EFFECTS OF DIFFERENT LEVELS OF FERTILIZER COMBINATION ON GROWTH, QUALITY AND YIELD OF RHODES GRASS *(CHLORIS GAYANA*) CULTIVARS IN KITHOKA, MERU COUNTY, KENYA

By

ROTICH KIBII CHRISTOPHER

A THESIS SUBMITTED TO SCHOOL OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND RURAL DEVELOPMENT OF THE KENYA METHODIST UNIVERSITY

June, 2020

DECLARATION

This thesis is my original work and has not been submitted for award of degree in any other university.

Signature…………………………… Date: ……………………………..

Rotich Kibii Christopher (Agr-3-1463-2/2017)

RECOMMENDATION

This thesis has been submitted for our approval as University Supervisors:

Signature…………………………… Date: ………………………………

Dr. Mworia Mugambi, PhD

Department of Agriculture & Natural Resources

Kenya Methodist University

Signature……………………….. .Date: ……………………….

Dr. William Ncene, PhD

Department of Agriculture & Natural Resources

Kenya Methodist University

DEDICATION

This thesis is dedicated to my dear family for their support and encouragement; my father; Dr. David Kuna, my mum; Sellina Chepkemoi and my wife Sarah Chepngetich.

ACKNOWLEDGEMENT

Firstly, I would like to thank God for the gift of life and secondly, I am grateful to Dr. Mworia Mugambi for tirelessly spending most of his time for guidance during the study. I am also thankful to Dr. William Ncene, my second supervisor for his critique and consistent support from the time of conception of the proposal to the execution of data collection. I would also like to express my gratitude to Dr. David Mushimiyimana, the late professor Peter Kamau and other instructors of Kenya Methodist University for their advisory role, scientific guidance and continued support during my study. Finally, I acknowledge the support and encouragement from my wife Sarah Chepngetich, My son Walter and daughter Sheryl.

God bless them mightily.

ABSTRACT

The livestock productivity is affected by several constraints which include poor genetic potential of breed, inadequate quality and quantity feed, livestock diseases and lack of adequate livestock extension services. Therefore, livestock production can be improved by cultivating fodder crops that are of high quality. The quality of fodder is generally low especially in crude protein (CP) content during the dry season. As a result livestock productivity and reproductive efficiency become low. Thus improved fodder production is needed through cultivation of improved forages. Production of forage is important and plays an effective role in development of livestock production systems. However, high quality and quantity of forage production has been a challenge to most livestock keepers due to lack of knowledge on the optimum dosage of both organic and in-organic fertilizers for improved grasses. The study was carried out at Kenya Methodist University farm in Kithoka, Meru County. The objective of this work was to determine growth, biomass yield and quality of two varieties of Rhodes grass *(Chloris gayana)*: Bhoma Rhodes grass and Katambora Rhodes grass varieties as animal feeds. The Bhoma variety is commonly grown in the region unlike Katambora variety. The soil analysis showed that the soil had adequate levels of Phosphorus, Potassium and Calcium. The treatments comprised of; control (L1) = 0 Kg CAN/ha and 0 tons Manure/ha, L2=75 kg CAN/ha and 5 tons Manure/ha, L3=100 kg CAN/ha and 10 tons Manure/ha and L4= 125 kg CAN/ha and 15 tons Manure/ha with two varieties of Rhodes grass. Randomized Complete Block Design (RCBD) was used at field level with 9 blocks of 2 m by 1 m separated by 1.0 m pathway. Analysis of variance (ANOVA) was conducted and significant means were separated using Least Significant difference (LSD). Application of different fertilizer combination levels had significant effect ($P < 0.000$) on all agronomic parameters. Fertilizer combination did not have significant effect on ash content ($P=0.215$), nitrogen free extract ($P= 0.006$), metabolizable energy ($P= 0.248$) and invitro dry matter digestibility ($P = 0.940$) while there was significant effect on % dry matter, ether extract, crude protein and crude fibre. The study conclude that maximum plant attributes were produced in treatment of 125 kg CAN/ha + 15 manure/ha hence it's the best regime recommended to the farmers. Bhoma Rhodes grass variety is better suited to climatic conditions of Kithoka because it responded better on the treatments.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

A.S.L	**:**	Above sea level
C4	**:**	Carbon 4
CAN	**:**	Calcium Ammonium Nitrate
CP	**:**	Crude Protein
Cv	**:**	Cultivar
DM	**:**	Dry Matter
DMY	**:**	Dry Matter Yield
FAO	**:**	Food and Agriculture Organization
FYM	**:**	Farm Yard Manure
IVDMD	**:**	In Vitro Dry Matter Digestibility
KALRO	**:**	Kenya Agricultural and Livestock Research Organization
KSC	**:**	Kenya Seed Company
LSD	**:**	Least Significant Difference
ME	**:**	Metabolizable Energy
NDF	**:**	Neutral detergent fibre

CHAPTER ONE

INTRODUCTION

1.1 Background information

The livestock productivity is affected by several constraints which include poor genetic potential of breed, inadequate quality and quantity feed, livestock diseases and lack of adequate livestock extension services. Therefore, livestock production can be improved by cultivating fodder crops that are of high quality. The quality of fodder is generally low especially in crude protein (CP) content during the dry season. As a result livestock productivity and reproductive efficiency become low. Thus improved fodder production is needed through cultivation of improved forages (Abebe et al., 2015). The study was therefore carried out at Kenya Methodist University farm in Kithoka Meru County to determine growth, production and quality of two cultivars of Rhodes grass *(Chloris gayana),* Bhoma and Katambora varieties as affected by fertilizers. Rhodes grass is one of the livestock fodder crops in the region but most farmers lack knowledge of the recommended crop husbandry practices hence the fodder is low in nutrients content.

Fodder production plays a successful role for the economic growth of agriculture. Fodder crops are the most vital and cheap food resource for animals with high metabolizable energy and other nutrients such as carbohydrates and protein. Consistent supply of adequate quality forage is a prerequisite requirement in livestock keeping (Bakhashwain, 2010). The quality of fodder from cereals is usually lower than that needed for many livestock groups to meet production goals, while a mixture of legumes and cereals are good source of animal protein and carbohydrates (Karadau, 2003).

Production of high dry matter of fodder is essential in leads to increase in the number of livestock .The increasing number of livestock is a good indicator of a given nation ability to meet the needs of rising number of citizens. Therefore, the quality of a fodder produced is also essential in ensuring balanced nutrition needs of the citizens consuming livestock products from animals feeding on quality fodders. For this case, higher production of quality fodder is of paramount consideration to livestock keepers because production of livestock products rely majorly on the feed quality and quantity (Arshad et al., 2016).

The increase in demand for animal products that are consumed locally and for export necessitates for farmers to have quality forage varieties that ensures consistent supply of feeds to their livestock. Reliance on long-term forage crops should ensure that animal feed is continuously available year round. The development of forage is creating more attention in the tropics and subtropics across the world. New fodder plant varieties from other localities have been introduced in locations where they did not exist before from native countries to enhance fodder development in developing countries (Yossif & Ibrahim, 2013).

Rhodes grass is one of the perennial improved grass which can be grown on-farm and used by small-holder farmers. (Abebe et al.,2015). Rhodes grass (*Chloris gayana*) is native long term grass of tropical and subtropical countries. It was mainly originated from African Countries i.e. (South Africa, Kenya, and Zimbabwe). Rhodes grass is a perennial grass and it’s one of the C4 forage grass and it come from the sub-family Chloridoideae (Arshad et al., 2020)**.** It is found in open grassland, or in grassland with small patches of trees, next to lakes or in waterlogged places up to 2000 m a.s.l. Rhodes grass can be used as pasture and in production of hay. It is can also be used to stabilize areas that have been disturbed (Mohamed & Gebeyew, 2018).

