroaching forbs species suppress palatable grasses and herbs (Scholes and Archer 1997) through competition for soil moisture and nutrients. The proportion of forbs in farmers' practice plot was higher; this was due to the faster growth of annual weeds, which are pioneer plant communities in degraded ecosystems (Marie et al 2014).

Similarity in herbaceous species composition between the two land use systems

About 15 species out of 24 herbaceous species recorded from manure application site were found also in the farmers' practice. 8 plant species recorded only at the manure application site and one plant species recorded only from the farmers' practice site. The Sorensen's similarities of herbaceous species in terms of species richness of the two land use systems were about 33.33%. This indicated as higher dissimilarity of herbaceous species between the two land use systems. This dissimilarity difference to some extent might have resulted from the management role provided by manure application in restoration of fast growing plants in degraded pasture lands.

Effect of manure application on the herbaceous species diversity

The overall diversity of herbaceous plants is much higher in manure application than farmers' practice, which may be a consequence of the high species richness in manure application (Table 1). The herbaceous species richness, Alpha diversity, Simpson and Shannon diversity index were significantly ($p<0.05$) higher in the manure application (13.6, 3.15, 0.80 and 1.99) compared to the farmers' practice (9.7, 2.56, 0.74 and 1.73), respectively (Table 1). The present result suggests that the main reason for low herbaceous species richness in farmers' practice are increased grazing pressure (Sisay and Baars 2002; Desalew 2008; Angassa et al 2010); and heavy grazing, trampling and inappropriate management interventions (Amaha 2006), might lead to a reduction in herbaceous species diversity.

Table 1. Species diversity (mean) of manure treated and untreated pasture land

Land use system	N	Alpha	Species richness	Shannon diversity index (H)	Evenness	Simpson
Manure application	30	3.15	13.6	1.99	0.67	0.80
Farmers'practice	30	2.56	9.7	1.73	0.57	0.74
P value		0.003	<0.001	<0.001	0.001	0.003

N= Number of quadrats

The value of herbaceous species evenness in the manure application and farmers' practice were 0.67 and 0.57, respectively (Table 1), indicating significantly lower species evenness in the farmers' practice than the manure application pasture land ($p=0.001$). This could result from repeated habitat disturbances in the farmers' practice due to frequent and intensive interference of livestock for grazing. This might indicate that the existence of variations in species diversity was a result of the heterogeneous distribution of species due to protection vegetation establishment factors. A low equitability/evenness value means that there is the dominance of one or more species in the community. While high equitability/ evenness means that, there is a uniform distribution among the species in samples, demonstrating that individuals are well distributed (Cavalcanti and Larrazabal 2004). In agreement with the above statements, the species distribution in the manure application was uniform distribution among the species in sample than farmers' practice.

Effect of manure application on biomass yield and plant height of herbaceous species

There were significant variations in total fresh biomass yield of the natural pasture with the treatments (P<0.001) Table 2. Aboveground biomass of herbaceous species were higher in the manure application area than farmers' practice (15.90 and 10.29 ton/ha, respectively). The mean aboveground biomass yield measured in manure application was 54.52% higher than that of the adjacent farmers' practice. If the current level of herbaceous aboveground biomass removal is sustained for a longer period of time, it might lead to reduction in productivity of the grazing resource (Keya 1998).

Table 2. Fresh biomass, plant height, basal cover, dry matter percentage and dry matter yield (Mean) of manure application and adjacent farmers' practice pasture land

Land use system	N	Plant height (cm)	Fresh biomass (ton/ha)	Dry matter percentage	DMY (ton/ha)	Percent cover/basal cover
Manure application	30	56.82	15.90	77.19	3.87	1.93
Farmers' practice	30	33	10.29	66.22	2.93	1.47
P value		<0.001	<0.001	<0.001	0.01	<0.001

N= Number of quadrats, DMY= dry matter yield

The results indicated that application manure for pasture plots resulted in increased biomass production in comparison with non manured plots (farmer's practice). The increasing of forage yield following nutrient addition (manure application) was described by earlier study (Blonski et al 2004). A previous study showed that the application of livestock manure could improve the native pasture land production (Mut 2009). The biomass production in the manure application site better than the farmers' practice, this might be due to better pasture land management practice (manure application) in the areas, but the farmers' practice areas have deteriorated through continuous overgrazing and the mismanagement system of the community (Ahmed 2006; Ibrahim 2016). On the other hand, the highest scores for biomass were recorded at manure application sites reflecting the benefits of appropriate management interventions. The same trend was also observed with percentage cover where manure application site and farmers' practice had 1.93 and 1.47, respectively. The basal cover data demonstrated that there was significant variation (P< 0.001) between the land use types (Table 2). The result showed that the basal cover difference was in relation to variation in species composition between the land use types. The mean score exposed that the farmers' practice pasture land scored least mean basal cover, while the manure application pasture land attained the highest mean basal cover. Therefore, the present study confirmed that manure application would promote re-vegetation of various herbaceous species that might lead to higher basal cover.

The plant height was significantly increased by treatment application (P<0.001) relative to the farmers' practice plot (Table 2). The tallest mean plant height (56.82cm) was recorded in plots treated with manure application, while the shortest (33cm) was observed under farmers' practice plot. Manure plays an important role in nutrient cycling which provides nutrients for plant growth (Nebi 2018). According to the reports of Khan et al (2010), Brock et al (2006) and Nikoli and Matsi (2011) stated farm yard manure supplies all major nutrients (N, P, K, Ca, Mg and S) as well as micronutrients (Fe, Mn, Cu and Zn) which are necessary for plant growth. Hati et al (2006) reported that cattle manure application improved physical properties of the soil, which promoted higher nutrient and water uptake by plant roots and increased plant growth.

Farmers' perception towards manure application in pasture land

Based on the criteria mentioned by farmers (group discussion) in Table 3, farmers were reported that the manure applied pasture land has better grasses, good quality of forage and new varieties (increased species compositions) of forages has been emerged as compared with the field which was not applied manure in the their adjacent pastureland. The manure applied pastureland was recorded higher mean (4.14) compare to the farmers' practice (2.14) (Table 3). Hence, it is quit evidence that farmers in the Ayba kebelle clearly shows the effect of manure application on pasture land to boost production and productivity of the degraded pasture land. Therefore, this positive observation of farmers on the application of manure on pasture land has an implication for further scaling up of the practice in the whole pasture land Ayba kebelle and beyond in other kebelles in the district.

Table 3. Farmers observations based on their merits

List of merits	Farmers' practice	Manure application	p-value	t-value
Amount of hay yield increased	1	4		
Forage quality improved	1	4		
Soil fertility will enhance	1	5		
Cost effectiveness	5	4		
Simplicity to apply	5	3		
Species composition increased	1	4		
Basal cover enhanced	1	5		
Total score	15	29		
Mean	2.14	4.14	0.025	-2.556

NB: 1.Very poor 2. Poor 3. Good 4. Very good 5. Excellent

Financial analysis

Manure application to pasture land costs about ETB 2500 per hectare while the conventional practice had no any cost of production as indicated below (Table 4). Although manure treated forage production has cost implication, it yielded a higher dry mass harvested from this production method which also resulted in higher net benefit (ETB 16850) by fully recovering the costs incurred in the production process.

