

Biomass yield and nutritive quality of four varieties of *Pennisetum purpureum* as influenced by three cutting intervals in the humid zone of Nigeria

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Abstract
This experiment was conducted to determine the effect of cutting intervals on the dry matter (DM) yield, yield components and nutrient contents of four varieties of Pennisetum purpureum. Varieties experimented include: Local green, Local purple, S13 and S15. These were planted in a randomized complete block design with three replicates. All the four varieties of P. purpureum were cut at intervals of 4, 8 and 12 weeks after cutback (WAC) to represent first, second and third cutting intervals respectively. Results showed that the dry matter yield of the P. purpureum grasses significantly decreased from first to third cutting intervals. Variety S15 recorded a higher (P < 0.05) dry matter yield (13.26 t ha^{-1}) at the first cutting interval. Variety S13 had higher leaf proportion (89) at first cutting interval and tiller density (137.00 tiller^{-1} m^{2}) at third cutting interval (than the other varieties). Cutting intervals had significant effect (P < 0.05) on the crude protein (CP) content of the grasses which was higher at second cutting interval for S15. In contrast, the neutral detergent fibre (NDF) and acid detergent fibre (ADF) increased from first to third cutting intervals for all the varieties. The CP and fibre contents of the Pennisetum varieties at different cutting intervals were within the levels recommended for optimum animal performance.

Keywords: Cutting intervals, dry matter yield, *Pennisetum purpureum*, nutrient contents, tiller density

Introduction
In spite of the immense contribution of the livestock sector to the national economy, animal production is extremely low, mainly due to poor standard of feeding both in terms of quantity and quality. Forage is the major nutritional resource for ruminants particularly in sub-Saharan African countries (Akinsoyinu and Onwuka, 1988) and most of the forages that provide animal nutrition are supplied by the natural vegetation and generally referred to as natural pastures. Even pastures in the rangeland provide the 'cheapest feed', it is deficient in nutritional quality for most of the year and so is incapable of sustaining the animals year-round (Ademosun, 1973). The carrying capacity of pastures is much lower than that of sown pastures with a good management system. One of the sown pastures that have in recent years gained much attention by livestock owners and researchers is *Pennisetum purpureum* (Elephant grass).

The importance of Pennisetum species can be seen from the role the forage plant plays as major livestock feed in Smallholder Dairy Production System in the tropics. This grass is the main fodder grown by over 70 % of Smallholder farmers in most regions of East Africa, especially in Kenya and normally provides over 40 % of livestock feeds (Potter, 1987). It has also been reported that it is one of the most promising and highest yielding fodder crop (Anindo and Petter, 1994) providing dry matter yield that surpasses most tropical grasses (Skerman and Riveros, 1990).

Like other tropical grasses, elephant grass is considered to be high in structural cell wall carbohydrates, that increases rapidly with advance in maturity, although this is contrary to its crude protein content and digestibility (*van* Soest, 1994). This implies the need for production strategies that can help improve the overall yield of elephant grass. Forage resource improvement with emphasis on management practices that promote yield and nutritive value are, therefore, one of the important measures that have to be taken to reverse the prevailing scenario of poor animal productivity. Harvesting of forage species at the right stage of growth with proper grazing management is among the strategies towards improving the nutritive values of natural pasturelands (Valdes *et al.*, 1998). The main objective of the present study was to evaluate the effects of variety and varying cutting intervals on the growth performance, biomass yields and chemical composition of four *Pennisetum purpureum* varieties in the humid savannah zone of Nigeria.

Materials and Methods

The experiment was conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria ($7^0$58'N; $3^0$20'E) in the humid savanna agro-ecological zone. The area has a mean annual rainfall of 1230mm in a bimodal distribution pattern with peaks in June/July and September/October and a major dry season between November and March.

