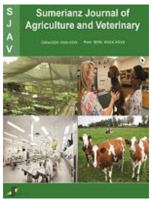
Sumerianz Journal of Agriculture and Veterinary, 2022, Vol. 5, No. 1, pp. 6-13
ISSN(e): 2617-3077, ISSN(p): 2617-3131
Website: https://www.sumerianz.com
DOI: https://doi.org/10.47752/sjav.51.6.13



Original Article Open Access

Defoliation Frequencies of Forage Legumes: Effects on Yield and Nutritive Value for Beef Cattle Production

Tersur Theophilus Akpensuen
Department of Animal Production, Faculty of Agriculture, University of Jos, Nigeria
Email: theophilusa@unijos.edu.ng

(Corresponding author)

Article History

Received: 3 January 2022

Revised: 18 February 2022

Accepted: 23 February 2022

Published: 26 February 2022

How to Cite

Akpensuen, T. T., 2022. "Defoliation Frequencies of Forage Legumes: Effects on Yield and Nutritive Value for Beef Cattle Production." *Sumerianz Journal of Agriculture and Veterinary*, vol. 5, pp. 6-13.

Abstract

A study was conducted to determine the effect of cutting frequencies for 2 temperate (*Trifolium pratense* and *Trifolium repens*) and 2 tropical (*Stylosanthes guianensis* and *Centrosema molle*) forage legumes on dry matter yield and nutritive value for beef cattle production in a cool tropical environment of Jos, Nigeria. It was a factorial experiments with four forage legumes and three defoliation frequencies (4 x 3) making twelve treatments combinations arranged in a randomized complete block design and replicated four times. The study was conducted in 2016 and 2017. The result showed that total dry matter yield (DMY) was higher (p<0.05) in *T. pratense* in 2017 (3.06 t/ha), while *C. molle* produced least DMY (1.01 t/ha). The temperate species performed better after each cut in DMY. Crude protein content was higher (p<0.05) in *T. repens* (26. 12 %) at the third cut. The tropical species were higher (p<0.05) in fibre contents. Dry matter intake (3.88 %), digestible dry matter (71.24 %) , total digestible nutrients (70.2 %) and relative feed value (214.53) were all higher (p<0.05) in *T. repens* at third cut. The temperate forage legumes generally showed more resilience to cuttings compared to the tropical species. Therefore the crops can be grown in the cool tropical environment of Jos, Nigeria as supplementary forage feeds.
Keywords: Dry matter yield; Nutrient contents; Temperate; Tropical; Legumes; Nutrient requirement.

1. Introduction

The importance of legumes in the agricultural system can not be overemphasised. [1] noted that legumes are important in temporary grassland through their ability to contribute to the nitrogen (N) economy of the sward through N fixation by associated rhizobial bacteria. Legumes improve the protein contents of mixed grass-legume pastures by keeping the crude protein level above the critical level of 7%, below which voluntary intake declines. Incorporation and maintenance of cool-season species into the warm-season perennial pasture will provide a higher level of vegetation cover to the pasture land for an extended period and reduce the risk of soil erosion [2]. Legumes also act as a cover crop to control weeds and conserve soil moisture during dry periods [3], control pests and protect soil from erosion including loss of soil organic matter by water and wind erosion [4].

Red clover *(Trifolium pretense* L., *T. pretense)* and White clover *(Trifolium repens* L., *T. repens)* are important forage legumes in the temperate regions of the word. *T. pratense* is one of the important herbage legumes cultivated in the temperate region of the world [5]. The forage crop is adapted to a wide range of climatic conditions, soil types, fertility levels and different patterns of management [6, 7]. *T. repens* is a forage legume that is generally considered the most common and important grazing legume in all the temperate regions of the World [8, 9]. Søegaard, *et al.* [1] noted that *T. repens* is more applicable to grazed and cut-and-grazed situations, has higher yield stability compared to other legumes which increase with age, adapted to a wide range of farming and environmental conditions. *Stylosanthes guianensis* cv (*S. Guianensis)*cook is one of the forage legumes well suited to the sub-humid tropical zone with a marked dry season [10]. Mannetje [11] pointed out that the herbaceous perennial legume is primarily used for pasture in humid tropical regions and is widely used in different tropical environments. *Centrosema molle* (*C. molle*)is widespread in the humid-tropics from the tropic of cancer in the northern hemisphere to the tropic of Capricorn in the southern hemisphere, and up to an altitude of 1600 m [12]. It is considered to be a valuable feedstuff since it provides fresh green matter during the dry season [12].