Rhodes grass has various names for different varieties but in English it is known as Rhodes grass, it has a lot of green matter with leaf of 1-2 m long and it has different fodder attributes. The culms are tufted, with nearly no rooting from the nodes. It has deep roots that go up to 4.5 m. It has linear leaves with blades that are gloriously flat 12-50 cm long x 10-20 mm wide, elongated to the tip. The crown of the seed has an open like hand shape and has 2 to 10 unilateral or double-sided racemes, 4 to 15 cm long. It has colored light to greenish brown flowers and as they mature they become darker brown (Allah & Bello, (2019).

The grass has heavily imbricated spikelets that are over 32 with two awns. It has caryopsis fruits with longitudinal groove. Due to natural distribution of Rhodes grass across Africa and its natural stands, it shows its adaptability to wide environment. It also reflects the enormous intra-specific variation hence various forms which can exploit different environments. Rhodes grass has a high protein content (9-12 %) with an average water intake of about 600 mm to 1200 mm. Sowing Rhodes grass for more than three years gives rise to development (Arshad et al., 2016)**.** Rhodes grass grows on different types of soils. It grows best on well drained moderate to high fertility soils. It can also survive on unfertilized soils although it produces less biomass and if it's grazed regularly it might get diminished. It is not tolerant to water logging. Rhodes grass has some establishment problems on very acidic soils but it is tolerant to saline conditions. Generally, Rhodes grass is a poor shade tolerant forage crop. Once well-established, Rhodes grass recovers well after fire. Due to its vigorous fibrous root system, Rhodes grass is moderately drought resistant. In addition, due to its vigorous horizontal root (stoloniferous) growth and extensive roots, Rhodes grass has great contribution in soil binding and soil erosion control (Abebe et al., 2015).

1.2 Problem statement

Shortage of quality and quantity of animal feeds is a critical problem due to increasing human population that has led to portions of land previously used for pasture production being allocated to growing of food crops. The problem has also been escalated by the limited knowledge on the cop husbandry practices that influence growth, biomass yield and quality of fodder. Most of the livestock farmers in Kithoka do not apply manure or fertilizers during establishment and growth stages of grass. This has lowered quality of the pasture hence the need for identification of high yielding and nutritious fodder species. This shortage has affected livestock performance mainly during long drought spells subsequently leading to low milk production, deterioration of body score, high susceptibility to infections, low reproductive efficiency, low growth rate and high number of deaths of the young livestock (Yisehak, 2008).

Forage resource improvement with emphasis on management practices that promote yield and nutritive value are, therefore, some of the important measures that would reverse the prevailing scenario of poor animal productivity. The research was therefore carried out to find out suitable Rhodes grass variety in Kithoka that could produce high quality feeds under different fertilization levels.

The use of nitrogenous fertilizers with an aim of increasing crude protein (CP), energy levels and biomass of fodder is to be one methods recommended in enhancing animal productivity in less developed countries (Allah & Bello, 2019). Nitrogen and phosphorous fertilizers play a very important role in enhancing the growth rate, quality and quantity of fodder. Because of the lack of knowledge on the optimum dosage of fertilizers for improved grasses and the effect on growth and production parameters, high quality and quantity of forage production have been a challenge for most livestock farmers (Arshad et al., 2016).

1.3 Objectives

Overall objective was to determine the effect of different levels of fertilizer combination on growth, biomass yield and quality of two cultivars of Rhodes grass in Kithoka, Meru County, Kenya

Specific Objectives were;

i. To determine growth of two cultivars of Rhodes grass under varied fertilization levels in Meru County.

ii. To determine biomass yield of two cultivars of Rhodes grass under varied fertilization levels in Meru County.

iii. To determine quality of two cultivars of Rhodes grass under varied fertilization levels in Meru County.

1.4 Research hypothesis

i. There are significant differences in growth of the two cultivars of Rhodes grass under varied fertilization levels in Meru County.

ii. There are significant differences in biomass yield of the two cultivars of Rhodes grass cultivars under varied fertilization levels in Meru County.

iii. There are significant differences in quality of the two cultivars of Rhodes grass under varied fertilization levels in Meru County.

1.5 Justification

Land sub divisions in Kenya in response to escalating population pressure has resulted to gradual decline in farm size rendering to land previously used for fodder and pasture production being replaced by cereal cultivation. Livestock farmers in Kithoka, Meru County depend on different varieties of pasture to feed their dairy animals. However dairy farming in the region is faced with a challenge of poor quality fodder which is not even readily available due to high demand and growing number of dairy farmers who are increasingly adopting commercialized dairy farming.

Rhodes grass (*Chloris gayana Kunth*) being one of the improved pasture species has been increasingly cultivated globally by livestock farmers due to its high dry matter yield, favourable economics of cultivation, and superiority over other perennial forage grasses (Allah & Bello, 2019). However, there is limited information on the crop husbandry practices that influence biomass production and quality of these species. There is also change of climatic conditions of Kithoka location due to its proximity to Isiolo, which is one of the driest places in Kenya.

The adoption rate of improved cultivated livestock fodder is high because of the income that will be found from sales of animal products from animals that have been fed with quality forage. Due to local and international high demand of livestock products for consumption (Osman et al., 2013), production of forage crops is gaining greater importance. Expansions in the development of forage crops require diversification of the pattern of forage with new improved cultivars. Intensive pasture production uses fodder types that demonstrate their broadness in biomass yields production per unit area, tastiness, quality and bioavailability of nutrients, sturdiness under defoliation periods and during poor climatic conditions, struggle and being compatible with other pasture ecosystem (Muhammad & Abubakar, 2004). Pasture management methods such as fertilization and spacing are used to achieve a suitable high productivity balance. The growth and herbal yield of newly introduced pasture species such as Rhode grass (Chloris gayana Kunth) must therefore be evaluated by subjecting them to certain management practices for optimum production, yield and nutritional value to improve the availability of good quality feed for better livestock production. Therefore, this work aimed to assess the growth and biomass yield of Rhodes grass herbage due to effect of both organic and inorganic fertilizers.

The study will contribute a lot of knowledge on husbandry practices that will make farmers produce quantity and quality of a climate smart cultivar of Rhodes. For this case the Bhoma variety showed that its best suited to the climatic conditions of Kithoka, Meru County. However the study was limited by the fact that there was no interaction of the farmer yard manure and CAN to check on the performance of varieties when applied a lone.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and distribution of Rhodes grass

Rhodes grass is a South African native and was called Rhodes after Cecil Rhodes, who popularized it. It is spread worldwide in temperate and humid regions. This has been introduced into various countries such as India, Pakistan, Australia and the United States. It was introduced in Australia in the early 20th century by soldiers from the Boer wars. It has been sown commonly in subtropical regions of Western Australia from the year 2000. The species was introduced via the USA in India, and later in 1920 in Karnataka. Rhodes grass, being resistant to drought, is found in semi-arid and other low-lying regions (Allah & Bello, 2019). It is also distributed in Africa's tropics and subtropics, thus adapting to the wide climatic conditions (Arshad et al., 2012; Arshad et al., 2014).

2.2 Factors affecting yield and quality of fodder production

2.2.1 Agro-ecological factors

Rhodes grass is a long term stoloniferous fodder which grows in wide range of climates (rainfall and temperature) and types of soils. The grass grows best in areas with annual rainfall above 600 mm and altitudes between 1400 and 2400 m (CASCAPE, 2015). The grass grows well with optimum annual rainfall with a summer-rainfall range of 600-750 mm (Ecocrop, 2014). However, it can as well do well with rainfall range of 310-4030 mm annually (Duke, 1983). It is deep rooted hence can withstand drought up to 6 months as well as 15 flood days (FAO, 2014). Mostly it is grown as pasture with annual temperature of 16.5 ° C - 26° C (Cook, 2005).

