SOIL & CROP SCIENCES | RESEARCH ARTICLE

Farmers’ utilization practice, yield and chemical composition of selected improved forages grown in natural resource management areas of Farta District, South Gondar Zone, Ethiopia

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Abstract: The study was conducted with the objective of assessing farmers’ utilization practice, yield and chemical composition of selected improved forages grown in natural resource management areas of Farta District, Ethiopia. The methodology of this study encompassed questionnaire survey, group discussion, field measurement and laboratory analysis. Simple random sampling was used to select a sample consisting of 100 households in the district. Forage samples were collected from three sample places in mid and highlands Kebeles (lower level political administration in Ethiopia). Samples of forages were taken after 2 months of equal cutting and used to determine the biomass yield and chemical composition. The collected data were analyzed by SPSS and SAS software. The result indicated that of the total respondents 91% and 88% of in high land and midlands, respectively, did not use any forage improvement practice after plantation. Concerning forage utilization as feed, 96 and-94% in the high and midland, respectively, practiced cut and carry system. From the sampled forages, a biomass DM yield of Sesbania sesban in

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PUBLIC INTEREST STATEMENT

In Ethiopia, due to the inconsistency of feed quality and quantity, livestock perform poor especially in dry seasons of the. This condition calls for integration of improved forage that could have several advantages over conventional feed resources available. Though improved forages were being introduced as biological soil conservation and animal fodder in government intervention areas of Ethiopia, little is known about how farmers perceive the production and utilization of such forages. Farmers’ perceptions about technology were one of the factors, which can facilitate or undermine adoption of improved forage technology; proceed to the types of improved forages grown on natural resource conservation areas of an agro-ecological zone and institutional factors individual farmers from using the feed resource management technology. The study aims to analyze farmers’ perceptions, assess the utilization practice and identify production and utilization of improved forages grown on soil conservation areas of selected of Farta district, Ethiopia.
highland midland of the study area was 7.8 and 7.64t/ha, Elephant grass 14.28t/ha and 13.84t/ha and Tree Lucerne 7.65t/ha and 7.4t/ha, respectively. The crude protein (CP) content of sample forages was varying from 8.02% in Elephant grass to 25.9% in Sesbania sesban. Overall, improved forages grown in natural resource management areas have a very important function in terms of contribution of nutrients to livestock and indirectly for the household economy in both mid and highland areas. Hence, intervention on management and utilization of forages grown in the natural resource areas is crucial to exploit the resources.

Subjects: Agriculture; Environmental Sciences; Forestry
Keywords: DM yield; chemical composition; improved forage; natural resources

1. Introduction

Livestock production is an important and integral part of the agricultural sector in Ethiopia (Assefa, Nurjeta, & Banerjee, 2013; CSA (Central Static Agency), 2016). The majority of livestock are dependent on variety of feed resources which vary both in quantity and quality throughout the year. For optimum livestock productivity, however, the availability of feed resources should match with the number of animals in a given area (Assefa et al., 2013).

In the highland areas of the country, livestock feed resources are either unavailable or are of insufficient quantities due to fluctuation weather conditions. This results in poor quality, which does not provide adequate nutrition for the livestock. These constraints result in low performance of livestock (Gebremedhin, Ahmed, & Ehiu, 2003). Proper uses of improved forages can help not only mitigate livestock feed shortages but also help to reduce pressure on natural pastures, support system substantially and enhance natural assets and system reliance (Nigussie & Alemayehu, 2013).

Despite different forages that have been introduced long ago; these resources have not been well managed and used in the highlands of Ethiopia. Natural resource management areas are used as feed source for livestock and help to rehabilitate the land by appropriate interventions. Though there are many important types of forage in these areas, there is little or no information concerning the status of smallholder farmers’ utilization practice, feed contribution (yield) and chemical composition of different forages available. However, the information would help to properly plan on the utilization status and design interventions to maintain the productivity of these areas that in turn increase livestock and crop productivity or maintain ecosystem health. Hence, this research was conducted with the aim to assess farmer utilization practice, yield and nutritive value of improved forages grown in the natural resource areas of Farta District, South Gondar Zone, Ethiopia.