Defoliation is the removal of plant forages by grazing of animals or by mechanical means. This is an important factor in forage management for continuous productivity. The amount of forage dry matter yield and quality produced in a given season by a forage crop is very important for the livestock production. The abilility of a crop to withstand defoliation through cutting or grazing is therefore an important factor to consider in selecting a forage crop. The response to defoliation of a forage plant depends upon its seasonal yield of carbohydrate storage, and its growth habit [13]. In this regard, the timing and intensity will determine ths ability of forage crop to survive, regrow and produce good quantity and quality forages. The productivity of legumes through various cutting regimes will be an important factor in the tropical evironment for improve livstock production. Most forage legumes in the tropics have poor regrowth abilility after defoliation. Moreso, information on forage dry matter of various species at different defoliation frequencies or interval is scarce especially on legumes. There is the need to study how tropical legumes respond to defoliation frequencies and compare with their temperate counterparts. How much yield could be obtained from defferent cutting frequencies in a growing season and place cound be useful in palnning feeding programme for a particular number of animals at a given time. This study was, therefore, designed to evaluate the yield and quality of two tropical forage legumes (*S. guianaisis* and *C. molle*) and compare to two temperate forage legumes (*T. pratense* and *T. repens*) at different three (3) defoliation frequencies in Jos, Nigeria.

2. Materials and Methods

2.1. Location of the Study

The experiment was carried out at the Nigerian Institute for Trypanosomiasis Research (NITR), Vom, Jos, Nigeria (9°43'60N, 8°46'60E; 1223 masl) [14]. Meteorological data of the study area during the 2016 and 2017 cropping seasons were obtained from the Potato Programme of the National Root Crops Research Institute (NRCRI), Vom, Jos, as shown in Table 1. The area is characterised by two major seasons. The rainy season extends from late-May to early October each year, while the dry season starts from late-October to early-May. Peak rainfall normally occurs in August. Temperatures range from 15 – 27 ^{o}C during the rainy season and 7 – 18 ^{o}C during the hamattam (dry) season, while 18 – 32 ^{o}C is normally observed late in the dry season (March –early May). Grasses found on these highlands are shorter and the trees are fewer than at lower levels [15]. Soil samples (0-15 cm depth) of the experimental site were collected at different site randomly with a soil auger and physical and chemical properties were determined. The soil is low in N content (3.3 g/kg), fair in K (247 mg/L) and P (7.5 mg/L). Soil in this area is classified as clay-loam, generally sticky when wet, has low fertility and quickly becomes hard when there is no rain for 2 - 3 days and cracks easily [15].

Table-1. Monthly mean maximum and minimum temperatures and rainfall for 2016, 2017 plus medium-term mean rainfall(2004-2015) for Vom, Jos

	Maximum Temp(^{o}C)			**Minimum Temp(^{o}C)**			**Rainfall(mm)**		
Month	2016	2017	2004-2015	2016	2017	2004-2015	2016	2017	2004-2015
January	29	30	29	12	11	11	0	8	9
February	32	31	30	15	13	15	10	2	2
March	32	34	32	18	19	19	28	19	18
April	32	32	30	17	15	16	10	83	82
May	30	29	28	19	20	18	217	138	145
June	29	28	27	18	17	17	15	173	192
July	27	29	25	20	18	18	225	384	207
August	26	27	25	18	17	17	301	401	290
September	27	25	26	17	16	17	209	181	205
October	29	25	27	17	17	16	60	170	182
November	30	27	29	13	12	13	0	0	0
December	27	30	28	12	10	11	0	3	3

Source: National Root Crop Research Institute, Vom.

2.2. Land Preparation and Experimental Design

The land was ploughed and harrowed twice using a tractor mounted with appropriate implements. All debris was removed to make clean seedbeds. It was a factorial experiment with four forage legumes (*T. pratense*, *T. repens*, *S. guianensis* and *C. molle*) and three defoliation frequencies making twelve treatments combinations. This was arranged in a randomized complete block design replicated three times. Five weeks interval was allowed between the defoliation periods from where the re-growths were harvested for DM yield estimation and nutritive value evaluation. Thirty-six plots of 5 x 3 m were used for the study with 1 m spacing between blocks and 0.5 m spacing between plots in a block. The temperate forage legume seeds of red clover (AberClaret variety) and white clover (AberHerald variety) were obtained from the Institute of Biological, Environmental and Rural Sciences (IBERS), University of Aberystwyth, United Kingdom. The tropical forage legume seeds of Cook stylo and Centro were obtained from the Feeds and Nutrition Research Programme of the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika, Zaria, Nigeria.

