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Taxonomical identification, biomass production and nutrient composition of *Moringa sp.* as a fodder crop

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Abstract

The study was conducted to identify the moringa species and to determine biomass production of *Moringa sp.* as a fodder crop. An experimental plot (2100 cm x 300 cm) was divided into three equal subplots (900 cm x 300 cm). Chemical fertilizer was applied (100-90-30, NPK), one-fifth of the total fertilizer after each harvest and the recommended amount of cow dung. Weeds were controlled in the experimental plot as they appeared. In a harvesting day, one unit of land containing 54 plants was cut into 3 different sections considering different cutting heights 1.5, 2 and 2.5 feet and cutting intervals after planting were 40, 50 and 60 days, respectively. The experimental design was 3 x 3 factorial design in this study. All plants were randomly selected from each harvested plot and separated manually into their different botanical fractions such as stem, twigs and leaves. The different fractions weight were recorded using an electric balance and freshly harvested biomass were sun dried. To identify the moringa plant taxonomically, the herbarium sheets were prepared with the samples from 6 different locations of Bangladesh. The herbarium sheets were matched with the control moringa herarium sheet at the library of Bangladesh National Herbarium Center, Mirpur Dhaka. As per result, the biomass yield of moringa at 40 days from sowing was significantly highest ($p<0.01$) in 1.5 feet (278 kg/hec) to 2 feet (264 kg/hec) cutting from the ground compared to 2.5 feet (207 kg/hec). Similar trends were observed in 60 days. Interaction effect between cutting height and cutting interval was found significant. Moringa leaves contained crude protein (CP) 28.21% whereas stem and twigs contained 11.13% and 13.49% CP respectively in this study. Considering all the results it can be concluded that *M. olifera* may be cultivated as fodder crop and harvested with optimum cutting height of 1.5 feet at the age of 60 days.

Keywords: Moringa; Toxonomy; Biomass yield; Cutting intervals; Nutrients composition.

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Introduction

Moringa (*Moringa oleifera* L.) is the most widely cultivated species of a monogeneric family, Moringaceae, that is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh, Afghanistan and nowadays it is widely cultivated around the world (Jed and

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Fahey, 2005). It is a deciduous plant and could grow up to 8 m height (Keay, 1989). The indigenous knowledge and use of moringa is referenced in more than 80 countries and it are known in over 200 local languages. This moringaceae family is composed with 14 known species, of these *M. oleifera* and *M. stenopetala* are most commonly cultivated in South India, Ethiopia, Philippines, Sudan and other tropical countries (Fahey, 2005). *M. oleifera* and *M. concanensis* are found almost all over in Bangladesh (Ahmed *et al.,* 2009). Moringa is well known for its nutritional and medicinal values from the ancient time and utilized by Romans, Greeks, Egyptians and northern Nigeria (Dalziel, 1956; Keay, 1989). The variety of essential phytochemicals, energy and vitamins are present in moringa leaves, pods and seeds (Makkar and Becker, 1996 and 1997; Nuhu, 2010; Mutayoba *et al.,* 2011).

A total of 250,000 species of flowering plants are referred to as medicinal plants. The World Health Organization (WHO) enlisted some 21,000 medicinal plant species (Penso, 1980). The annual growth of herbal market is about 15 percent and the global herbal market by 2050 is expected to be about US$ 5 trillion (WHO, 2002). In Bangladesh, we have about 500 plant species as medicinal plant including moringa because of their therapeutic properties (Ghasi, 2000). Our native herbs and plants alone or in combination can be used as feed additives for improving the production performance and products quality (Sarker *et al.,* 2017).