2. Materials and methods

2.1. Description of the study areas

The study was conducted in Amhara National Regional State, South Gondar Zone in Farta district, Ethiopia (Figure 1). It is located 100km North-East of Bohir Dar, capital city of Amhara National Regional State. Geographically Farta district is located in northwestern Ethiopia and stretches between 09°36’ N latitude and 39°30’ E. The district has the total land area of 107,076.6 ha with an elevation ranging from 1920-4135masl. In the study, there are 41 kebeles (lower level of local administration in Ethiopia) were included. From them 52% of the kebele falls under the Highland (Dega) agro-ecological zone, which is characterized by severe frost attack every year from October to December.

The study site has a bimodal rainfall distribution with short and long rainy seasons covering from March to April and June to September, respectively. The district receives an average annual rainfall of 900-1099 mm with annual temperatures are 9–25°C, respectively. Topography of the district
comprises 29% flat land, 45% mountain and hills, and 26% valley bottom. Out of the total area of the district 11,567.98 ha and 1140 ha belong to grazing land and bush and shrubs, respectively (FDOA, 2016).

2.2. Data collection

2.2.1. Assessment of farmers’ perception

For the purpose of study, kebeles were stratified into two based on agro-ecological differences (high and midland). The high land and midland study kebele were represented by Wowa Magera and Kolay Dengorse, from which three were natural resource conservation sites were purposively selected. The total sample size of households selected for the study was 3047. Out of these total populations, based on the Cochran formula, the sample size of the study was calculated as follows:

\[ n = \frac{N}{1 + N(e^2)} \]

where:

- \( n \) = represents sample size, \( N \) = represents total number of households of in the study area, \( e \) = represents maximum variability or marginal error (10%) or 0.01, \( 1 \) = represents the probability of the event occurring.
2.2.2. Survey data collection

To assess farmer's utilization systems of selected improved forages in the study area, socio-economic raw data were mandatory. Such data were collected by questionnaire, focused group discussion, personal communications, field observation and documents review methods were used. The household questionnaires were designed in line with stated specific objectives. The questionnaire includes diverse issues that could provide understanding of the socio-economic attributes of the study households and their utilization systems.

2.2.3. Forage sampling

Sample forages in natural resource management areas Sesbania (Sesbania sesban), Elephant grass (Pennisetum purpureum) and Tree Lucerne (Chamaecytisus palmensis) species were sampled by using quadrant method (1 m × 1 m). Representative samples of forages were taken from three different area closures and then samples were mixed together and finally weighed by a spring balance.

2.3. Chemical analysis of forages

Representative samples of selected improved forages were taken starting from highland to midland by 1-day gap after 45 days of equal cutting. At the time of cutting, the edible parts of the forage (leaf and stem) parts were collected from different sampling places. After weighing the biomass yield samples were mix together and -300 g of representative samples were used for laboratory work. The air-dried samples were analyzed for Dry Matter (DM), Ash, Crude Protein (CP), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL).

2.4. Data analysis

The collected data were analyzed using Statistical Analysis System software (SAS, 2002). Descriptive statistics were employed to describe qualitative variables and means separation was done. Chi-square test (P-value) was used to test the level of significance.

The following statistical Model was used: \[ Y_{ij} = \mu + a_i + e_{ij} \]

where \( Y_{ij} \) = means for response variable; \( \mu \) = overall mean; \( a \) = effects of agro-ecology (high land and midland)

\( e \) = error term

3. Results and discussion

3.1. Socio-economic characteristics

3.1.1. Household characteristics

Out of the interviewed households heads in the highlands, 83% and 17% were male and female whereas in midland 87% and 13% were male and female (Table 1). The average age of the interviewed household heads were 45.18 ± 1.4 and 42.14 ± 1.7 years in high and midland areas, respectively, and ranged from 28 to 73 years. In addition, from the interviewed household heads in both agro-ecologies, 98% of the household heads are Orthodox Christian followers.

Low level of education and high illiteracy rate in highland and midland of the study area has a typical impact in the general life of the households. The overall educational status of respondents in study area, 64% of the sample household heads were illiterate, 23.7% of the respondents were literate (1–4), 9.7% were literate (5–8) primary education, 2.6% of the participants were (9–12) junior secondary education. Based on the result, majority of the household heads were illiterate, this indicates that it makes difficult to apply the overall extension services in agricultural production.
Improved forage production was significantly (p < 0.05) affected by level of education of the household heads in both high and mid-altitude areas.

