EFFECT OF PIG MANURE RATES, PLANTING METHODS AND HARVESTING STAGES ON PRODUCTIVITY OF *Panicum maximum* AND PERFORMANCE OF GROWING RED SOKOTO BUCKS

BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE,
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MARCH, 2021

DECLARATION

I hereby declare that this dissertation titled "**Effect of pig manure rates, planting methods andharvesting stageson productivity of *Panicum maximum* and performance ofgrowing Red Sokoto Bucks"** has been written by me and is a product of research work conducted by me at the National Animal Production Research Institute, Shika, Zaria and the Teaching and Research Farm, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, under the supervision of Dr M.R. Hassan and Dr R.J. Tanko. It has not been accepted in any previous application for higher degree. To the best of my knowledge, this thesis contains no materials previously published or written by another person except where due references have been made in the text.

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CERTIFICATION

This dissertation titled "**Effect of Pig Manure Rates, Planting Methods and Harvesting Stages on Productivity of *Panicum maximum*and Performance of GrowingRed Sokoto Bucks"** by IDOWU Waheed, meets the regulations governing the award of degree of Master of Science (M.Sc.) of Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to almighty Allah, the lord of the worlds and my parents, Mr Abubakar Adeagbo Idowu and Mrs Risikat Eyitayo Idowu.

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All praises and adorations are due to almighty Allah, the elevator of the humble, relegator of the arrogant, cherisher, sustainer and sole administrator of the whole universe. I beseech his mercy and blessings upon the noble soul of Prophet Muhammad (S.A.W), may the mercy of God almighty be upon us all.

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ABSTRACT

This study was conducted to evaluate the effects of pig manure rates, planting methods and stages of harvest on productivity of *Panicum maximum* and performance of growing Red Sokoto bucks fed *Panicum maximum*at the experimental field of the Feeds and Nutrition Research Programme, National Animal Production Research Institute, Shika, Zaria and the Teaching and Research farm, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. Two trials were conducted, trial I was agronomic studies that was laid in split plot (4 × 2 × 3) factorial arrangement replicated three times in RCBD. They were pig manure application (0, 5, 10 and 15t/ha), two planting methods (Drilling and broadcasting), and three stages harvest (6, 9 and 12 WAP). Data were collected on morphometrics, fresh and dry matter yield (t/ha) and proximate composition. Trial II was evaluation of growth performance, nutrient digestibility, nitrogen balance and economics of growing Red Sokoto Bucks fed 50:50 Concentrate/*Digitaria smutsii* hay (C:D), 75:25 concentrate/*Panicum maximum*hay(C:P), (50:50) C:P and (25:75) C:P for 90 days at 3% Bwt. Twelve bucks weighing 10.5±0.5kg were used with 3 replicate bucks/treatment in a CRD. Yield and proximate composition were determined at 6, 9 and 12 weeks after planting. Results from trial I showed Stand count ($36/m^2$), Plant height (212.82cm), and leaf area index (3.91) were significantly ($P<0.05$) affected by manure rates at 10t/ha. Stages of harvest had significant ($P<0.05$) effect on all the agronomic indices measured with 9^{th} week after planting having the best performance of all the agronomic parameters. The fresh forage yield (65.22t/ha) was affected ($P<0.05$) by manure rates at 10t/ha. Harvesting stages had significant ($P<0.05$) effect on both the fresh (88.83t/ha) and dry matter yield (26.14t/ha) of *P.maximum*at 12^{th} week of harvest. All the parameters of proximate composition were affected ($P<0.05$) by manure rates with CP of (12.62%). Harvesting stage had significant effect ($P<0.05$) on all the proximate composition of the forage with DM% (93.79) at week 9 and 13% CP at week 6 of harvesting. The interaction between the three factors showed significant ($P<0.05$) effects on the proximate composition of the *P.maximum*. Conclusively, application of pig manure to *P.maximum* under drilling method at the rate of 10t/ha gave a higher nutritional quality at week 9 and better forage yield at week 12. Results from trial II showed that ADWG (34.13g/day) and FCR (11.52 kg DMI/kg gain) were significantly ($P<0.05$) higher in bucks fed (50:50) C:P mixture. Also, digestibility coefficient of DM (75.01%), CP (79.52%), and other nutrients were significantly higher in bucks fed (50:50) C:P mixture. The nitrogen retained as % intake was significantly higher (57.33%) in bucks fed C:P mixture (75:25). It was therefore concluded from this study that 50% concentrate mixed with 50% *Panicum maximum* hay recorded a better result in terms of growth performance and nutrient digestibility of growing Red Sokoto bucks, thus, 50:50 concentrate/*Panicum maximum* is recommended for better growth performance and nutrient digestibility of growing Red Sokoto Bucks.

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ABBREVIATIONS

ACI = Average concentrate intake

ADF = Acid detergent fibre

ADWG = Average daily weight gain

AFI = Average feed intake

ANOVA = Analysis of variance

AOAC = Association of Analytical Chemistry

BDG = Brewer's dried grain

C:D = Concentrate : *Digitariasmutsii*

C:P = Concentrate : *Panicum maximum*

CEC = Cation exchange capacity

CF = Crude fibre

CP = Crude protein

CRD = Completely randomized design

Cu = Copper

DIP =Digestible intake protein

DM = Dry matter

DMI = Dry matter intake

DMRT = Duncan's multiple range test

DWss = Dry weight of sub-sample

EE = Ether extract

FBWG = Final body weight gain

FCR = Feed conversion ratio

Fe = Iron

FWss = Fresh weight of sub-sample

g = gram

H = stage of harvest

IARMS = Institute for Agricultural Research Meteorological Station

IBW = Initial body weight

K = Potassium

Kg = Kilogram

LAI = Leaf area index

LL = Leaf length

LOS = Level of significance

LW = Leaf width

M = Manure rates

ME = Metabolizable energy

Mg = Milligram

MJ = Mega joule

ml = Mililitre

N = Nitrogen

NAR = Net assimilation rate

NDF = Neutral detergent fibre

NOL = Number of leaves

NPN = Non protein nitrogen

NRC = National Research Council

OM = Organic matter

PAN = Plant Available Nitrogen

P = Phosphorus

P = planting methods

PH = Plant height

RDP = Rumen degradable protein

RGR = Relative growth rate

RIF = Return to investment on feeds

SARA = Sub acute ruminal acidosis

SAS = Statistical analysis software

SEM = Standard error of means

TFW = Total fresh weight

TN = Tiller number

VFA = Volatile fatty acids

Zn = Zinc

CHAPTER ONE

1.0 INTRODUCTION

Ruminant animals rely on pasture plants for their nutrition than any other feed resources (Aderinola *et al* 2007). Most plants depend on soil for their nutrient supply and grazing ruminants derive virtually all their nutrients from plants growing on such soils. Unfortunately, most of the tropical soils are characterized with low nutrient quality, translating to the poor nutrient quality of forage grown on them (Aregheore, 2002). Fertilizers are used to improve soil chemical and biological properties which is reflected on phytonutrient content and palatability of herbage plants (Alalade *et al.*, 2013). Application of farm yard manure has resulted in the improvement of both the productivity and quality of tropical crops (Ahmed *et al*., 2012).

Pig manure is a very good source of organic matter which plays a vital role in improving the physical, chemical and biological properties of the soil, by activating the activities of soil microorganisms, thereby enhancing the slow release of plant nutrients with a resultant environmental harmony (Sharma and Mitta, 1991). Efficient and effective use of pig manure ensure sustainable crop productivity, because soil organic matter is maintained, nutrients are released more slowly, stored for a longer time in the soil, improved root development and high crop yield (Sharma and Mitta, 1991). Use of pig manure will lead to improvement in productivity of livestock and economic status of the farmers, thereby preventing further environmental degradation due to indiscriminate use of inorganic fertilizers by the farmers (Hassan *et al*., 2016). Despite its availability in appreciable quantity, its use as a source of crop nutrient has not received adequate research attention (Giwa and Ojeniyi, 2004).

Forages are the natural and primary feed resource for ruminants as they improve the rumen pH and rumen microbial activities. Lamidi and Ogunkunle (2015) reported that animals fed on dry

grain diets suffer from numerous gastro intestinal disorder. Ruminant production in the tropics are reared basically on natural pastures that do not contain adequate nutrients to meet the nutrient requirement of the animals (Matesz, 2001). *Panicum maximum*is propagated by seed and tillers and considered to be the most valuable fodder plant in the area where it is found naturally, it has high seed and leaf production and very palatable to game and livestock. It is widely cultivated as pasture and used for making good quality hay (Gibbs *et al.*, 1990). It grows rapidly and occurs in abundance when grown on a fertile soil (Botha and Botha, 1996).Animal fattening implies controlling what livestock such as cattle, sheep, and goatseat by using high quality feeds in order to generate faster weight gains. It is a strategic feeding option which produces a quick result within 2-3 months and it is technically simple (Lamidi and Ogunkunle, 2015). High quality grasses and agro-industrial by-products can be used as feed sources. In this regard, *ad libitum* feeding will result in increased daily weight gains of up to 700g per day. This is rarely achievable with low quality and quantity feed. Besides, *Panicum maximum* is often considered as one of the best species for beef production. However, there are vast differences between guinea grass cultivars in terms of potential production, quality of the herbage and reaction to Nitrogen fertilization (Aganga and Tshwenyane, 2004).

1.1 Justification of the Study

Pastoralist-farmers' conflict in Nigeria has grown, spread and intensified over the past decades and today poses a very serious threat to national security, scores of lives and properties have been lost. It is not only destroying the livelihood but also threatening the national cohesion. Recent estimates indicate that Nigeria's national herd comprises 18.4 million cattle, 43.4 million sheep and 76 million goats (FMARD, 2017) and the majority of animals are raised in extensive production systems comprising of smallholders and herders.Establishment and demarcation of

ranches for nomads particularly by the local government authority especially along the identified nomadic route has been recommended. However, this is also threatened by population explosion (Gambari *et al.*, 2018), therefore, there is need for farmers to cultivate forage for their animals. *Panicum maximum* is one of the best choice for farmers' cultivation due to its higher dry matter yield per hectare, palatability, ease of establishment and high nutritional quality.

Excessive use of synthetic fertilizers have caused tremendous harm,one of the problems of inorganic fertilizer in Nigeria is that fertilizers are not supplied at the right time in addition to huge cost of procurement. Improper chemical fertilizer application has ruined tropical soils as continuous usehas resulted in soil acidification, loss of soil structure, loss of biodiversity etc. thus cannot sustain soil fertility for a long time (IFDC, 2000).

In Nigeria, small-scale livestock farmers hardly utilize pig manure as a source of fertilizer for their crops, despite its availability and low cost. Therefore, it is hypothesized that utilization of pig manure, with appropriate agronomic practices, will help to provide cheap and sustainable option instead of synthetic fertilizers for forage crops production in Nigeria (Hassan *et al*, 2016). However, there is need to identify and establish the appropriate rate of application of the pig manure so as to prevent excess or inadequate application which may have a negative consequence on the plant growth and/or nutritive quality. Anderson *et al.*, (2013) recommended a maintenance dressing of 200-400kgN /ha/yr to promote healthy, productive stands on less fertile soils. While organic manure is known to have cumulative effect of nutrient supply on the soil, application of pig manure at 0, 5, 10 and 15t/ha which is equivalent of 0, 96.5, 193.0 and 289.5kgN /ha respectively could save farmers' cost in supplying nutrients needed by the plants. Hence, the justification for graded levels of pig manure in growing *Panicum maximum.*

Researchers vary in their recommendations of an optimum harvesting stage at which a balance is obtained between dry matter yield and quality, Akinola, (2018) reported that, 6-8 weeks grazing or cutting intervals are adequate to ensure stand longevity and provide the highest leaf yield and leaf percentage which are major determinants of forage quality, going above this recommendation revealed whether 6-8 week is the optimum cutting intervals or as the harvesting stages increased there was an increment in forage yield and quality of *Panicum maximum.*

A grassdrill is the best method of seeding on level and sloping areas, but the preferred method will depend on slope and conditions of the planting site (Thom *etal*, 2011).Abdul Azeez and Yushau, (2017) reportedthat highest yield of *Panicum virgatum*was obtained by dibbling followed by drilling and broadcasting methods respectively. Drilling and broadcasting methods were chosen in this study because of the levelness of the experimental field.

Amajorchallengeto livestock producers is getting adequate quantity of quality feeds throughoutthe year. Forages grow rapidlyduring the wet season, become fibrous, coarse and low in nutrients as the season advances towards the dry season.In order to solve the limitations of feeds for ruminants especially during dry season, there is a need for developing a feed conservation strategy during the period of abundant supply(rainy season) so as to redistribute the feed supply over the year to meet the requirements oflivestock resources (Robert *et al*., 2003). Concentrate supplements was used in the diet to maintain a balance between energy and protein for efficient microbial multiplication, degradation and utilization of the diets.

1.2 Objectives of the Study

1.2.1 Broad Objective

The main objective of this work is to study the effects of different rates of pig manure application, planting methods and stage of harvest on the forage yield and quality of *Panicum maximum*and performance of Growing Red Sokoto bucks on the forage.

1.2.2 Specific objectives:

i. To determine the levels of pig manure application, planting methods and stage of harvest on forage yield and quality of *Panicum maximum.*

ii. To determine the growth performance of growing Red Sokoto bucks fed diets containing *Panicum maximum*hay supplemented with concentrate.

iii. To determine the cost of feeding *Panicum maximum*hay supplemented with concentrate to growing Red Sokoto bucks in Samaru, Northern Guinea Savanna of Nigeria.

1.3 Hypotheses

H_o: levels of pig manure application, planting methods and stage of harvest have no effect on growth, forage yield and quality of *Panicum maximum*

H_a levels of pig manure application, planting methods and stage of harvest have effect on growth, forage yield and quality of *Panicum maximum*

H_o: Feeding *Panicum maximum*hay supplemented with concentrate to growing Red Sokoto buckshas no effect on their growth performance.

H_a: Feeding *Panicum maximum*hay supplemented with concentrate to growing Red Sokoto buckshas effect on their growth performance.

Ho: Feeding *Panicum maximum*hay supplemented with concentrate to growing Red Sokoto bucksis not cost effective.

H_a: Feeding *Panicum maximum*hay supplemented with concentrate to growing Red Sokoto bucks iscost effective.

CHAPTER TWO

2.0 REVIEW OF LITERATURE

2.1 Origin and Distribution of Guinea Grass(*Panicum maximum*)

Guinea grass is a forage grass that is native to Eastern and Western Africa and is found in tropical and sub-tropical regions (Muir and Jank, 2004). Guinea grass belongs to the family poceae, sub family panicoidae and tribe paniceae and constitutes an agamic complex with *P. infestum* anders and *P. trichcladumK. Schum*. *Panicum maximum* is adaptable to diverse ecosystems and is grown in several countries (Savidan,1983). It is the most productive seed propagated tropical forage grass and the second most cultivated forage in Brazil (Sousa*et al*., 2011).

Panicum maximum(Jacq.) is a 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. It 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, woodlands and shady places within 16.3^{o}N and 28.7^{o}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 species is a very diverse genus, with its natural range of distribution in the tropics and in warmer temperate regions. It is one of the largest genera within the Poaceae, consisting of about 450 annual and perennial species (Aliscioni *et al.,* 2002). Parsons (1972) has pointed out that it spread from Guinea Coast of West Africa to Barbados during the Seventeenth Century and Brazil in the Eighteen Century via slave ship.

2.2 Description of Guinea Grass(*Panicum maximum*)

Panicum maximum is a robust, densely tufted perennial grass which grows up to 3m tall. Rhizome, may bear hairy reduced-leaf remnants. Stem, stout, erect, glabrous to hairy, nodes often densely hairy (Chen and Hutton, 1992). Leaf sheet glabrous to stiff hairy, often with dense patches of hairs at junction with leaf blade. Ligule membranous, to 6mm long. Leaf blade flat, linear to 90cm long and 3.5cm wide, glabrous to softly or coarsely hairy upper surface, margin may be rough to touch (Akinola, 2018). Inflorescence, a many branched, erect or slightly nodding panicle, to 60cm tall and 20cm wide, with 3-7 whorled branchlets. Spikelets clustered on branchlets, short stalked to 4mm long, green to purplish, oblong, blunt-tipped or slightly pointed, glabrous or slightly hairy, first glume,1/3 length of spikelets, second glume equal length to spikelet, upper floret fertile, developing a dull, white seed (Davies Garden 2013).

2.2.1 Cultivars of Guinea Grass(*Panicum maximum*)

In the past 20 years, nine new cultivars of *Panicum maximum*have been released as a result of selection programme in different research stations: IZ-I in (1979), Tobiata in (1982), *Centenaria*in (1986), *Centauro*in (1988), *Aruana*in (1989), *Vencedor*in (1990), *Tanzania*in (1990) and *Mombasa*in (1993) (Jank, 1995) and Masai in (Euclides *et al.*, 2008). Most studied cultivar in the century is cultivar Colonial. But because of its low productivity in less fertile soil and its sensitivity to mismanagement, researchers and farmers started to look for better cultivars than Colonial in these respects (Carvalho, 2002).

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 programme are now appearing in the

market. Cultivar BRS Tamani released in 2015 (Jank *et al.,* 2016). Ina two-year study 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 *et al*.,1995). In another trial, Colonial 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 into 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 Corte) in Braziil. 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 tones DM/ha/year. It produces about 11% of its annual yield in winter and flower once in a year in autumn (April to June). Crude protein content in leaves and stem is about 13.4 and 9.7%, respectively (Jank, 1995).

2.3 Environmental Requirement of Guinea Grass(*Panicum maximum*)

2.3.1 Soil Requirement

Panicum maximum grows best on deep, moist, fertile soils but will grow in most soil types provided they are well drained and moderately fertile with reasonable moisture availability. Generally intolerant to water logging or salinity and very acid soils, although Vencedor and Centenario are bred to tolerate acidic soils (Bruce, 2008). It is well adapted to sloppy, cleared land in rain forest areas (FAO, 2009).

Hutton, (1989) reported that, *Panicum maximum* grows in most soil types, provided they are well drained, moist and fertile, although some varieties are tolerant to lower fertility and poorer

drainage. Tolerance of low soil pH and Al^{+++}saturation is also variable. Some varieties require liming on acid ultisols and oxisols for best results.

2.3.2 Moisture/Rainfall Requirement

Guinea grass is mostly grown in the wet and seasonally dry tropics, preferably with a rainfall of over 1500mm, but will extend to about 1000mm rainfall areas in the sub tropics (Bruce, 2008). Guinea grass prefers fertile soil and is well adapted to a wide variety of conditions. It grows especially well in shaded, damp areas under trees and shrubs and is often seen along rivers (Van, 1999). Drought tolerance depends on the cultivar but should not exceed 4-5 months (Cook *et al* 2005). Average annual dry temperature should range between 19.1^0c to 22.9^0c. Short types are more tolerant to cooler temperature than tall types. It is tolerant of shade and fire (Aganga and Tshwenyane, 2004). Temperature response varies with genotype. Short varieties generally are less affected by cooler temperature than are many of the tall varieties, producing good early season growth. Tall varieties generally produce most growth in the middle of the warm season, although this varies somewhat with accession/cultivar (Bruce, 2008).

Climatic conditions which are suitable for growth of guinea grass ranges from warm temperature, dry to moist through tropical, very dry to wet forest life zones. It can endure annual temperature of 12.2^0-27.8^0C and pH of 4.3 to 8.4 (Akinola, 2018).

