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Comparison of biomass production and nutrient composition of three Napier cultivars in the Barind region of Bangladesh

MS Islam[1*], A Hossain[2], N Sultana[3], US Alam[2], and S Roy[4]

[1]Buffalo Production Research Division, Bangladesh Livestock Research Institute, Savar, Dhaka-1341, Bangladesh.
[2]Regional Station, Bangladesh Livestock Research Institute, Baghabari, Shahjadpur, Sirajgonj-6770, Bangladesh.
[3]Office of Director (Research), Bangladesh Livestock Research Institute, Savar, Dhaka-1341, Bangladesh.
[4]Regional Station, Bangladesh Livestock Research Institute, Rajabarihat, Godagari, Rajshahi-6290, Bangladesh.

Abstract

Fodder production plays a vital role in the Barind region of Bangladesh, especially in supporting livestock rearing. Three Napier cultivars named BLRI Napier 3 (BN-3), BLRI Napier 4 (BN-4), and Napier Color Variety (NCV), were used to know its production and nutrient components at the experimental plots of Bangladesh Livestock Research Institute (BLRI) regional station (RS), Godagari Rajshahi. The experiment was designed by three treatment groups (T1=BN-3, T2= BN-4 and T3= NCV) with five replications and the size of the experimental plots were (20 x 10) square feet. Composition of soil samples from each of the experimental plots were collected and examined from the Divisional Laboratory of Soil Resource Development Institute (SRDI), Rajshahi. First harvest was performed at 60 days after planting and following at 50 days intervals. Data from five successive harvests were gathered and statistically analyzed using SPSS software. The results showed no significant ($p>0.05$) differences in overall production parameters among the three cultivars. Biomass yield (ton DM/ha/cutting) in BN-4, BN-3 and NCV were found 9.18, 8.57 and 8.38, respectively. However, cultivars showed significant ($p<0.05$) variations in sheath weight, leaf weight, and leaf-to-stem ratio (LSR). The better LSR was estimated in BN-4 (0.47) compared to BN-3 (0.34) and NCV (0.38). Furthermore, Dry Matter (DM), Crude Protein (CP), Acid Detergent Fiber (ADF) and Ash in the whole plant were varied significantly ($P<0.05$) among three cultivars. In summary, the experiment indicates that BN-4 outperforms BN-3 and NCV in production yield, suggesting that BN-4 could be an ideal fodder cultivar for achieving optimal biomass yield in Barind areas.

Key words: Napier cultivar, Barind, Biomass yield, Botanical fraction, Nutrient contents

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*Corresponding author: siraj_blri@yahoo.com

Introduction

The Barind Tract is a significant geographical region in Bangladesh. It covers most of Rajshahi, Bogra, and Joypurhat districts of Rajshahi division and Dinajpur, Rangpur districts of Rangpur division in Bangladesh with a total area of 10,000 sq.km. In Bangladesh, total number of cattle population is 2.4 million where Rajshahi and Rangpur division accounted for 18% and 23% respectively (BBS, 2020).The climate of this region is predominantly tropical. Most of the farmers in this region produce paddy, oil seeds, pulses, and wheat as seasonal plant. Usually, they use the byproduct of paddy as livestock feed that remains in the field after harvesting. Due to continuous changes of cropping pattern and high-yielding variety (HYV) rice production, high environmental temperature, and lower rainfall, lack of awareness of the farmer, the scope for production of fodder is getting scarce day by day. With the rising cost of concentrate feed, farmers in this region are unable to achieve the desired profits from livestock farming, leading many to shut down their operations. Therefore, production of HYV of fodder for livestock feeding has been critical factor for the Barind areas livestock farmers. Napier *(Pennisetum purpureum)* shows its importance in the tropics and sub-tropics and has been the most promising of the HYV of fodder giving high nutritional value and adaptability that suppresses most tropical grasses (Humphreys, 1994). It is the forage of choice not only in the tropics but also worldwide (Hanna *et al.*, 2004) due to its desirable traits such as drought tolerance, adaptability to diverse soil conditions, and high efficiency in photosynthesis and water use (Anderson *et al.*, 2008). Napier grass has significant potential to contribute to sustainable livestock production in Bangladesh. But the production performance and adaptability of Napier grass is not equal throughout the country. According to Toker *et al.* (2007), drought is the most devastating abiotic stress, which is caused by insufficient rainfall and / or altered precipitation patterns. Fodder crop performances are positively correlated with the area, location, and season (Tessema *et al.*, 2010; Pandey and Roy, 2011). It is necessary to identify more adaptive Napier fodder that are suitable for Barind soil. BLRI is preserving various Napier variety that require evaluation regarding their yield and quality performance across different geographical and agro-climatic conditions in Bangladesh. However, only a limited amount of research has been conducted on the variety of Napier grass regarding their yield and quality response when grown under the climatic conditions of the Barind region. Therefore, the objective of our present study was to evaluate and compare the biomass yield, plant morphology and quality response of three varieties of Napier grass such as BN-3, BN-4 and NCV at Barind soil of Bangladesh.

