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Chemical composition and dry matter yield of four Napier grass cultivars influenced by harvesting ages

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Napier grass (*Pennisetum purpureum*) is the most popular fodder which is mainly used in the ruminant sector due to high yield capability and good nutritive value. The chemical composition of common Napier grass is highly influenced by the harvesting ages, which is decreased as age increased. Therefore, the main objective of this study is to investigate the effect of three different harvesting ages (45 days, 60 days, and 75 days) on the chemical composition and dry matter yield of Napier grass cultivars. This study was conducted at Pasir Akar Farm in Besut Terengganu. The chemical and mineral compositions of the Napier grass were analyzed using the proximate analysis and dry ashing method using Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES). The results of this study show that there were significantly decreased ($p < 0.05$) in the contents of chemical compositions in four Napier grass cultivars from 45 days to 75 days, which are 92.99 % to 81.63 % of moisture, 23.84 % to 14.09% of protein and 11.18 % to 7.02 % of ash, respectively. In terms of mineral compositions, the potassium, phosphorus, iron, and zinc also were signed decreased ($p < 0.05$) along the maturity (45 days to 75 days). The dry matter yield was significantly higher ($p < 0.05$) at 75 days (13.93 %) compared to 45 days (0.95 %). In conclusion, the different ages have a significant effect on the chemical compositions of different Napier grass cultivars and 45 days show the highest chemical composition contents.

Keywords: Napier grass, cultivars, proximate analysis, mineral composition, ruminant diet.

INTRODUCTION

The growing demand for meat consumption in South East Asia offered farmers within the region great opportunities to improve their system of livestock production (Wangchuk et al. 2015). However, the shortages of good quality of forage during the dry season have been frequently reported which limit the animal performance. Forages are known as the part of plants which offered to the livestock as a feed. It includes grass and legume play a major role in providing energy, protein, and minerals to the livestock (Jank et al. 2011 & Ogedegbe et al. 2012, Kamaruddin et al. 2020)

Napier grass, scientifically known as *Pennisetum purpureum* is an important forage which grows in the tropical and subtropical areas. Napier grass was introduced in Malaysia during 1920s and widely used in dairy and feedlot production systems (Kebede et al. 2016) contains high biomass production and high nutritive value (Azevedo et al. 2012 & Lounglawan et al. 2014, Kamaruddin et al. 2019, Kamaruddin et al. 2020). Napier grass has drawn attention as a bio-energy crop recently because of its high production of biomass (Haegele et al. 2017). The high production of biomass also important for livestock industry as it can reduce the cost of using the

pricy concentrated feed.

Only a few studies have been investigating the effect of harvesting ages on the chemical composition and dry matter yield. Wangchuk et al. reported that Napier grass with the ages of 30 days contain the highest percentage of protein, ether extract, and ash while the percentage of dry matter and crude fiber were highest value at days 60. Therefore, the main objectives of this study were to investigate the effect of different harvesting ages (45 days, 60 days, and 75 days) on the chemical composition and dry matter yield of selected Napier grass cultivars such as Red Napier, Zanzibar Napier, India Napier, and Uganda Napier

MATERIALS AND METHODS

Study site

This study was conducted at Universiti Sultan Zainal Abidin Farm in Pasir Akar, Besut, Terengganu (5°38'32.05"N, 102°28'25.57"E).

Figure 1: Location of study site. (Source: Google Earth).

The analysis of chemical composition of Napier grasses was conducted in Biochemistry Laboratory and Nutrition Laboratory, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus, Terengganu, Malaysia.

Experimental design

Four Napier grass cultivars known as (Red Napier, Zanzibar Napier, India Napier, and Uganda Napier) were selected and planted at three different harvesting ages which are 45 days, 60 days, and 75 days. The experiment was established with 3×5 factorial design in a Completely Randomized Design (CRD). The plot size was 0.4 m^2 x 0.4 m^2 (14.86 m^2) and a total of 12 plots.

Land preparation

The plots were ploughed with a tractor. There are 12 plots and each plot measuring 14.86 m^2. The spacing between plant in each row and between plots were 0.1 m^2 and 0.2 m^2, respectively. The parent plant stem with three nodes per cutting were planted 15 cm to 20 cm deep. The weed control was carried out in 40 days.