(Table 1). The range of family size per household across the interviewed households was a maximum of 7 ± 0.6 and minimum of 1 ± 0.4 (mean±SD). This indicates that when level of household heads educational status and family size increases, participation in modern livestock production system and improved forage production also increases.

3.1.2. Landholding and land-use systems
In the study area, the main landholding systems are communal and private holdings systems with different land-use systems.

Thus, the overall average private landholding per household in the study area were −1.26 ± 0.04 ha (Table 2). This figure is slightly higher than 1.00 ha reported for smallholder farmers in East Gojjam Zone Enebsie Sar Mider District (Addisu et al., 2016). Based on the survey result, improved forage production in natural resource conservation areas significantly (p < 0.05) affected by private landholdings. This is due to majority of improved forages was cultivated at private landholdings of natural resource conservation areas. In general, household in the midland (1.33 ± 0.02 ha) agro-ecological zone had better total private landholding than households of highland (1.2 ± 0.02 ha) agro-ecology of the study district (Table 2). This might be the existence of high human population in the high altitude and majority of the area in high land agroecology is more undulated and mountainous which is unsuitable for agricultural activities. In both study areas, from different land use practices, the largest share of land use is for crop production-1.1 ± 0.04 ha.

The land allocated for private grazing land in the study area was too small 0.23 ± 0.04 ha. This is due to shortage of land in which much of the land is allocated for cereal crop production mainly and the attitude that crop residue could be used as livestock feed source. On the other hand, the land which allocated for improved forage production in the study areas is higher than that of private grazing land 0.92 ± 0.04 ha in comparison it is slightly higher in high land which might be due to its topography, it is venerability towards soil erosion. Contradicting this finding is the result in East Gojijam Zone Enebsie Sar Mider district and for improved forage is too lower than that of the result in the study area-0.01 ± 0.004 (Endalew et al., 2016). This might be due to the fact that

| Household variables | Agro-ecology | Total N = 100 | Chi-square value |
|---------------------|--------------|---------------|-----------------|
|                     | Highland     | Midland       | N = 100         |                 |
| Sex                 | N = 50       | N = 50        | N = 100         |                 |
| Male                | 83%          | 87%           | 85%             |                 |
| Female              | 17%          | 13%           | 15%             |                 |
| Educational status  | N = 50       | N = 50        | N = 100         | 0.014**         |
| Illiterate          |              |               | 64%             |                 |
| Literate (1–4)      |              |               | 23.7%           |                 |
| Literate (5–8)      |              |               | 9.7%            |                 |
| Junior secondary education (9–12)| |               | 2.6%            |                 |

N = number of respondents, % = percent of respondents and * and **, shows significant at 5% and 1% level, respectively.
The majority of grazing lands were protected through natural resource rehabilitation measures through improved forage plantation in the study area.

### 3.1.3. Livestock holding and their utility

Livestock production is an important component of farming system in the study district. The population size of livestock owned by respondents could be an indicator of wealth status of the household in agreement with earlier reports in other areas of the country (Sisay, 2006). Among the species of livestock found in the area were: Cattle, sheep, goat, equines, and poultry and honey bee colonies. The average livestock holding per household was 5.8 ± 0.271 TLU. The livestock holding per household in the study area was less than the finding of Sisay (2006) in north Gondar district which was 7.06 and 7.23 TLU in high and midland areas, respectively. This is due to the shortage of grazing land that in turn affects the livestock holdings of households as indicated by Alemayhu (2016).

Among the species livestock kept by respondents, poultry and sheep are of the largest in terms of population size followed by cattle. The trend of livestock holding per household had decreased in the past decade which might be due to lack of feed and lack of labor to manage livestock in the study area. This is in agreement with the findings of Asmare and Meheret (2018) which observed similar trend in northwestern Ethiopia. Moreover, a similar trend of livestock production was reported for other areas of Ethiopia.

