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Evergreen Fodder: A Review on Leaf Biomass Yield and Chemical Composition of Fodder Trees and Shrubs in Ethiopia

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ABSTRACT

The feed shortage is the key bottleneck of livestock production sector in Ethiopia. Ever green fodder of trees and shrubs in agroforestry systems provides an alternative solution to boost availability of feed throughout the year. The paper was reviewed leaf biomass yield and chemical composition of major fodder trees and shrubs in agroforestry systems across different agroecologies in Ethiopia. Biomass DM yields of indigenous fodder trees were significantly different ($p < 0.05$) across agroecologies. In the highland, biomass yield/ha was greatest ($p < 0.05$) for E. brucei followed by *H. abyssinica* and *V. amygdalina* while the lowest was for *A. alpine*. In the midland, *D. steudneri* had the highest (p=0.001) biomass yield/tree while the least was observed in *M. ferruginea* and *V. amygdalina*. The highest biomass yield in the lowland was for *C. africana* and *E. racemose*. In general, the average DM biomass yields were 0.22- 15.43, 0.28–23.1 and 10.81 –54.1 kg DM/tree for highland, midland and lowland, respectively. *Erythrina brucei, Dracaena steudneri and Cordia africana* had the highest biomass yield in highland, midland and lowland, respectively ($p < 0.05$). There were significant differences in chemical composition among the fodder tree and shrub species. Chemical composition of the fodder species had on average 89.63 % Dry matter, 21.7 % Crud protein, 66.56 % Digestible dry matter, 52.95 % Neutral detergent fibber, 28.66 % Acid detergent fibber, 11.57 % Acid detergent lignin, 4.17 % Ether extract, 7.49 % Ash, 24.28 Hemicelluloses and 17.09 cellulose.

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Introduction

Ethiopia is the country with the largest livestock population in Africa. Livestock plays an important role in providing export commodities, such as live animals, hides, and skins to earn foreign exchanges to the country (CSA, 2021). Despite the number of livestock, productivity per head is very low (Shenkute et al., 2012). This is mainly caused by feed shortage and poor quality of forage (Tolera et al., 2012). The major feed resources are crop residues and natural pasture. Inadequate feed supply is a major constraint to ruminant production during the dry season in Ethiopia which is one of the reasons for poor performance of livestock. In many rural areas, the available feeds from grazing are not sufficient to meet the maintenance requirements of grazing animals during dry periods (Matlebyane et al. 2010). Because of population pressure the available grazing land is shrinking which could lead to land degradation and reduced feed availability (Berhanu et al. 2009). Thus, there is a need to fill the feed gap especially with protein source feed through increased utilization of evergreen fodder from trees and shrubs.

In Ethiopia, smallholder farmers carry out various agroforestry practices/systems depending on the socioeconomic and biophysical conditions such as coffee shade-based system, scattered trees on farmland, homegardens, woodlots, boundary planting and silvopastures (Iiyama et al., 2017). These agroforestry systems are endowed with indigenous and exotic fodder trees and shrubs thus considered as fodder banks. The fodder trees and shrubs are a viable way to increase the quality and availability of feeds for livestock (Ayenew et al., 2019). Fodder trees are recognized as an important component of animal feeds in many parts of the world (Lameso, 2021), as they contain high levels of crude protein, mineral and continue to produce well in the dry season because of their deep root systems (Mekoya et al., 2008).

Fodder trees and shrubs are a potentially cheap protein supplement for ruminants and highly valued by farmers particularly during the critical periods of the year when the quantity and quality of herbage is limited and considered as a more reliable feed resource of high quality to develop sustainable feeding systems. Fodder trees and shrubs have been used for generations as a multipurpose resource and farmers preferred them for high biomass production multi-functionality, life span and compatibility to the cropping system (Aynalem Haile and Taye Tolemariam, 2008). The main features of trees as a feed resource is the high crude protein content ranging from 10 to 25% DM and may be considered as a more reliable feed resource of high quality to develop sustainable feeding systems and increasing livestock productivity (Aynalem Haile and Taye Tolemariam, 2008). Fodder or browse production from trees and shrubs is one of the benefits of agroforestry. Agroforestry is a dynamic ecologically based natural resource management system that through the integration of tree/woody perennials in to farm and rangelands diversifies and sustains production for increased social, economic and environmental benefits (Franzel and Scherr, 2002). Azim et al., (2011) also pointed out trees and shrubs are increasingly recognized as important components of animal feeding, especially as suppliers of protein. The importance of trees and shrubs for their nutrition quality for browsing and grazing animals, especially in areas of poor quality pastures for ability of most browse species to remain green for a longer period is attributed to deep root systems, which enable them to extract water and nutrients from deep in the soil profile and this contributes to the increased CP content of the foliage.