Table 4. Costs and returns of manure treated and conventional practice in the study area

Variable costs	Manure treated (T1)	Conventional practice (T2)
Cost of fertilizer (manure) (ETB/Qt)	1500	0
Cost of manure application (ETB)	1000	0
Total variable cost (TVC) (ETB)	2500	0
Yield of dry mass or hay (ton/ha)	3.87	2.93
Price of hay (ETB/ton)	5000	5000
Total return from sale of hay (ETB)	19250	14650
Net return obtained (ETB)	16850	14650
ΔTVC	2500	
ΔNR	2200	
Advantage over the technology in %	15.02	

ΔNR = change in net return; ΔTVC = change in total variable cost; MRR = marginal rate of return

Manure treated pasture land had shown about 15.02% additional net benefits over the conventional practice assuming the same price for both the manure treated and conventional practice (5000 ETB/ton at the locality).Considering the economic status of farmers, using farmyard manure is considered an advisable management practice at the rate of 5–10 ton/ha (Asmare et al 2015).

Conclusions and Recommendations

The present study revealed that the manure application pasture land had better conditions than farmers' grazing site. The manure application site had significantly higher grass species composition and living plant basal cover. Present study has demonstrated that manure application is an important means of rehabilitating and renovating of herbaceous plant species. Quantitative analysis of diversity, fresh biomass and dry matter yield of herbaceous plant species recorded from the present study may provide baseline information for livestock feed resource projects, for evaluation of whether the manure application should be expanded, and for policymakers to take into account the value of manure application in their management decisions. Therefore, based on the present results, the authors recommended that manure application is an advisable and cheap strategy of natural pasture rehabilitation, and it should be widely practiced. Therefore consideration should be given for the expansion of manure application as a pasture land rehabilitation practice.

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2.3. Rehabilitation of Degraded Pasture Land through Demonstration of Urea Application: The Case of Ayba Kebelle, Southern Tigray, Ethiopia

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Abstract

The study was conducted in Ayba kebelle, Emba Alaje district in southern zone of Tigray region from June to October 2019 to demonstrate urea application in improving the productivity of degraded natural pasture land and to assess farmers' perception towards the technology. The study was carried out in a single plot design and a total of 60 quadrats of $0.5 \times 0.5\ m^2$ size were used for herbaceous vegetation data and analyzed by t-test equal variances using R-software. Generally, the study revealed that urea treated pasture land resulted significantly higher herbaceous species, diversity index, species richness and biomass production as compared to the conventional farmers' practice whereas the same attributes for forbs were found to be higher in the farmers' practice. Moreover, urea treated pasture land had also resulted the tallest plant height (72.6cm) as compared to the existing farmers' practice (48.1cm). Results from the financial analysis also indicated that urea application on the degraded pasture land was cost effective than the existing farmers' practice as the net return was found to be positive. Therefore, the study concluded that application of chemical fertilizer (urea) to pasture land as an intervention option for pasture land management has the potential to enhance herbaceous species rehabilitation and forge productivity where it generates better net returns at reasonable cost implications.

Key words: Botanical composition, forage yield, chemical fertilizer, perception

Introduction

The development of the livestock sub-sector in Ethiopia is hindered by many constraints, of which the unavailability of both quantity and quality feed is a major factor (Manaye et al 2009). The main feed resources for livestock in Ethiopia are natural pasture and crop residues, which are low in quantity and quality for sustainable animal production (Tessema et al 2002; Tessema and Baars 2004; Alemayehu 2004) also noted that more than 90% of the livestock feed is contributed by crop residues and natural pasture, this results in low growth rates, poor fertility and high mortality rates of ruminant animal (Odongo et al 2007). In order to solve the shortage of feed and increase livestock productivity, it is necessary to introduce new technologies to enhance quality forages with improved soil quality. Among the improved technologies introduced in pasture land in Ethiopia, urea application could play an important role in providing a significant amount of quality forage both under area enclosure.

The natural pasture, which accounts about 25% of total landmass of the country, contributes about 57% of the feed resources for ruminants. However, the productivity of the pasture lands in most parts of Ethiopia is extremely low (Ulfina 2013), due to seasonal fluctuation of rainfall and poor grazing land management, conversion of grazing lands in to crop lands, as a result of increased human population (Yadessa et al 2016). In addition, the available grazing lands are also overgrazed and unproductive due to continuous heavy grazing and mismanagement of grazing lands (Abule 2015), leading to low dry matter yield, which results critical shortage of animal feed, below the maintenance requirement of livestock throughout (Tessema et al 2010; Yadessa et al 2016). Soil fertility status of the grasslands is one of the factor that could contribute to the low productivity and quality of natural pasture (Adane and Berhan 2005; Yihalem et al 2005). However, improvement of degraded grasslands could be achieved through the application of organic and/or inorganic fertilizer (Tessema et al 2005; 2010). According to previous studies (Tessema 2005; Tessema et al 2010; Tesfay et al 2015) application of inorganic fertilizer can significantly improve the productivity and quality of grasslands in Ethiopia.

Even though the study area has high potential contribution to the smallholder's livestock production in the Southern of Tigray, poor productivity of the pasture lands both in quality and quantity of the grazing resource poses a great problem in livestock farming. This problem inevitably calls for improving the productivity of the pasture lands in that area. The specific objective of this study were to demonstrate urea application for improve the productivity of degraded natural pasture land and to assess farmers' perception on urea application technology on the natural pasture land improvements in the Southern highlands of Tigray.

Materials and Methods

Study area

The study was conduct at the highland of southern zone of Tigray, Emba alaje district, Ayba Peasant Association (PA). The altitude of the area is 2350 m a.s.l. with annual average rainfall of 912 mms and mean daily temperature ranges between 9–23 ºC. The rainfall is bi-modal with the

"Belg" rain (short rains) occurring in March to May and the "Meher" (main season) rains lasting from June to September. Major crop such as sorghum, teff, maize, wheat, barley, bean, linseed, onion, paper, cabbage, fruits are grown in the study area (Girmay et al 2014). Natural pasture is the major feed source in the area.

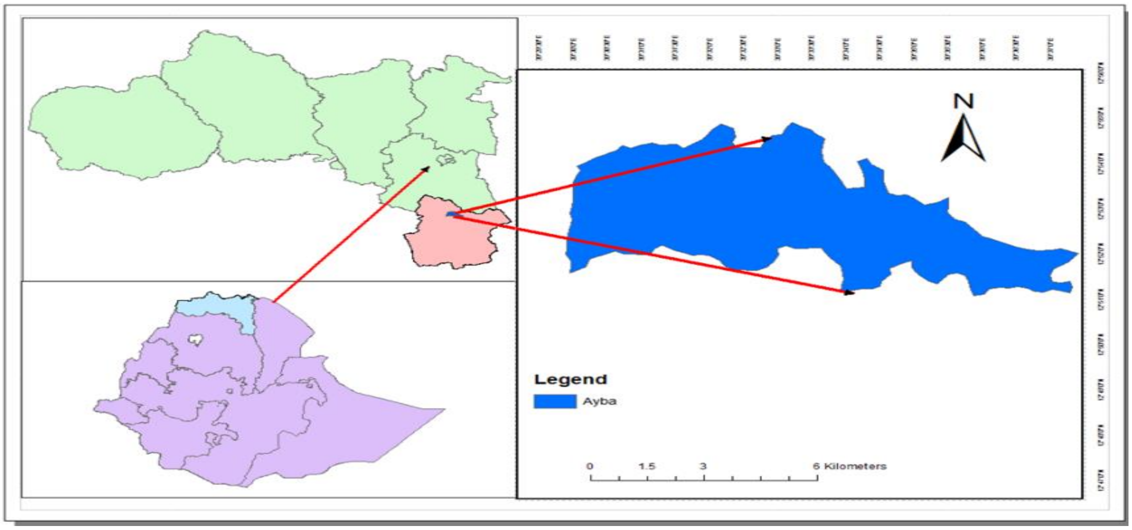

Figure 1. Map of study area (Ayba Kebele)

Site selection and management

Experimental area had been previously used as a common pasture land for many years. Later on, it was given for landless youth. A relatively flat field with less slop gradient variability was selected and demarcating before the execution of the experiment. The treatments (urea application and farmers' practice) were selected. Farmers' practice is a method of grazing livestock on a specific unit of land, where the animals have continuous, unrestricted access to the rangeland for a period of the year (referred to as growing season continuous grazing) (Vallentine 2001). An area were closed to livestock and protected by guards and bylaws against grazing and cutting during the wet season (two months) and grazed by livestock after two months. The protection from grazing is short-term and livestock are allowed to graze the enclosures when forage from the surrounding rangelands starts to decline (Verdoodt et al 2010).