Loch, (1980) recorded that, the grass is adapted to different soil types and textures, it does well on fertile barned soils with a range of sandy, red volcanic to clay loams soils and tolerate poorly drained low fertile soils. The grass can do well on fertile soils however; it does not withstand heavy stocking density or heavy grazing. Rhodes grass is one of the most salt-tolerant forage in C4 plants (Osman et al., 2014). Being tolerant to salinity enables it to be grown on wide environment such as under irrigation with minimal challenges. It does well on soils with considerable moisture content with pH range of 5.5 to 7.5. However it is not tolerant to acidic soils especially during the establishment periods. In general, Rhodes grass is a poor shade tolerant fodder crop. Once well established, thanks to its vigorous fibrous root system, Rhodes grass recovers well after fire. Rhodes grass has moderate resistance to drought. However, due to its robust horizontal root (stoloniferous) growth and extensive roots, Rhodes grass contributes greatly to soil binding and soil erosion control (Tewodros et al., 2012).

2.2.2 Biotic factors

Allah & Bello, (2019) reported that major pests such as armyworm (*Spodoptera frugiperda*) may affect Rhodes grass pasture. The following fungi have been recorded to affect Rhodes grass: *Aspergillusflavus, Cerebella andropogonis, Cladosporium* sp., *Clavicep s*sp., *Cochliobolusheterostrophus, Fusariumequiseti, F. oxysporum, Helminthosporiumcarbonum, Himaydis*sp., *Nigrosporasphaerica, Puccinia chlorides, Pythiumaphanidermatum, Tolyposporium chlorides, Trichoderma* sp., and *Uromyceskenyensis. Strigalutea*and *S. asiatica parasitize*. Nematodes separated from Rhodes grass include: *Helicotylenchusdihystera, H. nannus, H. pseudorobustus, H. cavenessi, Hemicycliphoratruncata, Hoplolaimuspararobustus, Meliodognyeacronea, M. incognita acrita, M. javanica, Pratylenchusbrachyurus, Rotylenchulusreniformis, Scutellonemaclathricaudatum, Trichodorus minor, Tylenchusspiralis,* *Xiphinemaelongatum, X. ifacolum*. Insect pests include Fallarmyworm (*Spodopterafrugiperda*), thrips and caterpillars of *Mocislatipes*, both easily managed by insecticides.

2.2.3 Inorganic fertilizers

Rhodes grass is productive in moderate to high fertile soils. If the soil is infertile, adding nutrients to the soil is necessary (CASCAPE, 2015). It is recommended that nitrogen and phosphorus fertilizers be added. It is necessary to apply DAP fertilizer at a rate of 100 kgha-1 at planting and urea at a rate of 50 kgha-1 after establishment and at any cut (ESGPIP, 2008). Some literatures suggest that 100kgha-1 nitrogen be added after each break. Manure can be applied at 5-10 tons per hectare (Trivedi, 2010). Grasses generally have a high requirement for N, P, and K after each cut or graze these nutrients should be applied. It is suggested that annual upkeep nutrient requirements for N, P and K is 50 - 300kgha-1, 10 - 20kgha-1 and 25 - 50kgha-1, respectively. In addition to increasing biomass, the application of fertilizer increases both nutritional value and yield. Rhodes grass responds well in some areas with high phosphorus and generally a spectacular linear response to nitrogen when phosphorus and potassium is supplied in plenty. In addition, an increase in yield and quality is as well noted (Trivedi, 2010). For each harvesting stage, split application of fertilizers is better than single applications with the normal rate of 275 to 400kg / h. The cut and carry system calls for more maintenance inputs than the grazing system (CASCAPE, 2015).

The average productive life of Rhodes grass is three years; optimum fertilization will prolong this. Given that, the grass responds well to manure, application of 10 to 15 tons of farm yard manure or compost manure along with 30 kg P20 /ha as the main fertilizer while top dressing with 20 kg N / ha was reported to have stable production of Rhodes grass .For production under irrigation, use of 20 kg N/ ha was reported to enhance forage production after every 2-3 weeks (Trivedi, 2010).

High crop responses were associated with the application of nitrogen fertilizer in relation to growth, tiller production and tissue concentration of the elements and yield. The nutritional value of the crops is also increased by fertilization with nitrogen (Onyeonagu, 2005). The study that was done by (Peake et al., 1990) indicated that, applying nitrogen to guinea grass at a rate of 0, 84 and 168 kgN/ha improved the dry matter yield of total herbage (5840, 8460 and 12400 kg / ha) respectively. The author suggested that, applying 400kgN / ha dose per year increased the dry matter yield of guinea grass in Cuba. Application of nitrogenous fertilizer was reported to increase the number of tillers per plant, the total yield of guinea grass for herbage (Edokwe, 1991). The author further noted that the yield of DM and CP on guinea grass sward was largely dependent on the amount of N fertilizer applied.

Use of agro-chemicals such as fertilizers for forage production increases growth, biomass yields and chemical composition of the grown forage. Rhodes grass has been found to grow and establish well with the application of nitrogenous fertilizer after application of phosphorous fertilizer at planting time. In addition, Rhodes grass productivity was good when nitrogen fertilizer was applied at different dosages (Brima, 2011). Rhodes grass yield components such as leaf area and leaf to stem ratio was reported to increase with increase of nitrogenous fertilizer (Yossif, & Ibrahim, 2013). Fertilizers also increased both the fresh and dried fodder yields (Mohammed, 2009). Therefore, application of nitrogenous fertilizer after applying the basal fertilizer generally enhances yield and yield components of the forage plants and their qualities (Brima, 2011).

For better green and dry matter yields from Rhodes grass, application of heavy nitrogenous fertilizers is necessary in order to achieve better outputs from the grass. An increase in nitrogen levels across management zones and irrigation levels from 240 kg / ha - 480 kg/ ha considerably led to an increase of biomass yield of Rhodes grass by 15.13% in first cut, and by 6.77% in second cut. Applying nitrogenous fertilizer at a rate of 480 kg / ha increased the amount of hay production from Rhodes grass during the second cut of 8.5 t/ha as opposed to other treatments that ranged from 7.4-8.4 t/ha with fertilizer concentration of 240-1200kg/h (Patil et al., 2016).

2.2.4 Farmyard manure

Farm yard manure has been noted to highly improve many growth parameters, nutrients and quality of fodder because it has essential nutrients for plant growth and performance (Arshad et al., 2017). Farmyard manure contains important nutrient composition that is suitable for pasture production when it is applied at growing time. Its nutrient content can be recycled and used for several seasons before it is exhausted to produce more herbage yields. It has been in use since long time ago as fertilizer in agriculture for crops production. Long term pastures have been reported to do well with farm yard manure due to their convenience and low cost of application. The use of manure from the farmyard for agricultural purposes is also useful in reducing emissions. With the application of farm yard manure for pasture production, it should be done in such a way that optimal herbage yield is achieved (Eneji et al., 2008).

2.2.5 Water/moisture level

Rhodes grass absorbs large quantities of water and it can produce dry matter yield of between 24-26 t / ha under irrigation as reported in south-western Australia's Mediterranean climate. The grass is tolerant to low moisture soils and still does averagely with optimal moisture content in the soil (Marais et al., 2003). Due to its deep rootedness, the grass can withstand low moisture level and produce enough biomass yields at a struggling moisture in the soil because its deep roots gain moisture from the inner part of the soil unlike on top soils. Due to being less prone to water stress, Rhodes grass was reported to produce biomass yields increase by 97% when compared to tall fescue 122% and Timothy grass 209% under intensive irrigation system (Eneji et al., 2008).