The eastern Ethiopia highlands have mixed crop-livestock production systems with livestock production being dominated by the semi-arid to arid climatic conditions. Moreover, natural pasture and crop residue are the main sources of feed characterized by zero grazing system with stall-feeding technique. However, feed shortage mainly during the dry season (March to June) when farmers finish stored feed is a critical problem in the described study area (Gebregziabher and Gebrehiwot, 2011). To alleviate these problems there is a need to introduce fodder trees and shrubs to the area which can be integrated with the food and/ or cash crops, planted at the border of crop fields or on marginalized lands. Similar observations have been reported in other regions that have similar production systems where fodder trees and shrubs become prominent in animal feeding towards the end of the dry season and the quality and quantity of grass is at its worst. For example, the farmers in Central Kenyan highlands have experienced the habit of planting fodder trees as a fodder bank around the compound or near the zero grazing units (Roothaert, 2000). Belete et al., (2012) also noted that browse species have considerable potential for mixed crop livestock production system to overcome low nutritive value of crop residues and mature native pasture that limit livestock productivity.

The paper reviews leaf biomass yield and chemical composition of fodder trees and shrubs in Ethiopia with the following specific objectives:

- To review the leaf biomass yield of fodder trees and shrubs across three agroecology in Ethiopia.
- To review chemical composition of fodder trees and shrubs leaves at different locations in Ethiopia.
- To review the difference between dry and wet season chemical composition of fodder trees and shrubs leaves at the same site in Ethiopia.

Leaf biomass yield of major indigenous fodder tree species in three agroecologies of Ethiopia

The biomass DM yield of indigenous fodder trees is presented in Table 1. Biomass DM yields of IFT were significantly different ($p < 0.05$) across agroecologies. In the high land, biomass yield/ha was greatest ($p < 0.05$) for E. brucei followed by *H. abyssinica* and *V. amygdalina* while the lowest was for *A. alpine*. In the midland, *D. steudneri* had the highest ($p=0.001$) biomass yield/tree while the least was observed in *M. ferruginea* and *V. amygdalina*. The highest biomass yield in the lowland was for *C. africana* and *E. racemose*. In general, the average DM biomass yields were 0.22- 15.43, 0.28–23.1 and 10.81 –54.1 kg DM/tree for highland, midland and lowland, respectively.

The most widely utilized fodder trees identified in the current study were *A. alpine, H. byssinica, E. brucei, V. amygdalina, C. Africana, M. ferruginea, D. steudneri, B. aegyptiaca, A. tortolis* and *E. racemose* during dry season. The leaf biomass yield per hectare observed in the current study revealed that the fodder species had high leaf DM yield to supplement the poor-quality feed during the dry season (Shimelse et al., 2010). This result was supported by previous studies concerning the available shrubs and fodder trees in different agroecologies of Ethiopia (Ayele et al., 2022, Geta et al., 2014). The variation in biomass DM yield of IFT in the current study could be due to tree management and differences in growth and dominance of the species as suggested by Ayele et al. (2022). Moreover, the biomass yield in each species was affected by variation in agroecology, which is potentially attributed to altitudinal differences, climatic factors, soil fertility and land use system (Geta et al., 2014).