2.3.3 Fertilizer requirement

Nitrogen fertilization is one of the most common practices since this nutrient was found to be one of the most limiting factors influencing yield and chemical composition of grass pasture. It is also the major factor for increasing the pasture yield and nutritive value of the plant including Crude Protein content and digestibility, which can improve livestock production (Peyraud and Astigarraga, 1998). Establishment fertilizer is necessary on infertile soils, using 20-40kg/ha P,

and about 50kg/ha N if limited in the soil prior to planting. Maintenance fertilizer is needed for pure grass swards especially in cut and carry systems. Inadequate N will lead to weakening of the stand and invasion by less desirable species. Maintenance dressing of 200-400kg/ha/yr N are required to promote healthy, productive stands on less fertile soils. Soils with a pH of less than 5 requires addition of lime to raise pH to 5.5-6 (Anderson *et al.*, 2013).

Once applied, the fertilizer increases the quality/quantity of deficient element(John, 2006). Sodehinde *etal*. (2006) observed that nitrogen fertilizer influenced positively the numbers of tillers produced perstand in an experiment on the effect of nitrogen on dry matter yield of *Panicum maximum*. The increased yield due to fertilizer application could be attributed to increase in both leaf production, increased number of tillers and photosynthesis directly(Aderinola *et al*., 2011). Natural pasture grasses are wild and are characterized bylow yield and poor nutrients (Babayemi and Bamikole, 2006) as they grow on infertile and erosion degraded soils.Tropical grasses have ability for high yield and the nutrient are simultaneously enhanced when treated withorganic/inorganic fertilizer or established with nitrogen fixing shrubs or tree legumes (Aderinola, 2011).Unfertilized grasses and those grown without legume companion had been found to be less nutritive as forage for goats (Bamikole and Babayemi, 2004).

2.3.4 Dry matter yield of Guinea grass(*Panicum maximum*)

Guinea grass ranks among those credited with a high dry matter yield potential and this is attributed to its high photosynthetic rate. For this reason, study gave an account of Relative Growth Rate (0.41-0.55g/dm/day) recorded for cultivated varieties (Akinola, 2018), also common for other grasses in the second week after sowing and ascribed to higher assimilation rates (1.80-2.14g/dm/week), respectively. The sole grass herbage yield commonly ranges from 5-

10t Dm/ha but up to 60t/haDM is realizable, depending on the cultivar, amount and distribution of rainfall, fertilizer N level and cutting management (Akinola, 2018).

Inoculation of guinea grass with *Spirillumlipoferum* results in such N fixation by the bacterium that can reduce nitrogen fertilizer application need by about 40kgN/ha. DM yield rises with increasing cutting interval but repeated defoliation reduces root mass as well as restrict root depth. Researchers vary in their recommendations of an optimum cutting interval at which a balance is obtained between dry matter yield and quality. It would appear that 6-8 weeks grazing or cutting intervals and to a height not less than 30cm above the ground level are adequate to ensure stand longevity and provide the highest leaf yield and leaf percentage which are major determinants of forage quality (Akinola, 2018).

Alalade *et al.* (2015) in an experiment to determine the effects of manure application on*Panicum maximum*and performance of West African Dwarf Sheep fed the*Panicum maximum* reported 57-61g/kg DM and 30-33g/kg NDF digestibility. In separate studies, Tessema *et al*.(2002) and Peiris and Ibrahim, (1995) reported an increase in IVOMD of grasses as Nitrogen levels increases. (Theron and Snyman, 2004) reported that organic matter digestibility (OMD) was significantly influenced by N-level and defoliation interval.The root length (shortest and longest) and biomass yield of *Panicum maximum* increased significantly as levels of fertilizer application increased 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* increased with the increasing level of N-fertilizer from 0.95 to 15.39 t/ha DM and 366.5 to 495.2 plant density per 0.6^2, respectively (Diriba, 2000).Fernandes *et al.* (2015) investigating sources and rate of fertilization on the productivity of *Panicum maximum*reported

an increased dry matter production with the application of N rates only in the second harvest, of the five harvests performed.

2.4 Manure

Manure is any material that could be added to the soil to improve its fertility and improve plant growth. There are different types of manures and the most common organic manure available include cow, horse, sheep, goats and poultry manure (Nweze and Ifeanyi, 2010). Manure has a long lasting effect than the equivalent nutrient level of chemical fertilizer due to a large proportion of mineral nutrients combined with organic substances which are released gradually as they decompose, hence, improved yield may continue years after the addition of manure to the soil (Plaster, 1992).

Manure is composed of animal faeces and urine and may contain livestock beddings, additional water and wasted feeds. It is a valuable fertilizer that contain a broad range of nutrients such as nitrogen (N), phosphorus P, and potassium K as well as micro nutrients such as Cu, Mn and Zn. Manures with added beddings are also an excellent source of organic matter which improve soil quality when added to the land, the water.Thenutrient and organic matter content of manures, however vary greatly, making them more difficult to manage than synthetic fertilizers (Ackerman Cicek, 2010).

Herbage yield and nutritional composition of *Panicum maximum*fertilized with poultry manure equivalentat therate of 200kgN/ha were improved in derived savannah zone of Nigeria and these will ensure good quality forage. Therefore, poultry manure can be a good alternative to the use of the unaffordable inorganic nitrogen fertilizer thathas been recently discovered to pose threat to the environment on the long term basis (Alalade *et al*., 2015).

2.4.1 Factors affecting manure composition

The primary factor that affect manure composition are livestock type, age (stage of growth),and feeding practices (all of which determines nutrient excretion rate) as well as the amount of bedding or water added to the manure, type of manure storage, time that the manure spent in storage and weather conditions (Ajiboye *et al*., 2004).

2.4.2 Hog manure

The application of hog manure to farm land is an economical and environmentally sustainable mechanism for increasing crop production while providing a waste management service for the hog industry. Application of swine manure to crop land is one of the most obvious methods of recycling plant nutrients (Sutton *et al*., 1978).

Swine manure application resulted in similar or higher crop and pasture yield than inorganic fertilizers (Evans *et al.*,1977; Burns *et al.*,1987; Chase *et al.,* 1991). However, because of slow release of N from manure, residual N recovery from manure was twice that from inorganic fertilizers. On an equal N-basis, Miller and Mack (1978) reported lower corn grain yield and lower plant N recovery from manure was twice that from inorganic fertilizer.

Hog manure has most of the nutrients required for plant growth. The effluent can reduce the need for commercial nutrients in crop production. However, the nutrient composition of manure varies considerably. The composition varies with variation in moisture content, the type of hog, age,and composition of feed, ration, climate, and the presence of beddings (SSCA, 2000). Swine manure contains all of the 13 essential nutrients that are used by plants. These include Nitrogen (N), Phosphorus (P), Potassium (K), Calcium, Magnesium (M), Sulphur (S), Manganese (Mn), Copper (Cu), Zinc (Zn), Chlorine (Cl), Boron (B), Iron (Fe), and Molybdenum (Mo). Plant nutrients originate from the feed, supplement, medications and water consumed by the animals.

Using swine manure as a source of fertilizer for crops or trees may provide a portion or all of the plant requirement. (ASAE 1998). The amount of the nutrient provided depends on the nutrient content of the manure while the amount of manure applied per acre (application rate) is typically based on the nitrogen need of the plant. However, phosphorus need can also be used to determine the application rate (ASAE 1998).

Meanwhile, not all the nitrogen in swine manure is immediately available for plant use. The nitrogen that is available for plant use is called the plant available nitrogen (PAN). Nitrogen can be present in manure as ammonium N, organic N and nitrate N (John *et al*., 2006).

2.5 Pests and diseases of Guinea grass(*Panicum maximum*)

Insect pests that damage the guinea grass and cause forage yield and quality reductions include *Acrosternum marginatum*, *Petrusa epilepsies* and spittlebugs (*Deois* and *Aeneolamia* spp). In colombia, guinea grass accessions CIAT 6799 and 16042 were reported to be resistant to *Aeneolamia reducta* which, together with their nymphs, feed on plant sap and in severe cases, cause weakening, stunting and yield reduction. Isolated from the grass are the nematodes *Helicotylenchus* and *Pratylenchus* spp. The major disease that cause seed yield reduction include ergot (*Claviceps* spp), *Fusarium* spp, smut (*Ustilago* spp) and a leaf spot caused by *Cercospora fusimaculosus* (Akinola, 2018).

2.5.1 Chemical composition of Guinea grass (*Panicum maximum*)

Variation in chemical composition is due mainly to the season and stage of growth with indication of forage nutrient concentrations that include 5-25% CF, 34-47% ADF, 0.10-0.30% P, 1.5-2.2% K, 0.5-0.9% Ca and 0.04-0.17% Na. The DM and CP digestibilities are put at 40-64% and 15-73%, respectively. A source reported a straw content of 92.5% DM, 4.3% CP, 40.4% CF, 1.4% EE, 12.2% ash, 75.1% NDF, 44.7% ADF, 5.0% ADL, 1.63%K, 0.46% Ca, 0.30% Mg,

152ppm Mn, 35ppm Zn and 6ppm Cu. (Akinola, 2018). Abdu *et al.,* (2012) reported 7.31% CP 87.17% organic matter, 23.18% Crude fibre, 2.18% Ether extract, 7.39% Nitrogen free extract in *Panicum maximum.* Alalade *et al.* (2013)investigating the effects if 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 3.74%Kcal/kg Gross energy.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 40-43% in the stem and 36.3-35.8% in the leaf; and 67.7-69.4% in the stem and 62.2-63.1 in the leaf

2.6 Forage conservation

Ruminant animals are primarily forage consumers. A major challenge to livestock producers is getting adequate quantity of quality feeds throughout the year. Forages grow rapidly during the wet season, become fibrous, coarse and low in nutrients as the season advances towards the dry season. This is because tropical grasses grow and mature under a high temperature regime. High temperature stimulates growth and ageing of grasses with a consequent fall in intake and digestibility by ruminant animals, which eventually hamper development of the animal.

In order to solve the limitations of feeds for ruminants especially during dry season, there is a need for developing a feed conservation strategy during the period of abundant supply(rainy season) so as to redistribute the feed supply over the year to meet the requirements of livestock resources. Forage conservation basically aims to produce, at low cost, a stable product suitable for ruminant animal feeding with minimum loss of nutritive value. It also bridge the gap betweenthe feed requirement of the animals and the production of the forages. (Robert *et al*., 2003).

Forage is preserved as either hay or silage. In hay production, the crop is dried so that it is essentially biologically inactive both with respect to plant enzyme activity and microbial spoilage. The low moisture content also permits easier transportation by reducing the weight per unit of dry matter (DM). Haymaking is dominant in those areas of the world where good drying conditions prevail. However, it may also be used in humid climates where ensiling has been considered too difficult because of forage characteristics, high temperatures or tradition (ShinnersandKevin,2014).

2.6.1 Hay making

Forage can be conserved to feed livestock duringperiods of shortage caused by limited pasture growth or inadequate pasture conditions or when fed as asupplement (for example, when supplementing with a legume). Conserved forages can take the form of hay, haylage or baleage, and silage (Brink*et al,* 2014). While several techniques have been proven as efficient ways to store forages, it is important to keep in mind that, at best, conserved foragescan rarely match the nutritive value of fresh forage, and some losses of highly digestible nutrients (sugar, protein, and fat) are unavoidable(Romero *et al.*, 2014).

The goal in forage conservation should focus on minimizing losses, which start immediately after cutting.The process of selecting a conservation technique should take into account the suitability of the forage for a given technique, storage capability, weather conditions, and the intended use of the conserved forage. The selected conservation technique should maximize nutrient conservation efficiency and minimize production costs (Collins and Owens, 2003).

Hay can be defined as animal feed produced through dehydration of green forage to moisture content of between 15-20% which is low enough to inhibit activities of plant microbes and enzymes and without deterioration of nutrients. *Pennisetum clandestinum, Panicum*

maximum, Cenchrus ciliaris, Cynodon spp. and *Digitaria decumbens* are examples of forages used to make hay (Skerman, and Reverous, 1990). Hay is defined as forage conserved under aerobic dry or limited moisture conditions. Fresh forage typically has between about 75% and 85% moisture concentration (Collins and Coblentz, 2013). Thus, the goal in hay production is to remove moisture as quickly as possible to achieve a target moisture concentration equal to or less than 20% (or a target dry matter concentration greater than 80%). The process of reducing moisture is called curing and is normally accomplished with energy provided in the (field curing) or by artificial barn drying using forced heated or unheated air. Moisture concentration less than 20% (preferably less than or equal to 15%) prevents plant respiration and allows for an almost complete conservation of plant nutrients for extended period (months). Factors that influence the process of moisture loss for hay production can be classified into three types: (1) forage-related, (2) weather-related, and (3) management-related (Rotz 1995; Collins and Owens, 2003).

After preparing the hay, store it in the form of bales in a shady and well-ventilatedplace. Earlier bales of the hay were prepared with hand, but now bales of differentsizes are made with the help of machines in developed countries, and it is easy to protect these bales from water and rain(Muhammad, 2011). Proper storage is a critical step in making high-quality hay. Hay bales should be stored in well-ventilated farm sheds that also provide sufficient cover from the rain. It is important to ensure that the sheds or barns do not expose the hay to very moist conditions causing spoilage from mould. Hay sheds can be built using simple materials, such as wooden poles and grass thatching. Wooden pallets or a raised platform can be used to avoid placingthe hay directly on the shedfloor(Irenie *et al*., 2016).

The primary objective of any hay-feeding program is to provide plenty of high-quality hay to meet the animals' nutritional needs. Many factors affect the quality of hay: soil fertility, the stage

of forage maturity when harvested, the moisture available during the growing season, harvesting conditions and storage.

Because of those factors, most operations produce hay of varying qualities in different cuttings. To determine the quality of each cutting, have the hay analyzed by a laboratory. If you know the quality ofeach cutting, you not only can feed the highest quality hay to animals with the highest requirements, butyou also can estimate the amount of supplement needed to meet animal requirements with each quality of hay (David and Sim,2018).

2.6.2 Seed treatment

Seed treatments aredefined as chemical or biological substances that areapplied to seeds or vegetative propagation materials tocontrol disease organisms, insects, or other pests. Seed treatment pesticides include bactericides, fungicides,and insecticides. Most seed treatments are applied totrue seeds, such as corn, wheat, or soybean, whichhave a seed coat surrounding an embryo. However,some seed treatments can be applied to vegetativepropagation materials, such as bulbs, corms, or tubers(such as potato seed pieces), Bruce *et al.*(2001).

Seed treatments are used on many crops to control avariety of pests. Seed treatments are commonly usedto ensure uniform stand establishment by protectingagainst soil-borne pathogens and insects. In fact, theyare considered so essential for corn standestablishment that virtually all corn seed is treated.Seed treatments have had phenomenal success in eradicating seed-borne pathogens, such as smut orbunt, from wheat, barley, and oats. Seed treatmentscan be used to suppress root rots in certain crops.Finally, some newer systemic seed treatments cansupplement or may provide an alternative totraditional broadcast sprays of foliar fungicides orinsecticides for certain early-season foliar diseases andinsects.Although seed treatments have important benefits,they also pose certain risks. One risk is accidentalexposure of workers who produce or

apply seedtreatments. Another risk is contamination of the foodsupply by accidental mixing of treated seed with food or feed grain. A third risk is accidental contamination of the environment through improper handling oftreated seeds or seed treatment chemicals. All of theserisks can be minimized by proper training and properuse of seed treatment pesticides Bruce *et al.*(2001).

2.6.3Planting methods in Guinea grass(*Panicum maximum*)

Abdul Azeez and Yushau, (2017) reported that, the herbage yield of *Panicum virgatum* was significantly influenced by sowing methods at all level of treatments. The highest yield was obtained by dibbling followed by drilling and broadcasting method, respectively.

A grassdrill is the best method of seeding on level and sloping areas, but the preferred method will depend on slope and conditions of the planting site. If the drill does not have a packer wheel system, a culti-packer or roller should be trailed behind.Seed may be broadcasted by usingwhirlwind or end gate seeders. Cover seed with ¼ inch of soil or less. Roll, cultipack or use some othersuitable method to firm seedbed before and after seeding (NRCS, 2009).

2.7 Effect of Concentrate Supplement on Ruminants

Inclusion of supplemental feeds creates a complexity in the feeding scenario that may result in an improved or detrimental animal response (Moore *et al*., 1999) cited in Adeleke, (2016).Supplemental feeds often times have physical structure, solubility, degradation, and chemical characteristics that are different from the base forage utilized. The respective differences may be advantageous to the manipulation of nutrient synchrony. Conversely, Hersom, (2008) reported that the properties of the supplement may exacerbate an asynchronous dietary nutrient supply. In that regard, negative associative effects would be detrimental to the process of dietary synchrony.

Bach *et al*. (2005) reported that rumen micro-organisms use carbohydrates as the main energy sources, although protein can also be used. When adequate energy sources are supplied in the rumen, ammonia N can be converted to microbial protein. If the rate of protein degradation exceeds that of carbohydrate degradation, inefficient microbial protein synthesis may occur. Therefore, synchrony between the supply of energy and N to the rumen microorganism should improve the efficiency of the rumen microbes in capturing N and use of energy for microbial growth (Yang *et al.,* 2010). Since anaerobic fermentative digestion in the rumen provides microbial cells which supplies protein to the animal, the efficiency of microbial growth therefore influences the protein-energy (P/E) ratio in the rumen. Poor microbial growth due to inadequate dietary N for example will result in low P/E in the nutrients available to the animal (Leng, 1982; Adeleke, 2016).

According to (Hersom, 2008; Adeleke, 2016), the most frequent supplement strategies include controlling the timing of feed and nutrient delivery, attention to the balance of energy to protein in the diet. An important observation is that each particular type of supplement (i.e., energy or protein) also generally supplies other ancillary nutrients. The complement of energy and protein in supplements may include the likelihood of dietary nutrient synchrony in forage fed cattle (Hersom, 2008; Adeleke, 2016), but more important is the synchronization of the rate of degradation of feed nitrogen and carbohydrate or organic matter components (Rusell and Hespell, 1981; Orskov, 1982).

Maximum fermentation rates are attained when all factors required by the ruminal microorganisms are available, namely, a source of energy (sugars, cellulose), nitrogen (N), sulphur (S) and minerals. When the rate of fermentation is restricted, feed intake decreases; and nutrient availability to the animal is likewise limited (Norton, 1994). Khampa and Wanapat

(2007), reported that manipulating rumen fermentation through strategic supplementation with concentrate and forages could improve rumen efficiency through maintaining optimum pH, optimizing volatile fatty acids (VFAs) and ammonia-nitrogen (NH_3-N) utilization for microbial protein synthesis and reduction of methane (CH_4) production, thereby enhancing the productivity of ruminants in the tropics.

2.8.1 Rumen environment and nutrient synchrony

The rumen is an environment with diverse population of microorganisms, consisting of bacteria (10^{10}-10^{11}cells/ml, of more than 50 genera), ciliate protozoa (10^4-10^6/ml, of 25 genera), anaerobic fungi (10^3-10^5 xoospores/ml, of five genera) and bacteriophages (10^8-10^9/ml),(Kamara, 2005).The ruminal microbial ecosystem can be divided into two groups, microbes that ferment structural carbohydrates and those that ferment non-structural carbohydrate (NSC, Rusell *et al*., 1992). The rumen microorganisms ferment dietary carbohydrate and protein to obtain energy and N for maintenance and growth. Through this process, the two major nutrients or products (VFAs and microbial protein) for the host animals are produced (Yang *et al*., 2010).

