THE EFFECT OF INTERCROPPING LABLAB (*Lablab purpureus* L.*)* AND COWPEA (*Vigna unguiculata* L.) AT DIFFERENT PLANTING DENSITIES WITH NAPIER GRASS *(Pennisetum purpureum)* ON YIELD AND NUTRITIONAL QULITIES

MSc THESIS

BY

NEGASU GAMACHU DINSA

OCTOBER , 2018

JIMMA, ETHIOPIA

THE EFFECT OF INTERCROPPING LABLAB (*Lablab purpureus* L.) AND COWPEA (*Vigna unguiculata* L.) AT DIFFERENT PLANTING DENSITIES WITH NAPIER GRASS *(Pennisetum purpureum)* ON YIELD AND NUTRITIONAL QULITIES

By

Negasu Gamachu Dinsa

A Thesis

Submitted to School of graduate studies, College of Agriculture and Veterinary Medicine, Jimma University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Animal Nutrition

Major advisor: Mr. Kassahun Desalegn (Ass. Professor)

Co-advisor: Dr. Amsalu Nebiyou (PhD)

October, 2018

Jimma, Ethiopia

JIMMA UNIVERSITY

COLLEGE OF AGRICULTURE AND VETERINARY MEDICINE

MSc THESIS APPROVAL SHEET

We, the undersigned, member of the Board of Examiners of the final open defense by **Negasu Gemechu** have read and evaluated his/her thesis entitled **"The Effect of Intercropping Lablab (*Lablab purpureus* L.) and Cowpea (*Vigna unguiculata* L.) at Different Planting Densities with Napier Grass (*Pennisetum purpureum*) on Yield and Nutritional Qualities"** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree Master of Science in **Animal Nutrition.**

Mr. Zemene Worku Name of the Chairperson	[signature] Signature	12/02/2018 Date
Mr. Kassahun Dessalegn Name of Major Advisor	---------- Signature	---------- Date
Prof. Soloman Demeke Name of the Internal Examiner	[signature] Signature	12/02/2018 Date
Dr. Getnet Assefa Name of the External Examiner	[signature] Signature	Oct 12, 2018 Date

DEDICATION

I dedicate this thesis to my Father Gamachu Dinsa and my mother Dawitu Kenea who nursed me with care and affection, tirelessly labored and sacrificed whatever they had for my education to reach me on this stage of education, the opportunity of which they themselves have never had.

STATEMENT OF THE AUTHOR

I declare that this thesis is my real work and that all sources of materials used for this thesis have been duly acknowledged. This thesis had been submitted in partial fulfillments of the requirements for MSc degree at Jimma University (JU) College of Agriculture and Veterinary Medicine and it is made available at the University's Library to borrowers under rules and regulations of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Brief quotations from this thesis are allowed without prior and /or special permission provided that due acknowledgement of source is properly made. Requests of permission for extended quotations reproduction of this manuscript in whole or in part may be granted by the head of the Department of Animal Sciences or by the Dean of the School of Graduate studies when in his /her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Negasu Gamachu Dinsa   **Signature _______________**

Place: Jimma University, Ethiopia

Date of Submission: __________________

BIOGRAPHICAL SKETCH

The author Negasu Gamachu was born to his father Ato Gamachu Dinsa and mother W/ro Dawitu Kanea on 28 September 1989 in Najo district west Wollega Zone of Oromia, Ethiopia. He attended his elementary school in 1996 to 2001 grades 1-6 and in 2002-2003 grades 7-8 at Yambal Gara oli and Burka Chochi elementary School respectively. Then after he was attended secondary school from 2005-2006 and preparatory school from 2007-2008 at Najo secondary and preparatory school. After successful completion of University Entrance Examination, he then joined Jigjiga University in 2009 and attended his degree in Animal and Range Sciences and Awarded bachelor of sciences degree on 2nd July, 2011 with distinction.

Then after he was employed by Oromia Agricultural Research Institute (IQQO), from April 08, 2012 to September 23, 2016 assigned to Haro Sabu Agricultural Research Center to work as **Junior Researcher** of Animal Nutrition and Range Land Resource Management Research Division. Thereafter in September, 2016 he joined Jimma University college of Agriculture and Veterinary Medicine, School of Graduate Studies to pursue his MSc. in Animal Nutrition.

ACKNOWLEDGMENTS

Above all thanks to the almighty GOD who gave me peace and health throughout my life and gave me strength and patient to finalize this work even in terrible situations I faced in this MSc study.

I would like to thank Oromia Agricultural Research Institute for giving me the chance of pursuing MSc study.

I express my greatest gratitude to my major advisor Mr. Kassahun Desalegn. The technical support, constructive idea and suggestion given by him have been with me in guiding and assisting me is gratefully acknowledged. I am also greatly indebted to my co-advisor Dr. Amsalu Nabiyou for his valuable technical advice, constructive comments as well as voluntary assistance for the completion of the study.

I would like to extend my thanks to Prof. Taye Tolamariam for his front-line role at early time of proposal development to give me direction. Thanks to my friend Gizahu Wakgari who helped me throughout my thesis work, to facilitated all the process started from field experimental site selection to the end of the final thesis write-up and for his encouragements, I would like to say him God bless you!. I am also greatly indebted to my friend Temesgen Terefa for his support in my data handling and all members of livestock research process of Haro Sabu Agricultural Research Center, Animal Nutrition and Rangeland management team and finance staff.

I am very grateful to thank Mr. Fikiru Asrat who helped me in soil analysis at Oromia water works design and supervision enterprise at soil fertility and water laboratory service. It is also necessary to recall Mr. Tadele Alemu from Holata Bee Research Center for his support me to rendering during the proximate analysis, in *vitro* and in *sacco* forage qualities analysis at Holeta Agricultural Research Center; animal nutrition analytical laboratory.

The last but not the least my deepest thanks go to all my families, classmate, colleagues and my friends,Waktola Tafase, Shiferaw Ashagriew, Miniyehun Getachew, Ofijan Tesfaye, Ararsa Derara, Sisay Lagase, Malaku Mulugeta and Gemeda Terfasa who had been encouraging me for the successful completion of my thesis work.

ABBREVIATIONS AND ACCRONYMS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
AP	Available phosphorus
BNF	Biological Nitrogen Fixation
CEC	Cation Exchange Capacity
CP	Crude Protein
CPY	Crude Protein Yield
CSA	Central Statistical Agency
DAP	Di ammonium Phosphate
DM	Dry Matter
DMY	Dry Matter Yield
FAO	Food and Agriculture Organization of the Utited Nations
GDP	Gross Domestic Product
GHG	Green House Gases
HSARC	Haro Sabu Agricultural Research Center
ILRI	International Livestock Research Institute
INDMD	*In Sacco* Dry Matter Degradability
INOMD	*In Sacco* Organic Matter Degradability
IPCC	Inter Intergovernmental Panel on Climate Change
IVDMD	*In vitro* Dry Matter Digestibility
IVOMD	*In vitro* Organic Matter Digestibility
ME	Metabolizable Energy
NASA	National Aeronautical and Space Administration
NDF	Neutral Detergent Fiber
OC	Organic Carbon
OM	Organic Matter
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis Systems

TABLE OF CONTENTS

LIST OF TABLES

Page

LISTS OF TABLES IN APPENDICES

Page

LISTS OF FIGURES IN APPENDICES

Page

ABSTRACT

This study was conducted with the objectives of determining the effect of intercropping lablab (Lablab purpureus L.) and cowpea (Vigna unguiculata *L.) at different planting densities with napier grass (Pennisetum purpureum) on yield and nutritional qualities and changes in the soil chemical properties due to legumes inter-cropping effects. The field study was conducted at Haro sabu Agricultural Research site. The experimental design was factorial combination arrangement in randomized complete block design (RCBD) with three inter and intra spaces (i.e. 1m ×0.5m, 0.75m × 0.5m, 0.5m× 0.5m) and intercropping with two tropical legumes (i.e. lablab and cowpea) with three replications. Treatments were T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing and totally nine treatments were used. Soil samples were collected before and after forage harvested. Agronomic parameters, biomass yield, chemical analysis, in vitro dry and organic matter digestibility (IVDMD, IVOMD) and in sacco DMD and OMD of forage samples were determined. Results showed that intercropping increased the soil pH value from 5.8 (before planting) to 6.0 (after planting) for T2 and organic carbon increased from 3.72 (before planting) to 4.11 (after planting) for T7 and total nitrogen increased from 0.31 to 0.35 for T5 and T7. There was no significant (p> 0.05) effect of intercropping on agronomic parameters of Napier grass such as plant height (PH) and number of leaves per tiller (NLPT). However, number of tillers per plant (NTPP), leaf length (LL) and total number of leaves per tiller (NLPT) were significantly affected by intercropping at different planting densities of Napier grass (p<0.05). Intercropping of lablab and cowpea had significant effect (p<0.05) on dry matter yield, total dry matter yield and total crude protein yield (TCPY) of the Napier grass and but had no significant effect (p>0.05) on crude protein yield. Intercropping at different planting densities significantly affected the proximate composition of Napier grass such as Ash, CP, OM and NDF. However, the DM, ADF, ADL, Hemicelluloses and cellulose contents of the Napier grass was not significantly (P>0.05) affected. Napier grass intercropped at different planting densities with lablab and cowpea had significant effect (P<0.05) on the in vitro dry and organic matter digestibility (IVDMD, IVOMD) and increased digestibility. The OM degradation constant (a, b, c and PD (a + b), were significantly different (P<0.05) but 'ED' were not and for DM degradation 'c' and 'b' was not significant (P>0.05) for Napier grass intercropped with lablab and cowpea at different planting densities. In conclusion, Napier grass intercropped with lablab and cowpea at a planting density of 24 plants m^{-2} (1m×0.5m space) could be a better choice for high yield and forage quality in the current study. However, it is suggested to do on animal performance trial of this result based on animal feeding practice and economic feasibility in order to come up with sound recommendations.*

Key Words: Cowpea, Digestibility, Lablab, Intercropping, Napier Grass, Nutritive qualities, Dry Matter and Organic Matter Digestibility

1. INTRODUCTION

The population of Ethiopian livestocks were 59.5 million cattle, 30.70 million sheep, 30.20 million goats, 2.16 million horses, 8.44 million donkeys, 0.41 million mules, and about 1.21 million camels and 56.53 million poultry (CSA, 2017). Despite the large number of livestock resources of Ethiopia own, its productivity was extremely low in the contribute of gross domestic product (GDP) at household and national levels (Tolera, 2008). The low productivity is chiefly due to inefficient nutritional and management practices, high level of disease and parasitic incidence, low genetic potential of the indigenous cows, poor access to extension and credit services and inadequate information to improve animal performance (Haile, 2011). Among these constraints, inadequate quantity and quality feedstuffs were identified as a major limiting factor to the development of livestock production and productivities in peri-urban and urban (Gizaw, 2010; Duguma *et al.*, 2011) and the most bottleneck of livestock farming in Ethiopia is shortage of livestock feeds in terms of quantity and quality, especially during the dry season (Hassen *et al*., 2010).

According to Tessema and Baars (2006) productivity of livestock which plays a crucial role in peasant farming systems is much lower than expected. This is due to the dependence of livestock on naturally available feed resources and little development of forage crops for feeding to animals (Demissie *et al.,* 2017). Livestock depend on natural pastures and crop residues and both quantity and quality of these feed-stuffs are too low to sustain satisfactory levels of animal production (Tessema and Baars, 2006). These natural pastures are declining from time to time in both quantity and quality (Ulfina *et al.*, 2013). Fast growth of population has reduced the natural grazing lands of the country from time to time due to demand of land for crop production(Yayneshet, 2010).

The quantity and quality of natural pastures vary with agro ecology, rainfall pattern, soil type and cropping intensity (Tolera, 2008). Also human population associated with expansion of crop lands, seasonal fluctuation of rainfall resulted low total herbage and dry matter production and lacks of grazing land management techniques (Ocho *et al*., 2016). According to Belaynesh (2006) Natural pastures which provide more than 90% of the livestock feed are generally very poorly managed. The total grazing and browsing land was estimated to be 61–65 million ha and the productivity estimate of natural pasture for the lowlands was 1 ton

DM/ha, while for the highland and mid-altitude on freely drained soils was 3 tons of DM/ha and on seasonally waterlogged fertile areas yield was about 4–6 tons of DM/ha which is further deteriorating (Alemayehu, 1998; Mengistu, 2006). Moreover these feed resources are high in fiber, with low to moderate digestibility and low levels of nitrogen (Habte, 2000). Low quality feeds are associated with a low voluntary intake, resulting in insufficient nutrient supply, low productivity and even weight loss (Hindrichsen *et al.*, 2004). The yields of tropical grasses depend on many factors; most importantly, soil fertility and environmental conditions (ILRI, 2010a).

Most tropical countries face shortages of fertilizers, especially nitrogen (N). The shortage of N available in the soil is primarily limiting plant growth and productivity. According to Quadros *et al.,* (2003) the amount of biomass produced by vegetation in forage plant communities is often limited by N availability. According to Plénet and Cruz (1997) N availability in soil is mostly insufficient for plant growth up to the start of flowering period.

In forage crop production systems, grass-legume intercropping are preferred due to their several advantages over monoculture. One of the advantage of grass-legume intercropping is to improve the productivity of pasture lands by improving soil fertility and the feed value of the biomass produced since they have more protein content than naturally occurring grass swards and serve as good quality and quantity dry seasons feed source (Zewdu, 2006). Consequently the proper management of nitrogen fertilization in forage cultivate should provide N in sufficient quantities during the vegetation development so that they could achieve their growth potential in the wake of intercepted light amounts (Plénet and Cruz, 1997). When grass-legume intercropping, the legumes have the ability to fix atmospheric nitrogen into the soil by symbiotic living with bacteria of *Rhizobium* species and sustaining of soil fertility (Albayrak *et al.,* 2004). The other advantages of intercropping grass-legume include the control of erosion, weed control and prolonged stand longevity (Casler, 1998).

Tropical legumes are *annual or* short term species in association with productivity could be an advantage in improving the supply of cell wall carbohydrates containing grass species such as Napier grass nutrients to livestock (Bayble *et al.,* 2007). Forage production strategy that can contribute in improvement of the CP concentrations and others nutrient content of animal feed is the development of grass-legume intercropping (Bogdan, 1977) and thereby their productivity could be the cultivation of grass-legume intercropped and offer them to animals during critical periods in their production cycle and when other sources of feeds are in short supply (Association, 2000).

Integration of forage legumes into forage production systems help smallholder farmers to produce more biomass forage and increase fodder production in quality and quantity which contributes to livestock directly (Tadesse *et al*., 2012). The reason of yield advantage of intercropping are mainly that environmental resources such as water, light and nutrients can be utilized more efficiently in intercropping than in the respective sole cropping systems (Liu *et al.,* 2006). Therefore, the use of grass-legume forage intercropping help to increase productivity of land and livestock feedstuffs.

Napier grass *(Pennisetum purpureum)* was selected for this study based on its high potential biomass yield to fill the gap of feed shortage intercropping with cowpea *(Vigna unguiculata)* and lablab *(Lablab purpureus)* to improvement nutritional values of Napier grass and soil fertility. According to Mengistu (2006) Napier grass is among forage grown for feeding dairy cattle in Ethiopia. Napier grass could play an important role in providing a significant amount of biomass yield of 20 to 30 t DM/ha/year with good agronomic and management practices (Farrell *et al.,* 2002). It is an adaptable, vigorous, highly productive species and with stands considerable periods of drought. It rapidly recovers from stagnation of growth with the onset of rains after extended dry periods (Sollenberger et al., 1990). Napier grass is palatable and could be fed fresh, as silage or directly grazed on the field (Woodard and Prine, 1991). However, like other tropical grasses Napier grass is considered to be low in CP and high in structural cell wall carbohydrates (Van Soest, 1994). This implies the need for production strategies that can help improve the CP concentration and digestibility of Napier grass (Chalchissa *et al*., 2014).

Dolichos lablab has been noted for decades as being one of the most agro-morphologically diverse (Pengelly and Maass, 2001) and versatile tropical legume species through its roles as pulse, vegetable (green bean, pod, leaf), forage/green manure, herbal medicine, and even ornamental (Adebisi and Bosch, 2004). Dolichos lablab plants can fix up to 400 kg N $ha^{-1}yr^{-1}$ (Amel *et al.,* 2014), reducing the need for expensive and environmentally damaging nitrogen fertilizer. Similarly, cow pea plays an important nutritional role in the sub-Saharan areas because of high protein content in its grains and leaves (Pasquet and Fotso, 1994). Cowpea can fix atmospheric nitrogen to ammonia and improve soil fertility and cropping system productivity (Geleti *et al.*, 2014). CRI (2006) report that Cowpea can fixing atmospheric nitrogen up to 240 kg/ha and leaves about 60 to 70 kg nitrogen for succeeding crops. Grasses-legumes intercropping of Napier grass with legumes species improve the nutritive value of Napier grass (Mohammed *et al*, 2016). However, according to (Zewdu, 2006), there was significant effect of plant pattern on morphological characteristics and production of the Napier grass. There is a controversial idea about the planting densities on the biomass yield and nutritional value of Napier grass in different parts of the country. In addition lgumes like lablab can be well associated with Napier grass but the effect of the two and above legumes plant species on yieldand the nutritive qualities of Napier grass is poorly documented .Considering the above merits of Napier grass, lablab and cow pea, evaluating the effect of these two forage legumes on the yield and quality of Napier grass will be of great importance. Information on the management practices and cropping system that influence yield quantity and nutritive quality of this selected species when intercropped with lablab and cowpea at different planting densities of Napier grass was not well practiced in our country (Mohammed *et al*, 2016). Therefore the current study was being carried out with the following objectives:

General objective

- To determine the effect of inter-cropping lablab and cow pea on the productivity and nutritional qualities of Napier grass and changes in the soil chemical properties.

Specific objectives

- To evaluate the effect of inter-cropping lablab and cowpea on the productivity of Napier grass
- To determine the effect of inter-cropping lablab and cowpea on the nutritional qualities of Napier grass
- To determine changes in soil chemical properties due to inter-cropping lablab and cowpea with Napier grass

2. LITERATURE REVIEW

2.1. Botanical description and Adaptation of Napier Grass

Napier grass is a perennial C4 grass species that native to Sub-Saharan Africa from where it is believed to have been distributed to other tropical and subtropical regions around the world (Harris *et al.,* 2010; Kandel *et al.*, 2016). It has been reported to be adapted a wide range of soil conditions and agro-ecologies, from sea level to 2500 meters, and it can offer strong resistance dry spells, although it grows best in areas where the annual rainfall is between 750 and 2500 mm (Singh *et al.*, 2013). It is a tall, stout and deep-rooted perennial bunch grass well known for its high yielding capability and mainly used for cut-and-carry feeding systems for livestock (Woodard and Prine, 1991; FAO, 2015).