Plant sampling

The Napier grass cultivars were collected randomly and cut up to 5 cm from the ground using sickle knife (Wangchuk et al. 2015). Then, the samples were chopped using chopped into smaller pieces.

Plant sample preparation

The fresh samples of Napier grass were dried in the oven at a temperature of 105 ˚C for 24 hours (AOAC, 1990). Then, the dried samples were ground using a HGBTWTS3 model of glass blender to produce a homogenous powdered sample. The ground samples were stored in a labelled ziplock plastic bag and it was placed in a cool and dry conditions in a chiller.

Proximate composition analysis

Proximate analysis was used to determine qualitative and quantitative measurement content of moisture (dry matter), total solids, protein, ether extract, crude fibre, total ash, phosphorus and Nitrogen-Free Extract (NFE) according to AOAC (2005). All the samples were analyzed in the triplicate. Details procedures of each parameter were explained below.

Dry matter

The fresh samples were used in this analysis. The crucibles were dried with cover for four hours in an oven at a temperature of 105 ºC. The crucibles were cool until reaching the room temperature. Five grams of the fresh samples were weighed then it was placed into the crucibles. The samples were placed uncovered in oven at temperature of 105 ºC for the next six hours. The samples were removed and were cooled in desiccator. The crucibles were weighed after it reaches room temperature. Below is the formulation for dry matter:

$$\% \, Moisture = \frac{W_2}{W_2} - \frac{W_3}{W_3} \times 100 \quad \textbf{Eqn. 1}$$

Where,

W_1 = Weight of crucible (g)
W_2 = Weight of crucible + weight of wet sample (g)
W_3 = Weight of crucible + weight of dry sample (g)

% Dry matter = 100 - % Moisture

Ash analysis

Ash is an inorganic residue remaining after water and organic matter has burnt away. Firstly, the crucibles were dried with the covers in an oven at a temperature of 105 ºC for four hours. The crucibles were cooled in a desiccator and weighed it after reaching the room temperature. The samples were weighed and placed into the crucible. The samples were dried in an oven for one day if samples were contained high moisture. The samples were placed in a muffle furnace and the temperature was set to 550 ºC for overnight. The samples were removed and cooled in a desiccator, then it was weighed after it reached room temperature. The percentage of ash was calculated by using a formula:

$$\% \, Ash = \frac{(W_3 - W_1)}{W_2} \times 100 \quad \textbf{Eqn. 2}$$

Where,

W_1 = Weight of crucible (g)
W_2 = Weight of the sample (g)
W_3 = Weight of crucible + ash (g)

Crude protein

The crude protein was determined using Kjeldahl method. In this method, three parts which are digestion steps, distillation steps and titration steps were involved.

In digestion step of Kjeldahl method, sulfuric acid digests the proteins and other organic components in the presence of catalysts with organic nitrogen was converted to the ammonium sulphate. One g of sample was inserted into a digestion tube followed by addition of catalyst Kjeltabs Cu 3.5. After that, concentrated H_2SO_4 was added into the digestion tube and it has been shaken gently to ensure the sample mix with the acid. The rack loaded with exhaust system AV into a digestion block and then was attached it to the digestion tubes in the rack. The temperature was set at 420 ˚C. Samples were digested for around 60 - 90 minutes until it turned into clear with a green / blue solution.

In distillation step of Kjeldahl method, the digested samples in the digestion tube were placed in the distillation unit. Before that, 25 ml of receiver solution consist of 25 ml of 2 % boric acid with 10 drops of indicator solution has been filled into a conical flask hence been placed to the distillation unit. Then, 70 ml distilled water and 50 ml of 32 % of NaOH was added into the digestion tube automatically. This process took around 4 minutes. The receiver solution in the distillate flask was changed into green color due to the presence of alkali (ammonia).