Microbial protein synthesis (MPS) is important in ruminants because microbial protein synthesized in the rumen provides from 50% to nearly all amino acids required by ruminants, depending on the rumen undegraded protein (RUP) concentration of the diet (NRC, 2000). Non-structural carbohydrate (NSC)-fermenting microorganisms usually represent a predominant population of rumen microbial flora in high producing ruminant animals, such as lactating dairy cows and feedlot beef cattle. The nitrogen requirement of NSC-fermenting microbes can be met by either ammonia or peptides and amino acids (Rusell *et al*., 1992; Adeleke, 2016).

Microbial processes in the rumen confer the ability on ruminants to convert fibrous feeds and low quality protein, even non-protein nitrogen, into valuable nutrients for the ruminant animals (Dewhurst *et al*., 2000; Chandrasekharaiah *et al*., 2012). Microbial proteins synthesized within the rumen provide a major source of amino acids to ruminant animals.

According to Kung (2011) cited in Adeleke (2016), the optimum pH of the rumen for efficient and effective fermentation and degradation of feeds (especially fibre) ranges from 6.2to 6.8. At pH below 6.0 - 6.2, fibrolytic bacteria in the rumen become less active and fiber digestion is decreased. Further decrease in pH to between 5.8 – 5.9 causes mildly acidic rumen environment and cessation of fiber digestion. Excessive feeding of concentrate, especially grains has been implicated as the cause of acidosis in ruminants when rumen pH falls below 5.0 – 5.2 (Allen, 1997; Carro *et al*., 2000). Kanjanapruthipong and Leng (1998) reported that ruminal fluid ammonia is the major source of nitrogen for microbial synthesis and growth and that critical levels of ammonia nitrogen has been raised from 50 – 250 mg/litre of rumen liquor.

In ruminant nutrition, concurrent ingestion of forage and concentrate implies occurrence of rumen degradable protein (RDP; NPN and rumen degradable true protein) and energy (ruminally fermentable carbohydrates) for the ruminant animals to consume or be present in the diet and rumen, so that an increase or optimization of microbial efficiency would occur (Hersom, 2008; Yang *et al*., 2010). The synchrony ingestion of protein and energy is important for the ruminant micro flora (Schilcher *et al*., 2013).

According to Hersom (2008), parameters such as ruminal pH, total VFA and individual acid concentration, microbial nitrogen yield, and body weight (BW) gain, milk production, or carcass weight accumulated are useful indicators of synchrony of release of nitrogen and energy in the rumen during dietary degradation. For example, Chumpawadee *et al*., (2006) fed diets containing

3 levels of synchrony index to Brahman cattle at the rate of 2.5% body weight by separate concentrate and roughage. The authors observed a linear increase in average daily gain, dry matter, organic matter and neutral detergent fiber digestibility, and ruminal total volatile fatty acids concentration at 6 hours post feeding. They concluded that synchronized rate of dietary energy and nitrogen degradation improved ruminal fermentation and degradability which led to higher growth rate in Brahman cattle fed with straw-based diets.

A rapid release of nitrogen not matched to the release of organic matter from the carbohydrate source could lead to a high absorption of ammonia from the rumen. In that regard, ammonia not captured in the rumen is absorbed and converted into urea in the liver (Baah *et al*., 2011). According to Yang *et al*. (2010), there are several ways to supply energy and N to the rumen concurrently. These include: i) changing the concentrate: forage ratio; ii) supplementation of energy or protein sources; iii) using index values and; iv) change of feeding frequency or pattern. Newbold and Rust (1992) suggested that even if the total amount of rumen degradable protein supplied each day meet the requirement of rumen microbes, difference between feeds in terms of degradation of protein or energy substrate may cause short-term imbalances between nitrogen and energy supply to rumen microorganisms.

2.8.2 Response of ruminants to supplement and roughages

Schilcher *et al*., (2013) investigated the health of different wild ruminant species in relation to feeding management. In the morning, the test animals were offered with a mixture of concentrates, vegetables and fruits, and at the same time hay. They observed severe lesions on the rumen mucosal of the animals which are fundamental characteristics of sub-acute ruminal acidosis (Krause and Oetzel, 2006). This is because of initial low hay intake as the animals usually eat the concentrate mixture in preference before hay. The authors therefore, suggested

that roughage be offered in the morning before the concentrate meal. Earlier, Morita and Nishino (1991) offered diets to steers separately by feeding hay before concentrate and observed greater DMI in steers fed hay before concentrate compared to their counterparts fed concentrate before hay. Similar results were obtained when this sequence of feeding (concentrate supplement fed 40 min before or after feeding hay) was compared with feeding mixed diet of hay and concentrate (Morita and Nishino, 1993). However, Nocek *et al*. (1986) observed that the amount of DM intake increased when the mixed ration was offered. On the other hand, some reports pointed out that offering the mixed ration had no effect on DM intake (Holter *et al*., 1977). Voight *et al*. (1978) cited by Adeleke (2016) reported that cellulose digestibility in the fore stomach increased when chopped rye grass was fed before feeding barley or corn.

Sarker *et al* (2017), reported that rice straw TMR, either in mash or in block forms give a better result in terms of milk yield, milk composition, and concentration of TVFAs and NH_3-N in the rumen which helps in the microbial protein synthesis and enhance higher milk production. Pathak (2008) reported that Diets containing a mixture of forages andconcentrates increase microbial protein synthesisbecause of improved synchronization of nutrientrelease, an improved ruminal environment for morediverse ruminal bacteria species, increased amountsand types of substrates, increased intake andsubsequently, increased rates of solid and liquidpassage.Microbial protein synthesis isdependent upon suitable N and carbohydratesources. Even though trace minerals and vitaminsare adequate for maximal microbial protein synthesisin many feeding conditions, inadequate traceminerals and vitamins, in some cases, could limitmicrobial protein synthesis. Protein sources, whichare low in DIP, may limit the microbial proteinsynthesis when calculated to meet animalrequirements based on dietary CP. In order to obtainmaximal microbial protein synthesis, the nitrogenrequirement of the rumen bacteria has to

be metfirst. Nitrogen sources also must include amino acidsand peptides in addition to NPN (Pathak, 2008).

2.8.3 Rumen volatile fatty acids

As a primary energy source for ruminants, volatile fatty acids (VFA) have been estimated to provide up to 75% of the total metabolizable energy, Bergman, (1990) cited by Gregory (2015). Thus, it is not surprising that diets promoting fermentation and greater production of VFA also promote greater levels of productivity (e.g. milk production) than less fermentable diets (Kolver and de Veth, 2002; Oba and Allen, 2003). However, as a weak acid, VFA will dissociate in the rumen releasing a proton thereby decreasing ruminal pH under most circumstances. Thus, when production of VFA exceeds the ability to neutralize the protons, ruminal pH decreases and ruminal acidosis can occur.

Ruminal acidosis occurs in dairy (Penner *et al*., 2007; Penner and Oba, 2009), and beef cattle (Bevans *et al*., 2005; Weirrenga *et al*., 2010). However, the most common form of ruminal acidosis in dairy cattle is thought to be sub-acute ruminal acidosis (SARA) whereas, lactic acidosis or acute is thought to be the primary form in beef cattle fed high-concentrate diets (Schwaiger *et al*., 2013). Sub-acute ruminal acidosis (pH < 5.8) is caused by a rapid rate of VFA production while, for acute acidosis (pH < 5.2), the pH depression is often associated with an increase in lactic acid (Owens *et al*., 1998 cited in Gregory, 2015). While thresholds are used to characterize ruminal acidosis, the actual pH value that induces damage to the ruminal epithelium, alters the microbial community structure and activity, and results in depressed feed intake likely varies among animals.

2.8.5 Ruminal pH

The normal range of pH in the rumen is 5.7 to 6.7 which is less than the general extracellular pH around 7.4. Lower pH in the rumen is because of fermentation of the feed to organic acids which are readily dissociated and can cause decline in pH (Dijkstra *et al*., 2012). Type of the diet affects pH of the rumen not only due to change in VFA production pattern but also due to effects on rumination and saliva secretion. For example, high forage to concentrate ratio in the diet will increase rumination time which will stimulate more saliva production thus buffering the rumen fluid (Allen, 1997). When the length of the fiber is longer there is more floating mat in the rumen resulting greater ruminal contraction which can increase absorptive area thus affects ruminal pH (Yang and Beauchemin, 2007). Higher intake coupled with higher fiber intake will also increase the fractional rate of liquid passage rate from the rumen (Dijkstra *et al*., 2012). However, pH can also affect the pattern of VFA production independent of the diet since at lower pH a greater fraction of soluble carbohydrates are fermented to propionate than at higher pH (Bannink *et al*., 2008, Calsamiglia *et al*., 2008). Low pH is also favorable for VFA absorption because more undissociated VFA can be absorbed through passive diffusion on the same absorptive surface of rumen epithelium (Dijkstra *et al*., 1993).

Maintaining a healthy pH in the rumen is critical particularly for animals on high grain diet since there can be sharp decline in ruminal pH due to highly fermentable feed which affects microbial composition, value of the fermentation products as well as ruminal health. When pH falls below 5.5, ruminal epithelial tissue is damaged contributing to reduced intake and productivity (Krause and Oetzel, 2006). If pH is chronically low it can also lead to diarrhea, liver abscesses, inflammation, and lameness (Plaizier *et al*., 2008). Reduced pH (<6.0) also inhibits fiber digestion which reduces diet digestibility, absorbed energy supply, animal production, and

animal efficiency (Plaizier *et al*., 2008). For example Plaizier *et al*. (2001) reported about 20% decrease in 24h NDF degradation in cows induced with sub-acute ruminal acidosis (SARA). However, Krajcarski-Hunt *et al*. (2002) observed depressed in situ NDF digestibility only in corn silage and not in grass hay and legume hay when incubated in SARA induced lactating cows. In a continuous culture Calsamiglia *et al.* (2007) observed that low pH depressed NDF digestibility within the range of pH of 4.9 to 7 independent of the diet type but the depression was markedparticularly below 6. Grant and Weidner (1992) also suggested that critical pH for a lag in NDF digestion can range from 6.2 to 5.8 depending upon the type of forages.

It is important to note that the pH of rumen is not uniform and can vary by location and time after feeding. The cranial dorsal part of the rumen has higher pH compared to central and ventral rumen (Shen *et al*., 2012). Storm and Kristensen (2010) observed around 0.6 unit difference in pH between ventral sac (pH=6.6) and medial mat (pH=6.0) in the rumen of lactating cow fed mixed diet. This variation was not affected by particle size of the forages and was attributed to increased concentration of VFA in the medial mat compared to ventral sac of the rumen. Difference in pH at different location in the rumen could be due to imperfect mixing of rumen contents and buoyancy of solid particles and the associated microbes therein. The pH of the rumen does not remain the same throughout the day particularly for diets containing highly fermentable fraction of feed (Walsh*et al*., 2009). In a mixed diet or high concentrate diet fed once a day, the pH in the rumen starts to decline immediately after feeding and reaches a nadir at 9 to 11 h and starts to increase again (Hünerberg *et al*., 2015).

Increasing the amount of forages in the diet reduces the diurnal variation in pH in the rumen. A single pH value for various treatments reported in literature for cows which are not fed continuously are generally the average of samples taken at various time of the day after feeding

when fermentation is most active. To minimize the bias of rumen location in the reported ruminal pH, researchers usually collect ruminal samples from various locations and measure pH of pooled sample. However in manual sampling, CO_2 in the rumen fluid might escape due to exposure to the ambient air and can result higher reading compared to the actual in rumen (Smith, 1941). Use of rumen loggers in recent years have made continuous measurement of rumen pH possible with good accuracy without exposing the fluid to air (Penner *et al*., 2006, Hünerberg *et al*., 2015), but many of theseloggers have limited movement in the rumen and generally reside on the reticulum hence cannot give representative pH of entire rumen.

2.8.6 Nutrient digestibility, growth performance and nitrogen balance

Incorporation of Bambara nut seed meal in concentrate diets fed as supplements to WAD bucks on *Panicum maximum* significantly influenced dry matter intake (DMI), apparent N-digestibility but had nosignificant effect on N-feaces, N-balance, N-urine. Similarly Result also showed that apart from Ether extract and Energy,diets had no effect on apparent digestibility coefficients (%) except for Ether extract and Energy. Metabolic feacal nitrogen (MFN) (g 100g-1 DM), endogenous urinary nitrogen (EUN) and digestible crude protein (DCP) g day-1 Wkg0.75 values for maintenance were 1.16, 0.86, 0.79, 1.05; 0.11, 0.90, 0.86, 1.66 and 1.07, 0.48, 0.42 and 1.56 for diets A, B, C and D respectively. All diets promoted positive N-balance (Odoemelam *et al*., 2015).

(Anifowose *et. al*. 2016) reported that Dry matter digestibility of panicum: cowpea basal diets for 50:50, 60:40.70:30 and 80:20 were 81.55, 80.92, 78.99 and 78.74g/day respectively. There was no significant increase in dry matter digestibility between 50:50 and 60:40; though, they were both significantly higher than 70:30 and 80:20 which statistically similar and lower. The digestibility of organic matter increased statistically across treatments with increase in the

percent and panicum level, with 80:20 (99.27g/day) recording the lowest while 50:50 (84.84g/day) had the highest digestibility, suggesting that as more cowpea was used to replace panicumorganicmatter digestibility increased.

The crude protein(CP) digestibility for 60:40 (61.75g/day) was significantly higher than 50:50 (58.06g/day)and 70:30 (56.14g/day) which were statistically similar to each other while 80:20 (54.92g/day) recorded significantly least value, suggesting that the CP digestibility increased with increase in percent cowpea up to 60:40 but further decreased statistically as more cowpea replaced panicum. The crude fibre (CF) digestibility decreased statistically across treatments from 50:50 (66.82g/day) to 70:30 (58.77g/day) as more cowpea replaced panicum while CF digestibility for 70:30 and 80:20(59.18 and 58.77 g/day) were similar and lower (Anifowose *et. al*. 2016).

The result of dry matter and crude protein digestibility generally reported in this study are higher than 56.88 and 58.51, respectively reported by (Tona, 2011) for sheep fed *P. maximum*. The observation in this study is consistent with Aregheore (2000) who affirmed that digestibility of nutrients varies with nutrients composition of diet. The higher crude fibre digestibility observed in the 50:50 treatment diets might be related to changes in the rate of passing of ingesta from the rumen (Badamana,1992). The result obtained in this study is consistent with Ososanya *et al*.(2013) who fed corncobs and cowpea shells to West African dwarf sheep.

Anifowose, 2016 also reported that the result of nitrogen balance in goats fed panicum: cowpea shells mixture as basal diets to a concentrate diets. Nitrogen intake was significantly ($P<0.05$) affected with the dietary treatment. 50:50 diet having higher N intake (6.91g/day), which decreases with decrease in panicum in the basal diet. The increase is as a result of increase in the cowpea shell, having a higher CP value. The N intake of experimental animals fed 50:50 and

60:40 were similar but statistically (P<0.05) higher than 70:30. N balance and also statistically decreased further with decrease in in the level of cowpea added (80:20).

Total N outgo increased significantly across treatments as more cowpea replaced Panicum, with animals fed 50:50 diet having higher N outgo, followed by the rest of thetreatments which were similar.N balance were statistically higher and similar for 50:50 and 60:40 (3.56 and 3.72g/day, respectively), which were followed by 70:30 (3.04g/day) and the least was in 80:20 (2.59g/day). Both nitrogen observed and nitrogen retained as percent of intake for 60:40 were significantly (P<0.05) higher as compared to all other treatments with 80:20 recording the least value (Anifowose *et al*. 2016).

2.9 Goat production in Nigeria

The world goat population has been steadily increasing (39% increase from 1986 to 2000; (FAO 2008; Olafadehan *etal*.2016). Goat rearing in Nigeria is traditional and mainly depends on grazing andbrowsing which alone are not sufficient foroptimizinghigh productiveand reproductive performance.The importance of goats in the livelihood of the rural Nigerian populace which constitutes up to 80% of theNigerian population cannot be over emphasized (Ahamefule, 2005; Ukanwoko *etal*., 2009; Odoemelam (2015). It contributessignificantly to improved family nutrition and health, the sale of the animals and their products help stabilize household income. Nutrition has been identified as one of the major factors responsible for poor performance of these indigenous breeds (Adamu *etal*., 2010; Odoemelam, *etal*., 2013).

2.9.1 Origin and distribution of goats

Goat (*Capra hircus*) is the earliest domestic animal and probably the first ruminant livestock, after the wolf was domesticated (Zeder and Hasse, 2000). They are one of the smallest domesticated ruminants which are managed for the production of milk, meat, wool and leather

particularly in arid, semi-tropical or mountainous countries (Morand-Fehr, 2004). Goat is the most prolific ruminant among all domesticated ruminant under tropical and subtropical conditions. Due to their high tolerance to heat stress, goats can survive and produce in the most marginal regions of the world. On the other hand, goats, when managed well, contribute to the preservation of the ecosystems and can be used as biological tool for controlling the weeds, reducing the incidences of wildfire, improving rangeland and wildlife habitat. There has been a constant increase in goat population of the world since the 60s, especially in the developing countries of the world like Nigeria (Skapeters and Bampidis, 2016).

2.9.2 Breeds of goats in Nigeria

There are three main breeds of goats in Nigeria - The Red Sokoto, the Sahel and the West African Dwarf goat (Rotimi *etal*., 2017).

2.9.3Red Sokoto goats

Red Sokoto goats also known as Kano brown in Nigeria is the most widely spread breed of goats in Nigeria, commonly referred to as village goats in the northern part of Nigeria where it is being reared by almost two-third of the country, even though less common with transhumans pastoralists (Haumesser, 1975). It is characterized by uniform coat colour of dark red in both males and females and are well adapted to semi-arid region. They are of average height, shorter than Sahelian goats but taller than West African Dwarf goats (Adu *etal*., 1979).

Red Sokoto goat is known for its good quality leather which is known in Europe from the middle ages period onwards. Burns (1965) observed that the skins have coarse, thinly spaced outerhairs and small sweat and wax glands and lack fat.

2.9.4 Sahelian goats

It is also known as West African long legged goats bearing semblance with West African Dwarf goats in coat colour except for its long twisted horn, long leg and its body size, The Sahel goat is found along the northern border of Nigeria, it is often known as 'Balami'. The coat is white or dappled, the ears are pendulous and the legs are notably longer than other breeds, Rotimi *etal.* (2017). In nigeria, the Sahel goat is generally the most preferred breed of goats by pastoralists, they are similar in appearance to the sheep with which they are often herded together (Mason, 1988).

2.9.5. West African Dwarf (WAD) goats

The WAD is usually black, although patched, pied, and occasionally all-white animals can be seen. The breed is well adapted to humid environment and very resistant to trypanosomiasis as WAD goat is believed to be trypanotolerant because it thrives in tsetsefly infestedareas. Indeed, like muturu cattle, they may once have been the main race of goat over most of Nigeria. Just as the Zebu has replaced the Muturu, so WAD goats have been driven to remote areas in the savannahs, Adedeji *etal.* (2011).