### 3.1.4. Livestock feed resources

There were several feed resources for different species of livestock both in the high and midland areas of the study area including natural pasture, crop residues and forages grown in natural resource conservation areas. However, the availability and quality of these feed resources vary according to the environmental factors like rain and related factors. Of these feed resources, the main feed resources used by respondents were crop residue, followed by natural pasture which is in agreement with Addisu et al. (2016) in East Gojjam Zone Enebise Sar Mider district the main livestock feed resource for livestock was crop residues followed by natural pasture.

In the current finding, the contribution of natural pasture in both agro-ecologies was the second-largest feed contributor. The contribution of natural pasture from protected lands of highland areas estimated that 242,722ton DM feed is produced. About 301,329ton DM feed is produced from crop residues and crop aftermath (Firew and Getnet, 2010). According to Alemayehu and Alan (2013) natural pasture grazing and browse, crop residues, improved forage (improved pasture), agro-industrial by-products and non-conventional feeds are the main feed resources in the country. Therefore, the finding indicated that livestock feed resources in the study area mainly dependent on crop residues and natural pasture in which improved forages and other feed types need to be integrated to complement these feeds.
3.1.5. Types of improved forages grown in natural resource areas

Out of the total respondents, 82% and 70% in highland and midland, respectively cultivated Tree Lucerne (*Chamaecytisus palmensis*) followed by *Sesbania* (*Sesbania sesban*) 83% and 60% of the respondents in the highlands and midlands, respectively, cultivated *Sesbania* (Table 3). On the other hand, 58% and 42% of respondents in highland and midland of the study area, respectively, cultivated *Elephant grass* (*Pennisetum purpureum*). The relatively small proportion of respondents’ participation in elephant grass cultivation might be due to the fact that the grass is mainly used as backyard forages as observed by Gebreegziabher and Tsegay (2016) result in Wolaïta Zone, 88%, 84% and 56% of the respondents in the highland, midland and lowland, respectively cultivated the forage in the backyard system.

### Table 3. Types of improved forages cultivated in area closures

| Types of forages | Scientific name     | Level of abundance | Plantation place |
|------------------|---------------------|--------------------|------------------|
| *Sesbania sesban* | *Sesbania sesban*   | High*              | High ACs         |
| *Tree Lucerne*   | *Chamaecytisus Palmensis* | High              | Mid ACs          |
| *Elephant grass* | *Pennisetum purpureum* | Low               | Low AC           |
| *Alfalfa*        | *Medicago sativa*   | Mid**              | Mid With AC      |
| *Desho*          | *Pennisetum pedicellatum* | Low               | Low AC           |
| *Rhodes*         | *Chloris gayana*    | Mid                | Mid With AC      |
| *Vetch*          | *Vicia dasycarpa*   | Low***             | Low With AC      |
| *Cowpea*         | *Vigna unguiculata* | Low                | Low With AC      |
| *Green L. desmodium* | *Desmodium intortum* | Low               | Low With AC      |
| *Tagasaste*      | *Chamaecytisus palmensis* | Mid              | Mid AC           |

ACs: Area closures; AC: Annual crop; Area closures are prepared for eroded lands.

* highland = altitude between 1800 m and 2400 m above sea level; ** midland = altitude range 1200–2000 m above sea level; *** low land = altitude below 1200 m above sea level.

### Table 4. Selected improved forages and their Management activity in the study area

| Activities          | Agro ecology | Average | Chi-square value |
|---------------------|--------------|---------|------------------|
| Types of improved forages | Highland (%) | Midland (%) |            |        |
| Tree Lucerne        | 92           | 80      | 86               |            |
| Elephant grass      | 56           | 21      | 38.5             |            |
| *Sesbania sesban*   | 93           | 60      | 76.5             |            |
| Desho               | 24           | 18      | 21               |            |
| Alfalfa             | 16           | 11      | 13.5             |            |
| Management activity |              |         | 0.008***         |            |
| Yes                 | 9            | 12      | 11.5             |            |
| No                  | 91           | 88      | 89.5             |            |

*** Significant at 0.1% level
3.1.6. Management of improved forages in natural resource conservation areas

The management of improved forages both in highland and midland agro-ecologies are poor particularly in terms of proper harvesting of improved forages (Table 4). The main forage development strategies in the study area are strip establishment, backyard, improved forages in stock exclusion areas, legumes under sown in crops and over sown on grazing areas (low level), perennial-mixed grass/legume pastures and annual fodder crops. In agreement with this result, Yayneshet et al. (2016) the most common forage development strategies include alley cropping, backyard and along watersheds. Backyard and alley cropping are the common strategies across the seven districts in central and eastern Tigray.