Napier grass is a highly productive forage species that can be easily adopted by farmers. The importance of Napier grass (*Pennisetum purpureum*) can be seen from the role it plays as the major livestock feed in smallholder dairy production systems. Napier grass requires full land preparation and propagated usually by stem cuttings buried in 15 cm furrows, 2 nodes in soil and one exposed, but root splitting gives a better performance than stem cutting. It performs well in low, mid and highland areas of Ethiopia (Bediye *et al.*, 1998; Zewdu, 2005). Napier grass responds well to fertilizer applied after every cut (Bogale *et al.*, 2008).

The yield and nutritional values of Napier grass mainly depends on the type of cultivar used which in turn is influenced by both the environment and management practices employed.(Oliveira *et al.,* 2014). Napier grass yield have been reported around 60 tons /ha/year (Rengsirikul *et al.,* 2013) and about 10 tons/ha/one cut cycle of DM (ILRI, 2010b). The nutritional value and other nutritional qualities of Napier grass have been reported across different studies and show significant variation in dry matter production (DM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF). However on average, Napier grass is considered to contain 9% CP, 20% DM, 70% NDF, 50% ADF, 9% ash and 6% lignin in samples taken from 10–15 week old plants(Islam *et al.,* 2003; Gwayumba *et al.*, 2002).

2.2. Botanical Description and Adaptation of Cowpea (*vigna unguiculata* L.)

Cowpea is better adapted to high temperatures and other biotic stresses than other crop plant species (Hall *et al.*, 2003) and it is an annual herb with varying growth forms (Peksen, 2007).

It may be erect, trailing, climbing or bushy, usually indeterminate under favorable conditions. It has a strong taproot and many spreading lateral roots in surface soil (Peksen, 2007). It is primarily grown in drier regions of the world where it is one of the most drought-resistant food legumes (Dadson *et al.*, 2005). Cowpea is a heat-loving and drought-tolerant crop. The optimum temperature for growth and development is around 30 °C. Many workers have reported that cowpea is drought-tolerant and show a great deal of drought avoidance under conditions of water deficit. Drought avoidance by cowpea appears to be mainly due to several mechanisms for regulating rate of water uptake (Hall, 2004). According to Martins *et al.* (2003) cowpea grow best during summer, the base temperature for germination being 8.5 °C and for leaf growth 20 °C. It can grow under rainfall ranging from 400 to 700 mm per annum. Cowpeas utilize soil moisture efficiently and are more drought tolerant than ground nuts, soya beans and sun flowers. Cowpeas are grown on a wide range of soils but prefer sandy soils which are less restrictive to root growth. It is drought tolerant, can be grown on relatively poor soils, and fixes nitrogen, thereby improving soil fertility and more tolerant to infertile and acidic soils than many other crops and it thrives best in well-drained soil and less on heavy soils. Cowpea plays an important nutritional role in the sub-Saharan areas because of the high quality protein and vitamins contained in its grains and leaves (Fotso *et al.*, 1994). Because of its superior nutritional attributes, versatility, adaptability and productivity cowpea was chosen by the United State National Aeronautical and Space Administration (NASA) as one of few crops worthy of study for cultivation in space stations (Ehlers and Hall, 1997).

Cowpea is an herbaceous warm-season annual that is similar in appearance to common bean except that leaves are generally darker green, shinier, and less pubescent (Timko *et al.,* 2007). Cowpea also is generally more robust in appearance than common beans with better developed root systems and thicker stems and branches. Plant growth habit can be erect, semi erect, prostrate (trailing), or climbing depending mostly on genotype, although photoperiod and growing conditions can also affect plant stature (Timko *et al.*, 2007).

Most cowpea accessions have indeterminate stem and branch apicies. Flowers are borne on racemes on 15- to 40-mm peduncles that arise from the leaf axils. Cowpea seed weighs between 8 and32 mg and ranges from round to kidney shaped. Pods are cylindrical and may be curved or straight, with between 8 and 15 seeds per pod (Timko *et al.*, 2007).

Cowpea grain and forage biomass contain a dense nutritional profile that is beneficial for livestock. The grain and leaf of cowpea contains between 22% and 32% protein on a dry weight basis (Singh, 2005). Ash content ranged between 3-4%, crude protein, crude fat and moisture contents had range values of 20-27, 0.6-1, and 9-12, respectively (Henshaw, 2008).

2.3. Botanical description and Adaptation of Dolichos Lablab (*Lablab purpureus)*

Lablab is an ancient crop and has been documented by archaeo-botanical finds in India prior to 1500 BC (Fuller, 2003). Lablab (*Lablab* purpureus), formerly Dolichos lablab, also called Hyacinth bean, Egyptian bean, and Fuji mame (in Japan) is a popular legume vegetable in Southern Asia, China, Japan, West Africa, and the Caribbean (Valenzuela and Smith, 2002b). Furthermore (Morris, 2009) reviewed its bio-functional properties for use as pharmaceutical or nutraceutica.

Lablab is a fast growing legume that can provide fodder in less than 3 months after sowing (Heuzé *et al.*, 2016). It grows up to 1 m tall with long stems in climbing types extending as much as 6 m from the base of the plant (Valenzuela and Smith, 2002b). The leaves are trifoliate (having three leafs) and the flowers are purple or white. It has a strong taproot with many lateral and adventitious roots (Valenzuela and Smith, 2002b). Both determinate (bush) and indeterminate (vining) varieties exist (Valenzuela and Smith, 2002b). Lablab bean (*Lablab purpureus* L.) is a widely cultivated, highly drought tolerant legume vegetable crop grown in diverse environmental conditions (FAO and Isric, 2012). Lablab (*Lablab purpureus* L.) combines a great number of qualities that can be used successfully under various conditions. Its first advantage is its adaptability, not only is it drought resistant, it is able to grow in a diverse range of environmental conditions worldwide (Murphy and Colucci, 1999). It is reported to grow well under warm humid conditions at temperatures ranging from 18^{o}C to 30^{o}C and is fairly tolerant to high temperatures. Below 20^{o}C the plant have a reduced growth; leaves begin to drop at negative 2^{o}C but the plant can survive frost for a limited period (Murphy and Colucci, 1999).

Lablab is drought hardy and has been grown in arid, semi-arid and humid regions with rainfalls between 200 and 2500 mm (Hendricksen and Minson, 1985). It needs rainfall or irrigation (minimum of 10 to 20 mm) during germination and early establishment, although once established it is extremely resistant to drought (Mayer *et al.*, 1986). Being a hardy plant, lablab can be found throughout the tropics and subtropics; ranging from 30^{o} south to 30^{o} North Latitude. It is normally grown from sea level up to elevations ranging between

1800 and 2100 meters (Hendricksen and Minson, 1985; Mayer *et al.*, 1986). The leaves are excellent hay for cattle and goats, but the steam is difficult to dry and must be mechanically conditioned through crushing (FAO and Isric, 2012). The leaf has crude protein of 21 to 38% and the seed contains 20 to 28% crude protein (Abdallah *et al.*, 2015).

The level of crude protein of lablab is variable according to its morphological parts such as leaf, stem and seed fractions. However the mean crude protein content of lablab herbage was 17% with a range of 10% to 22% on a dry matter. Leaf crude protein varied from 14.3% to 38.5%, while the stem crude protein content ranged from 7.0% to 20.1%. Lablab follows a familiar growth pattern as protein content drops with maturity (Murphy and Colucci, 1999). The contents of crude fibre such as , neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) values for the lablab vary based on dry matter basis and various fractions. The average crude fibre of the whole plant is 27.8% with the average of NDF, ADF, and ADL being 43 %, 38.6%, and 7.1% respectively (Murphy and Colucci, 1999).

2.4. Intercropping Systems

The inter cropping system is defined as the combination of crops grown on a given area and time (Yellamanda *et al*., 2007). The important reasons to grow two or more crops together are the increase in productivity per unit area. In intercropping system, all the environmental resources utilized to maximize crop production per unit area per unit time). According to Grossman and Quarles (1993) inter-cropping is divided in to four basic spatial arrangements. 1) Row inter-cropping: two or more crops are planted simultaneously both in distinct rows. 2) Strip inter-cropping: planting two or more crops together in strips wide enough to permit separate crop production practices using machines but close enough for the crops to interact. 3) Mixed inter-cropping: planting two or more crops together without any distinct row arrangement. 4) Relay inter-cropping: planting of a second crop in to an already standing crop at a time when the standing crop is at its reproductive stage or has completed its stage or has completed its development but before harvesting.

2.4.1. Advantage of intercropping system

The principal advantage of intercropping is the more efficient utilization of the all available resources and the increased productivity compared with each sole crop of the mixture (Willey, 1979; Mucheru-Muna *et al.,* 2010). Yield advantage occurs because growth resources such as light, water, and nutrients are more efficiently absorbed and converted into crop biomass by the intercrop over time and space as a result of differences in competitive ability for growth resources between the component crops which exploit the variation of the mixed crops in characteristics such as rates of canopy development final canopy size (width and height) photosynthetic adaptation of canopies to irradiate conditions and rooting depth (Tsubo et al., 2001;Midmore, 1993).

Legumes enrich soil by fixing the atmospheric nitrogen converting it from an inorganic form to forms that are available for plants uptake. Biological fixation of atmospheric nitrogen can replace nitrogen fertilization wholly or in part. In addition, roots of the legume component can decompose and release nitrogen in to the soil where it made available to subsequent crops (Lunnan, 1989). Intercropping like common bean with corn improve silage yield and protein content of forage compared with sole crops (Lunnan, 1989).

The dry matter, crude protein and ash content of maize forage increased by intercropping with legumes compared with maize mono-culture (Javanmard *et al.,* 2009). Furthermore, intercropping legumes with maize significantly reduced neutral detergent fiber and acid detergent fiber content, increasing digestibility of the forage.

2.4.2. Advantage of mixing grasses and legumes for herbage yield and nutritive value

Integration of tropical legumes in the fodder grass production system has shown to enhance livestock feed production elsewhere (Njoka-Njiru *et al.,* 2006a). Legume-grass mixtures are easily established in degenerated pasture or field conditions. Legumes are rich in terms of protein concentration, whereas grasses have higher carbohydrate contents and can benefit from the nitrogen fixed by legumes when they are grown together (Albayrak and Türk, 2013). The grass-legumes mixture improved the forage yield, root: shoot ratio and contents of crude protein and lignin (Liu *et al.*, 2016). Improved yield is one of the benefits of sowing grass - legume mixtures (Berdahl *et al*., 2001; Papadopoulos *et al.,* 2012). Mixed cropping especially with legumes can improve both forage quality and yield because legumes are good source of protein (Zhu *et al.*, 2001). Inclusion of a legume in grass mixtures also improves feed quality as legume species fix nitrogen from the air.

Legumes have higher protein content than grasses and as a result the protein requirements of growing animals can be met to a large degree by adequate legumes in the forage mix. (Legesse *et al.,* 2012) found that alfalfa mixture with grass pasture contained more crude protein, compared to grass pasture. The DM yields of both the binary and ternary legume–grass mixtures were greater than the yield of any grass under mono-culture (Albayrak and Türk, 2013). Intercropping of fodder maize with lablab bean significantly increased protein content and reduced crude fiber content (Mugendi *et al.,* 2011). Under water stress crude protein content and mineral content of intercropped maize were increased. Intercropped maize had higher contents of mineral elements lower content of crude fiber and higher content of crude protein in the second season compared to pure stand of maize with applied nitrogen (Khogali *et al.*, 2011).

Cultivation of intercropping grass with legume has increased and growth a number of potential advantages yield in comparison to mono-cultures. Mixtures extend harvest and income flow, provide diversity of feed and reduce disease. The yield of grass/legume mixtures is more stable under changing environmental conditions than mono-cultures. This results in higher mean biomass production in comparison to their components grown in mono-culture (Arturi *et al.*, 2012). According to Njoka-Njiru *et al.* (2006a) napier grass intercropped with siratro and seca legumes did not influence the level of mineral in napier grass. Level of P and Ca increased over time from 9 months to 2 years while K declined. After 9 months the only significant effect of legume occurred in fiber and ash content of Napier grass. The sole Napier grass had higher fiber contents but lower ash than the intercropped Napier grass. After 2 years the Napier grass intercropped with siratro and seca had more CP (9.64 - 9.96%) than sole Napier grass (8.14%). However the level of fiber remained high but only the ADF content was significantly more in sole Napier grass than Napier grass grown with the legumes. The legume had significant effect on degradability of Napier grass (Njoka-Njiru *et al.,* 2006a).

Significant effects of Napier Grass/ Lablab associations and their interactions was observed on crude protein yield (CPY), *in vitro* organic matter digestibility (IVOMD), content of CP, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), ash and hemicelluloses (Bayble *et al.,* 2007). Association of Napier grass with Lablab species generally improved the nutritive value of Napier grass (Bayble *et al.,* 2007). Therefore, to this effect Napier grass may get additional nutritive value from intercropping Lablab. These indicated the possibility of improving the feeding of animals in tropical regions by planting

Napier grass which is reputed for its high biomass yield along with lablab, thus enhancing the quality of nutrients supplied to animals (Bayble *et al.,* 2007).

2.4.3. Biological nitrogen fixation

In the face of the prevailing N limitation rising costs of inorganic N fertilizers and deleterious side-effects of excessive N application (Galloway *et al*., 2008; Canfield *et al.*, 2010), increased sustainability and improved N self-sufficiency can be gained through home-grown N_2 fixing crops. Grassland-based livestock production of medium to high management intensity depends largely on high-yielding pure grass stands requiring large inputs of mineral N fertilizers. Production and distribution of mineral N fertilizers need large amounts of energy (Kitani, 1999;Engineering and Kitani, 1999) and their application can result in substantial N losses as nitrate (Ledgard *et al.,* 2009) and green house gases (GHG) to the environment (Suter *et al*., 2015; Schmeer *et al.,* 2014). For example, each kg of N produced as ammonium nitrate in the industrial Haber-Bosch process consumes 58 MJ of energy and emits 8.6 kg of CO_2 equivalents (Kitani, 1999). Moreover, according to the guidelines of the IPCC (2006), for every 100 kg of N fertilizer added to the soil, on average 1.0 kg of N is emitted as N_2O, a GHG that is approximately 300 times more potent than CO_2. A major challenge is to increase home-grown forage protein with reduced input of mineral N fertilizers and at the same time reduce N losses to the environment (Peyraud *et al.*, 2009; Lüscher *et al.*, 2014).

Grass-legume combinations (GLCs) with different grass legumes ratios (GLR) legumes were established and available N concentration increased when legumes component increased from GRL:1:0 (grass mono-culture) to GLR1:1 (Grass: legumes). But decreased as legumes component increase further from GLR1:3 (grass legume 1:3) to GLR0:1 Legume mono-culture (Li *et al.*, 2015). Legumes potential to Fixation of Atmospheric Nitrogen (ANF) depend on atmospheric nitrogen, therefore legume-based cropping systems important when fertilizer-Nitrogen is limited (Ito *et al.*, 1996). Biological N_2 fixation by leguminous plants is a significant source of available N in both natural and managed ecosystems (Galloway, 1998). Annual rates of symbiotic N_2 fixation by cultivated legumes are often at least one order of magnitude higher than rates of N_2 fixation in natural ecosystems (Cleveland *et al.*, 1999; Ledgard *et al.*, 1995). Cultivated legumes still provide nearly as much N annually to agricultural systems as N fertilizer although global inputs by fertilizer have recently exceeded those of N_2 fixation (Vitousek *et al.,* 1997).

Grass-legume mixtures offer the benefit of symbiotic N2 fixation by legumes, which are able to utilize atmospheric N_2 for their requirements and thereby produce more protein with less N input (Carlsson and Huss-Danell, 2003). Besides symbiotic N_2 fixation, other processes have been found to increase yield and efficiency in resource uptake by grass-legume mixtures. These include facilitation, that is N transfer from legumes to grasses (Pirhofer-Walzl *et al.,* 2012; Rasmussen *et al.,* 2013) and increased exploitation of soil resources through spatial (deep and shallow-rooting) or temporal niche complementarities in resource uptake (van Ruijven and Berendse, 2005; Mueller *et al.,* 2013). All of these processes can lead to considerable gains in N yield of mixtures compared to grass mono-cultures; consequently, the use of such mixtures in agricultural grassland systems could allow substantial reductions in the application of industrial N fertilizers.

2.4.3.1. Importance of lablab in the biological nitrogen fixation (BNF)

Biological nitrogen fixation (BNF) is the process whereby atmospheric nitrogen (N=N) is reduced to ammonia by living microorganisms e.g. rhizobium in the presence of nitrogenase enzyme (Lindemann and Glover, 2003b).

Lablab prolific root system remains in the soil after harvest and enriches the soil with organic carbon. Lablab plants conserved soil moisture; Lablab intercropping increased phosphorus and calcium content compared to mono crop (Kabirizi *et al.,* 2007). When in symbiotic association with *Bradyrhizobium japonicum*, Dolichos lablab (*Lablab purpureus*) is popular as a nitrogen-fixing green manure to contribute to soil N and improve soil quality. It is a popular choice as a cover crop on infertile, acidic soils, and it is drought tolerant once established (Valenzuela and Smith, 2002a). According to Lindemann and Glover (2003a) lablab can fix atmospheric nitrogen up to 120 to 200 kg N/ha when it is planted either as an intercrop or as a sole crop depending on the climatic and soil conditions. Creamer and Baldwin (2000) reported BNF of 40 to 80 kg N/ha when lablab is planted in sole cropping.

2.4.3.2. Importance of cow pea in the biological nitrogen fixation (BNF)

Cowpea is more tolerant of low fertile soil, due to its high rates of nitrogen fixation (Elowad *et al*., 1987), effective symbiosis with mycorrhizae (Kwapata and Hall, 1985), and ability to better tolerate soils over a wide range of pH when compared to other popular grain legumes (Fery, 1990). Cowpea plays a major role in tropical cropping systems as it has been estimated to fix as much as 201 kg N ha^{-1}per season and contribute up to about 42 kg N ha^{-1} to the N nutrition of a following maize crop (Dakora *et al.,* 1987). Because of its ability to improve the N economy of cropping systems cowpea is traditionally grown as an intercrop with millet, sorghum, maize, and more recently cassava (Ehlers and Hall, 1997).

2.5. Advantage of Intercropping Legumes on Nutritive Value of Napier grass

By the introduction of legumes in the system of fodder production, the quantity as well as quality of herbage production can be substantially increased (Powell and Unger, 1997). The benefits of growing grass and legumes as mixed fodder crop are to maximize yield and quality in forage production (Yisehak, 2008).