In titration step of Kjeldahl method, the distilled sample was titrated with standards hydrochloric acid 0.1 N. This process last until it was changed to pink/red. The volume of HCI used was recorded. Calculation of % protein in the sample using below formula:

$$\% \, Nitrogen = \frac{A \times (T-B) X \; 14.007 \times 100}{Weight \; of \; sample \; (g) \times 100} \quad \textbf{Eqn. 3}$$

$$\% \, Crude \; protein = \% \, N \; x \; F$$

Where,

T = Volume acid for sample
B = Volume acid for blank
A = Normality of HCL
F = Protein factor, 6.25

Ether extract

To determine the ether extract, one g of sample was weighed into filter paper (W1). The filter paper then has been inserted into the extraction thimble. Next, 150 ml of petroleum ether was measured using volumetric cylinder. After that, the extraction thimble was inserted into the thimble holder and have been put into the extraction cup. Then, the extracted cup containing with sample and 150 ml of petroleum ether was placed into the Automated Soxhlet Fat Extractor system. The extraction process took about 2 hours. After the extraction finished, the extracted cups containing petroleum were transferred into oven at 105 ºC for 2 hours. Then, extraction cups were transferred into a desiccator for the purpose of the cooling process. Lastly, the extracted cups were weighed using analytical weighing scale (W3).

The percentage of fat was calculated by using the below formula:

$$\% Fat = \frac{(w_3 - w_2)}{w_1} \times 100 \quad \textbf{Eqn. 4}$$

Where,

W1 = Weight of sample (g)
W2 = Weight of extraction cup (g)
W3 = Weight of extraction cup + fat (g)

Crude fibre

Crude fiber is commonly having, such as lignin, chitin, pentosan and cellulose. One g sample was inserted into fiber bag (W2) and was weighed using analytical weighing scale. The empty fiber bag (W1) and crucible also weighed (W6). After that, glass spacer was inserted into the fiber bag and then inserted into the bag and placed in the carousel. Next, the carousel was placed into the glass container which on the previewed position of the hotplate before the machine will run. After analysis has been completed, the fiber bags were removed from the carousel and it was placed into the crucible. The bags and crucible were dried for 4 hours at 105 ^{o} C. After that, it was cool in desiccator for 30 minutes. Then, the crucible and dried fiber bag was weighed using analytical weighing scale (W3). The crucible that contains with fiber bag placed in a furnace at temperature at 550 ^{o} C and burn for 4 hours. Next, the crucible was removed and cooled in desiccator again (W4). After crucible and ash of the empty fiber bag were cooled in a desiccator, it weighed to get the value of ash remained in the crucible (W7). Blank value (W5) could be got if the value of (W7) minus (W6).

The percentage of crude fiber was calculated using the below equation:

$$\% Crude\ Fiber = \frac{[(w_2 - w_1) - (w_4 - w_5)]}{w_2} \times 100 \quad \textbf{Eqn. 5}$$

Blank value (W_5) =$W_7 - W_6$

Where,

W_1= Weight of fibre bag (g)
W_2=Weight of sample (g)
W_3= Weight of crucible (g) + fibre bag after digestion (g)
W_4= Weight of crucible and ash (g)
W_5= Weight of blank value empty fibre bag (g)
W_6= Weight of crucible (g)
W_7= Weight of crucible + ash of empty fibre bag (g)

Nitrogen-free extract (NFE)

NFE supposedly represent soluble carbohydrate of feed such as starch and sugar. This fraction may also contain solubilized hemicellulose and lignin. Calculation of NFE was determined by using the formula:

$$Percentage\ of\ NFE = 100 - (\%\ EE + \%\ CP + \%\ ash + \%\ CF) \quad \textbf{Eqn. 6}$$

Mineral analysis

The mineral composition of phosphorus, potassium, calcium, zinc, iron, copper, and manganese were determined using the Inductively Couple Plasma Optical Emission Spectrometry (ICP-OES).

Biomass yield

Two kg of fresh samples from four cultivars of collecting Napier grass in the study area was weighted accordingly. Then, the samples were dried at room temperature until the weight were constants. The total experimental area for biomass determination is 143 m^2. Each Napier grass cultivar has three replicates, which each area consists of 11.90 m^2 of the experimental area.

Statistical analysis

Data of four Napier grass cultivars were analyzed by using Two-Way Analysis of Variance (ANOVA) by using Statistical Package for the Social Science (SPSS) version 24.0 software.