2.9.6 Population of goats in Nigeria

Goats constitute the largest group of small ruminant livestock in Nigeria totalling about 53.8 million and also constituting 6.2 percent of the World's goat population (FAOSTAT, 2011). Surveys have shown that up to 85 percent of rural households, poor farmers and smalltime business people of all age groups and sexes keep goat (FDLPCS, 2007). The ability of goats to tolerate harsh climates, the presence of trypanotolerance in some breeds (Salako, 2004), suitability to traditional systems on account of small size, short generation interval (Abdul-Aziz, 2010) and ability to thrive on poor quality diets provided by scarce grazing on marginal lands

(Adedeji *etal*., 2011) all combine to make small ruminants strategic to increasing livestock productivity in rural agricultural systems.

2.9.7 Importance of goats in rearing

Gambo *etal*. (2005) reported that among the cheapest and mostly affordable protein source for the ever increasing population in Nigeria is mainly the poultry products and chevons (goat meat). Okpeku *etal*. (2011) also reported that rearing of small ruminants (sheep and goats) would have lasting effects in bringing about social change by improving the incomes and standard of living. Provision of raw materials like fibre and skin to the local handcraft industries, income generation to the small holding livestock farmers, amongst others are the important of goat rearing highlighted by Okunlola, (2000). In addition, defaecation and urination from goats help in improvement of soil nutrient (Oguniyi, 2010).

2.9.8 Factors affecting goat production in Nigeria

The Productivity of ruminants is dependent on the potential of a feed to supply, through effective microbial degradation, balanced nutrients for production. Digestible dry matter intake is highly correlated with animal productivity offered individual feeds (Devendra, 1983). Voluntary Feed Intake (VFI) is the single most important factor affecting production in animals and is also associated with digestibility of the feed, and proportion of the digested material that's absorbed

According to ILRI (1995) during a global consultation to definethe priority for livestock research, feeding and nutrition was identified as the major constraint to productivity of the animals.Goats and sheep rearing in Nigeria, have been hampered over the years primarily by the seasonal nonavailability of good quality feeds which results into weight losses, low birth weights, lowered resistance to diseases, and reduced animal performance (Onwuka *et al*., 1989; Winrock international, 1992). Several survey reports (Okorie and Sanda, 1992) had indicated that supplementary feeding is rarely practiced by mostsmall ruminant farmers because of the high cost of supplementary feed ingredients.

Kagira and Kanyari (2001) reported that among several constraints that limit productivity oflivestock, diseases and parasites are of major importance. Parasitic gastroenteritishas been noted as major constraint to ruminants' productivity in terms of pathology and economic importance (Biu *et al*., 2009). Clarence *et al*. (1991) also reported that lameness due to diseased condition results in significant reduction in productivity of the livestock. Locomotory soundness is a requirement for effective grazing and reproductive performance in all classes of livestock (Egwu *et al*., 1994).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiment was carried out at the experimental field of the Feeds and Nutrition Research Programme of National Animal Production Research Institute, Shika, Zaria,Kaduna State, Nigeria. Shika is located on Latitude 11^0 12'N, Longitude 07^0 33'E at an altitude of 660m above the sea level, along Zaria-Funtua road is characterized by a defined wet and dry season. Wet season starts from late April to early May and ends in late September to early October while the dry season is from October to April. The total annual rainfall ranges from1110-1580mm with a long term average of 1058.60mm. Maximum air temperature of 30^0C were recorded in May and minimum air temperature of 18.23^0 C in October with relative humidity of approximately 70% during the rainy season (IARMS, 2018).

3.2 Meteorological Data of the Experimental Site

Weather observations at Shika during the experimental period in 2018 are presented in (Appendix i).Themaximum and minimum air temperatures of 35.16^0C and 18.23^0C were recorded in May and October respectively during the rainy days. The total annual rainfall of

992.6mm over a period of 5 months was recorded in 2018. The number of rainy days in Shika was 67 days. A mean relative humidity of 67.92% and mean sunshine of 6.75 hours were observed during the rainy season.

3.3 Soil Samples of Experimental Site

Soil samples were collected for nutrient analysis from the experimental site with the aid of Soil auger at four corners and centre of the plots at 0-15cm and 0-30cm depth to make a composite for soil analysis at the beginning of experiment so as to ascertain the level of nutrient in the soil as well as determining the nutrient requirement. The soil sample was analyzed for physical and chemical properties as described by A.E.S (1998). The analysis was carried out at the chemical laboratory of the Department of Soil Science, Faculty of Agriculture, Ahmadu Bello University, Zaria.

3.4Land Preparation and Experimental Design

A gross land area measuring 40m×20m (0.18ha) was used for the trial. The land was harrowed once with tractor coupled implements and seed beds were prepared to meet a better condition for germination and early establishment of seeds. The experiment was laid out in a split-plot design with 4x2x3 factorial arrangement, replicated three times. The treatments were: 4 levels of pig manure (0, 5, 10 and 15 t/ha), 2 planting methods (drilling and broadcasting) and 3 stages of harvest (6, 9 and 12 weeks after planting). The rate of pig manure application was the main plot factor, while planting methods and the Harvest time of *Panicum maximum* served as sub-plot factors. Forage samples cut at each stage of harvest were bulked, and sub-samples analyzed for proximate analysis. At 12 weeks after planting, the forages were all cut and preserved as hay for feeding growing Red Sokoto bucks in the second phase of the experiment.

3.5 Source of Experimental Materials and Planting

Dried pig manure was sourced from the Swine Unit of the Ahmadu Bello University Teaching and Research Farm, Shika, Zaria. The manure was applied by broadcasting and thereafter the seed beds were well prepared with the use of hoe. Seed of *Panicum maximum* used for the establishmentwas sourced from the Seed Store of the Feeds and Nutrition Research Programme of National Animal Production Research Institute, Shika, The seeds were soaked in hot water to break dormancy and treated against insect attack using insecticide (Apron plus) at 5g/kg. Drilling and broadcasting methods were used in planting of seed at the rate of 5kg/ha at 1cm depth, after which light coveringwith soil was done to enhance germination and establishment with inter row spacing of 50cm under drilling method. Weed was controlled by 3 hoe weedings throughout the experimental period.

3.6 Chemical Composition of Pig Manure

Pig manure used was analysed for its chemical composition in order to determine the nutrient composition, (Appendix ii). The result showed that the manure contained 1.93% total nitrogen (N), 1.094% phosphorus (P), 1.50% potassium (K) and micro minerals with 6800mg/kg iron (Fe), 183.50mg/kg copper (Cu), 352.25mg/kg manganese (Mn) and 307.25mg/kg zinc (Zn). This result indicate that pig manure is just slightly below 2.0% N present in poultry manure that is widely used byfarmers.

3.7 Data Collection

3.7.1 Growth Parameters

Data on crop phenology and yield was measured at 6, 9 and 12 weeks after planting on primary growth which represented three (3) growth stages of the grass as vegetative, boot and inflorescence stage.

3.7.1.1Establishment count

Seed emergence ($0.5m^2$)was monitored at 7 days after planting. Seedling count was done at 15 days after planting to estimate for percentage germination.

3.7.1.2 Number of tillers per plant

The determination of the tiller numbers was carried out by counting the number of tillers of the five randomly selected *Panicum maximum* stands at each harvesting date and average was computed.

3.7.1.3Plant height(cm)

Plantheight was determined by measuring from the ground level to the tip of the uppermost leaf inthe plant with the aid of a tape rule on 5 randomly selected plants per plot and the average was computed.

3.7.1.4 Leaf length (cm)

Leaf lengthwas measured using 30cm ruler from the tip of the leaf to the base of the ligule on 5 randomly selected plants per plot and average was computed.

3.7.1.5Leaf width (cm)

Leaf width was determined by measuring the width of leaf half way or mid-point of the leaf with the aid of 30cm ruler on 5 randomly selected plants per plot and average was computed.

3.7.1.6Percentage ground cover(%)

This was determined through visual estimate of plants within a given quadrat in percentage compared to the bare ground.

3.7.1.7Leaf area index

Leaf area index per plot was measured using Ceptometer. The Ceptometer was collected from the Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University Zaria. The ratio of leaf area to land area were taken above the plant and below the canopy at five different locations within a plot when the Photosynthetic active radiation was above 1000µm for efficient measurement while the averages were computed and recorded. The leaf area index is the ratio of leaf per plant to the unit area of land covered by each plant (Watson, 1952).

3.7.8Forage yield

Yield determination(t/ha) of fresh forage within each treatment were determined at 6, 9 and 12 weeks with the use of a $0.5m^2$quadrat and the forage was cut at 15cm above the ground level using a hand sickle for total fresh forage and sub-sample of 150-200g were taken, weighed and oven dried at 65^0C to a constant weight to estimate dry matter yield. Dry matter production were calculated as (TFW (DWss/FWss)) ×10=dry matter kg/ha. (Tarawali *et al*., 1995) where:

TFW= Total fresh weight from $0.5m^2$ in (g)

DWss= Dry weight of the sub sample in (g)

FWss= Fresh weight of the sub-sample in (g)

3.7.3 Chemical analysis

Forage harvested at each of the stages of harvesting were analyzed for dry matter (DM), Ash, crude fiber (CF), crude protein (CP), ether extract (EE) and Nitrogen Free Extract (NFE) using the standard procedure of AOAC (2005). Acid detergent fiber (ADF), Neutral Detergent Fiber (NDF) and lignin were determined by the method of Van-Soest *et al*. (1991). Mineral contents such as Calcium (Ca), Potassium (K), Sodium (Na) and Phosphorus (P) were determined using atomic absorption spectrophotometer. The analysis was done at the Department of Animal Science Laboratory, Faculty of Agriculture, Ahmadu Bello University, Zaria.

3.7.4 Statistical analysis and model

In experiment I, data on growth component were analyzed using the repeated measure analysis of variance (ANOVA) and forage yield was analyzed by one way ANOVA using general linear model procedure of SAS, (2005). Means were compared using Duncan Multiple Range Test, Duncan (1995) of the SAS package.

3.7.5 Model Experiment I

$Y_{ijk} = \mu + A_i + B_j + C_k + (A*B)_{ij} + (B*C)_{jk} + (A*C)_{ik} + (A*B*C)_{ijk} + E_{ijk}$

Where:

Y_{ijk} =Record of observations for dependent variable;

μ= Population Mean;

A_i = Effects of different pig manure rates (i= 0 t/ha, 5 t/ha; 10 t/ha and 15 t/ha) on *Panicum maximum.*

B_j= Effect of planting method; (j = Drilling and Broadcasting)

C_k= Effect of cutting stages (k = 6wks, 10wks and 14wks)

$(A*B)_{ij}$=effect of interaction between ith pig manure rates and jth planting methods

$(A*C)_{ik}$= Effect of interaction between ith pig manure rates and kth stages at harvest

$(B*C)_{jk}$= effect of interaction between jth planting methods and kth stages at harvest

$(A*B*C)_{ijk}$ = Effect of interaction between ith manure rates, jth planting method and kthstages at harvest

E_{ijkl}= random error assumed to be normally and independently distributed.

3.7.6 Hay preparation:

At the end of the study, the *Panicum maximum* was harvested with sickles at 10cm above the ground in the afternoon. The harvested forage materials were dried under shade at the Feed and

Nutrition Research Programme of National Animal Production Research Institute with regular turning for 5 days so as to reduce the moisture content to about (12-15%) before storing. Moisture test was carried out by twisting a small bunch of the forage stems so as to determine whether the forages were due for storage or not. The forages were later chopped to 1-5cm size after which they were stored in jute bags until required for feeding. The hay was dried under the shade at the Feed and Nutrition Research Programme of National Animal Production Research Institute.

3.8 EXPERIMENT II: Feed Intake, Body Weight Gain and Nutrient Digestibility of *Panicum maximum* Hay Supplemented with Concentrate fed to Growing Red Sokoto Bucks.

3.8.1 Management of experimental animals

Twelve growing Red Sokoto bucks weighing 10.5 ± 0.5kg were used for this study. The animals were sourced from Kafur market in Kafur Local Government Area of Katsina State. Metabolic cages, feeding troughs and drinkers were thoroughly washed and disinfected before the arrival of the animals. The animals were treated against endo- and ecto-parasites, using *Ivomec* at recommended dose (0.5ml/10kg body weight) subcutaneously and treated against any sign of infection during the adjustment period of 14 days.

3.8.2 Experimental design, treatments and feeding

A total number of 12 bucks were initially balanced for body weight and randomly allotted to four dietary treatments with three (3) animals per treatment,each buck served as a replicatein a Completely Randomized Design experiment (CRD). The experimental treatment 1 was the control where the bucks were fed with concentrate diets and *Digitaria smutsi* hay in (50:50) at 3% of body weight, treatment 2, 3 and 4 were fed concentrate and *Panicum maximum* at (75:25),

(50:50), and (25:75), respectively at 3% of their body weight. The experiment lasted for 90 days while body weight was measured at two weeks intervals to ascertain their body weight gain.

3.8.3 Proximate composition and metabolizable energy of experimental diets fed to growing red Sokoto bucks

The Proximate composition and metabolizable energy of experimental diets fed to growing red Sokoto bucks is presented in Appendix iii. The dry matter of the concentrate supplement was 92.66%, crude protein was 14.72%, crude fibre, ether extract, and Ash were 11.92%, 2.03% and 11.96% respectively. While the NFE, ADF, NDF and ME were 59.37%, 2.64%, 14.66%, and 11.63MJ/kg DM respectively. The dry matter of the *Panicum maximum* hay fed was 92.65%, CP, CF, EE, Ash and NFE were 11.65%, 38.70%, 0.35%, 6.33 and 43.01% respectively while the ADF, NDF and ME were 42.46%, 73.65% and 11.72MJ/kg DM respectively.

The Digitaria smutsii fed as a basal diet in control composed of 92.91% DM, while the CP, CF, EE, Ash and NFE were 6.31%, 29.61%, 5.99%, 5.51% and 47.09% respectively while the ADF, NDF and the ME were 30.16%, 59.55%, and 11.03 MJ/kg DM respectively.

3.9Growth Performance, Digestibility and Nitrogen Balance Study

3.9.1 Measurement of growth performance

Feed intake and weight gain were measured while feed conversion ratio wascomputed. Feed intake was calculated by the difference between feed supplied and left over in each pen. Weight gain was determined as the difference between the initial weight of the animal at the beginning of the experiment and subsequently two weeks intervals. Feed conversion ratio was calculated as the ratio of total feed intake in grams to total weight gain in grams within each replicate.

3.9.2 Digestibility and nitrogen balance study

Twelve bucks were housed in individual metabolic cages ideal for easy collection of urine and faeces as described by Osuji *et al*. (1993). Three bucks from each treatment were assigned to each of the experimental diet and fed once daily in the morning. The trial lasted for 21 days. The first 14 days was for acclimatization after which faecal and urinary collection followed in the subsequent 7 days (*Osuji et al*., 1993). Animals' feed intake was determined by subtracting the orts from the total feed supplied daily. Total faecal output from individual animals was collected daily in the morning, weighed, mixed thoroughly and 10% sub sample taken for dry matter determination. The total faecal samples collected over seven (7) days period was bulked and sub sampled for laboratory analysis. The total urine output for 24 hours was collected from individual animals for a period of 7 days. This was done by using graduated plastic containers and 10ml of 0.1N H_2SO_4 was introduced to trap ammonia. Ten percent of the daily urine output was taken from each buck and the total was bulked and stored in a freezer at 0^0C till needed for analysis.

3.10ChemicalAnalysis

Feeds and faeces was analyzed for dry matter (DM), Crude Fiber (CF), Crude Protein (CP), Ether Extract (EE) and Ash using AOAC (2005) procedure. Nitrogen Free Extract (NFE) was calculated by difference, NFE=100 - (CF + CP + EE + Ash). Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) were determined according to the method of Van-soest *et al.* (1991). Urine was analyzed for urinary nitrogen and crude protein using kjedahl procedure AOAC (2005). Samples of experimental diets and faeces were ashed by charring in muffled furnace at 550^0C for six (6) hours. Organic matter (OM) was obtained as the difference between the dry matter and the residual ash content.

3.11 Statistical Analysis and Model

In experiment II, data collected on daily feed intake, coefficient of apparent feed digestibility, Nitrogen retention and cost analysis were analyzed by ANOVA using General Linear Model Procedure of SAS, (2005). Significant ($P<0.05$) differences among treatment means was separated using Duncan Multiple Range Test (DMRT) of the same statistical package.

3.11.1 Model for Experiment II:

$Y_{ij} = \mu + T_i + E_{ij}$

Where:

Y_{ij} =record of observations;

μ= population mean;

T_i = effect of treatment (i=1, 2, 3 and 4);

E_{ij} = Random Error

CHAPTER FOUR

4.0 RESULTS

4.1 Physico-chemical Characteristics of the Soil at the Experimental Site

Table 1presents information on the physicochemical characteristics of the soil at the experimental site at 0-15 cm and 15-30cm respectively. The soil, at 0-15cm consist of 28% clay, 26% silt and 46% sand which is classified as being loamy soil. Whereas, at 15-30cm, it composed of 24% clay, 24% silt and 52% sand and thus classified as sandy-loam soil. The soil is slightly acidic with pH (6.36) and of moderate Organic carbon (0.58%). The total nitrogen (0.18%) and available phosphorus (4.53ppm) were low. The exchangeable cations, Ca^{2+}, Mg^{2+}, K^{+}were low to moderate in the soil while $Na^{+}$was of moderate status at both depths (0-15 and 15-30cm).At 15-30cm depth, the soil is slightly acidic (6.27) with low (0.48%)organic carbon. The

total nitrogen (0.18%), the available phosphorus (6.27ppm) were low. The soil has a low (6.40 cmol/kg) cation exchange capacity (CEC) and exchangeable acidity of 0.40cmol/kg at (0-15cm) depth while a moderate CEC (12.60 cmol/kg) and exchangeable acidity of 0.60cmol/kgwas recorded at (15-30cm) depth.

4.2 Effects of Pig Manure Rates, Planting Methods and Harvesting Stages on Growth Components of Guinea grass (*Panicum maximum*).

The effect of pig manure application rates, planting methods and stage of harvest (Table 2) showed that pig manure application rates had a significant ($P<0.05$) effect on establishment count of *Panicum maximum*with 10t/ha having a higher count than other rates of application. However, the establishment count was also influenced by the planting methods with the drilling method being higher than broadcasting method.

The result showed that the plant height (PH), leaf width (LW), tiller number (TN) and Leaf Area Index (LAI) of *Panicum maximum* significantly increased ($P<0.05$) 212.82cm, 3.06cm, 15.91, and 4.40, respectively in treatment 4 compared to the control. While, the number of leaves (NOL) was higher (70.82) at 15t/ha above the control.

The effects of planting methods did not show significant difference ($P>0.05$) in all the agronomic growth parameters (plant height, number of leaves, leaf length, leaf width, tiller numbers and the leaf area index) in the two methods of planting used.

The plant height (PH), of *Panicum maximum* was higher (281.90cm) at week 12 than the 6^{th} week while the number of leaves (83.33), leaf length (85.51cm), leaf width (3.05cm), and tiller number (17.94) of *Panicum maximum* were higher at 9^{th} and 12^{th} week of harvesting compared to the 6^{th} week. Meanwhile, there was a higher Leaf Area Index (4.87) at week 9 over the 6^{th} week of harvesting. Significant interaction is presented in Figures 1 and 2.

