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EFFECT OF MANURE AND HARVESTING AGE ON PHYSICAL AND CHEMICAL PROPERTIES OF *PENNISETUM* HYBRID SILAGE

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ABSTRACT

This study was conducted to investigate the combined effect of manure type and harvesting age on physical properties and chemical composition of silage produced from *Pennisetum* hybrid forage. The manure types were from cattle, poultry, swine, goat, while the harvesting times were 4 and 8 weeks after cutback (WAC). Colour results varied significantly ($P < 0.05$). Dry matter, ether extract, crude fibre, ash, crude protein (CP), neutral detergent fibre, acid detergent fibre and lignin contents of the silage varied significantly ($P < 0.05$). Higher CP content (91.0 $g.kg^{-1}$) of the silage was obtained from the interactive effect of poultry or goat manure and 4 WAC harvesting age of *Pennisetum* hybrid. Higher ash content (330.0 $g.kg^{-1}$) was recorded for the combined effect of goat manure and 4 WAC on the *Pennisetum* silage, while the least (70.0 $g.kg^{-1}$) occurred in grass without manure application sampled 8 WAC. Higher Ca (7.14 $g.kg^{-1}$) was recorded in silage from swine manure and 4 WAC harvesting age effect. Phosphorus content of the silage was higher (2.57 $g.kg^{-1}$) with poultry manure and 8 WAC effect, while the least (1.01 $g.kg^{-1}$ and 1.98 $g.kg^{-1}$) were from no manure effect at both harvesting ages. Crude protein content of silage made from the *Pennisetum* hybrid fertilized with either poultry or goat manure and harvested at 4 WAC was the best. Physical properties of the silage were generally of acceptable/desirable grades. With or without the manure application, the minerals of the silage were generally higher than the recommendation of ruminants.

Key words: colour; fibre; organic manure; proximate; regrowth; silage

INTRODUCTION

Natural grazing lands constitute the major feed resources in the developing countries, especially in Africa countries by providing more than 90 % of animal feed requirements either in the form of grazing resources or conserved forages (Kitaba and Tamir, 2007).

Inadequate supply of both quantity and quality feed is responsible for low livestock productivity (Peters, 1980). Ruminant production in Sub-Sahara Africa is seriously affected by seasonal availability of quality forages. The problem of pasture shortage is more severe in the dry season when ruminants subsist on very poor quality crop residues which results in correspondingly low level of production performance (Areegbe *et al.*, 2012). Grazing of ruminants have been used as palliative in the past, but could not satisfactorily address the problems of dry season feeding as animal losses are often recorded as a result of stress associated with prolonged search for green herbage that are usually of very poor quality (Mohammed, 1990).

Forage conservation in form of silage has been reported as a sustainable means of supplementing feed for ruminants in the dry season (Babayemi and Igbekoyi, 2008). Forage conservation is,

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therefore, promoted with the main objective of ensuring that quality feed is available for animals throughout the season. Silage making helps to secure feeds during seasons of high production for conservation and for later use in periods of relative shortage. In dealing with lack of feed during the dry season forage conservation especially as silage is considered to be the preservation technique with the greatest potential for protein rich foliage (Man and Wiktorsson, 2002).

The *Pennisetum* hybrid grass, which is derived from the cross of a short day photoperiod sensitive "maiwa" cultivar of bulrush millet or the pearl millet (*Pennisetum thyphoides* Schum) and the common elephant grass (*Pennisetum purpureum*), is known with high nutritive value and acceptability of the "maiwa" and the dry matter yield potential of elephant grass. Therefore, the objectives of this study was to investigate the effect of manure type and harvesting age on physical characteristics and chemical composition of silage produced from the *Pennisetum* hybrid grass.

MATERIALS AND METHODS

Experimental site

The field experiment was conducted at the Teaching and Research Farm; the chemical analyses were carried out at the Department of Pasture and Range Management Laboratory, Federal University of Agriculture, Abeokuta, Nigeria. The experimental site lies within the savanna agro-ecological zone of South-Western Nigeria (latitude: 7 °N, longitude 3.5 °E) (Google Earth, 2011). It experiences average annual rainfall of 1037 mm in a bimodal distribution pattern, with mean monthly temperature which ranges between 25.70 °C in July and 30.20 °C in February (Google Earth, 2011; OORBDA, 2011).

Land preparation, organic manure collection, analysis, application and planting of grass

A total land area, measuring 846 m^2 used for the experiment, was divided into three parcels with each parcel subdivided into equal plots of 12 m^2, and each plot was cleared, followed by ploughing and harrowing. After land preparation and before planting, soil samples were randomly collected from the plots at the depth of 0-15 cm using soil auger. The soil samples were bulked per replicate and thoroughly mixed, a sub-sample of 300 g was taken to determine the pre-planting nutrient status of the soil (Table 1).