RESULTS AND DISCUSSION

Proximate compositions

The results of the proximate composition of four Napier grass cultivars (Zanzibar Napier, Uganda Napier, Red Napier, and India Napier) at three different harvesting ages (45 days, 60 days & 75 days) were tabulated as shown in the Table 1, Table 2, Table 3, and Table 4, respectively. Based on the tabulated data shown in the tables, it can be seen clearly that there is a significant difference ($p < 0.05$) in the nutritional components of four Napier grass cultivars at three different harvesting ages (45 days, 60 days, and 75 days).

Table 1: Proximate composition of Zanzibar Napier grass cultivar

Parameters (%)	Zanzibar		
	45 days	60 days	75 days
Moisture	$89.71^{a} \pm 0.18$	$85.93^{b} \pm 0.41$	$83.60^{c} \pm 0.30$
Crude Fiber	$26.05^{a} \pm 0.35$	$26.64^{a} \pm 0.16$	$34.02^{a} \pm 0.34$
Crude Protein	$23.84^{a} \pm 0.28$	$18.35^{b} \pm 0.05$	$14.09^{c} \pm 0.01$
Ash	$9.22^{a} \pm 0.16$	$9.13^{a} \pm 0.03$	$9.32^{b} \pm 0.14$
Ether Extract	$2.68^{a} \pm 0.18$	$2.40^{a} \pm 0.14$	$2.01^{a} \pm 0.22$

Different letters in superscript (^{abc}) within same row indicate significantly different ($p < 0.05$) among the harvesting ages.

Table 2: Proximate composition of Uganda Napier grass cultivar

Parameters (%)	Uganda		
	45 days	60 days	75 days
Moisture	$92.16^{a} \pm 0.25$	$86.59^{b} \pm 0.25$	$81.63^{c} \pm 0.19$
Crude Fiber	$23.85^{a} \pm 0.23$	$36.10^{b} \pm 0.68$	$34.66^{b} \pm 0.09$
Crude Protein	$22.46^{a} \pm 0.14$	$16.86^{b} \pm 0.09$	$16.18^{c} \pm 0.17$
Ash	$9.53^{a} \pm 0.01$	$7.26^{b} \pm 0.07$	$7.02^{c} \pm 0.01$
Ether Extract	$2.76^{a} \pm 0.05$	$2.18^{b} \pm 0.07$	$1.88^{c} \pm 0.02$

Different letters in superscript (^{abc}) within same row indicate significantly different ($p < 0.05$) among the harvesting ages.

Table 3: Proximate composition of Red Napier grass cultivar

Parameters (%)	Red		
	45 days	60 days	75 days
Moisture	$88.84^{a} \pm 0.05$	$87.25^{b} \pm 0.25$	$85.33^{c} \pm 0.22$
Crude Fiber	$25.31^{a} \pm 0.23$	$27.51^{b} \pm 0.14$	$31.07^{c} \pm 0.67$
Crude Protein	$19.47^{a} \pm 0.55$	$18.09^{a} \pm 0.12$	$15.33^{b} \pm 0.18$
Ash	$11.18^{a} \pm 0.04$	$10.42^{b} \pm 0.01$	$8.41^{c} \pm 0.12$
Ether Extract	$3.45^{a} \pm 0.24$	$3.57^{a} \pm 0.20$	$2.12^{b} \pm 0.06$

Different letters in superscript (^{abc}) within same row indicate significantly different ($p < 0.05$) among the harvesting ages.

Table 4: Proximate Composition of India Napier grass cultivar

Parameters (%)	India		
	45 days	60 days	75 days
Moisture	$92.99^{a} \pm 0.22$	$87.34^{b} \pm 0.11$	$83.36^{c} \pm 0.19$
Crude Fiber	$23.72^{a} \pm 0.18$	$24.91^{b} \pm 0.16$	$32.02^{c} \pm 0.39$
Crude Protein	$23.29^{a} \pm 0.07$	$17.39^{b} \pm 0.15$	$15.91^{c} \pm 0.16$
Ash	$10.11^{a} \pm 0.04$	$9.16^{b} \pm 0.03$	$8.62^{c} \pm 0.20$
Ether Extract	$4.31^{a} \pm 0.22$	$3.51^{b} \pm 0.17$	$2.34^{c} \pm 0.07$

Different letters in superscript (^{abc}) within same row indicate significantly different ($p < 0.05$) among the harvesting ages.

