



Research Article

Fodder Production and Livestock Rearing in Relation to Climate Change and Possible Adaptation Measures in Manaslu Conservation Area, Nepal

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Abstract

A study was conducted to find out the production potential, nutrient composition, and the variability of the most commonly available fodder trees along with the varying altitude to help optimize the dry matter requirement during winter lean period. The study was carried out in Lho and Prok Village Development Committee of Manaslu Conservation Area (MCA), located in Gorkha district of Nepal. The study was divided in two parts: social and biological. Accordingly, a household (HH) survey was carried out to collect primary data from 70 HHs, focusing to the perception of respondents on impacts of climatic variability to the feeding management. The next part consists of understanding yield potential and nutrient composition of the four most commonly available fodder trees (*M. azedirach*, *M. alba*, *F. roxburghii*, *F. nemoralis*), within two altitude ranges: (1500-2000 masl and 2000-2500 masl) by using a RCB design in 2*4 factorial combination of treatments, each replicated four times. Fresh yield and dry matter yield of each fodder trees were significant ($P < 0.01$) between the altitude and within species. Fodder trees yield analysis revealed that the highest dry matter (DM) yield (28 kg/tree) was obtained for *F. roxburghii* but that remained statistically similar ($P > 0.05$) to the other treatment. On the other hand, most of the parameters: ether extract (EE), acid detergent lignin (ADL), acid detergent fibre (ADF), cell wall digestibility (CWD), relative digestibility (RD), digestible nutrient (TDN), and Calcium (Ca) among the treatments were highly significant ($P < 0.01$).

Keywords: Fodder trees; climate change; yield; nutrient; indigenous knowledge

Introduction

Inadequate feed supply is the major constraints in livestock rearing, especially in hills and mountainous region of Nepal (Devkota and Kolachhapati, 2009). Among them, low productivity of animal and poor availability of forage/fodder trees species are major concern (Reddy, 2006; Upreti and Shrestha, 2006; Saha et al., 1987).

Moreover, the problem of feeding is alarming due to insufficient forage, degrading pasture and grazing land, changes in season wise availability of forage, prolong seasonal drought and domination by the invasive species (Joshi, 2000; Reddy, 2006; DADO, 2010/11). Since 31% of people in Nepal are living below the poverty line and are struggling to secure year round food supply for sustaining

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their lives and livelihood in such condition, livestock sector being one of the major sources of income that supports livelihood options in hills and mountains of Nepal, so could potentially impact the livelihoods of herder community (DADO, 2010/2011).

Besides, people and livestock both components are vulnerable, especially for shortage of feed mainly due to climate change or the associated impacts. Change in climatic pattern are said to have a slow but alarming impact in this region especially to the forage availability, livestock feeds availability and managerial options within small livestock farmers (ICIMOD, 2007; Tulachan and Neupane, 1999; Tulachan, 2001; Dhakal and Devkota, 2012; Sarwar *et al.*, 2002).

The livestock sector, which is highly vulnerable to climate change impacts due to higher climatic sensitivity and lower adaptation flexibility, is experiencing low productivity in Nepal. Furthermore, climate change disproportionately affects mountains and hilly regions. In these aspects, Nepal is being considered as the fourth vulnerable country in the world (IPCC, 2007). Climate change is the major threats to climatic uncertainty (Deschenes and Greenstone, 2006). Evidence from the Intergovernmental Panel on Climate Change (IPCC, 2007) is now overwhelmingly convincing that climate change is real, that it will become worse, and that the poorest and most vulnerable people will be the worst affected. The IPCC predicts that by 2100 the increase in global average surface temperature may be between 1.8 and 4.0 °C with annual rise of 0.06 °C per annum (Shrestha *et al.*, 1999). With global average temperature increases of only 1.5-2.5 °C, approximately 20-30% of plant and animal species are expected to be at risk of extinction (FAO, 2007b). According to the GIEC report (2007), mountain and hill ecosystems are considered extremely vulnerable to climate change. An increase in extreme climatic events, such as drought and flood, is anticipated more constraint to profitable livestock production (Christensen *et al.*, 2007). Climate change has serious impact on livestock and livelihood of livestock keepers and brings additional challenge to food security and overall livelihood options in Nepal.