The experimental area measuring 324m^2 was cleared, ploughed and harrowed between March and April, 2008. The land was then divided into 3 blocks. Each block was further subdivided into 12 equal plots of 4 m^2. The planting space was 75cm by 50 cm. The study was designed as a 4 by 3 factorial experiment with three replicates. It comprised of four Pennisetum varieties and three harvest intervals (first, second and third) at four weeks intervals. The four *P. purpureum* varieties include two naturalized varieties commonly referred to as Local green and Local purple. The two other varieties, S13 and S15 were Elephant grass selections from the Department of Agronomy, University of Ibadan.

The four varieties of *P. purpureum* grasses were planted using the crown splits method of planting on May, 2008 and the plots were kept weed-free throughout the period of the study. Analysis of the bulked soil samples taken from 0-15 cm depth of the experimental site is presented in Table 1.

The *P. purpureum* varieties were cut back to a uniform height of 15 cm after 8 weeks of planting before sampling commenced.

Harvesting of forage materials

Agronomic data on growth parameters (i.e. plant height, leaf length, leaf width and tiller density), dry matter yield and leaf: stem ratio (weight of leaves and stem) were estimated first, second and third cutting intervals. The dry matter yield was determined using a 1m^{2}quadrat which was thrown three times. Sub samples of 500g were taken, weighed and oven – dried at 65 ^{0}C to constant weight and stored for analysis.

Data collection

Estimation of tiller density

The estimations of tiller density were carried out by counting the number of tillers within two randomly located 1m^2 quadrat at every harvesting time throughout the experimental period.

Estimation of plant height

Estimations of the height of the grasses were carried out by measuring from the base of the plant to where the last leaf on the stem emerges with the aid of a meter rule on ten randomly selected stands per plot at every harvesting time throughout the experimental period.

Estimation of leaf length

Leaf length of the grasses was estimated by measuring the length of the leaf from its tip to the ligule. This was done with the aid of a meter rule on ten stands that were randomly selected from each plot at every harvesting time throughout the experimental period.

Estimation of leaf width

The estimations of the width of the leaf of the grass were carried out by measuring the length of the leaf half way and at that point measure its width. This was done with the aid of a-12 cm rule on ten stands that were randomly selected from each plot at every harvesting time throughout the experimental period.

Estimation of proportions of leaf and stem

A fresh sample of 500 g weight from the grass per replicate were taken and separated into leaf blade and stem fractions and the proportion of each was calculated by weight as follows:

Percentage of leaf

$$= \frac{\text{Weight of leaf}}{\text{Weight of sample}} \times 100$$

Percentage of stem

$$= \frac{\text{Weight of stem}}{\text{Weight of sample}} \times 100$$

Estimation of total yield

The estimation of total yield was carried out by harvesting the herbage materials within the range of 1m x 1m quadrat at the different age at harvest throughout the experimental period. The quadrat was thrown three times per replicate. The dry matter percentage was estimated as:

Dry matter percentage

$$= \frac{\text{Weight of dry sample} \times 100}{\text{Weight of fresh sample}}$$

While dry matter yield was estimated as

Dry matter yield = dry matter percent x fresh sample from 1 m^2 which afterwards was extrapolated in tonnes per hectare.

The oven-dried samples were ground in a hammer mill to pass 1.0 mm sieve for the determination of proximate composition (AOAC, 2006) and fibre fraction (Goering and Van Soest, 1970). Data were analysed by the analysis of variance and means were compared and separated by the Duncan multiple range test (Duncan, 1955).

Results and Discussion

The pH value of 6.8 obtained from the soil sample of the experimental site at the commencement of this study indicated that it was a fairly neutral soil (Table 1). Total nitrogen (0.14 %) and available Phosphorus (74.11 mg kg^{-1}) showed that the soil was low in these important chemical nutrients which were required for good growth and quality of forage plants. The low level of these nutrients is responsible for the poor productivity of crops, especially forage plants on tropical soils (Mohamed-Saleem, 1972). The organic carbon content of the soil (3.21 %) was low hence there is need to enhance the quality of the soil to increase productivity of forages in the tropics.