2.3. Pasture Establishment

The trials were conducted when the rains were well established in the month of June during the 2016 and 2017 rainy seasons using seeding rates of 8.4 and 7.4 kg/ha for *T. pratense* and *T. repens*, and 8.8 and 11.6 $kgha^{-1}$*S. guianensis* and *C. molle*, respectively. The seeding rates were determined using Pure Live Seed (PLS) index described by Karki [16]. To overcome dormancy of tropical legume seeds and improve germination and establishment, seeds of stylo were scarified by immersing in hot water at 90°C for 1 min [17] prior to sowing, while seeds of Centro were immersed in hot water at 80 ^oC for 4 min [18]. Seeds of *T. pratense* and *T. repens* were planted at the recommended row spacing of 0.3 m (20), while those of *S. guianensis* and *C. molle* were planted at spacing of 0.3 and 0.5 m, respectively [18]. The recommended sowing depth of 0.5 cm was used for *Trifolium* species (20), while *S. guianensis* and *C. molle* were planted at 1 and 2.5 cm, respectively [18].

2.4. Forage Yield Estimation and Nutritive Vaklue Estimation

Forage dry matter yields (FDY) were determined by cutting 0.7 x 4 m strip in the middle of the plots.. Plants were cut at 5 cm above the ground level with a sickle to determine the forage yield at the defoliation frequencies. The cut forages were immediately weighed to determine fresh weight after which they were oven-dried at a temperature of 50^{o}C until a constant weight was achieved to determine forage dry matter yields. Five weeks interval was allowed after each cut before the next cut was carried out. Dried forage samples of the forage materials were ground with a Thomas Willey Laboratory Mill-Model 4 and passed through 1 mm sieve. Crude protein (CP) and ash were carried out using the Method of AOAC [19], while neutral detergent fibre (NDF) and acid detergent (ADF) analyses were carried out according to the method described [20]. Mineral composition (Ca, P, Mg, K and Na) of the samples were carried out using the atomic absorption spectrophotometer of AOAC [19]. Crude protein, ash and detergent fibre analyses were carried at the biochemistry and animal nutrition Laboratories, Departments of Animal Science and Animal Nutrition of Ahmadu Bello University, Zaria and University of Agriculture, Makurdi, Nigeria, respectively. Mineral analyses were carried out at the General Laboratory, Department of Soil Science, Ahmadu Bello University, Zaria, Nigeria.

Digestible dry matter (DDM), dry matter intake (DMI) , relative feed value (RFV), total digestible nutrients (TDN), net energy for lactation (NEl), net energy for maintenance (NEm) and net energy for growth (NEg) were estimated using the equations by Schroeder [21] as shown below;

% DDM = 88.9 – (ADF% x 0.779)
%DMI = 120 / NDF
RFV = (DDM % x DMI %) / 1.29
% TDN = 96.35 – (ADF % x 1.15)
NEl: Mcal/lb = (TDN % x 0.01114) - 0.054
NEm: Mcal/lb = (TDN % x 0.01318) - 0.132
NEg: Mcal/lb = (TDN % x 0.01318) - 0.459
The Mcal/lb values for NEl, NEm and NEg were converted to Mcal/kg by multiplying each value with 0.454

2.5. Statistical Analysis

All data generated were subjected to analysis of variance (ANOVA). The general linear model of SAS [22] statistical software was used for the analyses and means were separated using the Tukey [23] test.

$Y_{ijl} = \mu + A_i + B_j + A_i \times B_j + e_{ijkl}$

where,
μ = population mean;
A_i = ith effect of legume;
B_j = jth effect defoliation frequency;
A_i X B_j= Interaction between legumes and defoliation frequency; and
eijkl = Random error.

3. Results and Discussion

3.1. Results

Table 2 shows the effect of forage legumes and year on forage DMY at three frequencies. There were significant differences in dry accumulation among the legumes at all the cutting frequencies and total. The highest DMY was recorded in *T. pratense* at first and second cuts (1.68 and 1.24 t/ha) in 2017. *Trifolium repens* however, produced a higher DMY of 0.79 t/ha at the third cut in 2017 compared with the other legumes. It was also observed that the tropical species produced less total DMY in the two years compared with the temperate legumes. Consequently, total forage DMY resulting from the 3 cuts was highest (p<0.05) in *T. pratense* and for the year 2017 (3.06 t/ha). The total yield of *T. pratense* was 38.33 % higher than the best total yield of tropical species (*S. guianensis*) in 2016. The lowest value for total DMY (1.01 t/ha) was recorded in *C. molle* in year 2016. Dry matter yields decrease from the first to third cut in all the legumes.