Feeding is one of the main constraints in livestock production, which cost more than 70% of total cost of production (Sarwar *et al.*, 2002). Especially, within smallholder farmers, who are also within food insecurity issues, production of livestock by feeding with sufficient concentrate material is also a challenging job (Sarwar *et al.*, 2002; Younas and Yaqoob, 2005). The estimated shortage of dry matter is over 40% (Pande, 2004; 2005), though various pasture improvement program was launched by different sectors in Nepal in the past (Pande, 1994; 1997). Moreover, livestock is only the main income source for majority of the smallholder farmers therefore; development on new feeding technology and enhancement of the existing

technology to optimize utilization of the feed is one of the best alternatives (Saha and Gupta, 1987). In this context, those farmers who are highly dependent upon the natural resources like free pastureland, grazing land naturally will face the scarcity of the green fodder during dry period. Prolong drying during winter season cause the drying of the winter grasses so that there is heavy loss of milk production in this period (Pande, 2005) and results adverse impacts on people livelihood.

In these aspects, livestock being one of the important income and livelihood option in the hills of Nepal is in the need of some concrete finding about the feed availability to the ruminant livestock. Since number of the livestock is in increasing rate and those increased livestock populations need more grass and fodder to maintain nutritional requirement. In this situation, the available rangeland, the grazing land, and the pastureland might not full fill the additional nutrient requirement of the livestock. Furthermore, In the winter season, becomes dry so that less possibility of green roughage. By considering this situation, in this period, fodder trees can be the good source as a feed for ruminants. However, By considering this situation, In this period, fodder trees can be the good source as a feed for ruminants. In addition to this CC has also negatively affected the different aspects of the livestock production system and one of the major issues among them is decrease in green roughage availability. Changes in the climatic parameter leading to degrading of grazing land and seed germination and seeding establishment of the fodder trees so there is possibility of long-term instability of livestock production system. Therefore, following objectives were formulated to address the context:

- To identify the impact of climate change on livestock production system in Manaslu Conservation Area (MCA) considering its link to feed availability for livestock rearing during winter critical period
- To know nutrient composition, its variability along altitude to that of commonly available fodders trees in mitigating dry matter requirement during dry spring season in changing climatic condition.

Material and Methods

Study Site

The research was conducted in the Manaslu Conservation Area (MCA) of Gorkha district, which lies in the northern region of Western Development Region of the Nepal from February to August 2012. The study area is located in N 28°31.177', E 084° 50'066" to N 28° 34.527', E 084° 41.885' latitude and altitude 2000-2500 meter above sea level (masl) and 1500-2000 masl. Area (MCA) includes seven VDCs Sirdibas, Chumchet, Chekampar, Bihi, Prok, Lho and Samagaun. There are 1952 households and 4465 males

and 4465 females reside. It touches Tibet in north, Manang in west and Dhading in the east.

However, this area is recognized as highly remote area and it is much rich in natural flora and fauna with high variation in altitude and the latitude. Geopolitically, it is one of the most sensitive areas of Nepal. The Manaslu conservation area (MCA) is a protected area of Nepal established in 31st Dec 1998 and it covers 1663 km² in the Mansiri Himalayan range out of total 3610 km² area of the Gorkha district. This region occupies hilly region as well as mountainous region with 46.07% of the total area of Gorkha district Manaslu (Kutang) conservation area was selected for the study because this was one of the representing high hills of Nepal in which most of the farmers are livestock keeper and livestock is a complementary occupation along with cereal crop production. Livestock is the main stay among these farmers.