In the study areas, 91% and 88% of respondents in highland and midlands, respectively, do not use any management activities specifically for improved forages after plantation. But every farmer in area closures keeps the appropriate plantation time and plantation system by the help of kebele developmental agents. Based on the survey result, improved forage production was significantly (p < 0.01) affected by overall management activities applied for cultivated forages in area closure. This is due to low level of biomass product as well as low awareness towards management activity.

3.1.7. Harvesting and utilization practice of improved forages

Based on the survey result, 98.2% and 97% respondents in the highland and midlands harvest those improved forages in the area closures by personal judgment, when their canopy affects the crop production and (1.8%) and (3%) of the respondents harvest at the recommended harvesting time. Improved forages in area closures were cultivated in soil and water structures in line with annual crops. Due to this, forages were cut frequently in rainy seasons and they cut also at dry periods as a supplement for basal diets. Based on the survey result they harvest (cut) at any season of a year by personal judgments.

Not only the quantity of forages produced but the method of utilization of the produced forages in area closures are important for effective utilization of improved forages in area closures. About 96% in highland and 94% in midland of respondents used to cut and carry system to utilize their improved forages in area closures (Figure 2). This is due to the fact that, majority of production system is related with crop production system and area closure-based soil and water conservation structures. So, such production system inhibits those farmers to graze livestock's directly. In agreement with the above result, Adugna stated that all respondents in the highland, 98.4% in the midland used to cut and carry system to utilize their improved forages due to the nature of improved forage trees (height).

Feed conservation could be one possible solution for feed shortage areas during the dry seasons. The habit of making hay from improve forage trees in the study area is very low. From the interviewed samples, 4% and 8% in the highland and midland respectively, practice improved forage conservation for dry period feed shortages. In agreement with this result Zereu and Lijalem (2016) 4% and 12% of the respondents in the highland and midlands respectively, conserve.

Figure 2. Utilization systems of improved forages in area closures.
forages for dry period. In the study area, 91% and 83% of the respondents in highland and midland respectively, agree on natural resource management-based forage production system supports livestock nutrient requirement. Whereas, 9% and 17% of the respondents in the highland and midland of the study area were not agreed on the previous idea, this is due to its low biomass production of improved forages in area closures.

Both landowners and landless farmers whether those have a livestock or not have equal use right over improved forages which are cultivated on communal lands. These equal use strategies also supported by the bylaw of the kebele and district court.

3.2. Constraints for improved forage production

In Ethiopia, forage development strategy has been practiced for about five decades. But its adoption level in the farming community has been very low because of factors such as type of livestock production system, lack and unadoptable forage technologies, poor extension services and others (Gebreegziabher and Tsegay, 2016). Based on the survey result, 86% and 89% of the respondents in the highland and midlands ranks free grazing based livestock production system as first major constraint (Table 5). In disagreement with this result, Zereu and Lijalem (2016) stated that in the highland and midlands of Wolaita zone 93.3% and 94.7% ranked land shortage as a first major constraint, respectively. The reason for this difference is, in both study areas majority of crop, grazing and bare lands were developed by soil and water conservation structures and supported by biological systems like improved forages. On the other hand, the result also supported by Addisu (2016) which is ranked as awareness and skill 35.12%, impute shortage 27.98%, land shortage 13.1%, poor extension 12.5% and free grazing 11.31%

There also other constrains which are responsible for low production level of improved forages in the area closures of highland and midland agro-ecologies. Lack of appropriate forage technologies ranked as the second main constraint in both agro-ecologies, whereas lack of awareness was ranked third in the highland and fourth in midland agro-ecologies, this is due to the way of extension service of experts and in midland of the study area there was lack of private landholding than in the highland of the study area. In general, free grazing production system, lack of appropriate forage technologies, lack of awareness and poor extension service and land shortage were ranked first, second, third, and fourth, respectively, by the respondents as the constraints for improved forage production in area closures.