Intercropping of Napier grass with legumes species generally improve the nutritive value of Napier grass (Bayble *et al.*, 2007). Therefore, by this influence Napier grass may get additional nutritive value from intercropping of legumes. These indicated the possibility of improving the feeding of animals in tropical regions by planting Napier grass, which is reputed for its high biomass yield along with legumes such as cowpea and lablab, thus enhancing the quality of nutrients supplied to animals (Bayble *et al.,* 2007). Plant densities or pattern intercropping with has significant effect on dry matter production of the Napier grass. According to Wijitphan *et al.* (2009a) plant spacing did have effect on crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and dry matter digestibility. Also Wijitphan *et al.* (2009a) reported that there is a significant effect of plant spacing on total dry matter yields. The wider the plant the lower the dry matter yields.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted at Haro Sabu Agricultural Research Center during the main cropping season. The center is located in western Ethiopia at 550 km from Addis Ababa. It lies at latitude of 8°52’51” N and longitude 35°13’18’’ E and altitude of 1515 m.a.s.l. It has a warm humid climate with average minimum and maximum temperature of 14 and 30°C respectively (HSARC, 2012). The area receives average annual rainfall of 1000 mm and its distribution pattern is uni-modal (HSARC, 2012). The main rainy season covers from April to October. The soil type of the experimental site was vertisol with sandy loam in texture(Abebe, 2007). The area is characterized by coffee based farming and crop-livestock mixed farming system (HSARC, 2012).

Table 1: Agro-metrological data of the study area during 2017 at Haro Sabu Agricultural Research Center, Oromia, Ethiopia

Description	Months of the year 2017											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
RF (mm)	0.0	17.6	16.2	158.2	248.7	180.1	291.5	307.1	223.2	117.8	33.1	0.4
T^0C (Max.)	33.0	32.9	Xx	xx	27.4	27.2	24.6	25.2	26.1	26.7	27.3	29.7
$T\ ^0C$ (min.)	xx	8.8	14.5	15.7	14.6	11.6	11.4	11.3	11.2	10.9	10.5	10.3
RH (%)	37.2	54.5	45.3	58.3	66.9	69.0	77.2	73.8	74.7	77.5	72.7	53.7

Remarks: Max. = Maximum; Min. = Minimum; mm= millimeter RF= mean Rain fall; RH= Relative Humidity; T^0C = Mean temperature in degree Celsius; xx= data not available

Source: Asosa Meteorological Agency (2017)

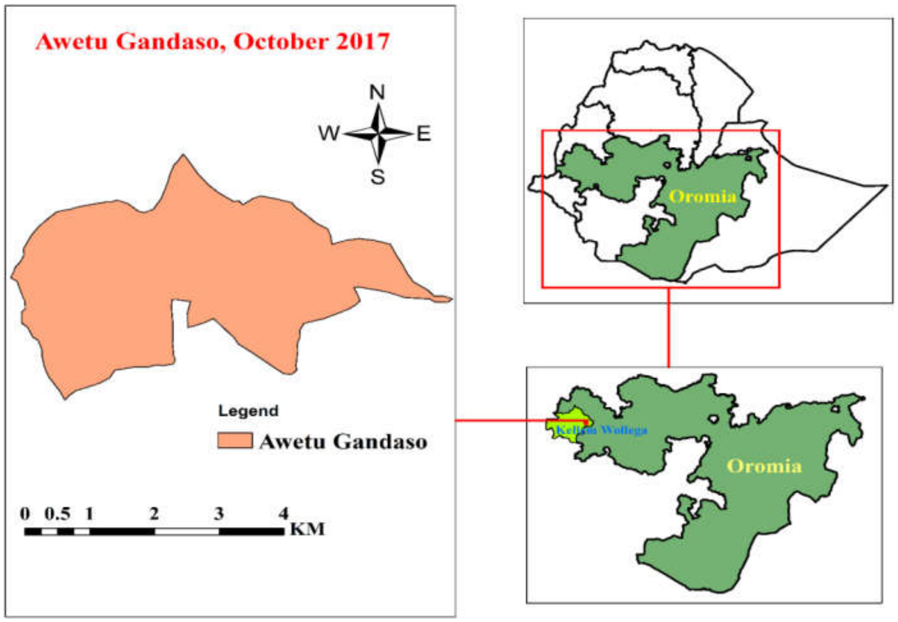


Figure3.1. Map of the purposed study area

3.2. Experimental Layout, Design and Treatments

The experimental design was factorial combination arrangement in RCBD with three blocks consisting of three levels of inter and intra row spacing of Napier grass (ILRI 16840 accession) i.e. 0.5 m × 0.5 m, 0.75 m ×0.5 m and 1 m × 0.5 m intercropping with two tropical forage legumes of cowpea (*vigna unguiculata* L.) Bole variety and Lablab *(Lablab purpureus)* 14455 accession between the rows of Napier grass and totally nine treatments were used (Table.2). Total area of land 525m^2 (35m × 15m) was selected and thoroughly prepared for sowing (Appendix figure.1). The land was ploughed and harrowed with a tractor and then hoe to make the soil fine. The land was divided in to three blocks and each of them has contained nine treatments. The plot size was 12m^2 (4mx×3m) and spacing between plot and between blocks was 1m and 1.5m respectively (Appendix figure.1). Treatments were assigned to each plot within a block by SAS 9.3 version generated randomization code to each plot.

The Napier grass ILRI 16840 (*Pennisetum purpureum*) which was used as a parent plant material was cut into stems with a minimum of three nodes per cut for planting and was planted 15-20cm deep at angle of about 30° - 45° (Ansah *et al*., 2010) and the seed of *vigna unguiculata* was drilled in between the rows of Napier grass at a seeding rate of 10 kg/ha (Mullen *et al*., 2003) and *Lablab purpureus* was drilled in between the rows of Napier grass at a seeding rate of 8 kg/ha in 7-10 cm depth (Antony, 2006; ILRI, 2010b). Fertilizer was applied at the rate of 100 kg ha^{-1} DAP during establishment for all experimental units. Weeding was done as early as possible to eliminate re-growth of undesirable plants and in order to promote fodder grass growth by increasing soil aeration the plots was kept weed free throughout growth period (Orodho, 2006).

Table 2: Row spacing, Plant spacing and intra row structure of the Napier grass during the experimental periods

Treatments	Row spacing(m)	Intercropped materials	Area/plant (m^2)	No. napier grass/plot
T1	1	-	0.5	24
T2	0.75	Lablab	0.375	32
T3	0.5	Cowpea	0.25	40
T4	1	Cowpea	0.5	24
T5	0.5	Lablab	0.25	40
T6	0.75	-	0.375	32
T7	1	Lablab	0.5	24
T8	0.75	Cowpea	0.375	32
T9	0.5	-	0.25	40

Where:-

T1= Pure Napier grass at **1m** row spacing

T2= Napier grass intercropped with lablab at **0.75m** row spacing

T3= Napier grass intercropped with cowpea at **0.5m** row spacing

T4= Napier grass intercropped with cowpea at **1m** row spacing

T5= Napier grass intercropped with lablab at **0.5m** row spacing

T6= Pure Napier grass at **0.75m** row spacing

T7= Napier grass intercropped with lablab at 1**m** row spacing

T8= Napier grass intercropped with cowpea at **0.75m** row spacing

T9= Pure Napier grass at **0.5m** row spacing

3.3. Data Collected

3.3.1. Soil Sampling and analysis procedure

3.3.1.1. Soil sample collection

Three composite soil samples from representing nine surface soils before forage planting practice were collected followed a ‘zigzag’ method where a conscious effort is made to force the path into corners and along edges as well as the central parts of the site being sampled by using auger (Ryan, 2017) and from each plot representing five surface soil samples (in each corner and center of plots) of the experimental field after forage harvesting was taken diagonally at a depth of 0-30 cm by using auger.

3.3.1.2. Soil analysis procedure

The collected soil samples were dried in open air, ground, sieved to pass through 2mm sieve for analysis of soil nutrients and then pounded to pass 0.2mm for nitrogen, soil pH, organic carbon, available phosphorus, electronic conductivity and Cation exchange capacity (CEC). Soil samples were analyzed at Oromia water works design and supervision enterprise at soil fertility and water laboratory service. The soil pH was measured with digital pH meter potential metrically in supernatant suspension of 1:2.5 soils to distilled water. Cation exchange capacity (CEC) was analyzed by ammonium acetate. Organic carbon was determined following wet digestion method as described by (Walkley and Black, 1934) and the available phosphorus was measured by shaking the soil samples with Extracting solutions of 0.03mole ammonium fluoride in 0.1mole hydrochloric acid by using Olsen II methods (Olsen, 1954).

3.3.2. Agronomic parameters

The number of tillers and leaves were counted and the height of the grass (cm) and the leaf length (cm) were measured at the last cut of sample grass on the 90 days. Four plants were randomly selected in the middle of each plot to avoid edge effect and tagged for data collection. Data were collected on four napier grass stand per plot on tiller number, plant height and leaf length, total leaves per plant and total leaves per tiller.

3.3.3. Biomass yield determination

Total forage per plot was harvested when Napier grass reached 90 days stage of maturity (Bayble *et al.*, 2007) and leguminous forages was at 50-55 days or 50 percent flowering stage based on continuous visual observation. The harvested green biomass was separated into grass and legume components. The fresh weight was recorded in the field using a top loading field balance. Fresh sub-samples were measured from each plot and each plant species separately weighed and chopped into short lengths (2-5cm) for dry matter determination. The weighed fresh sub-samples (FWss) were oven dried at 60°C for 72 hours and reweighed (DWss) to have an estimate of dry matter production. The dry matter production was calculated as (10 × TotFW × (DWss /HA × FWss)) (Tarawali, 1995). Where:

TotFW	Total fresh weight from plot in kg;
DWss	Dry weight of the sample in grams
FWss	Fresh weight of the sample in grams
HA	Harvest area
10	A constant for conversion of yields in kg m^2 to ton/ ha

Dry matter yield (DMY) was then multiplied with CP content of the feed samples to determine crude protein yield (CPY).

3.3.4. Chemical compositions

From each plot samples of Napier grass, lablab and Cowpea were taken and dried in a forced draft oven at 60°C for72 hours and samples were ground using Wiley mill to pass through a 1mm sieve screens for chemical analysis. The AOAC (1990) procedure was used for the determination of DM, Ash and CP. The DM content was determined by oven drying at 105°C for 24 hours. The ash component was determined by igniting the dried sample in a muffle furnace at $600^{O°}$C overnight. The residue after burning in the furnace was the ash. The OM was determined by subtracting the ash component from100. The nitrogen was determined using the micro-Kjeldahl technique. The CP was calculated as 6.25×Nitrogen. The method of Van Soest and Robertson (1985) was used to determine neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). Hemicelluloses was calculated by subtracting the ADF from the NDF content, while cellulose was determined by subtracting the ADL from the ADF content

3.3.5. *In Vitro* dry matter digestibility

All samples used for chemical analysis was used for *in vitro* dry matter digestibility (IVDMD). The two-stage rumen inoculates pepsin method of Tilley and Terry (1963) was used to determine IVDMD. Rumen liquor was collected from three rumen fistulated steers and transported to the laboratory using thermos flask that have been pre-warmed to $39^{O}C$. Rumen liquor was taken in the morning before animals were offered feed. A duplicate sample 0.5 g each was incubated with 30 ml of rumen liquor in 100 ml test tube in water bath at $39^{O}C$ for a period of 48 hour for microbial digestion followed by another 48 hour for enzyme digestion with acid pepsin solution. Blank samples containing buffered rumen fluid was incubated in duplicates for adjustment. Drying of samples residues were done at 105°C for 24 hours. The samples were then ashed to estimate IVOMD. An IVOMD analysis was carried out at Holeta Agricultural research center animal feed analytical laboratory.

Metabolisable energy (ME) was calculated from IVOMD using the equation: ME (MJ kg^{-1} DM) = 0.15*IVOMD (Pinkrton, 2005).

3.3.6. *In Sacco* digestibility

In Sacco digestibility was also done at Holeta Agricultural Research Center animal Nutrition analytical laboratory. Composite samples of Napier grass for each treatment were taken and dried in a forced draft oven at 60 °C for 72 hours. Samples were grounded through a 2 mm screen (mesh) using Wiley mill for *in Sacco* digestibility.

Nylon bag have Number 6.5×14 cm dimension with a pore size of 41 mm was taken into an oven dry at 60–65°C for 30 minutes and measure their empty weights immediately or after allowing to cool to room temperature in a desiccators and 3.0 g of dried forage samples were tightly using nylon string which is resistant to rumen micro-organisms and then take in three rumen fistulated steers for 0, 6, 12, 24, 48, 72 and 96 hours. Each feed sample was incubated in duplicates in the three steers for any one incubation time. At the end of each incubation hours, all the bags (including the zero hour samples) were immediately washed with cold water for about 30 minutes in a washing machine or under running tap water while rubbing gently between thumb and fingers until the water runs clear and then the washed bags were dry in an oven at 60–65°C for about 48 hours. Duplicate bags of each sample were washed without incubating in the rumen in order to determine the washing loss. The dried bags were then taken out of the oven and allowed to cool down in desiccators and weigh immediately.

The digestibility or Disappearance of DM (DMD) and OM (OMD) of each incubation time were determined as (AOAC, 1990).

$$\text{Disappearance} = \frac{(SWa - BW) \times DMa - (SWb - BW) \times DMb}{(SWa - BW) \times DMa}$$

Where:

SWa = Weight of the original sample + nylon bag

BW = Weight of empty nylon bag

DMa = Dry matter of feed sample

DMb = Dry matter of residue sample

SWb = Weight of the sample + nylon bag after incubation

The DMD and OMD values at various times of incubation is fitted to the exponential equation; $p = a + b\,(1 - e^{-ct})$.

Where; a= washing loss (rapidly soluble fraction); b= slowly degradable fraction and c= the rate of degradation, e =the natural logarithm, p = the potential disappearance of DM / OM at time t and t = time as described by(Ørskov et al., 1981) using the Neway Excel programme(Chen, 1995). The potential degradability (PD) was estimated as

PD = a + b Whereas the effective degradability of DM and OM (ED) was calculated using(Ørskov and McDonald, 1979) formula: $ED = a + [(b*c)/(c + k)]$ at 0.03/hour for grass rumen out flow rate (k). Where a, b and c are as described above and k = passage rate.

3.3.7. Statistical Analysis

Data were subjected to ANOVA procedure by using SAS software (SAS, 2009 version 9.3) (Littell et al., 2002). Significant means were separated and compared using Least Significant Difference (LSD) test at 5% significant level. The model used for data analysis was:-

$$\mathbf{Y_{ij} = \mu + T_i + B_i + e_{ij}}$$

Where;

Y_{ij} = Individual observation

μ = overall mean

T_i = treatment effect,

B_i =block effect

e_{ij}= Residual error

Since fistulated animals were used as a replication, the analysis of variance model for the *in Sacco* degradability parameters were

$$\mathbf{Y_{ij} = \mu + T_i + A_i + e_{ij}}$$

Where:

Y_{ij} = individual observation

μ = overall mean

T_i = Treatment effect

A_i = Animal effect

e_{ij} = residual error

4. RESULTS AND DISCUSION

4.1. Soil Physical and Chemical properties of the Study Area

4.1.1. Soil Physio- chemical properties before planting of forage

The soil physio-chemical analysis results before planting were shown in Table 3. The variations observed in most of the soil parameters such that soil pH, available phosphorus (AP), total nitrogen (TN), organic carbon (OC), organic matter (OM), and Cation exchange capacity (CEC) were not statistically compared but would help to see the general nutrient status of the soil before forage planted and after forage harvested. The pH of the soil of the composite sample before planting was 5.8 indicating that the soil was moderately acidic based on the rating suggested by (Karltun *et al.*, 2013).

The AP (5.9 ppm) of the study area before forage planted was rated as low based on classification that categorize a relative range of extractable phosphorous of 0.5 ppm, 6-10 ppm, 11-15 ppm, 16-20 ppm and 21-25 ppm as very low, low, medium, high and very high, respectively (Waugh, 1973). The TN, OC and OM percentage content of the study area before planting was 0.35, 3.72 and 6.41, respectively.

4.1.2. Soil Physico- chemical properties after forage harvested

The pH of the soil after harvest showed slight changes above or below the initial soil pH value depending upon the treatment combinations. The changes in soil pH above the initial value was noticed for treatments T1, T2, T3, T4 and T9.This small change might be due to high organic matter content of the soil that influences the change in pH values. The current result agreed with Abebe (2007) who reported that the soil which has high pH value contain high organic matter.

The AP for soil samples after harvest was lower than the initial soil P level. This might show that utilization of P by the grass and/or legume was high. P might have also been locked by fixation as the soil had an acidic condition. The AP values after forage harvest in the Napier grass with 0.75m x0.5m space intercropped by cow pea (T8) was increased and decreased in the rest treatments. The reduction in the AP is due to the sole Napier grass at different intra space and/or some mixture legumes using the available nutrient and at increase observed is due to the contribution to the soil by the legumes that has shown better with more proportion intra spaces of the Napier grass. Teshome *et al.*, (2012) reported that legumes in the mixture treatments facilitate the utilization of phosphorous.

OM will help to raise the pH and thereby have soil acidity partly corrected. At the same time the potential of such soils to provide mineralized ammonium-nitrogen and nitrate-nitrogen would be increased (Abebe, 2007). Except Napier grass intercropped with cowpea by 0.75m x0.5m spaces (T8) the OC and/or OM content of the soil was higher for soil samples taken after harvest as compared to the before planting soil samples (Table 4).

Total nitrogen (TN) is more often deficient than any other essential element in soils in general and acid soils in particular (Abebe, 2007). However, an excess amount on N in relation to other nutrients such as Phosphorus (P), potassium (K) and sulphur (S) can delay crop maturity (Brady and Weil, 2008). Except in the sole Napier grass planted with 1m x 0.5m space (T1) in all treatments TN content of the soil was higher for soil samples taken after harvest as compared to the before planting soil samples (Table 4) and this could be due to the N fixation by the respective legume mixtures and lower TN in the sole Napier grasses planted with 1m x 0.5m space (T1) was due to the absorption of only soil N by the Napier grass. According to the Netherlands Commissioned Ministry of Agriculture and Fisheries (1985) all of the soil samples analyzed after forage harvested were classified in the Very high range of the total nitrogen percentage contents. Similarly (Murphy, 1968; Tadesse *et al.*, 1991) also classified the soil total nitrogen content less than 0.10% as low, 0.10-0.15% as medium, 0.15-0.25% as high and greater than 0.25% as very high.