Research Method

Research was carried out mainly in two parts first was social and next biological. In the social parts of the research, 35 from Lho and 35 from Prok VDCs altogether 70 HHs were studied for the socioeconomic information. HHs survey, focus group discussion, key informant interview was conducted to find out the perception of the farmers on the perception of the farmers on the impacts of climate change and its adaptation strategies. In order to find the most abundant and the top most preferred species ranking method was used. The most abundant species were listed and used for further ranking exercises. The observation recorded was i) assessment of fodder trees owned and used by the farmers and ii) preference ranking of fodder trees under different criteria. The nutrient analysis of preferred and top ranked species was done in the laboratory. Criteria for preferring fodder species were developed by the farmers themselves. Farmers selected four criteria to be important determinant. The criteria used were: i) palatability, ii) growth rates, iii) adoptability (propagation easiness), and iv) overall preference of the fodder trees (farmers' basis were toxicity, easy looping, and other feeding quality parameters). List of ten most abundant species were first taken for ranking and described as 'I' most preferred to worst desired as 'X'.

Indexing and Ranking Tool

Scaling techniques, which provides the direction and extremity attitude of the respondent towards any proposition was used to construct index. The formula given below was used to find the index for intensity of various problem/reasons.



$$I_{\text{prob}} = \frac{\sum S_i f_i}{N}$$

Where, I_{prob} = Index value for intensity of problem, Σ = Summation, S_i =

Scale value of i^{th} intensity, f_i = Frequency of i^{th} response

N = Total number of respondents

Biomass Estimation

Each of the fodder trees *Melia azadirach* (Bakaino), *Morus alba* (Kimbu), *Ficus roxburghii* (Nimaro), *Ficus nemoralis* (Dudhilo) that were under farmers best preference ranking was selected for edible herbage biomass and chemical constituent study. The approximated yield of the green forage biomass of major fodder trees were measured by cutting one fourth of the fodder tree of the similar age (5-10 years) group (Vaidya and Gautam, 1989). Tree biomass was measured by looping finger size branches from approximately one fourth canopy area of each fodder tree and weighed within one hour of the collection of the fodder. To estimate the total biomass present on the fodder tree, destructive harvest technique i.e., cut and fresh weight method was employed (Nath et al., 2009; Vermijst and Telenius, 1999). Four fodder trees were taken to estimate total dry matter production per tree per year, proximate analysis.

Chemical Composition

A finger size twig with leaves of four most preferred species of the fodder tree were selected randomly within two different altitudes first 1500-2000 masl and other above 2000-2500 masl from sea level. The weight of sample was maintained as 200 gm each and taken to the laboratory after 2-3 hours of sun dry and dried at 60 °C for 72 hrs (checked for constant dry weight) in hot air oven and grinded to pass through 1mm sieve. The filtrate kept in tight plastic bags and stored at room temperature until, nutritional analysis at Nepal Agriculture Research Council Laboratory, Lalitpur.

Chemical Analysis Procedure

Chemical composition (CP, CF, EE, ash, and DM) of the plant sample was determined according to AOAC (1995) protocol. CP percent was determined by using Kjeldhal method (Anon, 1994; Nath et al., 2009). Organic matter (OM) content was obtained by subtracting percentage ash content from 100% (Omoniyi et al., 2013; Soest et al., 1991). Neutral detergent fibre (NDF), acid detergent lignin (ADL) and acid detergent fibre (ADF) were determined according to the procedure of Soest et al. (1991) and Omoniyi et al. (2013). Cellulose and hemicellulose were derived from NDF, ADF and ADL by using a simple calculation: Hemicellulose = NDF – ADF, (Omoniyi et al., 2013) Cellulose = ADF – ADL (Omoniyi et al., 2013; Soest et al., 1991). Calcium level Calcium was determined by titration (Turekin and Bolter, 1961; Omoniyi et al., 2013; Soest et al., 1991). The % CP was determined by using Kjeldhal method (Anon, 1994; Nath et al., 2009)