Materials and methods

Site of the experiment

The study was carried out at the experimental plots of BLRI, Regional Station, Godagari, Rajshahi from August 2022 to June 2023. The study area was geographically located between latitudes 24˚22'N and 24˚73'N and longitudes 88˚36'E and 88˚20'E. The site was topographically situated within the Barind tract and it was typically 23 meters (75 feet.) above the sea level.

Meteorological status of the experimental location

According to climate statistics, the area was located in a dry, humid zone with an average annual rainfall of 1400 to 1650 mm, with most of that rainfall falling between June and October (monsoon season). The middle of July marked the end of the hot season, which started earlier in March. In April, May, June, and July, the highest mean temperature recorded was approximately 25˚C to 35˚C, whereas in January, the lowest recorded temperature was approximately 7˚C to 16˚C (Habiba *et al.*, 2011).

Soil properties of the experimental fodder plots

Soil samples from the experimental fodder plots were collected and tested from the divisional laboratory of Soil Resource Development Institute (SRDI), Rajshahi. Different soil properties such as pH, total nitrogen (N_2), organic matter (OM), Potassium (K), Phosphorus (P), Boron (Bo), Sulphur (S), and Zinc (Z) were analyzed (Table 1).

Experimental design

A completely randomized design (CRD) consisted by three treatment groups (T1=BN-3, T2= BN-4 and T3= NCV) with five replications. The land was divided into 15 plots (each plot was 200 ft^2 with 10 ft. wide and 20 ft. length) according to the layout of the experiment (Figure 1).

T1R1	**T2R1**	**T3R1**	**T1R4**	**T2R4**
T3R4	**T2R5**	**T2R2**	**T1R2**	**T3R2**
T2R3	**T3R5**	**T1R3**	**T3R3**	**T1R5**

Figure 1. The design of experiment in the field. Five replicates were applied for each treatment and T represents treatment and R represents replication.

Land preparation and cultivation

The fodder plots were prepared with a single deep plough with two harrowings. The plots were prepared using standard agronomical procedures. Stem cutting bearing two nods was planted at a 45-degree angle and placed to a depth of 15-20 cm. Distance between two lines and two plants were 70 cm and 30 cm, respectively. Cow dung (60 kg/decimal) and Di-ammonium phosphate (DAP) (2.5 kg/decimal) were used before planting cultivars. Weeding was done at regular basis. In relation to the temperature of the environment around it, regular irrigation was performed for maximum growth in the Barind tract. Irrigation was done twice a week in the summer and intermittently every ten to twelve days in the rainy season. Following harvesting at predetermined intervals, urea fertilizer was applied during the required watering.