4.3Effect of Pig Manure Rates, Planting Methods and Harvesting Stages on Fresh and Dry Matter Yield of Guinea grass (*Panicum maximum*)

Results of fresh and dry matter yield of *Panicum maximum* forage as affected by pig manure rates, planting methods and harvesting stages are presented in Table 3. Application of pig manure at 5t/ha significantly ($P<0.05$) increased fresh forage yield, beyond which statistically similar yields were recorded. However, dry matter yield across the pig manure treatments were not significant ($P>0.05$). The two planting methods had no significant effect ($P>0.05$) on fresh and dry matter yield of *Panicum maximum.*

Fresh and dry matter yield of *Panicum maximum*increased significantly ($P<0.05$) at 12^{th} week after planting (88.83t/ha) and (26.14t/ha) respectively when compared with the 6^{th} week. Interaction was not significant.

Table 1: Physico-chemical properties of soil samples collected at the study area located at NAPRI during the rainy season of 2018.

Soil properties	**0-15cm**	**15-30 cm**
Particle size (%)		
Clay	28.00	24.00
Silt	26.00	24.00
Sand	46.00	52.00
Textural class	Loam	Sandy-loam
Chemical properties		
Total Nitrogen (%)	0.18	0.18
Organic carbon (%)	0.58	0.48
Available phosphorus(ppm)	4.53	5.28
pH (H_2O)	6.36	6.27

pH (0.01M $CaCl_2$)	5.30	5.36
Exchangeable cation (meq/100g of soil)		
Ca^{2+}	3.90	7.90
Mg^{2+}	0.67	2.99
K^{+}	0.33	0.18
Na^{+}	0.70	0.65
Exchangeable Acidity (H-Al^{3+})	0.40	0.60
Cation Exchange Capacity (CEC)	6.40	12.60

Analysed at the chemical laboratory, Department of Soil Science, Faculty of Agriculture, Ahmadu Bello University, Zaria.

4.4 Effects of Pig Manure Rates, Planting Methods and Harvesting Stages on the Proximate Composition of Guinea grass (*Panicum maximum*).

The effects of pig manure rates, planting methods and harvesting stages on the proximate composition of *Panicum maximum*are presented in Table 4. Pig manure application rates did not have significant (P>0.05) effect on the DM and Ash content of *Panicum maximum*but it ranges from 91.91% in the control to 93.18% in treatment 3. However, CP content significantly (P<0.05) higher (12.62)at 15t/ha application rate above the control.

CF was observed to be higher(33.23) at treatment 3 with (10t/ha) rate of manure application above the control. Ether extract (EE) was higher (0.61) at 15 t/ha application rate than the control. All the treatments have a higher (P<0.05) Nitrogen free extract (NFE) content but lower at 10t/ha manure rate. The crude fibre was significantly (P<0.05) higher (38.65) at 12^{th} than 6^{th}

week of after planting. Ether extract was higher (0.65) at week nine than the 6th week while the nitrogen free extract was higher (P<0.05) 9th week after planting than the 6th week. The Ash content of the forage was higher (11.86) at 6th week than the 12th week after planting.

The interactive effects of the manure rate, planting methods and harvesting stages on the proximate composition of *Panicum maximum* was significant (P<0.05). The significant interactions are presented in Figure 3.

4.5 Effects of Pig Manure Rates, Planting Methods and Harvesting Stages on the Fibre Fractions of Guinea grass(*Panicum maximum*)

The effect of pig manure rates, planting methods and harvesting stages on the fibre fractions of *Panicum maximum*are presented on Table 5. Acid Detergent Fibre (ADF) was higher (P<0.05) in the control than manure rates of 5, 10 and 15t/ha, respectively. Neutral Detergent Fibre showed no significant difference (P>0.05). However, the lignin content of the forage was higher at zero rate of manure application than other rates.

Table 2 : Effects of pig manure rates,planting methods andharvesting stages on growth components of *Panicum maximum*

Treatment	stand count/0.5m^2	PH (cm)	NOL	LL (cm)	LW (cm)	TN	L A I
Pig manure rate (t/ha). (M)							
0	31.33^{b}	156.11^{c}	50.20^{c}	67.56	2.54^{b}	11.69^{b}	2.47^{c}
5	26.50^{c}	190.62^{b}	62.47^{b}	68.77	2.94^{a}	13.29^{ab}	3.85^{b}
10	36.17^{a}	198.69^{b}	70.82^{a}	73.27	2.93^{a}	15.41^{a}	3.91^{ab}
15	23.67^{d}	212.82^{a}	62.47^{ab}	75.14	3.06^{a}	15.91^{a}	4.40^{a}
SEM	0.81	5.17	3.84	5.70	0.06	1.07	0.18
Planting methods (P)							
Drilling	34.58^{a}	188.16	63.87	74.51	2.87	13.80	3.76
Broadcasting	24.25^{b}	190.97	64.97	67.86	2.87	14.35	3.56

SEM	0.81	10.34	7.69	11.48	0.11	2.14	0.36
Stage of harvest (wk) (H)							
6	0.00	83.53^{c}	33.37^{b}	51.43^{b}	2.52^{b}	8.03^{b}	1.93^{c}
9	0.00	203.25^{b}	83.33^{a}	76.61^{a}	3.04^{a}	16.25^{a}	4.87^{a}
12	0.00	281.90^{a}	76.56^{a}	85.51^{a}	3.05^{a}	17.94^{a}	4.20^{b}
SEM	0.00	6.90	5.12	7.66	0.08	1.43	0.24

^{abc}Means with the same superscript along the columns are not significantly different, (<P0.05). M= Manure rate, H= Harvesting stage, P= Planting method, SEM=Standard Error of the Means, LOS= Level of Significance, PH= Plant height, NOL= Number of leaves, LL= Leaf length, LW= Leaf width, TN= Tiller number, LAI= Leaf area index.

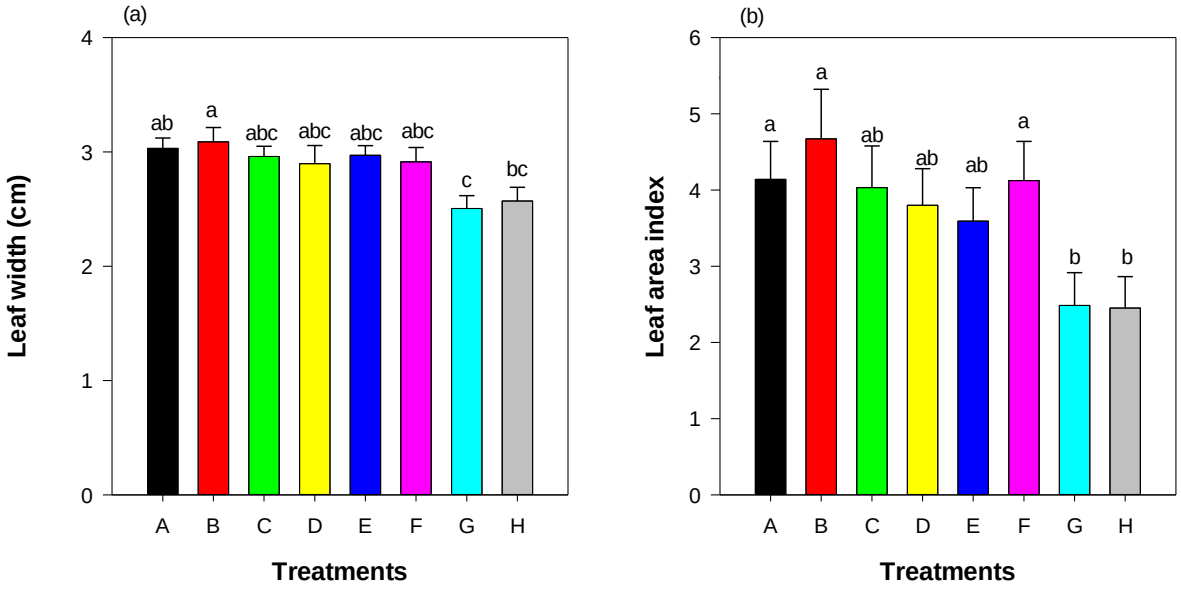


Fig. 1. Interactive effects of swine manure rate and planting method on leaf width (cm) and leaf area index of *Panicum maximum*. ANOVA results are presented in Table 2. Different lower-case letters on the bars depict

significant differences amongst the treatments ($p<0.05$). Treatments include **A:** 15 tons swine manure + drilling**;B:** 15 tons swine manure + broadcast**; C:** 10 tons swine manure + drilling; **D:** 10 tons swine manure + broadcast; **E:** 5 tons swine manure + drilling**;F:** 5 tons swine manure + broadcast**; G:** 0 tons swine manure + drilling; **H:** 0 tons swine manure + broadcast.

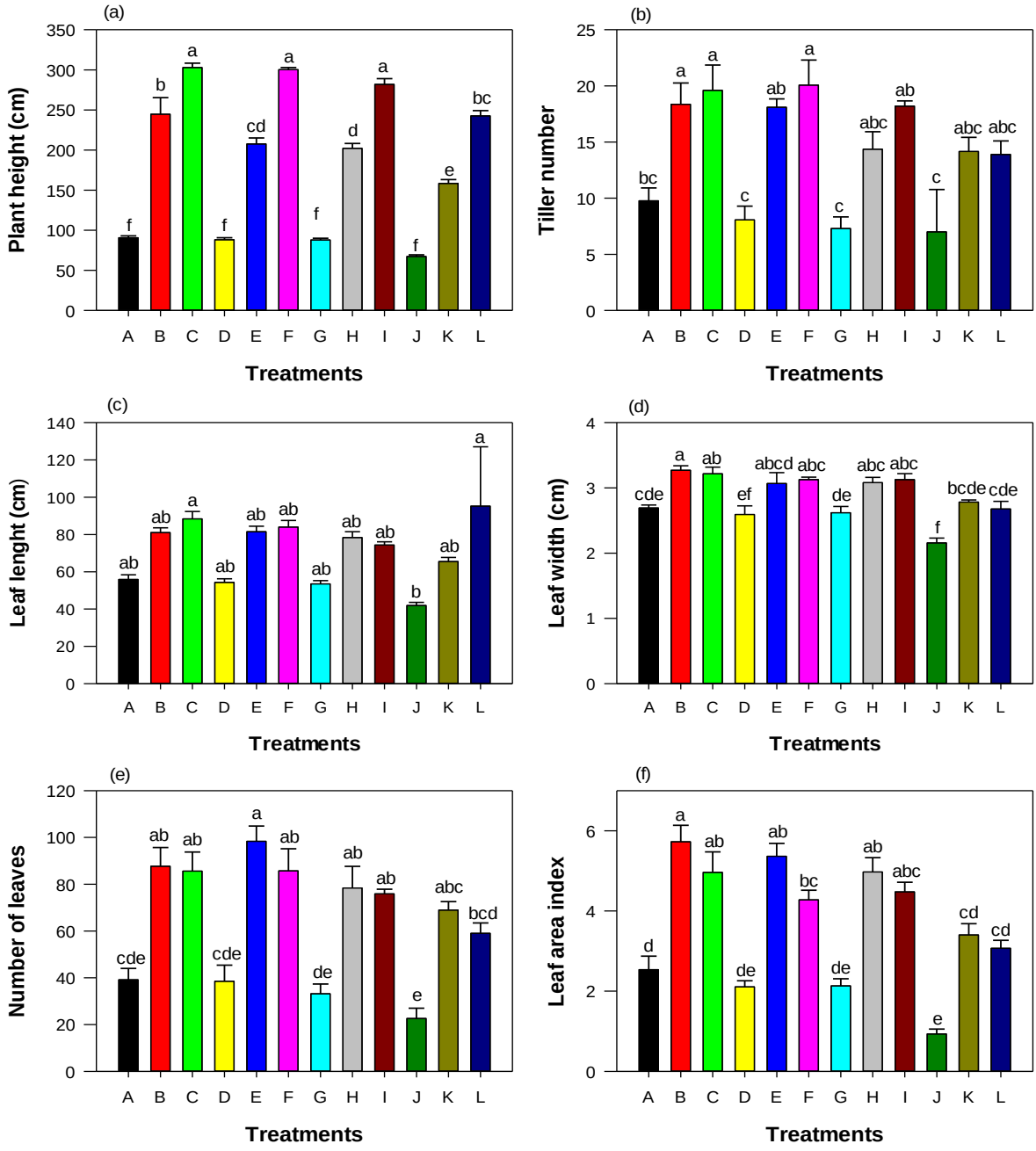


Fig. 2. Interactive effects of swine manure rate and stage of harvest on the agronomic properties of*Panicum maximum*. ANOVA results are presented in Table 3. Different lower-case letters on the bars depict significant differences amongst the treatments ($p<0.05$). Treatments include **A:** 15 tons swine manure + 6 weeks**;B:** 15 tons swine manure + 9 weeks**; C:** 15 tons swine manure + 12 weeks; **D:** 10 tons swine manure + 6 weeks; **E:** 10 tons swine manure + 9 weeks**;F: 10** tons swine manure + 12 weeks**; G:** 5 tons swine manure + 6 weeks; **H:** 5 tons swine manure + 9 weeks; **I:** 5 tons swine manure + 12 weeks; **J:** 0 tons swine manure + 6 weeks; **K:** 0 tons swine manure + 9 weeks; **L:** 0 tons swine manure + 12 weeks.

Table 3 Effect of Pig manure rates, planting methods andharvesting stages on fresh and dry matter yield of Guinea grass(*Panicum maximum*)

Treatment	Fresh forage yield (t/ha)	Dry matter yield (t/ha)
Pig manure rate (t/ha)(M)		
0	32.68[b]	8.10
5	57.44[a]	14.47
10	65.22[a]	15.88
15	59.67[a]	16.79
SEM	6.46	1.78
Planting methods(P)		
Drilling	49.44	12.85
Broadcasting	58.06	14.78
SEM	12.93	3.56
Harvesting Stage (WAP) (H)		
6	11.00[c]	3.24[c]
9	61.43[b]	15.22[b]
12	88.83[a]	26.14[a]
SEM	8.62	2.37

[abc]Means with the same superscript along the columns are not significantly different, (<P0.05). SEM=Standard Error of the Means.

Both the drilling and broadcasting methods of planting had no significant effects (P>0.05) on the Acid Detergent Fibre (ADF), Neutral Detergent Fibre (NDF), and Lignin contents of the *Panicum maximum.*

The Acid Detergent Fibre (ADF) and the Neutral Detergent Fibre increased significantly (P<0.05) across the harvesting stages. The Lignin content of *Panicum maximum* was higher (P<0.05) at 12th than the 6th week after planting. Significant interactions are presented in diagrams in the appendix.

4.6Effect of pig manure application rates on mineral composition (%)of Guinea grass*(Panicum maximum*)

The effects of Pigmanure rates, planting methods and harvesting stages on the mineral composition (%) of *Panicum maximum* is presented in Table 6. The pig manure rates application had no significant (P>0.05) effect on the Ca, K, Na, Zn, Cu and Fe contents of *Panicum maximum.* While there was higher (P<0.05) phosphorus (0.17) content at 10t/ha than the control. Planting methods had no significant (P>0.05) effect on the Ca, P, Zn and Cu while a significant effect (P<0.05) was observed on K (2.64%), Na (0.74%) and Fe (526.94mg/kg) contents of *Panicum maximum*in broadcasting over the drilling method of planting.

Calcium, Zinc, Copper, and Iron were significantly (P<0.05) affected by stage of harvest with the 9th week after planting showing a higher mineral contents than other stages of harvest while Potassium, Sodium, and Phosphorus were higher at 6th week after planting than other stages of harvest. The significant interactions are represented in Figure 5.

4.7 Growth Performance of Red Sokoto Bucks Fed Guinea grass(*Panicum maximum*) Hay and Mixtures of Concentrate.

Growth performance of red Sokoto bucks fed *Panicum maximum* hay supplemented with concentrates is presented in Table 7. There was significant (P<0.05) difference in the average hay

Table 4 Effects of pig manure rates,planting methods andharvesting stages on proximate composition (%) of Guinea grass (*Panicum maximum*)

Treatment	DM	CP	CF	EE	ASH	NFE
Pig manure rate (t/ha) (M)						
0	91.91	8.46^{d}	31.79^{b}	0.39^{c}	8.36	46.95^{a}
5	93.13	10.68^{c}	31.83^{b}	0.49^{b}	8.41	47.69^{a}
10	93.18	11.80b	33.23^{a}	0.53^{ab}	8.75	45.69^{b}
15	92.98	12.62^{a}	32.00^{b}	0.61^{a}	8.85	46.91^{a}
SEM	0.45	0.16	0.26	0.04	0.19	0.35
Planting methods (P)						
Drilling	92.65	12.06^{a}	32.56^{a}	0.54^{a}	8.77	46.01^{b}
Broadcasting	92.95	11.71^{b}	31.86^{b}	0.47^{b}	8.42	47.61^{a}
SEM	0.91	0.33	0.52	0.07	0.39	0.70
Stage of harvest (WAP) (H)						
6	92.06^{b}	13.00^{a}	27.17^{c}	0.51^{b}	11.86^{a}	47.36^{b}
9	93.76^{a}	10.85^{c}	30.81^{b}	0.65^{a}	7.58^{b}	50.10^{a}
12	92.57^{b}	11.80^{b}	38.65^{a}	0.34^{c}	6.34^{c}	42.98^{c}
SEM	0.60	0.22	0.34	0.05	0.26	0.47

^{abc}Means with the same superscript along the columns are not significantly different, (<P0.05). M= Manure rate, H= Harvesting stage, P= Planting method, SEM=Standard Error of the Means, LOS= Level of Significance, DM=Dry Matter, CP= Crude Protein, CF= Crude Fibre, EE= Ether Extract, NFE= Nitrogen Free Extract

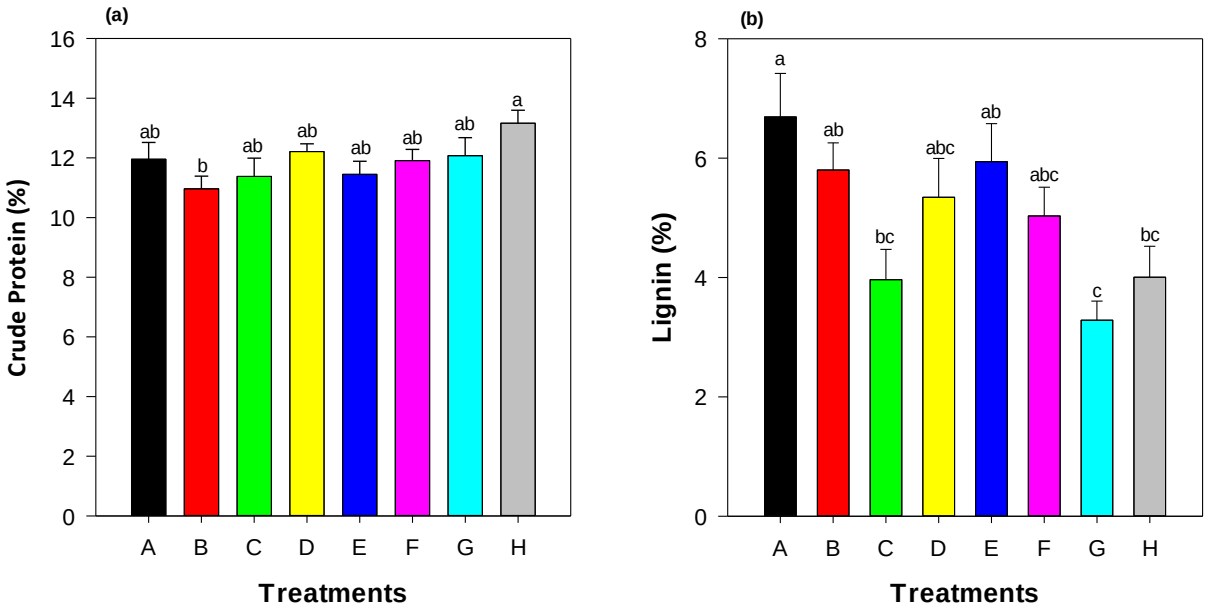


Fig. 3. Interactive effects of swine manure rate and planting method on lignin and crude protein (%) content of *Panicum maximum*. ANOVA results are presented in Table 2. Different lower-case letters on the bars depict significant differences amongst the treatments (P<0.05). Treatments include **A:** 15 tons swine manure + drilling**;B:** 15 tons swine manure + broadcast**; C:** 10 tons swine manure + drilling; **D:** 10 tons swine manure + broadcast; **E:** 5 tons swine manure + drilling**;F:** 5 tons swine manure + broadcast**; G:** 0 tons swine manure + drilling; **H:** 0 tons swine manure + broadcast**.**

