Influence of wilting period on mineral contents of grass-legume silage mixtures in Umudike, South East, Nigeria

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Abstract

*Forage conservation in form of silage production remains best option to ensure availability of adequate feed resource in the rainforest zone of Nigeria due to high relative humidity that negatively affects hay quality. Grasses like Panicum maximum (Guinea grass), Pennisetum purpureum (Elephant grass) are predominantly grown in this zone throughout the year, but decline in nutritive quality when dry season was at the peak. Centrosema pubescens (Centro) has been reported to posses good nutritive value which could be explore to improve some nutrients deficiencies in the grass species when incorporated in the silage. This experiment was conducted to evaluate the mineral contents of grass-legume silage mixtures as affected by wilting period in Umudike, Rainforest zone, Nigeria. The experiment comprised two factors namely: wilting period at two levels (6 and 12 hours after chopping) and forage composition in 5 different constituents (sole Panicum maximum (Guinea grass), sole Pennisetum purpureum (Elephant grass), Panicum maximum-Centrosema pubescens (Panicum*Centro: 50:50) mixture, Pennisetum purpureum-Centrosema pubescens (Pennisetum*Centro: 50:50) mixture and sole Centrosema pubescens (Centro). Thus, the experiment was a factorial arrangement laid out in a Completely Randomized Design (CRD). The mineral contents of silage were determined 12 weeks ensiling period. The results showed that wilting period and forage composition significantly (P<0.05) affected both macro and micro mineral concentrations of the silage. The ensiled materials wilted for 12 hours respectively recorded the highest values (0.291, 0.419, 0.316, 0.774 and 0.259 %) for Calcium (Ca), Phosphorus (P), Magnesium (Mg), Potassium (K) and Sodium (Na), when compared with 6 hours period of wilting. Meanwhile, Pennisetum*Centro silage mixtures recorded greater concentration of 0.323, 0.436, 0.319, 0.814 and 0.280 % for Ca, P, Mg, K and Na in relation to other forage composition. For micro mineral concentrations, similar (P<0.05) trend was observed on wilting period, while that of forage composition slightly differed with sole Centro silage recorded the higher Copper concentration (17.58mg/kg). It was evident from the outcome of this study that wilting period and forage composition enhanced the mineral contents of the silage produced in Umudike, rainforest zone, Nigeria. Pennisetum*Centro silage mixture wilted for 12 hours is therefore recommended for ruminant production.*

Keywords: forage composition, mineral contents, silage and wilting period

Influence de la période de flétrissement sur la teneur en minéraux des mélanges d'ensilage graminées-légumineuses à Umudike, Sud-Est de Nigéria

Résumé

La conservation du fourrage sous forme de production d'ensilage reste la meilleure option pour assurer la disponibilité de ressources alimentaires adéquates dans la zone