2.3 Uses of Rhodes grass

It can be used as forage grass to be grazed directly by cattle or fed in dry form as hay. It can also be used for impaired area stabilization. It can be used in a rotational pasture growing in both humid and sub-humid regions for pasture lay establishment. It is ideal as with all kinds of stocks for silage and hay, but can cause skin problems in horses (Yossif, & Ibrahim, 2013).

2.4 Varieties of Rhodes grass

The major types of Rhodes grass comprise of; Pioneer, Katambora, Fine Cut, Callide, and Top Cut. There are some other African varieties namely Giant Rhodes; Mbarara from Uganda, Rongai is grown near Nakuru; Kenya, Nzoia, Pokot and Masaba are grown in Kenya and Karpedo is suited to the drier areas of Kenya (Brima & Abusuwar, 2020). The breeding of different seeds of Rhodes grass is of importance to ensure high quality and quantity varieties for optimal forage production (Arshad et al., 2016).

2.5 Production of Rhodes grass

Crop spacing recommendations is necessary because crop overcrowding may reduce yields and fruit quality due to competition for light and soil nutrients. When crops are planted too close to each other, it can be difficult for the farmer to walk, spray pesticides or inspect the crops in the greenhouse. Appropriate spacing helps the farmer to maintain the required plant population that does not ail the quality and quantity of the resultant forage (EARO, 2004). Nadaf et al., (2005) reported that the grass species developed higher seed yield with distance spacing than close spacing due to reduction of plant competition.

Plant spacing of 25cm×85cm among 25cm×85cm, 50×85cm and 75×85cm spacing gave the highest fresh and dry matter yields of 25.54 and 11.28tons/ha of Sorghum almum in an experiment conducted to evaluate the cause of planting space on the biomass yields and nutrient composition of Columbus grass with rain fed (Ishiaku et al., 2016). The author further reported that, wider inter and intra row spacing of 75cm and 100cm recorded highest dry matter yields of *Vignaunguiculata L*. Walp var. Kanannadoin the semi-arid region of northwest. In their report, Allah & Bello, (2019) suggested the cultivation of Rhodes grass with 120KgN / ha and 30 cm inter row spacing.

2.6 Harvesting and post-harvest handling of Rhodes grass.

The Rhodes grass should be harvested at a flowering stage of 50 percent to obtain high quantity and quality feed. Early phase harvesting of Rhodes grass will ensure higher levels of crude protein (CP) in the harvested material. When the harvest time comes late the grass' basic protein level is small. Within 3-5 months after sowing, newly developed pasture via seed sowing can be utilized. The harvested material may be fed as fresh to the livestock or it may be made into hay for later feeding. If root splitting is used as planting material, the first harvest can take between two and three months, given that there is sufficient application of moisture and fertilizer (CASCAPE, 2015).

Rhodes grass makes fine hay, whether it is cut at late or a bit earlier at the beginning of the flowering. Old stands offer hay that is of low quality. It is not suitable for producing silage.

Procedures should be observed when planning correct hay making. Rhodes grass can be grazed within 4 to 6 months with optimal herbage attained during the second year. Rhodes grass is resistant to heavy grazing and cutting but very frequent defoliation reduces yield (CASCAPE, 2015). In the first year, Rhodes grass can be harvested in October depending on the soil and environmental conditions. It can be harvested at any time of year after the first year, when it hits the optimal harvest level. This should be harvested in areas where freezing occurs before the onset of winter. Studies show that cutting in irrigated conditions is better at every 28 days than cutting in a 14 days period. It is better to take cuttings at monthly intervals based on the year of establishment. Rhodes grass field harvesting takes several months during the year of establishment since it can be harvested monthly based on rain (irrigation) and fertilizer or manure availability. When grass of Rhodes is used for grazing, caution should be taken since overgrazing can damage the pasture. Rhodes grass is very attractive to cattle, therefore when using grass pasture from Rhodes, it is easier to follow cut and carry program. Digestibility and the contents of crude protein (CP) decrease as the plant matures. Therefore regular cutting and fertilization of the crop is needed for better utilization. Rhodes grass should be cut or burned over mature ground. Burning is important in Rhodes grass because the grass is resistant to fire (CASCAPE, 2015).

2.7 Economic yield components of Rhodes grass

The high yields of fodder in any forage are due to all production plant characteristics such as height of plant, tillers per plant, leaves per tiller, yield of leaves, green fodder and dry fodder yield (Arshad et al., 2016). Selection for one character would result in improvement of all desirable agronomic characteristics and poor production of any of the above characteristics due to poor management of the forage results in low yields of biomass from a forage plant (Yossif & Ibrahim, 2013).

2.7.1 Plant heights

Rhodes grass growth performance varies with cultivar type, plant age, and other environmental factors. However the grass has been reported to be averagely up to 90 cm tall (FAO, 2009). In his research, Yisehak, (2008) stated that Rhodes plant heights were 50 – 120 cm when measured and health tillers were 90 to 200 cm tall. The foliage length was 25 to 50 cm and 0.3 to 0.9 cm. While studying in Ethiopia, Arshad et al., (2014) recorded that the height of Rhodes grass grown sole in Ethiopia's savannah area ranged from 100.7 to 121.0 cm tall at 8 weeks after sowing. The minimum plant height for all eight cuttings was 91.7 cm and 116.9 cm, while the average plant height for all eight cuttings was 116.2 and 155.9 after each plot obtained 86 kg / ha of P_2O_5 before sowing and 55 kg / hectare before second watering.

Osman et al., (2014), while researching on the development of various Rhodes grass varieties, reported that Katambora Australia recorded 78-87 cm of plant height, Katambora Zimbabwe recorded 80-95 cm of flowering at 50 per cent. The author reported the lowest plant height of 108.58 cm followed by 110.03 cm in various parcels with various treatments. The maximum plant height reached during the test, however, was 125.38 cm followed by 116.88 cm. When NPK fertilizers were applied at the rate of 100 kg/ha at sowing then nitrogenous fertilizer of 50kg/ha after 6 weeks of emergence, Bakhashwain, (2010) reported the highest heights of sole grown Rhodes grass as (85.5 cm) and (87.25 cm) for both cuts. Other scholars obtained similar conclusions (Ibrahim et al., 2006). Arshad, (2015) recorded lowest plant height with Top cut (114.29 cm) followed by the Callide (115.82 cm) while working with other varieties of Rhodes grass. Nevertheless, Finecut (131.98 cm) reached the highest plant height followed by the Katambora (123.03 cm).

2.7.2 Tillers per plant

While working with different varieties of Rhodes grass, Yossif, & Ibrahim, (2013) noted that highly significant responses were observed for different varieties to the tillers per plant. The author deduced that the lowest total number of tillers / plant was obtained in Top cut (4.15) and the Calide (4.27) followed. However, Finecut (5.38) achieved the highest overall tillers per plant followed by the Katambora (5.23) throughout the experiment. Their findings were similar to those of (Ali et al., 2001), who also noted the difference for the tillers per plant in Rhodes grass cultivars.

Allah & Yakubu, (2015) reported 81 tillers as the maximum number of tillers per plant. However, at 10 weeks after sowing the author reported the growth parameters of Rhodes grass sown at Sokoto, a semi-arid region of Nigeria with 79 tillers. When nitrogen was added 100 kg / acre, (Arshad et al., 2016) recorded the lowest tillers/plant in Rhodes grass as (4.02) followed by (4.09). The highest tillers / plant obtained was (4.86) followed by the (4.63). Similar findings have been reported by Saad, (2010) who also observed variations for the tillers / plant in Rhodes grass cultivars when NP was applied to Rhodes grass at a pace of 100:50 kg per acre. Similarly, Brima et al., (2011) recorded more tillers per plant of (5.45) with the same application rate. Arshad, (2015) reported the lowest Callide tillers / plant with the same study (4.23) followed by the Katambora (4.39). The author however registered Finecut's highest tillers / plant (5.12) followed by the Pioneer (4.98). Their findings came from the study of Ali et al., (2001) who also reported the difference for the tillers / plant in the Rhodes grass cultivars.

