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Short Communication

Neglected grass species of Southern Africa: Nutritive value of conserved *Hyperthelia dissoluta* harvested at different growth stages

Gramíneas descuidadas del sur de África: Valor nutritivo del forraje conservado de Hyperthelia dissoluta *cosechado en diferentes estados de crecimiento*

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Abstract

Native species like *Hyperthelia dissoluta* have great potential in livestock production but not much has been done to improve their contribution to that sector. This study examined 2 conservation methods (drying and ensiling) and 3 different growth stages, namely: elongation stage (January), early flowering (February) and late flowering stage (March) of *H. dissoluta* in terms of nutritional composition and digestibility. The method of conservation had a significant effect (P<0.05) on nutritive value, with silage having more P and CP than hay. Stage of growth had an effect (P<0.05) on all nutritional properties of both hay and silage: Phosphorus, Ca and CP concentrations and digestibility of hay and silage decreased with maturity, while NDF and ADF concentrations increased. Silage pH value was significantly higher at elongation (5.2) and late flowering growth stages (5.7) than at early flowering (4.4). Dry matter digestibility of the conserved material reached levels as high as 82% for silage made at the elongation stage with all values at least 60%. We conclude that *H. dissoluta* can be conserved as both silage and hay to produce a good quality feed. Harvesting at the early flowering stage would seem to provide a good compromise between quantity (not measured in this study) and quality of harvested forage. Further studies seem warranted to determine the acceptability and intake of the material by livestock, the advantages of adding fermentable carbohydrates during ensiling and DM yields in different areas and a range of seasonal conditions.

Keywords: Air drying, hay, perennial native grasses, plastic bag silo, quality silage.

Resumen

Especies nativas como *Hyperthelia dissoluta* tienen un gran potencial para la producción pecuaria, pero se ha trabajado poco para mejorar su contribución. En el presente estudio, conducido en Simbabwe, se evaluó el efecto de 2 métodos de conservación (henificación y ensilado) y 3 etapas de crecimiento: elongación (enero), floración inicial (febrero) y floración final (marzo), en la composición nutricional y la digestibilidad de *H. dissoluta*. El método de conservación tuvo un efecto (P<0.05) en el valor nutritivo, resultando en el ensilaje concentraciones de fósforo (P) y proteína cruda (PC) más altas que en el heno (0.63–1.69 y 4.5–8.2%, respectivamente, vs. 0.16–0.66 y 2.3–6.5%). La etapa de

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crecimiento tuvo un efecto (P<0.05) en todos los componentes nutritivos tanto del heno como del ensilaje: las concentraciones de P, calcio y PC y la digestibilidad disminuyeron con la madurez, mientras que las concentraciones de fibra (FDA y FDN) incrementaron. El pH del ensilaje fue significativamente más alto en la etapa de elongación y al final de la floración (5.2 y 5.7, respectivamente) que en la etapa inicial de la floración (4.4). La digestibilidad de la materia seca (MS) del forraje conservado presentó niveles elevados (60% y más), alcanzando 82% para ensilaje en la etapa de elongación. Concluimos que es posible producir de *H. dissoluta* tanto un heno como un ensilaje de buena calidad. Cosechando el pasto en la etapa de floración inicial parece ser un buen compromiso entre la cantidad del forraje (no determinada en este estudio) y su calidad. Se sugieren estudios para evaluar la aceptabilidad y el consumo del forraje conservado por el ganado, estudiar posibles ventajas de la adición de carbohidratos fermentables durante el ensilado y determinar los rendimientos de MS en diferentes áreas y condiciones estacionales.

Palabras clave: Calidad, ensilaje, gramíneas perennes nativas, heno, secado, silo de bolsas plásticas.

Introduction

Feed shortage, both in quantity and quality, is the principal constraint to livestock production in subtropical Africa (Smith 2002; Gusha et al. 2014). Here, almost every smallholder farmer faces this challenge during the annual dry period of 7–9 months (Mapiye et al. 2006; Ngongoni et al. 2006). The quality of forage generally declines as plants mature and become more fibrous and crude protein levels fall to as low as 2% dry matter (Smith 2002), resulting in accumulation of poor quality biomass, which is lowly digestible and low in nutrients (Ball et al. 2001). The biomass is either consumed by veld fire during the dry season or breaks down during the following rainy season. This results in low productivity, long calving intervals and high livestock mortality (Lukuyu et al. 2011). However, we consider that there are some native grass species, which have been neglected in terms of looking for solutions to these problems but which, because of their adaptation to local climatic conditions, may have the potential to modify the perennial feed deficit problems.

