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YIELD AND NUTRITIVE QUALITY OF FOUR NAPIER (Pennisetum purpureum Schumach.) CULTIVARS HARVESTED AT DIFFERENT AGES AS FRESH AND ENSILED FODDER

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By

MOHAMAD ZAIHAN BIN ZAILAN

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May 2016

Chair: Associate Professor Dr. Halimatun Yaakub, PhD

Faculty: Agriculture

Studies were conducted to evaluate the yield and nutritive quality of four Napier (*Pennisetum purpureum*) cultivars namely Common, Silver, Red and Dwarf Napier harvested at 4, 6 and 8 weeks age as fresh and ensiled fodder. Common, Silver and Red Napier were classified as tall cultivars while Dwarf Napier is a short cultivar. The harvesting ages selected were within of the range of optimum cutting age for Napier grass.

Study 1 was conducted to determine the dry matter yield and leaf to stem ratio of fresh Napier cultivars at 4, 6 and 8 weeks old. The dry matter yield of Common Napier reached a peak of 6 tonnes ha^{-1} cut^{-1} at 6-week old. The dry matter yield of Red Napier gradually increased and peaked 6 tonnes ha^{-1} cut^{-1} at 8 weeks old. Silver Napier yielded a similar dry matter production as Dwarf Napier as well as the lowest yield throughout the study. The leaf to stem ratio of Napier cultivars declined significantly from 3.24 at 4 weeks to 1.94 at 6 weeks. Dwarf Napier had the highest leaf to stem ratio (3.93) among the cultivars.

The nutritional composition and digestibility of fresh Napier cultivars at 4, 6 and 8 weeks were evaluated in Study 2. Dwarf Napier had the highest nutritive quality among the cultivars throughout the harvesting ages (12 to 20% CP). Overall, tall cultivars have higher NDF, ADF and ADL content than Dwarf Napier. Interestingly, the crude protein content of Red Napier (11%) remained unchanged throughout the harvesting ages. In terms of digestibility, Dwarf Napier and 6-week old Red Napier were classified as high quality feed (> 70% IVDMD and > 65% IVOMD).

Study 3 was conducted to evaluate and compare the nutritional composition and digestibility of fresh and ensiled cultivars at 6 and 8 weeks harvesting age. The crude protein of Common Napier increased significantly after ensiling process from 8 to 9%. In contrast, a significant loss in crude protein content was observed in ensiled Silver Napier (9% CP) compared to the fresh forage (10% CP). A significant loss in cell wall constituent of Napier grass was observed in ensiled cultivars regardless of the harvesting ages. All cultivars have similar IVDMD, and the IVDMD declined from 68 to 60% after ensilation. Nevertheless the improvement in IVOMD from 52 to 58% in silage might derive from the bacteria population.

In conclusion, Common Napier is recommended to be harvested at 6 weeks age to obtain highest dry matter yield as well as minimizing loss of nutritive value. Red Napier could be harvested at 6 and 8 weeks age since there were no change in crude protein content. Dwarf Napier had superior quality and could be harvested at 6 weeks since the crude protein was able to fulfill the requirement for growing and lactating animals. The dry matter yield of Dwarf Napier could be maximized by harvesting at 8 weeks age. Silver Napier had similar dry matter yield and no advantage in nutritive quality compared to Dwarf Napier. Nevertheless, Silver Napier is suggested to be harvested at 6 weeks since significant loss in nutritive value was observed especially crude protein at 8 weeks.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

HASIL DAN KUALITI NUTRITIF EMPAT NAPIER (*Pennisetum purpureum* Schumach.) KULTIVAR DITUAI PADA UMUR YANG BERBEZA SEBAGAI FODER SEGAR DAN PERAM

Oleh

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Satu kajian telah dijalankan untuk menilai hasil dan kualiti nutritif empat Napier (*Pennisetum purpureum*) kultivar dinamakan sebagai Napier Umum, Perak, Merah, Kerdil yang dituai pada minggu ke-4, 6 dan 8 sebagai foder segar dan silaj. Napier Umum, Perak dan Merah diklasifikasikan sebagai kultivar tinggi manakala rumput Kerdil adalah kultivar rendah. Peringkat penuaian telah dipilih dalam lingkungan umur tuaian optima bagi rumput Napier.

Kajian 1 telah dijalankan untuk menentukan hasil berat kering dan nisbah daun kepada batang bagi Napier kultivar pada minggu tuaian ke-4, 6 dan 8. Hasil berat kering bagi Napier Umum mencecah kemuncak, 6 tan ha^{-1} $potong^{-1}$ pada minggu ke-6. Hasil berat kering Napier Merah meningkat secara berperingkat dan mencanak naik kepada 6 tan ha^{-1} $potong^{-1}$ pada umur minggu ke-8. Napier Perak menghasilkan berat kering yang sama seperti Napier Kerdil sekaligus merupakan hasil yang terendah sepanjang kajian dijalankan. Nisbah daun kepada batang bagi kultivar Napier menurun secara signifikan dari 3.24 pada minggu ke-4 kepada 1.94 pada minggu ke-6. Napier Kerdil mempunyai nisbah daun kepada pada tertinggi (3.93) diantara kultivar.

