EFFECTS OF FERTILIZER LEVELS AND HARVEST TIME ON YIELD OF *Panicum maximum* cv. Mombasa AND ITS NUTRIENT DIGESTIBILITY BY RED SOKOTO BUCKS

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SEPTEMBER, 2018

DECLARATION

I declare that the work in this Thesis entitled "**Effects of fertilizer levels and harvest time on yieldof *Panicum maximum* cv. Mombasa and its nutrient digestibility by Red Sokoto bucks"**have been carried out by me in theDepartment of Animal Science, Ahmadu Bello University, Zaria. The information derived from literature has been duly acknowledged in the text and list of references was provided. No part of this thesis was previously presented for another degree or diploma at any university.

_____	_____	_____
Name of student	Signature	Date

CERTIFICATION

This Thesis entitled "**Effects of fertilizer levels and harvest time on yieldof *Panicum maximum* cv. Mombasa and its nutrient digestibility by Red Sokoto bucks"** byUmar Saleh JIBRIL, meets the regulations governing the award of the degree of Masters of Science (MSc.) of the Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This Thesis is dedicated to the memory of my beloved Mother, Hajja Dada Umaru Bajoga. You will forever remain in my heart. May you continue to rest in peace.

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ABSTRACT

The first study was carried out to determine the effects of application of varied levels of fertilizer (NPK 15-15-15) and harvest time on yield and chemical composition of *Panicum maximum* cv. Mombasa in Shika, Northern Guinea Savannah of Nigeria.The experiment was laid out in 4x3 factorial arrangements in Randomised Complete Block Design (RCBD) with 3 replicates (Blocks). The 2 factors were fertilizer levels (0, 200, 300 and 400 Kg/ha NPK 15-15-15) and harvest time (8, 10, and 12 weeks after planting, WAP). The fresh and dry matter yields of *Panicum maximum* cv. Mombasa were influenced positively with increasing levels of fertilizer and harvest time. Total dry matter increased significantly ($P<0.05$) from 2.30 tonnes/ha in the control to 4.20 tonnes/ha in 400kg fertilizer applied treatment and total fresh weight also increased significantly ($P<0.05$) with age, from 8.6 tonnes/ha at 8th week to 21.00 tonnes/ha at week 12 after planting. Results from the study revealed that Crude protein content of the forage increased significantly ($P<0.05$) from 7.83% in the control (0kg/ha NPK) to 11.66% in treatment with 400kg/ha NPK. Crude fibre decreased from36.94% in the controlto33.96% in treatment with 400kg/ha NPK. CP of *Panicum maximum* cv. Mombasa declined with maturity (from 10.29%at 8to 9.24% at 12 weeks after planting). CF and Ash's percentages increased ($P<0.05$) with age. DM, OM, CP and NFE of the forage were highest in week 8 after planting and declined thereafter. ADF values indicated a decrease as NDF values showed an increase as fertilizer levels were increased. NDF and lignin content of the forage increased with age. P (from 1.46 g/kg at in the control to 1.75 g/kg in treatment with 300kg/ha NPK) and K (from 4.73 g/kg at in the control to 8.42 g/kg in treatment with 300kg/ha NPK) content of the forage was affected positively whereas Ca and Na did not change significantly ($P>0.05$) with fertilization. It can be concluded that the application of NPK (15-15-15) at the rate of 400kg/ha improved the nutritive value and yield of *Panicum maximum* cv. Mombasa. *Panicum maximum* cv. Mombasa was at its best nutritive value at 8th week after planting but yielded more dry matter at 12th week after planting. Thus, farmers are encouraged to apply NPK (15-15-15) at 400kg/ha and harvest *Panicum maximum* cv. Mombasa at 10^{th} week for better forage in terms of nutritive value and yield. The second experiment was conducted to investigate the effects of Concentrate inclusion levels on nutrients digestibility and Nitrogen balance in Red Sokoto bucks fed *Panicum maximum* cv. Mombasa based diets. The Concentrate inclusion levels were 15, 30, 45 and 60 % (Treatments 1, 2, 3 and 4, respectively). Twelve (12) Red Sokoto bucks were randomly assigned to the four treatments in a Completely Randomised Design (CRD).Dry matter

digestibility was significantly (P<0.05) higher in bucks fed diet containing 60% Concentrate (75.21%) compared to the other three Treatments. Bucks fed diet containing 60% Concentrate had the highest (P<0.05) Organic matter digestibility (75.32%) compared to the other Treatments. Nitrogen free extract and Neutral detergent fibre digestibility followed a similar pattern of change as in Organic matter. Bucks fed Treatments with 45 and 60% Concentrate inclusion showed significantly (P<0.05) higher ether extract digestibility compared to those fed 15 and 30 %. Crude fibre digestibility was significantly (P<0.05) higher in bucks fed diet containing 30% Concentrate (84.59). Treatments 3 and 4 were similar, whereas Treatment 1 recorded the lowest (68.74%) crude fibre digestibility. Crude protein digestibility increased with increasing Concentrate levels. Highest (P<0.05)CP digestibility values were observed in bucks fed diet containing 60% Concentrate (81.77%) while bucks fed diet containing 15% Concentrate recorded the least values. Acid detergent fibre digestibility followed a trend similar to that of crude protein. Nitrogen intake increased significantly (P<0.05) with an increase in Concentrate levels. Bucks fed diet containing 60% Concentrate (8.36g/day) were significantly higher (P<0.05) in Nitrogen intake. Faecal nitrogen loss decreased significantly (P<0.05) as Concentrate inclusion levels increased (from 1.52 g/day in treatment with 60% Concentrate to 2.32 g/dayin treatment with 150%), while Urine nitrogen loss followed a trend opposite to that of faecal nitrogen loss. The highest (P<0.05) Total Nitrogen excreted was observed in treatment 3 (3.00g/day). Nitrogen retained was similar in bucks fed diet containing 30 and 60% Concentrate but was significantly higher (P<0.05) in bucks fed diet containing 15 and 45% Concentrate. Nitrogen absorbed as a percentage of intake and Nitrogen retained as a percentage of intake followed the same pattern. Bucks fed diet with 60% Concentrate inclusion were significantly higher (P<0.05) while bucks fed diet containing 15 and 45% Concentrate were lower in these parameters. In conclusion, the inclusion of Concentrate in *Panicummaximum* cv. Mombasa based diet increased the diet's intake, digestibility and Nitrogen retention in Red Sokoto bucks. It is therefore recommended that farmers could incorporate 60% Concentrate in a *Panicummaximum* cv. Mombasa based diet for improved digestibility and nitrogen retention in Red Sokoto bucks.

CHAPTER ONE

1.0 Introduction

Nigeria is an agricultural country with diverse vegetation, varying from rainforest to the Sahel. About 32.42 million hectares of grazing land and 39.41 million hectares of cropland in Nigeria provide a substantial amount of feed for the country's livestock(Shiawoya and Tsado, 2011). The savannah zone is home to about 80% of ruminant livestock population. Availability and quality of feedstuff are major constraints in the development of the livestock industry in this region. Extensive areas of the grazing lands are composed of indigenous species, which are of low quality (Shiawoya and Tsado, 2011). There is a wide variation in the quality and quantity of pasture available from one time of the year to another (Adamu, 2015). Hence, there is need to develop or adopt strategies, or technologies to provide highqualityforage for livestock in this region.

Several forage species, especially grasses have been introduced into Shika, Northern Nigeria and screened for productivity and adaptively over the past years. This has been in search of outstanding materials that could be used to partially or completely replace the low productive native grassland species (Whiteman, 1980). In some of the screening trials, Agishi (1978) on upland and Akinola and Olorunju (1990) on lowland reported some forage species that are well adapted to the Northern Guinea Savannah and produced a substantial amount of forage biomass.

There are many grass species that are used for pasture in the tropics and subtropics due to their high dry matter yields and good animal feed quality. *Panicum maximum* is one of these extensively used forage grasses (Correa and Santos, 2003). *Panicum maximum* (Guinea grass) is a native of tropical Africa, extending to the sub-tropics of South

Africa. It occurs at forest edges in the bush, as a pioneer grass covering the land cleared from the forest and in grassland with scattered trees where it tends to grow in high shades under trees (Whiteman, 1980). Proper soil fertility management and understanding the nutritional requirement of this grass species are extremely important for pasture management, which is reflected by higher feed yield and their availability for animals. The use of inorganic fertilizers can significantly increase forages production, providing greater capacity and thus resulting in higher milk and meat production per unit of area used (Pereira *et al*., 2011; Iwanmoto *et al.,* 2015). The increased yield due to fertilizer application could be attributed to increased in both leaf production, increased number of tillers and photosynthesis directly (Aderinola *et al*., 2011).Dry matter yield also generally increases with increasing fertilizer rates (Carvalho *et al.,* 2000; Adewumi, 2013). Fertilization enhances nutrient digestibility, which can improve livestock Production (Peyraud and Astigarraga, 1998). Fertilizer contributes to the greater productivity of Mombasa Guinea Grass by increasing production per cycle and the number of harvest cycles (Pereira *et al.,* 2012; Hare *etal.,* 2015). Increasing rates of nitrogen significantly increased CP and NDF concentrations in stems and leaves and; ADF concentrations in stems (Peyraud and Astigarraga, 1998; Adewumi, 2013; Hare *et al.,* 2015) andreduction in the crude fibre content of stem (Onyeonagu *et al.,* 2012).In addition, it can also provide other supplementary effects that will increase the efficiency of the system as a whole, such as the production of soilage or hay to be used during the dry season (Cecato *et al.,* 2001). Stage of maturity also affects the quality and quantity of *Panicum maximum.* Dry Matter yield increases with advancing maturity, but quality declines (Taute *et al,*2002). Onyeonagu (2012) noted that cutting interval and fertilizer application havesignificant influence on the chemical composition of *Panicum maximum* forage.

Ruminant production is one of the major livestock activities in most of the developing countries in the tropics (Okoruwa and Agbonlahor, 2016). Ruminant livestock play an important role in the economic development of Nigeria in terms of feeding the steadily growing population and providing the investible resources for national development (Bolaji *et al.,* 2016).Over the years, there has been a great increase in the production of goats in Nigeria which has resulted in poverty alleviation and the supply of high-quality animal protein in order to meet the demand of the teeming population (Ibrahim *et al.,* 2014). Goats are classified as an important small ruminant on account of their unique ability to adapt and maintain themselves in a harsh environment. (Bolaji *et al.,* 2016). Goats are one of the most prolific of all domesticated ruminants under tropical and subtropical conditions (Webb and Mamabolo, 2004) and their small size relative to cattle contributes to their wide distribution and easy management among Farmers. (Bolaji *et al.,* 2016). The Red Sokoto, is the most important goat breed in Nigeria, accounting for about 70% of the estimated 34.5 million goats in Nigeria (Osuhor *et al.,* 1998). Animal protein is one of the most important components of human diet and its consumption varies from country to country (Okai *et al.,* 2005). Goats as a multipurpose animal are a major source of milk, skin and manure apart from meat. Goats also provide income for meeting household needs (Peacock *et al .,* 2005). Nigerian small ruminant industry is faced with the problem of meeting the nutritional requirements of the animals (Jones and Wilson, 1987; Fasae *et al.,* 2005). Goats in Nigeria suffer several nutritional stresses in the dry season as a result of seasonal variability that affects the availability and nutritive quality of pastures which in turn causes marked decrease in nutrient intake and performance of the animal (Bolaji *et al.,* 2016).Therefore, study on the effects of fertilizer and harvest time on *Panicum*

*maximum*cv. Mombasa and Concentrate inclusion levels in *Panicum maximum*Mombasa based diets isvery important.

1.1 Justification ofthe Study

The main limitations to animal production in Nigeria include lack of green feed for at least half of the year, coupled with the low nutritive quality of the forages (Jones and Wilson, 1987; Alan *et al.*, 2013). Also, soil fertility problems are found in most tropical pasture situations (Adewumi, 2007). Thus, the introduction of more nutritive forages and the use of fertilizers can help in alleviating these problems. Forage production is gaining more attention in the tropics and sub-tropics; in both developed and developing countries. New species, varieties and cultivars of forage and pasture plant have been introduced from areas and countries rich in forage and pasture plant to areas where they are scarce (Yossif and Ibrahim, 2013).Goats are one of the most important small ruminants in Nigeria, providing meat, skin and manure to farmers. Therefore, there is a need to adopt new strategies to provide feeds that will meet the nutritional requirements of goats in the dry season.

Panicum maximum cv. Mombasa being forage with high Crude protein (10-14%) and herbage yield of up to 40.2 tonnes dry matter per annum (Jank, 1995) can be useful in alleviating the ruminants' nutritional crisis in Nigeria. There is little or no work on this new cultivar (*Panicum maximum* cv. Mombasa) in this part of the country. It has been established that Concentrate inclusion in a forage based diet improves nutrient intake and digestibility of the forage (Yang *et al.*, 2001; Gaafar *et al.*, 2009; and Lima *et al.*, 2016). Therefore, this study is aimed at evaluating the effects of fertilizer levels and harvest time on yield and nutritive composition of *Panicum maximum* cv. Mombasa in Shika and Concentrate inclusion levels on nutrients intake, digestibility and Nitrogen balance of *Panicum maximum* cv. Mombasa hay - based diets in Red Sokoto bucks.

1.2 Objectives of the Study

The objectives of the studies include:

- To evaluate the effectsof fertilizer levels on dry matter yield and chemical composition of *Panicum maximum* cv. Mombasa.
- To evaluate the effects of harvest time on dry matter yield and chemical composition of *Panicum maximum* cv. Mombasa.
- To determine the effects of Concentrate inclusion levels on nutrient intake and digestibility of *Panicum maximum* cv.Mombasa hay- based diets in Red Sokoto bucks.
- To determine the effects of Concentrate inclusionlevels on nitrogen balance of *Panicum maximum* cv.Mombasa hay- based dietsin Red Sokoto bucks.