The effect of legumes and cutting frequencies on nutrient content results are presented in Table 3. The CP and ash contents were higher (p<0.05) in *T. repens* in the third cut (26.13 %), while the lowest value was recorded in *S. Guianensis* (16.58 %). The CP of the tempearte leguimes was 22 % higher than the topical species. On the othe hand, the fibre fractions (NDF and ADF) were, however, higher (p<0.01) in *S. guianensis* at the first cut and lowest values were observed in *T repens*. In all the legumes tested in this evirnment, the contents of CP and ash increased, while those of NDF and ADF decreased from the first to the third cut.

Table 4 shows the effect of forage legumes and cutting frequencies on dry matter intake (DMI), digestible dry matter (DDM), relative feeding value (RFV) and total digestible nutrient (TDN). The DMI, DDM, TDN and RFV values were highest (p<0.05) in *T. repens* at the third harvest (3.99. DMI was significantly higher in the third cut (3.88%) in *T. repens*, while the first cut in *S. guianensis* had the lowest intake (2.48 %). Similar pattern results were observed in DDM, TDN and RFV. The temperate species (*T. Pratense* and *T.repens*) were higher in the parameters considered compared to the tropical forage (*C. molle and S. guianensis*). There was a decrease from the first to the third cut in all the forage species in all the parameters considered.

Table-2. Effect of forage legumes and year on forage dry matter yield of four forage legumes at different cutting frequency (t/ha)

Legume	Year	1st cut	2nd cut	3rd cut	Total
T. Pratense	2016	1.05c	1.02b	0.62c	2.57b
	2017	1.68a	1.45a	0.72b	3.06a
T. repens	2016	0.92d	0.68c	0.48d	2.09c
	2017	1.10b	1.02b	0.97a	2.76b
S. guianensis	2016	1.10b	0.53c	0.23g	1.91d
	2017	0.71e	0.25d	0.15g	1.13ef
C. molle	2016	0.43f	0.23d	0.33f	1.01ef
	2017	0.63e	0.31d	0.37e	1.35e
	SEM	0.01	0.06	0.02	0.15

Means with different superscript within a column differ significantly different at 5 % level of probability according to Tukey test, *= Standard error of means

Table-3. Effect of forage legumes and cutting frequencies on nutrient contents of four forage legumes (average of year 2016 and 2017)

Legumes	Cuts	Nutrient contents (%)			
		CP	ASH	NDF	ADF
T. repens	1st cut	23.15c	13.24c	32.51i	24.80h
	2nd cut	24.23b	14.36b	32.58i	24.71h
	3rd cut	26.13a	15.21a	32.29i	22.06k
T. pratense	1st cut	19.90f	12.21e	34.37g	25.80g
	2nd cut	20.44e	12.97d	33.58h	24.51i
	3rd cut	20.99d	13.19cd	30.89j	23.06j
C. molle	1st cut	18.23j	10.83h	46.64b	32.73b
	2nd cut	18.91h	11.80f	43.01d	30.58d
	3rd cut	19.69g	11.93f	39.26f	29.30f
*S.*guianensis	1st cut	16.58l	9.79j	48.36a	34.42a
	2nd cut	17.26k	10.45i	44.44c	31.17c
	3rd cut	18.87i	11.51g	40.93e	29.80e
	SEM*	0.12	0.12	0.23	0.17

Means with different superscript within a column differ significantly different at 5 % level of probability according to Tukey test, *= Standard error of means

The result in Table 5 shows the effect of forage legumes and cutting frequencies on digestible energy (DE), net energy of lactation (NE_L), net energy of maintenance (NE_M) and NE_G (Mcal kg^{-1}). Third harvests of *T. repens* were highest (p<0.05) in DE, NE_L, NE_M and NE_G. No difference (p>0.05) was observed between the first and second cuts of *T. repens* and the second cut in *T. Repens* for all the energy parameters. The temperate species showed generally higher in all the energy parameters compared to the tropical species. There was an increase in energy contents from the first to the third cut in all the legumes.