CEC is the reversible process by which positive ions or exchangeable cations are exchanged between the negatively charged solid and the liquid phase of soils (Abebe, 2007). Reduction of CEC values after forage harvest in the sole Napier grass planted with 0.5m × 0.5m space (T9), the Napier grass with 0.5m × 0.5m space intercropped with cowpea (T3), Napier grass with 0.75m × 0.5m space intercropped with cowpea (T8) and Napier grass with 1m x 0.5m space intercropped with lablab (T7) and increase in the sole Napier grass planted with 1m x0.5m and 0.75m × 0.5m space (T1) and(T6) and Napier grass with 0.75m × 0.5m space intercropped with lablab (T2), Napier grass intercropped with cowpea with 1m × 0.5m space (T4), and Napier grass with 0.5 m × 0.5m space intercropped with lablab (T5). The reduction in the CEC is due to the sole Napier grass using the available nutrient and the increase is due to the contribution to the soil due to the legumes that has shown better with more proportion of the legumes in the mixture treatments (Animut and Hailemariam, 2014).

Table 3: Some soil physicochemical properties after and before forage harvested

Treatments	PH (1:2.5 H_20)	Available (ppm)	Nutrient (%)			CEC (mg/100 g soil)
		P	OM	OC	TN	
CS	5.8	5.90	6.41	3.72	0.31	40.10
T1	6.0	4.22	6.84	3.97	0.31	40.90
T2	6.0	4.02	6.42	3.72	0.32	40.16
T3	5.9	4.14	6.89	4.00	0.34	37.98
T4	5.9	3.24	6.85	3.97	0.31	41.72
T5	5.8	3.94	6.74	4.09	0.35	41.86
T6	5.8	3.44	6.72	4.07	0.35	40.46
T7	5.7	3.43	6.29	4.11	0.35	34.84
T8	5.8	5.52	6.30	3.66	0.32	36.38
T9	6.0	4.10	6.96	4.04	0.35	36.44

T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing, PH = power of Hydrogen, P = Phosphorus, TN = total nitrogen, OC = organic carbon, OM = organic matter, CEC = Cation exchange capacity, ppm = parts per million, mg = milligram, g = gram, mmhos= mili mhos, Cs=composite soil sample

4.2. Agronomic parameters

The results of effect of intercropping of Napier grass with lablab and cowpea at different planting densities on some plant morphological characteristics of Napier grass were presented in Table 5. Except for plant height (PH) and number of leaves per tiller (NLPT) other agronomic parameters were significantly affected by intercropping of lablab and cowpea with different spaces of Napier grass ($p<0.05$).

4.2.1. Plant Height

Plant height of Napier grass was not affected ($P>0.05$) by Napier grass intercropping with lablab and cowpea at three different planting densities Table.5. This is in agreement with the reported of Animut and Hailemariam (2014) that stated different legumes mixed with *Sudan* grass by different ratio had no much variation on plant height. However, relatively within the treatments the longest height was measured at napier grass intercropped with cowpea (T3) at 0.5m × 0.5m space has (182.75cm) followed by sole napier grass with 0.5m × 0.5m space (T9). This result was agreed Abdallah *et al.,* (2015); Tilahun *et al.,* (2017) who reported that narrow space give a longest height of dasho grass when harvested at different age maturity by different spaces, rather wider space of dasho grass was depressed. The current result was also in agreement with the report of Olanite *et al.* (2010) who noted that plant height of *S. almum* were greater at less dense row spacing than high dense row spacing.

4.2.2. Number of tillers per plant

Number of tillers per plant (NTPP) of Napier grass was significantly ($p<0.05$) affected by intercropping of lablab and cowpea by three different densities. The Napier grass intercropped with lablab at 1m × 0.5m space (T7) had highest (NTPP) as compared to the other treatments. While Napier grass intercropped with lablab (T5) at 0.5 m × 0.5m space had lower Number of tiller per plant (NTPP) when compared with sole Napier grass planted by the same spaces i.e. 0.5m × 0.5m space (T9) and this might be due to the increased amount of legumes intercropped and lower amount of the grass returned development of root at the time when the plant formed many tiller due to narrow space that did not get enough space.

Table 4: Least square means and standard errors for morphological characteristics of Napier grass

Trts	Morphological characteristics				
	PH (cm)	NTPP	LL (cm)	TNLPP	NLPT
T1	165.25±9.72	25.00±2.64^{ab}	108.92±1.81^{ab}	245.66±5.21^{bcd}	12.17±1.01
T2	161.75±19.22	22.33±3.52^{abcd}	117.08±4.63^{a}	246.08±1.58^{bcd}	13.17±0.71
T3	182.75±16.09	18.00±0.57^{de}	116.80±1.97^{a}	264.92±5.35^{a}	12.25±1.52
T4	155.92±22.70	24.33±1.76^{abc}	108.42±4.29^{ab}	236.67±2.48^{d}	14.34±1.55
T5	161.17± 18.47	16.33±2.33^{e}	111.08±6.12^{ab}	258.83±9.16^{ab}	13.25±1.37
T6	154.42±15.17	24.00±3.00^{abc}	104.17±3.75^{b}	242.67±7.08^{cd}	10.82±1.34
T7	169.17±11.02	26.66±1.33^{a}	114.08±1.02^{ab}	263.00±1.29^{a}	12.65±2.55
T8	160.58±9.75	19.00±3.60^{cde}	114.17±2.51^{ab}	248.08±1.37^{bcd}	12.67±1.52
T9	173.17±15.80	19.66±1.33^{bcde}	116.50±1.84^{a}	254.83±3.62^{abc}	12.50±0.63
Mean	165.65	21.70	112.28	251.29	12.64
P-value	0.8017	0.0096	0.0420	0.0086	0.9157

$^{a, b\ c\ d\ e}$ Means in a columns, values followed by different letters differ significantly (P < 0.05), T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing, LL = Leaf length, NTPP =Number of tiller per plant, PH= plant height

Napier grasses intercropped with cow pea (T3) at 0.5m × 0.5m space and Napier grasses intercropped with cow pea (T8) at 0.75m × 0.5m space had lower when compared to the sole Napier grass planted at 0.5m x 0.5m (T9) and 0.75m × 0.5m (T6) space. Napier grass intercropped with cowpea (T4) at 1m × 0.5m space was lower as compared to the values in sole Napier grass planted at 1m × 0.5m space (T1).

4.2.3. Leaf length

For the leaf length (LL), the intercropped Napier grass with legumes at three different planting densities was significantly (p<0.05) longer than the sole Napier grass planted with three different spaces across all the treatments. The longest LL was recorded for Napier grass intercropped with lablab (T2) at 0.75m × 0.5m space followed by Napier grasses intercropped with cow pea (T3) at 0.5m × 0.5m space. The higher yield at closer spacing is attributed to the higher tiller height and number per unit area, as well as to number of leaves per plant. The result is in line with the finding of Alalade *et al*. (2014) who recorded highest mean values of leaf length for Panicum maximum when intercropped with *Stylosanthes hamata* and *Canavalia* than for the sole Panicum maximum. Yasin *et al.* (2003) reported that narrow planting density (10 and 30 cm) produced longer leaves than wider planting density (10 and 50 cm) supports the results of which that narrow spacing in Napier grass increased interplant competition, causing individual plants to grow taller with longer internodes, plus slender, thin and weak stalks due to poor light exposure and hence poor photosynthetic output.

4.2.4. Total number of leaves per plant

In the forage agronomy the Leaves are an excellent indicator of Herbage yield and nutritional quality and the higher the amount of leaves has the higher content of protein and digestible dry matter (Miller, 1984). Total number of Leaves per plant (TNLPP) which determines the photosynthetic capacity of the plants was significantly ($P<0.05$) affected by intercropping legumes at different planting densities (Table 5). The highest TNLPP (263±1.29) and (264.92±5.35) were obtained from Napier grass intercropped with cowpea and lablab at narrow spaces i.e. 0.5m × 0.5 m space(T3) and 1mx0.5m space(T7) (Table.5). This is in line with Ishiaku (2016) who reported that total number of leaves per plant (TNLPP) of columbus grass (*Sorghum almum*) was greater at the lower planting density under rain fed conditions in Nigeria.

4.2.5. Number of leaves per tiller

Number of leaves per tiller (NLPT) was not affected ($P>0.05$) by Napier grass intercropping with legumes at different planting densities spaces (Table.5). But numerically the Napier grass intercropped with cowpea (T4) at 1m × 0.5m space had highest NLPT as compared to the other treatments followed by Napier grass intercropped with lablab at 5m × 0.5m space (T5). Whereas the sole Napier grass planted at 0.75m × 0.5m space without intercropped (T1) followed by sole Napier grass planted at 0.5m x0.5m space without intercropped (T9) had lowest NLPT.

4.3. Herbage Yield Determination

Dry matter yield (DMY) over nine treatments were affected (P <0.05) by Napier grass intercropping with lablab and cowpea at three different planting densities (Table.6). The pure stand of Napier grass (T9) planted at 0.5m × 0.5m spaces had more DMY (23.06%) as compared to the other treatments.

Nevertheless, improvement in the DMY of napier grass with three different spaces intercropped with legumes had been observed where the Napier grass intercropped with lablab (T2) at 0.75m × 0.5m space had the highest followed by sole napier grass planted without intercropped at 0.5m × 0.5m space (T6), Napier grass intercropped with cowpea (T3) at 0.5m × 0.5m space and napier grass intercropped with lablab (T7) at 1m × 0.5m space. The current study agreed with the finding of Animut and Hailemariam (2014) who noted that significant (P <0.05) variation was observed in the biomass yield when Napier grass intercropped with legume grown as mixture. This result was agreed with many other previous findings. For instance, Wijitphan *et al*. (2009b) showed that there was an increment of biomass in Napier grass intercropped with lablab association and Napier grass biomass is increased when inter and intra row spacing is decreased. Zewdu (2008) noted that difference in DM yield among the different plant density in Napier grass and DMY increased as plant density increased. Wijitphan *et al.* (*2*009b) obtained the maximum green matter yield of forage with 0.5m × 0.5m spacing. The current study contradicts with other previous finding. For instance, Njoka-Njiru *et al.* (2006b) did not observe significant effect (P>0.05) in DMY of Napier grass when it is intercropped with Seca *stylo* and siratro, rather herbage yield of Napier grass was depressed. Mohammed *et al*, (2016) also noted that Spacing and intercropping legumes with Napier grasses had no significant effect (P>0.05) on DMY of the Napier grass.

Intercropping has a highly significant effect on the total dry matter yield (TDMY) and total crude protein yield (TCPY) (P<0.05). In evaluating forage crops, CP content should not be used as the only parameter to be considered. It is the CPY, which describes the overall and actual productivity of quality forage. Intercropped Napier grass with lablab and cowpea had higher TCPY value at three different planting densities.

Table 5 : Least square means and standard errors for productivity yield Napier grass (ton/ha)

Treatments	Herbage productivity yield (ton/ha)			
	DMY	CPY	TDMY	TCPY
T1	5.36± 0.53bc	0.74± 0.12	4.48± 0.44b	0.62± 0.10d
T2	6.83± 0.54ab	0.97± 0.075	10.69±0.53a	1.53±0.08a
T3	5.93±0.58abc	0.90±0.11	9.52±0.77a	1.41±0.09a
T4	4.93±0.37bc	0.73±0.057	9.10±0.85a	1.25±0.07ab
T5	4.80±0.31c	0.73±0.08	9.43±0.11a	1.39±0.00a
T6	6.23±0.76abc	0.74±0.08	5.29±0.64b	0.62±0.07d
T7	5.65±1.16abc	0.86±0.16	9.35±0.95a	1.36±0.14a
T8	5.38±0.05bc	0.74±0.01	10.01±0.26a	1.05±0.21bc
T9	7.51±0.80a	0.94±0.10	6.26±0.66b	0.77±0.08cd
Mean	5.33	0.82	8.23	1.11
P-value	0.04632	0.4716	<.0001	<.0001

[a, b c d] Means in a columns, values followed by different letters differ significantly (P < 0.05), T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing, CPY= crude protein yield; DMY= dry matter yield; TCPY= Total crude protein yield (Crude protein yield of napier grass and both legumes; TDMY= Total dry matter yield (the sum of all harvests forages of Napier grass and both legumes from each plots).

Whereas sole Napier grass of TCPY mean comparison treatments were not significant (P>0.05). This is due to the component legumes had benefitted through transfer of fixed N_2 by the legume components to grass intercropped with legume mixture was possibly to utilizing the additive resources soil nutrients more efficiently (Geleti *et al.,* 2003). The present result is in agreement with the finding of (Mohammed *et al*, 2016) who reported that intercropping of Napier grass with lablab produce significantly higher TDMY and TCPY when compared to the sole Napier grass.

As shown in Table 7, significant effect (P<0.05) were observed on DMY of lablab and cowpea intercropped with Napier grass by three different spaces also significant effect

(P<0.05) observed on mean comparison were observed on CPY of lablab and cowpea intercropped with Napier grass by three different spaces. This is in line with Hassen *et al.* (2006) who reported that Lablab produced more forage DM both as a pure crop and as a simultaneously planted intercrop .

Table 6: Least square means and standard errors Herbage productivity yield for lablab and cowpea intercropped at different planting density

Legume types	Row spacing	Herbage productivity yield (tone/ha)	
		DMY	CPY
Lablab	1m x 0.5 m	3.64±0.29[b]	0.77±0.05[b]
	0.75 m x 0.5 m	3.86±0.39[b]	0.87±0.11[ab]
	0.5 m x 0.5 m	4.63±0.32[a]	0.98±0.05[a]
Cowpea	1m x 0.5 m	4.17±0.48[a]	0.89±0.08[ab]
	0.75 m x 0.5 m	4.63±0.21[a]	0.98±0.04[a]
	0.5 m x 0.5 m	3.59±0.37[b]	0.78±0.04[b]
Mean		4.09	0.88
P –value		0.033	0.039

[a, b]Means in a columns, values followed by different letters differ significantly (P < 0.05); CPY = Crude Protein Yield; DMY = Dry Matter Yield; ha = hectare; M = meter

4.4. Chemical Composition

Analysis of variance showed that there was a significant (P<0.05) effect of intercropping of lablab and cowpea with Napier grass at three different planting densities on Ash, organic matter (OM), crude protein (CP) and neutral detergent fiber (NDF) (Table 8).

Regarding the DM content, there was no significant (P >0.05) variation among the DM values of the sole Napier grass and intercropping with legumes. This can be attributed to the differences in soil related factors, climate and probably the physiological stage of the plant at harvest. Animut and Hailemariam (2014) reported that not observed different DM value when Sudan grass intercropping with lablab at different plant mixing proportion.

The ash content is the concentration of minerals in the forages. Forage with higher ash content indicates a high concentration of minerals. The ash content was highest (P<0.05) for Napier grass 1m × 0.5m space intercropped with lablab (T7) and was least for Napier grass with 0.5m × 0.5m space intercropped by cowpea (T3) and for Napier grass with 1m × 0.5m space intercropped cowpea (T4). The concentration of minerals in forage varies due to factors like plant developmental stage, morphological fractions, climatic conditions, soil characteristics and fertilization regime (McDowell and Valle, 2000; Jukenvicius and Sabiene, 2007). Animut and Hailemariam (2014) observed that sole Sudan grass planted without lablab and cowpea showed significant variation ($P < 0.05$) on the ash content of forage.

Analysis of variance showed there was significance different ($P<0.05$) on Napier grass intercropped with lablab and cowpea at three different planting densities on %OM content of Napier grass (Table 8). Organic matter (OM) is inversely related to Ash value and the lower Ash value content has higher OM content and vice versa. Among Napier grass intercropped with lablab and cowpea at three different planting densities the highest percent of OM was recorded from Napier grass intercropped with cowpea (T3) at 0.5m × 0.5m space (90.85±0.52%) followed by Napier grass intercropped with lablab (T5) at 0.5m × 0.5m space (90.03±037%) and Napier grass intercropped with cowpea (T4) with 1m × 0.5m space (90.01±0.07%) and the lowest value (88.98±0.46%) was obtained from Napier grass intercropped with lablab (T7) at 1m × 0.5m space.

Significant variation was observed ($P < 0.05$) in the CP content of Napier grass intercropping with cowpea and lablab of the treatments at different planting densities. The Napier grass intercropped with cowpea (T4) at 1m × 0.5m space had highest in the %CP content followed by Napier grass intercropped with lablab(T7) at 1m ×0.5m space while the sole Napier grass planted at 1m × 0.5m space (T1) has the lowest followed by sole Napier grass planted at 0.75m × 0.5m space (T6) of all. The difference in %CP content of the studied Napier grass might be due to atmospheric nitrogen fixation by the respective legumes intercropped. This result is in line with the findings of Bayble *et al.* (2007) who reported that Napier grass associations with lablab and desmodium resulted in higher ($P < 0.05$) CP content than sole Napier grass or when harvested forage at ninety days. The CP content of all treatments is above the minimum level of 7% required for optimum rumen function (Van Soest, 1994). The main advantages of legume-cereal mixtures have been increased CP yield relative to sole cereal crops (Demissie *et al*., 2017). Legumes supply nitrogen to grass-legume mixtures, so it may produce more forage yield than grasses grown alone and grasses grown in intercropping with legumes also contain a higher percentage of protein. Liu *et al.* (2006) concluded that crude protein of plants in intercropping system was increased when compared with those for mono-cropping maize.

The neutral detergent fiber (NDF) content of a feed is important for determining within the parameter of digestibility. Roughage diets with NDF content of 45-75% and below 45% were generally considered as medium and high quality feeds respectively (Singh and Oosting, 1992). Accordingly, the current results in NDF content lies in medium range signifying the good nutritional value of the forages of the current study. According to Van Soest (1982) reducing the contents of in NDF content has been associated with increasing digestibility and hence improve feed intake. The lower NDF content in Napier grass/legume associations as compared to Napier grass sole indicated improvement in nutritive value, since decrease in NDF content has been associated with increase in digestibility and hence feed intake (Van Soest, 1994). Legumes benefited Napier grass by fixing atmospheric nitrogen and therefore improving the CP content and reducing the fibers content of forages (Schwenke and Kerridge, 2000).