3.3. Feed shortage and its coping mechanism

The availability of feed resources in the highlands of Ethiopia depends on the mode and intensity of crop production as well as population pressure (Seyoum, Getinet, Abate, & Dereje, 2001). Based on the respondents in the study area 89.6% and 84.4% in highland and midlands, respectively were used crop residues (Table 6). Hay and improved forages in area closures were among the

| Table 5. Major constraints for improved forage development in the study area No of respondents by rank Weight Index Rank |
|---------------------------------------------------------------|
| Major constraints 1st | 2nd | 3rd | 4th | Weight | Index Rank |
| Free grazing production system | 94 | 72 | 40 | 17 | 689 | 0.491 1st |
| Lack of appropriate forage technologies | 52 | 28 | 20 | 6 | 322 | 0.229 2nd |
| Lack of awareness | 28 | 17 | 8 | 7 | 201 | 0.143 3rd |
| Land shortage | 24 | 26 | 4 | 6 | 190 | 0.135 4th |
| Total | 198 | 143 | 72 | 36 | 1402 | 1 |

Index = sum [(number of respondents of the 1st rank X 4) + (number of respondents of the 2nd rank X 3) + (number of respondents of the 3rd rank X 2) + (number of respondents of the 4th rank X 1)]/Total weight
Table 6. Feed resources availability in different seasons

| Feed source       | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Natural pasture   |     |     |     |     |     |     |     |     |     |     |     |     |
| Crop related      |     |     |     |     |     |     |     |     |     |     |     |     |
| Weed from crops   |     |     |     |     |     |     |     |     |     |     |     |     |
| Hay               |     |     |     |     |     |     |     |     |     |     |     |     |
| Concentrate       |     |     |     |     |     |     |     |     |     |     |     |     |
| Improved Forage   |     |     |     |     |     |     |     |     |     |     |     |     |

Sep: September; Oct: October; Nov: November; Dec: December; Jan: January; Feb: February; Mar: March; Apr: April; May: May; Jun: June; Jul: July; Aug: August.

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most common feeds used by both farms with medium and small herd sizes in the dry season, whereas grazing pasture and crop weed feeding were dominant in the wet season (July to August). Concentrates such as noug seedcake, Atela and wheat bran were sometimes provided to supplement the basal diet at feed shortage time.

In agreement with this result, during dry season 90% of the respondents use crop residues as number one feed source followed by hay 58.8% and stubble grazing 56.1% (Endale et al., 2016) Meta-Robi district, West Shewa Zone. In disagreement with the current study, Tesfaye reported that the major dry season feed resources for cattle in Metema district were natural pasture 55.7%, crop residues 20.7%, stubble 14.3% and hay 9.3%. This difference is mostly due to agro-ecological and farming systems differences between the two districts.

3.4. Biomass yield of selected improved forages

In the study, the largest portion of dry matter yield was obtained from crop residues in both agroecology of the study area. Based on Farta district forage expert, in the highland production system, the estimated available feed supply met about 73% of the maintenance DM requirement of livestock per farm per year, which is higher than that of midland of the study area 68%. The result showed that there was 27–32% current feed gap both in highland and midlands. The use of improved forages as animal feed was well adopted by farmers because they feed their animals properly as a supplement and its trend becomes gradual changes in both the study areas.

As the biomass yield of those forage species indicates that, due to agro-ecological difference, biomass yield of selected improved forages also varied. Yayneshet et al., (2016) indicated that in Tigray region, introduced forages were tested on station in different ecological zones and considerable efforts were made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions. In both study sites, farmers used (cut) those improved forage 6–10 times per year but it depends on the season and rainfall availability. Based on respondents, they not consider the appropriate timing and season before they used. But the main consideration was the availability of abundant forage canopy for their animals and canopy effect of those forages on crop production.