In agreement with the current finding, Ayele et al. (2022) reported that on average mid land agroecology had less biomass yield of fodder trees (7.98–19.78 kg/tree) than lowland (9.87–178.06 kg/tree) in Kellem wolega, Ethiopia. Additionally, Shimelse et al. (2010) reported similar results for leaf biomass DM yield of browse species which ranged from 77.6 to 871 kg/plant in Nechisar National Park, Ethiopia. In contrast to the current findings, Geta et al. (2014) reported higher biomass yields of 24.55 kg/tree to 958.76 kg/tree of IFT in Wolayta zone, southern Ethiopia. The total biomass yield per hectare reported in the current study was less than the value (500–800 kg/ha) reported by Ayele et al. (2022) in Kellem Wollega and 29 kg/ha – 959 kg/ha in Wolayta, south Ethiopia (Geta et al., 2014). This variation may be due to difference in land use, soil fertility and amount of rain fall. Generally, the result revealed that the highest biomass yield was recorded in *E. brucei* followed by *M. ferruginea*, then *C. africana* in the three districts and lowest in *V. amygdalina*. In agreement with the current study Geta et al. (2014) reported that *E. brucei* and *C. africana* have high crude protein content and can be sources of protein supplements for ruminant animals. Some possible inconsistencies in biomass yield and values of chemical composition reported by Mekoya et al. (2008) could be due to variations in season of samples collection, soil fertility and altitudinal differences of the sampling site.

Table 1. Leaf biomass yields (kg) of major selected indigenous fodder trees of the three agroecology sites of Sidama, Ethiopia.

Plant species	Density (plant/ha)	Biomass Yield (kg DM /plant)	Total biomass (kg DM/ha)
Highland			
Arundinaria alpina	1523[a]	0.22[d]	335.1[c]
Hygenia abyssinica	76.7[b]	5.22[b]	400.4[b]
Erythrina brucei	43.3[c]	15.43[a]	668.1[a]
Vernonia amygdalina	28.3[d]	1.13[c]	31.9[d]
CV	18.3e	44.12	24.8
p value	0.02	0.001	0.002
Midland			
Cordia africana	86.7[b]	7.1[c]	615.6[b]
Erythrina brucei	23.3[d]	8.07[b]	188.0[d]
Mellettia ferruginea	220[a]	2.97[d]	653.4[a]
Vernonia amygdalina	31.7[c]	0.28[e]	8.88[e]
Dracaena steudneri	18.3[e]	23.15[a]	4237[c]
CV	18.2	16.27	22.3
p value	0.02	0.001	0.002
Lowland			
Balanites aegyptiaca	43.3[b]	7.1[b]	307.4[a]
Cordia africana	20[c]	10.81[a]	216.2[c]
Acacia tortolis	66.7[a]	4.1[c]	273.5[b]
Euclea racemose	8.3[d]	9.67[a]	80.3[d]
CV	26.1	24.44	25.1
p value	0.005	0.001	0.006

Mean values in a column within Agroecology having different superscripts differ significantly each other; kg = kilogram; DM = Dry mater; ha = hectare

Chemical Composition of Fodder Trees and Shrubs Leaves in western Harerge, Ethiopia

The chemical composition leaves of fodder trees and shrubs are presented in Table 2. The ash content of the selected fodder trees and shrubs ranged from 7.3 to 16.6%, being the highest for *Cordia africana* but the lowest for *Combretum molle*. This variation may be due to environmental factors and varietal difference of the plants. Generally, the high ash content of such fodder trees and shrubs is indicative for such feed resources to be rich in minerals and may satisfy mineral requirement of the animals. The crude protein content of *Acacia brevispica* was the highest (*Erythrina abyssinica* > *Cordia Africana* > *Combretum molle)*. The crude protein content of *Acacia brevispica* was in agreement with the report of Rahim et al. (2013) who found shrub leaves to contain of 16.6% crude protein. Likewise, the crude protein content of *Erythrina abyssinica* and *Cordia africana* was similar to the report of Simbaya (2002) who noted fodder trees to have crude protein contents of about 14.29%.