*de forêt tropicale du Nigeria en raison de l'humidité relative élevée qui affecte négativement la qualité du foin. Des graminées comme Panicum maximum (herbe de Guinée), Pennisetum purpureum (herbe d'éléphant) sont principalement cultivées dans cette zone tout au long de l'année, mais leur qualité nutritive décline lorsque la saison sèche était à son apogée. Il a été rapporté que Centrosema pubescens (Centro) possède une bonne valeur nutritive qui pourrait être explorée pour améliorer certaines carences en nutriments chez les espèces de graminées lorsqu'elles sont incorporées dans l'ensilage. Cette expérience a été menée pour évaluer la teneur en minéraux des mélanges d'ensilage de graminées et de légumineuses affectées par la période de flétrissement à Umudike, dans la zone de forêt tropicale, au Nigéria. L'expérimentation comprenait deux facteurs à savoir : la période de flétrissement à deux niveaux (6 et 12 heures après la coupe) et la composition du fourrage en 5 constituants différents (sole Panicum maximum (Guinea grass), sole Pennisetum purpureum (Elephant grass), Panicum maximum-Centrosema pubescens (Panicum*Centro : 50 :50), mélange Pennisetum purpureum-Centrosema pubescens (Pennisetum*Centro : 50 :50) et sole Centrosema pubescens (Centro). Ainsi, l'expérience était un arrangement factoriel présenté dans un plan complètement randomisé (PCR). La teneur en minéraux de l'ensilage a été déterminée sur une période d'ensilage de 12 semaines. Les résultats ont montré que la période de flétrissement et la composition du fourrage affectaient de manière significative (P<0,05) les concentrations macro et micro minérales de l'ensilage. Les matériaux ensilés flétris pendant 12 heures respectivement enregistraient les grandes valeurs (0,291, 0,419, 0,316, 0,774 et 0,259 %) pour le calcium (Ca), le phosphore (P), le magnésium (Mg), le potassium (K) et le sodium (Na), par rapport à une période de flétrissement de 6 heures. Pendant ce temps, les mélanges d'ensilage Pennisetum*Centro ont enregistré une plus grande concentration de 0,323, 0,436, 0,319, 0,814 et 0,280 % pour Ca, P, Mg, K et Na par rapport aux autres compositions fourragères. Pour les concentrations de micro-minéraux, une tendance similaire (P<0,05) a été observée pendant la période de flétrissement, tandis que celle de la composition du fourrage différait légèrement avec l'ensilage de sole Centro qui enregistrait la concentration de cuivre la plus élevée (17,58 mg/kg). Il ressort clairement des résultats de cette étude que la période de flétrissement et la composition du fourrage améliorent la teneur en minéraux de l'ensilage produit à Umudike, dans la zone de forêt tropicale, au Nigéria. Le mélange d'ensilage Pennisetum*Centro fané pendant 12 heures est donc recommandé pour la production de ruminants.*

Mots-clés: composition fourragère, teneur en minéraux, ensilage et période de flétrissement

Introduction

The availability of green forage material is highly seasonal in the humid tropics. Plant grows rapidly mostly in the raining season, thereby generating abundant forage materials in right quantity and quality. Consequence of this situation, livestock production is adversely affected because of inadequate feed supply during any prolonged dry season resulting in severe moisture stress among the animals (t'Mannetje, 2000). This challenge could be reduced by conserving the surplus forage materials during the wet season

(Olorunnisomo and Adesina, 2014). In an attempt to ameliorate this situation, forage conservation in form of silage remains the preferred option to explore in order to increase feed availability during the dry season, due to its less dependent on weather condition (t'Mannetje, 2000).

Silage making has great potential in solving seasonal shortage of feed for ruminants, when excess forage produced during the wet season are conserved and kept for use during the dry period. Better understanding of silage-making principles would avail farmers the privilege of achieving all year-round animal production, which consequently increase animal products, farmer's income and possibly government revenues. Silage should therefore be produced under the best condition so as to produce silage with the best dry matter and high digestibility coefficient.

There are many factors affecting silage quality which includes; forage composition, wilting intensity/period, high pH, presence of high moisture content, temperature level, presence of oxygen, presence of mould in plant materials and the likes. Among all the factors, degree of wilting is very important in determining the silage quality. Likewise, forage species has great influence on silage quality because most tropical grass species undergo poor fermentation during ensiling due to their high buffering ability (i.e. their resistance to changes in pH) (Gallaher and Pitman, 2001; Olorunnisomo and Adesina, 2015). To enable them to undergo a more satisfactory fermentation, two techniques are available to small holders, wilting the forage prior to and adding a fermentable substrate at ensiling (Moran, 2005).

Meanwhile, the nutritive value of silage prepared from tropical grasses and agricultural wastes is often limited by their low protein content (Gallaher and Pitman, 2001). In order to improve the protein content and other cell contents of pure grass silage, there is the need to introduce leguminous plant which are higher in cell contents than grass counterpart, and have the propensity of improving quality of the silage. *Centrosema pubescens* which is predominantly found in Umudike environment throughout the growing seasons and has been reported to have high crude protein and ash content by Castillo *et al*. (2003), and thus making it appropriate to be incorporated with grasses that are deficient in nitrogen content and other cell contents.