Table-4. Effect of forage legumes and cutting frequencies on dry matter intake (DMI), digestible dry matter (DDM), relative feeding value (RFV) and total digestible nutrient (TDN) of four legumes (avearge of year 2016 and 2017)

Legumes	Cuts	DMI (%)	DDM (%)	TDN (%)	RFV
T. repens	1st cut	3.69c	69.56c	67.80c	199.35c
	2nd cut	3.71b	69.64c	67.94bc	200.20c
	3rd cut	3.88a	71.24a	70.28a	214.53a
T. pratense	1st cut	3.49e	68.79d	66.67d	188.17e
	2nd cut	3.57d	69.80c	68.18b	193.33d
	3rd cut	3.71b	70.90b	69.82a	204.20b
C. molle	1st cut	2.68i	64.39g	58.70h	127.65j
	2nd cut	2.78h	65.07f	61.18g	140.73h
	3rd cut	3.05f	66.07d	62.65e	156.56f
*S.*guianensis	1st cut	2.48k	62.08i	56.76i	134.65i
	2nd cut	3.59j	63.39h	60.49h	149.29g
	3rd cut	2.93g	65.67e	62.07f	199.37k
	SEM*	0.02	0.13	0.20	0.94

Means with different superscript within a column differ significantly different at 5 % level of probability according to Tukey test, *= Standard error of means

Table-5. Effect forage legumes and cutting frequencies on digestible energy (DE), net energy of lactation (NEL), Net energy of maintenance (NEM) and NEG (avearge of year 2016 and 2017, Mcal/kg)

Legume	Cut	DE	NE_L	NE_M	NE_G
T. repens	1st cut	3.06b	0.32b	0.34b	0.19b
	2nd cut	3.07b	0.32b	0.34b	0.19b
	3rd cut	3.14a	0.33a	0.36a	0.21a
T. pratense	1st cut	3.03c	0.31c	0.34b	0.19b
	2nd cut	3.07b	0.32b	0.34b	0.19b
	3rd cut	3.12a	0.33a	0.36a	0.21a
C. molle	1st cut	2.79h	0.27f	0.29e	0.14e
	2nd cut	2.86f	0.28e	0.30d	0.16c
	3rd cut	2.91d	0.29d	0.31c	0.16c
S.guianensis	1st cut	2.73i	0.26g	0.27f	0.13f
	2nd cut	2.84g	0.28e	0.30d	0.15d
	3rd cut	2.89e	0.29d	0.31c	0.16c
	SEM*	0.01	0.001	0.001	0.001

Means with different superscript within a column differ significantly different at 5 % level of probability according to Tukey test, *= Standard error of means

Table-6. Recommended nutrient requirements for beef cattle from NASEM [23]

Nutrient	Growing and Finishing calves	Dry gestation cows	Lactating cows
CP (%)	12-14	7-9*	11
Ca (%)	0.31	0.18	0.58
P (%)	0.21	0.16	0.26
Mg (%)	0.10	0.12	0.20
K (%)	0.60	0.60	0.70
Na (%)	0.06-0.08	0.06-0.08	0.10
S (%)	0.15	0.15	0.15
Cu (ppm)	10	10	10
Zn (ppm)	30	30	30
Fe (ppm)	50	50	50
Mn (ppm)	20	40	40
NEM(MCal kg^{-1})	1.08-2.29	0.97-1.10	1.19-1.28
NEG(MCal kg^{-1})	0.53-1.37	NA^Y	NA^Y
TDN (%)	$65\text{-}70^W$	$55\text{-}60^Z$	65

* 7% for middle 1/3 of pregnancy, 9% for late 1/3 of pregnancy, Z-55% for middle 1/3 of pregnancy, 60% for late 1/3 of pregnancy, Y-NA, not available, W-for 6-10 months old growing bulls.

4. Discussion

The DMY of *T. pratense* at different cutting frequencies were lower than range 14.5 - 12.2 t/ha and 17.1 - 9.5 t/ha reported by Cupina, *et al.* [24] and Hejduk [25] from the first to third cut, repectively for different *T. pratense* varieties. This might be due to differences in variety, number of established plants/m^2 (plant density) and environmental conditions. The decrease in dry matter yields of *C. molle* after the first cut reported in this study is in contrast with the findings of Bernes and Addo-Kwafo [26] in Ghana who reported an increase in DMY after the first cut. The decrease in DMY from first to the third cut of all the legumes agreed with the report by Surmen, *et al.* [27]. The higher total DM yields of the temperate forages from the cuts indicate that the legumes have better re-growth potential and can withstand grazing than the tropical forage legumes in a growing season. Therefore, the temperate legumes could be used in feeding more animals.