Determination of Ash

One gram dried sample of each species was taken in a crucible and charred over a low flame and kept in a muffle furnace set at 550 °C until white ash was obtained (Omoniyi

et al., 2013; Anon, 1994; Nath et al., 2009). The ash content was moistened with water, dried on steam and then on hot plate (Omoniyi et al., 2013; Soest et al., 1991). The crucible was again placed in the muffle furnace at 550 °C, until a constant weight was obtained (Omoniyi et al., 2013). The percent ash was calculated as:

$$\text{Ash percent (\%)} = \frac{\text{Weight of sample after ash}}{\text{Weight of air dried sample}} \times 100$$

Calculation of Estimated Parameters

Cell content, Neutral detergent soluble (NDS), Cellulose, hemicelluloses, Dry matter digestibility (DMD), cell wall digestibility (CWD), relative digestibility (RD) and total carbohydrate content (CHO) was obtained by using formula and deriving the process into calculation.

Relative digestibility of the forage (RD): The relative approximation values of this analysis have 50 and 87% variation within accurate value. Relative digestibility = ADL/NDF

Cell wall digestibility (CWD): This value gives the approximation of the cell wall digestibility of the forages (John and Daniel, 2002).

$$\text{Cell wall digestibility percentage} = 100 - \text{ADF} / \text{NDF} \times 10$$

$$\text{Digestible dry matter (DDM):} \\ \text{Digestible dry matter percentage (DDM)} = 88.9 - (0.779 \times \text{ADF}) \text{ (John and Daniel, 2002)}$$

$$\text{Total digestible nutrients (TDN):} \text{TDN percentage} = 82.38 - (0.7515 \times \text{ADF}) \text{ (John and Daniel, 2002)}$$

Carbohydrate (CHO): It is the total amount of soluble and insoluble fraction of carbohydrate. Carbohydrate was determined by difference, using following formula:

$$\text{Carbohydrate percentage} = 100 - (\text{moisture} + \text{crude fat} + \text{ash} + \text{protein})$$

Intake potential (IP): Intake potential (percentage body weight) or dry matter intake (DMI) = 120/NDF (John and Daniel, 2002)

$$\text{Dry matter digestibility (DMD):} \text{Dry matter digestibility (DMD)} = 1.06\text{NDS} - 18.06 + \text{NDF} (176.39 - 40.50 \log_e A) \times 100$$

Where, NDS = 100 - % NDF and A = ADL (John and Daniel, 2002)

Result and Discussion

Impacts of Climate Change on Feed Availability

Furthermore, various climatic information and its impacts on livelihood options of livestock farmers and adaptation measures followed were accessed from the MCA area. The study revealed that only few of the respondents (2.9%) had little information on climate change while nearly one third of the respondent (32.9%) had little information on the climate change and majority of the population (38.6%) have no information about the climate change and its worse impacts. Majority of the respondent (40.0%) have self-

experiences on climate change while a few (8.6%) percent of the respondent got information from researcher, visitors and majority (37.2%) of the respondent got information from media tools. The study revealed that majorities (87.1%) of the respondent were facing climate change worse impacts in the MCA while the problem faced were floods, landslides, drought in spring season and loss of water resources and ecological environments. Most of these problems were found to be increasing. One half of the respondent (50.0%) perceived the loss of forage biodiversity as urgent and immediate while nearly one fourth of the respondents (21.4%) perceived as medium term problem and nearly one third (28.6%) perceived as long term problem. Majority of the respondent (78.6%) revealed that grazing area was decreasing while remaining nearly one fifth of the respondents (21.4%) revealed no change in the total area of grazing land. Similarly, loss of forage species was another problem. Majority of the respondent (41.4%) experienced that loss of forage biodiversity was a severe problem while 27.1% revealed no problem in the forage biodiversity.