According to this study, the biomass yield of Sesbania sesban ranged from 7.8 t/ha in highland to 7.64 t/ha in midland and it have yellowish flowers at the stage maturity (Table 7). In agreement, yield of Sesbania sesban has ranged from 4 to 12 tones dry matter/hal/year in Ethiopia depending upon location and Sesbania sesban tree has up to 20 flowers which are yellow with purple or brown streaks on the corolla (Heering, Nokoe, & Mohammed, 1996a). Therefore, based upon this Sesbania sesban is a potential plant species to be used as animal feed in both highland and midland agro-ecologies and due to its attractive flowering color, it plays a significant role for honey bee production in watersheds and a decorative or festive material (Nigussie & Alemayehu, 2013).

| Feed stuffs       | Biomass yield in agro-ecology (t/ha) | Highland | Midland |
|-------------------|--------------------------------------|----------|---------|
|                   | S_1   | S_2   | S_3   | Average | S_1   | S_2   | S_3   | Average |
| Sesbania sesban   | 7.7   | 7.2   | 7.93  | 7.8     | 7.4   | 7.8   | 7.72  | 7.64    |
| Elephant grass    | 14.14 | 14.62 | 14.08 | 14.28   | 14.86 | 13.84 | 13.82 | 13.84   |
| Tree Lucerne      | 7.72  | 7.62  | 7.65  | 7.65    | 7.25  | 7.5   | 7.46  | 7.4     |
Sample of forage was taken when the forage was 6–10 years old addition it has 3–4 m height at the time of sample collection. The sample taking age is supported by Megerssa (2016), who reported that Sesbania sesban plant was grown rapidly that it attained an average plant height of 3.3 and it may grow up to 8 m and up to 20 cm stem diameter. The plant thrives under-repeated cutting and coppices readily with many branches arising from the main stem below cutting that helps it when the cutting frequency becomes at the recommended time the yield becomes high.

In general, the biomass yield of Tree Lucerne (Chamaecytisus palmensis) ranged from 7.63 t/ha in highland to 7.4 t/ha in midland study areas. In agreement with this result, it produces up to 12 t ha⁻¹ year⁻¹ dry matter (DM) of which four to five ton is leaf (Kindu, Wilington, Melkamu, Annet & Peter, 2016). The same source indicated that Tree Lucerne productivity, forage quality and proportions of botanical fractions are highly affected by location, cutting month and management practices like cutting frequency, grazing and fertilization.

3.5. Chemical composition of selected improved forages

Dry Matter (DM), Crude Protein (CP), Ash, Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) are parameters used to evaluate sample improved forages show in (Table 8). Nutrient deficit was one observed problem in both study areas, it might be minimum production of high quality improved forages and poor nutritive value of the major feeds (crop residues) in relation with the greater number of livestock population in the area.

The dry matter (DM) content of all sample fresh forges was above 91%. The amount of dry matter (DM) content of legumes species was similar in highland and midlands of the study area which is 92% and 92% for Tree Lucerne and Sesbania sesban, and also for grass species (Elephant grass (Pennisetum purpureum)) it measures 91% and 91% in highland and midlands of the study area.

Effect of different harvesting days had significant effect on the chemical composition and herbage yield of Pennisetum purpureum species, which resulted in an increase in dry matter (DM), ADF and NDF with increase in harvesting day agrees with the report of Taye and Solomon (2007), who recorded a similar trend when Napier grass was harvested at 60, 90 and 120 days and should be expected with increasing grass maturity.

Elephant grass is fast-growing and has a high annual productivity that depends on climatic and soil conditions. Yields ranged from 20 to 80 t/DM/ha/year under high fertilizer input.

| Sample Code            | Chemical composition (%) |
|------------------------|--------------------------|
|                        | DM  | Ash | CP  | NDF | ADF | ADL |
| Tree Lucerne (Highland)| 92  | 4.34| 24.41| 65.67| 48.84| 10  |
| Tree Lucerne (Midland) | 92  | 4.34| 25.1 | 66.79| 46.84| 9.64|
| Elephant (Highland)    | 91  | 10.98| 8.02 | 80.12| 63.15| 15.15|
| Elephant (Midland)     | 91  | 16.48| 8.3  | 81.27| 65.26| 15.15|
| Sesbania sesban (Highland)| 92   | 9.78| 25.17| 42.35| 27.36| 5.35|
| Sesbania sesban (Midland)| 92    | 10.1 | 25.9 | 40.17| 25.26| 4.57|