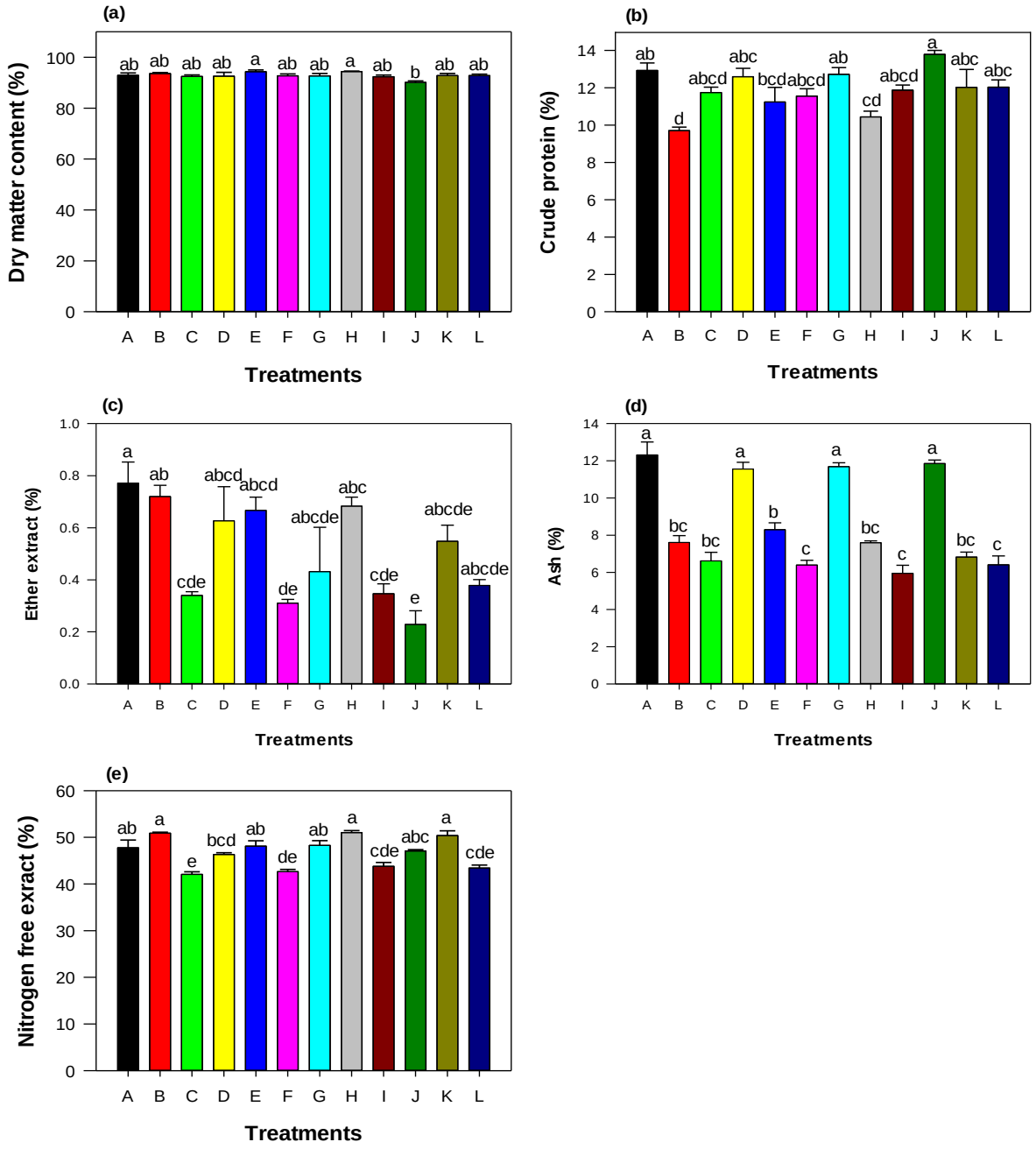


Fig. 4. Interactive effects of swine manure rate and stage of harvest on the proximate composition of *Panicum maximum*. ANOVA results are presented in Table 3. Different lower-case letters on the bars depict significant differences amongst the treatments ($p<0.05$). Treatments include **A:** 15 tons swine manure + 6 weeks**;B:** 15 tons swine manure + 9 weeks**; C:** 15 tons swine manure + 12 weeks; **D:** 10 tons swine manure + 6 weeks; **E:** 10 tons swine manure + 9 weeks**;F: 10** tons swine manure + 12 weeks**; G:** 5 tons swine manure + 6 weeks; **H:** 5 tons swine manure + 9 weeks; **I:** 5 tons swine manure + 12 weeks; **J:** 0 tons swine manure + 6 weeks; **K:** 0 tons swine manure + 9 weeks; **H:** 0 tons swine manure + 12 weeks**.**

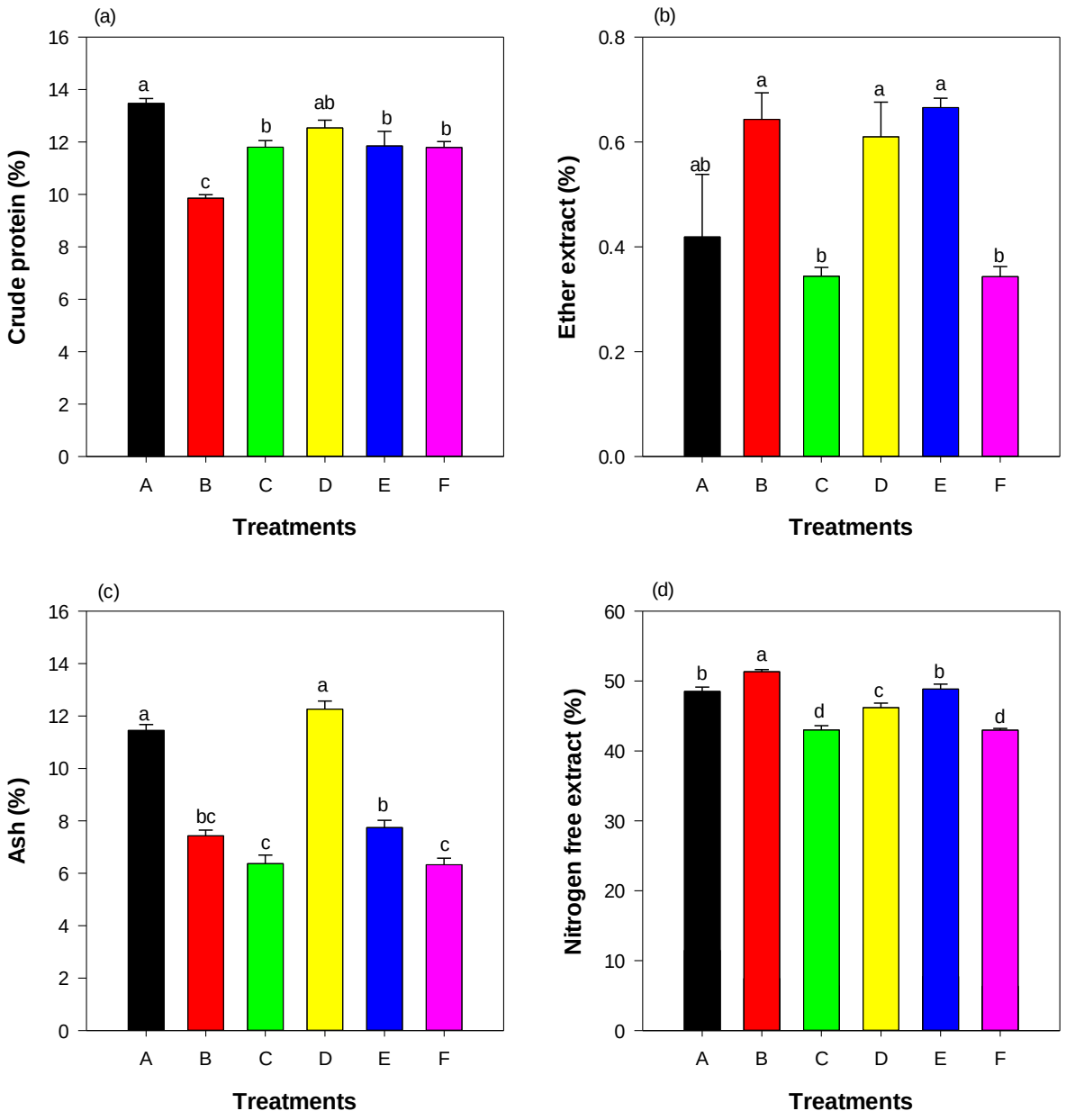


Figure 5. Interactive effect of planting method and stage of harvest on the proximate composition of *Panicum maximum*. ANOVA result are presented in Table 4. Different lower-case letters on the bars depict significant differences amongst the treatments ($p<0.05$). Treatments include **A:** drilling + 6 weeks**;B:** drilling + 9 weeks**; C:** drilling + 12 weeks; **D:** broadcast + 6 weeks; **E:** broadcast + 9 weeks**;F: 10** broadcast + 12 weeks**.**

Table 5 Effect of pig manure rates,planting methods, harvesting stagesand their interactions on fibre fraction of Guinea grass(*Panicum maximum*)

Treatment	ADF	NDF	LIGNIN
Pig manure rate (t/ha) (M)			
0	39.95[a]	68.63	6.45[a]
5	39.56[b]	69.94	4.66[b]
10	39.25[b]	69.85	3.65[c]
15	38.32[b]	69.36	3.49[d]
SEM	0.51	0.53	0.16
Planting methods (P)			
Drilling	39.38	69.67	5.05
Broadcasting	39.18	69.36	4.97
SEM	1.01	1.06	0.32
Stage of harvest (WAP) (H)			
6	30.71[c]	58.94[c]	3.12[c]
9	42.46[b]	73.65[b]	5.71[b]
12	44.66[a]	75.95[a]	6.20[a]
SEM	0.67	0.71	0.21

[abc]Means with the same superscript along the columns are not significantly different, (<P0.05). SEM= Standard Error of the Mean, LOS = level of significance, WAP= Weeks After Planting, ADF= Acid Detergent Fibre, NDF= Neutral Detergent Fibre

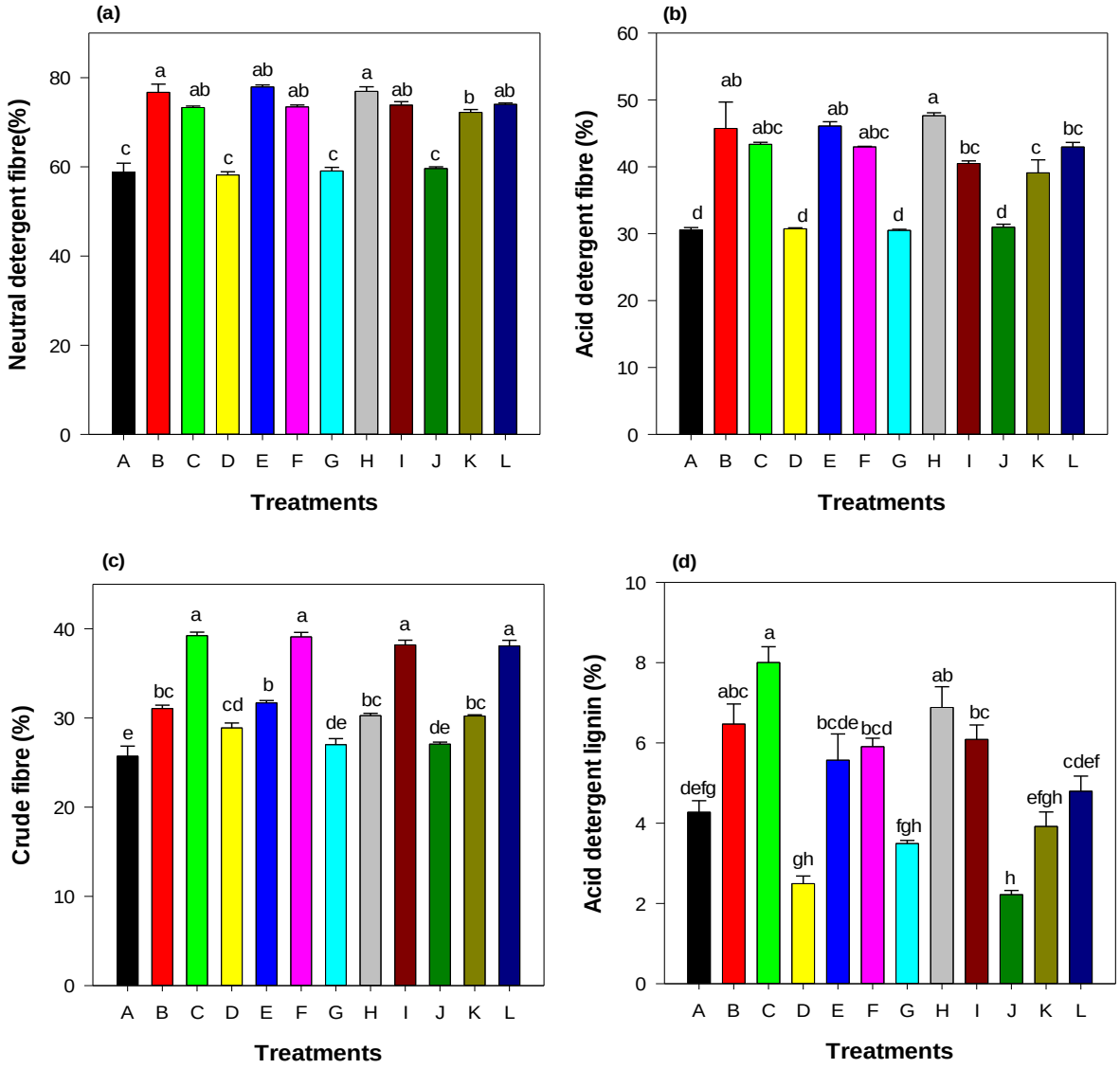


Fig. 6 Interactive effect of swine manure rate and stage of harvest on the fibre fraction of *Panicum maximum*. ANOVA results are presented in Table 3. Treatments include **A:** 15 tons swine manure + 6 weeks**;B:** 15 tons swine manure + 9 weeks**; C:** 15 tons swine manure + 12 weeks; **D:** 10 tons swine manure + 6 weeks; **E:** 10 tons swine manure + 9 weeks**;F: 10** tons swine manure + 12 weeks**; G:** 5 tons swine manure + 6 weeks; **H:** 5 tons swine manure + 9 weeks; **I:** 5 tons swine manure + 12 weeks; **J:** 0 tons swine manure + 6 weeks; **K:** 0 tons swine manure + 9 weeks; **H:** 0 tons swine manure + 12 weeks**.**

intake across the treatments, the highest intake was recorded in bucks fed (25:75) concentrate/forage ratio compared to the control. Average concentrate intake was higher ($P<0.05$)

in dietary treatment two with (75:25) concentrate/forage ratio than the control. Meanwhile, averagefeed intake (AFI) and initial body weight (IBW) were not ($P>0.05$) significantly different. Final

body weight in dietary treatment two and three were similar and higher ($P<0.05$) with (75:25) and (50:50) concentrate/forage ratio, respectively than the control. Total weight gain (TWG) and average daily weight gain (ADWG) were higher in bucks fed 50:50 ratio of concentrate and *Panicum maximum* than the control and treatment four. While the feed conversion ratio (FCR) was

least and best ($P<0.05$) in bucks fed (50:50) *Panicum maximum*/concentrate ratio when compared with other treatments.

4.8 Apparent Nutrient Digestibility of Red Sokoto Bucks Fed Diets Containing Mixtures of Guinea grass (*Panicum maximum*) and Concentrates.

The apparent nutrient digestibility of red Sokoto bucks fed diets containing mixtures of *Panicum maximum* and concentrates is presented in Table 8. The diets had no ($P>0.05$) significant effects on the dry matter and organic matter digestibility. Meanwhile, crude protein was significantly ($P<0.05$) affected by the diets with mixture ratio of (75:25), (50:50) and (25:75), C:P respectively having higher digestibilitythan the control diet. The crude fibre was also affected ($P<0.05$) by the diets with the (50:50) and (25:75) C:P having higher CF digestibility than the control and the bucks fed (75:25). Apparent ether extract digestibility was also affected ($P<0.05$) by the diets with the control having the highest (85.72%) value while (25:75) had the least (27.38%) value. The diets had effect ($P<0.05$) on the apparent ash digestibility with the treatment

(75:25) and (50:50) at par (86.93%) and higher than the control and (25:75) with 81.13% and 79.95% respectively. Diets two (75:25) and three (50:50) had effect (P<0.05) on the nitrogen free extract and apparent digestibility

Table 6. Effect of rates of pig manure application, planting methods andstages of harveston mineral composition (%) of Guinea grass(*Panicum maximum*)

Treatment	Ca (%)	K (%)	Na (%)	P (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)
Pigmanure rate (t/ha)							
0	0.56	2.51	0.65	0.11^{c}	10.58	0.02	533.38
5	0.56	2.76	0.74	0.14^{bc}	9.96	0.02	510.12
10	0.55	2.78	0.77	0.17^{a}	5.89	0.02	510.98
15	0.56	2.76	0.68	0.15^{ab}	6.52	0.02	533.14
SEM	0.03	0.12	0.05	0.01	0.002	0.002	0.03
Planting methods							
Drilling	0.55	2.64^{b}	0.68^{b}	0.15	8.37	17.41	516.88^{b}
Broadcasting	0.56	2.77^{a}	0.74^{a}	0.14	8.11	16.61	526.94^{a}
SEM	0.06	0.23	0.11	0.02	0.004	0.004	0.06
Stage of harvest (WAP)							
6	0.07^{c}	3.89^{a}	2.08^{a}	0.25^{a}	7.21^{b}	2.79^{c}	68.93^{b}
9	0.86^{a}	2.20^{b}	0.02^{b}	0.13^{b}	10.55^{a}	25.48^{a}	758.52^{a}
12	0.74^{b}	2.02^{b}	0.02^{b}	0.05^{c}	6.96^{c}	22.76^{b}	738.27^{c}
SEM	0.04	0.16	0.07	0.02	0.003	0.003	0.04

[abc]Means with the same superscript along the columns are not significantly different, (<P0.05). M= Manure rate, H= Harvesting stage, P= Planting method, SEM=Standard Error of the Means, LOS= Level of Significance. WAP= Weeks after planting

which is similar to that of the control diet but higher than that of (25:75). Acid Detergent Fibre and Neutral detergent fibre were affected (P<0.05) by (50:50) and (25:75) C:P, while the (50:50) and four (25:75) had similar and higher apparent digestibility, diets one and two had the least, respectively.