Among chemical constituents of forage plants, mineral concentration has been reported to be very low (Spear and Fahey, 1994), there is therefore the need to preserve fresh forage with barest minimal loss of mineral concentration during conservation. It is for this reason that the experiment was carried out to evaluate effects of wilting period and forage composition on mineral contents of silage. With a view to provide the farmers with the necessary information on the best wilting period that would produce good quality silage from grass mixtures and the best forage composition that would improve the nutritive quality of the silage.

Materials and Methods

Experimental site

The experiment was carried out in the Pasture Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State. Umudike is located on latitude 05° 21°N and longitude 07° 33°E with an elevation of about 112m above sea level. The location has an annual rainfall of 177-2000mms per annum (April - October) and a short period of dry season (November - March) with a relative humidity of about 50 - 90% and monthly temperature range of 17°C - 36°C (Meteorological station NCRCI, Umudike, 2018).

Experimental design

The experiment comprised two factors namely: wilting period at two levels (6 and 12 hours after chopping) and forage composition in 5 different constituents (sole *Panicum maximum* (Guinea grass 100%), sole *Pennisetum purpureum* (Elephant grass 100%), *Panicum maximum-Centrosema pubescens* (Panicum*Centro: 50:50) mixture, *Pennisetum purpureum-Centrosema pubescens* (Pennisetum*Centro: 50:50) mixture and sole *Centrosema pubescens* (Centro 100%). Thus, the experiment was a factorial arrangement laid out in a Completely Randomized Design (CRD). There were 10 treatments combinations replicated three time

Source of experimental forage materials

Fresh forage materials were harvested manually from natural vegetation around Umudike environment in May, 2021 for this study. The harvested forage materials include two varieties of grass species and one leguminous specie namely: *Panicum maximum* (Guinea grass), *Pennisetum purpureum* (Elephant grass) and *Centrosema pubescens* (Centro).

Silage Preparation

The forage materials harvested at their vegetative stage were manually chopped to about 2-3cm length using a matchet to facilitate wilting, ease the filling, increase surface area for microbial action and also help rapid exclusion of air. The chopped materials were spread and allowed to wilt in a room with an average temperature of 27.5^{o}C for 6 hours and 12 hours respectively to reduce moisture content. The chopped materials were filled in a number of 30 plastic buckets (4-litres, i.e. mini silos) with different proportions of forage mixtures (i.e. 100 % sole grass and legume and 50 to 50 % of legume to each grass. A total of ten (10) treatment combinations were fully filled and properly compacted by exerting pressure on the chopped materials in thirty buckets (mini silos). In addition, dried grains measuring 48g were added to the fills as a fermentable substrate. Thereafter, the silos were covered with black nylon and sands were placed on the top and closed with a steal tape.

Ensiling process of the forage materials

After the silos had been properly filled and covered with air tight material, ensiling commenced on May 23rd, 2021. Thereafter, the silos were kept in a room at normal temperature for another 8 weeks storage period.

Ten (10) treatment combinations are herein presented

Treatment 1*: Panicum maximum* only (100%) wilted for 6 hours (Pmw6)
Treatment 2: *Pennisetum purpurem* only (100 %) wilted for 6 hours (Ppw6).
Treatment 3: *Panicum maximum* + *Centrosema pubescens* (50:50 %) wilted for 6 hours (PmCpw6)
Treatment 4: *Pennisetum purpurem* + *Centrosema pubescens* (50:50 %) wilted for 6 hours (PpCpw6).
Treatment 5: *Centrosema pubescens* only (100 %) wilted for 6 hours (Cpw6).
Treatment 6*: Panicum maximum* only (100 %) wilted for 12 hours (Pmw12)
Treatment 7: *Pennisetum purpurem* only (100 %) wilted for 12 hours (Ppw12).
Treatment 8: *Panicum maximum* + *Centrosema pubescens* (50:50 %) wilted for 12 hours (PmCpw12)
Treatment 9: *Pennisetum purpurem* + *Centrosema pubescens* (50:50 %) wilted for 12 hours (PpCpw12)
Treatment 10: *Centrosema pubescens* only (100 %) wilted for 12 hours (Cpw12).