1.3 Hypotheses

EXPERIMENT I:Effects of Fertilizer Levels and Harvest Time on Yield and Nutritive Composition of *Panicum maximum* cv. Mombasa.

- H_O: Fertilizer levels have no significant effect on dry matter yield and chemical composition of *Panicum maximum* cv. Mombasa.
- H_A: Fertilizer levels have a significant effect on dry matter yield and chemical composition of *Panicum maximum* cv. Mombasa.
- H_O: Harvest time have no significant effect on dry matter yield and chemical composition of *Panicum maximum* cv. Mombasa.
- H_A: Harvest time havesignificant effect on dry matter yield and chemical composition of *Panicum maximum* cv. Mombasa.

Experiment II:Effects of Concentrate Inclusion Levels on Intake, Digestibility and Nitrogen Utilisation in Red Sokoto Bucks Fed *Panicum maximum*cv. Mombasa Hay - based Diets.

- H_O : Concentrate inclusion levels have no significant effects on nutrientintake and digestibility of *Panicum maximum* cv. Mombasa hay-based diets in Red Sokoto bucks.
- H_A : Concentrate inclusion levels have significant effects onnutrient digestibility of *Panicum maximum* cv. Mombasa hay-based diets in Red Sokoto bucks.
- H_O : Concentrate inclusion levels have no significant effects on nitrogen utilisation of *Panicum maximum* cv. Mombasa hay-based diets in Red Sokoto bucks.
- H_A : Concentrate inclusion levels have significant effects on nitrogen utilisation of *Panicum maximum* cv. Mombasa hay -based dietsin Red Sokoto bucks.

CHAPTER TWO

2.0 Literature Review

2.1 Pasture Production in Nigeria

The introduction of pasture crops into Nigeria started in the 1950s (Onifade and Agishi, 1988) and over the years pasture agronomists and ruminant livestock nutritionists have investigated pasture plants that could stand the variations of agro-ecological zones (De Leeuw and Brinckman, 1974; Olubajo, 1974 and Ademosun, 1974). Various grass species exist in Nigeria presently and the notable ones include *Cynodon nlemfuensis*, Andropogon spp. (*Andropogon gayanus* and *Andropogontectorum*), *Panicum maximum, Pennisetum spp. (*with *Pennisetum purpureum and Pennisetum pedicellatum), Imperata cylindrica, Melinis minutiflora, and Setaria sphacelata*. Also, a number of exotic plants such as *Cenchrus ciliaris, Anthephora nigritana* and others were successfully established (Oyenuga, 1967). The productivity, chemical composition and nutritive value of grasses and legumes found in Nigeria vary greatly according to species, the nature and fertility of the soil, water relations; seasons of the year, disease incidence and the stage of growth at which the grass species are cut or grazed. The effect of seasonality on ruminant livestock production is also very important. During the mid-wet season, forage biomass is higher in quality and quantity, with crude protein up to 9% in most of the native grasses. Natural grasses and legumes are rich and highly digestible at this period. As the dry season sets in the protein level drops and the crude fibre quantity increases. There is an increase in lignin content and voluntary intake decreases (Aregheore, 2009).The marked seasonal changes affect the quality and quantity of forage (Aregheore, 1996). Under favourable conditions, dry matter yield in the northern savannahs can reach as much as 2000 kg per hectare. However, after the rainy season, the quantity of forage declines rapidly and the lack of woody vegetation means that

little forageis available in the dry season (Aregheore, 2009).The severity and duration of low-quality feed differ from the south to the north within the states. To worsen the ecology and its available food resources further, there is the widespread annual burning of native grasslands, thereby drastically reducing the amount of forage on offer (Nuru, 1996). A combination of the following factors - low-quality roughage and bush burning, which reduce the biomass available in quantity and quality – have been observed to lead to weight losses ranging from 300 to 400 g per head per day for cattle (Zemmelink, 1974) and up to 15% of body weight in sheep (Otchere *et al.,* 1977).

2.2 Factors Affecting Forage Yield and Quality for Livestock

2.2.1 Species and/or cultivars selection

Species or cultivars selection generally represents a simple but highly effective tool for adaptation of feedstuff production to environmental conditions. For example, in temperate zones, biennial or perennial legume or grass species are the most common whilst annual species can be in the first place in regions with intensive drought or frost period (Hakl *et al.,* 2017).There is a range of other grass species important for specific environments. Selection of appropriate species or composition of a mixture of species remains the basic tool for a successful start of forage production. Breeding process is intended to improve the properties of the selected species important for human civilization (Hakl *et al.,* 2017). Yield improvement in forage crops during the last century has lagged far behind that of annual grain crops (Brummer, 1999) because breeders changeharvest index rather than total biomass production, which is an explanation for low yield progress of perennial forage crops. Lamb *et al.,* (2006) concluded that evidence for changes in lucerne forage yield for cultivars released between 1940 and 1995 was environmentally dependent. The following is an example of high practical impact on forage production. It has long been a goal for forage

breeders to combine the stress tolerant characteristics of Festuca species with the earliness and high nutritive value of Lolium species. Some breeding programmes have been designed to transfer Festuca genes into Lolium, and as a result, some Festulolium cultivars have been developed in Europe and in the USA. Festulolium provides specialized function and novel alternatives to existing grass species/cultivars that may lack resilience against abiotic or biotic stresses (Humphreys *et al.,* 2003).

2.2.2 Harvest frequency and time

It is well known that higher cutting frequency improves the nutritive value of harvested forage because of reduced stem weight proportion and its better digestibility in relation to lower lignification. However, it must be remembered that more intensive cutting regime reduces stand yield and persistence (Hakl *et. al.,* 2017). Harvest time influences the nutritive value of pastures (Taute *et al,*2002; Sarwar *et al.,*2006; Okwori and Magani 2010).Forage quality declines with age as the proportions of stem and fibre increases as the forage matures. However, biomass yield increases significantly with age.

2.2.3 Nutrients

There is a lack of long-term studies investigating the indirect effect of organic and N fertilization on yield within applied crop rotation. Long-term absence of fertilization provided average annual dry matter yield 8.64 tonne/ha. Indirect application of mere manure or slurry significantly increased yield to 9.68 and 9.37 tonne/ha, respectively (Hakl *et al.,* 2017). According to Lissbrant *et al.*(2009), low P and K soil fertility reduced fibre concentrations in lucerne forage. Increasing rate of N reduced plant density but maintained stem density up to N3 level. Intensive fertilization also increased stand height which was in line with lower leaf weight ratio

2.2.4 Forage conservationfactors

Forage conservation cannot be excluded from the group of highly important factors affecting the quality of feed for animals; however, its impact is strongly limited in terms of forage quality before conservation. The conservation of forage crops is one of the most riskintensive processes undertaken by farm managers. From the time of harvest, until it is used as feed, it is subject to significant losses both in quantity and quality. These losses occur during harvesting and field operations and later during storage and handling of the product. To minimize the risk associated with forage conservation it is important to understand these processes, how they interact with one another and how their effects can be mitigated through various management practices(Hakl *et al.*, 2017).

2.2.5 Environment factors

Moisture, temperature, and the amount of sunlight influence forage quality. Rain damage is very destructive to forage quality. When bad weather delays harvesting, the forage crop becomes more mature and hence lower in quality. High temperatures may increase lignin accumulation and decrease quality, but drought stress may actually benefit quality by delaying maturity (Jerry and Marvin, 2003).

2.3 Origin and Distribution of*Panicum maximum*

Guinea grass (*Panicum maximum* Jacq.) is a major pan-tropical grass used throughout the tropics for pasture, cut-and-carry, silage and hay**.** It is native to tropical Africa and is now widely naturalized in the tropics. *Panicum maximum* is indigenous to the subtropical areas of Southern Africa where it occurs mainly in the sub habitat under trees (Pieterse *et al.*, 1997).

It is naturally found in open grasslands, woodland and shady places within 16.3°N and 28.7°S. Guinea grasses are well established throughout tropical countries of both

hemispheres where they play important role in beef and dairy production (McCosker and Teitzel,1975).

Panicum is a very diverse genus, with its natural range of distribution in the tropics and warmer in temperate regions. Parson (1972) hadpointed out the spread from the Guinea Coast of West Africa to Barbados during the Seventeenth Century and Brazil in the Eighteenth Century via slave ship. Mombasa grass is a *Panicum maximum* Cultivar whose genetic origin lies in Africa (Reynoso, 2009).

2.4 Description of *Panicum maximum*

Panicum maximum is a tropical grass, turfed and is perennial grass in nature. It is one of the most important tropical grasses and it is occurring naturally in Nigeria. It is high yielding and response very well to nitrogenous fertilizer application (Sodeinde*et al.,* 2005) and can withstand regular cutting regrowth (Aganga and Tshwenyane, 2004). It is a fast-growing and leafy grass, which is palatable to livestock with a good nutritional value. However, it is generally recommended to be supplemented with protein sources of protein in order to meet nutritional requirements or improve animal performance.

2.5 Environmental Requirements of *Panicum maximum*

Panicum maximum grows best under an annual rainfall above 1000 mm with no more than a 4 to 5-month dry period. Average annual day-temperature should range from 19.1°C to 22.9°C. Small types are more tolerant of cooler temperatures than tall types. It prefers well-drained, moist and fertile soils (Cook *et al.,* 2005). It is tolerant of light frost and low soil pH if drainage is good (FAO, 2009) and also tolerates fire and shade (Aganga and Tshwenyane, 2004). It is well adapted to sloping, cleared land in rainforest areas (FAO, 2009). Drought tolerance depends on the cultivar, but should not generally exceed 4 or 5 months. Guinea grass can be sown with companion legumes such as

Centrosema pubescens, Leucaena leucocephala, Pueraria phaseoloides or Macroptilium atropurpureum(Cook *et al.,* 2005).

2.6 Cultivars of *Panicum maximum*

In the past 20 years, nine new cultivars of *Panicum maximum* have been released as a result of selection program in different research stations: IZ-I (1979), Tobiata (1982), Centenaria (1986), Centauro (1988), Aruana (1989), Vencedor (1990), Tanzania (1990) and Mombasa (1993) (Jank, 1995) and Massai (Euclides *et al.,* 2008).Most studied cultivar in the last century is cultivar Colonial. But because of its low productivity in less fertile soils and its sensitivity to mismanagement, researchers and farmers started to look for cultivars better than Colonial in these respects (Carvalho, 2000).

Recently, cultivar BRS Zuri was released in 2014, a higher-yielding higher-quality accession from the germplasm bank. Its advantage is the very intense growth and also a high degree of resistance to a leaf spot disease caused by *Bipolaris maydis*, a major problem for some cultivars, such as cv. Tanzania. The first products of the breeding program are now appearing in the market. Cultivar BRS Tamani released in 2015 and cv. BRS Quênia to be released shortly (Jank *et al.,* 2016). Cultivars like Tanzania and Mombasa showed improved productivity in total and leaf dry matter, high seed yield and better distribution in dry matter throughout the year (Jank and Costa, 1990). In another trial,Coloniao yielded better than Aruana though Aruana presented better annual dry matter distribution (Cecato *et al.,* 2014).

Mombasa grass is a *Panicum maximum* (Jacq.) cultivar whose genetic origin lies in Africa. It was introduced to America in 1967. Mombasa is a cultivar produced as a result of direct selection from ORSTOM (Institut Francais de Recherche Scientifique Pour le Development en Cooperation) collection. It was released in 1993 by CNPGC (Centro National de Pesquisa de Gade de Corte) in Brazil. Mombasa is a bunch grass

with an average of 165cm height and erected leaves of about 30mm width averagely. It can yield up to 40.2 tonnes DM/Ha/year. Crude protein content in leaves and stem is about 13.4 and 9.7% respectively (Jank, 1995).

2.7 Chemical Composition of*Panicum maximum*

Peres *et al.*(2012) in an experiment to determine the chemical composition of *Panicum maximum* Mombasa reported 99.1 to 102.2 g/Kg crude protein, 707.3 to 649.6 g/kg NDF and 386.6 to 384.4 g/kg ADF in spring and summer respectively but Hare *et al*.(2015) reported crude protein of *Panicum maximum* Mombasa ranging from 2.8 to 4.9 % in the stem and 6.3 to 9.0 % in the leaf; ADF 40 to 43 % in the stem and 36.3 to 35.8% in the leaf. Abdu *et al.*(2012) reported 7.31%, CP 87.17% Organic matter, 23.18% Crude fibre, 2.18% Ether extract, 7.39% Ash, 59.94% Nitrogen free extract in *Panicum maximum.*Alalade *et al.* (2012) investigating the effects of intercropping Canavalia with *Panicum maximum*reported 7.49 to 9.85% CP, 72.41 to 66.28% NDF, 44.42 to 59.46% ADF, and 3.72 to 3.78 Kcal/kg Gross Energy. The mineral composition ranges from 0.14 to 0.22 % K, 0.13 to 0.28 % Ca, 0.19 to 0.13 % P, 0.25 to 0.38 mg/100g Mg, 23.90 to 39.60 mg/100g Fe, 29.60 to 35.70 mg/100g Zn and 6.30 to 7.40 mg/100 g Cu.

2.8 Effect of Fertilization on Grasses

2.8.1 Dry matter yield

Tropical grasses positively respond to increased N supply in the soil with regards to dry matter production (Mello *et al.*, 2008; Castagnara *et al*., 2011). The root length and biomass yield of *Panicum maximum* increased significantly as levels of fertilizer application increased (from 0 to 200kg N/ha) and with age of harvest, increase in

biomass yield will ensure forage availability for ruminant animals (Aderinola *et al.*, 2011).