Preference of Fodder Trees

In an average, *F. roxburghii* fodder tree was best preferred (index value 0.72) and followed by *M. alba* (index value 0.67), *M. azedarach* (index value 0.64) and *F. glomerata* (index value 0.55). On the basis of growth and productivity, *M. azedarach* species found to be the best fodder (index value 0.77) and it was followed by *F. roxburghii* (index value 0.75) and lowest for wild species such as Takpa and other thorny species. Accordingly, for the palatability of the fodder trees, *F. roxburghii* was found to be the most palatable (index value 0.69) which was followed by *M. alba* (index value 0.67), *F. glomerata* (index value 0.60) other Takpa and thorny species (index value 0.56) and finally least preferred for *M. azedarach* (index value 0.47) respectively. Similarly, the adoptability of *F. roxburghii* was highest (index value 0.69) which was followed by *M. azedarach* (index value 0.60), *F. glomerata* (0.59) other Takpa and thorny species (index value 0.57) and finally *M. alba* (0.53) respectively. Similar type of ranking was carried by Dhungana et al. (2012) and observed the similar results in Hemja VDC of Kaski District Nepal (Table 1).

Yield Potential of Fodder Tree

The fresh roughage yield of within 5-10 years range were statistically highly significant among the fodder trees species and altitudes of fodder trees species cultivated ($P < 0.01$). The highest fresh matter yield/tree was found in *F. roxburghii* (72.00 kg) while the lowest was found for *M. azedarach* and *F. roxburghii*. Within two altitude ranges, higher fresh yield/tree (73.19 kg) was found at lower altitude, and lower fresh yield/ tree (53.19 kg) was found for higher altitude range. The dry matter yield of the fodder was statistically non-significant ($P > 0.05$). Similarly, percentage dry matter yield of was significantly varied according

species while highest value was obtained for *M. azedarach* while statistically similar for the rest of the species. Percentage dry matter did not vary significantly within two altitude range. The lower dry yield obtained in this study was also similar to the reported value (15-60 kg DM per year) of Panday (1982). While, lower yield at higher altitude and higher yield at lower altitude was also supported by Pande (1991). The higher production at lower

altitude might be due to higher adaptation of species at lower altitude range (such as temperature, relative humidity, soil nutrient cycling, soil moisture, and precipitation might be influencing factor for higher adaptation) and more per unit area solar radiation at lower altitude for photosynthetic activities by the leaves of the plants (Fig. 1).

Table 1: Preference ranking of the fodder by farmers on the basis of the fodder value (overall preferences) in MCA

Name of the fodder	Overall preferences		Growth and productivity		Palatability		Adoptability	
	Index value	Rank	Index value	Rank	Index value	Rank	Index value	Rank
<i>M. azedarach</i>	0.64	III	0.77	I	0.47	V	0.60	II
<i>M. alba</i>	0.67	I	0.53	III	0.67	I	0.53	V
<i>F. roxburghii</i>	0.72	II	0.75	II	0.69	III	0.69	I
<i>F. glomerata</i>	0.55	IV	0.45	IV	0.60	II	0.59	III
Other (Takpa, thorny species)	0.41	IV	0.50	V	0.56	V	0.57	IV