Komposisi nutrisi dan kecernaan bagi kultivar Napier segar pada minggu ke-4, 6 dan 8 telah dinilai dalam kajian 2. Napier Kerdil mempunyai kualiti nutritif yang tertinggi diantara kultivar sepanjang umur tuaian (12 ke 20% CP). Secara keseluruhan, Napier tinggi menpunyai kandungan NDF, ADF dan ADL yang lebih tinggi berbanding Napier Kerdil. Yang menariknya, protin kasar bagi Napier Merah (11% CP) tidak berubah sepanjang umur tuaian,. Dalam istilah kecernaan, Napier Kerdil dan Napier Merah pada umur 6 minggu diklasifikasikan sebagai makanan kualiti tinggi (> 70% IVDMD and >65% IVOMD).

Kajian 3 dijalankan bagi menilai dan membandingkan komposisi nutrisi dan kecernaan bagi kultivar segar dan peram pada tuaian minggu ke-6 dan 8. Protin kasar bagi Napier Umum meningkat ketara selepas proses pemeraman daripada 8 ke 9%. Sebaliknya, kehilangan signifikan bagi kandungan protin kasar dalam Napier Perak peram (9% CP) berbanding jenis segar (10% CP). Kehilangan ketara bagi kandungan dinding sel dalam rumput Napier diperhatikan dalam kultivar peram tanpa mengira

umur tuaian. Kesemua kultivar mempunyai IVDMD yang sama, dan IVDMD menurun daripada 68% ke 60% selepas diperam. Akan tetapi, peningkatan dalam IVOMD dari 52 ke 58% dalam silaj kemungkinan berasal daripada populasi bakteria.

Sebagai kesimpulan, Napier Umum, disarankan untuk dituai pada umur 6 minggu untuk memiliki hasil berat kering yang tertinggi sekaligus meminimakan kehilangan nilai nutritif. Napier Merah boleh dituai pada umur 6 dan 8 minggu memandangkan tiada perubahan dalan kandungan protin kasar. Napier Kerdil mempunyai kualiti atasan dan boleh dituai pada minggu ke-6 memandangkan protin kasar dapat memenuhi keperluan bagi haiwan yang meningkat dewasa dan haiwan dalam laktasi. Hasil berat kering bagi Napier Kerdil boleh dimaksimakan dengan tuaian pada minggu ke-8. Napier Perak mempunyai hasil berat kering yang sama dan tiada kelebihan dalam kualiti nutritif dibandingkan dengan Napier Kerdil. Namun begitu, Napier Perak disarankan untuk dituai pada minggu ke-6 memandangkan kehilangan signifikan dalam nilai nutritif diperhatikan terutamanya protin kasar pada minggu ke-8.

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I certify that a Thesis Examination Committee has met on 3 May 2016 to conduct the final examination of Mohamad Zaihan Bin Zailan on his thesis entitled "Yield and nutritive quality of four Napier (*Pennisetum purpureum* Schumach.) cultivars harvested at different ages as fresh and ensiled fodder" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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LIST OF ABBREVIATIONS

ADF	Acid detergent fiber
ADL	Acid detergent lignin
ATP	Adenosine triphosphate
AA	Amino acid
ANF	Anti-nutritive factor
CHO	Carbohydrate
CO_2	Carbon dioxide
CT	Condensed tannin
CP	Crude protein
°C	Degree Celsius
DE	Digestible energy
DMY	Dry matter yield
G3P	Glyceryldehyde-3-phosphate
g	Gram
GE	Gross energy
ha	Hectare
HCl	Hydrochloric acid
IVDMD	*In vitro* dry matter digestibility
IVOMD	*In vitro* organic matter digestibility
kg	Kilogram
LAB	Lactic acid bacteria
LSR	Leaves to stem ratio
MJ	Mega joule
ME	Metabolisable energy
CH4	Methane gas
mM	Milli Molarity
ml	Milliliter
mm	Millimeter
NDF	Neutral detergent fiber
N	Nitrogen
OM	Organic matter
OAA	Oxaloacetate

h^{-1}	per hour
%	Percentage
RUBISCO	Ribulose-1,5-biphosphate carboxylase
RUP	Rumen undegradable protein
NaOH	Sodium hydroxide
H_2SO_4	Sulphuric acid
WSC	Water soluble carbohydrate

CHAPTER 1

INTRODUCTION

The ruminant industry in Malaysia is faced with the problem of high cost of production. The scarcity of feed resources has made farmers dependent on imported commercial concentrate feed. Farmers need to find alternative sources of feed to substitute the heavy use of expensive commercial concentrates. Ironically, Malaysia can grow a wide range of forages that could reduce the use of concentrate feed and lower the feed cost.