Harvesting and data collection

Data were collected from each harvest. The first harvest was done at 60 days after planting, and successive harvests were performed at the intervals of 50 days. During harvest, plants were cut about 5 to 10 cm above from the ground. Green biomass yield was measured by weighing the total mass. To measure plant height, the tallest tillers from five randomly chosen hills in each plot were selected and measured ground level to the top of the tiller. A total of five harvests were documented over the course of the year. Urea (60kg/ha) was uniformly applied following each harvest. Each cultivars, one-kilogram fodder sample was manually separated into three parts: leaf blade, leaf sheath, and stem. The stem weights were divided by the leaf weights to calculate the leaf-to-stem ratio (LSR).

Determination of nutrient composition of the fodder cultivars

Nine (9) samples, three from each cultivar, were randomly taken for dry matter (DM), crude protein (CP), and crude fiber (CF) determination at each cut (Table 4). The chemical analysis of fodder sample was performed at Animal Nutrition laboratory of BLRI, Savar, Dhaka. The chemical analysis of the sample was done by the following methods described by the Association of Official Analytical Chemist (AOAC, 2005). The CP content was analyzed on the Kjeldahl method with the Kjeltec™ 8400 analyzer unit (FOSS, Hoganas, Sweden). Acid detergent fiber (ADF) was measured following the method of Van Soest *et al.* (1991) using an ANKOM 2000 Fiber Analyzer (ANKOM Technology, NY, USA).

Statistical analysis

The collected data were statistically analyzed using the Compare Means (CM) procedure of one-way Analysis of Variance (ANOVA) and Post Hoc Multiple Comparisons in SPSS.

Result and discussion

Chemical composition of experimental soil

Table 1 illustrated the analyzed soil composition of the experimental plots. The soil was reddish clay with a slightly alkaline pH of 7.4. The pH level of present finding contrasted with Muslehuddin *et al.* (2008) who stated that the soils of the Level Barind Tract (AEZ 25) was found to be acidic in nature having the pH values varied from 4.9 to 6.5.

Table 1. Soil composition of experimental fodder plots

Soil constituents	Measuring unit	Mean ±SD
pH		7.4±0.42
Organic matter (OM)	%	1.585±0.56
Total Nitrogen (N2)	%	0.0925±0.03
Potassium (K)	Millitulanko/100 g	0.1175±0.04
Phosphorus (P)	µg/g	18.175±6.18
Sulphur (S)	µg/g	15.475±4.75
Boron (Bo)	µg/g	0.35±0.44
Zinc (Zn)	µg/g	0.905±0.51

SD=Standard deviation.

Ideal pH value helps fodder to absorb essential nutrients more efficiently and enhance growth and yield. The solubility of nutrients changes with pH levels, making it crucial to maintain soil pH between 6.5 and 7.5, as this range allows most nutrients to be accessible to plants, helping to sustain soil fertility (Daji, 1996). The value of OM of the present study was 1.58 percent, which was slightly lower compared with the findings of Islam *et al.*, 2017 who found 1.75 and 0.34 percent of OM in normal soil and sandy soil, respectively. Total Nitrogen, Phosphorus, and Sulphur content of the soil of the present study were 0.092%, 18.17 µg/g, and 15.47 µg/g respectively.

Production performance of three cultivars

The mean comparison with standard error of biomass production of three cultivars are shown in Table 2. Results showed that biomass yield for three cultivars differed significantly ($p<0.05$) for the 1st, 2nd, and 3rd cutting but did not differ in overall cutting. In the 1st cutting, leaf number/plant and leaf length were varied significantly ($p<0.05$) among the cultivars where NCV showed better biomass yield compared to others. On the other hand, 2nd cutting, BN-3 and BN-4 showed considerably higher biomass yield compared to NCV. Leaf length and tiller number per hill also showed significant ($p<0.05$) variation among treatments. The higher tiller number per hill was in BN-4. Results in 3rd cutting showed non-significant ($p>0.05$) in all other parameters except biomass yield.