Table 7: Least square means and standard errors for Chemical composition of Napier grass

Ttrs	Chemical composition (%for DM basis and %DM for others)								
	DM	Ash	OM	CP	NDF	ADF	ADL	Hemi.	Cellu.
T1	94.07±0.11	10.30±0.06[ab]	89.71±0.06[bc]	12.22±0.5[c]	66.78±1.61[a]	43.50±1.94	9.24±0.40	23.28±0.37	34.26±1.53
T2	94.57±0.63	10.30±0.33[ab]	89.70±0.33[bc]	14.85±0.20[a]	63.20±0.51[b]	42.06±0.53	8.94±0.35	21.14±0.61	33.11±0.39
T3	94.23±0.22	9.15±0.52[c]	90.85±0.52[a]	14.19±0.26[ab]	63.39±1.35[b]	43.28±1.54	9.31±0.23	20.11±0.48	33.96±1.31
T4	93.97±0.16	9.99±0.07[bc]	90.01±0.07[ab]	15.34±0.28[a]	63.29±0.66[b]	41.93±0.36	8.79±0.65	21.36±0.56	33.14±0.89
T5	93.90±0.21	9.97±0.37[bc]	90.03±0.37[ab]	13.19±0.50[bc]	63.90±0.74[b]	40.86±0.41	8.60±0.16	23.04±1.09	32.26±0.57
T6	94.18±0.09	10.24±0.75[ab]	89.76±0.75[bc]	12.65±0.51[c]	64.63±0.44[ab]	43.17±0.98	8.82±0.37	21.47±1.42	34.35±0.64
T7	93.93±0.13	11.02±0.46[a]	88.98±0.46[c]	15.15±0.53[a]	63.37±0.53[b]	42.02±0.54	9.21±0.23	21.35±0.157	32.81±0.33
T8	93.90±0.09	10.430±0.11[ab]	89.57±0.11[bc]	14.31±0.35[ab]	63.46±0.81[b]	42.06±0.68	8.88±0.17	21.40±0.33	33.17±0.52
T9	94.23±0.06	10.50±0.37[ab]	89.50±0.37[bc]	13.28±0.69[bc]	63.57±0.30[b]	42.93±1.10	9.14±0.87	20.65±1.23	33.78±1.79
Mean	94.11	10.21	89.79	13.91	63.95	42.42	8.99	21.53	33.43
P-value	0.628	0.034	0.034	0.002	0.054	0.648	0.657	0.256	0.885

[a, b ,c] *Means in a columns, values followed by different letters differ significantly (P < 0.05); T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing, ADF = Acidic detergent fiber, ADL = Acidic detergent lignin, CP = Crude protein, DM= Dry matter, NDF=neutral detergent fiber, Trts=treatment*

Intercropping Napier grass with lablab and cowpea at different planting densities have a significant impact (P<0.05) on %NDF contents of the Napier grass. The least %NDF contents was recorded from Napier grass intercropping with cowpea and lablab compared to sole Napier grass planted with three different space. Among Napier grass planted sole and intercropped with legumes at different planting densities the highest value was recorded from Napier grass planted sole at 1m x0.5m space (T1) (66.78±1.61%) followed by Napier grass planted sole at 0.75m × 0.5m spaces (T6) (63.46±0.44%) while the rest treatments are statistically similar. This current result agreed with Njoka-Njiru *et al*. (2006b) who noted that intercropping of Napier grass with legumes has significant effect on NDF contents of the forage. Bayble *et al.* (2007) noted that intercropping Napier grass with legumes has an advantage in reducing NDF content of forage. However the current result was disagreed with the finding of Mohammeda *et al.*(2016) who noted that Spacing, intercropping and interaction of spacing with intercropping Napier grass with lablab has no significant effect on NDF contents of the forage. This difference is might be due to atmospheric nitrogen fixation by the respective legumes are improve nutritional values. Generally, the mean values of NDF (63.95%) obtained in the present study was lower than the mean NDF values of reported by Animut and Hailemariam (2014) around 70.36% . The variability in %NDF content might be attributed to varietal difference of the legumes mixed with the grass at two studies.

Intercropping legumes at different planting densities did not have a significant impact (P>0.05) on DM, ADF ADL, Hemicelluloses and cellulose contents of the forage. There was no significant variation observed (P > 0.05) in the ADF values in all treatments. This result is in line with the finding of Mohammed *et al* (2016) who noted that there is no significant effect (P > 0.05) of intercropping and spacing and their interactions on DM, ADF, ADL, and cellulose and hemicelluloses.

Njoka-Njiru *et al.,* (2006b) also reported that the level of fibers remained unaffected but only the ADF content was significantly more in sole Napier grass than Napier grass grown with legumes. Conversely, Bayble et al. (2007) noted that intercropping Napier grass with lablab resulted to significantly in reducing ADF content of forage at 90 days cutting stage but in that study both lablab and Napier grass were harvested together as a mixture.

The composition and content of cell walls are the key factors affecting herbage digestibility.

Napier grass intercropping with lablab and cowpea at different planting densities had no significant (P>0.05) effect on ADL. Ishiaku (2016) reported that ADL value of *Sorghum almum* were not affected significantly (P>0.05) when planted with different planting densities. However, the result of the current study was contrary with Tilahun *et al.* (2017) who reported that desho grass was affected by harvesting age and planting densities in the highlands of Ethiopia. However all the treatments consisted ADL value below 10% which limits DM intake (Reed *et al.*, 1988**).** Lignin is a component that gives strength and resistance to plant tissue thereby limiting the ability of rumen microorganisms to digest the cell wall polysaccharides.

Analysis of variance show that there was not significant (P>0.05) effect of Napier grass intercropped with lablab and cowpea at different planting densities on hemicelluloses. However, the highest hemicelluloses content (23.28±0.37%) was recorded from sole Napier grass at 1m × 0.5m space (T1) followed by Napier grass intercropped with lablab (T5) at 0.5m × 0.5m space (23.04±1.09%) whereas the lowest (20.11±0.48%) was recorded from Napier grass intercropped with lablab (T3) with 0.5m × 0.5m space followed by Napier grass at 0.5m × 0.5m planting space without intercropped (T9) (20.65±65) but statistically similar with the rest of treatments. This result is in line with Mohammed *et al*.(2016) who reported that no significant effect (P>0.05) of intercropping and spacing and their interactions on hemicelluloses and cellulose. Contrarily, the result was disagrees with Demissie *et al.* (2017) who reported that significant effect (P<0.05) observed when Mixed Pure Stands of Oats and Vetch by different plant population on hemicelluloses contents oats forage. Such variation might be associated with environmental factors. The higher hemicelluloses content in the feed limits forage intake and digestibility (Lundvall *et al.,* 1994).

The cellulose content of Napier grass did not show significant (P > 0.05) difference on the Napier grass intercropping with legumes and planted alone at three different planting densities. However, numerically the highest celluloses content (34.35±0.64%) was recorded from sole Napier grass at 0.75m × 0.5mplanting space without intercropped (T6) followed sole Napier grass at 1m x0.5m space without intercropped (T1) (34.26±1.53) whereas the lowest (33.11±0.39%) was recorded from plants Napier grass intercropped with lablab (T2) at 0.75m × 0.5m space with a mean of (33.11%). This result was contrarily with Demissie *et al.* (2017) who reported that Mixed and Pure Stands of Oats and Vetch significantly affected (P<0.05) of the cellulose contents oats forage. This difference might be due to harvest time, different ecological conditions and varietal materials different.

4.5. *In vitro* Digestibility

4.5.1. *In Vitro* dry matter digestibility

Napier grass at different planting densities intercropped with lablab and cowpea had significant effect (P<0.05) on the *in vitro* dry matter digestibility (IVDMD) (Table 9). Napier grass intercropped with lablab (T7) and cowpea (T4) at spacing of 1m × 0.5m has highest IVDMD with the mean result of (64.85±1.99%) and (66.92±0.66%) value respectively while other mean comparison were not significant (P>0.05). On the other hand, sole Napier grass planted at plant spacing of 0.5m × 0.5m (T9) has the lowest value of the IVDMD and generally IVDMD increased with wider spaces of Napier grass in the sole and intercropped at three different planting densities. The result noted by Bayble *et al.* (2007) for IVDMD of Napier grass at spacing of 1m x 0.5m intercropped with lablab harvested at 90 days was (68%) and it was higher than the mean result (64.85±1.99%) for Napier grass at 1m × 0.5m space intercropped with lablab of the present finding. Such variation could be associated with various factors like rain, humidity, light and temperature, soil fertility, and other management practices have very profound influence on IVDMD of Napier grass (Assefa and Ledin, 2001).

The nutritive value of forages like voluntary feed intake, crude protein and structural carbohydrates and the digestibility of the grass could be improved when inclusion of associated legume with grass (Demissie *et al.,* 2017). Grass associated with legume inclusion might increase feed intake as the IVDMD and feed intake are positively correlated (Van Soest, 1994). The IVDMD value of Napier grass with different spaces intercropping by lablab and cowpea of the current study was fit the digestibility of tropical grasses which lies between 50 to 60% (Owen and Jayasuriya, 1989).

Table.8: Least square means and standard errors for *In vitro* dry matter (IVDMD), organic matter digestibility (IVOMD) and ME content of Napier grass

Treatments	IVDMD & IVOMD percentage values (%)		
	IVDMD (%)	IVOMD (%)	ME (MJ/ kg)
T1	55.75±1.74^{b}	56.86±2.29^{cd}	8.53±0.34^{cd}
T2	57.64±1.06^{b}	58.20±1.58^{bcd}	8.73±0.23^{bcd}
T3	55.82±1.17^{b}	62.22±0.82^{ab}	9.33±0.12$^{a\ b}$
T4	66.92±0.66^{a}	60.70±1.28^{abc}	9.33±0.19^{ab}
T5	54.26±2.01^{b}	60.39±0.58^{abcd}	9.06±0.08^{abcd}
T6	53.99±0.90^{b}	57.69±1.66^{cd}	8.65±0.25^{cd}
T7	64.85±1.99^{a}	63.73±0.98^{a}	9.56±0.14^{a}
T8	56.77±1.54^{b}	56.35±2.16^{de}	8.45±0.32^{de}
T9	53.03±1.87^{b}	52.58±0.65^{e}	7.88±0.09^{e}
Mean	57.67	58.75	8.81
P –value	<.0001	0.0012	0.0012

$^{a, b, c, d, e}$ Means in a columns, values followed by different letters differ significantly (P < 0.05); T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing, IVDMD = In vitro Dry Matter Digestibility, IVOMD = In vitro Organic Matter Digestibility, kg = kilo gram, ME = Metabolizable Energy, MJ = Mega Joule

4.5.2. *In vitro* organic matter digestibility

The effect of intercropping of Napier grass with lablab and cowpea at different plating densities on IVOMD was significant (P < 0.05). This is in line with the finding of (Mohammed *et al*, 2016) who noted that Napier grass intercropped with lablab with different spaces or planting densities was significantly (P < 0.05) higher values of IVOMD than sole Napier grass. Mixing of Napier grass with lablab and cowpea improved the IVOMD of the Napier grass indicating that the feeding value of Napier grass can be enhanced in terms of nutrient content and digestibility. The IVOMD values of all the treatments were above the critical threshold level of 50% required for feeds to be considered as having acceptable digestibility (Owen and Jayasuriya, 1989).

The forages below this level of IVOMD content may result in reduced feed intake due to lower nutrient content and digestibility. The highest IVOMD value (63.73%±0.98) was recorded from Napier grass intercropping with lablab (T7) at 1 m × 0.5 m space and the lowest value (52.58±0.65%) was recorded from sole Napier grass planted at 0.5m × 0.5m space without intercropped with legumes (T9) which was lower than the 67.96% noted by (Bayble *et al.,* 2007) at ninety days of harvesting. Such variation might be due to a number of factors likes, climate, season, weather, soil type and fertility, soil moisture, physiological and morphological characteristics and these factors may vary with annuals versus perennials, grasses versus legumes, etc. (Kilcher, 1981). Those factors bring rate of change in nutrient composition and digestibility with advancing plant development and maturity stages. Generally, increased with wider spaces of Napier grass in the sole and in intercropped.

4.5.3. Metabolizable energy

Since the ME was calculated from IVOMD values in this study, the ME content took a similar trend like that of IVOMD, and generally increased with increasing proportion of legumes in the mixture. Metabolizable energy of all treatments were above the critical threshold level of 7.5 (MJ kg^{-1} DM) for roughages and forages as noted by Owen and Jayasuriya (1989).

4.6. *In sacco* Digestibility

4.6.1. *In Sacco* DM disappearances and rumen degradability characteristics

Analysis of variance show that there was a significant effect ($P<0.05$) of Napier grass intercropping with lablab and cowpea at different planting densities on the *in sacco* dry matter disappearances (INDMD) of Napier grass at 12 and 72 hours of incubation time (Table 10). Across all incubation periods (Table.10) there was the trend in variation of the incubation hours between Napier grass intercropped with two legumes and Napier grass planted alone at different planting densities. Napier grass intercropped with lablab at 1m x 0.5m spaces (T7) had higher disappeared percent value when compared with Napier grass grown alone at the same space (T6) and similar trend Napier grass intercropped with lablab at 0.5m × 0.5 m (T5) was quick degraded than Napier grass grown alone at the same space (T9) at 12, 96 and 48 hours of incubation respectively. Napier grass intercropped with lablab with 0.75m × 0.5 m (T2) was quick disappeared than Napier grass grown alone with the same space (T6) at 48 hours of incubation. This was in agreement with (Mohammed *et al*, 2016) who noted that Interaction of intercropping and spacing has a significant effect on *in sacco* DM disappearance at 12 and 48 hours of incubation times (P<0.05). Generally a DM disappearance was higher in Napier grass intercropped with lablab than alone.

Napier grass intercropping with cowpea (i.e. T3, T4 and T8) at three different planting densities were disappearance more than Napier grass grown alone at the same planting densities (i.e. T1, T6 and T9) at 72 hours of incubation. I*n sacco* DM recorded at 48 hours incubation period was highest in Napier grass intercropping with lablab and cowpea and the lowest value was recorded in Napier grass planted alone at three planting densities because 48 hours of incubation time is considered as good measurement of *in sacco* DM disappearance in the animal digestive system. Generally, from 12 to 96 hours of incubation, the *in sacco* DM disappearance also increases. This is similar to the result reported by (Klopfenstein *et al.*, 2001a) who reported that *in sacco* DM disappearance increase with time incubation hours.

In general, effect of intercropping lablab and cowpea at different plants densities was significant for DM disappearances across the incubation hour for 12 and 72 incubation hours. The greatest DM disappearance at 12-hour incubation was recorded in Napier grass intercropped with cowpea (T4) at 1m x0.5m space (40.00±1.64%) followed by Napier grass intercropped with lablab (T5) at 0.5m x 0.5m space (38.09±1.75) and Napier grass intercropped with lablab (T7) at 1m x 0.5m space (38.36±0.84%) whereas the lowest DM disappearance at 12-hour incubation was recorded from Napier grass at 0.75m x0.5m space without intercropped (T6) (32.37±1.80%) followed by Napier grass 1m x 0.5m space without intercropped (T1) (33.41±0.72%) and Napier grass with 0.5m x 0.5m space without intercropped (T9) (36.30±1.77%). Napier grass intercropped with lablab (T7) at 1m x 0.5m space was also the greatest DM disappearances at 72 and 96 h incubation in contrast to the rest of the treatments (P < 0.05).

Table 9: Least square means and standard errors for *In sacco* DM disappearances of Napier grass

Treatments	*In sacco* DM disappearances (%) at Rumen incubation time (hr)					
	6	12	24	48	72	96
T1	21.68±1.17	33.41±0.72[bc]	43.08±4.63	66.77±2.35	72.02±0.14[bcd]	82.77±0.47
T2	23.22±0.67	37.23±1.84[ab]	45.27±2.50	71.60±0.58	73.84±0.68[abc]	83.74±0.50
T3	23.50±1.10	37.87±0.47[ab]	43.34±0.26	68.16±2.43	71.68±0.71[cd]	85.04±1.17
T4	21.11±1.07	40.00±1.64[a]	43.93±0.74	70.87±1.78	72.96±0.86[abc]	84.40±0.90
T5	21.47±0.89	38.09±1.75[a]	45.35±0.61	72.03±1.57	72.30±1.25[bcd]	83.50±0.92
T6	20.98±0.66	32.37±1.80[c]	42.94±0.66	67.73±0.45	70.40±1.17[d]	81.81±0.44
T7	23.80±0.24	38.36±0.84[a]	46.13±1.07	70.61±0.71	74.88±1.066[a]	85.28±1.28
T8	22.99±1.58	36.50±1.77[abc]	44.42±0.70	69.05±1.02	74.16±1.28[ab]	84.26±0.24
T9	21.70±1.18	36.30±0.82[abc]	42.81±0.23	66.84±1.43	70.57±1.07[d]	82.82±1.38
Mean	22.27	36.68	44.14	69.29	72.54	83.74
P- value	0.387	0.051	0.855	0.144	0.005	0.160

[a, b c d] means in a columns, values followed by different letters differ significantly ($P < 0.05$), hr = hour; DM = dry matter, T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing

Yet at a 48-hours incubation, the Napier grass intercropped with lablab (T5) at 0.5m x 0.5m space had the greatest DM disappearances (72.03±1.57%) followed by Napier grass intercropped with lablab (T2) at 0.75x0.5m space (71.60±0.58%) and the least value of DM disappearances Napier grass at 1m x0.5m spaces without intercropped (T1) (66.77±2.35%) and napier grass at 0.5m x0.5m space planted without intercropped (T9) (66.84±1.43%).

Generally, the highest *in sacco* DMD was recorded at 96 hours incubation period and the lowest value was obtained at 6 hours incubation period in all treatments in the present study. This is similar to the result reported by Klopfenstein *et al.* (2001b) indicated that the period of incubation period increases from 0 to 96 hours in the rumen, the *in sacco* DM degradability also increases.

Analysis of variance showed that there was a significant effect ($P<0.05$) of Napier grass intercropped with lablab and cowpea at different planting densities on the Rumen DM disappearances characteristics of Napier grass at k= 0.03 per hour of rumen fractional outflow rates for all treatments except for the slowly degradable fraction and rate of degradation(*c*) (Table .11). The greatest washing loss (*a)* of Napier grass was recorded in Napier grass intercropped with cowpea and lablab (T4 and T7) at 1m × 0.5m space while the least value recorded was in the Napier grass planted at 1m × 0.5m space without intercropped (T1). For potential degradability(PD) the highest value was recorded in Napier grass intercropped with lablab (T7) at 1m × 0.5m space while in the Napier grass planted with 0.5m × 0.5m space without intercropped (T9) recorded the least value ($P < 0.05$).

The highest effective degradability (*ED*) value was recorded in Napier grass intercropped with lablab (T7) at 1m × 0.5m space followed Napier grass intercropped with cowpea (T4) at 1m × 0.5m space and the least value was recorded in Napier grass planted at 0.75m × 0.5m space without legumes intercropped(T6). Generally, Napier grass intercropping with lablab has higher Rumen DM degradability characteristics when compared with Napier grass planted alone at different planting densities. This was in agreement with (Njoka-Njiru *et al.,* 2006a) who noted that washing loss and effective degradability was significantly higher in the intercropped Napier grass than the sole Napier grass. Napier grass intercropping with cowpea at three different planting densities was higher than Napier grass grown alone with the same space by rapid soluble fractions (wash losing).