Source: Field survey, 2013

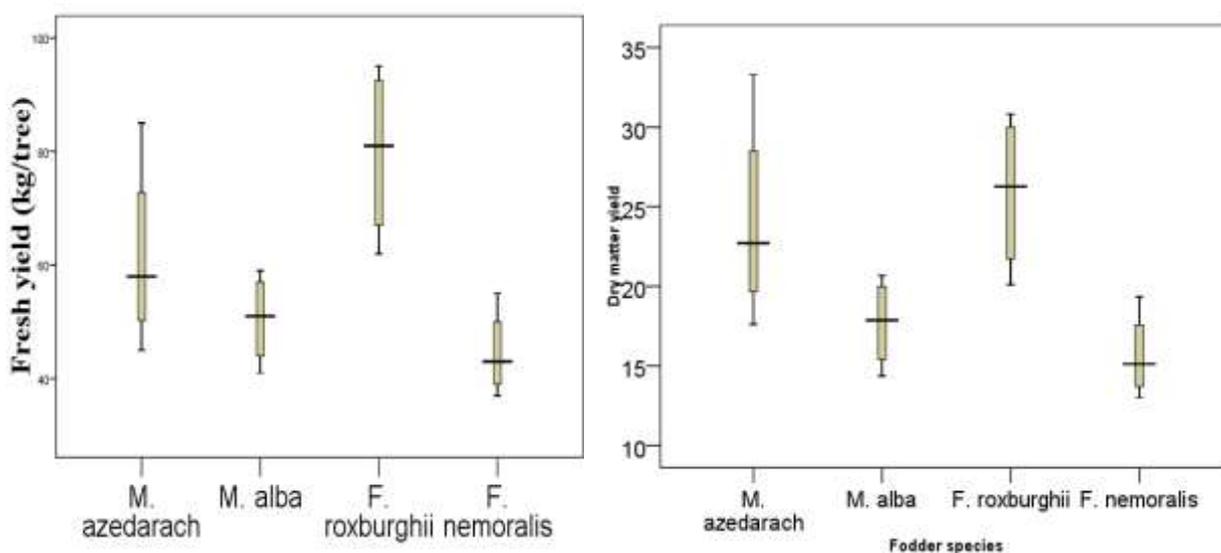


Fig. 1: Yield potential of fodder trees (descriptive statistics)

Nutrient Composition

Table 2 shows the proximate composition analysis revealed that most of the parameters such as ADF, ADL, CP, EE, ash, Calcium (Ca) content were highly significant among the species except NDF content. The highest ADF and ADL value were obtained for *F. glomerata* (54.27%) and *F. roxburghii* (37.22%). The ADF percentage was also statistically similar for *M. azedarach*, *M. alba* and *F. roxburghii*. Similarly, the protein content of the fodder trees between species was non-significant while EE content was highly significant between the species. *M. alba* (3.26%) had the highest level of EE, which was statistically similar to that of *M. azedarach* (3.04%), while the lowest value was found for *F. roxburghii* (2.64%) which was statistically similar to that of *F. glomerata* (2.80%). The highest value of the Ca was found for *M. azedarach* and *F. roxburghii* while rest of two species had lower Ca content with no statistically difference value ($P>0.05$). Similarly, the highest ash content was found in *F. roxburghii* (17.08%) while rest of species had lower ash content with no significance difference ($P>0.05$). Similarly, between two attitudes, there was no significance difference in the value of NDF, ADL, ADL, CP, and Ca content for each of the fodder tree species. Similarly, EE was higher in lower altitude fodder and lower for higher altitude whereas for ash content, it was higher for higher altitude and lower for lower altitude fodder species. The combination effect of species and altitude for ADF, ADL, EE, and ash content of the fodder trees differ significantly, while NDF, CP and Ca content, were statistically similar for most of the treatment.

The CP content of *F. roxburghii* was observed to be 12.03%, which is similar to the finding of Singh *et al.* (2009), Malla (2004) and Upreti and Shrestha (2006) but was higher than the value reported by Singh (1982) and lower than reported by Dhungana (2012) (18.13%). In the same way CP content of *M. azedarach* (12.27%) and *M. alba* (10.07%) was much lower than the value (24.02%) and (18.93%) obtained by Upreti and Shrestha (2006). The CP content of *F. glomerata* fall within the range reported by Osti *et al.* (2006) whereas for *M. alba* CP content was lower than the value suggested by Osti *et al.* (2006) (18.43±8.06) and Upreti and Shrestha (2006). The variation in nutrient content of same species might be due to variation in maturity stage of twigs during sampling time (Najumair *et al.*, 1964). Another reason might be that period of forage collection was winter (February- March) in which less soluble nitrogen availability on the soil and helps to decrease the protein content of the fodder.