Table 2. Mean proximate chemical composition and cell wall constituents of selected fodder trees and shrub leaves in the West Hararghe, Ethiopia

Fodder Tree and Shrub species	Chemical composition on %DM basis								
	DM	%Ash	%CP	%NDF	%ADF	%ADL	Hcel	Cel	RFV
Acacia brevispica	93.3^{c}	8.7^{c}	17.5^{a}	47.49^{c}	24.87^{d}	19^{b}	22.6^{a}	5.8^{b}	136.3^{a}
Cordia africana	94.2^{b}	16.6^{a}	14.1^{c}	59.1^{a}	53.3^{a}	34.6^{a}	5.8^{d}	18.7^{a}	74.8^{d}
Combretum molle	95.9^{a}	7.3^{d}	8.9^{d}	48.4^{b}	33.4^{c}	23.4^{b}	15.1^{b}	10^{b}	121.3^{b}
Erythrina abyssinica	94.6^{b}	13.7^{b}	15.8^{b}	50.2^{b}	37.4^{b}	20.3^{b}	12.7^{c}	17.1^{a}	112.9^{c}
Mean	94.5	11.5	14.1	51.3	37.2	24.3	14.1	12.9	111.3
LSD (5 %)	0.4	1.0	1.6	2.1	2.2	6.5	2.3	6.1	5.7
P-value	**	**	**	**	**	**	**	**	**
CV (%)	0.5	9	11.4	4.2	6.2	27.5	16.4	48.5	5.3

Note: Means followed by different superscripts within a column are significantly different at P ≤ 0.05 level of significance; **=significant at P<0.01; DM= dry matter; CP=crude; NDF=neutral detergent fiber; ADF= acid detergent fiber; ADL= acid detergent lignin; Hcel= hemicelluloses; Cel=cellulose and RFV= relative feed value

The neutral detergent fiber (NDF) contents of *Cordia africana* was significantly (P <0.01) highest. The result of this study (table 2) shows that the NDF contents of fodder trees and shrub was higher than that reported by Azim et al. (2011) for fodder tree leaves. This may be due to the season of sample leaf collection, stage of maturity of the plant, and environmental factors. The NDF content of roughage feeds with less than 45% was grouped as a high-quality feed, while feed with NDF content of 45-65% was categorized as medium quality feed. Therefore, all experimental fodder trees and shrubs had less than 65% of NDF content and can be categorized as medium quality feed. NDF content above 55% was reported to limit DM intake, indicating that the NDF content of the *Cordia africana* (59.14%) in this study could affect feed intake of animals, which may limit productivity. The ADF content of the fodder tree and shrub species was significantly different (P<0.05) and was in the order of *Cordia africana* > *Erythrina abyssinica* > *Combretum molle* > *Acacia brevispica*. Cellulose and hemicellulose contents were also significantly different among plant species. Regarding the relative fee value (RFV), *Acacia brevispica* had significantly higher (P<0.01) RFV than *Combretum molle*, *Erythrina abyssinica* and *Cordia africana*.

Nutritional composition of fodder trees and shrubs in eastern Ethiopia

The nutrient chemical composition of different fodder trees and shrubs showed wide variations. The values of chemical composition variations in the present evaluated species ranged from 88.35 to 90 % DM, 14.66 to 25.13 % CP, 59.94 to 71.99 % DDM, 1.83 to 2.52 % DMI, 47.52 to 65.36 % NDF, 21.7 to 37.16 % ADF, 9.42 to 14.49 % ADL, 3.04 to 5.78 EE, 7.51 to 12.60 % Ash, 10.35 to 32.23 Hemicelluloses, 11.59 to 22.67 cellulose and 117.48 to 142.46 RFV (Table 3). These variations could be associated with the agroclimatic condition and morphological differences of the species. Solomon (2001) noted that the high variability in the composition of different fodder trees and shrubs could be attributed to within species variability owing to factors such as plant part, harvesting regime, season and location. The difference in chemical composition between species and within genera associated with the inherent nature of the species (Belete et al., 2012). The evaluated fodder trees and shrubs species found to have on average 21.7 % CP. Inline to this study high CP content of different browse species ranges 17 to 22 % was also reported by (Vu et al., 2011). Among the present evaluated species, the lowest CP ranged from 14 to 16% was also recorded by the *Morus alba* species. These values are comparable to those reported by (Azim et al., 2011) indicated CP content of 15.46 % from the same species. High CP content of browse species provide vitamins and mineral elements, which are often lacking in mature natural grassland pastures, especially during the dry season (Skerman et al., 1988). Most of the Ethiopian dry forages analysed and roughages had on average 6.2% CP content, which suggests that the microbial requirement can hardly be met unless supplemented with protein rich feeds (Seyoum and Zinash, 1989).