Implementation of urea demonstration

After selecting the interested farmers, practical and theoretical training was provided to district experts, development agents and land less youth which enabled them to develop skill on the general management practice of pasture land. A total of 200 land less youth were participated and a total of 6.3ha were covered by urea application. Urea application was demonstrated in the interested land less youth that keep mainly dairy cattle. Participant farmers had prepared their own pasture land, which are used as inputs for the demonstration of the urea application and the Agricultural Growth Program (AGP) project was provided the raw materials like urea.

Figure 2. Urea top dressing

Study design and measurements

The study design was single plot design. The treatments for the study were farmers' practice and urea application. The amount of urea that are used in the experiment was 150 per ha. The size of experimental plot was 100 m^2 (10m x 10m). Data collected included biomass yield, perception data, pasture botanical composition, dry matter yield, species richness, and ground cover/basal cover. For determination of species composition, forage samples were harvested at the end of the day (104 days for urea application and 60 days for farmers' practice).

Forage sampling procedures

A sixty (two land use system×30 quadrats) 0.5cm × 0.5cm quadrat size were placed randomly in every plot. Botanical compositions and total dry matter yield were determined by harvesting from three times laid quadrats of size 0.5cm x 0.5cm from each plot randomly at its 50% flowering stage, at a height of 5cm near the ground. After harvesting, the total fresh weight of the forage sample from each quadrats was measured immediately for biomass yield determination using a sensitive balance. Furthermore, all species were listed, recorded and identified based on their leaf and stem structure and floristic (flowering) characteristics of each botanical component. Sub-samples representing 10% of the whole forage samples harvested from the treatments were taken for determination of dry matter yield. Identification of the species was undertaken with the assistance of local community farmers. The nomenclature was done by following (Fromann and Persson 1974) and (Edwards et al 2000). Herbaceous species were categorized into four palatability classes, as highly palatable (decreasers), palatable, less palatable (increasers), and unpalatable (invaders) based on the opinion of livestock owners. The average height of five random sampled plants in each quadrats was measured in centimeter from the ground surface to the top of the main stem at maturity (then the average was taken).

Dry matter yield

The dry matter yield of each quadrats was determined by drying a representative sample in an air dry for partial dry matter determination. The dry matter yield of each quadrats was converted to tons per hectare after drying. Dry matter production was calculated through the values of green production and dry weight percentage. Dry matter percentage = dry weight / fresh weight x100. The dry matter production (ton/ha) was calculated as (10 x TotFW x (DWss /HA x FWss)) (Tarawali et al 1995). Where, TotFW = Total fresh weight, DWss = reweight subsample, FWss = Fresh weight subsamples and HA = Harvesting area.

Basal cover

In each quadrat the basal cover or area (the area occupied at the intersections of the plant-soil interface) of the living plant parts were estimated. Basal estimation has done by clipping for clear observation, accordingly plants basal covers in the quadrats were cut, to facilitate visual estimation of basal cover of living plant parts. The basal cover rating of the quadrats was considered ‘excellent’ when completely filled (>75%), “good” when partially filled (60-74%), “poor” when 50-69% filled, “very poor” when <50% filled.

Herbaceous species diversity

Herbaceous species diversity was measured for individual land use of each quadrat and calculating an index based on the number of species and their abundance. The herbaceous species richness, alpha diversity and Simpson index were calculated by Magurran (1988) and Efron and Tibshirani (1993) formula. Shannon diversity index calculated by Kent and Coker (1992) formula:

$H = -\sum_{i=1}^{s} Pi \ln(Pi)$ Where: H'= Shannon diversity indices, S= the number of species, Pi=proportion of individual species and InPi=log proportion of individual species

Species evenness: - Species evenness (a measure of species balance) is a measure of the relative abundance of the different species making up the richness of an area. Equitability (E) calculated as follows:

$\text{Equitability (evenness)} = \frac{H}{H\ max}$ Where H'= Shannon diversity indices, S= the number of species, Hmax = is the maximum level of diversity possible within a given population, which equals lnS (ln number of species).

Sorensen's coefficient of similarity

Herbaceous vegetation heterogeneity was calculated from the *Beta* component of diversity, which was estimated by using the Sørensen similarity index between all pairs of $0.25m^2$ quadrats. This index ranges from zero (when the two compared sets are dissimilar and have not species in common) to one (in cases of complete similarity). In consequence, the higher this similarity coefficient, the lower the *Beta*-diversity or the species composition heterogeneity of the pasture stand. All similarity indices represent variations over three parameters: species composition in each of two sites and the species shared between the two sites (Novotny and Weiblen 2005). The widely used Sørensen similarity index (Magurran 2004) measures similarity in species composition for two sites, A and B, by the equation

$Sc = \left(\frac{2C}{A+B}\right) x100$ Where, Sc = Sorensen's similarity index, A = number of species in urea application site, B = number of species in the farmers' site, C = the number of species common in the urea application and in the farmers' pasture land.

Farmers' perception

Farmer's perception were collected from randomly selected 45 participant farmers through group discussion to compare the improved technology (urea application) and farmers' practice.

Financial analysis

The comparative analysis included the variable costs and benefits for the calculation. Net return was calculated to determine the profitability of urea application following Upton formula (Upton

1979). The gross field benefit per day was calculated by dividing the final sell of the biomass. 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). The cost was calculated based on cost needed for the different activities and in puts used for the application. However, the cost of harvesting and transporting ripe hay from pasture was not calculated.

Statistical analyses

Prior to further statistical analysis, normality and equality variance of the data was checked using Kolmogorov- Smirnov and Levene's test, respectively (Mekuria et al 2015). Data collected from herbaceous vegetation composition, species diversity, and aboveground biomass were analyzed by t-test with equal variances to determine if there were significant differences between means of the various herbaceous characteristics with respect to different land management practices using R-software version 3.3.3 (The R Core Team 2018). Significant differences were declared at $p \leq 0.05$. Farmers' perception was collected through participatory rural appraisal approach using group discussion and data were analyzed using SPSS version 20 and means comparison was tested using t-test of Independent Samples Test with Levene's Test for Equality of Variances.

Results and Discussion

Effect of urea application on the botanical composition of herbaceous species

Appropriate grassland management through fertilization makes it possible to improve the botanical composition and quality of the forage (Marie et al 2014). Species composition of pasture lands was observed to be diverse in the field study. A total of 16 herbaceous species were identified in the farmers' practice site, of which 8 were grasses, three were herbaceous legumes and five were forbs. Among the identified species, annuals and perennials consisted of 8 (50%) of them were found to be annuals while the remaining 8(50%) were perennial species indicating the severe degradation level of the experimental site prior to this study. Moreover, 4 species were found to be more palatable, 2 species medium palatable and 6 species less palatable to ruminant animals. On the other hand, 22 herbaceous species were identified in the urea treated plot/s. The functional group distribution of these species were 13 grasses, 5 legumes, and 4 forbs. Urea application increases grasses species composition of pasture land (Adane 2003; Tesfay et al 2015). This is because grass dominant pastures will give greater responses to N (Steele 2008) the percentage increase in the proportion of grass reflects the role of nitrogen fertilizer in influencing the grass-legume botanical composition in favor of grass growth. It also shows 89.16-90.75% of grass species composition is increased due to use of urea application (Tesfay et al 2015).