Animal manures from cattle, poultry, goat and swine used for the study were collected from the Teaching and Research Farm. Representative samples were taken from the heap, oven-dried to a constant weight at 65 °C, thereafter milled through

Table 1. Physico-chemical properties of the composite soil samples taken at 0-15 cm depth from the experimental site before planting

Chemical properties	Values
pH	7.03
Total nitrogen (%)	0.11
Organic carbon (%)	1.29
C:N ratio	28.38
Available P ($mg.kg^{-1}$)	53.87
Acidity ($cmol.kg^{-1}$)	0.13
CEC	1.79
Exchangeable cations ($cmol.kg^{-1}$)	
Sodium (Na)	0.80
Potassium (K)	0.20
Calcium (Ca)	2.77
Magnesium (Mg)	2.72
Particle size	
Sand (%)	77.93
Silt (%)	17.33
Clay (%)	4.73

Table 2. Mineral composition of animal manures

Nutrients	Cattle	Swine	Poultry	Goat
N ($g.kg^{-1}$)	15.60	16.90	30.20	15.3
P ($g.kg^{-1}$)	6.90	6.30	10.60	8.70
K ($g.kg^{-1}$)	7.30	7.60	10.30	8.90
Ca ($g.kg^{-1}$)	21.20	31.60	37.20	24.20
Mg ($g.kg^{-1}$)	11.70	19.20	17.30	12.50
Na ($g.kg^{-1}$)	1.10	1.60	2.10	1.30
Fe ($mg.kg^{-1}$)	615.00	651.00	631.00	576.00
Zn ($mg.kg^{-1}$)	54.80	81.20	75.40	38.60
Cu ($mg.kg^{-1}$)	29.10	27.30	32.70	23.80
Mn ($mg.kg^{-1}$)	322.00	260.00	218.00	257.00

a 1 mm sieve and were separately analysed to determine the mineral composition in each manure type (Table 2). Thereafter, the remaining collected manures, from which samples were taken, were broadcast to individual plots according to their treatments. After the application of manures, the plots were left for two weeks for the mineralization to take place before planting of the grass at 1 m × 1 m intervals. Eight weeks after planting, the grasses were cut back to 10 cm above ground level to allow uniform regrowth.

Experimental design

The study was a 5 × 2 factorial experiment arranged in a completely randomized design, which comprised of five manure types (cattle, poultry, swine, goat and no-manure as control) and two harvesting times (4 and 8 weeks after cutback). The experiment was replicated thrice.

Harvesting of forage materials

Samples of the grass fertilized with animal manures were harvested at 4 and 8 weeks after cutback (WAC) 15 cm above the ground level. The samples were chopped into pieces of 2-3 cm in length, wilted for 4 hours to reduce their moisture contents at a temperature of 23.4 °C and relative humidity of 71.2 % before ensiling. The forages were carefully packed into laboratory bottle silos (960 ml) after mixing thoroughly following the method described by Yokota *et al.* (1995) and were ensiled for a period of 6 weeks at an ambient temperature of 26 °C. At the expiration of the ensiling, the bottle silos were opened for determination of physical properties according to the procedures of Bates (1998). Also, samples of 300 g were taken from each of the silos and oven-dried at 65 °C to a constant weight. The dried samples were thereafter milled through a 1 mm sieve for chemical analyses.

Chemical analyses

The approximate composition of the silage was determined according to the procedure of AOAC (2000). Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Acid Detergent Lignin (ADL) were determined using the method of Van Soest *et al.* (1991). The mineral compositions for Calcium, Potassium, Phosphorus and Magnesium were determined using Atomic Absorption Spectrophotometer (Fritz and Schenk, 1979). All the values after chemical analyses are in the dry matter form.

Statistical analysis

The data collected were subjected to a two-way analysis of variance and the treatment means were separated using Duncan Multiple Range Test of SAS (1999) package.

RESULTS AND DISCUSSION

Table 3 presents the effect of manure type and harvesting age on the physical properties of silage produced from *Pennisetum* hybrid. Odour, moisture and mouldiness percentages were similar ($P > 0.05$), while the colour results were significantly

Table 3. Effect of manure type and harvesting age on the physical properties of silage produced from *Pennisetum* hybrid grass

Manure type	Harvesting age	Colour	Odour	Moisture	Mouldiness
	←		%		→
Cattle	4 WAC	8.00^{ab}	16.67	7.33	9.00
Swine	4 WAC	8.67^{ab}	19.33	7.67	9.00
Goat	4 WAC	8.33^{ab}	20.00	8.00	9.00
Poultry	4 WAC	7.00^{b}	17.67	7.33	9.33
Control	4 WAC	7.67^{ab}	16.33	8.00	8.67
Cattle	8 WAC	7.33^{ab}	25.33	6.33	9.00
Swine	8 WAC	8.33^{ab}	24.67	8.00	9.00
Goat	8 WAC	8.33^{ab}	25.00	6.67	9.00
Poultry	8 WAC	9.00^{a}	25.67	8.00	9.00
Control	8 WAC	9.00^{a}	24.33	8.33	9.00
SEM		0.14	0.19	1.04	0.20