M. oleifera variety from pure line breeding program ensures highest productivity and drought-tolerance, growing typically in tropical regions that can be grown in varied types of soils. The most popular species is *M. oleifera*, a multi-purpose tree originally from India and now found in most tropical countries. It is essential to know the taxonomy about the moringa variety available in Bangladesh. Taxonomy is the science of naming and classifying organisms. Nomenclature is important in order to provide the correct name of a plant. The naming activity is under the control of the International Codes of Botanical Nomenclature (ICBN) published by the International Association of Plant Taxonomy (IAPT). Taxonomy began about 300 years before Christ by Theophrastus (370-285 BC). Carolus Linnaeus (1707-1778) is regarded as the founder/father of taxonomy till today. In last two and half century only one million animals and 0.5 million plants identified, this forms only 10% of world's organisms. So that taxonomical identification is essential for his miracle Moringa tree in Bangladeshi perspective.

In addition, adequate and regular supply of quality fodder is essential for the development of livestock to meet the increasing demands of burgeoning population. The Moringa species are currently of wide interest because of their outstanding economic potential. Moringa leaves are a good and healthy nutritious source for livestock (Nouman *et al*., 2013). The tree is one of the best nutritious trees, which can provide sufficient fodder for livestock during dry season. It is a fast-growing tree with efficient capability of re-growth after pruning and capacity to produce good quality higher leaf biomass per unit area (Foidl *et al.,* 2001). The biomass production of moringa as a fodder crop has been reported in some literature based on different climatic condition and geometry (Huque *et al.* 2016; Mendieta-Araica *et al.,* 2011) Scanchez *et al.,* 2006; However, reports on yields of moringa fodder under different condition as affected by cutting height, cutting intervals and planting pattern in Bangladesh have yet to be studied. Therefore, the present study was conducted with the objective to optimize the cutting interval at different plant spacing for maximum biomass with better nutritional quality for sustainable production of livestock. In addition, the taxonomical identification of *Moringa Spp.* was also studied with the sample of different locations in the northern part of Bangladesh.

Materials and Methods

a) Taxonomical identification of Moringa

Herbarium sheets were prepared from different botanical fractions of moringa. The specimen moringa plants are collected as whole and part of plant along with flowers (Fig. 1) followed by methods stated by Jones and Luchinger (1987), Anonymous (1996) and Manilal and Kumar (1998). Herbarium sheets were prepared using BLRI and samples from 6 Northern regions Rajshahi, Rangpur, Dinajpur, Bogura, Panba and Jashore of Bangladesh. Fifteen fresh specimens of the collected species and the same as herbarium specimens were examined and checked. Before putting the specimens in the collection bag, carefully removed all the insects, spider-webs and foreign bodies attached to specimens. Then the specimens mounted in 42 cm x 29 cm (16 ½″x 11 ½″) size blotting paper. Poisoning kills the plants and prevents the formation of abscission layer and thereby the leaves, flowers and fruits were intact with the specimen (twig) and were not getting detached from the plant. Then the specimens are spread out for pressing and drying. The dried plant specimens are mounting on herbarium sheets and pasted with natural glue and a label at the right-side bottom corner. Investigation and identification criteria of the studied species were based on the authentic flora and taxonomic references of Hedge (1992) and Harley *et al.* (2004). Finally, the Moringa samples were identified by Bangladesh National Herbarium Center (BNHC), Mirpur, Dhaka, Bangladesh.

b) Production of moringa

i. Experimental plot preparation and management

This experiment was carried out at the Cattle Research Farm, Pachutia, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh. Recommended dose of nutrient in the soil was applied as per Bangladesh Agricultural Research Institute (BARI), Gazipur. Plants of Moringa were raised from seedlings. The seeds were prepared in a nursery and transplanted after 3 weeks. Twenty tones/ha of cattle manure were applied in pits one week before planting. *Moringa Spp.* leaves were harvested at the research farm of Bangladesh Livestock Research Institute and data were recorded. An experimental plot of 2100 cm × 300 cm was used to cultivate moringa for the determination of biomass yield. The plot was divided into three equal units having specific number of moringa plants and harvested at three different cutting intervals (40, 50 and 60 days) based on other literature. In a harvesting day, one unit of land (900cm × 300 cm) containing 54 plants was divided into 3 sections for harvesting the plants at three different cutting heights (1.5, 2.0 and 2.5 feet). Plant heights were recorded weekly for 10 randomly selected plants in each treatment/replicate. The biomass production was determined in an area of 20x20 m in each treatment/replicate. Samples were collected from the top of the branch to the end of the soft stem part, considered as 3 different cutting heights. Samples of the freshly harvested biomass were sun dried at 37^{o}C, ground through a 1mm screen and stored at 4^{o}C prior to analysis.