The dry matter yield and harvestable stand density of *Panicum colorutum w*ith the increasing level of N-fertilizer from 0- 95 kg/ ha increased from 9.48 to 15.39 tonnes/ha (Diriba, 2000). Fernandes *et al.*(2015) Investigated sources and rate of fertilisation on the productivity of *Panicum maximum* Mombasa reported an increased dry matter production with the application of N rates only in the second harvest, of the five harvests performed. Gilbert and Clarkson (1993) observed that high levels (500kg/ha N) of nitrogen fertilization produced an extremely high yield of Rhodes grass and curvilinear effect of N-application rates on grass yield have been reported in tropical and subtropical regions of Australia.

Generally, forages with protein contents above 6 - 8% have greater digestibility because of the availability of required N for ruminant microbes (Styter and Dinius, 1979). Theron and Snyman(2004) reported that Organic Matter Digestibility (OMD) was significantly influenced by N-level and defoliation interval.Alalade *et al.*(2015) in an experiment to determine the effects of manure application and performance of West African Dwarf Sheep fed *Panicum maximum* reported 57 - 61 g/kg DM, 30 - 33 g/kg CP and 15 - 44 g/kg NDF digestibility. In separate studies, Tessema *et al.*(2002) and Peiris *et al.* 1995) reported an increase in IVOMD of grasses as Nitrogen levels increases.

2.8.2 Chemical composition

Tropical grasses are characterized by low nutritive value due to the higher lignin content and less degradable materials in their cell wall due to the rapid rate of achieving maturity (Minson, 1990). Fertilization has been reported to alter the morphogenesis, structural and production characteristics of Mombasa, Tanzania and Mulato grasses,

providing substantial increases in the tissue flow and contributing to the greater accumulation of forage biomass (Castagnara, 2011). Aderinola (2013) studied theeffect of varying levels of inorganic fertilizer application (0, 50, 100 and 200 kg/ha) on the chemical composition of *Panicum maximum* reported significant changes in crude protein (CP), Ash, Dry matter (DM), phosphorus (P) with fertilization. Crude protein (CP), Calcium (Ca), Phosphorus (P), Ash, NDF, ADF and ADL significantly differ at different fertilizer levels (Hassan *et al.,* 2015). Fertilization increased forage production, crude protein, nitrogen accumulation and green colour index of Mombasa grass (Escarela *et al.,* 2017). According to Aderinola *et al.*(2011) Fertilizer application positively affects the Ash and Crude protein content of Forages, while reducing the lignification of the plant materials. Although, high application levels of N increased the NO_3-N concentration of plants, which was especially evident shortly after N application during the vegetative stage (Taute*et al,*2002)

In a study to determine the effects of Nitrogen fertilization and cutting interval on *Panicum maximum* Onyeonagu *et al.*(2012) observed an increased in Crude protein content with increasing levels of fertilizer. Phosphorus, Iron and Zinc contents increased with increased Nitrogen rates while Sodium, Potassium and Ash contents were affected adversely as fertilizer levels increased though but did not influence the ADF and NDF concentrations (Fernandes *et al.,* 2015). Galloway and Cowling (2002) also observed that Nitrogen, Potassium and Phosphorus contributed satisfactorily to plant growth and were utilized well by grass, the phosphorus level also increased as the grass aged and withincrease in fertilizer applied. *Cynodon dactylon* planted under NPK and cow dung application responded better and yielded higher levels of minerals (Imoro *et al.,* 2012).The potassium and phosphorus levels in the forages increased with increase in nitrogen and age at harvest (Adewumi, 2013). Onyeonagu *et al.*(2012) also reported a

decrease in Phosphorus, Sodium, Zinc, Potassium and Iron of *Panicum maximum* with nitrogen fertilization.

2.8.3 Digestibility

Fertilizer application affects the chemical composition of grasses in a positive manner. This, in turn, helps in providing rumen microbes more energy to act on the forage and subsequently improving its digestibility and utilisation. The digestibility of grass is greatly influenced by species, agronomic practices and morphologies of forages (Sarawar *et al.*, 1995). Forage digestibility is associated with intake, dietary N content and physical form of the forage.

2.9 Effects of Harvest Time on Grasses

2.9.1 Dry matter yield

There are two phases in cut grasses, the first phase being leaf accumulation the main characteristic until stabilization (a condition in which the sward intercepts 95 % of light and the appearance of new leaves is compensated by senescence of the first leaves). After this phase, increases in herbage accumulation are due basically to stem accumulation and leaf senescence (Da Silva and Nascimento, 2007). Dry matter yield generally increases with increasing fertilizer rate and cutting interval (Carvalho *et al.*, 2000). Reynoso *et al.*(2009) concluded that herbage accumulation, morphogenic composition and sward structure in Mombasa grass can be influenced through defoliation intervals fine-tuned to plant response and environmental conditions. It favours greater leaf proportion in accumulated herbage. Longer cutting intervals bring about more plant height and herbage accumulation, which drive down leaf:stem and leaf:non leaf ratios and altered sward structure which in turn can diminish efficiency in pasture utilization, intake and animal performance. Morillo *et al.*(1997) had tested three

cutting frequencies (28, 42 and 56 days) and reported that *Panicum maximum* forage yield was not influenced by cutting interval.

2.9.2 Chemical composition

In most of the cases, pasture grasses in the tropics cannot satisfy even the minimum requirement of nutrients by animals due to harvesting at an advanced stage of maturity (Beyene, 1977). The potential degradable and undegradable fractions and the duration of the lag time are affected by cutting age (Vieira *et al.,* 1997). Plant age at cutting is a major factor that determines feeding value and the amount of crude fibre of grass (Harper, 1983). Stage of maturity also affected the quality and quantity of *Panicum maximum* with advancing maturity DM yield increased, but quality declined (Taute *et al*,2002). Onyeonagu (2012) noted that cutting interval and fertilizer application has a significant influence on the chemical composition of *Panicum maximum* forage. The effect of cutting interval showed that only CP value was significantly increased at 6 weeks cutting than at 9 weeks, but the EE, ADF and NDF values recorded their highest values at 9 weeks cutting than at 6 weeks cutting (Okwori and Magani, 2010). Sarwar *et al.,* (2006) reported 9.59%, 7.44% and 4.52% crude protein in *Panicum antidotale* at different clipping interval. Mineral nutrients of the plant are influenced positively by cutting stage (Morillo *et al.,* 1997).

2.9.3 Digestibility

High In vitro digestibility values ranging from 75 to 85 percent after one week of growth have been reported in several improved varieties of tropical pastures and also the IVDMD of *Panicum maximum* at age of six weeks ranges from 53.1 % to 72.1 % (Reid and Megerwa, 1973). Tegegn (2001) noted that the IVDMD of Panicum varied from 75.18 to 55.06 % and the application of different levels of N- fertilizer had a slightly significant difference on the forage at all stages of harvest. Dry matter

digestibility (DMD) linearly declines with increasing age of growth of grass species in the tropics, which is generally attributed to the increase in structural components (cell walls), a decline in the leave to stem ratio, and an increase in the proportion of senescent plants.

2.9 Use of*Panicum maximum*in Ruminant Feeds

Panicum Maximum can be effectively utilised by cattle (Difante *et al.,* 2009), sheep (Relling *et al.,* 2001; Alalade *et al.,* 2013) and goat (Aregheore, 2003; Ajayi *et al.,* 2005; Abegunde *et al.,* 2017). A study by Aina and Onwuka (2002) showed that *Panicum maximum* was among frequently picked grasses by grazing sheep and goat. Guinea grass cv. Mombasa gives higher daily weight gains while cv. Masai allows higher stocking rate (Euclides *et al.,* 2008). Alalade *et al.*(2015) fed *Panicum maximum* to West African Dwarf Sheep and reported a significant increase in crude protein, average weight gain and feed intake. Peres *et al.* (2012) reported a similar milk yield of a cow fed Mombasa grass and that fed black oats pasture and sorghum silage as roughage supplement. Relling *et al.*(2001) evaluated the utilisation of *Panicum maximum* at different stages of maturity by sheep and concluded that the forage is best utilised at early stages of growth but at later stages of maturity, it needs to be supplemented to meet the maintenance requirement of sheep.

The inclusion of 30% of Gliricidia leaves in Guinea grass diet gave high live weight gain, double growth rate compared to grass only and better feed utilisation efficiency (Phimphachanhvongsod and Ledin, 2002). Alalade *et al.*(2013) also reported an effective utilisation of *Panicum maximum* forage intercropped with *Canavalia ensiformis* byWest African Dwarf Sheep. Feeding goats with Guinea grass gave better results when it wss supplemented with a legume (Ajayi *et al.,* 2008). Concentrate supplementation also helps in better utilisation of *Panicum maximum* forage

(Aregheore, 2002). Ajayi *et al.* (2008)observed that intercropping or supplementing Guinea grass with legumes increased Ca, P, Na and Fe solubility.

2.10 Effects of Concentrate on Ruminants

2.10.1 Nutrients intake

The incorporation of concentrates in ruminant diets is intended to increase the energy, proteins, minerals, and vitamins intake of the animal. The feed utilization, productive efficiency, and the fibre digestion may depend on the nature of the concentrate (Morand-Fehr and Sauvant, 1987).Aregheore (2003) reported a positive effect on the utilisation of *Panicum maximum* as a result of concentrate supplementation. Increasing the level of concentrate from 30% to 50% exerted a positive influence on growth performance, ruminal fermentation, and blood metabolites (Lima *et al*., 2016). Desnoyers *et al.*(2008) reported that dry matter intake of dairy goats was increased (2.69 to 2.88 kg/d) with increasing the percentage of concentrate in the diet from 30% to 60% but Agle *et al.,* (2010) observed no change in dry matter intake of lactating dairy cows fed diets contained 52% and 72% concentrate feeds. Similarly, Cantalapiedra-Hijar *et al.* (2014) also observed that there is no change in dry matter intake ass percentage of concentrate increases from 30% to 70% in the diet of goats. Intake did not influence dry matter, organic matter, crude protein and nitrogen freeextract (Lima *et al*., 2016). According to Fadiyimu *et al.*(2010) Nitrogen intake did not influencefaecal Nitrogen significantly. Urine Nitrogen increased as Nitrogen intake increases (Ahamafule *et al.,* 2006). Nitrogen retained is a major determinant of the protein status of ruminant animals (Abdu *et al.,* 2012)

2.10.2 Nutrients digestibility

Gafaar *et al.* (2009) working onConcentrate to Roughage ratio in Egypt observed increased crude protein digestibility as Concentrate to roughage ratio was changed from 60:40 to 40:60. Although, crude fibre, ether extract, nitrogen free extract and total digestible nutrients decreased with an increase in concentrate. Sanh *et al.*(2012) also observed a significantly lower crude fibre digestibility as concentrate was increased. Dry matter and organic matter were observed to decrease as forage to concentrate ratio was increased (Youngjun *et al.,* 2017).

2.10.3 Rumen pH

Long-term feeding of a high-concentrate diet causes a decreased ruminal pH value due to the accumulation of volatile fatty acids (VFA) and lactic acid, and a chronic digestive disorder known as subacute ruminal acidosis may occur (Lima *et al*., 2016). Therefore, determining the appropriate concentrate level is one of the most important factors for improved production. Low concentrate diets have higher ruminal pH as compared to diets with higher amounts of concentrates with large amounts of starch yielding greater lactic acid concentrations (Slyter, 1976).

2.11 Forage Conservation as Hay

Hay is the oldest and still the most important method of fodder conservation, despite its dependence on suitable weather at harvest time. It can be made with simple equipment, manually or with mechanization, and many small-scale farming systems make hay to assure livestock feed through the lean season. Haymaking involves reducing the moisture content of cut herbage in the field from an initial 70 - 90% to 15 - 20% - simple in theory, but very dependent on the weather and demanding skill and judgement from the farmer. Hay is classed as a roughage, i.e., a feed with over 18% crude fibre and under 16% crude protein (Aduku,2012) in its dry matter (DM); in practice, most hays

have a feeding value well below these levels. It is rarely a complete feed and must be used as part of an overall feeding system. Natural drying of mown herbage by sun and wind is still the commonest way of conserving fodder, natural grass and crop residues; auxiliary artificial drying is used, occasionally, in some of the more highly mechanized systems. Hay is the small-scale producer's best-conserved fodder since, in all but the most humid climates; it can be made with little equipment or costs other than labour. Drying, like other methods of conservation, reduces digestibility and intake, related to the time that the herbage is exposed to leaching and other losses in the field. Modern haymaking technology developed most rapidly in the colder, humid climates of the Northern Hemisphere, where a long winter limits the growing season and snow may for long periods prevent access to standing grass (Suttie, 2000).

2.11.1 Hay making

Haymaking turns green, perishable, forage into a product that can be safely stored and easily transported without danger of spoilage, while keeping losses of dry matter and nutrients to a minimum. This involves reducing its moisture content from 70 - 90% to 20 - 25% or less. Techniques for natural pasture, sown pasture and crops specifically cultivated for conservation at three levels of technology are considered: manual haymaking; simple mechanization with draught animal power or small tractors; and fully mechanized systems. Where hay is made from pasture, rather than arable crops, the fields may be both grazed and mown at different seasons of the year. If the main output of a field is hay, it will still be grazed when the weather is unsuitable, then left for the forage to reach the correct stage at the optimum season for haymaking; the aftermath may thereafter be grazed (Suttie, 2000).

Drying should be done as quickly as possible to minimize losses. At mowing, the herbage will contain between 70 and 90% of moisture, and this will have to be reduced

to between 12 and 20% before the hay can be stored safely. The safe moisture content will depend on a range of factors, including storage method; local climatic conditions; the size of stacks or bales (where the hay is to be stored) and the nature of the crop. As a very rough guide, 25% moisture is recommended as a maximum for long loose hay; 20% for chopped hay and 5% for pelleted, cured hay (Suttie, 2000).