Hyperthelia dissoluta (Figure 1), also known as yellow thatching grass or yellow tambookie grass, is a perennial grass that can reach heights of 1–3 m (Burkill 1985) and can produce average yields of 26 t DM/ha (Skerman and Riveros 1990; Heuzé et al. 2012). It prefers sandy soils and is usually found in disturbed areas, savannas, field margins, fixed dunes, velds, roadsides and deciduous bushland (Heuzé et al. 2012). It is tolerant of fire and in trials in Zambia over 3 years, fire actually increased the population of *H. dissoluta* (Kativu 2011). It requires annual rainfall in excess of 425 mm and grows well from low lying areas to above 3,000 masl (Skerman and Riveros 1990; Heuzé et al. 2012). It is dispersed throughout tropical Africa, Southern Africa and Madagascar, and has spread to tropical America (Burkill 1985). Despite its positive attributes, *H. dissoluta* has been neglected and not fully utilized.

In order to improve livestock productivity we consider the use of native high-producing veld grasses is imperative. Harvesting should be done when pastures are at a vegetative stage and still nutritious and forage is conserved as hay or silage for use during times of deficit. Traditionally, exotic fodder species and cereals have been planted to produce hay and silage; some are in direct competition with humans for land to produce foodstuffs for human consumption (Gusha et al. 2014).

We decided to evaluate the potential of adapted native grass species, using *Hyperthelia dissoluta* as an example, as conserved forage for dry season feeding. The study aimed to identify the most suitable harvesting and conservation strategies to produce high quality herbage for livestock feeding.

Figure 1. Mature *Hyperthelia dissoluta*.

Materials and Methods

Study site

The study was conducted at Henderson Research Institute, 30 km north of Harare (17°35' S, 30°58' E; 1,300 masl). The area receives an average rainfall of 870 mm annually (www.drss.com), which falls mainly between November and late March. The vegetation consisted mainly of tree savanna or bush clump savanna with tall perennial grasses such as *Hyperthelia dissoluta* and *Hyparrhenia filipendula* on red clay soils. However, during the year of study, rainfall pattern and amount were below average (555 mm total, mostly late in the season; Table 1) and crop failures were experienced, so biomass produced was probably well below normal and is not considered in this study.

Silage and hay preparation

The experimental design was a 2 x 3 factorial. There were 2 methods of conservation of the grass (either ensiled or dried as hay) and 3 growth stages [elongation stage in January (early growth stage), early flowering stage in February (middle growth stage) and late reproductive stage in March (late growth stage)]. At each stage of harvest 60 kg per site of *H. dissoluta* was harvested by cutting with a sickle at 5 cm above the ground from 3 different sites within the farm. The harvested *H. dissoluta* forage was transported to the bio-assay laboratory at the University of Zimbabwe and chopped into approximately 3 cm pieces manually using machetes. Ten kilogram samples of the chopped herbage were placed in polythene bags with a thickness of 150 microns. The contents of the bags were compacted and the bags compressed to remove air, tied to prevent the entry of air and inserted into another polythene bag. Three samples were prepared at each site and each stage of growth. The bags were left to ferment for 3 weeks at room temperature of about 25 ºC. The other 30 kg herbage at each site was divided into three 10 kg heaps, which were spread and dried under shade for 7 days, when the dried material was stored in hessian bags at room temperature. A total of 9 bags of silage and 9 heaps of hay were made at each harvesting stage and were used as replicates in the study.