DM = Dry Matter, CP = Crude Protein, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber, ADL = Acid Detergent Lignin
The crude protein (CP) content of sample forages was varying from 8.02% in Elephant grass (*Pennisetum purpureum*) to 25.9% in *Sesbania sesban*. Significantly there is no high gap between legume sample forages in both agroecology of the study area. Whereas in Elephant grass (*Pennisetum purpureum*), the result indicates higher deviation with legume species. This is due to ability of forages which fixes soil nitrogen by the help of special component in the root known as Ribosome. The CP content of *Sesbania sesban* in the study area indicates 25.17% and 25.9% in both highland and midland of the study areas. In agreement of this result, nutritional profile of the seeds of *Sesbania sesban* were reported to contain 30% to 40% crude protein 5% to 6% of crude lipid and 2.7% to 3.3% of ash (Megerssa and Feyisa, 2016). The leaves and tender branches of this tree have high levels of protein (with 20% to 25% crude protein), and easily digestible when consumed by ruminants (Nigussie & Alemayehu, 2013).

The finding of Taye (2007) showed that cutting days of forages have its own impact on the CP content of them. It also implies, those forages which were cut on shorter days (60 days) have maximum CP content than long day (120 days) cutting duration. The ash content of the given forage species mainly indicates the amount of mineral availability in forages. Likewise the Ash content of sample forages in the study area was varied from 10.98% in Elephant grass from highland to 4.34% in Tree Lucerne both in highland and midlands, respectively. As the Table shows that there were no significant (p > 0.05) between sample forages in agro-ecology differences, but in Elephant grass the Ash content in highland and midland study areas accounts 10.98% and 16.48%, respectively.

The neutral detergent fiber (NDF) content of sample forages was above 40.17%. Elephant grass had slightly higher NDF contents than Tree Lucerne, whereas it had double gap with *Sesbaniasesban*. Singh and Oosting (1992) pointed out that roughage feeds containing NDF values of less than 45% could be classified as high quality, those with values ranging from 45% to 65% as medium and those with values higher than 65% as low quality. Based on it, *Sesbaniasesban* can be classified as high-quality feed, Tree Lucerne can be classified as medium quality and Elephant grass can be classified as low-quality feed. But the NDF value mainly depends on the time of cutting date, when forages cut at 30 days interval their quality becomes high but their biomass yield becomes low.

The acid detergent fiber (ADF) content of sample forages was varied from 25.26% in *Sesbaniasesban* to 65.26% in Elephant grass (*Pennisetumpurpureum*). According to Kellems and Church (2011), roughage with less than 40% ADF are categorized as high quality and those with greater than 40% as poor quality. Based on the laboratory result, those legume type sample forages are classified as high-quality feed stuff for the study area. Lignin (ADL) content of sample forages was varied from 4.57% in *Sesbania sesban* to 15.15% in Elephant grass (*Pennisetum purpureum*), which limits DM intake. The major cell well content of given forages was mainly depending on age of the plant. When the plant becomes aged the cell well content becomes very hard on the contrary when the plant becomes young the cell well part becomes more palatable. The Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) of elephant grass were not significantly different between highland midland of the study area. On average it accounts 40.66%, 52.8% and 23.5%, respectively. In disagreement with this result, the average NDF, ADF and ADL (lignin) values of elephant grass reported are around 67%, 42% and 6%, respectively (Chalchissa et al., 2014). The reason for the difference is their age after plantation.

*Sesbania sesban* seed contains various anti-nutritional factors such as tannins, saponins and trypsin inhibitors. These ant-nutritional factors are the major problems when the seed is used as animal feed. Phytochemical investigations in the seeds led to the isolation of oleanolic acid, stigmastane-5.24(28)-diene-3β-0-β-D-galactopyranoside and galactomannan. The extracts had a high content of phenols, flavonoids and anthocyanins (Kathiresh, Suganya, & Saravanakumar, 2012).
4. Conclusions and recommendations

As Ethiopian highlands are characterized by agrarian economy, livestock are integral parts of the agriculture sector. Livestock production in the study area is highly dependent on crop-related feedstuffs but improved forages in area closures have a capacity to support livestock feed throughout the year. Therefore, from the current study, it was concluded that those improved forages grown in area closures have capacity to support low quality feed sources as an alternative feeds for dry period feed shortage as well-nutrient gaps. Overall, improved forages grown in natural resource management areas have a very crucial role in contributing feeds to ruminant livestock. However, there was poor understanding on the proper management of improved forages grown. Therefore, appropriate management strategies should be designed to use the forages available in the natural resource conservation areas of highlands in Ethiopia.

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