2.11.2 Harvest and stage of growth

Pasture, natural or sown, will be managed, by grazing or taking silage cuts as necessary so that the herbage reaches a suitable stage for curing when good weather is expected. Where sown forage is to be cured, the crop will be chosen and its cultivation organized to match good haymaking weather. If a farm intends to make a lot of hay, consideration must be given to growing a range of species and cultivars to extend the season during which the various crops will be in peak condition for haymaking, and thus make the best use of the available equipment and labour. Herbage quality drops off rapidly with increasing maturity, especially after flowering, but very young, the leafy grass is less easy to handle than more mature herbage, and its yield is less.Geleti and Tolera (2003) and Okwori and Magani (2010) reported a decrease in crude protein and increase in the crudefibre of forages with age.

The time of harvest depends on the availability of suitable herbage and the weather pattern. The rest of the farming cycle and availability of labour and machinery of course also have a determining role. The aim is always to have both high-quality herbage and a high probability of suitable hay making weather coincide. Where there is an overall scarcity of forage, farmers may make hay even when the quality of the crop is poor. The time of day to start is equally weather dependent, but if the day dawns fair, it is best to mow as early as possible. If the crop is very wet due to previous rain or heavy dew, it

may be advantageous to wait an hour or two while the upper part of the crop dries somewhat, since standing grass will dry more quickly than a cut swath. Skerman and Riveros in (FAO, 1989) recommend waiting until the dew has dried. Early mowing allows the other operations, especially turning, to start early and increases the chances of having drying well advanced during the first day.

2.11.3 Hay storage

Stacks of loose material are the traditional method of storing large quantities of hay and apart from barn storage was the principal system on large as well as small farms until the introduction of the pick-up baler revolutionized commercial haymaking.

Once the hay has been field-dried to a suitable stage, it is carted to the stack-yard and built into stacks. The hay must be carefully built on to carts in the field and taken off in the same order as it was loaded. Skerman and Riveros (FAO, 1989) recommended stacking on a base of hardwood poles, but this will depend on availability and price. When building the stack, the centre must be tightly packed, otherwise, the stack will sag as it settles and rain may penetrate. The sides should slope outwards slightly to the eaves and the head thereafter rise gently to a point or ridge. Ropes or nets are used to protect the stacks against the wind. Thatching with coarse grass or straw is common in areas where rain is expected during storage. This should not be done immediately, because it is necessary to allow dissipation of heat and moisture following stacking (Suttie, 2000).

CHAPTER THREE

3.0 Materialsand Methods

3.1 EXPERIMENT I: Effects of Fertilizer Levels and Harvest Time on Yield and Nutritive Composition of *Panicum maximum* cv. Mombasa.

3.1.1 Location of the study area

The study was carried out at the Experimental Field of National Animal Production Research Institute, Shika, Kaduna State. Shika is located on Latitude 11^{o}12' N and Longitude 7^{o}33'E in the sub-humid zone of Nigeria (Ovimaps, 2016). The top soil (0-15cm) of the site has 15.5% Clay, 9.8 % Silt, 75.1% Sand, 5.4 pH, 0.1% N, 3.5 (ppm) Zn, 95.7(ppm) P 2.5 meq/100g Ca2+, 0.3 meq/100gK+ and 0.7meq/100g Mg2+ and 0.1 Meq/100g Na+ , respectively (Akpensuen, 2012).

3.1.2 Metrological data of the study area

Weather conditions of Shika and its environs during the experimental period (Raining season of 2016) are shown in Table 3.1. The maximum air temperature (35.16^{o}C) was recorded in May whereas the minimum (18.65^{o}C) was in October. Total annual rainfall of 906.40 mm was recorded in 2016. A total number of rain days in Shika were 76 days for 2016. The mean relative humidity and mean sunshine observed were 73.33% and 7.00 hours respectively.

Table 3.1: Weather observations at Institute for Agricultural Research (IAR) and environs during the experimental period

Months	Max. Air Temp. (^oC)	Min. Air Temp. (^oC)	*Rainfall (mm)	Relative Humidity (%)	Sunshine (Hours)
May	35.16	24.16	85.60 (7)	66.39	7.83
June	31.40	23.20	124.00 (12)	75.50	7.12
July	30.84	22.94	296.50 (20)	80.39	5.90
August	30.55	21.90	232.60 (20)	81.94	6.68
September	32.46	25.45	167.70 (17)	77.28	6.31
October	33.23	18.23	-	58.45	8.16
Total			906.40. (76)		
Mean	32.27	22.65	181.28(15.2)	73.33	7.00

Number of rainy days is in parenthesis.
Source: IAR, 2016
*Rainfall data sourced from Meteorological Station of National Animal Production Research Institute, 2016

3.1.3 Soil properties of the experimental site

Soil auger was used to collect samples from four corners and centre of the experimental site at about 15cm depth. Soil samples were collected before land preparation. The soil samples collected were bulked and a subsample taken to the Soil Science laboratory, Ahmadu Bello University, Zaria to determine its physical and chemical properties. Soil texture, particle size, total nitrogen, organic carbon, available phosphorus, soil pH, cations exchange capacity (CEC), electrical conductivity, calcium, magnesium, potassium, and sodium were analysed as described by A.E.S (1998).

3.1.4 Sources of Experimental materials and Experimental design

The *Panicum maximum*cv. Mombasa's seeds were sourced from the Feeds and Nutrition Research Programme of National Animal Production Research Institute, Shika, Zaria while the NPK fertilizer (15-15-15)was procured from Samaru Market, Zaria.

The field was ploughed, harrowed twice and levelled to provide a good seedbed for proper seed germination and seedlings establishment. The experiment was laid out in 4x3 factorial arrangements in Randomised Complete Block Design (RCBD) with 3 replicates (Blocks). The 2 factors were fertilizer levels (0, 200, 300 and 400 Kg/ha NPK 15-15-15) and harvest time (8, 10, and 12 weeks after planting, WAP). A total land area of 23.5 x 8m (188m^2) was used for the experiment. The field was divided into 3 blocks of 23.5 x 2m (47m^2) and 1m apart. Each block contains 12 experimental plot which were 1.5 x 2m (3m^2) at 0.5m apart. Seeds were drilled in rows 50cm apart in July 2016 at the rate 20kg/ha. The fertilizer was applied in two splits at 1 and 3 weeks after planting, applying half of the dose in each split. All plots were hand weeded twice at 3 and 5 weeks after planting. The forage was harvested at 12th week after planting.

3.1.5 Parameters measured

Data on leaf length, leaf width, leaf area index, tiller number, plant height and leaf number per plant were taken at 8, 10 and 12 weeks after planting while leaf to stem ratio and forage yield were determined at 8, 10 and 12 weeks after planting. Five (5) plants per plot were randomly selected and tagged for the various measurements according to the methods of Tarawali *et al.*, (1995).

3.1.5.1 Leaf length, leaf width and leaf area index

Leaf length was estimated by measuring from the tip of the leaf to the base of the ligule with the aid of a measuring tape while

the leaf width was determined by measuring the width of leaf half way or midpoint of the leaf length with the aid of measuring tape, all on the five randomly selected plants per plot. Leaf area index was calculated as the ratio of leaf area per plant multiplied by a factor (0.75) to the unit area of land covered by the plant (Watson, 1952).

$$LAI = \frac{\text{Leaf area per plant (cm)}\ x\ 0.75}{\text{Area of ground per plant (cm)}}$$

3.1.5.2 Stand count, tiller number, plant height and Leaf number

Stand count per plot was estimated at 10 days after planting. This was done by counting a number of plants within a $1m^2$ quadrant in each plot. Estimation of tiller number was carried out by counting the number of tillers within the five randomly selected plants per plot while the plant height was estimated by measuring plant from the base to the tip of youngest leave on the stem. This was done with the aid of a measuring tape on the same selected plants. Leaf number was estimated by counting the number of leaves in the 5 randomly selected plants.

3.1.5.3 Forage Yieldand Leaf to stem ratio

Sampling for yield estimation in each plot was carried out by cutting plants within a $0.5m^2$ quadrant with a sickle to the height of 10cm above the ground level. The samples were weighed as whole plant, leaf and stem components and thereafter dried in a unitherm oven at 80^oC for 48 hours and reweighed for estimation of yield. This was done at the 8th, 10th, and 12th week after planting.Leaf to stem ratio was determined by separating leaves from stems of forage samples obtained by cutting plants within a $0.5m^2$ quadrant with hand sickle to the height of 10cm above the ground level at 8, 10 and 12 weeks after planting. The samples were weighed and the proportions of each were calculated by weight as follows:

$$Percentage\ of\ leaf\ = \frac{weight\ of\ leaf}{weight\ of\ Sample} \times 100\ Percentage\ of\ stem$$

$$= \frac{weight\ of\ stem}{weight\ of\ Sample} \times 100$$

3.1.5.4 Hay preparation

At the end of the study,*Panicum maximum* cv. Mombasa was harvested with sickles in the afternoon when stem and leaves carbohydrates were at peak. The harvested forage materials were spread in a shade (for 8 days) so as to reduce the moisture content (to about 12 – 15%) before storing. Prior to storing, a small bunch of the forage stems were twisted so as to determine whether the forages were due for storage (if the stems are slightly bristle and there is no evidence of moisture on the twisted stems). The forages were later chopped to 1-5 cm size. The materials were then bagged in jute bags until required.

3.1.6 Chemical analysis

Proximate analyses were carried out using (AOAC, 2005) procedure to determine Dry matter (DM), Crude fibre (CF), Ether extract (EE), Ash and Nitrogen (N) which was then used to estimate Crude protein (CP) content of the forages. Nitrogen free extract was estimated by difference as % NFE = % DM - (% EE + % CP + % ash + % CF). Organic matter (OM) was also estimated by difference as OM = % DM - %Ash. The Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and lignin were determined according to methods of van-Soest *et al.*(1991). Calcium, Potassium, Sodium and Phosphorus contents of the forages were determined using atomic absorption spectrophotometer as described by AOAC (2005).

3.1.7 Statistical analysis

Data collected were subjected to the analysis of variance procedure using General Linear Model Procedure of SAS (2005) and where treatment Means differed significantly, they wereseparated using the Duncan's Multiple Range Test (DMR) (Duncan, 1955).

Below is the Experimental model used

$Y_{ijk} = \mu + A_i + B_j + (AxB)_{ij} + e_{ijk}$

Where:

Y_{ijk} = Independent variable.

μ = Overall mean.

A_i = Effect of fertilizer levels (i = 0, 200, 300 and 400kg NPK / ha).

B_j = Effect of Harvest time (j = 8, 10 and 12 weeks after planting).

$(AxB)_{ij}$= Effect of fertilizer levels by harvest time

e_{ijk} = Effect of random error.

3.2 EXPERIMENT II:Effects of Concentrate Inclusion Levels on NutrientIntake Digestibility and Nitrogen Utilisation in Red Sokoto Bucks Fed *Panicum maximum*cv. Mombasa Hay-based Diets.

3.2.1 Study area

The study was carried out at the Experimental Unit of the Teaching and Research Farm of Department of Animal Science, Ahmadu Bello University, Zaria. The farm is located at an elevation of 676m, latitude 11.16230 North and longitude 007.63530 East (GPS, 2016).

3.2.2 Sources of Experimental materials and Hay preparation

The Red Sokoto bucks were sourced from Lambar-Zango market along Zaria-Kaduna road (Open Market)and the ingredients for Concentrate formulations were procured from Samaru Market, Zaria.

3.2.3 Experimental animals and design

Red Sokoto bucks (12) with an average weight of 14.2±4kg were used in the study. The bucks were randomly assigned to four treatments balanced for weight with 3 bucks per treatment in a Completely Randomised Design (CRD). The four treatments were:

1. *Panicum maximum* cv. Mombasa hay based diet containing 15% Concentrate (T1)
2. *Panicum maximum* cv. Mombasa hay based diet containing 30% Concentrate (T2)
3. *Panicum maximum* cv. Mombasa hay based diet containing 45% Concentrate (T3)
4. *Panicum maximum* cv. Mombasa hay based diet containing 60% Concentrate (T4)

3.2.4 Experimental procedures and animals management

The experiment was carried out using the Methods of Osuji *et al.*,(1993). The experiment was carried out in March 2017, lasted for 21 days with 14 days adaptation period and 7 days collection period. The experimental animals were dewormed with Albendazole® at 1ml/10kg body weight while Ivermectin (*Ivomec*®) injection at 0.5ml/10kg body weight was used to treat the bucks against external parasites and mange. The animals were placed in an individual metabolic crate with different faecal and urine collection containers. The Concentrate and forages were prepared as Total mixed ration (TMR). The animals were fed at 3% of their body weight daily. The experimental diets were given daily at 08:00 hours and 16:00 hours. Clean drinking water was provided *ad libitum.* The composition of the experimental diets is shown in Table 3.2.

Table 3.2: Composition of the Experimental diets.

	Concentrate Inclusion Levels			
Ingredients	**15% (T1)**	**30% (T2)**	**45% (T3)**	**60% (T4)**
Maize offal	0.40	8.00	15.50	20.00
Cotton Seed Cake	12.10	15.00	15.00	16.00
Rice offal	0.50	5.00	12.50	22.00
Bone meal	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50
Mombasa Hay	85.00	70.00	55.00	40.00
Total	100	100	100	100
Calculated Analyses				
%Crude protein	14	14	14	14
ME:Kcal/kg	2062	2296	2349	2453
Cost/kg (₦)	59.48	63.41	66.96	70.03

3.2.5 Data collection

Initial and final weights of the experimental animals were taken on day 1 and day 21 of the experiment. Amount of feed offered daily was recorded. Samples of feed offered from day 15 to 21 were collected. Feed left over, faeces and urine were collected and measured daily during the collection period. A sample (10%) of the daily faecal output was takendaily to the laboratory for DM determination. The daily total faecal output collected during the 7 days collection period was bulked and a subsampled for analysis. Daily total urine was collected in a container with 10 ml 0.1M H_2SO_4so as to lower the pH to about 3 in order to prevent nitrogen loss. Twenty (20) ml urine sample was taken daily and stored in a refrigerator at -20^oC until when needed for analysis.