Table 2 shows the combined effect of variety and cutting intervals on yield components of *P. purpureum*. The Purple variety of Pennisetum produced the highest plant height of 155.5 cm at second cutting interval while S13 variety produced the shortest plant height at first cutting interval (71.75 cm) plant. The implication is that the

Table 1: Soil physical and chemical properties of the study area

Properties	Value
Physical properties	
Particle size (%)	
Clay	3.60
Silt	18.00
Sand	78.40
pH	6.80
Chemical properties:	
Total N (%)	0.14
Organic carbon (%)	3.21
Exchangeable cations (meg/100g of soil):	
Na+	0.23
K+	0.20
Ca++	0.71
Mg++	0.82

tall varieties will have less nutrient quality as most of the nutrients might have been utilized in the process of structural and reproductive stages (Butterworth, 1985). In addition, tall forage crops with small canopy may have low soil coverage thereby, providing less competition to the weed species and can also increase soil temperature, which might be detrimental to the soil (Olanite *et al.*, 2006). Moreover, higher plant height can be considered to be too tall for grazing hence, restricts the intake of small ruminants. The highest value of 95 cm for leaf length was significantly higher ($P < 0.05$) in S15 at second cutting interval than in other varieties and cutting intervals. Leaf width and leaf area were highest (4.50 cm and 320.52 cm^2 respectively) for S13 at second cutting interval. Higher leaf area production is an important component of yield, and it plays a vital role in increasing the green forage yield due to more assimilation of sunlight intercept on the leaf, which increases photosynthesis activity of the plant. Total number of tillers in a plant also contribute to the forage yield, plants with higher number of tillers can extract more nutrients from soil and result in maximum green forage production, which will hence benefit the ruminant animals (Bhatti *et al.,* 1985). Leaf: stem ratio decreased with age as was observed in all the varieties of Pennisetum experimented. Many reports have shown that higher leaf proportion is a desirable attribute in forage species, as leaves have higher nutritive quality in addition to being generally more digestible, thereby eliciting higher animal intake (Minson, 1990). Theurer (1970) reported that the leaf fraction of forage was highly relished by animals and that was the most desired part during grazing. Cultivars with more leaves were much higher in quality than cultivars that produced more stems (Beaty and Engel, 1980). In this study, the proportion of leaves to other yield components were higher in all varieties of Pennisetum when they were harvested at first cutting interval. This indicated that *Pennisetum purpureum* will be preferred at this stage pertaining to leaf proportion. The highest tiller density (137.00) recorded for S13 at the third cutting interval was however, not significantly ($P > 0.05$) different from (135.00 tiller density) recorded for S15 variety at third cutting interval. Rapid production of tillers most especially after plant establishment is a desirable characteristic for good weed control, high dry matter yield and persistence (Leach *et al.,* 1976). The highest dry matter (13.26 t ha^{-1}) yield was recorded for variety S15 at first cutting interval. This was followed by 12.92 t ha^{-1} produced by variety S13 at the same cutting interval, while the lowest dry matter yield of 5.31 t ha^{-1} was produced by the Purple variety at the third cutting interval. Reduction in the dry matter yield

Table 2: Effects of variety and cutting interval on yield components of four *P. purpureum* varieties