The effects of urea applications on ratios of legume, grass, and other plants in botanical composition were found to be different. The number of individual perennial grasses and legumes were higher at urea application than farmers' practice in the study area (Figure 3). The higher composition of the perennial grasses may imply the potential productive nature of the pasture land for livestock production (Amaha 2006). Similar results were reported by De-Val and Crawley (2005) indicating that in well managed areas highly desirable perennial grasses were found to be abundant. Livestock herbivory can cause shifts in plant species composition by replacing highly palatable grasses with unpalatable species (Rutherford et al 2012). Aydın and Uzun (2008) reported that the effects of urea applications on ratios of legume and grass in botanical composition were found to be significant higher.

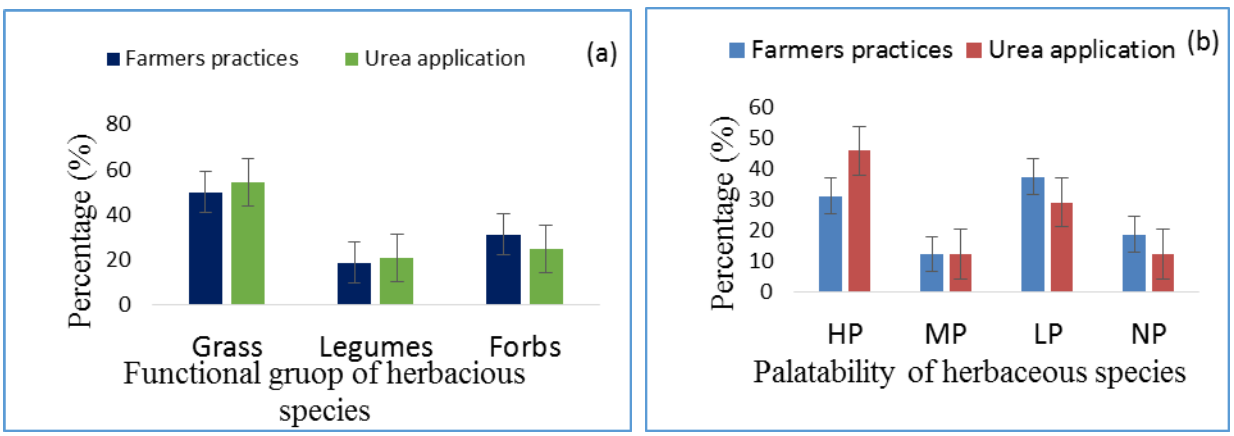

Figure 3. Functional group (a) and palatability (b) of herbaceous species in the two land use system (HP=highly palatable, LP= less palatable, MP= medium palatable, NP=non palatable)

The present result suggests that the main reason for a lower number of grass species in farmers' practice pasture land is the high grazing intensity and no fertilizer application. Hence, heavy grazing tends to reduce the presence of palatable species and consequently become dominated by other herbaceous plant or bushes (De Haan et al 1997). Ayana (1999) reported that species composition could depend on pasture management (intervention) and livestock population. Tessema et al (2011) also reported that the rapid disappearance of the perennial grass community and their subsequent replacement by annual herbs is due to the heavy grazing. Hence, selective grazing of palatable herbaceous plants by livestock enhances the growth of annuals and unpalatable herbaceous plants (Skarpe 1992) resulting in the decline of palatable species (Fensham et al 2010).

The forb herbaceous species proportion in the farmers' practice site was found to be higher than in the urea treated site (Figure 3). The urea untreated area (conventional grazing land) site was highly dominated by forbs, this is in line with prior studies (e.g., Sternberg et al 2000; Mphinyane et al 2008 and Kgosikoma 2011) reporting that herbaceous plants are highly responsive to grazing pressure. The increase in forbs in pasture lands threatens livestock production because encroaching forbs species suppress palatable grasses and herbs (Scholes and Archer 1997) through competition for soil moisture and nutrients. The proportion of forbs in farmers' practice plot was higher; this was due to the faster growth of annual weeds, which are pioneer plant communities in degraded ecosystems (Marie et al 2014).

Figure 4. Farmers' practice (right side) and urea application (left side)

Similarity in herbaceous species composition between the two land use systems

About 14 species out of 24 herbaceous species recorded in the urea treated sites were also found in the conventional practice. Urea treated plots had recorded 8 plant species while the conventional practice recorded only two. The Sorensen's similarities of herbaceous species in terms of species richness of the two land use systems were about 28%. This indicated a higher dissimilarity of herbaceous species between the two land use systems. This dissimilarity difference to some extent might have resulted from the management role provided by urea application in restoration of fast growing plants in degraded pasture lands.

Effect of urea application on the herbaceous Species diversity

The overall diversity of herbaceous plants is much higher in urea treated plots than the conventional practice, which may be a consequence of the high species richness in urea application (Table 1). The herbaceous species richness, Simpson and Shannon diversity index were significantly ($p<0.05$) higher in the urea application (17.67, 0.83 and 2.36) compared to the farmers' practice (9.7, 0.74 and 1.73), respectively (Table 1). The present result suggests that the main reason for low herbaceous species richness in farmers' practice are due to an intensively increase in grazing pressure (Sisay and Baars 2002; Desalew 2008; Angassa et al 2010); and heavy grazing, trampling and inappropriate management interventions (Amaha 2006), might lead to a reduction in herbaceous species diversity.

Figure 5. Cut and carrying system of top dressed pasture land

The value of herbaceous species evenness in the urea application and farmer practice were 0.83 and 0.74, respectively (Table 1), indicating significantly lower species evenness in the farmers' practice than the urea application ($p=0.001$). This could result from repeated habitat disturbances in the farmers' practice due to frequent and intensive interference of livestock for grazing. This might indicate that the existence of variations in species diversity was a result of the heterogeneous distribution of species due to urea application for vegetation rehabilitation factors. A low equitability/ evenness value means that there is the dominance of one or more species in the community. While high equitability/ evenness means that, there is a uniform distribution among the species in samples, demonstrating that individuals are well distributed (Cavalcanti and Larrazabal 2004). In agreement with the above statements, the species distribution in the urea application was uniform distribution among the species in sample than farmers' practice.

Table 1. Species diversity (mean) of pasture land treated with urea and untreated pasture land

Land use system	N	Alpha	Species richness	Shannon diversity index (H')	Dominance	Evenness	Simpson
Urea application	30	4.38	17.67	2.36	0.77	0.83	0.83
Farmers' practice	30	2.56	9.7	1.73	0.57	0.76	0.74
P value		<0.001	<0.001	<0.001	<0.001	0.02	<0.001

N= Number of quadrats

Effect of urea application on the total biomass yield and plant height of herbaceous species

There were significant variations in total fresh biomass yield of the natural pasture with the treatments ($P<0.001$) Table 2. Aboveground biomass of herbaceous species were higher in the urea application area than farmers' practice (17.24 and 10.15 ton/ha, respectively). The mean aboveground biomass yield measured in urea application was 69.85% higher than that of the adjacent farmers' practice. The mean fresh biomass yields recorded as a result of fertilizer application were the best, with what was recorded in farmers' practice plots. Chemical fertilizers improved total fresh biomass yield of natural pastures, which agrees with the finding of Yihalem (2004) reported from a well-managed natural pasture. According to Ahmed et al (2013) application of urea fertilizer increased hay yields of grasslands, because this fertilizer mineralized quickly to release N that fastened the growth of high proportions of grass species. The current study also agrees with the finding of Tessema et al (2010), Andic et al (2001) and Cahiti et al (2010) who reported that forage biomass yield production increased by chemical fertilizer application.