2.7.3 Leaves per plant

Research done by Yossif, & Ibrahim, (2013) on the effect of 100 kg N / ha urea (U), five ton / ha Farmyard Manure, three ton / ha Chicken Manure and Farm yard manure + Chicken manure and Urea + Farmyard manure + Chicken manure combinations with no fertilizer as controlled on Rhodes grass deduced that the number of leaves on each stem ranged from (4-11) when Urea was used , (4-10) with Farm yard manure, (4-9) Chicken manure, (4-11) Urea + Farmyard manure, (4-13) Urea + Chicken manure, (4-9) Farmyard manure + Chicken manure, (4-9) Urea + Farmyard manure + Chicken manure and (4-8) control. In another study by Allah & Yakubu, (2015) the number of leaves for each stem of Rhodes grass ranged from 10 to 13. However, at 10 weeks after sowing the author recorded the number of leaves for Rhodes grass sown at various locations in semi-arid regions of Nigeria as 6 leaves per plant. Bakhashwain, (2010) recorded 25.6 number of leaves per plant as highest number while 20.8 leaves per plant as the lowest when Rhodes grass was sown alone.

2.7.4 Number of leaves per tiller

Arshad et al., (2016), when analyzing the economic parameters of Rhodes grass, where 100 kg/acre of nitrogen was added, the author reported the highest leaves/tiller as (10.13) followed by (9.17) when the lowest leaves per tiller were (8.65) followed by (8.79). Similar results were noted from (Ali et al., 2001). Nadaf et al., (2004), found the leaves in the main tillers of pure Rhodes grass was 4.5 to 7.0 in the summer and 4.0 to 5.0 in the winter, whereas in the Rhodes grass component, the number of leaves in mixtures was 4 to 7 in the summer compared to 2-4 in the winter leaf stage. Upon application of NP fertilizer on Rhodes grass at a rate of 50-100 kg per acre. Arshad et al., (2014) recorded more leaves per tiller (10.55) followed by 50:50 NP kg per acre (9.45). Again, when researching various varieties of Rhodes grass, Arshad, (2015) deduced that Finecut (10.66) had the highest leaves / tiller, followed by the Pioneer (9.65), while the lowest leaves / tillers were found in Callide (9.11) followed by the Topcut (9.30). Different findings were also recorded by Arshad et al., (2019) while using different water levels for irrigation, Finecut (11.19) had the highest leaves per tiller, followed by Katambora (10.77), while Topcut (8.93) had the lowest leaves per tiller.

2.7.5 Leaf to stem ratio

Yossif & Ibrahim, (2013) in their study on Rhodes grass with different types of farm yard manure found that, its leaf to stem ratio to range from (0.65-1.35) when Urea was applied, (0.7-2.24) with farm yard manure, (0.81-1.66) Chicken manure, (0.66-1.82) Urea + Farmyard manure, (0.64-1.52) Urea + Chicken manure, (0.71-1.15) Farmyard manure + Chicken manure, (0.64-0.99) Urea + Farmyard manure + Chicken manure and (0.64-1.09) for control.

2.7.6 Leaf Area

Arshad et al., (2016), broadcasted 100 kg per acre of nitrogen in split doses in different interventions of Rhodes grass growth times and recorded the highest leaf area of (307.05 cm^2), followed by (283.59 cm^2) and lowest leaf area recorded was (266.35 cm^2) followed (273.24 cm^2). Similar results for the leaf area for Rhodes grass were obtained by Yossif et al., (2013) who also noted variation for the leaf area in Rhodes grass. When spreading NP fertilizer on Rhodes grass, the maximum leaf area of (324.21 cm2) was reported by Arshad et al., (2016) at 100-50 kg NP dose followed by 50-50 NP kg (299.52 cm2). Similarly, Yossif et al., (*2013*) observed same results with Rhodes grass. Arshad, (2015) observed that Finecut showed highest leaf area of (323.21 cm^2) followed by Katambora (298.52 cm^2) and lowest with Topcut (280.37 cm^2) followed by Callide (287.62 cm^2). Their findings were in agreement with those that were obtained by Mirza et al., (2002) with cultivar Finecut showing the highest leaf area of (339.37

cm^2), followed by Katambora (326.44 cm^2) and lowest leaf area was observed for Topcut (281.87 cm^2).

2.8 Biomass yields of different varieties of Rhodes grass

2.8.1 Green yield matter of Rhodes grass

The green matter in any forage usually tells the quality and quantity of a forage plant and sometimes it influences the dry matter yields of forage and its palatability Yossif *et al*., (2013) & Arshad *et al*., (2014). When Arshad *et al*., (2016) applied 100 kg/acre of nitrogen in split doses to Rhodes grass varieties, 22.35 ton/ha/cut was recorded and the highest production of green forage/ hectare was observed for Finecut (24.71 ton/ha/cut) followed by Katambora (23.77 ton/ha/cut) while the lowest production/ hactare was observed for Callide (17.2 ton/ha/cut).

In their analysis, Borhan et al., (2000) reported the highest yield per hectare for green fodder for Finecut cultivar as (23.53 ton / ha/cut) followed by Katambora (20.91 ton / ha / cut), whereas the lowest production per hectare was observed for Topcut (17.67 ton / ha / cut) and Callide (20.02 ton / ha /cut) respectively. Similar results for green fodder yield were obtained from (Arshad, 2015).

Trivedi, (2010) made 6 cuttings of Rhodes grass and achieved fresh biomass yield of 17.0 t / ha with rain fed while 17.6 t/ha highest fresh biomass yields was attained with irrigation after each plot received 86 kg/ha of P_2O_5 before sowing and nitrogen 55 kg/ha before second irrigation. Osman et al., (2014) recorded green fodder yields of varieties of Rhodes grass as for Katambora Australia 26.5-31.5 t/ha, Katambora Zimbabwe 22.7-35.4 t/ha. When 100 kg / acre of nitrogen was added the estimated highest average yield for green fodder per hectare was (22.35 ton / ha /

cut) followed by (19.86 ton / ha / cut), while the estimated lowest yield per hectare was (16.79 ton / ha / cut) and (18.02 ton / ha / cut) respectively (Arshad et al., 2016).

2.8.2 Dry matter yield of Rhodes grass

The weight of dry matter yield of any forage plant is always recorded on dry matter basis as opposed to on green matter content because the moisture content of any green plant varies from species to species. Hence to achieve a standardized conditions for nutrient analysis of any forage expressing their weights on dry matter basis give the exact nutrient composition of a forage plant without dilution of moisture content (Yossif & Ibrahim, 2013). The weight of herbage produced is one of the most significant features of the range plants and it is possibly the best sole measure of growth. Herbage yield of forage is its organic weight per unit area and it can comprise of the growing herbage above the ground or any organic matter whether live or dead plants. This is generally achieved in plant studies focused on calculation of biomass yields per unit area that can either be in cm^2 or m^2. The biomass is dried in the laboratory oven to constant weight and then its dry matter yield is measured and its weight expressed per unit area. Osman et al., (2014) applied 86 kg / ha of P_2O_5 per field and recorded that Katambora Australia Rhodes grass produced 7.7-8.5 DM t / ha while Katambora, Zimbabwe produced 6.9-10.0 DM t / ha. In another analysis, when grown with nitrogen fertilizers applied at 20kg / ha, the variety Katambora yielded up to 17 t / ha dry matter yield (Reed et al ., 2008). The mean average yield per cut of dry Rhodes grass hay obtained from manual and artificial fertilizer application was reported by Brima, (2011) & Arshad et al., (2014) to be 6.15 ton /ha and 7.4875 ton / ha respectively. Arshad et al., (2016) reported that the minimum average dry fodder yield per hectare was observed when 100 kg / acre of nitrogen was added (4.16 ton / ha / cut followed by

(4.75 ton / ha/cut), while the highest dry fodder yield per hectare was (6.41 ton / ha / cut) followed by (5.34 ton / ha / cut.