Feed cost represents major single cost item for livestock production as it accounts for more than 70% of the total cost of production. Farmers are inclined to choose cheap and accessible feed source to maximize their profitability. The considerations of nutritional composition of forages and requirement of the animal itself are crucial in formulating the least cost ration. With this knowledge, the utilization of available sources of feedstuffs such as forages could be optimised. The self-sufficiency of livestock products especially dairy products are extremely low compared to other tropical countries. There should be collaborations among farmers and researchers in searching for suitable adaptive strategies such as pasture-based production to increase the productivity intended for consumption.

Forages are the best feed resources for ruminants as forages do not compete with agricultural production of concentrate feed for human consumption. Forages can be digested and utilised by ruminant as a source of nutrient. There is no doubt that ruminant digestive tract is capable in providing a favourable environment as a host for symbiotic microbes (bacteria, protozoa and fungi) to hydrolyze cellulose, hemicellulose and other substances that are resistant to enzymes secreted by the host animal.

Guinea (*Megathyrsus maximus*) and Napier are the common cultivated grass species in Malaysia. Guinea grass yielded from 9 to 12 tonnes dry matter yield ha^{-1} cut^{-1} with cumulative mean of more than 20 tonnes ha^{-1} yr^{-1} (Ahmed *et al*., 2012; Munyasi *et al*., 2015). Napier is the most popular forage species due to high dry matter production, high nutritive value and it can be easily established through stem propagation. Besides, the Napier grass tends to produce high dry matter yield up to 70 tonnes ha^{-1} yr^{-1} (Wijitphan *et al*., 2009). The broad range in yield and nutritional composition is influenced by the morphology and management of Napier cultivars.

Generally, the determination of limiting factors is prerequisite in evaluating the yield and quality of grasses. The cultivar selection, cutting management (cutting frequency, interval and height) application of fertilizer (rate and type of fertilizer), soil condition, and environmental factors are among the crucial factors (Jusoh *et al*., 2014; Lounglawan, *et al*., 2014). Napier grass was first introduced to Malaysia in the 1920's and there were many cultivars introduced in Malaysia since 1950's known as Common Napier, Red Napier, Taiwan Napier, Dwarf Napier, Dwarf "Mott", Australian Dwarf, Indian Napier, Uganda Napier and King grass (Halim *et al*., 2013; Jusoh, 2005). However, very few comparative studies on Napier cultivars had been done.

The terminology of "cultivar" and "variety" bring a different meaning and these two terms often abused by farmers. According to Haynes (2009), varieties often occur in nature and most varieties are true to type, meanwhile cultivars is a combination of "cultivated" and "variety" which are not necessarily true type and it was selected and cultivated by humans. Nevertheless, it is possible for a plant to have both variety and cultivars. The documentation of Napier cultivars are scanty and cannot be relied upon for choosing the best cultivars. A number of Napier grass cultivars have been in circulation, often with more than one name (Struwig, 2007).

Napier grass grows best in high-rainfall areas up to 1500 mm rainfall yr^{-1} but it does not tolerate flooding (FAO). The estimated area prone to flood disaster is 9% of total area in Malaysia (D/iya *et al*., 2014). In spite of flood, tropical countries are more vulnerable to drought compared to temperate countries and therefore, the conservation of feed is crucial to preserve the quality and supply adequate feed to livestock. Silage was found to be more suitable than hay making process because of high relative humidity, more than 90% which will easily spoil the hay.

Statement of problem

Many cultivars of Napier grass (*Pennisetum purpureum*) have been planted in Malaysia as discussed previously. Common Napier, Red Napier, Taiwan Napier, Indian Napier, Uganda Napier, King grass, Zanzibar Napier and Kobe Napier are classified as tall cultivars whereas Dwarf Napier, Dwarf "Mott", Australian Dwarf are short cultivars. Generally, tall cultivars with a high yielding grass are normally grown in several areas under a cut-and-carry system in Malaysia. Common Napier is among the highest yielding crops and has a better nutritive value as compared to Uganda Napier (Halim *et al*., 2013). Red Napier was high in metabolisable energy and this crucial parameter reflected the actual level of energy available for absorption (Haryani *et al*., 2012). Dwarf Napier has high leaf to stem ratio and this associated with good forage quality. However, Silver Napier was recently introduced without any documentation regarding the performance of this cultivar. There is a need to have comparative evaluation of these Napier cultivars so that definite recommendations can be made in the choice and management of the respective cultivars. Four cultivars (Common, Red, Dwarf and Silver Napier) were selected for this study.

Objectives

The general aim of the proposed project is to investigate the yield and nutritive value of four Napier (*Pennisetum purpureum*) cultivars harvested at different ages as fresh and ensiled fodder.

The specific objectives of the projects are as below:

1) To determine the dry matter yield and proportion of leaves to stem fraction of different Napier cultivars harvested at 4, 6 and 8 weeks age
2) To evaluate the nutritional composition and digestibility of different Napier cultivars harvested at 4, 6 and 8 weeks age.
3) To evaluate and compare the nutritional composition and digestibility of fresh and ensiled Napier cultivars harvested at 6 and 8 weeks age

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