The NDF values of the present fodder trees and shrubs species have also on average 52.95 %. According to Garcia et al., (2003) as NDF values increase, total feed intake will also decrease. In the present evaluated species, the highest NDF and Hemicelluloses contents which shows low fodder value and less potential to be preferred by livestock were recorded by the species *Cajanus cajan*. Comparable to this study Cheva Isarakul (1992) reported 61% NDF value. However, the highest Cellulose content, which is the principle carbohydrate constituent of plant cell membranes and implying as potential source of carbohydrate to feed scared of livestock was recorded in the species *Morus alba*. Moreover, based on the quality standard described by (Garcia et al., 2002; Rivera and Parish, 2010) the CP value of the evaluated specie fall in the prime and very good quality standard, and NDF value ranged from very poor (>65%) to very good (47 to 53%). Similarly, the ADF content of most of the treatment species except *Morus alba* falls in the excellent to prime quality standard range (i.e. 31 to 35% and <31%, respectively). The DDM values of all species fall in the very good and prime quality standard. Moreover, DMI of the treatment species fall in the very good range except *Cajanus cajan* which falls in the fair range. Maximum DMI is very important factor in ensuring the release of adequate nutrients for maintenance and production. Therefore, among the studied species *Moringa oleifera* and *Morus alba* would be preferred for their high DMI values.

Table 3. Nutritional value of fodder trees and shrubs planted at Kersa experimental site, eastern Ethiopia

Trees/Shrubs	DM%	CP%	DDM%	DMI%	NDF%	ADF%	ADL%	EE%	Ash%	Hem	Cel	RFV
Sesbania esban	89.8b	20.0ab	71.2a	2.3b	51.9b	22.6c	11.0ab	3.0c	9.2b	29.2ab	11.5b	127.9b
Moringa oleifera	88.3c	25.1a	71.9a	2.5a	47.0c	21.7c	9.4b	4.5b	9.8b	25.3b	12.2b	142.4a
Cajanus cajan	90.9a	27.1a	63.1b	1.8c	65.3a	33.1b	11.3ab	5.7a	7.5c	32.2a	21.8a	89.8d
Morus alba	89.3bc	14.6b	59.9c	2.5a	47.5c	37.1a	14.4a	3.3c	12.6a	10.3c	22.6a	117.4c
CV (%)	0.5	23.8	2.3	4.0	3.9	6.9	17.6	11.5	7.5	11.3	16.5	4.5
LSD	0.9	9.7	2.9	0.1	3.9	3.7	3.8	0.9	1.3	5.3	17.9	10.2

Chemical compositions and in vitro digestibility values of fodder trees in north eastern Ethiopia

All the chemicals analysed varied significantly ($p < 0.001$) among the tree species. The mean dry matter varied from 909 g kg−1 for C. sinensis and D. glabra to 935.3 g kg−1 for *A. nilotica*, whereas the organic matter varied from 933.2 g kg−1 for *T. indica* to 971.4 g kg−1 for *A. nilotica*. The ash content was the lowest for *A. nilotica* and the highest for *T. indica*. The CP content was the highest for *B. discolor* and the least for *D. glabra*. The NDF content of the cell wall ranged from 329 g kg−1 for *T. indica* to 636.5 g kg−1 for *Z. spina-christi*, and that of the ADF varied from 265.8 g kg−1 for *A. tortilis* to 381.8 g kg−1 for Z. spina-christi. The leaves of *D. glabra* were the least lignified and those of *A. nilotica* were the most lignified. The in-vitro digestibility test indicated that *A. tortilis* had the most digestible OM in the DM while *C. sinensis* had the least digestibility in the leaves compared to other tree and shrub species (Table 4). The crude protein, which protein was the highest for *B. discolor* (181.9 g kg−1DM) and the least for *D. glabra* (116.4 g kg−1) indicating that *B. discolor*, is discolor was the most protein rich of all the rest. The comparison between the leguminous and the non-leguminous types of species revealed significant differences ($p < 0.05$) between the two types for all chemicals but CP. The leguminous species had significantly higher DM, OM, lignin and in vitro digestibility, whereas the non-leguminous species had significantly higher ash, NDF, ADF and hemi-cellulose.