Table 10: Least square means and standard errors for *In sacco* dry matter rumen degradability characteristics

Trts	Rumen Degradability Characteristics				
	a	*b*	PD (*a* + *b*)	*c*	ED (kp= 0.03)
T1	7.09±0.93^{f}	77.66±3.93	84.75±4.75^{ab}	0.0343±0.007	47.23±1.88^{bcd}
T2	10.56±0.31^{cd}	75.86±1.63	86.42±1.90^{ab}	0.0303±0.002	48.45±0.72^{ab}
T3	12.88±0.82^{b}	76.96±2.34	89.85±2.71^{ab}	0.0247±0.002	47.39±0.34^{abcd}
T4	14.42±0.23^{a}	75.23±1.49	89.64±1.31^{ab}	0.0251±0.001	48.57±0.91^{ab}
T5	11.26±0.44^{c}	74.94±1.01	86.20±0.56^{ab}	0.0290±0.000	48.07±0.56^{abc}
T6	8.59±0.41^{de}	76.43±1.69	85.03±1.29^{ab}	0.0277±0.001	45.26±0.44^{d}
T7	15.29±0.10^{a}	76.10±3.29	91.39±3.39^{a}	0.0248±0.002	49.42±0.22^{a}
T8	9.75±0.70^{de}	77.36±1.43	87.11±0.84^{ab}	0.0286±0.000	47.51±0.02^{abcd}
T9	8.36±0.16^{ef}	75.66±0.71	84.03±0.58^{b}	0.0294±0.001	45.85±0.56^{cd}
Mean	10.92	76.25	87.16	0.02824	47.50
P-value	<.0001	0.989	0.036	0.404	0.032

$^{a, b c d e f}$ *Means in a columns, values followed by different letters differ significantly (P < 0.05), a= washing loss (rapidly soluble fraction), b = slowly degradable fraction, c = the rate of degradation, ED = Effective Degradability, PD = Potential Degradability, T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacingTrts=treatment*

4.6.2. *In sacco* OM disappearances and rumen degradability characteristics

Analysis of variance showed that there was a significant effect (P<0.05) of Napier grass intercropping with lablab and cowpea at different planting densities on *in sacco* organic matter disappearances (OMD) at 6, 48 and 96 hours of incubation time but No significant differences (P>0.05) were observed at rest hours of incubation time (Table.12).

Napier grass intercropped with lablab at 0.75m × 0.5m spaces (T2) had the greatest OM disappearances when compare with Napier grass grown alone planted with the same space (T6) at 6 hours of incubation and Napier grass intercropped with lablab at 0.5m × 0.5 m (T5), Napier grass intercropped with lablab with 1m × 0.5 m (T7) were similar OM disappearances value with Napier grass grown planted alone with the same space (T9) and (T1) at 6 hours of incubation.

Napier grass intercropped with lablab at different planting densities has no difference disappearance percent value than Napier grass grown alone with the same space at 48 hours of incubation. This result disagree with Mohammed *et al.* (2016) who noted that interaction of intercropping and spacing has a significant effect on *in sacco* OM degradability at 48 hours of incubation times ($P<0.05$). Nevertheless, improvement in the *in sacco* OM disappearances of Napier grass with three different spaces intercropped with lablab had higher Napier grass planted without intercropped was observed.

Napier grass intercropping with cowpea (T3) at 0.5m x0.5m space had higher degraded than Napier grass grown alone with the same space at 96 hours of incubation while decrease in the rest incubation hours. Napier grass intercropping with cowpea (T4) at 1m × 0.5m space had the higher disappearance percent than Napier grass grown alone with the same space at 96 hours of incubation 6 and 96 hours of incubation. Napier grass intercropping with cowpea (T8) at 0.75m × 0.5m space had the highest degradability than at 48hrs and no difference has been observed the in the rest treatments. This was in agreement with (Njoka-Njiru *et al.*, 2006a) who noted that OM disappearance at 48 hours of incubation was significantly higher for intercropped Napier grass than sole Napier grass. Generally, the extent of digestion of Napier grass when intercropped with lablab and cowpea at three planting densities than for sole Napier grass.

Table 11: Least square means and standard errors for *In sacco OM* disappearances for Napier grass

Trts	*In sacco* OM disappearances (%) at Rumen incubation time (hr)					
	6	12	24	48	72	96
T1	21.24±0.67[bcd]	32.18±1.09[a]	41.79±1.64	68.30±2.08[ab]	74.21±1.32	76.00±0.3[d]
T2	23.74±0.58[a]	29.53±1.29[ab]	42.61±1.54	69.03±1.22[ab]	73.65±2.46	78.98±0.9[aBc]
T3	22.74±0.56[ab]	28.19±0.68[b]	37.93±0.18	67.77±1.31[ab]	76.46±0.85	79.36±0.42[ab]
T4	23.65±1.18[a]	29.64±0.80[ab]	40.41±2.44	70.45±2.76[ab]	74.91±0.11	80.07±0.18[a]
T5	22.39±0.17[abc]	29.09±1.98[b]	41.46±2.58	71.51±0.42[ab]	74.49±0.89	80.23±0.95[a]
T6	20.25±0.12[d]	30.41±0.82[ab]	39.79±1.04	68.93±0.92[ab]	73.97±1.39	77.36±0.80[bcd]
T7	20.41±0.17[cd]	28.48±1.59[b]	43.83±1.42	70.23±1.05[ab]	76.28±0.67	79.80±1.42[ab]
T8	21.35±1.17[bcd]	30.71±1.70[ab]	42.28±0.84	72.18±0.21[a]	73.49±3.04	78.27±0.39[abcd]
T9	22.11±0.46[abc]	30.67±1.68[ab]	40.38±1.11	67.39±1.59[b]	73.66±0.98	76.79±0.84[cd]
Mean	21.98	29.88	41.16	69.53	74.59	78.54
P –value	0.016	0.151	0.284	0.044	0.804	0.016

[a, b] *Means in a columns, values followed by different letters differ significantly (P < 0.05), hr = hour, OM = organic matter, T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing, Trts=treatments*

The Rumen degradability characteristics of treatments studied were presented in Table 13. Accordingly intercropping of lablab and cow pea had a significant effect for all Parameters (P<0.05) except Effective degradability (P>0.05) and Napier grass intercropping with cowpea (T3) at 0.5m × 0.5m space has the highest washing loss (rapidly soluble fraction), insoluble but slowly degradation fraction and potential degradability, but has the lowest rate of degradation. It reflected that these treatments have highly degraded materials as energy source and high degraded protein source in the rumen. However, the Lowest value recorded for slowly degradable fraction (*b*) and potential degradability (*a* + *b*) in the Napier grass at 1m × 0.5m space without intercropped (T1). Moreover, the Effective degradability of each treatment was not significantly (p>0.05).

Table 12: Least square means and standard errors for *In sacco* Organic matter rumen degradability characteristics

	Rumen degradability characteristics				
Trts	*a*	*b*	PD (*a* + *b*)	*C*	ED (kp= 0.03)
T1	12.69±0.08^{ab}	71.81±0.14^{d}	84.50±0.18^{d}	0.0257±0.001^{a}	45.85±0.86
T2	13.78±1.54^{a}	75.14±1.68^{bcd}	88.92±1.46^{bcd}	0.0229±0.002^{ab}	46.27±0.67
T3	13.95±0.49^{a}	83.21±1.55^{a}	97.15±1.89^{a}	0.0182±0.001^{b}	45.23±0.38
T4	13.17±0.64^{ab}	79.34±3.93^{ab}	92.50±3.72^{ab}	0.0220±0.002^{ab}	46.25±1.21
T5	12.36±0.40^{ab}	78.51±3.52^{abc}	90.86±3.61^{bc}	0.0233±0.002^{a}	46.32±0.35
T6	12.01±0.56^{ab}	75.63±0.92^{bcd}	87.63±0.40^{bcd}	0.0234±0.000^{a}	45.14±0.16
T7	11.53±0.38^{b}	78.39±1.148^{abc}	89.92±1.52^{bcd}	0.0241±0.001^{a}	46.37±0.16
T8	11.28±0.42^{b}	75.22±0.11^{bcd}	86.505±0.53^{cd}	0.0261±0.000^{a}	46.25±0.81
T9	13.89±0.41^{a}	73.86±0.76^{d}	87.75±0.55^{bcd}	0.0224±0.001^{ab}	45.37±0.98
Mean	12.74	76.79	89.53	0.0231	45.89
P-value	0.050	0.014	0.009	0.0310	0.865

[a, b c d] Means in a columns, values followed by different letters differ significantly (P < 0.05), a= washing loss (rapidly soluble fraction), b =slowly degradable fraction; c = the rate of degradation, DMD = Dry Matter Degradability; ED = Effective Degradability; PD = Potential Degradability, T1= Pure Napier grass at 1m row spacing, T2= Napier grass intercropped with lablab at 0.75m row spacing, T3= Napier grass intercropped with cowpea at 0.5m row spacing, T4= Napier grass intercropped with cowpea at 1m row spacing, T5= Napier grass intercropped with lablab at 0.5m row spacing, T6= Pure Napier grass at 0.75m row spacing, T7= Napier grass intercropped with lablab at 1m row spacing, T8= Napier grass intercropped with cowpea at 0.75m row spacing, T9= Pure Napier grass at 0.5m row spacing, Trts=treatment

5. CONCLUSION

Intercropping of lablab and cowpea with Napier grass at different planting densities at Haro sabu Agricultural research center in western Ethiopia has revealed that to produce high quantity of livestock feed with higher nutritional quality and improvement of soil fertility structure when incorporating a legume with fodder grass production system. The results further indicated that there were improvements of soil chemical properties after forage harvested when compared with initial soil sample taken before forage planting and through production system soil improvement was observed. Intercropping increased the PH Value but did not affect the available phosphorous content of the soil before and after forage harvested. Also increase total nitrogen and organic carbon of the soil among the soil parameters.

Intercropping of Napier grass with lablab and cowpea at different planting densities has significant effect ($P<0.05$) on number of tiller per plant (NTPP), leaf length (LL) and total numbers of leaves per plant (TNLPP) of Napier grass but for plant height (PH) and number of leaves per tiller (NLPT) were not significant effect ($p>0.05$) by Napier grass intercropping with lablab and cowpea at different planting densities.

Napier grass intercropping with legumes at different planting densities resulted to higher dry matter yield (DMY), total dry matter yield (TDMY) and total crude protein yield (TCPY). Napier grass intercropping with lablab and cowpea at different planting densities had no significantly different ($P>0.05$) on crude protein yield (CPY) of the Napier grass. Significant effect ($P<0.05$) were observed on DMY of lablab and cowpea intercropped with Napier grass at different planting densities and on CPY of lablab and cowpea intercropped with Napier grass by three different spaces.

Significant variation was observed among sole and intercropped Napier grass with lablab and cowpea at different planting densities on the on Ash, Organic matter (OM), crude protein (CP), neutral detergent fiber (NDF) and no significant variation on dry matter (DM), acid detergent fiber (ADF), acid detergent lignin (ADL), Hemicelluloses and cellulose contents of the Napier grass ($P>0.05$). However, intercropping of Napier grass with lablab and cowpea at different planting densities increased the OM and CP contents ($P<0.05$) of the Napier grass.

Intercropping of legumes increased the *in vitro* dry matter digestibility (IVDMD) and in vitro organic matter digestibility (IVOMD) of Napier grass than sole cropping system. Napier grass intercropped with lablab and cowpea at different planting densities had significant effect ($P<0.05$) on the in vitro dry and organic matter digestibility (IVDMD, IVOMD) and increased digestibility. *In sacco* dry matter disappearances (DMD) and *in sacco* organic matter degradability (OMD) of Napier grass for many of the incubation hours was relatively higher for the Napier grass intercropping with lablab and cowpea at a planting density of 24 plants m^{-2} (T7 and T4) respectively.

6. RECOMMENDATION

From the present study, legumes improved the overall total herbage yield and nutritive value of fodder grasses than sole one. Accordingly, Napier grass intercropped with lablab and cowpea at a planting density of 24 plants m^{-2} could be a better choice based on forage quantity and quality for the first three months stage of harvest. Therefore to strengthen this research it is advisable to do on animal performance trial based on animal feeding practice and it is economic feasibility and as well as the next stage of re-harvesting Napier grass with possible way of intercropping legumes once the Napier grass established order to come up with sound recommendations.

.

.

7. REFERENCES

Abdallah, O., Hamza, N. B. & Dagash, Y. 2015. Agronomic and molecular evaluation of six lablab bean (Lablab purpureus L.) cultivars. *Internat J Sci Res Agric Sci,* 2**,** 7-15.

Abebe, M. 2007. Nature and management of acid soils in Ethiopia. Haramaya University, Ethiopia.

Adebisi, A. & Bosch, C. 2004. Lablab purpureus (L) Sweet, Prota 2: Vegetables/Légumes. *Wageningen, Netherlands*.

Alalade, J., Akingbade, A., Akinlade, J., Akanbi, W., Gbadamosi, J., Okeniyi, G., Ajibade, A. & Akanji, K. 2014. Herbage Yield And Nutritive Quality Of Panicum Maximum Intercropped With Different Legumes. *Int. J. of Sci., Environment and Technol,* 3**,** 224-232.

Albayrak, S., Güler, M. & Töngel, M. Ö. 2004. Effects of seed rates on forage production and hay quality of vetch-triticale mixtures. *Asian Journal of Plant Sciences,* 3**,** 752-756.

Albayrak, S. & Türk, M. 2013. Changes in the forage yield and quality of legume–grass mixtures throughout a vegetation period. *Turkish Journal of Agriculture and Forestry,* 37**,** 139-147.

Alemayehu, M. 1998. Natural pasture improvement study around smallholder dairy areas. *MoA Small Dairy Development Project (SDDP), Addis Ababa, Ethiopia*.

Amel, B., Sihem, T., Mohamed, O. S. & Abdelkader, B. 2014. Effects of inoculation by bradyrhizobium japonicum strains on nodulation, nitrogen fixation, and yield of lablab purpureus in Algeria. *Türk Tarım ve Doğa Bilimleri,* 7**,** 1870-1876.

Animut, G. & Hailemariam, F. B. 2014. Agronomic Practices, Yield, Chemical Composition And In Vitro Dry Matter Digestibility of Sudangrass Sorghum Sudanese L Mixed With Lablab (Lablab Purpureus L And Cowpea (Vigna Unguiculata L.) At Babile Eastern Ethiopia. MSc thesis, Haramaya University. Haramaya, Ethiopia.

Ansah, T., Osafo, E. & Hansen, H. H. 2010. Herbage yield and chemical composition of four varieties of Napier (Pennisetum purpureum) grass harvested at three different days after planting. *Agricultural and Biology Journal of North America, 5, 923-929*

Arturi, M. J., Aulicino, M. B., Ansín, O., Gallinger, G. & Signorio, R. 2012. Combining Ability in Mixtures of Prairie Grass and Clovers. *American Journal of Plant Sciences,* 3**,** 1355.

Assefa, G. & Ledin, I. 2001. Effect of variety, soil type and fertiliser on the establishment, growth, forage yield, quality and voluntary intake by cattle of oats and vetches cultivated in pure stands and mixtures. *Animal Feed Science and Technology,* 92**,** 95-111.

Association, E. E. 2000. *Annual report on the Ethiopian economy*, The Association.

Bayble, T., Melaku, S. & Prasad, N. 2007. Effects of cutting dates on nutritive value of Napier (Pennisetum purpureum) grass planted sole and in association with Desmodium (Desmodium intortum) or Lablab (Lablab purpureus). *Livestock Research for Rural Development,* 19**,** 120-136.

Bediye, S., Sileshi, Z., Tadese, T. T. & Ayalew, L. 1998. Evaluation of napier (Pennisetum purpureum) and pennisetum hybrids (Pennisetum purpureum x Pennisetum typhoides) in the central highlands of Ethiopia. *Ethiopian Journal of Animal Production,* 194-202.

Belaynesh, D. 2006. Floristic composition and diversity of the vegetation, soil seed bank flora and condition of the rangelands of the Jijiga Zone, Somali Regional State, Ethiopia. *An MSc Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia. 144p.*

Berdahl, J. D., Karn, J. F. & Hendrickson, J. R. 2001. Dry matter yields of cool-season grass monocultures and grass–alfalfa binary mixtures. *Agronomy Journal,* 93**,** 463-467.

Bogale, S., Melaku, S. & Yami, A. 2008. Influence of rainfall pattern on grass/legume composition and nutritive value of natural pasture in Bale Highlands of Ethiopia. *Livestock Research for Rural Development,* 20**,** 2008.

Bogdan, A. 1977. *Tropical pasture and fodder plants*, Longman. United Kingdom.

Canfield, D. E., Glazer, A. N. & Falkowski, P. G. 2010. The evolution and future of Earth's nitrogen cycle. *Science,* 330**,** 192-196.

Carlsson, G. & Huss-Danell, K. 2003. Nitrogen fixation in perennial forage legumes in the field. *Plant and soil,* 253**,** 353-372.

Casler, M. 1998. Genetic variation within eight populations of perennial forage grasses. *Plant breeding,* 117**,** 243-249.

Chalchissa, G., Mekasha, Y. & Urge, M. 2014. Feed resources quality and feeding practices in urban and peri-urban dairy production of southern Ethiopia. *Tropical and Subtropical Agroecosystems,* 17.

Chen, X. 1995. Neway Excel, an Excel application program for processing feed degradability data. International Feed Resources Unit. Rowet research institute. Aberdeen.United Kingdom.

Cleveland, C. C., Townsend, A. R., Schimel, D. S., Fisher, H., Howarth, R. W., Hedin, L. O., Perakis, S. S., Latty, E. F., Von Fischer, J. C. & Elseroad, A. 1999. Global patterns of terrestrial biological nitrogen (N2) fixation in natural ecosystems. *Global biogeochemical cycles,* 13**,** 623-645.

Creamer, N. G. & Baldwin, K. R. 2000. An evaluation of summer cover crops for use in vegetable production systems in North Carolina. *HortScience,* 35**,** 600-603.

CSA 2017. Agricultural sample survey of 2016-2017. Report on livestock and livestock characteristics, Vol. II .Statistical Bulletin No. 505. Addis Ababa, Ethiopia.

Dadson, R. B., Hashem, F., Javaid, I., Joshi, J., Allen, A. & Devine, T. 2005. Effect of water stress on the yield of cowpea (Vigna unguiculata L. Walp.) genotypes in the Delmarva region of the United States. *Journal of Agronomy and Crop Science,* 191**,** 210-217.