Table 2. Production parameters among three fodder cultivars (mean±SE)

Parameter	Biomass yield (ton DM/ha)	Plant height (inch)	Leaf number/plant	Leaf length (inch)	Tiller No/hill	Stem perimeter (inch)
			1st cutting at 60 days			
BN-3	4.14±0.08^{b}	37.00±1.41	12.60±0.40^{b}	22.60±1.81^{b}	3.60±0.24	1.94±0.19
BN-4	4.68±0.091^{ab}	36.80±1.67	15.60±0.60^{a}	31.20±2.08^{a}	5.20±0.80	2.20±0.12
NCV	4.84±0.12^{a}	37.80±2.37	12.60±0.51^{b}	12.60±2.14^{ab}	5.20±0.58	2.38±0.22
			2nd cutting at 50 days			
BN-3	9.07±0.192^{a}	90.60±1.91	19.00±0.71	31.80±0.49^{a}	11.20±0.49^{b}	2.56±0.19
BN-4	9.10±0.08^{a}	85.60±1.29	19.00±0.71	24.20±1.83^{b}	13.60±0.75^{a}	2.36±0.19
NCV	8.35±0.09^{b}	90.40±0.74	19.40±0.81	30.80±1.49^{a}	11.80±0.20^{ab}	2.14±0.08
			3rd cutting at 50 days			
BN-3	12.52±0.15^{b}	99.80±1.43	21.60±0.60	31.80±0.49	18.40±1.33	2.56±0.19
BN-4	13.70±0.13^{a}	100.20±2.58	21.40±0.68	31.80±0.97	17.20±0.66	2.36±0.19
NCV	11.96±0.06^{c}	101.2±1.67	20.00±0.83	30.60±0.93	18.20±0.58	2.50±0.16
			Overall cutting			
BN-3	8.57±0.92	75.80±7.45	17.73±1.06	28.73±1.30	11.07±1.67	2.35±0.13
BN-4	9.18±0.99	74.20±7.32	18.67±0.73	29.07±1.29	12.00±1.40	2.31±0.09
NCV	8.38±0.78	76.47±7.46	17.33±0.98	29.33±0.99	11.73±1.44	2.34±0.09
Overall	8.71±0.51	75.49±4.19	17.91±0.53	29.04±0.68	11.60±0.85	2.33±0.06

Mean with uncommon superscript within the same column differ significantly at ($p<0.05$); BN-3, BLRI developed Napier hybrid-3; BN-4, BLRI developed Napier hybrid-4; NCV, Napier Color Variety.