ii. Data collection

The fresh biomass from each plot was weighed and recorded to estimate fresh matter yield. The material obtained from each plot was separated into three fractions: a fine fraction, which included leaves, petioles and soft stems, twigs - a slender woody shoot growing from a branch and a coarse fraction, which included stems larger than 5 mm in diameter. The weight of each fraction was recorded and all samples were taken for subsequent chemical analysis. Average height of the plants was estimated by measuring the heights of five randomly selected plants in each sub-plot of each treatment. The measurements were made between the plant base (ground) and the highest top of the leaves. Mortality was calculated as percentage of plants that died at the end of the year, divided by the number of live plants at the beginning of the corresponding year, for each sub-plot.

iii. Proximate analysis

Moringa leaves, twigs and stems were cut from trees then spread on the ground for sundrying. The leaves were then removed manually, grounded into powder and preserved in to air tight bag. The moisture (930.15), total ash (942.05), crude protein (990.03), and ether extract (991.36) contents of the feed samples were analyzed in triplicate according to the method described by the AOAC (2000). Nutritional analyses were done at Animal Nutrition laboratory under the Animal Production Research Division of BLRI, Savar, Dhaka, Bangladesh. NDF and ADF were determined'

iv. Experimental design and Statistical analysis

The experiment of this study was conducted by 3 x 3 factorial designs (3 cutting interval x 3 cutting height). The analytical measurements were done in triplicates, and the results were presented as the average of three analyses ± standard deviation (SD). Statistical analysis was done using the SPSS statistical package (IBM Corp., IBM SPSS Statistics for Windows, Version 16.0, Armork, NY, USA) with univariate analysis of General Linear Model (GLM). A P value of <0.05 was taken as statistically significant based on Tukey's tests.

Results and Discussion

Taxonomical identification

Fifteen herbarium sheets were prepared with the moringa sample of BLRI research farm and 6 Northern districts (Rajshahi, Rangpur, Dinajpur, Bogura, Panba and Jashore) of Bangladesh. The samples were taken as fresh leaves, twigs, flowers, roots etc. from moringa plants and prepared the herbarium sheets. The procedure of taxonomical identification was followed according to Olson (1999). The herbarium sheets were then sent to Bangladesh National Herbarium Center, Mirpur, Dhaka for taxonomical identification. They matched moringa leaf, flower, seed and root of our herbarium sheets with their control or standard moringa herarium sheets at their library and finally they identified the plant is *Moringa oleifera* Lam-

Biomass production of *M. oleifera* Lam. – horseradish tree

The effects of different cutting height on biomass production and the ratio of leaf: stem of the moringa plants are shown in Table 1. Total fresh biomass yield, coarse fractions, total yield of DM, and height significantly ($P < 0.05$) as the cutting interval was prolonged from 40 to 60 days (Fig. 2).

The fine fractions of fresh moringa and DM were not significantly different between cutting frequencies in the first year. However,

a b c d

Fig. 1 Herbarium sheet of *Moringa SP.* Sample were collected from (a) Rangpur (b) Rajshahi (c) BLRI research farm (d) Accession number from Bangladesh National Herbarium Center, Mirpur, Dhaka

Classification for Kingdom to Species of *Moringa oleifera* Lam.