Dakora, F. D., Aboyinga, R. A., Mahama, Y. & Apaseku, J. 1987. Assessment of N 2 fixation in groundnut (Arachis hypogaea L.) and cowpea (Vigna unguiculata L. Walp) and their relative N contribution to a succeeding maize crop in Northern Ghana. *World Journal of Microbiology and Biotechnology,* 3**,** 389-399.

Demissie Negash , G. A., Mengistu Urgie And Solomon Mengistu 2017. Chemical Composition and Nutritive Value of Oats (*Avena Sativa*) Grown in Mixture with Vetch (Vicia Villosa) With or Without Phosphorus Fertilization in East shoa Zone, Ethiopia. *Academic Research Journal of Agricultural Science and Research,* 5**,** 471-479

Duguma, B., Kechero, Y. & Janssens, G. 2011. Analysis of constraints facing urban dairy farmers and gender responsibility in animal management in Jimma town. *African Journal of Basic and Applied Sciences,* 3**,** 313-318.

Ehlers, J. & Hall, A. 1997. Cowpea (Vigna unguiculata L. Walp.). *Field Crops Research,* 53**,** 187-204.

Elowad, H. O., Hall, A. E. & Jarrell, W. M. 1987. Comparisons of ureide and acetylene reduction methods for estimating biological nitrogen fixation by glasshouse-grown cowpea. *Field Crops Research,* 15**,** 215-227.

Engineering, I. C. O. A. & Kitani, O. 1999. *CIGR Handbook of Agricultural Engineering: Energy and Biomass Engineering/Vol. Ed.: Osamu Kitani*, American Society of Agricultural Engineers.

FAO, I. WFP (2015) The state of food insecurity in the world. Meeting the, 2015.

FAO, I. & ISRIC, I. 2012. JRC: Harmonized World Soil Database (version 1.2). *FAO, Rome, Italy and IIASA, Laxenburg, Austria*.

Farrell, G., Simons, S. & Hillocks, R. 2002. Pests, diseases and weeds of Napier grass, Pennisetum purpureum: a review. *International Journal of Pest Management,* 48**,** 39-48.

Fery, R. L. 1990. The cowpea: production, utilization, and research in the United States. *Horticultural Reviews, Volume 12*, 197-222.

Fotso, M., Azanza, J.-L., Pasquet, R. & Raymond, J. 1994. Molecular heterogeneity of cowpea (Vigna unguiculata Fabaceae) seed storage proteins. *Plant Systematics and Evolution,* 191**,** 39-56.

Fuller, D. Q. 2003. African crops in prehistoric South Asia: a critical review. Heinrich-Barth-Institut.

Galloway, J. N. 1998. The global nitrogen cycle: changes and consequences. *Environmental pollution,* 102**,** 15-24.

Galloway, J. N., Townsend, A. R., Erisman, J. W., Bekunda, M., Cai, Z., Freney, J. R., Martinelli, L. A., Seitzinger, S. P. & Sutton, M. A. 2008. Transformation of the nitrogen cycle: recent trends, questions, and potential solutions. *Science,* 320**,** 889-892.

Geleti, D., Baars, R. & Kurtu, M. 2003. Variations in dry matter yield and nutritive value of Panicum coloratum and Stylosanthes guianensis mixed pasture as influenced by harvesting cycles. *Challenges and Opportunities of Livestock Marketing in Ethiopia***,** 311.

Geleti, D., Hailemariam, M., Mengistu, A. & Tolera, A. 2014. Biomass yield potential and nutritive value of selected alfalfa (*Medicago sativa L.*) cultivars grown under tepid to cool sub-moist agro-ecology of Ethiopia. *Journal of Agricultural Research and Development,* 4**,** 7-14.

Gizaw, S. 2010. *Sheep and goat production and marketing systems in Ethiopia: Characteristics and strategies for improvement*, ILRI (aka ILCA and ILRAD).

Grossman, J. & Quarles, W. 1993. Strip intercropping for biological control. *The IPM practitioner (USA)*.

Gwayumba, W., Christensen, D., Mckinnon, J. & Yu, P. 2002. Dry matter intake, digestibility and milk yield by Friesian cows fed two Napier grass varieties. *ASIAN Australasian Journal Of Animal Sciences,* 15**,** 516-521.

Habte, T.-Y. 2000. Livestock feed security and associated impact on sustainable agriculture development.

Haile, A. 2011. *Breeding strategy to improve Ethiopian Boran cattle for meat and milk production*, ILRI (aka ILCA and ILRAD).

Hall, A. E., Cisse, N., Thiaw, S., Elawad, H. O., Ehlers, J. D., Ismail, A. M., Fery, R. L., Roberts, P. A., Kitch, L. W. & Murdock, L. L. 2003. Development of cowpea cultivars and germplasm by the Bean/Cowpea CRSP. *Field Crops Research,* 82**,** 103-134.

Haro Sabu Agricultural Research center (HSARC). 2012. *Annual report of Haro Sabu Agricultural Research center. Haro Sabu.*

Harris, K., Anderson, W. & Malik, R. 2010. Genetic relationships among napier grass *(Pennisetum purpureum Schum.*) nursery accessions using AFLP markers. *Plant Genetic Resources,* 8**,** 63-70.

Hassen, A., Ebro, A., Kurtu, M. & Treydte, A. 2010. Livestock feed resources utilization and management as influenced by altitude in the Central Highlands of Ethiopia. *Livestock Research for Rural Development,* 22**,** 229-233.

Hassen, A., Gizachew, L. & Rethman, N. 2006. Effect of Lablab purpureus and Vicia atropurpuria as an intercrop, or in a crop rotation, on grain and forage yields of maize in Ethiopia. *Tropical grasslands,* 40**,** 111.

Hendricksen, R. & Minson, D. 1985. Lablab purpureus: a review.

Henshaw, F. 2008. Varietal differences in physical characteristics and proximate composition of cowpea (Vigna unguiculata). *World Journal of Agricultural Sciences,* 4**,** 302-306.

Heuzé, V., Tran, G., Sauvant, D., Renaudeau, D., Bastianelli, D. & Lebas, F. 2016. Lablab (*Lablab purpureus*).

Hindrichsen, I., Wettstein, H.-R., Machmüller, A., Soliva, C., Bach Knudsen, K. E., Madsen, J. & Kreuzer, M. 2004. Effects of feed carbohydrates with contrasting properties on rumen fermentation and methane release in vitro. *Canadian journal of animal science,* 84**,** 265-276.

ILRI, 2010a. Information leaflet on livestock feeds and feeding technologies for small small-scale farmers. Report of World Food Prize Borlaug-Ruan Intern, Trisha Collins.

ILRI, 2010b. Napier or elephant grass ILRI 14984 *(Pennisetum purpureum)* for livestock feedon small-scale farms. Information leaflet on livestock feeds and feeding technologies for small-scale farmers. Fodder Adoption Project fodderadoption.wordpress.com.

Ishiaku, Y. M. 2016. Effect of plant spacings on yield and quality of Columbus grass (Sorghum almum) under rainfed condition in Shika, Nigeria. *Journal of Animal Production Research,* 28**,** 318-328.

Islam, M., Saha, C., Sarker, N., Jalil, M. & Hasanuzzaman, M. 2003. Effect of variety on proportion of botanical fractions and nutritive value of different Napiergrass (Pennisetum purpureum) and relationship between botanical fractions and nutritive value. *ASIAN AUSTRALASIAN JOURNAL OF ANIMAL SCIENCES,* 16**,** 837-842.

Ito, O., Johansen, C., Adu-Gyamfi, J., Katayama, K., Kumar Rao, J. & Rego, T. 1996. Roots and nitrogen in cropping systems of the semi-arid tropics. Proceedings of the International Workshop: Dynamics of Roots and Nitrogen in Cropping Systems of the Semi-Arid Tropics, International Crops Research Institute for the Semi-Arid

Tropics (ICRISAT), Patancheru, Andhra Pradesh, India, 21-25 November 1994. Japan International Research Center for Agricultural Sciences.

Javanmard, A., Nasab, A. D. M., Javanshir, A., Moghaddam, M. & Janmohammadi, H. 2009. Forage yield and quality in intercropping of maize with different legumes as double-cropped. *Journal of Food, Agriculture and Environment,* 7**,** 163-166.

Juknevičius, S. and Sabienė, N., 2007. The content of mineral elements in some grasses and legumes. *Ekologija*, *53*(1), pp.44-52.

Kabirizi, J., Mpairwe, D. & Mutetikka, D. The effect of integrating forage legumes in smallholder crop/livestock farming systems on food, fodder and animal performance. Conference on International Agric. Res. for Development Tropentag, 2007. 9-11.

Kandel, R., Singh, H. P., Singh, B. P., Harris-Shultz, K. R. & Anderson, W. F. 2016. Assessment of Genetic Diversity in Napier Grass (Pennisetum purpureum Schum.) using Microsatellite, Single-Nucleotide Polymorphism and Insertion-Deletion Markers from Pearl Millet (Pennisetum glaucum [L.] R. Br.). *Plant molecular biology reporter,* 34**,** 265-272.

Karltun, E., Lemenih, M. & Tolera, M. 2013. Comparing Farmers'perception Of Soil Fertility Change With Soil Properties And Crop Performance In Beseku, Ethiopia. *Land Degradation & Development,* 24**,** 228-235.

Khogali, M. E., Ahmed, E. E. & El-Huweris, S. O. 2011. Effect of nitrogen, intercropping with lablab bean (Lablab purpureus) and water stress on yield and quality of fodder maize. *Journal of Science and Technology,* 12**,** 55-66.

Kilcher, M. 1981. Plant development, stage of maturity and nutrient composition. *Rangeland Ecology & Management/Journal of Range Management Archives,* 34**,** 363-364.

Kitani, O. 1999. CIGR handbook of agricultural engineering. *Energy and biomass engineering,* 5**,** 330.

Klopfenstein, T. J., Mass, R., Creighton, K. & Patterson, H. 2001a. Estimating forage protein degradation in the rumen1. *Journal of animal science,* 79**,** E208-E216.

Klopfenstein, T. J., Mass, R., Creighton, K. & Patterson, H. 2001b. Estimating forage protein degradation in the rumen 1. *Journal of animal science,* 79**,** E208-E216.

Kwapata, M. & Hall, A. 1985. Effects of moisture regime and phosphorus on mycorrhizal infection, nutrient uptake, and growth of cowpeas (Vigna unguiculata (L.) Walp.). *Field Crops Research,* 12**,** 241-250.

Ledgard, S., Giller, K. & Bacon, P. 1995. Atmospheric N2 fixation as an alternative N source. *Nitrogen fertilization in the environment.***,** 443-486.

Ledgard, S., Schils, R., Eriksen, J. & Luo, J. 2009. Environmental impacts of grazed clover/grass pastures. *Irish journal of Agricultural and food research*, 209-226.

Legesse, G., Small, J. A., Scott, S. L., Kebreab, E., Crow, G. H., Block, H. C., Robins, C. D., Khakbazan, M. & Mccaughey, W. P. 2012. Bioperformance evaluation of various summer pasture and winter feeding strategies for cow-calf production. *Canadian journal of animal science,* 92**,** 89-102.

Li, Q., Song, Y., Li, G., Yu, P., Wang, P. & Zhou, D. 2015. Grass-legume mixtures impact soil N, species recruitment, and productivity in temperate steppe grassland. *Plant and soil,* 394**,** 271-285.

Lindemann, C. & Glover, R. 2003a. Nitrogen Fixation by Legumes, New Mexico State University, Mexico.

Lindemann, W. C. & Glover, C. 2003b. Nitrogen fixation by legumes. New Mexico State University, Cooperative Extension Service.

Littell, R. C., Stroup, W. W. & Freund, R. J. 2002. *SAS for linear models*, SAS institute.

Liu, J., Zeng, Z., Jiao, L., Hu, Y., Wang, Y. & Li, H. 2006. Intercropping of different silage maize cultivars and alfalfa. *Zuo wu xue bao,* 32**,** 125-130.

Liu, M., Gong, J.-R., Pan, Y., Luo, Q.-P., Zhai, Z.-W., Xu, S. & Yang, L.-L. 2016. Effects of grass—legume mixtures on the production and photosynthetic capacity of constructed grasslands in Inner Mongolia, China. *Crop and Pasture Science,* 67**,** 1188-1198.

Lundvall, J., Buxton, D., Hallauer, A. & George, J. 1994. Forage quality variation among maize inbreds: in vitro digestibility and cell-wall components. *Crop science,* 34**,** 1672-1678.

Lunnan, T. 1989. Barley-pea mixtures for whole crop forage. Effects of different cultural practices on yield and quality. *Norwegian Journal of Agricultural Sciences (Norway)*.

Lüscher, A., Mueller‐Harvey, I., Soussana, J.-F., Rees, R. & Peyraud, J.-L. 2014. Potential of legume□based grassland–livestock systems in Europe: a review. *Grass and Forage Science,* 69**,** 206-228.

Mayer, L., Chandler, D. & Taylor, M. 1986. Lab-lab purpureus-A fodder crop for Botswana. *Bulletin of Agricultural Research in Botswana,* 5**,** 37-48.

McDowell, L.R. and Valle, G., 2000. Major minerals in forages. *Forage evaluation in ruminant nutrition.*, pp.373-397.

Mengistu, A. 2006. Country Pasture/Forage Resource Profiles. *Ethiopia View Article PubMed/NCBI Google Scholar*.

Midmore, D. J. 1993. Agronomic modification of resource use and intercrop productivity. *Field Crops Research,* 34**,** 357-380.

Miller, D. A. 1984. *Forage crops*, McGraw-Hill.

Mohammeda Semman, G. A., Mengistu Urgeb 2016. Effect of different spacing of Napier grass (Pennisetum purpureum) intercropped with or without Lablab (Lablab purpureus) on biomass yield and nutritional value of Napier grass. *Scientific Journal of Pure and Appiled Sciences,* 5**,** 496-508.

Morris, J. B. 2009. Morphological and reproductive characterization in hyacinth bean, Lablab purpureus (L.) Sweet germplasm with clinically proven nutraceutical and pharmaceutical traits for use as a medicinal food. *Journal of dietary supplements,* 6**,** 263-279.

Mucheru-Muna, M., Pypers, P., Mugendi, D., Kung'u, J., Mugwe, J., Merckx, R. & Vanlauwe, B. 2010. A staggered maize–legume intercrop arrangement robustly increases crop yields and economic returns in the highlands of Central Kenya. *Field Crops Research,* 115**,** 132-139.

Mugendi, D., Waswa, B., Mucheru-Muna, M., Kimetu, J. & Palm, C. 2011. Comparative analysis of the current and potential role of legumes in integrated soil fertility management in East Africa. *Fighting poverty in Sub-Saharan Africa: the multiple roles of legumes in integrated soil fertility management.* Springer.

Mullen, C., Holland, J. & Heuke, L. 2003. Agfacts: Cowpea, lablab and pigeon pea.

Murphy, A. M. & Colucci, P. E. 1999. A tropical forage solution to poor quality ruminant diets: A review of Lablab purpureus. *Livestock Research for Rural Development,* 11**,** 1999.

Murphy, H. F. 1968. A report on the fertility status and other data on some soils of Ethiopia.

Njoka-Njiru, E., Njarui, M., Abdulrazak, S. & Mureithi, J. 2006a. Effect of intercropping herbaceous legumes with Napier grass on dry matter yield and nutritive value of the feedstuffs in semi-arid region of eastern Kenya. *Agricultura tropica et subtropica,* 39**,** 260-272.

Njoka-Njiru, E., Njarui, M., Abdulrazak, S. & Mureithi, J. 2006b. Effect of intercropping herbaceous legumes with Napier grass on dry matter yield and nutritive value of the feedstuffs in semi-arid region of eastern Kenya. *Agricultura tropica et subtropica,* 39**,** 255-267.

Ocho, F. L., Abdissa, F. M., Yadessa, G. B. & Bekele, A. E. 2016. Smallholder farmers' knowledge, perception and practice in pesticide use in South Western Ethiopia. *Journal of Agriculture and Environment for International Development (JAEID),* 110**,** 307-323.

Olanite, J., Anele, U., Arigbede, O., Jolaosho, A. & Onifade, O. 2010. Effect of plant spacing and nitrogen fertilizer levels on the growth, dry matter yield and nutritive quality of Columbus grass (Sorghum almum stapf) in southwest Nigeria. *Grass and Forage Science,* 65**,** 369-375.

Oliveira, M. L. F., Daher, R., Figueiredo, E., De Amara Gravina, G., Da Silva, V. B., Rodrigues, E. V., Orio, Shimoya, A., Do Amaral Junior, A. T., Da Silva Menezes, B. R. & Dos Santos Rocha, A. 2014. Pre-breeding of elephant grass for energy purposes and biomass analysis in Campos dos Goytacazes-RJ, Brazil. *African Journal of Agricultural Research,* 9**,** 2743-2758.

Olsen, S. R. 1954. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate*, United States Department Of Agriculture; Washington.

Orodho, A. 2006. The role and importance of Napier grass in the smallholder dairy industry in Kenya. *Food and Agriculture Organization, Rome) Retrieved August,* 24**,** 2011.

Ørskov, E. & Mcdonald, I. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *The Journal of Agricultural Science,* 92**,** 499-503.

Ørskov, E., Reid, G. & Mcdonald, I. 1981. The effects of protein degradability and food intake on milk yield and composition in cows in early lactation. *British Journal of nutrition,* 45**,** 547-555.

Owen, E. & Jayasuriya, M. 1989. Use of crop residues as animal feeds in developing countries. *Research and Development in Agriculture,* 6**,** 129-138.

Papadopoulos, Y., Mcelroy, M., Fillmore, S., Mcrae, K., Duyinsveld, J. & Fredeen, A. 2012. Sward complexity and grass species composition affect the performance of grass-white clover pasture mixtures. *Canadian Journal of Plant Science,* 92**,** 1199-1205.

Pasquet, R. S. & Fotso, M. 1994. Répartition des cultivars de niébé (Vigna unguiculata (L.) Walp. du Cameroun: influence du milieu et des facteurs humains. *Journal d'agriculture traditionnelle et de botanique appliquée,* 36**,** 93-143.

Peksen, E. 2007. Dynamics of flower appearance, flowering, pod and seed setting performance and their relations to seed yield in common bean (Phaseolus vulgaris L.). *Pakistan Journal of Botany,* 39**,** 485.

Pengelly, B. C. & Maass, B. L. 2001. Lablab purpureus (L.) Sweet–diversity, potential use and determination of a core collection of this multi-purpose tropical legume. *Genetic Resources and Crop Evolution,* 48**,** 261-272.