4.9 Nitrogen Balance of Red Sokoto Bucks Fed Mixtures of Guinea grass(*Panicum maximum*)Hay and Concentrates.

The nitrogen balance of red Sokoto bucks fed mixtures of *Panicum maximum*hay and concentrate in ratios is presented in Table 9. Bucks fed (75:25) concentrate/hay ratio had a higher (P<0.05) nitrogen intake (5.93) than control but similar to 50:50 concentrate/hay ratio which was also higher than the control diet while the control diet and 25:75 were at par and lower than treatment 75:25 and 50:50.

Faecal nitrogen loss followed the same pattern as that of the nitrogen intake (P<0.05) while the control and 50:50 C:P were similar and lower than that of 75:25 C:P with 25:75 C:P having the least faecal nitrogen loss. However, urinary nitrogen loss was observed to be higher (P<0.05) in (50:50) C:P with 76% increase over the (75:25) C:P. However, the total nitrogen loss, nitrogen retained and the percentage nitrogen absorbed were not significantly (P>0.05) affected by the diets fed.

4.10 Economics of Feeding Mixtures of Concentrates and Guinea grass (*Panicum maximum*) Hay to Growing Red Sokoto bucks.

Cost implication of growing red Sokoto bucks raised on diets containing concentrate, *Digitariasmutsii* and *Panicum maximum* hay is presented in Table 10.The result showed

significant difference (P<0.05) in hay intake (kg), cost of *Digitaria smutsii* and *Panicum maximum* consumed, concentrate intake (kg), total feed intake (kg), cost of concentrate consumed (₦), total cost of feed consumed (₦), cost/kg feed, cost per kg gain, net benefit (₦) and return to investment on feed (RIF), There were no significant differences (P>0.05) in value of gain, and cost of concentrate/kg.

The value of gain ranged from ₦11,833.00 to ₦ 13,600.00 with (50:50) C:P being the highest and the control being the lowest; the total cost of feed ranged consumed from ₦1,139.70 to ₦1,489.40 from (25:75) C:P to (75:25) C:P. The cost/kg gain values ranged from ₦478.40 to ₦1,292.60 with (50:50) C:P having the lowest and control having the highest. The Net benefit ranged from ₦10,394.10 to ₦12,236.00 with (50:50) C:P having the highest net benefit while the control had the lowest. Return to investment on feeds (RIF) were 9.60, 8.99, 7.95 and 7.23 for (25:75) C:P, (50:50) C:P, (75:25) C:P, and the control, respectively.

Table 7Growth performance of growing Red Sokoto Bucks fed Guinea grass(*Panicum maximum*)hay and mixtures of concentrates.

Parameters	Control	75:25	50:50	25:75	SEM	P-Value
IBW (kg)	10.67	10.67	10.73	10.93	0.11	0.991
FBW (kg)	11.83^{b}	13.33^{a}	13.60^{a}	12.10^{b}	0.11	0.360
ADWG (g)	13.89^{b}	31.75^{a}	34.13^{a}	13.89^{b}	0.40	0.001
TWG (kg)	1.17^{b}	2.67^{a}	2.87^{a}	1.17^{b}	0.03	0.001
TCI (kg)	15.09^{b}	23.65^{a}	16.31^{b}	7.72^{c}	2.31	0.0002
THI (kg)	15.15^{b}	8.71^{c}	16.52^{b}	23.26^{a}	1.54	0.0001
TFI (kg)	30.24	32.36	32.83	30.98	3.48	0.790
FCR	27.16^{c}	12.50^{b}	11.52^{a}	29.26^{c}	1.00	0.030

[abc]Means with different superscripts within rows differed significantly ($P<0.05$), TCI= Average Concentrate Intake, IBW= Initial Body Weight, FBW= Final Body Weight, TWG= Total Weight Gain, ADWG= Average Daily Weight Gain, FCR= Feed Conversion Ratio, SEM= standard Error of the Mean, THI= Total hay intake

Table 8 Apparent nutrient digestibility of growing Red Sokoto Bucksfed Guinea grass(*Panicum maximum*)hay and concentrates.

Parameters	Control	75:25	50:50	25:75	SEM	P-Value
Dry Matter	71.36	73.64	75.01	72.04	0.21	0.352
Organic Matter	70.92	72.34	72.56	74.37	0.21	0.460
Crude Protein	71.05^{b}	81.04^{a}	79.52^{a}	78.17^{a}	0.18	0.010
Crude fibre	91.49^{b}	90.95^{b}	94.28^{a}	94.27^{a}	0.07	0.001
EtherExtract	85.72^{a}	67.16^{b}	58.00^{c}	27.38^{d}	0.33	0.0001
Ash	83.13^{b}	86.93^{a}	86.93^{a}	79.95^{c}	0.11	0.009
Nitrogen free extract	58.48^{ab}	63.09^{a}	62.05^{a}	54.19^{b}	0.33	0.008
Acid Detergent Fibre	63.20^{b}	54.48^{c}	76.58^{a}	81.79^{a}	0.29	0.0001
Neutral Detergentfibre	59.54^{b}	49.06^{c}	72.90^{a}	81.14^{a}	0.42	0.0003

^{abcd}Means with different superscripts along the same row are significantly different (P<0.05)SEM= standard error of the mean

Table 9 Nitrogen balance of red Sokoto bucks fed mixtures of Guinea grass(*Panicum maximum*)hayand concentrate in ratios.

Parameters	Control	75:25	50:50	25:75	SEM	P-Value
Nitrogen Intake	5.76[b]	8.93[a]	7.41[ab]	5.79[b]	0.08	0.023
Faecal Nitrogen Loss	3.04[ab]	4.36[a]	2.90[ab]	2.58[b]	0.07	0.044
Urinary Nitrogen Loss	0.33[bc]	0.19[c]	0.80[a]	0.53[ab]	0.01	0.002
Total Nitrogen Outgo	3.36	4.55	3.70	3.12	0.07	0.259
Nitrogen Retained	2.39	3.84	3.71	2.67	0.06	0.110
Nitrogen Absorbed as % intake	41.33	57.33	49.67	46.33	1.09	0.529

[abc]Mean with different superscripts along the same row are significantly different (P<0.05), SEM =standard error of the mean

Table 10Economic of feeding mixtures of concentrates andGuinea grass(*Panicum maximum*) hay to growing red Sokoto bucks.

Parameter	Control	75:25	50:50	25:75
Final weight (kg)	11.83	13.33	13.60	12.10
Total weight gain(kg)	1.17	2.67	2.87	1.17
Value of gain (₦)	11833	13333	13600	12100
Concentrate intake(kg)	15.10	23.65	16.32	7.72
Hay intake (kg)	15.15	8.71	16.52	23.26
Total feed intake(kg)	30.24	32.36	32.84	30.98
Cost of concentrate consumed(₦)	772.80	1210.64	835.42	395.36
Cost of hay consumed (₦)	666.45	278.72	528.53	744.32
Total cost of feed consumed (₦)	1439.3	1489.4	1364.00	1139.7
Cost of concentrate/Kg	51.19	51.19	51.19	51.19
Cost of hay/kg	44.30	32.00	32.00	32.00
Cost/Kg feed	47.59	45.99	41.54	36.78
Cost/ Kg gain (₦/Kg gain)	1292.6	575.90	478.4	1076.50
Net Benefit (₦)	10394.1	11844.00	12236.00	10960.30
Return to investment on feed (RIF)	7.23	7.95	8.99	9.61

[abc] Means within the same row with different superscripts are significantly different (P<0.05) SEM = Standard Error of mean, Price of growing buck/live weight = ₦ 1000/kg, *Digitaria smutsii* hay = ₦44.30/kg, cost of *Panicum maximum* hay =₦32.00, value of gain= final weight × ₦1000, Net benefit=value of gain-total cost of feed, RIF=net benefit/cost of feed,

CHAPTER FIVE

5.0 DISCUSSION

5.1. Experiment I

5.1.1Effects of Pig Manure Rates, Planting Methods andHarvesting Stage on Growth Components of Guinea grass (*Panicum maximum*)

The significant stand count observed at the initial establishment of *Panicum maximum* is an indication of the importance of soil nutrient in germination and early establishment of seed and seedling respectively. Highly fertile soil provide nourishment required for the endosperm in the germination process and seedling establishment, this is evident in the high stand count observed when pig manure was applied at the rate of 10t/ha. The significant stand count at drilling method could be attributed to the high concentration of the seeds in the drills during the planting. It could also be as a result of effective weed control which prevents competition between the *Panicum maximum* and the weeds for the growth factors such as solar radiation, soil nutrients, water and space.

There was an increase in plant height with increase in pig manure application rates,this could be attributed to the increase in the nutrient content of the soil with essential nutrient elements from pig manure such as nitrogen, phosphorus and potassium in plants, leading to formation of plant metabolites that helped to build the plant tissue. This is in agreement with the report of Nnandi *etal.* (2015) Feisal *etal*. (2012) with *Sorghum bicolor*, and in line with the findings of Farhed (2009) who used poultry manure and attributed the increase of plant height in maize to the

increase in the rate and availability of poultry manure throughout the growing season. Jibril,(2018) who used inorganic Nitrogen fertilizer on *Panicum maximum* cv. Mombasa also reported increasing plant height as the fertilizer nitrogen increases. The increase in tiller number with increase in pig manure application rates, this is related to the availability of N for the plants' use,this is in line with the report of Nnandi *etal.* (2015)who used poultry manure on *Panicum maximum*and revealed an increase in grass tiller number with poultry manure application. Barbosa *etal.*(1997) obtained a similar result with *Panicum maximum*. They reported that application of nitrogen, a major component of poultry manure significantly increased grass tiller numbers. Similar result was obtained in perennial ryegrass as reported by William and Asiegbu (1982) and Jibril(2018). It agrees with the finding of Barbosa *etal*. (1997)who obtained a similar result with *Panicum maximum* fertilized with poultry manure. Sodehinde *etal.* (2006) observed that nitrogen fertilizer influenced positively the numbers of tillers produced perstand in an experiment on the effect of nitrogen on dry matter yield of *Panicum maximum*.

Increased number of leaves and leaf width due to increase in rate of manure application could be connected with the availability of such essential nutrients as Nitrogen, Phosphorus and potassium in appreciable amounts in the manure. Adjolohoun *etal.* (2013) reported average leaf width of 3.35cm in a study of *Panicum maximum* ecotypes in the republic of Benin. Leaf area index (LAI) of 2.47-4.40 was observed in this study which increased with increase in manure rates of application.Thiscould be as a result of soil available nitrogen content, resulting in corresponding relative growth rate (RGR) of the *Panicum maximum*, formation of close canopy, maximum light interception, increased net assimilation rate (NAR), mobilization of photosynthetic assimilates and higher percentage ground cover. Narmhikaa *etal.*(2019)reported similar trend of leaf area index increase as the rate of manure application increased. This is however in contrary with the

findings of Alexandrio *etal.* (2005) and Jibril (2018) who reported LAI of 4-8in *Panicum maximum*cv. Mombasa fertilized with inorganic Nitrogen fertilizer. This disparity could be attributed to the difference of the type of fertilizer used, soil type or even the variation in variety.

Conversely, the drilling and broadcasting methods of planting did not affect the plant height, leaf length, tiller number and Leaf Area Index.

Plant height increased with advancement in the stage of harvest, this could be due to the ability of the plants to intercept more solar radiation during the active growth stage which enhanced production of more assimilates which is mobilized for building of plant tissues, hence,increased plant height at 12^{th} week of harvesting.The plant height obtained in this study was higher than what was reported by Adjolohoun *etal.* (2013); Jibril (2018) and Reynosoa*etal.* (2009). This variation could be due to use of pig manure which releases nutrient slowly and gradually as against the inorganic nitrogen fertilizer used on *Panicum maximum* cv. Mombasa in the former studies. Number of leaves, leaf length, leaf width and tiller number increased from week 6 after planting through week 9, after which no increment was observed. This implies that genetic potential of the plant cannot be exceeded even when the maturity stage increase. However, the Leaf Area Index increased as the harvesting stage increases until the 12^{th} week of harvest when the LAI declined. This could be due to the mobilization of photosynthetic assimilates for reproduction (seed production) as a result of which the leaves begin to be narrower, hence, reduction in the Leaf Area Index. This result coincides with the finding of Jimoh *etal.* (2019), Dele *etal.* (2018), Jibril (2018) and Olanite *etal.* (2006) who reported decline in Leaf Area Index as seed formation begins.

5.2 Effect of Pig Manure Rates,Planting Methods, Harvesting Stages on Fresh and Dry Matter Yield of Guinea grass (*Panicum maximum*)

Pig manure rates showed a significant increase on the fresh yield of *Panicum maximum*with 50% increase at 10t/ha over the control. This could be as a result of availability of essential nutrient in the soil.Theyield obtained in this study agrees with the report by Akinola, (2018) that, the sole grass herbage yield commonly ranges from 5-10t DM/ha but up to 60tDM/ha is realizable, depending on the cultivar, amount and distribution of rainfall, fertilizer N level and cutting management.

Panicum maximum, being a C_4 plant, grows better under a high solar intensity due to its higher photosynthetic ability and coupled with the increasing trend of Leaf Area Index as the plant ages, leading to the increment in the fresh yield and dry matter yield of *Panicum maximum*with advancement in the harvesting stages, This could be attributed to accumulation of biomass during the active vegetative growth, blooming stage through heading stage of the *Panicum maximum*. It could also be as a result of gradual release of nutrients to the plants over the time.

Austin, (1980) reported that optimum Leaf Area Index has been found to be responsible for the overall dry matter production and dry matter yield approaches a plateau with increasing LAI. This is in line with the report of Odhiambo (1974) that, the herbage yield of Napier grass increased up to 24 weeks of growth, although nutritive value started to decline between 12 and 17 weeks of growth.

5.1.3 Effect of Pig Manure Rates, Planting Methods andStages of Harvest on Proximate Composition (%) of Guinea grass (*Panicum maximum*)

The dry matter percentage in this study was affected by the pig manure rates.Increasein levels of application resulted in accumulation of dry matter which indicates a better nutritional components of the *Panicum maximum*.The highest dry matter content was observed at 10t/ha of

pig manure application which is equivalent to 193kgNha^{-1}in the manure applied.Thiscontradicts the finding of Dele *etal.* (2018) who reported higher DM% in the unfertilized *Panicum maximum* as against those fertilized with poultry manure.Thiscontradiction could be as a result of difference in manure used, application rates, and agro-ecological zone. However, it is within the range reported by Jimoh *etal.* (2019) who compared different types of manure on the chemical compositions of *Panicum maximum.* The authors reported 93.77% DM for the pig manure fertilized grass. However, the dry matter content increased from week 6 to week 9 and thereafter declined at week 12. This indicates that the younger the plants, the higher the nutritional contents while increase in age reduces the nutrient content due to transformation of the soluble carbohydrates into structural one as a result of increase in the cell wall structure of the plants which results in reduction of the nutrient content of the grass.

Meanwhile, the Planting methods did not affect the percentage dry matter but waswithin the 93% reported by Dele *etal*. (2018). The crude protein (CP) content as affected by the manure rate and age at harvest were significantly different. The CP content increased with increased manure rate but decreased with advancement in stage of harvest. The increase in the CP content with increased rate of N up to 283.9 kgNha^{-1} could be a result of better plant growth(Dele et al, 2018; Kering *etal*., 2011), which could be resultant effect of increased leaf nitrogen as well as tissue protein with the inclusion of the unfertilized grass whichwas slightly above the critical limit (7%) which intake of forages by ruminants and rumen activity would be adversely affected (Van Soest, 1994). The decline in the CP contents with the advancement of plant age in this study agrees with the reports of Dele *etal* (2018) on *Panicum maximum* with poultry manure; Jimoh et al (2019) on *Panicum maximum* and swine manure; Bilal *etal*. (2001) on *Pennisetumpurpureum* and Olanite *etal*. (2006) on two varieties of P. *maximum*. This could be due to increase in the

fibre fraction and a decrease in the leaf-stem ratio of the grasses with the advancement in the age of the grasses.

Panicum maximum under drilling method was also observed to have a better CP content, this could be due to the effect of manure and effective weed control as a result of definite inter-row spacing, thereby reducing weed interference on nutrient absorption and other growth factors. The Ash contents was not affected by manure rates and planting methods but with advancement in age, the ash contents declined, this may be due to decrease in water uptake capacity of the plant roots and consequently, reduction or stoppage of the silicic acid that is the major component of the ash (Quigley and Anderson, 2014). This finding is in line with Dele (2018; 2012) and Onyeonagu *etal*. (2012).

Ether extract contents increased with increase in manure application and in broadcasting method of planting, the increase in ether extract could be attributed to increase in the nitrogen content of the soil due to manure application which results in deposition of lipids in the vascular system of the plants. This is in agreement with the findings of Jibril (2018); Okwori and Magani (2010) but in contrary to Aderinola (2013) whose application of graded levels of inorganic fertilizer (NPK) to *Panicum maximum*showed inconsistency in the trend of the Ether extract contents as fertilizer levels increased.Meanwhile, ether extract decreased with increasing age at harvest while the highest value was at week 9 of harvesting, this implies that *Panicum maximum* cut at the 9th week of harvesting is capable of supplying more energy than those cut after. This is in agreement with the finding of Jimoh *etal.* (2015;2019) who used different manure types to evaluate the proximate composition of *Panicum maximum.*

The crude fibre was not much affected by manure rates except at 10t/ha application rate where the CF was higher than others, this could be due to the effect of manure in reducing the cell wall

accumulation as reported by Aderinola, (2013) that increase in growth due to nutrients availability reduces the rate of lignification in plant materials. Narmhikaa *etal.*(2019) reported no significant difference in CF% of *Panicum maximum* treated with manure rates but observed maximum CF in treatment 3 which is similar to what is observed in this study. The trend for the CF was directly proportional to increase in age of the plants due to increase in the structural components of the plants. Jibril (2018); Geleti and Torera (2003) and Taute (2002) reported similar results for CF in *Panicum maximum*.

There was a direct relationship between manure rates on Nitrogen Free Extract (NFE). NFE contents increased with increase in manure application rates except for the treatment 3 which showed a decline. This could be attributed to the availability of nutrients in the soil resulting in accumulation ofsoluble carbohydrates (starches and hemicellulose) which invariably increased the Digestible Energy content of the *Panicum maximum* while for the stages of harvest, reverse was the case as the NFE decreases with increase in age of the plants. This could be attributed to the increase in structural carbohydrates (cellulose and lignin) replacing the soluble ones, thereby decreasing the Digestible Energy and the overall Total Digestible Nutrients of the grass. It however agrees with the findings of Jibril (2018) and Jimoh *et al*, (2019) that NFE normally decreased with advancing season as a result of decrease in NFE content in all parts of snowberry studied.Deetz *etal*., (1996) reported that maturity through its effects on plant composition is recognized as a major determinant of forage quality.