Nutrient chemical composition analysis

Representative samples were collected from each treatment bag at day 22 from the day of making and were oven-dried for 48 h at 60 ºC. The samples were then ground through a 1 mm sieve and analyzed for nitrogen (N), dry matter (DM), acid detergent insoluble nitrogen (ADIN) and ash according to AOAC (2000). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined using the method of Goering and Van Soest (1970). Phosphorus (P) and calcium (Ca) concentrations were determined by the spectrophotometer method (Danovaro 2009) and the EDTA method (Kaur 2007), respectively. Digestibility was determined according to Tilley and Terry (1963) and silage pH using a digital pH meter.

Table 1. Rainfall received during the period of study (2014/2015 season) and medium-term (2005–2015) rainfall at the study site.

Month	Rainfall (mm) during study period (2014/2015 season)	Rainfall (mm) during 2005–2015
October	0	87
November	0	168
December	138	187
January	108	109
February	109	88
March	88	170
April	112	67
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
Total	555	876

Statistical analysis

Analysis of variance was carried out using the Proc GLM procedure (SAS 2010). The following model was fitted:

$$y_{ij} = \mu + \alpha_j + \beta_k + (\alpha\beta_{jk}) + \varepsilon_{ij}$$

where:

y_{ij} = digestibility and nutritive content;
μ = the overall mean common to all observations;
α_j = effect of growth stage;
β_k = effect of conservation method;
($\alpha\beta_{jk}$) = effect of the interaction of factors A and B; and
ε_{ij} = the residual error.

Results

Silage and hay harvested during the elongation stage of growth had the highest CP concentrations of 8.2 and 6.5% (DM basis), respectively (Table 1). Crude protein

Table 2. Nutrient composition (% DM) for hay and silage of *Hyperthelia dissoluta* conserved at 3 different harvest stages (early, middle and late, in summer 2014/2015).

Parameter	Conservation method						s.e.
	Hay			Silage			
	Early	Middle	Late	Early	Middle	Late	
DM	90.1a	90.2a	91.4a	25.9d	33.7c	38.0b	0.59
Ash	9.3a	6.4d	6.0d	8.4b	7.6c	6.2d	0.26
P	0.66b	0.19c	0.16c	1.69a	0.63b	0.64b	0.096
Ca	0.02b	0.02b	0.01c	0.03a	0.02b	0.01c	0.003
NDF	64.3e	68.5d	79.6a	54.9f	72.5c	75.9b	1.41
ADF	41.7d	49.5b	54.6a	42.2d	49.0bc	47.8c	0.71
ADIN	0.26a	0.26a	0.31a	0.18a	0.30a	0.28a	0.022
CP	6.5c	5.1d	2.3f	8.2a	7.6b	4.5e	0.19
Dig	73.1b	73.0b	59.5d	81.9a	75.3b	64.4c	2.59

Early = elongation stage; middle = early reproductive stage; late = late reproductive stage; DM = dry matter; P = phosphorus; Ca = calcium; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADIN = acid detergent insoluble nitrogen; CP = crude protein; and Dig = DM digestibility coefficient. Means within rows followed by different letters differ ($P<0.05$).

concentrations declined progressively with later harvesting to 4.5% for silage and 2.3% for hay at the late reproductive stage. Silage pH values (not reported in Table 2) were 5.2 at the elongation stage, 4.4 at the early reproductive stage and 5.9 at the late reproductive stage. Corresponding DM concentrations of the silages were 25.9, 33.7 and 38.0%, respectively. Phosphorus concentration in conserved forage declined significantly with age and at all stages was higher for silage than for hay (Table 1). Apparent digestibility of dry matter declined significantly as harvesting stage was delayed for both methods of conservation and was generally higher for silage than for hay.

Discussion

Though yield measurements were not taken because of unusual rainfall conditions and the native pastures, where *H. dissoluta* was sampled, presented a high variability of species mixtures, it was evident that biomass on offer increased, as could be expected, from the elongation growth stage to the early reproductive stage by an estimated 100% and from there to the late reproductive stage by an estimated 20%.

This study has produced some interesting information on the quality of hay and silage made from *H. dissoluta* at different stages of growth. The most striking finding was the high apparent in vitro DM digestibility of the conserved material. The highest digestibility coefficient obtained was 81.9% for silage made at the elongation stage of growth, while the lowest was 59.5% for hay made at late flowering. These values were much higher than the value of 56.5% reported by Heuzé et al. (2012). They are outstanding for a tropical grass and strongly suggest that this particular species warrants further study as a potential source of forage for livestock.