Determination of mineral contents of the silage

Twelve weeks after ensiling period, the silos were carefully opened and samples were collected. The sub-samples were taken and oven dried at a temperature of 60°C. On the 2nd day, the dried silage samples were crushed with blender to fine particles. The dried samples were well packed inside envelope and sealed for laboratory analysis. Calcium, Sodium, Phosphorus,

Magnesium, Copper and Iron were determined using Atomic Absorption Spectro-photometry (AAS) according to the procedure described by Fritz and Schenk (1979). Determination of Potassium was done using flame photometer after wet digestion in Nitric and per chloric acid.

Data collection and Statistical analysis

All data collected were subjected to Analysis of variance (ANOVA) using the general model as stated by Steel and Torrie, (1980). Significant differences between means were separated using the Duncan Multiple Range test (Duncan, 1955).

Experimental model

The statistical model of the experiment is herein expressed:

$Y_{ijk} = \mu + F_i + W_j + (F.W)_{ij} + e_{ijk}$

Where; Y_{ijk} = Single observation

μ = population mean

F_i = main effect of forage composition

W_j = main effect of wilting period

$(F.W)_{ij}$ = Interaction between forage composition and wilting period

e_{ijk} = Residual error

Results and Discussion

The main effect of wilting period and forage composition on some macro mineral contents of silage are presented in Table 1. The wilting period and forage composition significantly ($P<0.05$) affected the mean values of macro mineral contents of the silage. The ensiled materials wilted for 12 hours recorded higher values in all the parameters determined. In the case of forage composition, Pennisetum*Centro silage mixture had the highest ($P<0.05$) mean values for all the macro mineral contents except Magnesium, where Sole Centro was higher than others, but statistically similar ($P>0.05$) to that of Pennisetum*Centro silage mixture.

In Table 2, the interaction effect of wilting period and forage composition of the silage revealed that Pennisetum*Centro silage mixture which was wilted for 12 hours had the highest ($P<0.05$) values for Calcium, Phosphorus, Potassium, Magnesium and Sodium. Meanwhile, sole Panicum silage wilted for 6 hours recorded the lowest ($P<0.05$) mean values (0.237, 0.353, 0.249 %) for Calcium, Phosphorus and Magnesium, respectively. Panicum*Centro silage mixture wilted for 12 hours respectively had the least ($P<0.05$) concentration (0.716 and 0.228 %) for Potassium and Sodium.

The ability of forage to provide ruminants with sufficient supply of minerals is dependent on their mineral content and bioavailability (Spears and Fahey, 1994). Thus, adoption of any conservation principle that would improve the initial mineral contents of fresh forage material is very essential to livestock production. The macro mineral contents of the silage were greatly favoured with the extension of wilting period. This possibly suggests that mineral content of the silage might be increased due to gradual loss of moisture occasioned by prolonged wilting period. This could be attributed to increase in dry matter content as the wilting progresses. This agrees with the reports by Mustapha *et al*. (2015) and Imoro *et al*. (2012) which stated that Calcium concentration of forage plants generally become higher in the dry season than in wet season due to gradual decline in moisture content of the plant. The observation on influence of forage composition on macro mineral contents of the silage indicates that the poor quality of sole Pennisetum silage was enhanced with the inclusion of *C. pubescens* which is very high in mineral contents (Oyewole *et al.,* 2015). This was evident in the values recorded for

Table 1: Main effects of wilting period and forage composition on Macro mineral contents (%) of silage