Moisture content is an important factor which should be measured in forage sample as the forages nutritional quality was affected during drying process (Ahn et al. 2014). It can be measured by drying the sample till constant weight was achieved. The results of this study show, the different ages for harvesting have a significant effect ($p < 0.05$) on the moisture content of different Napier grass cultivars. The moisture content of Zanzibar Napier, Uganda Napier, Red Napier, and India Napier were decreased as the harvesting ages increased with the dropped value from 45 days to 75 days which are 6.11 %, 10.53 %, 3.51 % and 9.63 %, respectively. Ansah et al. (2010) found the similar results which are the moisture content was higher when harvested at 60 days compared to 120 days which recorded 52.12 % and 48.89 %, respectively. In terms of moisture content, India Napier cultivar showed the highest moisture content which is 92.99 %.

Ash is known as the amount of mineral in a plant (Eskandari et al. 2009). Based on the results obtained in Table 1, Table 2, Table 3, and Table 4 showed that the different ages for harvesting have a significant effect ($p < 0.05$) on the ash content of different Napier grass cultivars. The ash content of the most. Napier grass cultivars were decreased as the harvesting ages increased. The value decreased from 45 days to 75 days of Uganda Napier, Red Napier and India Napier were 2.51 %, 2.77 % and 1.49 %, discretely. Lounglawan et al. (2014) finding was similar with this result which found that ash content was lower in day 60 compared to day 30 which are 11.20 % and 13.89 %, accordingly. Among all the cultivars, the Red Napier showed the high ash content which is 11.18 %.

Protein is the most important factor in good quality of forage (Eskandari et al. 2009). This study revealed that the different ages for harvesting have a significant effect ($p < 0.05$) on the protein content of different Napier grass cultivars. The crude protein of all Napier grass cultivars was decreased when harvesting ages increased. The total decreased crude protein percentage of Zanzibar Napier, Uganda Napier, Red Napier, and India Napier, which recorded 9.75 %, 6.28 %, 4.11 % and 7.38 %, respectively. This finding was similar with the results obtained by Ansah et al. (2010) which found that crude protein was highest Napier grass harvested at day 60 compared to day 120 with 3.00 % of total dropped value. In this study the India Napier showed the high protein content which is 23.29 %.

Ether extract is an important component in good quality of forage. It is important for body maintenance and production (Ahmed et al. 2013). The results showed that different ages for harvesting have a significant effect ($p < 0.05$) on the ether extract content of different Napier grass cultivars. The percentage of ether extract was gradually decreased as harvesting ages increased. The total decreased percentage of ether extract Zanzibar Napier, Uganda Napier, Red Napier, and India Napier from 45 days to 75 days are 0.67 %, 0.88 %, 1.33 % and 1.97 %, respectively. Lounglawan et al. (2014) found the similar results which recorded 0.01 % dropped value from day 30 to day 60. India Napier cultivar showed the highest percentage of ether extract which are 4.31 %.

Crude fibre is an important constituent in finding a good quality of forage as it reduces the forage quality if the crude fiber content was too high (Ullah et al. 2010). The crude fiber percentage of Zanzibar Napier, Uganda Napier, Red Napier, and India Napier was highest when harvested at 75 days with each recorded 34.02 %, 34.66 %, 31.07 % and 32.02 %, respectively. This is similar with the findings of Lounglawan et al. (2014) which recorded 20.11 % higher percentage of crude fiber when harvested at 60 days compared to 30 days. Based on the result, Uganda Napier showed the highest percentage of crude fiber which are 34.66 %

Mineral Composition

The results of mineral composition of four Napier grass cultivars (Zanzibar Napier, Uganda Napier, Red Napier, and India Napier) were tabulated as shown in the Table 5, Table 6, Table 7 and Table 8

Potassium is important for the processes of plant development, including enzyme activation and photosynthesis (Prajapati et al. 2012). The results showed that potassium content was decreased as age increased. The total decreased values of Potassium from 45 days to 75 days of Uganda Napier and India Napier, which are 1.12 g/kg and 0.26 g/kg, respectively. Lanyasunya et al. (2007) found dissimilar results which recorded 12.7 g/kg increased value of plant when harvested at 6 weeks to 14 weeks. Red Napier showed the highest Potassium content among the cultivars which are 40.84 g/kg.