$^{a,b:}$ Means in same column with different superscripts are significantly ($p < 0.05$) different; WAC: weeks after cutback

different ($P < 0.05$). The colour ratings (7.00-9.00 %) of this study fell within the range of 5-8 (green to yellowish-green) and 9-12 (yellow to brownish), which are respectively regarded as desirable and acceptable ranges for silage (Bates, 1998). 't Mannetje, (1999) has reported that good silage usually preserves the original colour of the pasture or any forage. Interactive effect of poultry manure application and 4 WAC on the silage made recorded the least percentage in the colour (7.00 %) rating. The green/yellowish-green colour was closed to the original colour of the grass, which was an indication of good quality silage that was well preserved (Oduguwa *et al.*, 2007). Odour ratings (16.33-25.67 %) of this study were within the ranges of acceptable (11-23 %) and desirable (24-28 %) silage odour (Bates, 1998). Moisture constituents of this study were within the range of acceptable (6-8 %), reported in the silage physical evaluation sheet of Bates (1998). Most mouldiness values of this study were within the range of no-mould as reported by Bates (1998).

The interactive effect of manure type and harvesting age on the approximate composition and fibre fractions of silage produced from *Pennisetum* hybrid is presented in Table 4. The results of the dry matter (DM), ether extract (EE), ash and crude protein (CP) contents of the silage were significantly different ($P < 0.05$). Results of neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) contents of the silage were significantly different ($P < 0.05$). The CP content (91.00 $g.kg^{-1}$) of the silage made from grasses fertilized with poultry or goat manures and harvested at 4 WAC recorded significantly higher value than 74.00 g kg^{-1} reported for *Panicum maximum* cv. Ntchisi, when ensiled at 4 WAC (Babayemi, 2009). Similarly, the CP content of silage from grass, harvested at 4 WAC (63.00 - 79.30 $g.kg^{-1}$) with or without manures application, were higher than 52.00 $g.kg^{-1}$ reported for *Panicum maximum* cv. Ntchisi when ensiled at 8 WAC and sampled after 47 days (Babayemi, 2009). Better silage made from this study could be linked to manure application which enhanced the known quality of *Pennisetum* hybrid grass. The CP contents of the silage in this study surpassed the threshold of 60 g kg^{-1} required by rumen microbes to build their body protein (Van Soest, 1994). Hence, intake of forages by ruminants and rumen microbial activities would be positively affected. Therefore, the silage would provide adequate nitrogen requirement by rumen microorganisms to maximally digest the main components of dietary fibre leading to the production of volatile fatty acid (Trevaskis *et al*., 2001; Lamidi and Ogunkunle, 2016) which, in turn, facilitates microbial protein synthesis (Lamidi and Aina, 2013).

Pennisetum hybrid grass that were fertilized with goat, poultry or swine manure, produced silage of higher CP content at 4 WAC, when compared to the silage made from unfertilized grasses. The NDF, ADF and ADL contents of *Pennisetum*

Table 4. Effect of manure type and harvesting age on the chemical composition (g.kg^{-1} DM) of silage produced from *Pennisetum* hybrid grass

Manure type	Harvesting age	DM	CP	EE	Ash	NDF	ADF	ADL
		g.kg^{-1} DM						
Cattle	4 WAC	566.00^{ab}	81.70^{ab}	80.00^{bc}	130.00^{c}	560.00^{bcd}	360.00^{ab}	160.00^{abcd}
Swine	4 WAC	480.00^{c}	86.30^{a}	90.00^{bc}	120.00^{c}	600.00^{abcd}	360.00^{ab}	100.00^{f}
Goat	4 WAC	504.00^{b}	91.00^{a}	163.30^{a}	330.00^{a}	560.00^{bcd}	346.70^{b}	130.00^{e}
Poultry	4 WAC	500.00^{b}	91.00^{ab}	73.30^{bc}	243.30^{b}	540.00^{cd}	340.00^{b}	126.70^{ef}
Control	4 WAC	492.00^{c}	81.70^{ab}	140.00^{a}	136.70^{c}	540.00^{cd}	400.00^{a}	150.00^{bcde}
Cattle	8 WAC	570.00^{ab}	79.30^{ab}	60.00^{c}	80.00^{bc}	660.00^{a}	400.00^{a}	170.00^{ab}
Swine	8 WAC	572.00^{ab}	74.70^{ab}	80.00^{bc}	80.00^{bc}	660.00^{a}	280.00^{c}	140.00^{cde}
Goat	8 WAC	600.00^{a}	63.00^{b}	70.00^{bc}	90.00^{bc}	520.00^{b}	360.00^{ab}	133.30^{de}
Poultry	8 WAC	622.00^{a}	72.30^{ab}	100.00^{b}	90.00^{bc}	620.00^{abc}	380.00^{ab}	163.30^{abc}
Control	8 WAC	600.00^{a}	74.70^{ab}	90.00^{bc}	70.00^{c}	640.00^{ab}	400.00^{a}	180.00^{a}
SEM		1.12	2.20	6.40	19.90	11.80	7.30	4.90