As would be expected, quality, in terms of CP and fiber concentrations and DM digestibility coefficients of the conserved material, declined as harvesting was delayed from the elongation stage to the late flowering stage. Moore et al. (1991) reported that at late maturity forages become lignified with reduced digestibility.

Neutral detergent fiber (NDF) represents the cell wall portion of a feed, comprising ADF and hemicellulose and affects feed intake, with intake declining as NDF concentration in feed increases (Bosworth and Hudson 2005). The desirable level of NDF in feedstuffs is <55% (Mertens 2009). In our study all treatments had values above this, which should depress intake. It would be expected, however, that intake of forage with DM digestibility in the range 60–82% would be quite acceptable, suggesting that feeding studies with animals to test acceptability of the material, possible intake levels and in vivo digestibility are needed.

Silage is preserved by lowering the pH through lactic acid formation. For grass silages the recommended pH for a well preserved silage is between 4.2 and 4.7 (Pyatt and Berger 2000; Bosworth 2005). The pH values for elongation and late flowering growth stages were above these recommended levels for grass silage. This could be related to low soluble sugars during the elongation stage of growth (Abia et al. 2006) combined with high moisture levels in the fast-growing crop, while low moisture levels at late flowering could have prevented adequate compaction to remove air effectively (Ball et al. 2001). Wilting of material with high moisture levels prior to ensiling can improve the quality of the resulting silage. The benefits from adding a source of readily available carbohydrate, e.g. molasses or maize meal, should be investigated. Pyatt and Berger (2000) reported that forages with a DM above 35% at ensiling, like the material ensiled at late flowering, have less efficient fermentation because they are difficult to compact.

While the decline in CP and P concentrations in conserved material with delay in harvesting time were to be expected, the consistently higher CP and P concentrations in silage compared with hay were surprising. MacDonald and Clark (1987) reported results from 8 separate studies, showing there is an average of 34% CP loss during the drying process. Thus in our study the lower CP levels in hay could be associated with leaf loss and weathering damage during drying.

Method of conservation had no significant effect at P<0.05 on the Ca levels but growth stage at ensiling had a significant effect in silage with a trend of increasing Ca concentration with maturity (Urrutia et al. 2011). The Ca concentration in both hay and silage was below the minimum requirement for all classes of livestock (Fox et al. 1988) and if hay made from *H. dissoluta* is to be fed as a complete ration, a Ca supplement like limestone flour should be fed (Fox et al. 1988). Silage contained adequate levels of P for livestock feeding but hay made at early or late flowering had insufficient levels of P, especially for lactating females (Coates and Ternouth 1992), and supplements may be necessary if this material constitutes a major part of the diet.

The CP concentrations in hay were generally lower than the levels found in previous studies of 6.4% in late summer (Heuzé et al. 2012). If these conserved fodders were to be fed as a major part of the ration for livestock, especially lactating females, a protein supplement would need to be added to the ration. Acid detergent insoluble nitrogen (ADIN) is an indicator of the quantity of N that is indigestible in the rumen and intestines, and reflects the quantity of heat-damaged silage or hay (Dilley et al. 2013). In this study ADIN concentration was similar for both methods of conservation and stages of harvest and the quantity of ADIN was less than 12% of the total N in the forages, indicating that little heat damage took place (Seglar 2003).

Conclusion

We conclude that *H. dissoluta* has potential to produce good quality forage, which could be conserved as silage or hay for dry season feeding of livestock. Timing of harvest would depend on whether quantity or quality of conserved material was more important. Whether hay or silage was made would depend to some extent on weather conditions during the optimal time of harvesting and the ability to reliably dry hay. More research is needed to determine if quality of *H. dissoluta* silage can be improved by incorporating additives containing fermentable carbohydrates, e.g. molasses or maize meal, at ensiling. Further studies seem warranted to confirm that the high in vitro digestibility levels recorded in this study can be repeated with animals and to determine acceptability and intake with and without N and P supplements. Dry matter yields of this forage during a range of seasons and on a range of soil types would provide evidence whether satisfactory DM yields can be obtained in a range of situations.

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