Peyraud, J., Le Gall, A. & Lüscher, A. 2009. Potential food production from forage legume-based-systems in Europe: an overview. *Irish journal of Agricultural and food research***,** 115-135.

Pinkerton, B., 2005. Forage quality. Clemson University Cooperative Extension Service. Forage fact sheet 2. Cooperative Extension Service, Clemson University.

Pirhofer-Walzl, K., Rasmussen, J., Høgh-Jensen, H., Eriksen, J., Søegaard, K. & Rasmussen, J. 2012. Nitrogen transfer from forage legumes to nine neighbouring plants in a multi-species grassland. *Plant and soil,* 350**,** 71-84.

Plénet, D. & Cruz, P. 1997. Maize and sorghum. *Diagnosis of the nitrogen status in crops.* Springer.

Powell, J. M. & Unger, P. W. 1997. Alternatives to crop residues for sustaining agricultural productivity and natural resource conservation. *Journal of sustainable agriculture,* 11**,** 59-83.

Quadros, F. L. F. D., Bica, G. S., Damé, P. R. V., Dorow, R., Kersting, C. & Pötter, L. 2003. Levantamento das pastagens naturais da região de Santa Maria-RS, Brasil. *Ciênc. rural,* 33**,** 921-927.

Reed, J. D., Kebede, Y. & Fussell, L. K. 1988. Factors affecting the nutritive value of sorghum and millet crop residues. *Plant breeding and the nutritive value of crop residues***,** 233-249.

Rengsirikul, K., Ishii, Y., Kangvansaichol, K., Sripichitt, P., Punsuvon, V., Vaithanomsat, P., Nakamanee, G. & Tudsri, S. 2013. Biomass yield, chemical composition and potential ethanol yields of 8 cultivars of napiergrass (Pennisetum purpureum Schumach.) harvested 3-monthly in central Thailand. *Journal of Sustainable Bioenergy Systems,* 3**,** 107.

Ryan, J. 2017. Methods of Soil, Plant, and Water Analysis: A manual for the West Asia and North Africa region. International Center for Agricultural Research in the Dry Areas (ICARDA).

Schmeer, M., Loges, R., Dittert, K., Senbayram, M., Horn, R. & Taube, F. 2014. Legume-based forage production systems reduce nitrous oxide emissions. *Soil and Tillage Research,* 143**,** 17-25.

Schwenke, T. & Kerridge, P. 2000. Relative responsiveness of some tropical pasture legumes to molybdenum. *Tropical grasslands,* 34**,** 91-98.

Singh, B. 2005. Cowpea [*Vigna unguiculata* (L.) Walp]. *Genetic resources, chromosome engineering and crop improvement,* 1**,** 117-162.

Singh, B. P., Singh, H. P. & Obeng, E. 2013. 13 Elephantgrass. *Biofuel Crops: Production, Physiology and Genetics***,** 271.

Singh, G. & Oosting, S. 1992. A model for describing the energy value of straws. *Indian dairyman*.

Sollenberger, L., Jones, C., Albrecht, K. & Ruitenberg, G. 1990. Vegetative establishment of dwarf elephantgrass: Effect of defoliation prior to planting stems. *Agronomy Journal,* 82**,** 274-278.

Suter, M., Connolly, J., Finn, J. A., Loges, R., Kirwan, L., Sebastià, M. T. & Lüscher, A. 2015. Nitrogen yield advantage from grass–legume mixtures is robust over a wide range of legume proportions and environmental conditions. *Global change biology,* 21**,** 2424-2438.

Tadesse, T., Haque, I. & Aduayi, E. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis manual. *ILCA/PSD Working Document (ILCA)*.

Tadesse, T., Liben, M. & Asefa, A. 2012. Role Of Maize (Zea Mays L.)-Fababean (Vicia faba L.) intercropping planting pattern on productivity and nitrogen use efficiency of maize in northwestern Ethiopia highlands. *International Research Journals,* 2**,** 102-112.

Tarawali, S. 1995. *Methods for the evaluation of forage legumes, grasses and fodder trees for use as livestock feed*, ILRI (ILCA and ILRAD).

Teshome, A., Dechasa, N. & Alemayehu, Y. 2012. Sweet potato growth parameters as affected by farm yard manure and phosphorus application at Adami Tulu Agricultural Research Center, Central rifty valley of Ethiopia. *Agricultural science research journal,* 2**,** 1-12.

Tessema, Z. & Baars, R. 2006. Chemical composition, dry matter production and yield dynamics of tropical grasses mixed with perennial forage legumes. *Tropical grasslands,* 40**,** 150.

The Netherlands Commissioned by Ministry of Agriculture and Fisheries, 1985. Agricultural Compendium for rural development in the tropics and subtropics. The Netherlands ministry of agriculture and fisheries Amsterdam, Netherlands.

Tilahun, G., Asmare, B. & Mekuriaw, Y. 2017. Effects of harvesting age and spacing on plant characteristics, chemical composition and yield of desho grass (Pennisetum pedicellatum Trin.) in the highlands of Ethiopia. *Tropical Grasslands-Forrajes Tropicales,* 5**,** 77-84.

Timko, M. P., Ehlers, J. D. & Roberts, P. A. 2007. Cowpea. *Pulses, sugar and tuber crops***,** 49-67.

TOLERA, A. 2008. Feed resources and feeding management: A manual for feedlot operators and development workers. *Ethiopian Sanitary and Phytosanitary Standards and Livestock and Meat Marketing Program (SPS-LMM), Addis Ababa***,** 43.

Tsubo, M., Walker, S. & Mukhala, E. 2001. Comparisons of radiation use efficiency of mono-/inter-cropping systems with different row orientations. *Field Crops Research,* 71**,** 17-29.

Ulfina, G., Habtamu, A., Jiregna, D. & Chala, M. 2013. Utilization of brewer's waste as replacement for maize in the ration of calves.

Valenzuela, H. & Smith, J. 2002a. *Cowpea*, Cooperative Extension Service, College of Tropical Agriculture and Human Resources.

Valenzuela, H. & Smith, J. 2002b. *Lablab*, Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawai'i at Mānoa.

Van Ruijven, J. & Berendse, F. 2005. Diversity–productivity relationships: initial effects, long-term patterns, and underlying mechanisms. *Proceedings of the National Academy of Sciences of the United States of America,* 102**,** 695-700.

Van Soest, P. 1982. Nutritional Ecology of the Ruminant.'(0 and B Books Inc.: Corvallis, OR. USA).

Van Soest, P. J. 1994. *Nutritional ecology of the ruminant*, cornell university Press.

Van Soest, P. J. & Robertson, J. 1985. *Analysis of forages and fibrous foods*, Cornell University.

Vitousek, P. M., Mooney, H. A., Lubchenco, J. & Melillo, J. M. 1997. Human domination of Earth's ecosystems. *Science,* 277**,** 494-499.

Walkley, A. & Black, I. A. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science,* 37**,** 29-38.

Waugh, D. L. 1973. Discontinuous models for rapid correlation, interpretation, and utilization of soil analysis and fertilizer response data.

Wijitphan, S., Lorwilai, P. & Arkaseang, C. 2009a. Effect of cutting heights on productivity and quality of King Napier grass (Pennisetum purpureum cv. King Grass) under irrigation. *Pakistan Journal of Nutrition,* 8**,** 1244-1250.

Wijitphan, S., Lorwilai, P. & Arkaseang, C. 2009b. Effects of plant spacing on yields and nutritive values of Napier grass (Pennisetum purpureum Schum.) under intensive management of nitrogen fertilizer and irrigation. *Pakistan Journal of Nutrition,* 8**,** 1240-1243.

Willey, R. 1979. Intercropping Its Importance And Research Needs Part 1. Competition And Yield Advantages Vol-32. MPKV; Maharastra.

Woodard, K. & Prine, G. 1991. Forage yield and nutritive value of elephantgrass as affected by harvest frequency and genotype. *Agronomy Journal,* 83**,** 541-546.

Yasin, M., Malik, M. A. & Nazir, M. S. 2003. Effect of different spatial arrangements on forage yield, yield components and quality of mott elephant grass. *Pakistan Journal of Agronomy,* 2**,** 52-58.

Yayneshet, T. 2010. Ethiopia Sanitary & Phytosanitary Standards and Livestock and Meat Marketing Programme (SPSLMM) Texas A & M University System: Feed Resources Availability in Tigray Region, northern Ethiopia, for Production of Export Quality Meat and Livestock.

Yellamanda, R., Sankara, R. G., Reddy, Y. & Reddy, G. 2007. *Principles of agronomy*, Kalyani Publishers.

Yisehak, K. 2008. Effect of seed proportions of Rhodes grass (*Chloris gayana*) and white sweet clover *(Melilotus alba)* at sowing on agronomic characteristics and nutritional quality. *Livestock Research for Rural Development,* 20**,** 28.

Zewdu, T. 2005. Variation in growth, yield, chemical composition and in vitro dry matter digestibility of Napier grass accessions (Pennisetum purpureum). *Tropical science,* 45**,** 67-73.

Zewdu, T. 2006. The digestibility and degradability of mixtures of Napier grass and Sesbania leaves. *Tropical science,* 46**,** 6-12.

Zewdu, T. 2008. Effect of plant density on morphological characteristics, yield and chemical composition of napier grass (Pennisetum purpureum (L.) Schumach). *East African Journal of Sciences,* 2**,** 55-61.

Zhu, H., Ahmidouch, A., Anklin, H., Arenhövel, H., Armstrong, C., Bernet, C., Boeglin, W., Breuer, H., Brindza, P. & Brown, D. 2001. Measurement of the Electric Form Factor of the Neutron through d→(e→, e′ n) p at Q 2= 0.5 (GeV/c) 2. *Physical review letters,* 87**,** 081801.

8. APPENDICES

8.1. Appendix in table

Appendix 1: Mean square of ANOVA for morphological characteristics of Napier grass.

Source	DF	Mean square				
		PH (cm)	NTPP	LL (cm)	TNLPP	NLPT
TRT.	8	232.59 ns	38.29**	58.37**	278.06*	2.72ns
Rep.	2	3452.66**	83.59**	11.08ns	93.85ns	0.53ns
Error	16	422.11	9.76	39.61	69.05	7.14
Total	26					
CV (%)		12.40	14.39	5.60	3.31	6.39

**, ns= Significant and non significant at ($P < 0.05$); DF=degree of freedom; CV = coefficient of variation; LL = leaf length per plant; NTPP =Number of tiller per plant; PH= plant height; TRT= treatments, REP=replication.

Appendix 2: Mean square of ANOVA for herbage forage productivity yield (tone/ha)of Napier grass

Source	DF	Mean square			
		DMY	CPY	TDMY	TCPY
TRT	8	2.36ns	0.029ns	15.57**	0.38**
REP	2	0.37ns	0.03ns	1.70ns	0.07ns
Error	16	1.35	0.03	1.15	0.03
Total	26				
CV (%)		18.43	20.75	13.06	16.54

**, ns= Significant and non significant at ($P < 0.05$); DF=degree of freedom, CV=coefficient of variation; CPY= crude protein yield; DMY= dry matter yield; TCPY= Total crude protein yield (Crude protein yield of Napier grass and both legumes; TDMY= Total dry matter yield (the sum of all harvests forages of Napier grass and both legumes from each plots); TRT= treatments; REP=replication.

Appendix 3: Mean square of ANOVA for Chemical composition of Napier grass

Source	DF	Mean square								
		%DM	%Ash	%OM	%CP	%NDF	%ADF	%ADL	%Hemi.	% Cellu.
TRT	8	0.144ns	0.762**	0.762**	3.776**	3.932**	2.181ns	0.179ns	3.137ns	1.482ns
REP	2	0.071ns	0.599ns	0.599ns	0.063ns	8.352ns	5.758ns	3.435**	0.352ns	0.655ns
Error	16	0.186	0.265	0.265	0.710	1.553	2.902	0.242	2.189	3.432
Total	26									
CV (%)		0.46	5.05	0.57	6.06	1.95	4.02	5.48	6.87	5.542

**, ns= Significant and non significant at ($P < 0.05$); % Ash= ash percent; %CP= percent of crude protein; CV=coefficient of variation; %DM=percent of dry matter; %OM= percent of organic matter, %NDF= percent of neutral detergent fiber, %ADF=percent acid detergent fiber; %ADL = percent of Acidic detergent lignin; %Hemi.= percent of hemicelluloses; % Cellu.= percent of cellulose TRT= treatments; REP=replication

Appendix 4: Mean square of ANOVA for *In vitro* Digestibility of Napier grass

Source	DF	Mean square		
		IVDMD (%)	IVOMD (%)	ME (MJ/ kg)
TRT	8	71.862**	34.534**	0.775**
REP	2	3.023ns	11.963ns	0.267ns
Error	16	7.376	5.749	0.129
Total	26			
CV (%)		4.71	4.08	4.07

**=Significant: ns= non significant at ($P < 0.05$); TRT=treatments; REP=replication; DF= degree of freedom; CV=coefficient of variation; IVDMD = *In vitro* Dry Matter Digestibility; IVOMD = *In vitro* Organic Matter Digestibility; ME = Metabolizable Energy; MJ = Mega Joule

Appendix 5: Mean square of ANOVA for *In Sacco* DM Disappearances and Rumen Degradability Characteristics

Source	DF	Mean square										
		6 hr	12 hr	24 hr	48 hr	72 hr	96 hr	a	b	PD	c	ED
TRT	8	3.601ns	17.633**	4.423ns	12.440ns	7.312**	3.857ns	23.795**	2.654ns	19.854**	0.000ns	5.265**
Animal	2	3.199ns	1.839ns	15.318ns	9.051ns	9.171**	3.855	2.072ns	16.899ns	16.262ns	0.000ns	3.281ns
Error	16	3.132	6.729	9.305	6.705	1.615	2.172	0.72	14.075	16.663	0.000	1.803
Total	26											
CV (%)		7.94	7.07	6.91	3.73	1.75	4.02	7.20	6.87	4.68		2.82

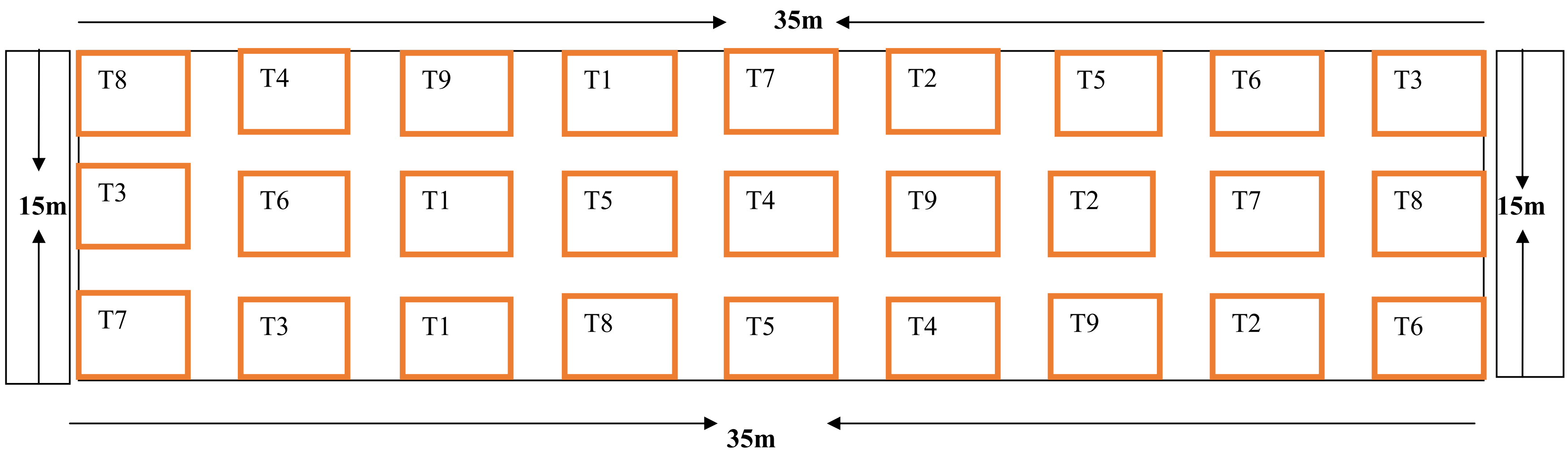
**, ns= Significant and non significant at ($P < 0.05$); TRT=treatments; DF= degree of freedom; a= washing loss (rapidly soluble fraction); b =slowly degradable fraction; C = the rate of degradation; CV = Coefficient of Variation; DMD = Dry Matter Disappearances; ED = Effective Degradability; hr = hour; PD = Potential Degradability.

Appendix 6: Mean square of ANOVA for *In Sacco* OM Disappearances and Rumen Degradability Characteristics

Source	DF	Mean square										
		6 hr	12 hr	24 hr	48 hr	72 hr	96 hr	a	b	PD	c	ED
TRT	8	4.897**	4.693ns	9.179ns	8.245**	3.734ns	6.976**	3.111**	34.909**	41.427**	0.000**	0.779ns
Animal	2	1.303ns	29.728**	14.580ns	0.544ns	11.511ns	1.188ns	1.942ns	29.197ns	22.175ns	0.000ns	0.350ns
Error	16	1.404	2.611	6.738	7.408	6.820	2.016	1.272	9.834	10.623	0.000	1.68
Total	26											
CV (%)		5.38	5.41	6.31	3.91	3.50	1.81	8.85	6.87	3.64	12.59	2.82

**, ns= Significant and non significant at ($P < 0.05$); TRT=treatments; DF= degree of freedom; a= washing loss (rapidly soluble fraction); b =slowly degradable fraction; c = the rate of degradation; CV = Coefficient of Variation; OMD = Organic Matter Disappearance

8.2. Appendix Figure



Appendix Figure 1: Experimental design setup.

Note

T1 = Sole Napier grass (1mx0.5m)

T2 = Napier grass x lablab (0.75mx0.5m)

T3 = Napier grass x cowpea (0.5mx0.5m)

T4 = Napier grass x cowpea (1mx0.5m)

T5 = Napier grass x lablab (0.5mx0.5m)

T6 = Sole Napier grass (0.75mx0.5m)

T7 = Napier grass x lablab (1mx0.5m)

T8 = Napier grass x cowpea (0.75mxo.5m)

T9 = Sole Napier grass (0.5mx0.5m

Original and image processed photo of Experimental on field

Appendix Figure 2: Experiment on field site

Original and image processed photo during growth and biomass yield data collecting with guidance of advisor

Appendix figure 3: photo of Agronomic and biomass yield data measured with guidance of advisor

Original and image processed photo during soil and forage sample preparation

Appendix figure 4: photo of soil and forage sample preparation

Original and image processed photo during laboratory analysis

Appendix figure 5: photo of sample laboratory analysis