The dry matter content of the sampled leaves indicated that the leaves had very high proportion of organic matter, which ranged from 908.8 to 935.3 g kg−1 DM. Figures for dry matter could go way below 900 g kg−1 DM depending on species and season of harvest (Domínguez et al. 2013 and Sandoval et al. 2005). The ash content was the lowest for *A. nilotica* and the highest for *T. indica* indicating that the latter was mineral rich compared to the other tree species. The ash content was generally lower compared to reported for leaves of some fodder trees and browse forages including *T. indica* (Sandoval et al.2005 and Njidda et al. 2013), which may be due to soil fertility differences, season of harvest and harvesting stages among sites. The CP content of all the seven fodder tree species was well above the minimum (70–80 g kg−1DM) level required for ideal ruminal fermentation, but it was below the content reported for five planted forage legumes, *Moringa spp*. and foliage of four highland fodder tree species (Mokoboki et al. 2002 and Melesse A 2011) It was within the range reported for leaves of some fodder trees (Sandoval et al. 2005 and Khanal RC, Subba DB 2001) including *Acacia nilotica, A. tortilis* and *Ziziphus spina-christi* (Inam et al. 2011 and Melaku et al. 2010) and browse forages (Njidda et al. 2013). And this is in contrary to CP of pre dominantly leaves and twigs of 21 fodder tree species of which seven of them had content below the minimum required level (Foguekem et al. 2016).

The neutral detergent fibre content of the cell wall (i.e., the insoluble) ranged from 329.9 g kg−1 DM in *T. indica* to 636.5 g kg−1 in *Z. spina-christi* indicating that the latter is the richest in its energy content compared to the others. The NDF contents are lower when compared with some reported studies for browse forages (Njidda et al. 2013), comparable to higher with the content for some fodder species reported by (Mokoboki et al. 2002; Mekonnen et al. 2009 and Sandoval-Castro et al. 2005) and much higher to *Moringa* species (Melesse, 2011).

The hemi-cellulose ranged from 42.1 in *B. discolor* to 263.9 g kg−1 in *D. glabra*, and this is partly lower and partly within reported range for browse species (Njidda et al. 2013). The acid detergent fibre ranged from 265.8 in *A. tortilis* to 381.8 g kg−1 in *Z. spina-christi*. The acid detergent fibre content fall within the reported range for some fodder trees (Khanal RC and Subba DB 2001), lower to comparable with figures reported for forage species (Mekonnen et al. 2009). It was comparable to higher than the reported figures for some tree fodders and browse species (Sandoval 2005 and Njidda et al. 2013) and higher to that of *Moringa* species (Melesse, 2011). The analysis of the lignin content indicated that the leaves of *D. glabra* were the least lignified and those of *A. nilotica* were the most lignified. The lignin content of the seven fodder tree species is generally low when compared to reported contents for leaves of some fodder trees (Khanal and Subba, 2001). The estimation of the in-vitro digestibility indicated that the *A. tortilis* (686.7 g kg−1) had the most digestible leaves and *C. sinensis* (511.4 g kg−1) had the least digest ible OM in the DM. The digestibility of the tree species is within reported ranged for some tree fodders (Sandoval et al. 2005) and comparable and even higher to digestibility of predominantly leaves and twigs of 21 fodder tree species (Foguekem et al. 2011). Generally, the observed variations in chemical compositions with reported works earlier on some of the species could be due to provenance differences, climatic influences on foliage growth and nutrient accumulation, soil fertility differences, season of harvest and harvesting stages among sites (Salem et al. 2006; Pamo et al. 2007 and Ouédraogo et al. 2008).