The results indicated that application urea for pasture plots resulted in increased biomass production in comparison with non-urea plots (farmers' practice). The increasing of forage yield following nutrient addition (urea application) was described by earlier study (Blonski et al 2004). A previous study showed that the application of urea could improve the native pasture land production (Mut 2009). The biomass production in the urea application areas better than the farmers' practice this might be due to better pasture land management practice (fertilizer application) in the areas, but the farmers' practice areas have deteriorated through continuous overgrazing and the mismanagement system of the community (Ahmed 2006; Ibrahim 2016). On the other hand, the highest scores for biomass were recorded at urea application sites reflecting the benefits of reduced disturbance such as the effects of heavy grazing, trampling, and inappropriate management interventions.

Figure 6. After urea application farmers were used cut and carrying system

The same trend was also observed with percentage cover where urea application site and farmers' practice had 2.57 and 1.47, respectively. The basal cover data demonstrated that there was significant variation (P< 0.001) between the land use types (Table 2). The result showed that the basal cover difference was in relation to variation in species composition between the land use types. The mean score exposed that the farmers' practice pasture land scored least mean basal cover, while the urea application pasture land attained the highest mean basal cover. Therefore, the present study confirmed that urea application would promote re-vegetation of various herbaceous species that might lead to higher basal cover.

Table 2. Fresh biomass, plant height, basal cover and dry matter yield ton/ha (mean) of urea application and adjacent farmers' practice pasture land

Land use system	N	Plant height (cm)	Fresh biomass	Dry matter percentage	Dry matter yield	Percent cover/basal cover
Urea application	30	103.93	17.24	74.49	4.27	2.57
Farmers' practice	30	33	10.15	66.22	2.93	1.47
P value		<0.001	<0.001	<0.001	<0.001	<0.001

N= Number of quadrats,

The plant height was significantly increased by treatment application (P<0.001) relative to the farmers' practice plot (Table 2). The tallest mean plant height (103.93cm) was recorded in plots treated with urea application, while the shortest (33cm) was observed under farmers' practice plot. This could be due to the fact that urea fertilizer quickly releases N which fastens plant growth (Ahmed et al 2013). Urea plays an important role in nutrient cycling which provides nutrients for plant growth (Nebi 2018.).

Fertilizers effects on herbage yield of pasture land

Dry matter yields were significantly ($p<0.001$) different among the treatments (urea application and farmers' practice) and higher results were obtained for application of urea (Table 2). Dry matter yields of herbaceous species were higher in the urea application area than farmers' practice (4.27 and 2.93 ton/ha, respectively). The mean dry matter yields measured in urea application was 45.73% higher than that of the adjacent farmers' practice. This is in agreement with results of Adane (2003). Urea application increase dry matter yields of pasture land (Adane 2003; Tesfay et al 2015). Earlier study in Ethiopia showed (Adane 2003; Ashagre 2008) that use of urea application increase dry matter yield range 3.45-5.14 ton/ha compared with control (1.75 to 2.31 ton/ha). The application of fertilizers on natural pasture has been shown to improve the herbage yields (Adane and Berhan 2005). Similarly, Hanife (2010); Yossif and Ibrahim (2013) reported application of fertilizer increased the forage yield of natural pasture. The total dry matter yield of fertilized plots of natural pasture was 9.47 ton/ha as compared to unfertilized plots which was 5.67 ton/ha (Adane and Berhan 2005).

Farmers' perception

During group discussion farmers reported that the community in Ayba pastureland did not used proper Pasture management except seasonal weed (invasive weed) and erosion control methods**.** The community used traditional local bylaw to manage the pastureland which did not included the pro poor concept. This means the resource rich households have the opportunity to use the pastureland, while the poor who have no animal does not have the chance to use from the pastureland. Based on the criteria mentioned by farmers in Table 3, farmers were reported that the urea applied pasture land has better grasses, good quality of forage and new varieties of forages has been emerged as compared with the field which was not applied urea in the their adjacent pastureland. The urea applied pastureland was recorded higher mean compare to the farmers' practice (Table 3). Hence, it is quit evidence that farmers in the Ayba kebelle clearly shows the effect of urea application on pasture land to boost production and productivity of the degraded pasture land. Therefore, this positive observation of farmers on the application of urea on pasture land has an implication for further scaling up of the practice in the whole pasture land Ayba kebelle and beyond in other kebelles in the district.

Table 3. Farmers' perception towards urea application

Parameters	Farmers' practice	Urea application	P-value	t-value
Amount of hay yield increased	1	4		
Forage quality enhanced	1	4		
Soil fertility improved	1	4		
Cost effectiveness	5	1		
Simplicity to apply	5	3		
Species compositions increased	1	4		
Basal cover enhanced	1	5		
Grass height increased	1	5		
Total score	16	33		
Mean	2	4.125	0.023	-2.55

NB: 1.Very poor 2. Poor 3. Good 4. Very good 5. Excellent

Financial analysis

Urea application to pasture land costs about ETB 2555 per hectare while the conventional practice had no any cost of production as indicated below (Table 4). Although urea treated forage production has cost implication, it yielded a higher dry mass harvested from this production method which also resulted in higher net benefit (ETB 18795) by fully recovering the costs incurred in the production process. This implies that demonstration of urea application had positive rate of return. Urea treated pasture land had shown about 28.3% additional net benefits over the conventional practice assuming the same price for both the urea treated and conventional practice (5000 ETB/ton at the locality). Hence, application of chemical fertilizer (urea) is beneficial to farmers as the expected net return and marginal rate of return were so attractive to invest more at time of dry season (Tesfay et al 2015, Nebi 2018).

Table 4. Costs and returns of urea treated and conventional practice in the study area (comparative analysis).

Variable costs	Urea treated (T1)	Conventional practice (T2)
Cost of fertilizer (urea) (ETB/Qt)	2355	0
Cost of urea application (ETB)	200	0
Total variable cost (TVC) (ETB)	2555	0
Yield of dry mass or hay (ton/ha)	4.27	2.93
Price of hay (ETB/ton)	5000	5000
Total return from sale of hay (ETB)	21350	14650
Net return obtained (ETB)	18795	14650
ΔTVC	2555	
ΔNR	4145	
Advantage over the technology in %	28.3	

ΔNR = change in net return; ΔTVC = change in total variable cost

Conclusion and Recommendation

Application of inorganic fertilizers such as urea application increased the botanical composition of herbaceous species; whereas, farmers practice decreased the botanical composition of herbaceous species and total dry matter yield production of the pasture land in the study area. This study showed that the application of urea on degraded pasture lands in the Southern zone of Tigray is a viable option to restore herbaceous vegetation composition, richness, diversity, and aboveground biomass. The study discovered that there is more accumulation of herbaceous diversity and richness in the urea application as a result of used improved pasture land management intervention (urea application) during the growing season, while in the farmers' practice, poor management intervention contributed to a reduction in herbaceous plants. Moreover, the study concluded that urea application is the potential option for future herbaceous palatable plant species improvement and conservation of key forage species. Therefore, based on the finding of the study it is highly recommended that the concerned governmental and nongovernmental organization should give emphasis to promote urea application for rehabilitation of degraded pasture land of southern Tigray region, Ethiopia.