	S15			Purple			Green			S13			
	Cutting interval												
Yield components	First	Second	Third	First	Second	Third	First	Second	Third	First	Second	Third	SEM
Plant height (cm)	89.70^{ef}	152.50^{ab}	137.50^{abc}	85.65^{ef}	155.50^{a}	143.50^{abc}	88.00^{ef}	126.00^{cd}	56.50^{g}	71.75^{fg}	130.00^{bc}	105.00^{de}	1.07
Leaf length (cm)	60.00^{cde}	95.00^{a}	75.50^{bc}	56.00^{de}	70.50^{bcd}	60.00^{cde}	55.20^{dc}	75.00^{bc}	48.99^{e}	52.25^{e}	79.00^{b}	52.50^{e}	0.74
Leaf width (cm)	2.95^{cd}	2.25^{de}	2.20^{de}	2.75^{cde}	3.00^{cd}	3.00^{cd}	3.45^{bc}	2.60^{de}	2.00^{e}	3.95^{ab}	4.50^{a}	3.50^{bc}	0.04
Leaf area (cm^2)	161.54^{bc}	195.71^{b}	152.31^{bc}	138.37^{c}	191.41^{b}	156.87^{bc}	171.25^{bc}	175.27^{bc}	86.88^{d}	186.71^{bc}	320.52^{a}	163.43^{bc}	2.19
Tiller density ($^{-1}m^2$)	60.50^{de}	100.00^{b}	135.00^{a}	71.00^{cde}	97.50^{bc}	109.50^{ab}	46.50^{e}	62.50^{e}	96.50^{bc}	86.00^{bcd}	128.50^{a}	137.00^{a}	1.29
DMY (t ha^{-1})	13.26^{a}	10.11^{b}	9.73^{b}	9.44^{b}	6.63^{c}	5.31^{c}	10.22^{b}	5.86^{c}	6.55^{c}	12.92^{a}	11.25^{b}	10.34^{b}	0.45
Leaf (%)	89.33^{a}	58.21^{cd}	65.54^{c}	86.80^{a}	61.68^{cd}	55.46^{cd}	83.50^{ab}	60.13^{cd}	55.32^{d}	89.44^{a}	75.19^{b}	64.81^{cd}	0.44
Stem (%)	10.67^{c}	41.08^{a}	34.64^{a}	14.26^{bc}	38.33^{a}	44.55^{a}	16.15^{bc}	39.87^{a}	44.68^{a}	10.59^{c}	24.82^{b}	35.20^{a}	0.48

$^{a,b,c...g}$ Means in the same rows with different superscripts are significantly ($P<0.05$) different.
SEM = Standard Error of Means

Table 3: Effects of variety and cutting interval interaction on the proximate fractions of four *Pennisetum purpureum* varieties (%)

Variety	Cutting Interval	CP	EE	CF	ASH	DM	NFE
S15	1	8.62^{c}	1.69^{l}	38.37^{f}	11.62d^{ef}	88.63^{a}	39.80^{b}
	2	8.97^{a}	2.21^{e}	41.65^{b}	11.97^{bc}	88.38^{h}	35.50^{g}
	3	8.48^{e}	1.87^{i}	37.37^{j}	11.49^{efg}	88.44^{f}	41.08^{b}
Purple	1	8.14^{i}	2.34^{c}	37.37^{k}	11.39^{fg}	88.51^{d}	40.86^{b}
	2	8.62^{c}	2.53^{a}	42.28^{a}	11.86^{bcd}	88.44^{f}	34.83^{h}
	3	7.94^{j}	1.95^{h}	38.59^{e}	11.55^{efg}	88.60^{b}	39.51^{g}
Green	1	8.48^{e}	1.96^{g}	37.69^{h}	11.55^{efg}	88.45^{f}	39.79^{c}
	2	8.75^{b}	2.29^{d}	40.23^{d}	12.54^{a}	88.55^{c}	36.56^{e}
	3	8.23^{h}	1.74^{k}	38.89^{f}	11.26^{g}	88.33^{i}	42.19^{a}
S13	1	8.36^{f}	2.13^{f}	37.93^{g}	11.74^{cde}	88.50^{d}	38.92^{c}
	2	8.59^{d}	2.37^{b}	41.27^{c}	12.13^{b}	88.40^{g}	35.78^{f}
	3	8.29^{g}	1.83^{j}	37.45^{i}	11.52^{efg}	88.48^{e}	40.95^{b}
SEM		0.00	0.00	0.00	0.01	0.00	0.01

$^{abc\,..l}$, Means in each column with different letters are significantly different ($P<0.05$)
CP= Crude protein, EE= Ether extract, CF= Crude fibre, DM=Dry matter, NFE= Nitrogen free extract

Table 4: Effects of variety and cutting interval interaction on the insoluble fibre fractions of four Pennisetum purpureum varieties (%)