$^{a-f:}$ Means on same column with different superscripts varied significantly (p > 0.05); WAC: weeks after cutback; DM: Dry matter; CP: Crude protein; EE: Ether extract; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin

hybrid ensiled at 4 and 8 WAC were higher than the results reported for unfertilized *Panicum maximum* cv. Ntchisi, ensiled at 4th and 12th week after cutback (Babayemi, 2009). Higher NDF content (660.00 g.kg^{-1}) was obtained from silage made from grass fertilized with cattle and swine manures and harvested at 8 WAC, while the least value (52.00 %) was in silage made from grass fertilized with goat manure at 8WAC. Majority of the NDF values recorded in this study were below the 650 g.kg^{-1}, suggested as the limit at which intake of tropical feeds by ruminants would be limited (Eastridge, 2006).

The interactive effect of manure type and harvesting age on the mineral composition of silage produced from *Pennisetum* hybrid is in Table 5. Calcium (Ca), Potassium (K), Phosphorus (P) and Magnesium (Mg) contents of the silage were significantly different (P < 0.05). Higher Ca (7.14 g.kg^{-1}) content was observed in the silage made from grass

Table 5. Effect of manure type and harvesting time on the mineral composition (g.kg^{-1} DM) of silage produced from *Pennisetum* hybrid grass

Manure type	Harvesting age	Calcium	Phosphorus	Potassium	Magnesium
		g.kg^{-1} DM			
Cattle	4 WAC	6.90^{bc}	2.27^{c}	22.70^{f}	1.26^{a}
Swine	4 WAC	7.14^{a}	2.37^{bc}	33.20^{b}	1.16^{b}
Goat	4 WAC	6.60^{d}	2.32^{bc}	20.20^{g}	1.27^{a}
Poultry	4 WAC	7.06^{ab}	2.46^{ab}	34.10^{a}	1.26^{a}
Control	4 WAC	7.10^{ab}	1.98^{d}	24.00^{de}	1.17^{b}
Cattle	8 WAC	6.99^{bc}	2.37^{bc}	24.16^{d}	1.17^{b}
Swine	8 WAC	6.84^{cd}	2.28^{c}	23.40^{e}	1.26^{a}
Goat	8 WAC	6.46^{e}	2.46^{ab}	24.47^{d}	1.06^{c}
Poultry	8 WAC	6.67^{d}	2.57^{a}	25.70^{c}	1.14^{b}
Control	8 WAC	6.78^{cd}	1.01^{e}	20.00^{g}	1.26^{a}
SEM		0.42	0.80	0.45	0.14

$^{a-d:}$ Means in same column with different superscripts are significantly (p < 0.05) different; WAC: weeks after cutback that was fertilized with swine manure at 4 WAC. The highest (34.10 g.kg^{-1}) and least (20.20 g.kg^{-1}) K contents were observed in silages that were made from the grass fertilized with poultry and goat manures, respectively, at 4 WAC. The phosphorus content of the silage, obtained from the grass fertilized with poultry manure, was significantly higher (2.57 g.kg^{-1}) at 8 WAC. However, the lowest (1.01 g.kg^{-1} and 1.98 g.kg^{-1}) P contents were recorded from the silage made from grasses without manure application at 8 and 4 WAC, respectively. The range of P in this study fell within the normal requirements for growing cattle (1.1 - 4.8 g.kg^{-1}) (Minson, 1990). The highest Mg content (1.27 g.kg^{-1}) was measured in the silage made from grass that was fertilized with goat manure and harvested at 4 WAC. The Mg contents of the silage in this study were lesser than the recommended range 2.0 g.kg^{-1} DM for ruminants in the tropics (McDowell and Arthington, 2005). There is a need to strengthen a *Pennisetum* hybrid silage with Magnesium in order to eliminate their deficiency in animals.

CONCLUSION

The physical properties (colour, odour, moisture and moldiness) of *Pennisetum* hybrid silage were generally of acceptable/desirable grades for high quality silage. Crude protein contents of the silage from the grass, fertilized with either poultry or goat manures and harvested at 4 WAC, were better than the other treatments. Hence, application of manure to the grass and harvesting at tender age will provide good silage for ruminants, especially during dry seasons, when quality and quantity of forages are very low.

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