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2.4. Demonstration of Urea Treatment Technology in Selected Kebeles of Western Zone of Tigray

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Abstract

The study was carried out to demonstrate the effect of urea treatment in enhancing the feeding value and utilization of sorghum stover as well as to investigate the perception of farmers towards the technology. It was conducted in four selected kebeles of Kafta Humera district in a total of four farmers' groups and one farmer group per selected kebele. Each group had a total of five members. Training on urea treatment procedures was given to the farmers and development agents before execution of the experiment. Urea and heavy plastic sheet and guiding manuals necessary for urea treatment preparation were provided to participating farmers. Permanent meeting, once per week, were made with group members to discuss problems and to suggest solutions. All necessary data, such as feed intake, milk yield of cows and farmers' perception were collected during the field visit. Urea treatment technology significantly increased the average daily milk yield of the milking cows from 2.39 to 3.85 liter with the average daily increment of 1.46 liter (61.1%). MRR analysis indicated each additional unit of one Birr per cow's cost increment resulted in 1.84 Birr benefit for feeding of urea treated sorghum stover as a supplement. Urea treatment increased sorghum stover intake, reduces sorghum stover wastage and improves the milk yield and body conditions of the lactating local cows. Thus, it is recommended that urea treatment technology together with affordable improved feed choppers should be introduced to wider areas for further popularization and scaling up of the technology.

Key words: Milk yield, feed intake, sorghum stover, perception, body condition

Introduction

Cereal crop residues, also called stover or straw, are the parts of the plant remaining after the grain crop has been harvested. They include the leaves and stems. Cereal residues can be collected and removed from the field, then chopped and stored for feeding animals during periods when range grazing is unavailable. Apart from being a source of animal feed, crop residues are used as building, roofing and fencing materials, as fuel and as fertilizer or surface mulch on crops.

Under Ethiopian context, crop residues form an integral part of feed resources especially during the dry season. The type of crop residues available for livestock feed depends on the agro-ecology or the farming system prevailing in an area. In the medium and low lands areas, residues of maize and sorghum are the dominant ones while in the medium and high land areas, tef, barley and wheat straws are the major crop residues used to augment the year round feed budget (Seyoum Bediye 1997).

Nowadays the demand of crop residues as livestock feed becomes higher because the area of the crop production is increased to feed the extremely growing human population, the size of grazing areas declines and over grazing is aggravated there by the feed shortage becomes a serious problem. This feed shortage problem is one of the major bottle nicks responsible for low productive and reproductive performance of animals.

Crop residues are characteristically low in crude protein content but high cell wall and cell wall constituents. Their crude protein content is lower than the threshold required for maintaining the nitrogen balance of the animal in the positive side (Seyoum Bediye 1997). As a result digestibility is low, rate of passage is low and voluntary feed intake is limited. The nutritive value, intake and digestibility of crop residues could be effectively improved by chopping, chemical treatments or supplementation with concentrates or molasses or other energy and protein rich feeds (Kategile et al 1981; Kifle Wahid et al 1983; Wanapat and Devendra 1985). Nevertheless these are not all available at all or expensive to purchase in the area.

Sorghum stover is by far the most popular ruminant feed in the western zone of Tigray. However, because its digestible crude protein content is low, animals fed only this forage do not perform well. Supplementing poor quality forages (sorghum & sesame stover) with feeds of high protein and energy improves the utilization of the Stover and performance of animal fed on it (Mohammed et al 1992).

Crop residues can be chopped up and mixed with molasses or treated with urea to make them more palatable, digestible and to improve their value as feed. Treating cereal straws with urea or mixing with molasses before feeding it to the animals will help them gain weight (Gashew and Getachew 1997). Therefore this study was carried out to demonstrate the effect of urea treatment in enhancing the feeding value and utilization of sorghum stover as well as to investigate the perception of farmers towards the technology in improving the milk yield of their lactating cows.

Materials and Methods

Description of the study areas

The demonstration of the urea treatment was carried out in four selected lowland kebeles of Kafta humera wereda of western zone of Tigray namely Adebay, Rawian, Maykadra and Bereket (Figure 1). The district is located 585 km from Mekelle, the capital city of Tigray region, Ethiopia. Kafta Humera accounts 49.13% of the total area coverage of Western zone of Tigray (HuARC, Unpublished). The wereda consists of two agro-ecological zones (midland and lowland) in which kolla (lowland) represents 85.7% and weynadega (midland) accounts for 14.3% of the land coverage of the district.

The geographic location of the district lies within the co-ordinates of 13^0 40'- 14^0 27' north latitude and 36^0 27'-37^0 32' east longitude. The agro-ecology of the Zone is hot to warm semi-arid lowland plains which are characterized by hot temperature, erratic rainfall, vast area of plain lowlands suitable for large scale and subsistence agriculture including crop and livestock. It has unimodal rainfall pattern and the annual rainfall is 448.8.5mm. The mean annual temperature of the area is 25oC to 27.5 oC (EARO 2002). The altitude of the district ranges from 500- 1850 m.a.s.l. The district shares borders with Tsegede in the south, Sudan in west and then the Tekeze River which separates Kafta Humera from Eritrea on the north and Sheraro on the East and on the southeast by Welkait. The study area represents a remote, tropical climate where extensive agriculture is performed manually by large numbers of migrant laborers.