Table 5: Mineral composition of Zanzibar Napier grass cultivar

Parameters (g/kg)	Zanzibar		
	45 days	60 days	75 days
Potassium	$7.76^{c} \pm 0.83$	$23.82^{a} \pm 0.76$	$12.84^{b} \pm 0.33$
Phosphorus	$2.06^{a} \pm 0.03$	$1.32^{b} \pm 0.00$	$0.77^{c} \pm 0.01$
Calcium	$0.52^{a} \pm 0.00$	$0.69^{a} \pm 0.05$	$0.78^{a} \pm 0.16$
Magnesium	$0.48^{b} \pm 0.01$	$0.54^{a} \pm 0.00$	$0.42^{c} \pm 0.01$
Iron	$0.25^{a} \pm 0.00$	$0.20^{a} \pm 0.01$	$0.19^{a} \pm 0.03$
Zinc	$0.02^{b} \pm 0.00$	$0.02^{b} \pm 0.00$	$0.03^{a} \pm 0.00$
Manganese	$0.06^{a} \pm 0.00$	$0.08^{a} \pm 0.00$	$0.06^{a} \pm 0.01$
Copper	$0.03^{b} \pm 0.00$	$0.04^{a} \pm 0.00$	$0.04^{a} \pm 0.00$

Different letters in superscript (^{abc}) within the same row indicate significantly different ($p < 0.05$) among the harvesting ages.

Table 6: Mineral composition of Uganda Napier grass cultivar

Parameters (g/kg)	Uganda		
	45 days	60 days	75 days
Potassium	$1.65^{a} \pm 0.11$	$1.42^{a} \pm 0.10$	$0.53^{b} \pm 0.13$
Phosphorus	$1.78^{a} \pm 0.08$	$1.08^{b} \pm 0.03$	$0.74^{c} \pm 0.02$
Calcium	$0.45^{a} \pm 0.11$	$0.40^{a} \pm 0.03$	$0.60^{a} \pm 0.13$
Magnesium	$0.48^{b} \pm 0.00$	$0.54^{a} \pm 0.01$	$0.42^{c} \pm 0.01$
Iron	$0.37^{a} \pm 0.01$	$0.11^{b} \pm 0.09$	$0.13^{b} \pm 0.02$
Zinc	$0.03^{b} \pm 0.00$	$0.03^{a} \pm 0.00$	$0.03^{b} \pm 0.00$
Manganese	$0.06^{a} \pm 0.00$	$0.06^{a} \pm 0.01$	$0.06^{a} \pm 0.01$
Copper	$0.03^{a} \pm 0.00$	$0.03^{a} \pm 0.00$	$0.03^{a} \pm 0.00$

Different letters in superscript (^{abc}) within the same row indicate significantly different ($p < 0.05$) among the harvesting ages.

Table 7: Mineral composition of Red Napier grass cultivar

Parameters (g/kg)	Red		
	45 days	60 days	75 days
Potassium	$5.15^{b} \pm 0.65$	$11.52^{b} \pm 0.78$	$40.84^{a} \pm 2.38$
Phosphorus	$1.94^{a} \pm 0.02$	$1.04^{b} \pm 0.00$	$0.68^{c} \pm 0.04$
Calcium	$2.24^{b} \pm 0.10$	$2.82^{b} \pm 0.13$	$4.49^{a} \pm 0.21$
Magnesium	$0.45^{a} \pm 0.00$	$0.23^{b} \pm 0.00$	$0.45^{a} \pm 0.01$
Iron	$0.52^{a} \pm 0.07$	$0.23^{b} \pm 0.03$	$0.19^{b} \pm 0.00$
Zinc	$0.02^{a} \pm 0.00$	$0.02^{a} \pm 0.00$	$0.02^{a} \pm 0.00$
Manganese	$0.08^{a} \pm 0.01$	$0.07^{a} \pm 0.01$	$0.08^{a} \pm 0.00$
Copper	$0.03^{a} \pm 0.00$	$0.03^{a} \pm 0.00$	$0.03^{a} \pm 0.00$