5.1.4 Effects of Pig Manure Rates,Planting Methods andHarvesting Stages on Fibre Fraction of Guinea grass (*Panicum maximum*)

The ADF content was not significantly affected by manure rates but slight decrease was observed as the manure rate increased with the exception of control which had a higher ADF content. It also increased with advancement in stage of harvest. The trend of result of lignin was

similar to that of the ADF. However, the ADF content falls within the range (34-47%) reported by Akinola (2018). This implies that increase in manure rates results in decrease in the structural carbohydrate and enhance the nutritional content of the grasses.

Increase in ADF and lignin as the plant matures indicates that as the plant matures, the fibre content of the grasses increase due to increase in stem to leaf ratio as harvest stage advanced. The values of ADF in this study is below that of Dele *etal.*(2018) whose values of ADF ranged between (41-44%). Meanwhile, the pig manure rates had no effects on the NDF content but ranged between (69-70%) which coincides with the values reported by Akinola, (2018) who reported 75.1%, Jimoh *etal.* (2019) reported 75.3% NDF with swine manure fertilization when comparing chemical composition of two varieties of *Panicum maximum* as affected by manure types but disagree with the reported values of Dele *etal.*(2018)which might be due to difference in manure types used.

As plant age increased, the NDF also increased due to increase in structural carbohydrate content of the grass and general peculiarity of plants that cell wall materials increases with increase in age. The values ranged between 59-76% in weeks 6 and 12 of harvesting. These values are also higher than what Dele *etal*.(2018) reported but similar to that of Olanite *etal*. (2006) and Jimoh *etal.* (2019).

5.1.5 Effect of Pig Manure Rates, Planting Methods, Harvesting Stages and their Interactions on Mineral Composition (%) of Guinea grass (*Panicum maximum*)

Calcium content of *Panicum maximum*wasnot affectedby manure rates effect on the Ca contents of *Panicum maximum.*The values of Ca obtained however were within the normal range of the ruminantanimals' requirement for calcium but in contrary with the report of Dele *etal.* (2018) who used poultry manure and observed the best calcium content in the control as against other

treatments. The Ca content of the *Panicum maximum* under the two planting methods followed the same trend as that of the manure rates. The calcium content obtained at the two planting methods, though not significant but is within the requirement (0.18 to 0.82% concentration) of different classes of ruminant animals according to McDowell (1992; 1997). While the calcium concentration during the stages of harvesting was higher at 9th week of harvesting, followed by the 12th week of harvesting, all within the normal concentration, with the exception of the 6th week harvesting stage falling below the normal range of calcium concentration.

The K content of the grass was not affected by the levels of manure application as well as the planting methods but higher K content was observed at the 6th week after planting followed by week 9 and 12 which were at par and lower than the 6th week. Thepotassium concentration observed in this study is above the 0.8% recommended for grazing animals (Underwood, 1981; Dele *etal.*2018). High K content in grasses ascertain water balance and osmotic pressure regulation, acid-base balance, and muscle contraction for ruminants (Dele*etal*., 2018).Farhad (2012) reported that high potassium forages and low sodium chloride diets appeared to contribute more to reproductive losses in herbivores but it has also been suggested that ruminants with high producing ability in terms of milk and other animal products may require K level above 1% under stress particularly heat stress (McDowell, 1985) and Dele, (2018) reported that excess K in forages lead to deficiency of other minerals, with attendant suppression of immunity.

The phosphorus contents of the *Panicum maximum*was significantly affected by the levels of manure application with the P content ranging from 0.11% in the control to 0.17% at10t/ha while the planting method had no significant effect on the calcium content but ranges from 0.14 in broadcasting to 0.15 in drilling methods while the harvesting stage had a pronounced effect on the P content of the grass, ranging from 0.05 at 12th week of harvesting to 0.25 at 6th week of

harvesting. However, the P content as affected by the manure rates, planting methods, and harvesting stages fell below the recommended (0.18-0.48%) requirements for different classes of ruminant animals as reported by Dele (2018) and McDowell (1992; 1997) in the planting methods and the harvesting stages except for the grass harvested at 6^{th} week after planting. This affirms the report of McDowell *etal*. (1984) that forages in Nigeria have been found to be P deficient, probably as a result of higher K content of the soil, antagonizing the uptake of P.

The Na contents varied across the levels of manure application, ranging from 0.65 in the control to 0.77 at10t/ha while the planting methods had significant ($P<0.05$) effect on the Na content of the grass ranging from 0.68 in drilling to 0.74 in broadcasting methods whereas, at 6^{th} week of harvest a higher value of Na was observed against the other harvesting stages which were at par. However, the sodium content observed in the levels of manure application and planting methods in this study was lower than the critical level (0.87g/kg) required for grazing ruminant animals, meanwhile, at the 6^{th} week after planting, the Na content recorded was higher than the critical level required. Thehigher Na content at week 6 could be as a result of active vegetative growth of *Panicum maximum* which enhanced more sodium uptake at this stage of growth.

This widespread deficiency in forage Na is corroborated with some earlier findings that the most prevalent mineral deficiency for grazing animals in the world is Na (Tudsri and Kaewkunya,2002; Anderson*etal.,* 2013). In addition, deficiency of this element has been reported in many developing countries (Aregheore, 2002). To meet the need of highly productive animals, forage should contain more than 0.15% sodium. Na deficiency is more likely to occur in animals grazing tropical pasture species and these plants generally accumulate less Na than temperate species(Morris, 1980).Natural forages low in Na has been reported in numerous tropical countries throughout the world (McDowell, 1985).

Pig manure rates and planting methods had no significant effects on the Zinc content of the *Panicum maximum*, however it ranged between 5.89-10.85mg/kg at 10t/ha to control while the harvesting stage showed a significant effect on the Zinc concentration at the 9th week of harvesting. Zinc (Zn) plays an essential role in animal nutrition as a component of a number of critical enzymes. Meanwhile, the values of Zn recorded in this study is above the critical level (5mg/kg) below which animal performance deteriorate and development of severe Zn deficiency such as loss of appetite, reduced growth and immunocompetence, loss of hair/wool, and keratotic skin lesions sets in (Underwood, 1981). Plant maturity has also been reported to affect Zn concentration of forage and it also depends upon the tissue type of plants (Underwood, 1981; Kabata, 1992). The manure rates and planting methods had no effects on the Cu content of the grass while an increment of 90% in Cu content was observed at the 9th week (25.48mg/kg) of harvesting over the 6th week (2.49mg/kg) while it has been suggested that the dietary requirement of ruminants for Cu ranges from 8 to 14 mg/kg (Khan *etal*., 2006; NRC, 1984).

The values of Cu gotten from this study is however above the minimum requirement for ruminant animals especially when harvested from 9th week and above after planting. The iron (Fe) content of the *Panicum maximum* was not affected by the rates of manure applications while the broadcasting method and the 9th week of harvesting showed a significant effect on the Fe content of the grass. The higher Fe content in the broadcasting method could be attributed to the less competition for the soil resources and as such were able to tap the mineral nutrients better than those under drilling method while the 9th week of harvesting was the best stage of harvesting for optimum Fe content in the forage. However, an optimum concentration of 50 mg/kg DM has been proposed as being adequate for grazing animals (Khan *etal.,* 2005; Miles *et al*., 1983).

5.2 Experiment II: Feed Intake, Body Weight Gain, Nutrient digestibility Nitrogen Balance and Economics of Growing Red Sokoto Bucks Fed Guinea grass (*Panicum maximum*)Hay Supplemented with Concentrate in Ratios.

5.2.1 Growth performance

All the animals in this study gained weight with those fed on (50:50) C:P producing the highest body weight gain than the control and (25:75) C:P but comparable to those fed on (75:25) C:P. This observation could be attributed to an efficient utilization of absorbed nutrients which is present at sufficient quantity in the animals fed (50:50) C:P. This result align with the finding of Anifowose *etal.* (2016) who fed *Panicum maximum* and cowpea shell based concentrate in ratios to growing red Sokoto bucks and Tona *etal*.(2014) who fed *Panicum maximum* and graded levels of *Moringaoleifera*-based concentrate to West African Dwarf goats.

In the present study, the highest feed conversion ratio was recorded in the animals fed (50:50) C:P. This could be due toassociative effect of feeding as a result of higher intake of concentrate and forage that stimulate appetite, increase rumen microbial replication, enhanced production of volatile fatty acid which is used as energy source in ruminants. Another reason could be the richness of the feed in energy and protein content, this also contributed to the higher feed conversion ratio in animals fed (50:50) C:P. This agrees with report of Anifowose *etal.* (2016) and Tona *etal.* (2014).

5.2.2 Apparent nutrient digestibility

The CP, CF, EE, Ash, NFE, NDF and ADF followed the same trend to a high extent with the bucks fed (50:50) C:P having the best coefficient of digestibility in all parameters. This is due to

the fact that the *Panicum maximum* consists of substantial amount of crude protein, coupled with that of the concentrate, as the crude protein in the diet increases, CP digestibility also increased. This coincides with the report of Anifowose *etal.* (2016) who observed a significantly higher nutrient digestibility in red Sokoto bucks fed *Panicum maximum* and cowpea shell in ratios 50:50 as compared to other treatments. Based on this finding, it could be concluded that feeding red Sokoto bucks with 50:50 C:P mixture is best in terms of digestibility coefficient when compared with 25:75 and 75:25 C:P fed to growing red Sokoto bucks.A similar observation was reported by Arigbede *etal.* (2005) who found that the digestibility coefficients of CP, NDF, ADF and ADL followed almost the same trend as the DM digestibility coefficients in diets containing graded levels of combinations of *Grewiapubescens* and *Panicum maximum.* Tona *etal*. (2014) reported similar observation when fed WAD bucks with *Panicum maximum* as a basal diet and supplemented with concentrate.

5.2.3 Nitrogen balance

The higher nitrogen intake in the group fed (75:25)C:P could be attributed to the higher level of concentrate: hay ratio. Higher concentrate intake depicts higher nitrogen intake, due to the higher palatability of the diet. Nitrogen loss through the faeces followed the same trend as the nitrogen intake due to the same reason stated for the higher intake. However, the highest urinary nitrogen loss was observed in the group fed (50:50) C:P. Losses of nitrogen through the urinary tract are related to the rumen degradable protein content in the diet; in addition, the higher the consumption of this nutrient, the greater the amount of ammonia produced, which could exceed the requirement of ruminal microorganisms, hence resulting in increased synthesis of urea in the liver and higher excretion via urine. Therefore, it was observed that diets containing 50:50C:P

presented higher nitrogen loss in urine in relation to other diets while those fed 75;25 concentrate/hay had the highest nitrogen intake and faecal nitrogen loss.

This is in agreement with Anifowose *etal.*(2016) who fed *Panicum maximum* with Bambara nut based concentrate to red Sokoto bucks in ratios and also in concordance with the report of Santos *etal.* (2014) who worked on nitrogen metabolism in lactating goats fed with diets containing different protein sources. Contrarily, Ramos *etal*. (2014) reported no significant effect of C:F ratio on the faecal nitrogen and urinary nitrogen of growing sheep. The disparity here could be as a result of the forage fed and the concentrate ratio. Meanwhile, total nitrogen loss, nitrogen retained and the percentage nitrogen retained were not affected by the dietary treatments.This is similar to the report of Moorby *etal*. (2006). However, the percentage nitrogen retention ranged from 41.33% in control to 57.33% in bucks fed (75:25) C:P. All animals were in a state of positive nitrogen balance, this implied that all the bucks received adequate nitrogen from the diets fed.

5.2.4Economics of feeding mixtures of concentrates and Guinea grass (*Panicum maximum*) hay to growing red Sokoto bucks.

The higher cost of concentrate consumed by animals fed (75:25) C:P mixture in the present study implies that concentrate feeds account for a higher cost of production in animals, of which the concentrate consumed was 75% of the total feed intake, hence, the reason for the high cost of concentrate while reverse was the case for the cost of hay consumed with the animals fed on 25:75 C:P mixture having the 75% of the total feed intake as hay, hence, the reason for the higher cost of hay consumed. However, total cost of feed consumed was 23.5% higher in animals fed 75:25 C:P than those fed (25:75) C:P due to the same reason stated for the higher cost of concentrate and hay respectively. Meanwhile, cost/kg gain was lowest in animals fed (50:50) C:P

mixture as compared to animals fed other dietary treatments, making the 50:50 C:P mixture the most economical diet in this study. Net benefit of feeding the experimental diets was highest in those animals fed (50:50) C:P mixture than the control. Return to investment on feed was highest in animals fed (25:75) C:P mixture, probably as a result of least cost/kg feed due to lower cost of *Panicum maximum,*even though, there was a positive return to investment in all the dietary treatments, it is concluded that, it is more profitable and economical to feed growing red Sokoto bucks on 50:50 C:P mixture. This is in agreement with previous studies of Anifowose *etal.* (2016) who reported higher productivity of red Sokoto bucks fed 50:50 *Panicum maximum* with cowpea shell based concentrate.

CHAPTER SIX

6.0 SUMMARY CONCLUSION AND RECOMMENDATION

6.1 Summary

Two trials were conducted, namely, agronomic trial which looked into the Effect of Pig Manure Rates (0, 5, 10 and 15t/ha), Planting Methods (drilling and broadcasting) and Harvesting Stages (6, 9 and 12 weeks after planting) on productivity (forage yield and nutritional quality) of (Guinea grass)*Panicum maximum* at the National Animal Production Research Institute, Shika, Zaria during the rainy season of the year 2018. The trial was laid in a split plot design (4×2×3) factorial with RCBD, forage collected at each of the harvest stages were oven dried to a constant weight at 65^0C, milled and subjected to laboratory proximate analysis. Data on forage yield and nutritional quality of the forage collected at 6, 9 and 12 weeks after planting were subjected to three way analysis of variance, using General Linear Model of SAS 1995 while means were separated with DMRT. Results obtained from the study revealed that, drilling method of planting, 10t/ha rate of pig manure application and harvesting at 12^{th} week of planting, produced *Panicum maximum* with higher yield and good nutritive quality.

Thesecond trial was on Growth performance, nutrient digestibility and Nitrogen balance of growing Red Sokoto bucks fed *Panicum maximum* hay and mixture of concentrates. A total of 12

growing Red Sokoto bucks were balanced for weight and randomly allotted to four dietary treatments: (50:50) concentrate to *Digitaria smutsii* hay, (75:25) concentrate to*Panicum maximum* hay, (50:50) concentrate to *Panicum maximum* hay and (25:75) concentrate to *Panicum maximum* hay, three replicates per treatment in a completely randomized design, the trial lasted for 90 days while weight of the animals was taken at fortnight interval. Digestibility and nitrogen balance studies were conducted at the end of 90 days feeding trial, the animals were housed in individual metabolic cages. Daily faecal and urinary output were collected analysed and computed. Results from the 90 days feeding trial showed that bucks fed (50:50) concentrate to *Panicum maximum* had a higher weight gain, feed conversion ratio, digestibility return to investment.

6.2 Conclusion

It was concluded that;

1. Drilling method of planting, 10t/ha rate of pig manure application and harvesting at 12 weeks after planting, produced *Panicum maximum* with higher yield and good nutritive quality.
2. *Panicum maximum* and concentrate fed at 50:50 ratio exhibited efficient nutrient digestibility, nitrogen balance and retention, and good growth in growing red Sokoto bucks.
3. *Panicum maximum*and concentrate fed at 50:50 was more profitable with positive return on investment.

6.3Recommendations

From the findings, it is recommended that,

1.Farmers should use drilling method of planting, apply pig manure at 10t/ha, and harvest *Panicum maximum*at 12^{th} week after planting for higher productivity andgood nutritional quality in the Northern Guinea Savanna of Nigeria and feed *Panicum maximum* and concentrate at

50:50, for efficient nutrient digestibility, nitrogen balance and good growth of Red Sokoto bucks in the Northern Guinea Savanna of Nigeria.

2. Farmers should feed *Panicum maximum*and concentrate in the ratio 50:50 to Red Sokoto bucks for positive and higher return on investment which is an indication of profitability.

3. Further research could be carried out to feed the *Panicum maximum*to Red Sokoto bucks in accordance to the pig manure treatment in the agronomic phase to evaluate the effect of the rates of manure application on the growth performance, nutrient digestibility and nitrogen balance.

6.4Contributions to Knowledge

1. Application of 10t/ha of pig manure equivalent to 193kgN/ha improved herbage yield by 65% and 40% increase in forage quality compared to control (0 manure application)
2. Feeding a proportion of 50:50 *Panicum maximum*concentrate supplement resulted in better (17.5%) nutrient digestibility and 145% higher daily gain in growing Red Sokoto Bucks

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Appendices

Appendixi:**Weather observation at IAR during the experimental period**

Months	Max Air Temp (^{o}C)	Min Air Temp (^{o}C)	Relative Humidity (%)	Rainfall (mm)	Sunshine (Hours)
May	35.16	24.16	56.10	81.30	7.83
June	31.40	23.20	70.47	133.30	7.12
July	30.84	22.94	75.94	218.40	5.90

August	30.55	21.90	78.12	268.80	6.68
September	31.62	25.45	71.19	229.20	6.51
October	33.23	18.23	55.68	61.60	6.55
Total	192.80	135.88	407.50	992.60	40.59
Mean	32.13	22.65	67.92	165.43	6.75

Source: Meteorological Station, Institute for Agricultural Research, 2018

Appendix ii: **Chemical composition of pig manure applied to *Panicum maximum***

Parameter	Value
Total N (%)	1.93
P (%)	1.09
K (%)	1.50
P/N	0.57
K/N	0.78
Micro mineral (g/kg)	

Fe	6800.00
Cu	183.50
Mn	352.25
Zn	307.25

N= Nitrogen, P= phosphorus, K= Potassium, Fe= iron, Cu= Copper, Mn= Manganese, Zn= Zinc.

Source: Chemical laboratory, Department of soil science, faculty of Agriculture, Ahmadu Bello University, Zaria

Appendix iii:Ingredients composition of concentrate supplement fed to growing Red Sokoto bucks

Ingredients	Percentage(%)
Maize offal	51
Rice offal	15
Cotton seed cake	15
Brewer's dry grain	17

Bone meal	1.5
Salt	0.5
Total	100
Calculated analysis (%)	
Crude protein	15.63
Metabolizable Energy	2306
Cost/kg (₦)	55.68

Appendix iv: Chemical Composition and Metabolizable energy of Experimental Diets Fed to Growing Red Sokoto bucks

Parameters (%)	Concentrate	*Panicum maximum*	*Digitariasmutsii*
Dry matter	92.66	92.65	92.91
Crude protein	14.72	11.65	6.31

Crude fibre	11.92	38.70	29.61
Ether extract	2.03	0.35	5.99
Ash	11.96	6.33	5.51
NFE	59.37	43.01	47.09
ADF	2.64	42.46	30.16
NDF	14.66	73.65	59.55
ME(MJ/KgDM)	11.63	11.72	11.03

NFE= Nitrogen Free Extract, ADF=Acid Detergent Fibre, NDF=Neutral Detergent Fibre.
ME (MJ/kg DM) = 11.78 + 0.0064 + (0.00065EE) 2-0.0118A (Alderman 1985)

Analysed at the biochemical laboratory, Department of Animal Science, Ahmadu Bello University, Zaria