Kingdom Plantae – Plants
Subkingdom Tracheobionta – Vascular plants
Superdivision Spermatophyta – Seed plants
Division Magnoliophyta – Flowering plants
Class Magnoliopsida – Dicotyledons
Subclass Dilleniidae
Order Capparales
Family Moringaceae – Horse-radish tree family
Genus *Moringa* Adans. – moringa
Species *Moringa oleifera* Lam. – horseradish tree

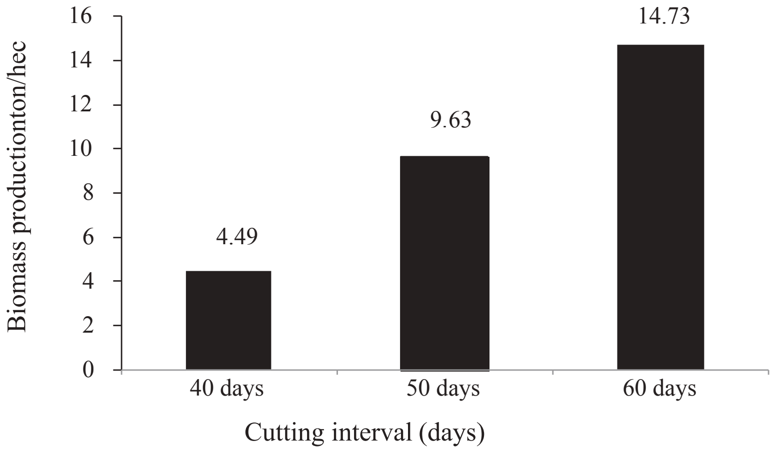

Fig. 2 Effect of cutting intervals (days) and biomass yield (ton/hectare) of moringa (1.5 feet)

biomass yield in the botanical fraction such as leaf, twigs and stem of moringa crop was significantly affected by cutting interval, plant height and their interaction effect. During research period, highest fresh and dry biomass yield of moringa crop was recorded with 60 d cutting interval of 1.5- and 2-feet height while at 2.5 feet cutting interval was non-significant in case of fresh and dry biomass. Moringa has successfully been grown as field crop for biomass production and high dry matter yields of 4.2 to 8.3 t ha-1

Table 1. Fresh biomass yield of *Moringa oleifera* with its different botanical parts at different cutting intervals

Parameter	Cutting the plant from ground (Treatments)			Level of significance
	1.5 feet	2.0 feet	2.5 feet	
Leaf (kg/hec.)				
40 day	104.93 ± 5.95^{ab}	112.97 ± 7.21^{a}	94.10 ± 5.19^{b}	*
50 day	175.76 ± 11.83	161.40 ± 13.40	185.02 ± 12.77	NS
60 day	260.17 ± 18.47^{a}	224.95 ± 27.89^{ab}	185.99 ± 13.04^{b}	*
Twig (kg/hec.)				
40 day	83.42 ± 4.72	77.04 ± 7.02	68.03 ± 4.68	NS
50 day	113.41 ± 6.81^{b}	104.20 ± 8.81^{b}	139.37 ± 9.81^{a}	*
60 day	173.76 ± 11.37	163.40 ± 23.23	137.67 ± 11.30	NS
Stem (kg/hec.)				
40 day	89.65 ± 8.53^{a}	73.77 ± 6.75^{a}	45.05 ± 3.91^{b}	*
50 day	272.21 ± 22.29	245.14 ± 26.60	209.34 ± 16.27	NS
60 day	551.39 ± 48.35^{a}	440.28 ± 78.08^{ab}	316.40 ± 36.45^{b}	*
Total biomass (kg/hec.)				
40 day	278.02 ± 16.87^{a}	263.79 ± 19.13^{a}	207.18 ± 11.82^{b}	*
50 day	561.38 ± 36.14	510.74 ± 42.32	533.75 ± 32.68	NS
60 day	945.34 ± 69.59^{a}	828.63 ± 125.32^{ab}	640.07 ± 57.78^{b}	*
Leaf : Stem				
40 day	1.31 ± 0.11^{c}	1.67 ± 0.11^{b}	2.23 ± 0.14^{a}	*
50 day	0.69 ± 0.05^{b}	0.75 ± 0.07^{b}	0.94 ± 0.06^{a}	*
60 day	0.50 ± 0.03^{b}	0.74 ± 0.10^{a}	0.50 ± 0.03^{b}	*

*, Significantly different ($P<0.05$) : NS, Non-significant ($P>0.05$)

were harvested after every 40 days when planted at different spacing and cutting frequencies (Sanchez *et al*. 2006). Total amount of leaf per plant was affected by the interaction of both factors i.e., cutting intervals and cutting height while crop harvested (Table 1 and Fig. 3).