In the overall cut, non-significant variations ($p>0.05$) were found in all parameters among three cultivars. Our study yielded a total of five harvests over the year. Overall dry matter of biomass yield of BN-3, BN-4 and NCV of present study were 8.57 ton/ha, 9.18 ton/ha, and 8.38 ton/ha respectively. The dry matter yield in the present study was lower as compared with the findings of Amin *et al.* (2016) and Schreuder *et al.* (1993). This variation may be due to the soil conditions and fertilizer doses. Reported on-farm dry matter yields from different regions of the country averaged about 16 tones/ha/ harvest (Wouters, 1987) with little or no fertilizer, while according to Schreuder *et al.* (1993) yields on research stations vary between 10-40 tones dry matter per hectare depending on soil fertility, climate, and management factors. According to the findings of Sarker *et al.* (2021), reported that average biomass yield on fresh basis of BN-1, BN-3, and BN-5 at drought location was 23.25 (ton/ha/harvest) which was slightly similar to our present findings. Soumya (2011), experimented on comparative performance of 8 hybrid Napier cultivars and obtained the highest green yields of 52.67 t/ha which was higher than our study though he calculated total yield in green fresh basis of cultivars. Dry matter yield generally increases with increasing fertilizer rate and cutting interval (Carvalho *et al.*, 2000). Notably, plant biomass yield is influenced by multiple factors, including plant height, the number of tillers, and leafiness, which is measured by both the number of leaves and leaf area per plant. Plant height did not differ significantly ($p>0.05$) among the cultivars. Overall plant height of present study was 75.49 inch (191.76 cm) which was higher than the findings of Sarker *et al.* (2021), found than average plant height of BN-1, BN-3 and BN-5 at drought location was 136.5 cm. In a recent study, Maleko *et al.* (2019) reported stem height of four Napier cultivars ranged from 145.44 to 210.81 cm with significant variations among them which aligns with the findings of our present study. The average number of tillers per hill of present study was 11.60, which is in general agreement with Maleko *et al.* (2019) who reported 9.96 to 28.87 numbers per hill of four Napier cultivars. Table 3 depicts the botanical fractions among three fodder cultivars. Significant differences ($p<0.05$) were observed among the cultivars in terms of sheath weight, leaf weight, and stem-to-leaf ratio. BN-3 showed higher sheath weight compared to other cultivars but the proportion of leaf in BN-4 (288.67) was considerably higher than BN-3 (224.33) and NCV (246.00). Moreover, the higher proportion of leaf may increase more nutritional value of fodder as leaves generally contain higher protein content and essential nutrients compared to stems. Better LSR was observed in BN-4 (0.47) cultivar compared to BN-3 (0.34), and NCV (0.38). This results is compatible with the findings of Ahmed *et al.* (2021), who found that the average LSR of BN-3 were 0.62, 0.53 and 0.46 at 40, 50 and 60 days of cutting interval respectively. On the other hand, LSR ratio of the present study was lower than the results with Sarker *et al.* (2021) who stated that the highest LSR was obtained in BN-3 (0.86) at non drought and drought location (0.95) regardless of cultivar.

Nutritive value

The nutrient components in the whole plant of three cultivars are depicted in Table 4. The overall DM content of Napier varieties was 20.86%, and the highest value was found in BN-4 (21.72). The overall crude protein percentage in our experiment

Table 3. The botanical fractions among three fodder cultivars (Mean±SE)

Parameters	Stem weight (Weight/kg)	Sheath weight (Weight/kg)	Leaf weight (Weight/kg)	leaf-to-stem ratio (LSR)
BN-3	641.67±2.33	134.00±2.52[a]	224.33±3.38[b]	0.34 ±0.05[b]
BN-4	618.67±23.78	87.33±10.05[b]	288.67±14.34[a]	0.47 ±0.19[a]
NCV	642.00± 05.57	112.00±11.27[ab]	246.00±6.57[ab]	0.38 ±0.06[ab]
Overall mean	634.11±8.07	111.11±8.06	253.00±10.53	0.40 ±0.12

Mean with uncommon superscript within same column differ significantly at ($p<0.05$), BN-3, BLRI developed Napier hybrid-3; BN-4, BLRI developed Napier hybrid-4; NCV, Napier Color Variety.

showed 7.67 where NCV showed significantly higher value (8.09%). Thomas (2008) reported that the Napier hybrid typically contains approximately 10.2% crude protein (CP) which is in close agreement with our findings. Similarly, Wangchuk *et al.* (2015) reported CP contents in 3 Napier hybrid cultivars to be 16.5% to 17.2% in leaf, 3.6% to 5.6% in stem and 10.4% to 11.2% in whole plant and cutting intervals was 45-50 days, which are in the line with the present study. However, results of the present study contrasted with study of Ahmed *et al.* (2021), stated that CP concentration in the whole plant of the BN-3 was 7.63% at 60 days but it was significantly declined with the increasing cutting period. Various studies have shown a strong link between cutting and an increase in dry matter, alongside a reduction in nutritive value. When fodder is harvested at early developmental stages, it has a relatively higher crude protein content. However, with later harvesting, levels of crude fiber, acid detergent lignin, hemicellulose, and cellulose increase, leading to reduced dry matter digestibility (Mirza *et al.*, 2002).