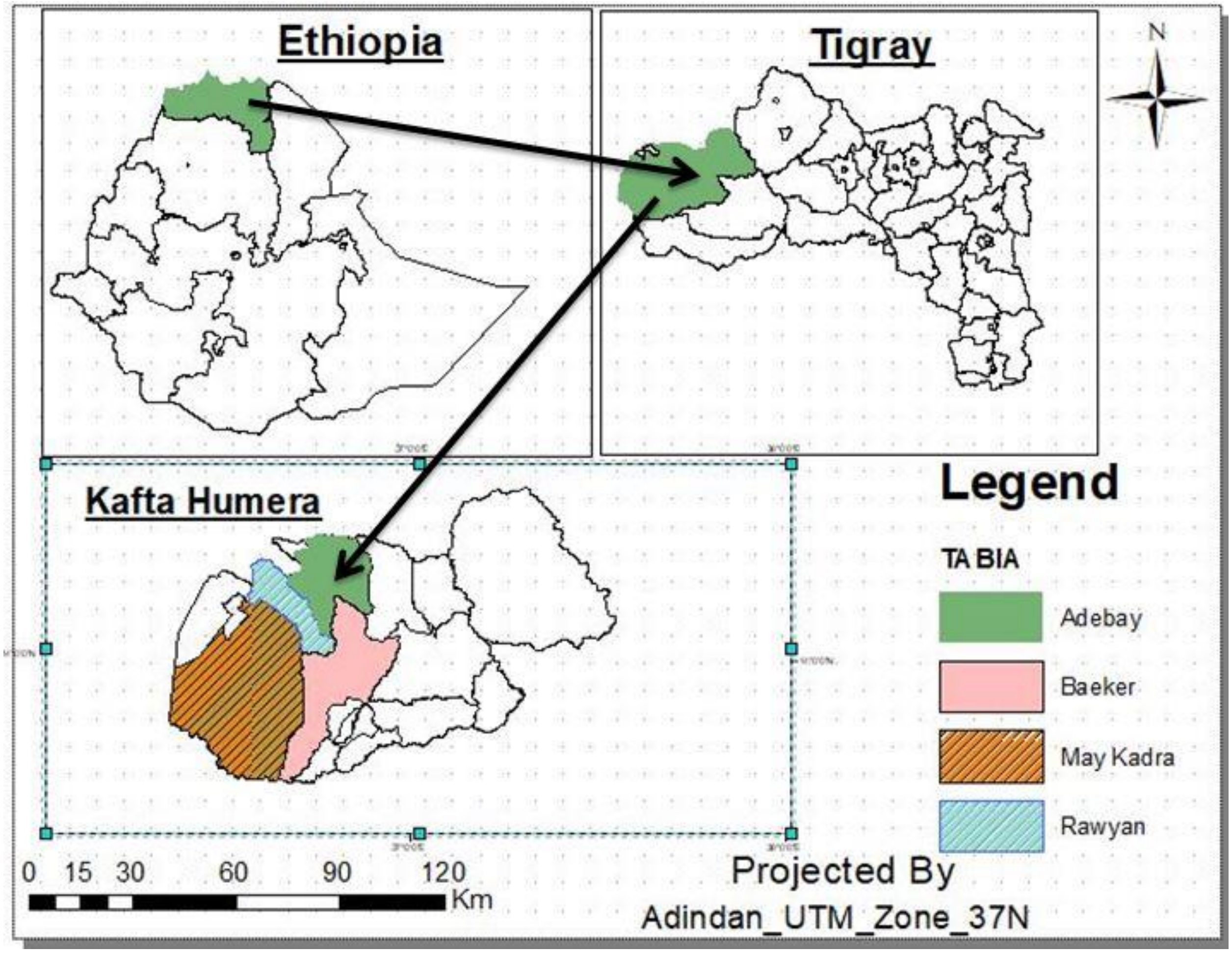

Figure 1: Map of study Kebeles

Farmers' selection and training

Four farmers' groups containing interested member farmers were established in four selected kebeles of kafta humera (Adebay, Rawian, Baeker and Maykadra) wereda of western zone of Tigray. There was one farmers' group in each selected kebeles. Each group had a total of four members of which one was elected as team leader for effective communication between researchers and community members. Before execution of the experiment, training concerning urea treatment preparation procedures was given for the members of farmers' group and the development agents of each selected kebeles for about two days. All input materials (urea & heavy plastic sheet) and guiding manuals necessary for urea treatment preparation were provided and the farmers were encouraged to design and implement together with researchers. Technical advice for team leaders and group members was given during field visit and through training and recurrent meetings. Permanent meetings once per a week were made to discuss problems and to suggest solutions being with group members. In most cases, extension workers were playing the role of facilitating while the actual implementation and routine work was left to the farmers themselves.

Procedures for preparation of urea treated stover

The procedures followed for preparation of urea treated sorghum stover is indicated below:

- ✓ A pit with a dimension of 1m x1mx2m (length, width and height) was manually prepared using a hoe.
- ✓ The sorghum Stover was manually chopped in to 2-3 cm length using an axle.
- ✓ Spread a layer of chopped stover on large, thick plastic sheet and sprinkled it with a mixture of urea and water
- ✓ Added another layer for stover and sprinkled with more urea and water. Repeated for several layers. For 100kg of straw, you would need 50 liters of water and 4-kg of urea.
- ✓ Wrapped the plastic sheet over the top and sides of the pile so it was sealed completely. Put a stone on it to kept it air tight
- ✓ The stover was sealed for two weeks (14 days).
- ✓ Before feeding, opened the sheet and took out enough treated stover for a day and then covered the rest of the stack with the plastic sheet.

The stover that had been taken out from the pit was left for about 20 minutes until the ammonia smell disappeared and then it was offered to animals.

Experimental animals and feeding management:

Experimental animals: A total of fifteen begait lactating cows of interested farmers (one per a farmer) at mid lactation (5-8 weeks after calving) were selected purposively for the demonstration feeding trial based on the farmers' willingness. The selected cows were in the second parity and dewormed against internal & external parasites prior to the execution of the demonstration.

Experimental feeds and feeding: Grazing, adlib untreated sorghum stover and 6 kg treated stover were given daily. The level of urea treated stover supplementation for the dairy lactating begait cows was decided based on the recommendation developed by the Ethiopia Sheep and Goat Productivity Improvement Program (Alemu 2008). Selected begait cows were offered 3kg treated stover mixed with the untreated stover at 2 h in the morning before they were allowed to graze and they were also offered 3 kg treated stover mixed with the untreated stover at 12 hour in the evening before they rested. Each selected dairy lactating cows was supplemented with urea treated stover for a consecutive thirty (30) days.

Data collection

The data that were collected in the demonstration included:

Farmers' perception: The Farmer' attitude to the urea treatment technology was assessed through a prepared checklist at the end of the demonstration.

Milk yield: Initial daily milk yield of the selected lactating begait cows before they were supplemented with urea treated sorghum stover was recorded for about 20 consecutive days. Similarly, the final daily milk yield of the lactating begait cows after they were supplemented with urea treated sorghum stover was recorded for 30 consecutive days.

Body condition: The body condition of the lactating cows before and after they fed urea treated sorghum stover was visually observed based on the change of skin hair smoothness.

Feed intake: A weighted amount of feed (both untreated and treated sorghum stover) was offered twice per day at 8: 00 am in the morning before the lactating begait cows allowed to graze and 5: 00 pm in the afternoon before they allowed to rest. For each selected lactating cow, the feed offered and refusal were recorded. The amount of feed consumed was determined as the difference between the feed offered and refusal on dry matter basis.

Partial budget analysis

The partial budget analysis was performed to evaluate the economic advantage of the urea treatment using the procedures of CIMMIT (1988). The analysis involved the calculation the variable costs and the benefits obtained from the result. At the beginning of the demonstration, the purchase prices of urea treatment materials (heavy plastic, Urea, water) were recorded. During the whole demonstration period, the milk production of each lactating begait cows and the selling price of milk per a head were recorded. The partial budget analysis method measures profit or losses, which were the net benefits or differences between gains and losses for the proposed change and includes calculating net return (NR), i.e., the amount of money left when total variable costs (TVC) were subtracted from the total returns (TR).

NR (Birr) = TR-TVC……………………………………Equation 1

Total variable costs include the costs of all inputs that change due to the change in production technology. The change in net return (ΔNR) was calculated by the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC), and this was used as a reference criterion for decision on the adoption of a new technology:

ΔNR = ΔTR- ΔTVC………………………………………Equation 2

The marginal rate of return (MRR) measures the increase in net income (ΔNR) associated with each additional unit of expenditure (ΔTVC). This was expressed by percentage.

$$MRR\ (\%) = \frac{\Delta NR}{\Delta TVC} \times 100 \quad \text{………………………… Equation 3}$$

Duration, monitoring and data recording

The data were recorded over a period of 30 days after an adaptation period of fourteen days.

Field visits were carried out once per a week to monitor the feed intake and milk yield of the lactating cows. Change on body conditions of the lactating cows were visually assessed based on the changes on the skin hair smoothness. The farmers themselves recorded the intake of untreated and treated sorghum stover and daily milk yield on data recording sheet prepared with local language (Tigrigna).

Statistical analysis

Paired t-test of SPSS 22 was used to analyze the change in milk yield and feed intake of the sorghum stover before and after the cows fed urea treated stover (SPSS, 2013)

Result and Discussion

Response of lactating cows to urea treated sorghum stover

Result of the demonstration indicated that urea treatment technology significantly ($P < 0.0001$) increased the average daily milk yield of the milking cows of FRG members from 2.39±1.30 liter to 3.85±1.02 liter with the average daily increment of 1.46±0.54 liter (61.1%) (Table 1). This positive effect of urea treatment on milk yield of the lactating cows was in support of previous studies (Teshome 2009; Gunnum et al 2013; Gelane 2017 and Lemma and Endalew 2017). The milk yield of begait lactating cows supplemented with urea treated sorghum stover was higher than that reported by Teshome (2009) and Lemma and Endalew (2017) on Fogera cows supplemented with urea treated rice straw in Ethiopia but lower than those reports by Wanapat et al (2013), Gunnum et al (2013) and Gelane (2017) on Holstein cross bred dairy cows supplemented with urea treated rice straw in Australia, Thailand and Ethiopia, respectively. The variation in the milk yield of lactating dairy cows supplemented with urea treated crop residues in different areas might be the variations in the type of crop residue used, lactation stage and parity and breeds of the dairy cows used ,study time and others.