3.2.6 Chemical analysis

Dry matter (DM), Crude fibre (CF), Ether extract (EE) and Ash of samples of dietary treatment, Concentrate and faeces were determined using different procedures as described by (AOAC, 2005). Nitrogen (N) which was used to estimate Crude protein (CP) was determined using Kjeldahl procedure as described by (AOAC, 2005). Acid detergent fibre (ADF), Neutral detergent fibre (NDF) and lignin were determined using Methods of Van-Soest *et al.*(1991). Nitrogen free extract and Organic matter (OM) were estimated by difference as

% NFE = % DM - (% EE + % CP + % ash + % CF) and

% OM = %DM - % ash respectively.

Urine Nitrogen was also determined using the Method of AOAC (2005).

Alderman (1985) formula was used to estimate the metabolisable energy as

ME (MJ/kg DM) = 11.78 + 0.00654CP + $(0.000665EE)^2$ – CF (0.00414EE) -0.0118A

Where: A= Ash, CP= Crude protein, EE= Ether extract, CF= Crude fibre.

3.2.7 Statistical analysis

Data collected on nutrient intake, nutrient digestibility and nitrogen utilisation from the experiment were subjected to Analysis of Variance using General Linear Model Procedure (Proc. GLM) of SAS (2005) and where significant differences were observed, treatment means were separated by Duncan's Multiple Range Test (Duncan, 1955) of the SAS package.

The following formulae were used to calculate the Average daily dry-matter intake and apparent dry-matter digestibility:

Average daily dry matter intake $= A - B$

Apparent dry matter digestibility $= \frac{(A - B - C)}{A - B} \times 100$

Where:

A = average dry matter offered daily.

B = average dry matter refused daily.

C = average dry matter voided in faeces daily

(Osuji *et al.*,1993)

Nutrient Digestibility $= \frac{Nutrient\ \ intake - Nutreint\ \ in\ faeces}{Nutrient\ \ intake}$

Below is the Experimental Model used

$Y_{ij} = \mu + D_i + e_{ij}$

Where:

Y_{ijk} = Independent variable.

μ = Overall mean.

T_i = Effect of treatment diets (i =Diet containing 15, 30, 45, 60% Concentrate).

e_{ij} = Effect of random error.

CHAPTER FOUR

4.0 Results

4.1 EXPERIMENT I: Effects of Fertilizer Levels and Harvest Time on Yield and Nutritive Composition of *Panicum maximum* cv. Mombasa.

4.1.1 Soil characteristics of the study area

Table 4.1 presents information on the physiochemical characteristics of the soil of the experimental site at 0-15cm. The soil consists of 16% clay, 30% silt and 54% sand. It is a sandy loam soil. The soil is acidic with pH and Organic carbon of 5.50 and 0.67% respectively. The Nitrogen content of the soil was 0.175% while the available phosphorus was 23.28ppm. The exchangeable cations present in the soil are $Ca^{2+,}$ $Mg^{2+,}$ K^{+} and Na^{+}. The soil has cation exchange capacity, exchangeable acidity and electrical conductivity of 8.70cmol/kg, 0.80cmol/kg and 0.070dsm respectively.

Table 4.1: Physical and chemical properties of soil of the Experimental area.

Soil Properties	0-15 soil depth
Physical Properties :	
Particle size (%)	
Clay	16
Sand	54
Silt	30
Textural class	Sandy Loam
Chemical Properties:	
Total Nitrogen (%)	0.175
Organic carbon (%)	0.67
Available phosphorus (ppm)	23.28
pH H_2O	5.50
pH (0.01M $CaCl_2$)	4.80
Exchangeable Cation (meq/100g of soil):	
Ca^{2+}	4.0
Mg^{2+}	1.50
K^+	0.64
Na^+	0.32
Exchangeable acidity (H-Al^{3+}):	0.80
Cation Exchangeable Capacity (CEC)	8.70
Electrical conductivity (dsm)	0.070

4.1.2 Growth parameters of *Panicum maximum* cv.Mombasa

4.1.2.1 Effects of fertilizer levels on growth parameters

The effects of fertilizer rates on plant height (PH), leaf length (LL), leaf width (LW), leaf number (LN), tiller number (TN) and leafarea index (LAI) of *Panicum maximum* cv. Mombasa is shown in Table 4.2. Plant height was highest at treatment with 300kg/ha NPK (133.7cm) while the other treatments were statistically similar. Leaf length was lower (46.1cm) in the control (0 kg/ha NPK) than the other treatments which were similar statistically ($P>0.05$). Leaf width followed the same trend as leaf length. Treatments with 200, 300, and 400kg/ha NPK had leaf width of 2.3cm, 2.4cm, and 2.4cm respectively. Leaf number varied significantly ($P<0.05$) from 33.3 in treatmentwith 200kg/ha NPK to 70.3 in treatment with 300kg/ha NPK. Treatment with 0 and 400 kg/ha NPK had statistically similar leaf number. Tiller number ranged from 22 in treatment with 400kg/ha NPK to 12 in both treatment with 0 and 200kg/ha NPK. Leaf area index was highest at treatments with 300 and 400kg/ha NPK (7) while the control (4.8) had the least leaf area index.

4.1.2.2 Effects of harvest time on growth parameters

The effects of harvest time on plant height, leaf length, leaf width, leaf number, tiller number and leafarea index of *Panicum maximum* cv. Mombasa is presented in Table 4.2. Plant height differed significantly ($P<0.05$) across the periods measured (8, 10, and 12 weeks after planting). It was highest at 12 weeks (215.8cm) and lowest at 6 weeks (40.6cm) after planting. Plant height increased with age which is natural in all grasses as they grow taller with age. Leaf length increased significantly ($P<0.05$) from 6 (37.1cm) and reached its peak at 8 weeks after planting (70cm). It decreased ($P<0.05$) thereafter to 42.6cm at 12 weeks after planting. Leaf width was at its peak at 8 and 10 weeks after

planting (2.6cm) while the narrowest leaves were recorded at 6 weeks after planting (1.6cm). Highest tiller number (23) was observed at 8 weeks after planting, it then decreased ($P<0.05$) to 18 and 14 tillers at 10 and 12 weeks after planting respectively. Leaf number followed exactly the same trend as leaf width. It ranged from 23.2 – 65 leaves per plant. Leaf area index reaches its peak at 8 (7.1) and 10 (7.6) weeks after planting and then decreased ($P<0.05$) to 5.4 at 12 weeks after planting. All interactions between fertilizer levels and weeks after planting were not significant ($P>0.05$).

Table 4.2: Effects of fertilizer rates and harvest time on growth parameters of *Panicum maximum* cv. Mombasa.

Treatment	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf number	Tiller number	Leaf area index
Fertilizer Levels						
0 kg/ha	105.80^{b}	46.10^{b}	2.20^{b}	47.50^{b}	12.00^{c}	4.80^{c}
200 kg/ha	120.90^{a}	54.00^{a}	2.30^{a}	33.30^{c}	12.00^{c}	6.30^{b}
300 kg/ha	133.70^{a}	51.30^{a}	2.40^{a}	70.30^{a}	15.00^{b}	7.00^{a}
400 kg/ha	120.20^{a}	55.70^{a}	2.40^{a}	41.00^{b}	22.00^{a}	7.00^{a}
SEM	4.85	2.88	0.08	4.53	1.30	0.50
LOS	*	*	*	*	*	*
Weeks After Planting						
6 weeks	40.60^{d}	37.10^{c}	1.60^{c}	23.20^{c}	5.00^{d}	4.50^{b}
8 weeks	82.70^{c}	70.00^{a}	2.60^{a}	57.90^{a}	23.00^{a}	7.10^{a}
10 weeks	141.40^{b}	55.40^{b}	2.60^{a}	65.00^{a}	18.00^{b}	7.60^{a}
12 weeks	215.80^{a}	42.60^{c}	2.40^{b}	46.00^{b}	14.00^{c}	5.40^{b}
SEM	4.85	2.88	0.08	4.53	1.30	0.50
LOS	*	*	*	*	*	*
Interaction						
FxW	NS	NS	NS	NS	NS	NS

^{a,bc} Mean values with different superscripts within a column differed significantly (P<0.05), SEM: Standard error of means, LOS: Level of significance, *: Significant at P<0.05, FxW: Interaction between fertilizer and weeks after planting, NS : Not significant at P>0.05

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4.1.3 Forage yield of *Panicum maximum*cv. Mombasa

4.1.3.1 Effects of fertilizer levels on fresh and dry matter yields of Panicum maximum cv. Mombasa

Stand count and effects of fertilizer levels on total fresh weight (TFW), leaf fresh weight (LFW), stem fresh weight (SFW), total dry matter (TDM), leaf dry matter (LDM), stem dry matter (SDM) and Leaf to stem ratio are shown in Table 4.3. Treatment 2 and 4 had the highest ($P<0.05$) standof 23 and 21 plants/m^2 respectively while the control (0kg/ha NPK) (17) and treatment with 300kg/ha NPK (15) had similar stand count. Forage yields significantly changed as fertilizer levels were increased. Total fresh weight (TFW), leaf fresh weight (LFW), stem fresh weight (SFW) and total dry matter (TDM) followed the same trend. In these parameters, all treatments with fertilizer (treatments with 200,300 and 400 kg/ha NPK) were at par but were higher ($P<0.05$) than the control. In total fresh weight (TFW), treatment with 200, 300 and 400 kg/ha NPK had 16.00 tonnes/ha, 16.40 tonnes/ha and 17.60 tonnes/ha respectively while it corresponding dry matter (Total dry matter) are 3.80 tonnes/ha, 4.00 tonnes/ha and 4.20tonnes/ha. Treatment with 300kg/ha (2.20 tonnes/ha), 400kg/ha (2.20 tonnes/ha) and 200kg/ha NPK (1.90 tonnes/ha) had the highest leaf dry matter (LDM) while the control (1.30 tonnes/ha) was the lowest. Fertilizer application influenced stem dry matter (SDM). Treatments with 200 and 400 kg/ha NPK did not differ significantly ($P>0.05$) but were higher than the control (1.4 tonnes/ha) whereas treatment with 300kg/ha NPK (1.70 tonnes/ha) was similar ($P>0.05$) to the control.Leaf to stem ratio in all the treatments was at par. The values for the leaf to stem ratios ranged from 1.3 in treatment with 300kg/ha NPK to 0.9 in the control and treatment with 200kg/ha NPK.

4.1.3.2 Effects of harvest time on fresh and dry matter yields of Panicum maximum cv. Mombasa

Effects of harvest time on total fresh weight (TFW), leaf fresh weight (LFW), stem fresh weight (SFW), total dry matter (TDM), leaf dry matter (LDM), stem dry matter (SDM) and Leaf to stem ratio are presented in Table 4.3. All forage yields increased significantly ($P<0.05$) with harvest time. Total fresh weight (TFW) values ranged from 8.60 tonnes/ha at week 8 to 21.00 tonnes/haat week 12 after planting.Leaf fresh weight (LFW) and leaf dry matter (LDM) followed the same trend. Harvest at 10 and 12 weeks after planting were similar and higher ($P<0.05$) than that at 8 weeks after planting. Leaf fresh weight (LFW) was highest at 10th and 12th week after planting (9.20 and 8.80 tonnes/ha respectively) whereas leaf dry matter (LDM) was lowest at 8th week after planting (1.10 tonnes/ha). Leaf to stem ratio was influenced by harvest time. It decreased as the grass matures from 8 to 12 weeks after planting. Leaf to stem ratio was highest at 8th week (3.1) and lowest at 12th week after planting. Stem fresh weight (SFW) values were 2.70tonnes /ha, 6.20 tonnes/ha and 12.20 tonnes/ha at 8, 10 and 12 weeks after planting respectively. Total dry matter (TDM) significantly ($P<0.05$) increased from 1.5 tonnes/ha at 8th week to 584.1kg/ha at 12th week after planting. The interactions between fertilizer levels and harvest time were not significant ($P>0.05$).

Table 4.3: Effects of fertilizer levels on forage yield (Tonnes/ha) of *Panicum maximum* cv. Mombasa

Treatment	Stand count/m^2	TFW	LFW	SFW	TDM	LDM	SDM	L:S RATIO
Fertilizer Levels								
0 kg/ha	17^{b}	9.90^{b}	6.00^{b}	3.80^{b}	2.30^{b}	1.30^{c}	1.40	0.90
200 kg/ha	23^{a}	16.00^{a}	8.00^{a}	8.00^{a}	3.80^{a}	1.90^{b}	2.00	0.90
300 kg/ha	15^{b}	16.40^{a}	9.30^{a}	7.10^{a}	4.00^{a}	2.20^{a}	1.70	1.30
400 kg/ha	21^{a}	17.60^{a}	8.50^{a}	9.10^{a}	4.20^{a}	2.20^{a}	2.00	1.10
SEM	1.20	3.00	0.90	1.50	0.70	0.25	0.25	0.25
LOS	*	*	*	*	*	*	NS	NS
Weeks After Planting								
8 weeks		8.60^{c}	6.00^{b}	2.70^{c}	1.50^{c}	1.10^{b}	0.40^{c}	3.10^{a}
10 weeks		15.40^{b}	9.20^{a}	6.20^{b}	3.30^{b}	2.00^{a}	1.30^{b}	1.60^{b}
12 weeks		21.00^{a}	8.80^{a}	12.20^{a}	5.80^{a}	2.50^{a}	3.60^{a}	0.70^{c}
SEM		2.60	1.20	1.70	0.80	0.30	0.40	0.40
LOS		*	*	*	*	*	*	*
Interaction								
FxW		NS	NS	NS	NS	NS	NS	NS

[a,bc] Mean values with different superscripts within a column differed significantly (P<0.05), SEM: Standard error of means, LOS: Level of significance, *: Significant at P<0.05, NS: Not significant at P>0.05, FxW: Interaction between fertilizer and weeks after planting. TFW:Total fresh weight, LFW: Leaf fresh weight, SFW: Stem fresh weight, TDM: Total dry matter, LDM: Leaf dry matter, SDM: Stem dry matter.