Factors	Calcium	Phosphorus	Magnesium	Potassium	Sodium
Wilting period					
6 hours	0.286^{b}	0.397^{b}	0.276^{b}	0.768^{b}	0.247^{b}
12 hours	0.291^{a}	0.419^{a}	0.316^{a}	0.774^{a}	0.259^{a}
SEM	0.0011	0.0015	0.0015	0.0018	0.0008
Forage Composition					
Sole Panicum	0.258^{c}	0.385^{b}	0.264^{d}	0.759^{b}	0.238^{cd}
Sole Pennisetum	0.254^{c}	0.394^{b}	0.278^{c}	0.743^{c}	0.235^{d}
Panicum x Centro	0.256^{c}	0.393^{b}	0.297^{b}	0.734^{c}	0.239^{c}
Pennisetum x Centro	0.323^{a}	0.436^{a}	0.319^{a}	0.814^{a}	0.280^{a}
Sole Centro	0.309^{b}	0.429^{a}	0.323^{a}	0.804^{a}	0.274^{b}
SEM	0.0017	0.0023	0.0023	0.0028	0.0012
P-Values					
Wilting period	<0.001	<0.001	<0.001	0.023	<0.001
Forage Composition	<0.001	<0.001	<0.001	<0.001	<0.001
WP * FC	<0.001	<0.001	<0.001	<0.001	<0.001

a,b,c,d: means in the same column with different superscripts are significantly different (P<0.05), SEM= Standard error of mean, WP: Wilting period, FC: Forage composition

Table 2: Interaction effects of wilting period and forage composition on Macro mineral contents (%) of silage

Treatments		Calcium	Phosphorus	Magnesium	Potassium	Sodium
Wilting period	**Forage Composition**					
6 hours	Sole Panicum	0.237^{g}	0.353^{e}	0.249^{c}	0.739^{de}	0.215^{g}
6 hours	Sole Pennisetum	0.249^{f}	0.369^{d}	0.258^{hi}	0.755^{d}	0.228^{f}
6 hours	Panicum x Centro	0.263^{e}	0.399^{c}	0.272^{gh}	0.752^{d}	0.252^{d}
6 hours	Pennisetum x Centro	0.303^{c}	0.434^{ab}	0.291^{ef}	0.798^{bc}	0.273^{b}
6 hours	Sole Centro	0.289^{d}	0.428^{ab}	0.313^{cd}	0.794^{c}	0.268^{bc}
12 hours	Sole Panicum	0.278^{d}	0.419^{b}	0.278^{fg}	0.780^{c}	0.260^{c}
12 hours	Sole Pennisetum	0.258^{ef}	0.419^{b}	0.299^{de}	0.730^{ef}	0.241^{e}
12 hours	Panicum x Centro	0.248^{fg}	0.387^{c}	0.322^{bc}	0.716^{f}	0.228^{f}
12 hours	Pennisetum x Centro	0.343^{a}	0.439^{a}	0.347^{a}	0.829^{a}	0.289^{a}
12 hours	Sole Centro	0.329^{b}	0.432^{ab}	0.333^{ab}	0.814^{ab}	0.282^{a}
SEM		0.0023	0.0033	0.0033	0.0039	0.0017

a,b,c,d-i: means in the same column with different superscripts are significantly different (P<0.05), SEM= Standard error of mean.

Pennisetum*Centro silage mixture being higher than sole Pennisetum and sole Centro silage. This is in conformity with the report by Oyewole *et al*. (2015) that *C.*

pubescens interplanted with *Andropogon tectorum* had positive effects on the mineral composition of the forage. Similarly, Castillo *et al*. (2003) reported that association of *C. pubescens* with grass was beneficial in terms of mineral contents. The mineral contents available in forage materials either fresh or conserved doesn't necessarily translate to utilization by the animals. However, the variation in the bio availability of mineral contents of forage suggest that its prediction is practically difficult (NUTRIMIN, 2016). Meanwhile, the values observed for both macro and micro mineral contents in this study were greatly higher than the recommended values for cattle at different physiological state (Rasby *et al*., 2011). In contrast, the values recorded were below the recommended for ruminant nutrition by that of NUTRIMIN, 2016. This implies that for efficient utilization of the best silage produced in this study, there is great need for supplementation with salt lick to meet the animal requirements for optimum animal performance.

The main effect of wilting period and forage composition on some micro mineral contents of silage is as expressed in Table 3. Similar trend to that of Table 1 was observed for iron, zinc, manganese and copper except chromium that was not significantly (P>0.05) affected by wilting period.