The study that was carried out by Yossif & Ibrahim, (2013) on application of different types of farmyard manure and nitrogen fertilizer on Rhodes grass found out that, the dry matter yield ranged from (3.57-9.05) when Urea was applied, (4.52-8.95) with Farm yard manure, (4.76-14.05) for Chicken manure, (4.76-11.33) Urea + Farmyard manure, (5.24-9.28) Urea + Chicken manure, (4.05-12.29) Farmyard manure + Chicken manure, (4.76-10.95) Urea + Farmyard manure + Chicken manure and (4.368-10.71) DM t/ha control. Abass, (2007) witnessed comparable results, stating that all treatment with fertilizers had a trivial effect on fodder yield (fresh and dry). While Arshad, (2015) experimenting on different Rhodes grass varieties, the author found that the lowest dry matter production per hectare was noted in Topcut (4.38 ton / ha / cut) followed by Pioneer (5.012 ton / ha / cut) and Finecut (6.75 ton / ha / cut) achieved the highest dry fodder yield per hectare followed by Katambora (5.62 ton / ha / cut).

2.9 Chemical composition of Rhodes grass

The chief components for assessing pasture quality are crude protein, fibre content and energy content. The recommended protein content of tropical forages ranges from 40–130 g / kg, while the DM content in the early growth stages ranges from 150 to 250 g / kg and rises to 350 g / kg as the plants mature. The recommended protein content of any grass species that is fed as the sole fodder to an animal is 7.0 g/100g on dry matter basis below that, the animal will be lacking enough protein in the forage hence its productivity and growth will definitely go down (Bogdan, 1977).

The study by Tolera *et al.*, (2006) noted the DM of Rhodes grass sample to range from 247-292 g/kg, Ash 121-139 g/kg CP 96-124 g/kg. When researching the nutrient composition of Rhodes grass and Alfalfa, Osman et al., (2013) found that, application of 69 kg nitrogen fertilizer enhanced dry matter yields in Rhodes grass than the Alfalfa but lower in Crude protein content than Alfalfa plant compared with Fine Cut and Hay Maker with an average of 22.46%, 10.58% and 11.36%. Arshad et al., (2016) while studying on the required amount of irrigated water for optimal production of Rhodes grass found that, the highest crude protein contents recorded in Rhodes grass was (9.77 percent) followed by (9.69 percent), while the lowest crude protein content recorded was (6.75 percent). Similar results have been obtained for Rhodes grass crude protein content (Arshad et al., 2014) & Rahman, (2007). When Arshad et al., (2016) applied 100 kg / acre of nitrogen in split doses to Rhodes grass varieties; an average protein content of (9.77) was observed during the growth stages.

Trivedi, (2010) reported variable proportions of chemical composition of Rhodes grass with age during his study. The author reported the amount of organic compounds in Rhodes grass typically varies as follows: crude protein 9 – 13%, crude fiber 30 – 40%, ether extract 0.8 – 1.5%, nitrogen-free extract 42 – 48%.

When comparing the chemical composition of Rhodes grass varieties and Alfalfa plant, Osman et al., (2013) found lower neutral detergent fibre in Alfalfa plant compared with Rhodes grass varieties Fine Cut and Hay Maker with an average of 39.52%, 70.34% and 68.49%. The same applied to 24.6%, 42.4% and 45% acid detergent material. The author found that CP of 22.46% and 10.97% for Alfalfa and Rhodes grass respectively.

Brima & Abusuwar, (2020) stated that crop varies in organic compounds, crude protein 4-13%, crude fiber 30-40 %, ether extract 0.8-1.5 %, nitrogen-free extract 42- 48 % and digestibility is 40-60 % of dry matter making the crop highly palatable to animals.

CHAPTER THREE

RESEARCH METHODLOGY

3.1 Description of the area of study

The field trial took place at Kenya Methodist University Farm, Kithoka in Meru County which is an ecological agro-coffee zone in Kenya's central highlands. The place is situated on the eastern slopes of Mt Kenya at an altitude of around 1500 a.s.l. The average annual rainfall is 1200 mm which rains for two seasons; long rains season that is between October to December with an average rainfall of 650 mm, and short rain season that comes between March-May with an average rainfall of 550 mm. Monthly average temperature is 25 °C and the minimum is 14 ° C. Long term monthly temperature is 19.5°C (Mwenda, 2014). The soils in the region are predominantly humic Nitisols with moderate to high fertility and are deep, well weathered with clay texture (FAO, 1990).

3.2 Description of treatments

The treatment combinations entailed 8 different combination levels of Farm yard manure and CAN fertilizers which were applied randomly to two varieties of Rhodes grass, bhoma (V1) and Katambora (V2).

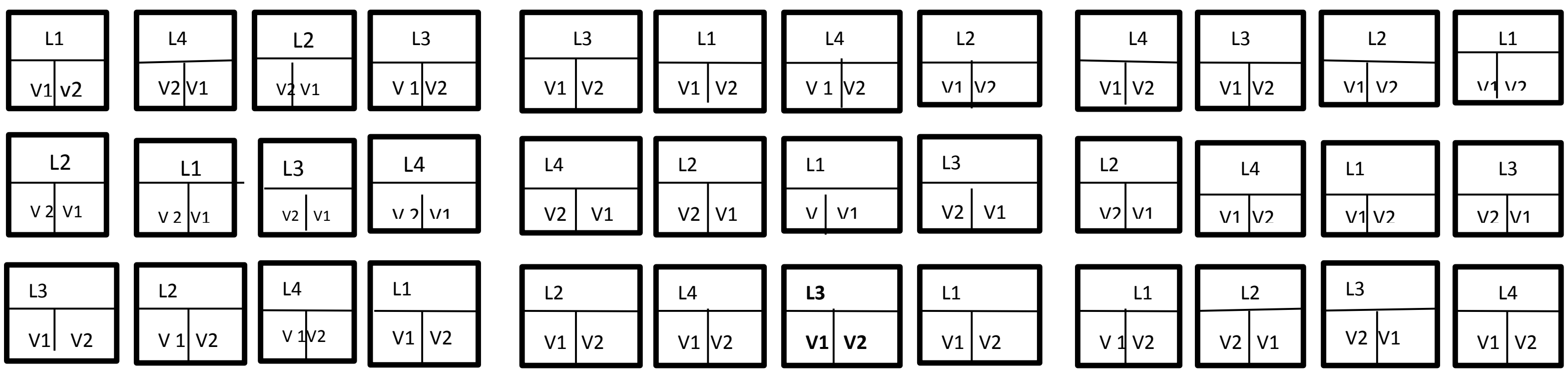
i. L1 = 0 Kg CAN/ha and 0 Tons Farmyard Manure/ha (control).
ii. L2 = 75 kg CAN/ha and 5 Tons Farmyard Manure/ha
iii. L3 = 100 kg CAN/ha and 10 Tons Farmyard Manure/ha
iv. L4 = 125 kg CAN/ha and 15 Tons Farmyard Manure/ha
.

3.3 Experimental design and layout

Randomized Complete Block Design (RCBD) was used at field level with 9 blocks of 2 x 1 m separated by 1.0 m pathway; each block was subdivided into twelve subplots of 1 x 1 m separated by 0.5 m pathways resulting in a total of 36 plots. The four treatments were replicated 9 times and randomly distributed to the subplots with two varieties of viable Rhodes grass seeds.