4.1.4 Proximate composition of *Panicum maximum* cv.Mombasa

4.1.4.1 Effects of fertilizer levels on chemical composition of Panicum maximum cv. Mombasa

The response of *Panicum maximum*cv. Mombasa to varied fertilizer levels (0, 200, 300, 400kg/ha) and harvest time (8, 10, and 12 weeks after planting) is presented in Table 4.4. Fertilizer levels did not significantly (P>0.05) affect DM, OM, Ash, and NFEcontent of Mombasa.Crude protein increased with increasing fertilizer rates. It differed significantly (P<0.05) in all the 4 treatments. It was highest at treatment with 400kg/ha NPK (11.66%) and lowest at the control (0kg/ha NPK) (7.83%). Crude fibre followed the opposite trend observed in crude protein. It decreased as fertilizer rates increased. The control (36.94%) had the highest CF while treatment with 400kg/ha NPK had the lowest (33.96%). Fertilizer application influenced ether extracts content of *Panicum maximum* cv.Mombasa. Treatment with 300kg/ha NPK (2.03%) and 400kg/ha NPK(2.10%) were similar and higher (P<0.05) than the control (1.66%) and treatment with 200kg/ha NPK (1.72%).

4.1.4.2 Effects of harvest time on chemical composition of Panicum maximum cv. Mombasa

Results of the effects of harvest time on the chemical composition of *Panicum maximum* cv. Mombasa is shown in Table 4.4**.** Time of harvest influenced all the nutrient contents of the forage determined except ether extracts. Dry matter was highest at 8 (94.14) and lowest at 10 (93.72%) and 12 (93.35%) weeks after planting respectively. Organic matter of the grass followed the same trend as dry matter, it was higher at week 8 (85.8%) while that of week 10 and 12 were at par and lower. The study revealed that Crude protein decreased (P<0.05) from 10.29% at 8 to 10.10% at 10 weeks after planting and least at 12th week after planting (9.24%). Crude fibre content

increased (P<0.05) with age of the forage. Maximum CF recorded in the study was at 12th week (36.01%). CF at 8th and 10th week after planting was at par. Ash content of *Panicum maximum* cv.Mombasa was higher (P<0.05) at 10 and 12 weeks after planting than at 8 weeks after planting. Harvest time did not influence ether extracts (EE) content of the forage. Nitrogen free extracts **(**NFE**)** was significantly higher (P<0.05) at week 8 (38.34%); and lower at 8 and 12th week after planting which were at par.

Table 4.4: Effects of fertilizer rates and harvest time on chemical composition (%) of *Panicum maximum* cv. Mombasa.

Treatment	DM	OM	CP	CF	EE	Ash	NFE
Fertilizer Levels							
0 kg/ha	93.68	84.25	7.83^{d}	36.94^{a}	1.66^{b}	9.43	37.82
200 kg/ha	93.53	84.37	9.57^{c}	36.46^{a}	1.72^{b}	9.16	36.62
300 kg/ha	93.78	84.53	10.43^{b}	34.96^{b}	2.03^{a}	9.25	37.11
400 kg/ha	93.94	84.37	11.66^{a}	33.96^{c}	2.10^{a}	9.57	36.65
SEM	0.29	0.29	0.25	0.24	0.15	0.25	0.65
LOS	NS	NS	*	*	*	NS	NS
Weeks After Planting							
8 weeks	94.14^{a}	85.8^{a}	10.29^{a}	35.16^{b}	2.01	8.34^{b}	38.34^{a}
10 weeks	93.72^{b}	84.41^{b}	10.10^{b}	35.58^{b}	1.89	9.31^{a}	36.84^{b}
12 weeks	93.35^{b}	83.69^{b}	9.24^{c}	36.01^{a}	1.74	9.66^{a}	36.70^{b}
SEM	0.28	0.42	0.80	0.32	0.33	0.33	0.77
LOS	*	*	*	*	NS	*	*
Interaction							
FxW	NS	NS	NS	NS	NS	NS	NS

^{a,bc} Mean values with different superscripts within a column differed significantly, SEM: Standard error of means, LOS: Level of significance, *:Significant at P<0.05, NS: Not significant at P>0.05, FxW: Interaction between fertilizer and weeks after planting, DM: Dry matter, OM: Organic matter, CP:Crude protein, CF: Crude fibre, EE: Ether extract, NFE:Nitrogen free extract.

4.1.5 Fibre fraction of *Panicum maximum* cv. Mombasa

4.1.5.1 Effects of fertilizer levels on Fibre fraction of Panicum maximum cv. Mombasa

The fibre content of *Panicum maximum*cv. Mombasa, as influenced by fertilizer levels, is presented in Table 4.4. Acid detergent fibre (ADF) decreased as fertilizer rates increased. The control (29.74%) had the highest($P<0.05$) ADF, treatments with 0 and 200 kg/ha NPK were similar whereas treatment with 400kg/ha NPK(28.01%) had the lowest ADF content. Neutral detergent fibre (NDF) followed a trend opposite to ADF. Fertilizer levels did not significantly ($P>0.05$) affect the lignincontent of *Panicum maximum* cv.Mombasa.

4.1.5.2 Effects of harvest time on fibre fraction of Panicum maximum cv. Mombasa

Table 4.5 indicated results of the response of Acid detergent fibre (ADF), Neutral detergent fibre (NDF) and lignin contents of Mombasa grass to harvest time. ADF was not influenced by harvest time but NDF and lignin content of the forage showed some significant changes. The NDFpercentages differed significantly ($P<0.05$) from 50.48% at 12th week to 49.52% and 49.18% at 10th and 8th week after planting respectively. The result from this study indicated that the lignin content of the grass increased with age. Although lignin at week 10 (21.55%) and 12 (21.68%) were not statistically ($P>0.05$)different but were higher than that at week 8 (20.96%).

Table 4.5: Effects of fertilizer levels and harvest time on fibre fraction (%) of *Panicummaximum* cv. Mombasa

Treatment	ADF	NDF	Lignin
Fertilizer Levels			
0 kg/ha	29.74[a]	48.62[c]	21.68
200 kg/ha	29.01[b]	49.70[b]	21.44
300 kg/ha	28.76[b]	49.80[b]	21.29
400 kg/ha	28.01[c]	50.77[a]	21.21
SEM	0.25	0.28	0.48
LOS	*	*	NS
Weeks After Planting			
8 weeks	29.14	49.18[b]	20.96[b]
10 weeks	28.94	49.52[b]	21.55[a]
12 weeks	28.56	50.48[a]	21.68[a]
SEM	0.22	0.37	0.63
LOS	NS	*	*
Interaction			
FxW	NS	NS	NS

[a,bc] Mean values with different superscripts within a column differed significantly, SEM: Standard error of means, LOS: Level of significance, *: Significant at P<0.05, NS: Not significant at P>0.05, FxW: Interaction between fertilizer and weeks after planting, ADF: Acid detergent fibre, NDF:Neutral detergent fibre.

4.1.6 Mineral content of *Panicum maximum* cv.Mombasa

4.1.6.1 Effects of fertilizer levels on mineral content of Panicum maximum cv. Mombasa

Table 4.6 presents the response of mineral content of *Panicum maximum* cv. Mombasa to varied fertilizer levels. Phosphorus and Potassium contents were significantly affected by fertilizer application. The control (0kg/ha NPK) had the lowest (1.46g/kg) Phosphorus content. The Phosphorus content did not differ ($P>0.05$) in treatments with 200, 300 and 400kg/ha NPK. The Potassium content of *Panicum maximum*cv. Mombasa increased significantly ($P<0.05$) as fertilizer levels increased. It increased from 4.73g/kg in the controlto 8.42g/kg at treatment with 400kg/ha NPK. Fertilizer levels did not significantly ($P>0.05$) affected Sodium and Calcium content of *Panicum maximum* cv.Mombasa.

4.1.6.2 Effects of harvest time on mineral content of Panicum maximum cv. Mombasa

Results of effects of harvest time on mineral content of Mombasa are presented in Table 4.6. Harvest time had no significant ($P>0.05$) effect on all the minerals content (Phosphorus,Potassium, Calcium, and Sodium) of Mombasa. Values for Phosphorus ranged from 1.17 – 1.85 g/kg. Potassium content was 6.49 g/kg at week 8 and 6.73g/kg at week 12. Calcuim content values ranged from 1.33-1.37g/kg while Sodium content of the forage ranged from 1.06 – 1.26g/kg. All interactions between fertilizer levels and harvest time were not significant ($P>0.05$).

Table 4.6: Effects of fertilizer levels and harvest time on mineral content (g/Kg) of *Panicum maximum* cv. Mombasa.

Treatment	P	K	Ca	Na
Fertilizer Levels				
0 kg/ha	1.46[b]	4.73[d]	1.31	1.13
200 kg/ha	1.70[a]	6.23[c]	1.34	1.16
300 kg/ha	1.75[a]	7.12[b]	1.38	1.14
400 kg/ha	2.02[a]	8.42[a]	1.38	1.15
SEM	0.25	0.25	0.30	0.28
LOS	*	*	NS	NS
Weeks After Planting				
8 weeks	1.85	6.49	1.33	1.26
10 weeks	1.17	6.66	1.35	1.12
12 weeks	1.63	6.73	1.37	1.06
SEM	0.44	0.33	0.31	0.33
LOS	NS	NS	NS	NS
Interaction				
FxW	NS	NS	NS	NS

[a,bc] Mean values with different superscripts within a column differed significantly (P<0.05), SEM: Standard error of means, LOS: Level of significance, *: Significant at P<0.05, NS: Not significant at P>0.05, FxW: Interaction between fertilizer and weeks after planting, P: Phosphorus, K: Potassium, Ca: Calcium, Na: Sodium.

4.2 EXPERIMENT II:Effects of Concentrate Inclusion Levels on NutrientIntake, Digestibility and Nitrogen Utilisation in Red Sokoto Bucks Fed *Panicum maximum*cv. Mombasa Hay-based Diets.

4.2.1 Chemical composition and metabolisable energy of the experimental diets fed to growing Red Sokoto bucks.

The chemical compositions of the experimental diets are presented in Table 4.7. The dry matter (DM) of the diets ranged from 95.15 – 95.50%. Organic Matter (OM) was similar across the treatments, though Treatment 2 (15% Concentrate) had the lowest OM (87.80%). Ash content of the diets varied from 6.16% in Treatment 4 to 7.70% in Treatment 2. Treatment 1 had higher Ether extract (25.50%) than the other Treatments. The EE was 25.00, 23.28 and 20.40% in Treatment 2, 3 and 4 respectively. Crude protein (CP) content of the experimental diets was similar across the Treatments. It was 13.25, 13.90, 13.00 and 14.15% in Treatments 1, 2, 3 and 4 respectively. Crude fibre (CF) was highest in Treatment with 15% Concentrate (31.10%) and lowest in Treatment with 60% Concentrate (24.90%). Nitrogen free extract (NFE) % in the experimental diets ranged from 17.13% to 29.39% in Treatments 1 and 4 respectively. Treatment 1 had the highest lignin content (19.87%) while the lowest lignin content was recorded in Treatment 4 (14.29%). Treatment 1 recorded the highest Acid detergent fibre (ADF) content and lowest Neutral detergent fibre (NDF) as 35.33 % and 39.80% respectively. The metabolisable energy of the diets was similar. The metabolisable energy was 8.51, 8.94, 9.17 and 9.7MJ/Kg in Treatment 1, 2, 3 and 4 respectively.