Table 4. The nutrient composition of three cultivars (Mean ±SE)

Nutrient components	BN-3	BN-4	NCV	Overall mean
	Mean ± SE	Mean ± SE	Mean ± SE	
Dry matter (DM) %	21.24± 0.59[a]	21.72±0.11[a]	19.63±0.24[b]	20.86±0.36
Ash%	13.90±018[b]	13.67±0.08[b]	17.09±0.09[a]	14.89±0.55
Crude protein%	7.37±0.10[b]	7.50±0.0.08[b]	8.09±0.11[a]	7.67±0.12
ADF%	42.20±0.27[a]	39.51±0.11[c]	41.07±0.01[b]	40.92±0.40

Mean with uncommon superscript within same row differ significantly at ($p<0.05$); BN-3= BLRI developed Napier hybrid-3; BN-4= BLRI developed Napier hybrid-4; NCV= Napier Color Variety; ADF=Acid detergent fiber SE=Standard error.

In case of ash and crude protein content, NCV cultivar had the higher ($p<0.05$) value in comparison with others two cultivars. This study offers valuable insights into the potential yields, growth, and nutritional quality of BN-3, BN-4, and NCV in Barind soil. The differences observed in various parameters across these three varieties indicate potential for selection, particularly for breeding programs aimed at enhancing yields under Barind environmental conditions.

Conclusion

All three fodder cultivars showed strong performance at the experimental location, though they varied in forage yield, botanical makeup, and quality. Among the three cultivars, BN-4 produced the highest biomass yield and exhibited the highest leaf-to-stem ratio (LSR), while NCV had the highest crude protein and ash content. In conclusion, BN-4 cultivar appeared to be well-suited to the Barind areas for productive use as ruminant feed. Nevertheless, additional research, involving animal performance trials and comprehensive economic analysis, is suggested to achieve more accurate results.

Ethical approval

This article does not contain any studies with animals performed by any of the authors. No need for ethical approval for this study.

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Conflicts of interest

The authors declare no conflicts of interest regarding the publication of this paper.

Reference

Ahmed, S., Rakib, M.R.H. and Jalil. M.A. 2021. Forage growth, biomass yield and nutrient content of two different hybrid Napier cultivars grown in Bangladesh. Bang. J. Anim. Sci., 50(1): 43-49.

Amin, R., Sarker, N.R., Ali, M.Y., Hasem, M.A. and Khatun, M. 2016. Study on cutting intervals on biomass yield, nutritive value and their oxalate content of different high yielding napier *(P. purpureum)* cultivars. Asian Australas. J. Biosci. Biotechnol., 1(1): 100-107.

Anderson, W.F., Dien, B.S., Bradson, S.K. and Peterson, J.D. 2008. Assessment of Bermuda grass and bunch grasses as feed stocks for conversion of ethanol. Appl. Biochem. Biotechnol., 145: 13–21.

AOAC, 2005. Official Methods of Analysis of the Association of Official Analytical Chemist. Benjamin Franklin Station. Washington.

BBS, 2020. Agriculture Sample Census. Livestock report, National series- 3.

Carvalho, C., Menezes, J.B. and Coser, A.C. 2000. Effect of fertilizer and cutting frequency on yield and nutritive value of Elephant grass. Ciencia. Agro. tec., 24: 233-241.

Daji, J.A. 1996. A text book of soil Science, Media promoters and publishers, Bombay.

Habiba, U., Shaw, R. and Yukiko, T.Y. 2011. Drought Risk Reduction through a Socio-Economic, Institutional and Physical Approach in the Northwestern Region of Bangladesh. Envin. Hazards., 10: 121-138.

Hanna, W.W., Chaparro, C.J., Mathews, B.W., Burns, J.C., Sollenberger, L.E. and Carpenter, J.R. 2004. Perennial Pennisetum's. In: Moser LE; Burson BL; SollenbergerLE,eds. Warm-Season (C4) grasses. American Society of Agronomy Monograph Series No. 45. Madison, WI, USA. p: 503–535.