Figure 3.1

Plot layout and treatment distribution



L1= 0 Kg CAN/ha + 0 Tons Farmyard Manure/ha, L2=75 kg CAN/ha + 5 Tons Farmyard Manure/ha, L3=100 kg CAN/ha + 10 Tons Farmyard Manure/ha, L4= 125 kg CAN/ha + 15 Tons Farmyard Manure/ha, V1= Bhoma Rhodes grass, V2= Katanbora Rhodes grass.

3.4 Field establishment

In preliminary stages of preparation, all weeds were cleared manually by use of sickles. The land was ploughed by tractor and leveled by grading all raised areas to obtain uniformly flat plots of fine till and effective germination. The sowing rate of Rhodes grass seeds was 4 kg/acre and was sown in a well prepared farms applied with farmyard manure at a rate of 0 ton/ha, 5 ton/ha, 10 ton/ha and 15 ton/ha. After two weeks of emergence CAN fertilizer was applied at the rate of 0 kg/ha, 75kg/ha, 100kg/ha and 125kg/ha. Both manual and chemical weeding was done. Manual weeding was done on 15th day and 30th day after germination. Chemical weeding was done on 45th day.

3.5 Soil and manure analysis

Soil samples were extracted in the experimental field at intervals of 2m at 30cm depth before sowing. From each block, a composite sample of three cores was taken diagonally. The sample cores were placed into a bucket, thoroughly mixed and about 200 g taken as the final composite sample, put in courier sample bag, labeled well and sent to Kenya Agricultural & Livestock Research Organization, Kabete for determination of phosphorus, Potassium, pH and minor elements such Mg and Mn. At the laboratory, air-drying of the samples was done by spreading the sample in trays before soil laboratory analysis. Well composed manure was also sent for analysis of micro elements.

The levels of soil phosphorus, Potassium and Magnesium were found to be high while soil reaction (pH) was 6.57 which is satisfactory for grass growth. Total Organic Carbon was moderate while Calcium, total Nitrogen and Sodium were adequate. The manure sample had low

Calcium content, high level of Iron and manganese while other nutrient elements were within the normal range. The soil and manure analysis results are given in appendix 1.

3.6 Data collection

The following agronomic and quality parameters were collected.

3.6.1 Plant height (cm)

The height of the Plant was obtained by recording the heights of three tagged plants from the bottom to the top of the tip of the longest leaf at 30days, 60 days and 90 days after sowing. The average height of each plant was calculated for each plot.

3.6.2 Number of tillers per plant

Tillers were counted after every 30 days for three months after sowing with the aid of three tagged plants.

3.6.3 Leaf to stem ratio

Five plants were randomly cut per plot with leaves being stripped off from the stem. The leaves and stems were dried on the sun to a constant weight and their weights were recorded for dry matter determination. The leaf to stem ratio was attained by expressing the dry weight of leaves on the dry weight of stems. This measurement was done after 90 days from sowing (maturity stage).

3.6.4 Number of leaves per plant

Leaves were counted on the three tagged grasses per plot. Then the average number of leaves/ grass was obtained. This measurement was done after every 30 days three times from the time of sowing.

3.6.5 Leaf area.

Five leaves from the three tagged plants were selected randomly per plot to calculate leaf area by multiplying the length and maximum width, and then multiplied the calculated value by a correction factor of 0.75 (Watson & Watson, 1953). Then the mean of leaf area per plant were obtained for each plot.

3.6.6 Number of nodes per plant.

Number of nodes/ plant was counted on the three tagged plants per plot. Then the average number of nodes/ plant was obtained. This measurement was done after every 30 days three times from the time of sowing.

3.6.7 Green and dry matter

At 50% flowering, a fresh sample was harvested for each variety by randomly cutting 5 plants per row 5cm above the ground in each plot and their weights were recorded. The harvested fresh materials were sealed in polythene bags and were taken to the nutrition laboratory in the department of Animal Production, University of Nairobi for oven drying at 60^{o}C. The other plants within each plot were harvested by cutting at 5cm above the ground. They were placed into gunny bags and weighed using a hanging round scale to the nearest 1000g to obtain the fresh biomass yield per plot. After drying the 1 kg fresh samples in an oven of 60^{o}C to a constant weight, weight loss was written down and the samples were ground using a Wiley mill standard model No.3 with sieve of 0.5mm. The dry DM content for each sample was determined by drying at 105^{o}C in an oven for 5hrs. Subsequently, the biomass yield (dry matter) per ha was estimated.

3.6.8 Proximate composition

Dried milled samples were analyzed following the Association of Official Analytical Chemist, (1995) procedure for dry matter, Ash, crude protein, Ether extract (lipids), Crude fibre, and Nitrogen-free extract (carbohydrates). Dry matter digestibility was done using the two level of *invitro* dry matter digestibility following the Tilley & Terry, (1963) protocol.

3.7 Data analysis

The data on height, tillers/ plant, leaf to stem ratio, number of leaves/ plant, leaf area, green and DM and proximate composition for the two Rhodes grass was summarized in excel spread sheet and analyzed using Predictive Analytics Software-PASW 26. Analysis of variance (ANOVA) was conducted to determine if there were significant differences between treatment means at ($P<0.05$). Post hoc test using Least Significant difference (LSD) was conducted if the ANOVA indicated that there were significant differences ($P<0.05$).

CHAPTER FOUR

RESULTS AND DISCUSSION

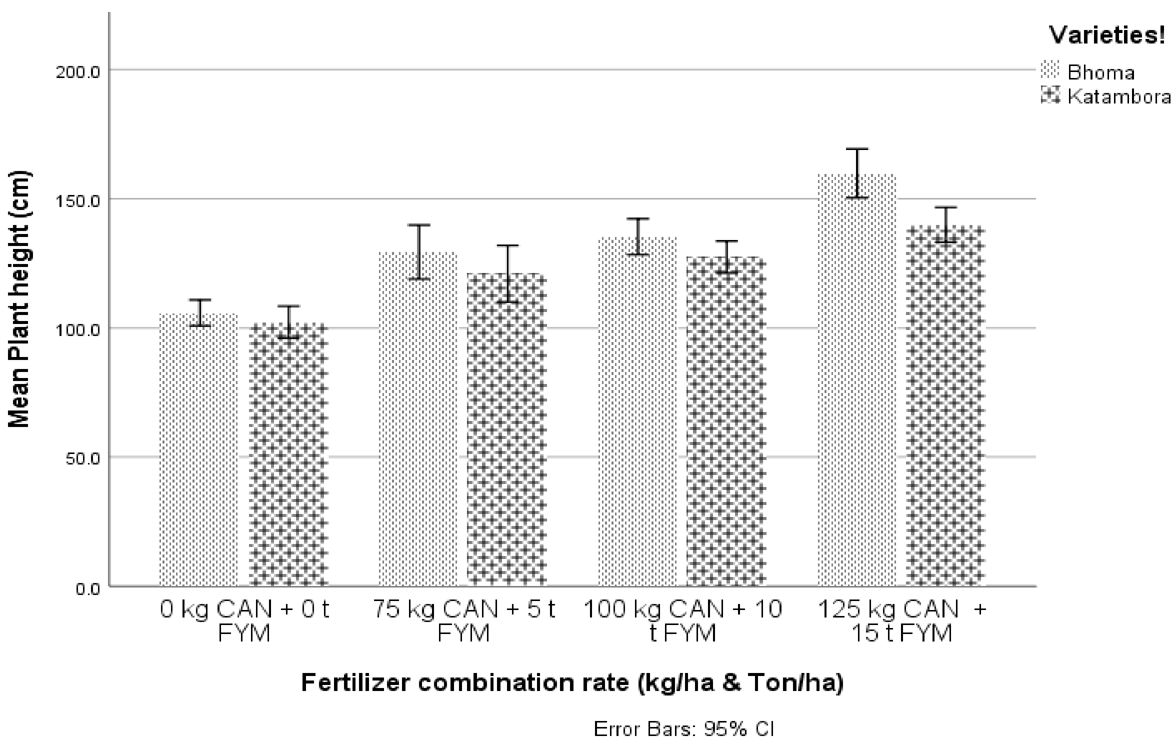
This chapter presents a summary of the outcomes of the study and the results are presented systematically based on the research objectives.