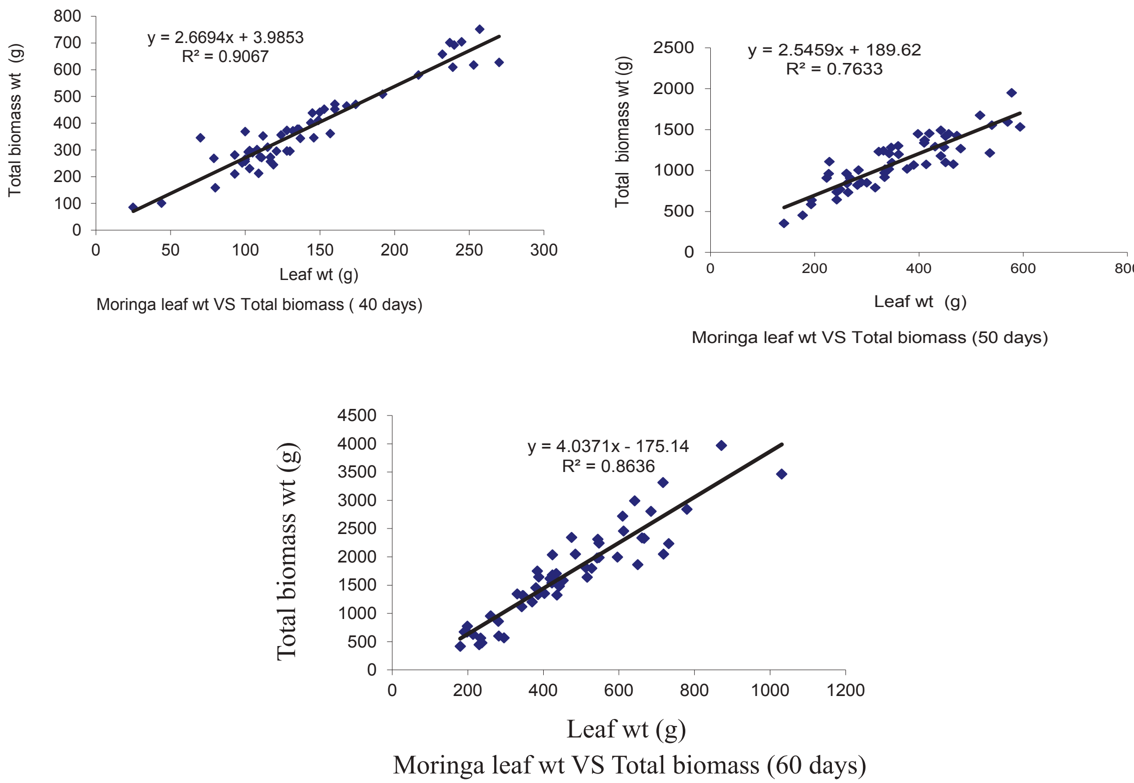

Fig. 3 Effect of leaf and total biomass production in the moringa plant

Results of the field trial on moringa cultivation conducted at BLRI research farm were summarized and the biomass yield of moringa at the cut on 40 days from sowing was significantly highest ($p<0.01$) in 1.5 to 2 feet cutting from the ground compared to 2.5 feet. Similar trends were observed in 50 and 60 days cutting. Fresh moringa leaf weight was significantly highest at 40 days in 2 feet cutting height compared to other two cutting heights but the twigs were increased in 1.5 to 2 feet cutting height. The biomass of leaf and twig at 50 to 60 days were gradually increased compared to 40 days after planting of moringa plants (Table 1). Interaction effect between cutting height and cutting interval was found significant ($P<0.05$) which is shown in Table 2. Leaf and stem ratio of moringa increased with the increase of cutting height (Fig. 3).