Variety	Cutting Interval	NDF	ADF	ADL	HEMICELL	CELLULOSE
S15	1	63.98^{i}	41.74^{cd}	11.08^{g}	22.24^{ab}	30.66^{cde}
	2	65.68^{d}	42.30^{cd}	11.88^{d}	23.55^{a}	30.42^{de}
	3	66.62^{c}	47.25^{d}	13.55^{b}	19.37^{b}	33.70b^{c}
Purple	1	63.88^{j}	40.37^{cd}	11.07^{g}	23.51^{a}	29.30^{e}
	2	64.75^{f}	42.90^{c}	11.39^{c}	21.86^{ab}	31.50^{bcde}
	3	69.84^{a}	48.93^{ab}	11.39^{e}	20.90^{ab}	31.50^{bcde}
Green	1	63.49^{k}	40.80^{cd}	11.25^{f}	22.70^{a}	29.54^{c}
	2	64.60^{g}	46.19^{b}	12.76^{c}	19.50^{b}	33.43^{bcd}
	3	65.69^{e}	41.63^{cd}	11.79^{d}	22.97^{a}	29.84^{e}
S13	1	61.39^{l}	39.57^{d}	9.87^{h}	21.81^{ab}	29.70^{e}
	2	64.13^{h}	42.38^{cd}	11.17^{fg}	27.5a^{b}	31.21^{cde}
	3	66.88^{b}	50.93^{a}	13.56^{b}	15.96^{c}	37.37^{a}
SEM		0.00	0.14	0.01	0.01	0.14

abc..l, Means in each column with different superscripts are significantly (P<0.05) different.
WAC=weeks, SEM= standard error of means, NDF= neutral detergent fibre, ADF= acid detergent fibre, ADL= lignin, HEMICEL= hemicellulose, CELL= cellulose.

of all the varieties from first to third cutting intervals could be attributed to the fact that the nutrients in the soil have being depleted which is generally common with tropical soils. This however calls for regular addition of fertilizer into the soil in other to enrich the soil for plant growth. The differences in yields observed in the varieties of *Pennisetum* understudied could possibly be due to the accumulation of carbohydrate plant reserves built up at different rates.

From this study the crude protein contents for all the varieties of *Pennisetum*, increased from 4weeks after cutback to second cutting interval, but dropped after that, with highest value obtained in S15 ($P < 0.05$) (8.97 %) at second cutting interval and lowest value obtained in Purple variety (7.94 %) at third cutting interval. However, the crude protein values obtained from this study fall within the range of 6.5 – 8.0 % recommended for optimum performance of tropical ruminant animals (Minson, 1980). It has been reported that as plant matured, even the leaves would become more fibrous and less digested (*v*an Soest, 1982). This might have been the reason for lower content of crude protein, ether extract and ash at third cutting interval of the *Pennisetum* varieties.

The NDF and ADF contents of the *Pennisetum* varieties recorded higher values at third cutting intervals compared to the first cutting interval. Variety S13 recorded lowest values of 39.57 in ADF contents and 61.39 % for NDF at first cutting interval. This value agreed with the reports of Zinashi *et al.* (1995) that there is increase in fibre content of forage with increased cutting intervals. This can be attributed to an increase in cell wall content as the plants mature. This is also in order with findings of Olanite *et al.* (2006) that fibre content increases as crude protein decreases. The highest NDF content of the Purple variety at third cutting interval might be due to the stemmy nature of the forage.

Values obtained showed that the Purple variety had the highest values of NDF content and therefore the most fibrous of the varieties. The purple pigmentation of the variety could be responsible for this, due to colour change. However, the fibre contents of all the *Pennisetum* varieties obtained in this study at different cutting intervals obtained in this experiment fall within the range that can be digested by ruminant animals.

Conclusion

From the study, variety S15 is superior to the other varieties in terms of high dry matter yield and higher crude protein content whereas in terms of leaf and tiller numbers, variety S13 was superior to other varieties. Animals grazing the four varieties are likely to benefit more from the two aforementioned grasses. However, in all the three cutting intervals, the four varieties of *Pennisetum purpureum* produced reasonable amount of dry matter yield with good quality. This shows the regrowth and persistency of *Pennisetum* varieties at continuous cutting intervals. Looking at the benefits of the forage crop from high yield, quality to persistency, *P. purpureum* can be the used as one of the sown pastures for animal production in the nearest future.

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