Humphreys, L.R. 1994. Tropical forages: Their role in sustainable agriculture. Longman, Harlow, UK. p: 414.

Islam, M.S., Sarker, N.R., Habib, M.A., Ali, M.Y. and Yeasmin, T. 2017. Effect of different soil types on growth and production of Napier-4 at the Regional Station of BLRI. Asian J. Med. Biol. Res., 3(2): 182-185.

Maleko, D., Mwilawa, A., Msalya, G., Pasape, L. and Mtei, K. 2019. Forage Growth, Yield and Nutritional Characteristics of Four Varieties of Napier Grass *(Pennisetum purpureum Schumach)* in the West Usambara Highlands, Tanzania. Sci. Afri., 6: e00214.

Mirza, S.N., Mohammad, N. and Qamar, I.A. 2002. Effect of growth stages on quality of forage grasses. Pakistan J. Agric. Res., 17: 145-147.

Moslehuddin, A.Z.M., Habibullah, Moniruzzaman, M. and Egashira, K. 2008. Mineralogy of Soils from Different Agro ecological Regions of Bangladesh: Region 25 – Level Barind Tract and Region 27 – North–eastern Barind Tract. J. Fac. Agr., Kyushu Univ., 53(1): 163-169.

Pandey, K.C. and Roy, A.K. 2011. Forage Crops Varieties. *Indian Grassland and Fodder Research Institute (IGFRI),* Jhansi, Uttar Pradesh, India.

Sarker, N.R., Habib, M.A., Yeasmin, D., Tabassum, F. and Mohammed, R.M. 2021. Studies on Biomass Yield, Morphological Characteristics and Nutritive Quality of Napier Cultivars under Two Different Geo-Topographic Conditions of Bangladesh. Am. J. Plant Sci., 12: 914-925.

Schreuder, R., Snijders, P.J.M., Wouters, A.P., Steg, A. and Kariuki, J.N. 1993. Variation in DM digestibility, CP, yield and ash content of Napier grass (Pennisetum purpureum) and their production from chemical and environmental factors. Res. Rept., Natl. Anim. Husb. Res. Station., KARI, Naivasha, Kenya, 28.

Soumya, P. 2011. Evaluation of Promising Hybrid Napier Cultivars under Varying Plant Population. M.Sc. Thesis, Faculty of Agriculture, Kerala Agricultural University, Thrissur, p: 73.

Tessema, Z.K., Mihret, J. and Solomon, M. 2010. Effect of defo-liation frequency and cutting height on growth, dry-matter yield and nutritive value of Napier grass *(Pennisetum purpureum (L.)* Schumach). Gra. and For. Sci., 65: 421-430.

Thomas, C.G. 2008. Forage Crop Production in the Tropics. 2nd Editon, Kalyani Publishers, New Delhi, p: 333.

Toker, C., Canci, H. and Yildirim, T. 2007. Evaluation of Perennial Wild Cicer Species for Drought Resistance. Gen. Res. and Cro. Evo., 54: 1781-1786.

Van Soest, P.J., Robertson, J.B. and Lewis, B.A. 1991. Methods for Dietary Fiber, Neutral Detergent Fiber and Non-starch Polysaccharides in Relation to Animal Nutrition. J. Dairy. Sci., 74(10): 3583-3597.

Wangchuk, K., Rai, K., Nirola, H., ThuktenDendup, C. and Mongar, D. 2015. Forage Growth, Yield and Quality Responses of Napier Hybrid Grass Cultivars to Three Cutting Intervals in Himalayan Foothills. Tropi. Grasds., 3: 142-150.

Wouters, A.P. 1987. Dry matter yield and quality of Napier on farm level 1983-1986, Research Report, Ministry of Livestock Development, Nairobi Kenya. 39.