M. oleifera grows faster under the subtropical low lands and this species is commonly used and consumed as a fodder and vegetable in South Asia and Africa (Yang *et al.* 2006). Leaf harvesting from fodder trees has been practiced since ancient times for being used especially in rainy and summer seasons (Stür

Table 2. Interaction effect on fresh biomass yield of *Moringa oleifera* with its different cutting interval (days) and cutting heights (feet)

Parameters	Mean ± SE	Interaction within Cutting Interval, CI (days), P value			Interaction within Cutting Height, CH (feet), P value			Interaction (CI x CH) Level of Sig.
		40x50	40x60	50x60	1.50x2.0	1.5x2.50	2.0x2.50	
Leaf (kg/hec.)	167.25±4.82	0.00	0.00	0.00	0.24	0.03	0.33	* (0.03)
Twig (kg/hec.)	117.81±3.70	0.00	0.00	0.00	0.34	0.35	0.98	*(0.03)
Stem (kg/hec.)	249.25±11.84	0.00	0.00	0.00	0.07	0.00	0.03	NS (0.07)
Total biomass (kg/hec)	534.32±18.86	0.00	0.00	0.00	0.11	0.02	0.11	*(0.04)

*, Significantly different ($P<0.05$) : NS, Non-significant ($P>0.05$)

et al. 1994). In the present study, the potential of moringa crop for producing better yield with good chemical composition was studied under different planting space and cutting intervals. Maximum fresh and dry biomass was harvested from moringa plants grown with cutting interval of 60 d while a reduction was observed at higher cutting height. A positive correlation between planting space and yield has been reported in literature for various plant species like *Sesbania grandiflora, Leucaena leucocephala* and *Gliricidia sepium* (Ella *et al*., 1989; Blair *et al.,* 1990; Stür *et al*., 1994).

Nutritional value of *Moringa oleifera*

The data in Table 3 revealed that moringa leaves contained appreciable amounts of crude protein (28.21%), crude fiber (9.14%), ash (8. 19%) and crude fat (5.33%). These values differed from the values reported (Ogbe and Affiku, 2012; Zanu *et al*. 2012) earlier, which may be attributed to difference in agro-climatic conditions, environment, the season of harvesting, maturation stage of leaves, post-harvest treatments, etc. Leaf and mixed foliage contained higher crude protein compared to stem and twigs. Likewise, twig contained higher fat (ether extract) compared to others botanical fractions in the moringa plant of our study.

The crude protein content in leaf and mixed foliage were varied 27.11 to 19.00 % at different cutting intervals. The highest CP content was observed in leaf followed by mixed foliage (Fig. 4). Aregheore (2002) reported that moringa fresh leaves are rich in crude protein (CP) contents ranging between 19.3–24.3 percent Makkar and Becker (1996, 1997) reported 18747.14 and 1121.00 mg kg-1 Ca and P contents, respectively in moringa

Table 3. Overall chemical composition of *Moringa oleifera*

	DM	Ash	CP	CF	ADF	NDF	EE
Leaf	20.15 ± 3.12	8.19 ± 0.11	28.21 ± 0.08	9.14 ± 0.21	39.31 ± 1.31	51.07 ± 4.21	5.33 ± 0.12
Stem	13.50 ± 2.15	9.01 ± 0.81	11.13 ± 0.18	22.10 ± 10.2	26.32 ±1.01	65.13 ± 2.50	3.57 ± 0.18
Twigs	11.91 ± 5.10	5.16 ± 1.01	13.49 ± 1.21	30.19 ± 1.11	17.71 ±1.12	68.30 ±0.41	6.28 ± 0.31
Mixed foliage	13.17 ± 2.80	7.17 ± 1.70	23.15 ± 1.41	27.06 ± 0.81	38.31 ± 0.42	57.80 ± 1.51	3.90 ± 0.63

DM-Dry matter, CP-Crude protein, CF-Crude fat, ADF-Acid detergent fiber, NDF-Neutral detergent fiber, EE-Ether extract leaves. In addition, being rich in vitamins, use of moringa can make up the nutritional deficiency in livestock and human beings.