Table 4.7: Chemical composition and Metabolisable energy of the Experimental diets

	Concentrate Inclusion Levels			
Parameters (%)	**15%(T1)**	**30%(T2)**	**45%(T3)**	**60%(T4)**
Dry matter	95.15	95.50	95.45	95.00
Organic matter	88.98	87.80	88.85	88.84
Ash	6.17	7.70	6.60	6.16
Ether extract	25.50	25.00	23.28	20.40
Crude protein	13.25	13.90	13.00	14.15
Crude fibre	31.10	27.40	27.20	24.90
Nitrogen free extract	17.13	21.20	25.37	29.39
Lignin	19.87	16.06	16.47	14.29
Acid detergent fibre	35.33	31.50	29.97	28.15
Neutral detergent fibre	39.80	47.03	48.97	52.56
Metabolisable Energy (ME:MJ/Kg)	8.51	8.94	9.17	9.70

4.2.2 Nutrient intake

Table 4.8 represents the nutrient intake of the bucks in the study. Dry matter intake was similar (P>0.05) in bucks fed diet containing 30% Concentrate inclusion (347.64 g/day) and 60% Concentrate inclusion (350.82 g/day) which were significantly (P<0.05) higher than bucks fed diet containing 15% (335.29 g/day) and 45% (338.30 g/day)Concentrate inclusion. Bucks in fed treatment 4 (60%) had the highest OM intake (328.07 g/day) while the other treatment were significantly (P>0.05) similar. The ether extract was statistically similar in treatment with 15% (93.38g/Day) and 30% (92.10g/Day)Concentrate inclusion, Bucks fed treatment 3 (45%) was 82.53g/day while those fed treatment 4 recorded 75.33g/day.Highest NFE intake (108.53 g/day) was recorded in bucks fed diet containing 60% Concentrate whereas the other treatments were statistically (P>0.05) similar. The highest Crude protein intake value was recorded in bucks fed treatment 4 (52.25 g/day) and the lowest was in those fed treatment 2 (46.09 g/day). Though, treatment 1 (15%) and 2 (30%) did not differ significantly (P>0.05) but treatment 3 (45%) and 4 (60%) were similar. Crude fibre intake was statistically similar (P>0.05) in bucks fed diet containing 15% (110.26 g/day), 30% (99.02 g/day) and 45% (96.55 g/day) and these were significantly (P<0.05) higher than bucks fed diet with 60% Concentrate (91.95 g/day) recorded the least CF intake. Acid detergent fibre intake was highest in bucks fed diet with 15% Concentrate (124.50 g/day and lowest in bucks fed 60% Concentrate.Bucks fed diet with 30% Concentrate (114.68 g/day) were significantly (P<0.05) higher than those fed diets with 45% (106.25 g/day) and 60% (103.95 g/day)Concentrate. Nutrient detergent fibre intake was highest in bucks feddiet containing 60% Concentrate (194.10 g/day) and least in bucks fed diet containing 15% Concentrate (140.25g/day). Treatment 2 (30%) and 3 (45%) were statistically (P>0.05) similar.

Table 4.8: Nutrients intake of Red Sokoto bucks fed graded levels of concentrate in *Panicummaximum* cv. Mombasa based diet.

	Concentrate Inclusion Levels					
Parameter (%)	**15% (T1)**	**30%(T2)**	**45%(T3)**	**60%(T4)**	**SEM**	**LOS**
Dry matter	335.29[b]	347.67[a]	338.39[b]	350.82[a]	4.11	*
Organic matter	313.55[b]	319.63[b]	314.99[b]	328.07[a]	5.26	*
Ether extract	93.38[a]	92.10[a]	82.53[b]	75.33[c]	3.01	*
Crude protein	46.69[b]	46.09[b]	50.60[a]	52.25[a]	2.01	*
Crude fibre	110.26[a]	99.02[a]	96.55[a]	91.95[b]	2.08	*
Nitrogen free extract	76.92[b]	77.91[b]	76.12[b]	108.53[a]	5.68	*
Acid detergent fibre	124.50[a]	114.68[b]	106.25[c]	103.95[c]	3.57	*
Neutral detergent fibre	140.25[c]	171.21[b]	173.61[b]	194.10[a]	6.11	*

[abc] Means with different superscripts within a row differed significantly (P<0.05), SEM: Standard error of means, LOS: Level of significance, *:Significant at P<0.05

4.2.3 Nutrient digestibility

The results for apparent nutrients digestibility are presented in Table 4.9. Crude protein (CP), Dry matter (DM), Nitrogen free extract (NFE), Neutral detergent fibre (NDF) and Acid detergent fibre (ADF) followed the same trend (Highest digestibility values were recorded in bucks fed diet with 60% Concentrate inclusion level).

Crude protein (CP) digestibility was significantly higher ($P<0.05$) (81.77%) in bucks fed 60% Concentrate inclusion than the other Treatments. The CP digestibility in bucks fed 15, 30 and 45% Concentrate inclusion were 69.58, 69.62 and 73.09% respectively. Bucks in 30% Concentrate inclusion recorded the highest Crude fibre (CF) digestibility (84.59%) whereas those in Treatment with 60% Concentrate inclusion level recorded the least digestibility (68.74%). Treatments with 30% (61.72%) and 45% (62.30%) Concentrate inclusion levels did not differ significantly ($P>0.05$) in Acid detergent fibre (ADF) digestibility. Bucks fed 60%Concentrate inclusion had the highest(66.10%) value whilethose fed 15% recorded the lowest (56.08%) in ADF digestibility. The results showed that Nitrogen free extracts (NFE) digestibility ranged from 30.72% in bucks fed 15% Concentrate inclusion to 57.60% in bucks fed 60% Concentrate inclusion. The highest Neutral detergent fibre (NDF) digestibility value was recorded in the 60% Concentrate inclusion (81.35%) which is significantly ($P<0.05$) higher than the other Treatments. NDF digestibilities were 67.91, 71.04 and .82% in Treatments 1 (15%), 2 (30%) and 3 (45%) respectively which were not significantly ($P>0.05$) different but significantly lower than NDF digestibility in 60% Concentrate inclusion level. Dry matter (DM) digestibility was highest in Treatment with 60% Concentrate inclusion (75.21%) and lowest in Treatment with 15% Concentrate inclusion (63.76%) and Treatment with 45% Concentrate inclusion (63.97%). Ether extract (EE) digestibility increased with increasing levels of Concentrate. For Ether extracts

digestibility, bucks on 45% and 60% inclusion level were not significantly different but were significantly higher than those on 15% and 30% inclusion levels which were at par.

Table 4.9: Nutrients digestibility of Red Sokoto bucks fed graded levels of concentrate in *Panicum maximum* cv. Mombasa based diet.

Parameters (%)	Concentrate Inclusion Levels					
	15%(T1)	30%(T2)	45%(T3)	60%(T4)	SEM	LOS
Dry matter	63.76^{c}	66.50^{b}	63.97^{c}	75.21^{a}	1.16	*
Organic matter	64.60^{b}	66.23^{b}	64.78^{b}	75.32^{a}	3.97	*
Ether extract	79.73^{b}	78.45^{b}	80.33^{a}	85.08^{a}	2.76	*
Crude protein	66.58^{c}	69.62^{b}	73.09^{b}	81.77^{a}	2.76	*
Crude fibre	77.47^{b}	84.59^{a}	76.01^{b}	68.74^{c}	3.37	*
Nitrogen free extract	30.72^{b}	30.82^{b}	30.77^{b}	57.60^{a}	3.93	*
Acid detergent fibre	56.08^{c}	61.72^{b}	62.30^{b}	66.10^{a}	1.72	*
Nuetral detergent fibre	67.91^{b}	71.04^{b}	70.82^{b}	81.35^{a}	3.76	*

^{abc} Means with different superscripts within a row differed significantly (P<0.05), SEM: Standard error of means, LOS: Level of significance, *:Significant at P<0.05

4.2.4 Nitrogen balance

The results in Table 4.10 showed the Nitrogen balance of the bucks in the study. Nitrogen absorbed, Nitrogen absorbed as a percentage of intake and Nitrogen retained as a percentage of intake changed in a similar pattern. Treatment 4 (60% Concentrate inclusion level) was highest while Treatments 1 (15% Concentrate) and 3 (45% Concentrate) which were statistically similar (P>0.05) were the least. Nitrogen intake, Faecal Nitrogen loss, Urine Nitrogen loss and Total Nitrogen outgo showed different trends as Concentrate levels increased.

Nitrogen intake significantly (P<0.05) changed as Concentrate inclusion levels increased. Bucks fed diet containing 45% (8.36 g/day) and 60% (8.10g/day) were similar (P>0.05) and statistically higher (P<0.05) than those fed diet containing 15% (7.47g/day) and 30% (7.37g/day) Concentrate. Faecal Nitrogen loss decreased as Concentrate levels increased. Bucks fed diet 15% Concentrate inclusion were highest (2.83g/day) while those fed 60% Concentrate inclusion (1.52g/day) recorded the lowest faecal Nitrogen loss. However, Urine Nitrogen loss increased across the Treatments as Concentrate inclusion levels increased. Bucks fed Treatment 3 (45%) and 4 (60%) had the most Urine Nitrogen loss (1.06 and 0.76g/day respectively). Bucks fed on diet containing 15% (0.51g/day) and 30% (0.55g/day) Concentrate inclusion were similar (P>0,05) in Urine Nitrogen loss. Total Nitrogen outgo was higher in bucks fed diet containing 45% Concentrate inclusion (3.00g/day) than all the other Treatments. Treatment 1 (15% Concentrate inclusion) (2.82 g/day) and 2 (30% Concentrate inclusion) (2.73g/day) were statistically (P>0.05) similar whereas Treatments 4 (60% Concentrate inclusion) (2.59g/day) was the lowest in terms of Total Nitrogen outgo. Nitrogen absorption showed an irregular pattern. Bucks fed Treatment 1 (5.16g/day) and 3 (5.13g/day) were similar (P>0.05). Bucks fed diet with 30% Concentrate

(5.92g/day) differed from those fed diet with 60% Concentrate (6.84g/day) significantly ($P<0.05$). Highest values for Nitrogen retention were recorded in bucks fed Treatment 2 (5.37g/day) and 4 (5.77g/day) while the lowest values were recorded in bucks fed Treatments 1 (4.65) and 3 (4.37). Nitrogen absorbed as a percentage of intake was highest in Treatment 4 (60%) (81.77%) while the lowest value was observed in Treatment 1 (15%) (69.01%).Although, there were no significant ($P>0.05$) differences between Treatments 1 (15%) and 3 (45%). Nitrogen retained as a percentage of intake was also higher ($P<0.05$) in bucks fed diet with 60% Concentrate (69.06%) compared to the other Treatments. Bucks fed diet with 30% Concentrate retained 66.31% nitrogen while those fed diet with 45% Concentrate were the least (59.26%) in nitrogen retention.

Table 4.10: Nitrogen balance of Red Sokoto bucks fed graded levels of concentrate in *Panicum maximum* cv. Mombasa based diet

	Concentrate Inclusion Levels					
Parameters (g/day)	**15%(T1)**	**30%(T2)**	**45%(T3)**	**60%(T4)**	**SEM**	**LOS**
Total Nitrogen Intake	7.47^{b}	7.37^{b}	8.10^{a}	8.36^{a}	0.30	*
Faecal Nitrogen Loss	2.32^{a}	2.18^{b}	2.24^{b}	1.52^{c}	0.04	*
Urine Nitrogen Loss	0.51^{c}	0.55^{c}	0.76^{b}	1.06^{a}	0.10	*
Total Nitrogen Outgo	2.83^{b}	2.73^{b}	3.00^{a}	2.59^{c}	0.07	*
Nitrogen Absorbed	5.16^{c}	5.92^{b}	5.13^{c}	6.84^{a}	0.30	*
Nitrogen Retained	4.65^{b}	5.37^{a}	4.37^{b}	5.77^{a}	0.36	*
Nitrogen Absorbed as %Intake (%)	69.01^{c}	73.09^{b}	69.62^{bc}	81.77^{a}	2.01	*
Nitrogen Retained as %Intake (%)	62.18^{bc}	66.31^{b}	59.26^{c}	69.06^{a}	3.06	*

^{abc} Means with different superscripts within a row differed significantly (P<0.05), SEM: Standard error of means, LOS: Level of significance, *:Significant at P<0.05

CHAPTER FIVE

5.0 Discussions

5.1 EXPERIMENT I: Effects of Fertilizer Levels and Harvest Time on Yield and Nutritive Composition of *Panicum maximum* cv. Mombasa.

5.1.1 Growth parameters of *Panicum maximum* cv. Mombasa

5.1.1.1 Effects of fertilizer levels on growth parameters

The increase observed in Plant height could be attributed to the more availability of nutrients which influenced the growth rate of the grass. Adjolohoun *et al.*,(2013) in a study of *Panicum maximum* ecotypes in the Republic ofBenin reported an average leaf width of 3.35cm and leaf length of 77cm.The Leaf area index values in this study were within the range of 4 – 8 reported by Alexandrino*et al.* (2005) in *Panicum maximum* cv. Mombasa.

5.1.1.2 Effects of harvest time on growth parameters

The trend in Plant height was similar to the findings of Reynoso *et al.*(2009) in *Panicummaximum* cv. Mombasa which were 42 and111.1cm at 3 and 7 weeks respectively. Plant height increased with age which is natural in all grasses as they grow taller with age. The result of Leaf lengthin this experiment was lower than the range of 47-107cm reported by Adjolohoun *et al.* (2013)for *Panicum maximum* ecotypes in the Republic of Benin. Leaf width was slightly lower than that observed by Adjolohoun *et al.*(2013) of 2.5-4.2cmas *Panicum maximum* matures. This trend could be attributed to physiological nature of grasses, as leaf width of grasses decreased after reaching its peak. Leaf number was lower (28-84) to that reported by Adjolohoun *et al.*(2013) in

some *Panicum maximum* ecotypes. This could be due to cultivar and location difference. The Leaf area index observed in the study is in concurrence with the results of Alexandrino*et al.* (2005) who recorded a maximum LAI of 8 in *Panicum maximum* cv. Mombasa but Adjolohoun *et al.*(2013) reported values less than these in other *Panicum maximum* ecotypes. The variation could be due to cultivar and environmental differences.

5.1.2 Forage yield of *Panicum maximum*cv. Mombasa

5.1.2.1Effects of fertilizer levels on fresh and dry matter yields of Panicum maximum cv. Mombasa

The stand counts in all the treatments were above the minimum of 10 plants/m^2 recommended for good pasture establishment (Primefact, 2010). The Total fresh weight (TFW), leaf fresh weight (LFW), stem fresh weight (SFW) and total dry matter (TDM) in this study were similar to the report of Fernandes *et al.*(2015) working with*Panicum maximum* cv. Mombasa. Castagnara *et al.*(2011) reported a linear positive response of *Panicum maximum*cv. Tanzania and Mombasa to Nitrogen fertilization. This can be attributed to the increased availability of nutrients to the grass for uptake. The trend observed in leaf dry matter (LDM) andstem dry matter (SDM) were similar to the reports of Cecato *et al.*(2014) who worked on irrigated *Panicunm maximum* cv. Mombasa and Fortes *et al.*(2014) working on other varieties of *Panicum maximum*. The positive effect of fertilizer on leaves could be due to accelerated development of leaves over stem (Pereira *et al.*, 2012).