Table 1: Average milk yield of Begait Dairy cows (Mean ±SD liter/day) at mid lactation before and after they fed urea treated sorghum stover

Number of farmers	Cows per member	Milk yield (liter/day)			P-value
		Before fed Urea-treated stover	After fed Urea-treated stover	Difference (%)	
15	1	2.39±1.30	3.85±1.02	1.46±0.54	0.000*

* Significant at P <0.0001

Feed intake

The dry matter intake of lactating begait cows supplemented with urea treated sorghum stover is presented in table 2. The daily dry matter intake of treated sorghum stover by urea was significantly (P<0.05) higher than untreated sorghum stover. The dry matter intake of sorghum stover in the current study is somewhat agrees with the findings of Parnich (1983) who reported that the daily feed intake of treated and untreated rice straw in the lactating cows was 5.65kg and 4.91kg, respectively. However, the intake of sorghum stover in the demonstration was significantly higher than the intake of maize stover in crossbreed heifers by Sekhonyana and Fulpagare (2015) but lower than the intake of rice straw reported by Wanapat et al (2013) and Lemma and Endalew (2017) and the intake of teff straw by Dejene et al (2009). The variation in the feed intake of urea treated crop residues in different areas might be the variations in the type of crop residue used, lactation stage and parity and breeds of the dairy cows used ,study time and others. Moreover, In Ethiopia, it was also found that urea treatment was more effective in improving the chemical composition (Crude protein and mineral matter) and degradability of sorghum stover (Daniel *et al*., 2017). Urea has got a considerable attention in ruminant nutrition because it improves the palatability of the treated crop residue by solubilizing the Hemicellulose fractions, thus improving the DM digestibility and daily DM intake (Mir et al 1991; Jabbare et al 2009 and Ali et al 2012).

Table 2: Feed intake of untreated and treated sorghum stover (Kg DM/cow/day) (Mean ±SEM)

Parameters	DMI (Kg/cow/day)
Untreated Stover	4.42±0.1
Treated stover	5.75±0.1

Farmers perception

Farmers' involved in this experiment (FRG members) appreciated the technology. They responded that it had a great advantage because it gave a promising result in milk yield, reduces feed wastage as it improves the palatability of the stover and brought a visible change in body conditions of the experimental cows and their calves (Table 3). Some of the FRG members also tried to compare milk yield obtained while supplementing sesame seed cake and urea treated sorghum stover. The milk yield obtained was similar in both cases. Moreover, they were highly interested to make themselves ready to prepare urea treated stover enough for the animals they have with their own urea and heavy plastic sheet for the whole dry season of every year if they get affordable improved chopper. In their conclusion remarks, they also added that they are eager to purchase affordable improved choppers either individually or in cooperatively whenever there is supply of choppers.

Experience sharing on urea treatment was carried out in collaboration with the extension workers of the study kebeles. During the experience sharing, all participants appreciated the technology. They said that they had no information about this technology before and then they were highly interested to practice it to maximize milk yield of their dairy cows and utilization of the sorghum stover if the technology is full package technology. According to the participants, full package technology meant the urea treatment technology together with improved chopper for minimizing the time spent and huge labour required for chopping the sorghum stover manually during preparation of urea treated stover. The farmers also finally concluded that urea treatment technology without chopper is half technology because it is labour intensive and time consuming for the chopping the sorghum stover manually.

Table 3: Farmers' perception towards Urea treatment

Attributes		Animal Preferences, N (%)		
		Less preferred	Moderately preferred	Highly preferred
Untreated Stover		30(100%)	-	-
Treated Stover before they adapted		30(100%)	-	-
Treated Stover after they adapted		-	2(6.7%)	28(93.3%)
		Palatability, N (%)		
		Less palatable	Moderately palatable	Highly palatable
Untreated Stover		30(100%)	-	-
Treated Stover before they adapted		30(100%)	-	-
Treated Stover after they adapted		-	2(6.7%)	28(93.3%)
Change in body condition of cows after they fed treated stover			No change	Improved
	Cows		-	30(100%)
	Calves		4(13.3%)	26(86.7%)
Change in the feed intake of sorghum stover after they fed treated stover			No change	Increased
			-	30(100%)
Sorghum Stover wastage while cows feeding treated stover			No change	Reduced
			5(16.7%)	25(83.3%)

Partial budget analysis

The partial budget analysis of the urea treatment technology is presented in table 3.The results suggested that supplementation of cows with urea treated sorghum stover was more profitable than supplemented with untreated sorghum stover. Higher net return and change in net return observed in urea treated sorghum stover feeding cows and this could be due to improvement of the nutrient content of the stover. Feeding urea treated sorghum stover as a supplement was more expensive compared to the corresponding costs for untreated sorghum stover. The costs in sorghum stover urea treatment were mainly pit preparation, urea purchasing, and chopping. Marginal rate of return measures the increase in net income and effects of additional investment in a new technology on additional net return.

The partial budget analysis indicated that urea treated had higher MRR compared to the untreated one, which is due to the improvement of milk yields of the cows. Based on the result MRR analysis, each additional unit of one birr per cow's cost increment resulted in 1.84 birr benefit for feeding of urea treated sorghum stover as a supplement. This indicated that cows fed with urea treated sorghum straw performed well and had a higher milk yield and sold at premium price and earn better net return.

Table 4: Partial budget analyses of Urea treatment technology

	Untreated	Treated
Number of cows	15	15
Purchase price of sorghum stover (ETB/head)	0	0
Total sorghum stover intake (kg)	1500	1500
Total urea intake(kg)	0	4
Cost of sorghum stover (ETB/head)	0	0
Cost of labor (ETB/head)	0	200
Cost of urea (ETB/head)	0	40
Cost of water	0	30
Total variable cost (ETB/head)	0	274
∆ TVC	0	274
Total milk produced(liter)	1075.5	1732.5
Milk production (litr/head)	71.7	115.5
Selling price of milk (ETB/head)	1720.8	2772
Total Rate of return(TRR)	1720.8	2498
∆TRR	0	777.2
Net return (NR)(ETB/head)	1720.8	2224
∆NR	0	503.2
Marginal rate of return (MRR %)	0	183.65

Conclusion and Recommendation

Based on the milk yield and body condition improvements because of urea treatment technology and positive perception of farmers, urea treatment increases voluntary sorghum stover intake and palatability, reduces sorghum stover wastage and improves the milk yield and body conditions of the lactating local cows. Thus, it is recommended that urea treatment together with affordable improved choppers should be introduced to wider areas for further popularization and scaling up and out of the technology. It is practically more applicable in dry season (January to mid-June) when there is quality feed shortage. Dry season is the critical time for feeding Urea treated sorghum stover for lactating cows and any ruminant animals to ensure sustainable improved ruminant production. Based on MRR analysis, each additional unit of one birr per cow's cost increment resulted in 1.84 birr benefit for feeding of urea treated sorghum stover as a supplement. This indicated that cows fed with urea treated sorghum straw performed well and had a higher milk yield and sold at premium price and earn better net return.

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