Table 4. Mean nutritional compositions of seven fodder tree species (on g kg−1 DM), N = 80

Tree species	DM	OM	Ash	CP	NDF	ADF	Hemi-cellulose	Lignin	IVDOMD
A. nilotica	935.3a	971.4a	28.6a	157.6a	342.1a	284.7ae	57.4a	110.7a	622a
A. tortilis	920.2b	943.7b	56.3b	152.9a	338.4b	265.8b	72.6b	108.2b	686.7b
B. discolor	930.4a	957.7c	42.3c	181.9b	329.9c	287.8e	42.1c	102.1c	647.5ab
C. sinensi	908.9c	935.2bd	64.8bd	159.3ab	630.9d	379.5c	251.3d	78.2d	511.4d
D. glabra	908.8c	938.9bd	61.1bd	116.4c	635.2e	371.3d	263.9e	72.3e	555.9e
T. indica	922b	933.2bd	66.8bd	159.3ab	329c	279.7a	49.3f	101.1c	669.6bc
Z. spina-christi	906.3	941bd	59b	162.7ab	636.5e	381.8c	254.8d	74.9f	550.4e
Mean	918.4	945.9	54.1	155	469.8	323.4	146.4	92.3	603.6
SE	1.33	1.71	1.71	2.82	16.74	5.58	11.28	1.77	7.78
F value	52.9	29.5	29.5	13.4	49,581.9	1764.9	6536.5	984.1	54.2

SE standard error of the overall mean for each parameter; Means in same column with different superscript are significantly different P < 0.05

Chemical Composition and In-vitro Organic Matter Digestibility of fodder trees in southern Ethiopia

Chemical composition and in vitro organic matter digestibility of multipurpose fodder trees are presented in Table 5. The highest (p<0.05) ash content was recorded for *M. alba* in dry and wet season while the lowest (p<0.05) was for *E. cymosa* in the dry season. The current ash content for *M. alba* was shown higher result than reported earlier for *G. latifolum*, *A. indica* and *V. amygdalina* (Atangwho et al. 2009; Okp et al. 2017 and Sodamade, 2013). However, the ash content observed for *E.cymosa, M. ferruginea* and *V. amygdalina* was comparable with the result reported by (Belachew et al. 2013) for *E. capensis, F.sycomorus*, *M.lanceolata* and *R.glutinosa*. The highest (p<0.05) CP content was for *M.alba* during dry and wet season and *M.ferruginea* during wet season while the lowest (p<0.05) was for *C. africana* in the dry season.

Crude protein content *for M. alba* in wet season is comparable with the result reported by (Aynalem Haile and TayeTolemariam 2008) for *B. polystachya* and *M. lanceolata* but higher than the result reported earlier (Takele et al. 2014 and Okpe et al. 2017) for *V.amygdalina*, *E.cymosa* and *C. africana* and (Sodamade, A., 2013) for *E. capensis, F.sycomorus, M. lanceolata* and *R. glutinosa*. However, it was lower than the result reported for *V. amygdalina* and *G. latifolum* (Atangwho et al. 2009). The CP content for *C. africana* and *V. amygdalina* in the current study was lower than the result reported by (Shenkute et al.2012 and Amsalu et al. 2018). The CP content for *B.aegyptiaca* during dry period was higher than the result reported by (Shenkute et al. 2012) but it is comparable with the result reported for *B. aegyptiaca* and other MPTs in the dry season (Njidda et al. 2013).

E. cymosa and *C.africana* shown the highest (p<0.05) NDF content and the lowest (p<0.05) was recorded for *B.aegyptiaca* during dry and wet season. The NDF content observed for *B.aegyptiaca* in the current study was shown lower result than the result reported by (Assen Ebrahim et al. 2016) for *M. alba* leaf collected during dry period and for *C.africana* reported by (Amsalu et al. 2018). The NDF content for *C.africanain* the current study is higher but the NDF content for *B .aegyptiacais* lower than the result reported by (Takele et al. 20114; Shenkute et al.2012 and Amsalu et al. 2018). However; the NDF content for *C. africana* is comparable with the value reported for *F. sycomorus* and *M. lanceolata* by (Belachew et al. 2013)