Different letters in superscript (^{abc}) within the same row indicate significantly different ($p < 0.05$) among the harvesting age

Phosphorus is essential for the forming of bones and dents. It is one of the main constituents of Triphosphate Adenosine (ATP). The results showed that the phosphorus content in the Zanzibar Napier, Uganda Napier, Red Napier, and India Napier was decreased along the maturity with the total value decreased from 45 days to 75 days of 1.29 g/kg, 1.04 g/kg, 126 g/kg, and 1.19 g/kg orderly. Lanyasunya et al. (2007) found dissimilar finding which stated that the phosphorus content in plants were increased 0.8 g/kg when the harvesting ages increased. In this study, the phosphorus content was highest in Zanzibar Napier cultivars when harvested at 45 days which are 2.06 g/kg.

Calcium is needed by animals for bone maintenance and also plays a significant role in normal muscle and nerve functions (Soetan et al. 2010). This study found that calcium content of Zanzibar Napier, Uganda Napier and Red Napier were respectively recorded 0.26 g/kg, 0.15 g/kg and 2.25 g/kg increased as the grass age increased. Lanyasunya et al. (2007) found 5.0 g/kg of Calcium value decreased in plants from 6 weeks to 14 weeks. The India Napier cultivars showed the highest Calcium content when harvested at 60 days, which are 1.48 g/kg.

Magnesium is an important factor for the growth and development of plants. In plants, it plays an important role in protein synthesis and photosynthesis (Chen et al. 2017, Soetan et al. 2010). The Magnesium content in Zanzibar Napier, Uganda Napier and India Napier showed an increased from 45 days to 60 days. The total Magnesium value increased of Zanzibar Napier, Uganda Napier and India Napier were recorded as 0.17 g/kg, 0.06 g/kg, and 0.05 g/kg, respectively. These results were dissimilar with the finding of Lanyasunya et al. (2007) which found that

Magnesium content was 0.3 g/kg decreased from week 6 to week 12. The Magnesium content in Zanzibar Napier was highest at 60 days, which are 0.543 g/kg.

Iron is crucial to keep proper functioning of haemoglobin which required to hold oxygen in the blood. Iron deficiency disrupts the blood production which may lead to anaemia in ruminants (Soetan et al. 2010). The results showed that Iron content in Napier grass cultivars was decreased when harvesting ages increased. This finding was supported by the finding of Red Napier have the highest Iron content at 45 days which are 0.524 g/kg.

Zinc plays a key role as a part of a variety of essential enzymes in animal nutrition. Severe deficiency of Zinc caused appetite loss, decreased growth and immunocompetence and hair loss in ruminants (Soetan et al. 2010). Most of the Napier grass cultivars were decreased as the harvesting ages increased. The value of Zinc decreased from 45 days to 75 days in Red Napier and India Napier, which are 0.001 g/kg and 0.001 g/kg, respectively. Lanyasunya et al. (2007) recorded 3.00 mg/kg of total Zinc content was increased in plants from 6 weeks to 14 weeks. Uganda Napier showed the highest Zinc content when harvested at 60 days, which are 0.034 g/kg.

Manganese is an important microelement in animal body. Manganese deficiency in the ruminants is associated with impaired reproductive ability, skeletal defects in the calves and less than adequate productivity. However, the high Manganese content in forage can affect the growth of the livestock (Mirzaei, 2012). This study revealed that Manganese content has a significant effect on the cultivars of Napier grass. However, the Manganese content has no significant effect on the harvesting ages. The results showed that the Manganese content of Zanzibar Napier, Uganda Napier and India Napier were highest when harvested at 60 days, which are 0.075 g/kg, 0.063 g/kg, and 0.065 g/kg accordingly. Among the Napier grass cultivars, Red Napier contained the highest Manganese value at 75 days, which are 0.078 mg/kg.