Table 4 presents the interaction effects of wilting period and forage composition on some micro mineral contents of silage. It was observed that all the mean values were significantly (P<0.05) influenced by interaction of wilting period and forage composition. A similitude of the trend noticed in the effects of interaction on macro mineral contents were observed in the contents of the minerals across the variables.

Table 3: Main effects of wilting period and forage composition on Micro mineral contents (mg/kg) of silage

Factors	Iron	Zinc	Manganese	Copper	Chrominum
Wilting period					
6 hours	161.95^{b}	65.61^{b}	34.97^{b}	15.22^{b}	0.66
12 hours	168.63^{a}	67.82^{a}	36.82^{a}	16.81^{a}	0.67
SEM	0.597	0.551	0.121	0.249	0.007
Forage Composition					
Sole Panicum	155.41^{b}	60.02^{b}	33.69^{c}	14.55^{c}	0.60^{c}
Sole Pennisetum	156.18^{b}	59.05^{b}	34.46^{c}	15.50^{bc}	0.59^{c}
Panicum x Centro	157.10^{b}	57.42^{b}	35.89^{b}	15.65^{bc}	0.57^{c}
Pennisetum x Centro	180.67^{a}	80.09^{a}	37.89^{a}	16.79^{ab}	0.82^{a}
Sole Centro	177.11^{a}	76.99^{a}	37.54^{a}	17.58^{a}	0.76^{b}
SEM	0.943	0.872	0.192	0.394	0.011
P-Values					
Wilting period	<0.001	0.010	<0.001	<0.001	0.782
Forage Composition	<0.001	<0.001	<0.001	<0.001	<0.001
WP * FC	<0.001	<0.001	<0.001	<0.001	<0.001

a,b,c: means in the same column with different superscripts are significantly different (P<0.05), SEM= Standard error of mean, WP: Wilting period, FC: Forage composition

Table 4: Interaction effects of wilting period and forage composition on Micro mineral contents (mm/kg) of silage

Treatments		Iron	Zinc	Manganese	Copper	Chrominum
Wilting period	**Forage Composition**					
6 hours	Sole Panicum	146.10^{h}	54.45^{e}	30.72^{f}	12.50^{d}	0.56^{f}
6 hours	Sole Pennisetum	154.17^{fg}	60.33^{de}	32.91^{e}	14.95^{cd}	0.62^{de}
6 hours	Panicum x Centro	165.82^{cd}	66.66^{c}	37.21^{bc}	16.75^{abc}	0.67^{cd}
6 hours	Pennisetum x Centro	171.28^{cd}	73.52^{b}	36.99^{bc}	14.70^{cd}	0.76^{b}
6 hours	Sole Centro	172.41^{c}	73.10^{b}	37.03^{bc}	17.20^{abc}	0.73^{bc}
12 hours	Sole Panicum	164.72^{de}	65.59^{cd}	37.65^{c}	16.60^{abc}	0.65^{d}
12 hours	Sole Pennisetum	158.19^{ef}	57.78^{e}	36.02^{c}	16.05^{bc}	0.57^{e}
12 hours	Panicum x Centro	148.39^{gh}	48.19^{f}	34.58^{d}	14.55^{cd}	0.47^{f}
12 hours	Pennisetum x Centro	190.05^{a}	86.67^{a}	38.79^{a}	18.88^{a}	0.87^{a}
12 hours	Sole Centro	181.81^{b}	80.89^{a}	38.05^{ab}	17.95^{ab}	0.79^{b}
SEM		1.330	1.230	0.271	0.557	0.015

Conclusion

Having considered the results of this study, the following conclusions were made:
Wilting period of ensiled forage material at 12 hours improved the mineral contents of the silage produced while Incorporation of Centro into sole Pennisetum silage enhanced its mineral contents.

Recommendation

For high quality silage with better mineral contents, Pennisetum*Centro silage mixture wilted for 12 hours is therefore recommended, because inclusion of legume in sole grass silage has improved the mineral contents of silage mixtures.

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