5.1.2.2 Effects of harvest time on fresh and dry matter yields of Panicum maximum cv. Mombasa

The Total fresh weight (TFW), Leaf fresh weight (LFW) and leaf dry matter (LDM) trends was similar with the trend observed by Onyeonagu and Asiegbu (2005). Leaf to stem observed in this experiment was in concurrence with the trend observed by Lazo *et al.* (1996) and Wilman *et al.* (1976) working with ryegrass. This is attributed to the fact that leaf proportion of grasses is highest at early growth stages and subsequently declines considerably (Wilman *et al.*, 1976). The trends in Stem fresh weight (SFW) and Total dry matter (TDM) in the study is as a result of the fact as the grass matures it increases in stem proportion. Although, highest forage yield was observed at week 12 Onyeonagu and Asiegbu (2005) reported the highest yield at week 6 after planting.

5.1.3 Proximate composition of *Panicum maximum* cv.Mombasa

5.1.3.1Effects of fertilizer levels on chemical composition of Panicum maximum cv. Mombasa

The trend in Crude protein confirmed the increasing trend observed in the literature (Periera and van Bosch, 2012 and Escarela *et al.,* 2017) who worked on Mombasa and Carpici (2001), Dasc and Comaki (2011), Otega-Gomez *et al. (*2011), and Adewumi (2013) who worked on other Panicum cultivars. This could be due to the fact that increasing fertilizer levels increased the availability of Nitrogen in the soil for plant absorption. This allows for more Nitrogen absorption and accumulation in the plant tissues. Crude fibre in this experiment followed the same trend as reported by Aderinola, (2013), Turk *et al.* (2007), Dasc and Comaki, (2011) and Escalera *et al.* (2017). This can be attributed to the increased growth rate as a result of the

availabilityof nutrients thus, reducing lignification rate of plants materials (Adewumi, 2013). The result on Ether extracts observed in the study was in concurrence with that reported by Okwori and Magani (2010) but Aderinola (2013) who applied NPK to *Panicum maximum* at graded levels(0, 50, 100 and 200kg/ha) observed an inconsistent trend in EE content as fertilizer level was increased. The fertilizationfavours more lipid accumulation in the plants' tissues.

The trend in Acid detergent fibre (ADF) in the study coincided with that observed by(2001) and Dasc and Comaki (2011). This could be attributed to reducing effects of fertilizer on ADF (Ball *et al.,* 2001). Though, Riguera *et al.*(2013) and Wilman *et al.*(1976) reported no significant variation in ADF as fertilizer doses increased. Neutral detergent fibre (NDF) followed a trend opposite to ADF. Carpici (2001), Dasc and Comaki (2011) and Hassan *et al.*(2015) reported a similar result. But Balaban*et al.*(2010) observed a negative relationship between fertilizer and NDF content. This is so because as ADF fraction of forage decreases as NDF increases.

This change in Phosphorus confirmed the Findings in the literature (Adewumi, 2013; and Aderionola, 2013) as fertilizer levels are increased. This can be attributed to increased availability of Potassium to the plant for absorption as levels of fertilizer increases. Although, Pritichard (1964) reported an increase in Calcium content as nitrogenous fertilizer was increased while Fernandes *et al.*(2015) observed a decrease in Sodium as nitrogenous fertilizer is increased in*Panicummaximum* cv. Mombasa grass in Brazil.

5.1.3.2 Effects of harvest time on chemical composition of Panicum maximum cv. Mombasa

The trend observed in Crude protein is in concurrence with the findings of Geleti and Tolera (2013) who reported a similar trend at the same periods (8, 10 and 12 weeks). Daniel (1996); Taute *et al*, (2002), Sarwar *et al*.(2006), Okwori and Magani (2010) also reported a similar trend in CP as grass matures. This is because as grass matures it gets more lignified thus reducing the CP content as CP has a negative correlation with lignin. Geleti and Tolera (2013) and Taute *et al*,(2002) reported a result similar in Crude fibre to that obtained in this study. This can be attributed to the increase in lignification of grasses with age. This translates into more fibre percentage in the forage material. The Ash content observed in this experiment confirmed the findings of Adewumi (2013) working on the effects of fertilizer on *Panicum maximum* cv. Tanzania. Geleti and Tolera (2013) observed no significant changes in Ash content with age. The trend in Nitrogen free extracts **(**NFE**)** content in this study can be attributed to the decrease in soluble carbohydrates as a result of the lignification of the plant's tissue as it matures.

The NDF in this study is in concurrence with the trend reported by Okwori and Magani (2010) and Ortega-Gomez *et al.*(2011) in some grass species. However, Geleti and Tolera (2013) reported an inconsistent trend in NDF as *Panicum Coloratum* matures. The trend observed in this study may be due to changes in the physiology of the plant as it matures. This reduces the amount of cell cytoplasm accompanied by an increase in percentage fibre content. The trend in lignin content of the *Panicum maximum* cv. Mombasa was similar to that reported by Carpici (2001) and Gomide (1978) whereas Geleti and Tolera (2013) observed an insignificant difference in lignin as grass matures. This can be attributed to the need for more fibre for support as the grass grows taller.

5.2 EXPERIMENT II:Effects of Concentrate Inclusion Levels on NutrientIntake, Digestibility and Nitrogen Balance in Red Sokoto Bucks Fed *Panicum maximum*cv. Mombasa Hay-based Diets.

5.2.1 Chemical composition and metabolisable energy of the experimental diets

The Dry matter content in the diets was similar to that observed by Bolaji *et al.*(2016) when forage was mixed with Concentrate at 60:30 ratio. The high DM could be due to the fact that the diets were prepared from dried ingredients which were characteristically high in DM. The Crude protein of the diets was above the minimum range of 10 – 12% CP reported as the moderate level required by ruminants for minimum growth performance. Though, NRC, (2007) and Van soest, (1994) reported the range of 6 – 8% CP as efficient for rumen function and maintenance. The Crude fibre in the experimental diets was higher than that reported by Sanh *et al.*(2002) when Panicum was mixed with Concentrate in the ratio of 70:30, 50:50 and 30:70. This could be attributed to the constituents of the Concentrates used. The variation in the values of lignin, NDF and ADF in the diets were a reflection of the Crude fibre content in the diets. The Neutral detergent fibre is below the 60% suggested by Muia (2000) as the critical limit for efficient utilisation of roughages by the ruminant. The metabolisable energy of the experimental diets was above the 7.7 MJ/kg recommended for ruminant maintenance.

5.2.2 Nutrient intake

The trend in Dry matter intake increased as concentrate level increased. This trend is similar to that reported by Ramos *et al.*(2014) who reported an increase from 994 – 1031g/day as concentrate inclusion level increased from 30-70%. Organic matter intake increases similar to what was observed by Lima *et al.*(2016). Although the figures in this study were lower than that of Lima *et al.* (2016). The higher DM and OM intake as

concentrate inclusion level increased could be as a result of increased palatability of the diet as concentrate was increased. The crude protein intake in this experiment followed a trend similar to the findings of Lima *et al.* (2016) who reported higher CP intake in 25:75 forage to concentrate ratio. The intake decreased as forage proportion increased. This increase in CP intake with more concentrate could be a reflection of the DM intake of the diets. The pattern in the CF intake change is opposite to that observed in CP intake. This is similar to the report of Sanh *et al.* (2002) who varied forage to concentrate ratio from 70:30 to 30:70. This also reflects DM intake and CF contents of the experimental diets. The pattern of NFE intake could be due to the NFE content and the organic matter intake of the test diets. The ADF intake in the study was lower than that reported by Ramos *et al.* (2014). Although, the trend is the same as the one in this experiment.NDF intake followed the trend opposite to that of ADF. This pattern of change is similar to that reported by Ramos *et al.* (2014) and Lima *et al.*(2016). This is a reflection of ADF and NDF in the diets and the CF intake of the bucks**.**

5.2.3 Nutrient digestibility

The trends in CP digestibility coincided with the trend observed by Youngjun *et al.* (2017) who studied the effects of forage to concentrate ratio in growing goats and deers. The CF is comparable with the findings of Varaprassad *et al.* (1995) although Gaafar *et al.*(2009) reported a decrease (from 68 to 65%) in CF digestibility as forage proportion was decreased from 60 to 40%. This is because activities of rumen microbes are affected by lowered rumen pH as a result of an increase in less-fibrous carbohydrates in the Concentrates which in turn affects fibre digestion. Results on ADF were in concurrence with that of Gaafar *et al.* (2009). Bamikole and Babayemi (2004) reported similar digestibility in OM as Concentrate levels increased as that observed in this experiment. Gaafar *et al.*(2009) reported a similar pattern of change in NFE digestibility

as Concentrate level was increased but the values from this study were lower than values obtained by the authors (70.75% at 60:40 forage to Concentrate ratio). The NDF digestibility in this study was in agreement with the findings of Lima *et al.,* (2016) and Youngjun *et al.* (2017) but Islam *et al.* (2000) observed no significant difference in NDF digestibility as Concentrate levels increased. Dry matter digestibility observed in this study is similar to the report of Gaafar *et al.,* (2009) though, Bamikole and Babayemi (2004) and Youngjun *et al.* (2017) observed a linear positive increase in DM digestibility with increased Concentrate levels. Ether extract (EE) digestibility increased with increasing levels of Concentrate.

On a general note, overall digestibility of the hay increased as Concentrate inclusion levels increased. This agreed with reports from the literature (Cantalapiedra-Hijar *et al.*(2008); Gaafar *et al.* (2009); Lima *et al.*(2016); Youngjun *et al.*(2017).

5.2.4 Nitrogen balance

Nitrogen intake increased while Faecal Nitrogen loss decreased as Concentrate levels increased. Fadiyimu *et al.* (2010) observed an insignificant difference in faecal Nitrogen as Nitrogen intake varied. However, the trends in Urine nitrogen and Total nitrogen outgo in this study were comparable to the trends observed by Ahametule *et al.*(2006) and Fadiyimu *et al*. (2010) as Nitrogen intake increased. The trends observed in Nitrogen absorption and Nitrogen retention were similar to the reports of Pratap (1989) when Concentrate was supplemented to basal forage ration and Devanesa and Krishna (1996) when *Panicum maximum* was supplemented with groundnut cake and maize premix. The results from this study showed that Nitrogen absorbed as percentage intake and Nitrogen retained as a percentage of intake were similar to that reported by Alalade *et al.*(2015) who fed *Panicum maximum* to goats with increasing levels of Moringa as Concentrate.

The major indicator used to determine the protein nutrition status of ruminant livestock is Nitrogen retention (Abdu *et al.*, 2012). The results indicated a positive Nitrogen Balance (g/day). The increase in Nitrogen Balance as Concentrate inclusion levels increases could be as a result of increased digestibility of the forage.

CHAPTER SIX

6.0 Summary, Conclusions and Recommendations

6.1 Summary

Experiment I: The experiment was carried out to investigate the effects of varied levels of fertilizer (NPK 15-15-15) and harvest time on yield and chemical composition of *Panicum maximum* cv. Mombasa. The results from the study revealed a significant increasein both quality and yield of *Panicum maximum* cv. Mombasa as fertilizer levels and harvest time increased. Treatment with 400kg/ha NPK (15-15-15) fertilizer had higher crude protein (11.66%) and dry matter yield (4.2tonnes). Although, the quality of the forage declined with increased harvest time, with the crude protein decreasing from 10.29% to 9.24% from week 8 to 12 respectively. Forage yield increased with increased delayed harvest time. Total dry matter yield increased from 1.5 tonnes at 8th week to 5.8 tonnes at 12th week after planting.

Experiment II: The study was conducted to determine the effects of Concentrate inclusion levels on nutrients intake, digestibility and nitrogen balance in Red Sokoto bucks. Bucks fed diet containing 60% concentrate had higher dry matter digestibility, Crude protein digestibility, Nitrogen intake, Nitrogen retained and Nitrogen absorbed

6.2 Conclusions

The following conclusions were drawn based on the results of these studies.

1. Application of fertilizer (NPK 15-15-15) at the rate of 400kg/ha enhanced the quality of *Panicum maximum* cv. Mombasa in terms of its Crude protein (11.66%). The total dry matter (4.2 tonnes/ha) and leaf dry matter (2.2 tonnes/ha) also improved markedly.

2. Harvesting *Panicum maximum* cv. Mombasa at 8th week after planting resulted in better quality forage with regards to Crude protein (10.29%). But harvest at 12th week yielded more dry matter (5.8 tonnes/ha).

3. Inclusion of Concentrate from 15- 60% in *Panicummaximum* cv. Mombasa based diet increased the diet's digestibility from an average of 62.27 to 74.99% in Red Sokoto bucks.

4. Inclusion of Concentrate from 15- 60% in *Panicummaximum* cv. Mombasa based diet increased Nitrogen retention from 4.65 to 5.77 g/day in Red Sokoto bucks.

6.3 Recommendations

Based on the findings of the experiments, the following are recommended.

1. Farmers should use NPK 15-15-15 fertilizer at 400kg/ha on *Panicum maximum* cv. Mombasa and harvest at 10^{th} week after planting for improved nutritive value (10.10% CP) and forage yield (3.3 tonnes/ha DM).

2. Further studies should be conducted on regeneration potentials and cutting frequencies of the cultivar.

3. It can be recommended that farmers could incorporate 60% Concentrate in a *Panicummaximum* cv. Mombasa based diet for improved digestibility and nitrogen retention in Red Sokoto bucks.

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