Amino acid profiles of overall moringa were presented in Table 4. The amino acid content (mg/100g) of leaves was higher than that of mixed foliage which is due to the presence of a higher amount of non-protein nitrogen in the mixed foliage. The potential food value of the protein (as a source of amino acids) can be evaluated by comparison with the FAO reference pattern (Zarkadas *et al.* 1995). All essential amino acids are at higher in moringa plants.

These data suggest that both extracted and unextracted moringa leaves are good sources of protein supplement for high production cows (Zarkadas *et al*., 1995). Protein is an expensive nutrient in feed which is rich in moringa, the crude protein (CP) content in dried moringa is 18.40% (Sultana *et al.,* 2012) and besides this it has medicinal values which can be used for the performance and products quality enhancement for livestock and poultry. Sultana *et al.,* (2012) reported that moringa foliage fed to growing male goats is 3.29 times efficient than feeding Napier fodder for chevon production. Soil is an important factor that defines nutrient content and strength of the plant. Dania *et al.* (2014) showed that fertilizers when applied solely or in combination with others resulted in different nutrient compositions on plant

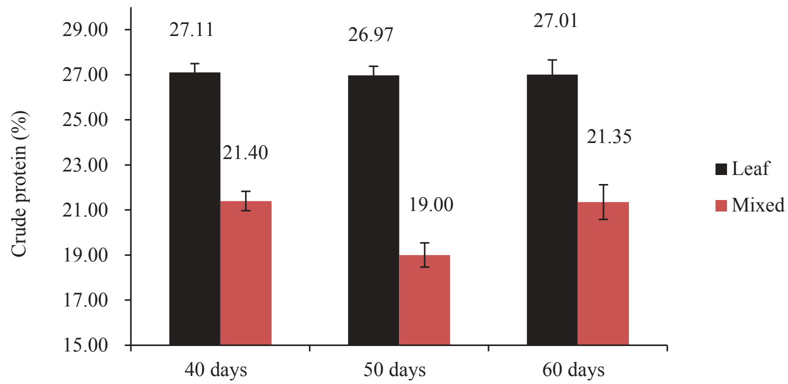

Fig. 4 Effect of crude protein in leaf and mixed foliage during different cutting intervals

Table 4. Amino acids composition of moringa leaves and mixed foliage (overall)

Amino acids (mg /100g)	Leaves*	Mixed (stems+leaves)*
Arginie	1.03	0.60
Isoleucine	0.98	0.56
Leucine	1.70	0.98
Lysine	1.03	0.58
Methionine	0.28	0.17
Phenylalanine	1.42	0.80
Threonine	1.08	0.61
Valine	0.87	0.51

*The values are analyzed at Department of Livestock Services (D LS) nutrition lab, Farmgate, Dhaka parts. NPK fertilizer, poultry manure and organic base fertilizer was provided to study the effect on the nutrient content and found that poultry manure gave the best results than phosphorous, potassium, sodium and manganese. Likewise, the stem girth and vegetative growth of moringa increased on application of poultry manure. The overall nutrient attributes of the plant remains same albeit nutrient variability. This makes moringa viable as a potential nutraceutical anywhere in the world. Roy *et al*. (2016) reported that *Moringa oleifera* had higher nutritional significance and less cost of production compared to Maize and Australian Sweet (AS) Jumbo silages.

Conclusion

The moringa species available at BLRI research farm and 6 different Northern districts were identified as *Moringa oleifera. M. oleifera* may be cultivated as fodder crop and harvested with optimum cutting height of 1.5 feet at the age of 60 days. Biomass production and nutritional composition were slightly varied with cutting intervals when considered at different cutting height. Moringa leaves contain crude protein (28.21%) in our study which might be used as potential protein source. More in-depth animal feeding trial is needed to determine nutritional value of moringa to be used as supplementary ingredients for reducing feed cost and improve products quality.

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