Copper is a critical trace element which all animals required and showed signs such as anemia, low productive performance and susceptible to diseases (Hefnawy et al. 2015). This result indicated that copper content has a significant effect on the cultivars of Napier grass. However, the Manganese content has no significant effect on the harvesting ages. This study found that all Napier grass cultivars used were increased as the harvesting ages increased. The escalated value of Zanzibar Napier, Uganda Napier, Red Napier, and India Napier from day 45 to day 60 which are 0.004 g/kg, 0.002 g/kg, 0.002 g/kg, and 0.007 g/kg, respectively. These results were supported by the finding of Lanyasunya et al. (2007) which found that Copper content in plants were 0.34 mg/kg increased from 6 weeks to 14

weeks. Red Napier showed the highest at 60 days, which are 0.037 g/kg.

Dry matter yield

Determination of dry matter is vital as it indicates

the amount of nutrients that are contained in a particular plant. The dry matter results of four Napier grass cultivars at three different harvesting ages were tabulated as shown in Table 9. The results show the harvesting ages have significant difference ($p < 0.05$) on the dry matter yield of Napier grass cultivars.

The dry matter yield of each Napier grass cultivar was increased with an increase of harvesting ages. Among the Napier grass cultivars, Zanzibar Napier showed the highest of dry matter yield, which is 13.93 kg per 11.89 m^2. In terms of harvesting ages, the Napier grass cultivars contain the highest dry matter yield when harvested at 75 days. The results were similar with finding of Halim et al. (2013) which reported that Red Napier contains, the higher dry matter yield when harvested at 75 days with 12.64 kg/ $m^{2.}$

Table 8: Mineral composition of India Napier grass cultivar

Parameters	India		
	45 days	60 days	75 days
Potassium	$3.68^{a} \pm 0.21$	$1.28^{b} \pm 0.11$	$1.69^{b} \pm 0.06$
Phosphorus	$1.95^{a} \pm 0.06$	$1.33^{b} \pm 0.04$	$0.76^{c} \pm 0.01$
Calcium	$0.81^{b} \pm 0.09$	$1.48^{a} \pm 0.11$	$0.52^{b} \pm 0.08$
Magnesium	$0.37^{b} \pm 0.01$	$0.42^{a} \pm 0.00$	$0.43^{a} \pm 0.00$
Iron	$0.48^{a} \pm 0.17$	$0.13^{b} \pm 0.00$	$0.09^{b} \pm 0.01$
Zinc	$0.03^{a} \pm 0.00$	$0.02^{b} \pm 0.00$	$0.02^{b} \pm 0.00$
Manganese	$0.06^{a} \pm 0.03$	$0.07^{a} \pm 0.00$	$0.05^{a} \pm 0.00$
Copper	$0.03^{a} \pm 0.00$	$0.03^{a} \pm 0.00$	$0.04^{a} \pm 0.00$

Different letters in superscript (^{abc}) within the same row indicate significantly different ($p < 0.05$) among the harvesting ages.

Table 9: Dry matter yield of Four Napier Grass cultivar.

Napier grass	Biomass Yield (kg)		
	45 days	60 days	75 days
Zanzibar	$1.55^{c} \pm 0.05$	$5.47^{b} \pm 0.0$	$13.93^{a} \pm 0.01$
India	$0.95^{c} \pm 0.01$	$3.25^{b} \pm 0.25$	$8.33^{a} \pm 0.05$
Red	$1.90^{c} \pm 0.08$	$2.40^{b} \pm 0.01$	$9.60^{a} \pm 0.08$
Uganda	$2.94^{c} \pm 0.20$	$3.41^{b} \pm 0.02$	$7.25^{a} \pm 0.03$

Different letters in superscript (^{abc}) within the same row indicate significantly different ($p < 0.05$) among the harvesting ages.

CONCLUSION

The finding of this study show that the different harvesting ages have a significant effect on the chemical compositions of different Napier grass cultivars. Based on the finding, the Napier grass contains the highest chemical composition when harvested at days 45. However, the Napier grass cultivars showed the highest of dry matter yield for days 75 growth. Among the cultivars of Napier grass, India Napier showed the highest chemical composition. Therefore, it was recommended that the Napier grass should be harvested between 45 days to 60 days to get the best quality of forage in terms of their chemical content.

CONFLICT OF INTEREST

The authors have declared that the present study was performed in the absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

NAK devised the project, the main conceptual ideas, manuscript preparation and proof outline. NA and NZAR were involved in the field sampling and lab analysis.

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