The higher cellular and lower fiber contents in the temperate legumes compared with tropical species reported by Lowe, *et al.* [28] and Archimède, *et al.* [29] are confirmed in this study. The higher CP composition in the later cuts in the legumes agreed with reports of Søegaard and Nielsen [30] and INRA [31]. This may be due to a higher leaf-to-stem ratio in subsequent cuts as leaves are always greater in CP content than stems. The ranges of CP content of the two temperate species in this study fell within 22.2 - 28.0 and 22.7 - 25.3% from the first to the third cut for *T. repens* and *T. pratense*, respectively reported by Søegaard and Nielsen [30]. The CP contents of *S. guianensis* in this study were within the range 12.1 - 18.1 g/100g reported by Sukkasem, *et al.* [32], higher than 10.4, 15.0, but lower than 19.9% reported by Liu, *et al.* [33]; Jingura, *et al.* [34] and Omole, *et al.* [35] in China, Zimbabwe and Nigeria, respectively. The NASEM [24] presented in Table 6 showed beef cattle CP requirements for a mature beef cow (>5 yr of age) suggest 7% for maintenance during mid-pregnancy, 9% during late pregnancy, 11% during lactating and 12– 14% for growing and finishing calves. The CP level in the legumes at the different defoliation frequencies tested exceeded the upper limit for these requirements, thereby eliminating the need for protein supplementation when feeding these crops. The amount of fibre fraction is an important factor to consider in ruminant animal feeding and nutrition. The lower fibre (ADF and NDF) fractions in the temperate legumes is an indication that the crops can be consumed and digested more than the tropical species. Ball, *et al.* [36] classified NDF and ADF based forage fibre into six quality standards: prime grade (<40% NDF, <31% ADF), grade 1 (40–60% NDF, 31– 35% ADF), grade 2 (47–53% NDF, 36 – 40% ADF), grade 3 (56–60 % NDF, 41–42 % ADF), grade 4 (61–65 % NDF, 43–45% ADF) and grade 5 (>65 % NDF, >45 % ADF) have been described for beef cattle. Based on the grading, the temperate species could be described as prime, while the tropical fell within the grade 1 category.

Radunz and Schriefer [37] classified intake of forages based on percentage of body weight as excellent (2.7 vs. 3.0), good (2.5 vs, 2.7), medium (2.0 vs. 2.5) and poor (1.5 vs 2.0) for dry cows vs. lactating beef cows, respectively. All the legumes at different cutting frequencies can meet the percent required intake for dry sows. However, only the temperate species could meet the requirement lactating beef cows. NASEM [38] stated TDN value of 55% in mid-pregnancy, 60 % in late pregnancy, 65 % after calving for mature beef cows and 65–70% for back growing and finishing calves. The TDN in the tropical species were below the requirement for lactating, growing and finishing beef cattle and can only be adequate for dry beef cows unlike the temperate species (*T. pratense* and *T. repens*) that were above the requirements. According to Largy [39] forages with a RFV of 100 are of higher quality, those less than 100 are considered lower in value and forage with an RFV of 100 would not be considered excellent-quality forage. High producing cows often require RFVs of 150 or greater [39]. In this study all the forages can be considered high value, but the tropical species at first and second cuts were lower than the 150 required for producing cows.

In terms of energy requirement, all the forage legumes at different cutting frequencies can not meet the requirement of 1.19-1.28, 0.97 – 1.10, and 1.08-2.29 Mcal/kg [38] for maintenance in lactating beef cows, dry cows and growing/finishing calves, respectively. Similarly, all the forages can not be able to meet the 0.53 – 1.37 Mcal/kg [38] required for growth in growing and finishing calves. This means beef animals must be supplied with feed higher in energy contents. Moreover, it is expected that the legumes can not be able to fully satisfy the energy requirement of animals.

5. Conclusion

The temperate forage legumes generally showed more resilience to cuttings and were better in quality compared to the tropical species. This resulted in higher total DMY, higher CP content, mores calculated values for DMI, DDM, TDN and RFV. These temperate forage legumes showed great risilience to defoliation in cool tropical environment of Nigeria. Therefore the forage crops can be grown in the cool tropical environment of Jos, Nigeria as supplementary feeds. However, more studies on earlier planting dates, organic manure application, mixture with tropical grasses and legumes should be conducted in this environment to generate more data for reaerch and industrial benefits.

Acknowledgement

Tertiary Education Trust Fund (TETfund), Nigeria partially funded this project. I'm grateful to Institute of Biological Environmental and Rural Sciences, University of Aberystwyth, United Kingdom for the temperate legumes seeds.

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