Effect of Altitude and Species On Cell Content, Hemicelluloses and Cellulose Content

It is evident from the Table 3 that the cell content, cellulose and hemicelluloses content of each fodder trees species was statistically non-significant. Altitude of the forage collection had no significant influence on the cell content, hemicelluloses content and cellulose content of the selected fodder tree species. Similarly, cell content was highly significant within species and but not differed significantly in two altitudes. The highest cell content was obtained for *M. azedarach* (52.03%) and *M. alba* (50.92%) and lowest was found for *F. roxburghii* (31.92%).

Table 2: Effect of altitude and species for nutrient composition

Species	NDF %	ADF %	ADL %	CP %	EE %	Ca %	Ash %
<i>M. azedarach</i>	47.97 ^c	42.53 ^b	13.35 ^d	12.27	3.05 ^{ab}	6.91 ^a	11.49 ^b
<i>M. alba</i>	49.08 ^c	41.41 ^b	21.82 ^c	10.07	3.26 ^a	6.84 ^a	12.60 ^b
<i>F. roxburghii</i>	56.97 ^b	47.85 ^b	37.22 ^a	12.03	2.64 ^c	3.81 ^b	17.08 ^a
<i>F. glomerata</i>	68.08 ^a	54.27 ^a	28.80 ^b	14.50	2.80 ^{bc}	2.81 ^b	11.59 ^b
Probability	<0.01	<0.01	<0.01	NS	<0.05	<0.01	<0.01
LSD	6.83	6.13	5.03	3.33	0.37	1.19	1.40
SEM±	2.32	2.086	1.71	1.132	0.01	0.41	0.48
Altitude							
2000-2500 masl	55.69	46.92	25.05	11.72	2.75 ^b	5.35	14.05 ^a
1500-2000 masl	55.36	46.11	25.54	12.72	3.12 ^a	4.832	12.33 ^b
Probability	NS	NS	NS	NS	<0.01	NS	<0.01
LSD	4.83	4.34	3.55	2.35	0.26	0.85	0.99
SEM±	1.64	1.48	1.21	0.80	0.09	0.29	0.33
CV%	11.82	12.69	19.12	12.22	2.94	5.09	13.19
Mean	55.52	46.51	25.29				

Means separated by the same letter(s) in the column are not significantly different at 5% level of significance. NDF: Neutral detergent fiber, ADF: Acid detergent fibre.

Table 3: Effect of species on cell content, hemicelluloses and cellulose content

Species	Cell content %	Hemicelluloses %	Cellulose %
<i>M. azedarach</i>	52.03a	5.43b	29.18a
<i>M. alba</i>	50.92a	7.67ab	19.59c
<i>F. roxburghii</i>	43.03b	9.16ab	10.62d
<i>F. glomerata</i>	31.92c	13.81a	25.47b
Probability	<0.01	<0.01	<0.01
LSD	6.83	6.96	3.46
SEM±	2.32	2.37	1.18
Altitude			
2000-2500 masl	44.31	8.77	21.86
1500-2000 masl	44.64	9.25	20.57
Probability	NS	NS	NS
LSD	4.83	4.92	2.45
SEM±	1.64	1.67	0.83

Means separated by the same letter (s) in the column are not significantly different at 5% level of significance.

Similarly, hemicelluloses and cellulose content was highly significant among the fodder trees species ($P < 0.01$). The highest hemicelluloses were found in *F. glomerata* (13.81%) and statistically similar result with *M. alba* and *F. roxburghii* and lowest was for *M. azedarach* (5.43%) whereas that for *M. alba* and *F. roxburghii* was statistically similar ($P < 0.05$). For cellulose content, *M. azedarach* had highest (29.18%) followed by *F. glomerata* (25.47%), *M. alba* (19.59%) and the least was for *F. roxburghii* (10.62%).