The lowest (P<0.05) ADF value was recorded for *B.aegyptiaca* during dry season and *V.amygdalina* during wet season. The highest (p<0.05) ADF was recorded for *E.cymosa* and *C.africana* during dry and wet season. The ADF content observed in the current study for *M.alba* in dry and wet season was lower than the result reported earlier for *V. amygdalina, E.cymosa* and *C.africana* by (Aynalem Haile and TayeTolemariam 2008 and Takele et al. 2014) for *B. polystachya, M. lanceolata* and *V. amygdalina*. The lowest ADL content was observed for *V.amygdalina*. The ADL content recorded in this study for *B. aegyptiaca* and *V. amygdalina* in wet season was lower than the result reported earlier (Aynalem Haile and Taye Tolemariam, 2008) for *B.polystachya, M. lanceolata* and *V. amygdalina* and within the range of the result reported by Takele et al. 2014 for *V. amygdalina, E. cymosa* and *C.africana*. The highest (P<0.05) IVOMD was recorded for *M.alba* and *V.amygdalina* during dry season. The IVOMD value for *M.alba, V.amygdalina* and *M.ferrgunea* in the current is higher than the result reported by (Aynalem Haile and TayeTolemariam 2008) for *B. polystachya, M. lanceolata* and *V.amygdalina*, (Assen et al. 2016) for M. alba leaf harvested in wet season and (Etana Debela and Adugna Tolera 2013) for leaf, twig, pod and whole forage of *M.oleifera* and *M. stenppetala*

Table 5. Chemical composition and in vitro organic matter digestibility of selected multi-purpose fodder trees

Season	Species	Chemical composition and in vitro organic matter digestibility (%DM)							
		DM%	Ash	EE	CP	NDF	ADF	ADL	IVOMD
Dry	*B. aegyptiaca*	97.2c	16.8b	1.0d	17.0b	34.9e	20.2f	11.9e	71.1c
	C.africana	98.1b	15.5c	1.4c	10.6e	61.2a	35.0b	22.2a	57.2e
	E. cymosa	98.4a	11.4e	4.3a	13.6d	53.4b	38.0a	17.3b	62.3d
	M.ferruginea	95.2d	12.2d	1.6c	16.5b	50.9c	32.4c	14.1c	76.1b
	M.alba	98.4a	21.1a	1.7b	19.2a	42.0d	20.6e	12.1d	81.3a
	V.amygdalina	95.6d	12.1d	0.7e	14.3c	43.1d	21.0d	10.2f	81.5a
Wet	*B. aegyptiaca*	95.8d	16.9b	1.4b	17.9b	29.8e	17.1	8.6e	79.1c
	C.africana	97.8c	11.5	1.2e	13.3d	56.9a	32.8a	18.0a	65.6e
	E. cymosa	98.0b	11.6c	4.6a	16.5c	50.9b	32.2b	17.3b	70.2d
	M.ferruginea	94.9e	11.9c	1.3c	20.1a	50.6b	28.5c	15.2c	83.2b
	M.alba	96.3c	18.6a	1.3c	20.7a	40.0c	21.2d	11.8d	83.1b
	V.amygdalina	94.9e	10.6d	1.3d	17.3b	36.2d	15.1f	8.7e	84.8a
	Species	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
P-value	Season	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	Species* Season	0.0001	<.0001	0.7048	<.0001	0.0849	0.0167	0.0035	<.0001

Different letters in the column shows significant (P < 0.05) difference DM = Dry matter, OM = Organic matter, EE = Ether extract, CP = Crude protein, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ADL = Acid detergent lignin, IVOMD=In-vitroorganic matter digestibility

Conclusion and Recommendation

Fodder trees and shrubs provide evergreen leaf fodder around the year to supplement nutritionally poor dry forage during dry season in Ethiopia. Tree leaf biomass fodder contains rich crud protein (cp), minerals than other feed sources. Fodder trees and shrubs produce cheapest and high leaf biomass fodder per a unit area which is accessible throughout dry season for livestock. *Erythrina brucei, Dracaena steudneri and Cordia africana* had the highest biomass yield in highland, midland and lowland, respectively. The chemical composition of fodder trees and shrubs leaves shown variation due to species, altitude, soil fertility, season, and others. Thus, I recommend the intensive fodder trees and shrubs planting via agroforestry campaigns to ensure sustainable feeding system in the whole Ethiopia.

Conflict of interest

There is no conflict of research interest.

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