The hemicelluloses content of *M. azedarach* was within the range reported by Osti et al. (2006). Similarly, for *F. glomerata*, hemicelluloses and cellulose percentage obtained in this study was higher than obtained by Osti et al. (2006) whereas for *M. alba*, both hemicelluloses and cellulose content was obtained within the range suggested by Osti et al. (2006). For *F. roxburghii*, hemicelluloses obtained in this study was higher (9.12%) than reported by Osti et al. (2006) (4.81±2.14) but cellulose content (10.62%) was lower than the reported by Osti et al. (2006). The higher hemicelluloses content and lower cellulose content might be due to collection of laboratory sample of fodder trees from high altitude range. This high hemicelluloses content and low cellulose content on the roughages of high altitude range represent the better quality of roughages as the altitude increase (Soest et al., 1991).

Combination Effect of Altitude and Species On Cell Content, Hemicelluloses and Cellulose Content

There was highly significant combination effects of the fodder species and altitude of forage collection on the total cell content of the fodder and similar result was obtained for hemicelluloses and cellulose content ($P < 0.01$) (Table 4). The higher cell content was obtained for *M. alba* fodder (53.59%) growing in the 1500-2000 masl which was also statistically similar for T1, T2 and T3 while lowest cell

content was found for *F. glomerata* 1500-2000 masl and that was statistically similar with T7 ($P < 0.05$).

Highest cell content for *M. alba* fodder than any other fodder species was due to succulent type and less maturity of fodder during collection. *F. glomerata* had lower water percentage and more dry matter percentage and because it is highly branching type fodder tree than any other remaining species. This might be major causes of less cell content and high hemicelluloses.

There was as par result of cell content of *F. glomerata* in higher and lower altitude but lower altitude had higher cell content. It might be more succulent type fodder in the lower altitude due its premature harvesting time.

Moreover, there was significant combination effect of forage species and altitude on cellulose content of the fodder. The highest cellulose content was found for *M. alba* 2000-2500 masl. This might be due to more succulent nature of *M. alba* fodder at lower altitude. Succulent type of fodder and young branches had lower cellulose content but higher soluble carbohydrate (Heady, 1975).

Similarly, considering two or more parameters independently, Cell content, hemicelluloses, and cellulose content of the fodder trees were highly significant among the species but not significant between the altitude ($P > 0.05$). Similarly, % NDS, % DMD, % CWD, RD, % TDN, % CHO, IP value of fodder trees varied significantly for most of the species but these value did not varied significantly between the two altitude considered ($P > 0.05$). In the ranking of the fodder trees based on their fodder value in terms of IP value and DMD value *M. azedarach* ranked in the topmost position on the basis of % DMD while *M. alba* ranked the topmost position on the basis of RFV of the fodder trees.

Table 4: Combination effect of altitude and species on cell content, hemicelluloses and cellulose content

Treatments	Cell content (organic material) %	Hemicelluloses %	Cellulose %
M. azedarach at 2000-2500 masl	52.51ab	5.12b	27.91b
M. azedarach at 1500-2000 masl	51.56ab	5.76b	30.45b
M. alba at 2000-2500 masl	48.24ab	5.11b	36.74a
M. alba at 1500-2000 masl	53.59a	10.23ab	2.44d
F. roxburghii at 2000-2500 masl	42.59bc	4.95b	0.66d
F. roxburghii at 1500-2000 masl	43.46abc	13.30ab	20.59c
F. glomerata at 2000-2500 masl	33.92cd	19.89a	22.14c
F. glomerata at 1500-2000 masl	29.93d	7.73b	28.80b
Probability	<0.01	<0.05	<0.01
LSD	9.66	9.84	4.90
SEM±	3.28	3.35	1.66
CV%	14.76	74.31	15.71
Grand mean	44.47	9.01	21.21

Means separated by the same letter (s) in the column are not significantly different at 5% level of significance.

Conclusion

Farmers have been adapting with changing climatic context using their available local resources and knowledge in livestock feeding management, that needs concrete and consolidated efforts to strengthen their capability in the coming days. This indicates the scope of introducing productive and nutritive fodder trees species even at the high altitude to help reduce fodder scarcity problem during winter. This finding also revealed the scope of promoting all available local fodder trees species as crude protein content of these species were similar.

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