4.1. Effect of fertilizer combinations on plant height

The height of the three tagged plants of each variety was measured using of a ruler from the base to the top of the leaf.

Figure 4.1

Effects of fertilizer combinations on plant height



The figure 4.1 showed that the treatment L4 produced the highest plant height followed by treatment L3 for both Bhoma Rhodes and Katambora Rhodes grass while the control had the lowest plant height in both varieties. In all treatments, the Bhoma variety depicted higher plant height compared to Katambora Rhodes grass variety.

Table 4.1

ANOVA table for plant height

Source	Sum of Squares	Df	Mean Square	F	Sig.
Blocks	840.158	8	105.020	.921	.506
Treatments	19247.295	3	6415.765	56.247	.000
Varieties	1772.109	1	1772.109	15.536	.000
Error	6729.774	59	114.064		
Total	28589.335	71			

a. R Squared = .765 (Adjusted R Squared = .717)

The analysis of variance ((ANOVA) showed that there was statistically significant difference ($P<0.05$) on the height of the two varieties at different levels of fertilizer combination. Also between varieties there was significant difference in in height. A post hoc test was then conducted to determine where the differences were.

Table 4.2

Post hoc test for Plant height

	L1	L2	L3	L4
L1		-21.122*	-27.322*	-45.789*
L2			-6.200	-24.667*
L3				-18.467*
L4				

*. The mean difference is significant at the 0.05 level

From the post hoc (table 4.2), it was found that there were statistically significant difference between control L1 and L2, L1 and L3, L1 and L4. The results indicated that height was positively affected by fertilization and manure at all the levels; however there was no difference between L2 and L3.

The results obtained in this study on plant height were similar to those of Mabu et al., (2019) who found significant ($P<0.05$) effect of increasing levels of nitrogen fertilizer on plant height of Rhodes grass. The taller heights of Rhodes grass obtained due to use of 125kgNha-1 indicated that the higher nitrogen fertilizer dose was needed in order to produce tall Rhodes grass plants in the research area. Ogedegbe & Ewansiha, (2016) also found out that there was significant difference on heights of Rhodes with increase in the levels of fertilizer and manure. Abate et al., (2020) on their study on effect of varying amounts of nitrogen fertilizer on biomass, seed yield and CP content of Rhodes Grass found out that there was significant effect of increasing levels of nitrogen on the height of Rhodes grass**.**

4.2 Effects of fertilizer combinations on number of tillers

Total number of tillers was counted on each of the three tagged plants in each plot for the two varieties. This parameter indicated the productivity aspect of a plant.

Figure 4.2

Effects of fertilizer combinations on number of tillers

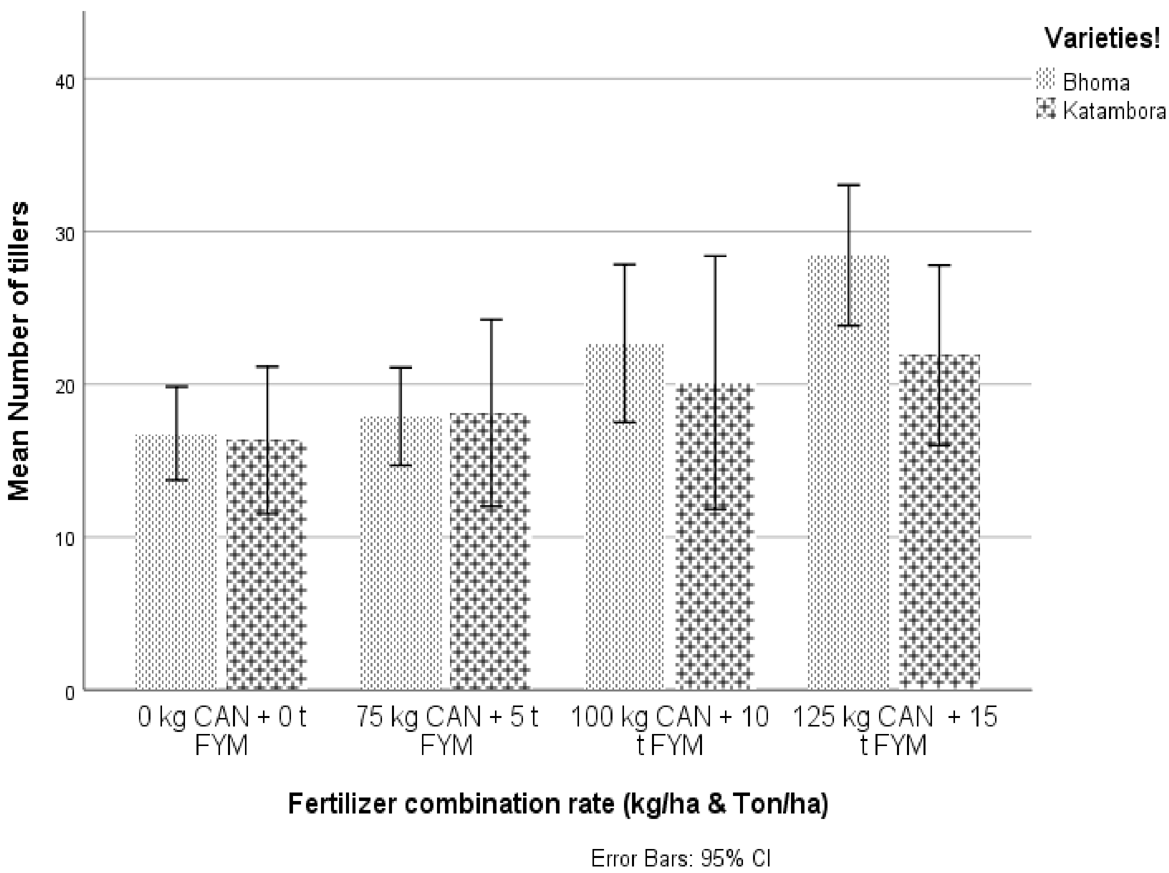


Figure 4.2 showed that Bhoma Rhodes grass variety produced more number of tillers than Katambora in all treatments while treatment L4 had the highest number of tillers for both Bhoma Rhodes and Katambora Rhodes grass. The number of tillers ranged from 16 to 28 tillers per plant

from control treatment to the highest treatment level of 125kg CAN and 15tons FYM. This is attributed to higher nutrients.

Table 4.3

ANOVA table for number of tillers

Source	Sum of Squares	Df	Mean Square	F	Sig.
Blocks	440.444	8	55.056	1.152	.344
Treatments	795.222	3	265.074	5.544	.002
Varieties	98.000	1	98.000	2.050	.158
Error	2820.778	59	47.810		
Total	4154.444	71			

a. R Squared = .321 (Adjusted R Squared = .183)

The analysis of variance (ANOVA) showed that there was statistically significant difference ($P<0.05$) on number of tillers at different levels of fertilizer combination but between varieties there was no significant difference. A post hoc test was then conducted to determine where the differences were. The post hoc results are shown in table 4.4.

Table 4.4

Post hoc test for number of tillers

	L1	L2	L3	L4
L1		-1.44	-4.83*	-8.61*
L2			-3.39	-7.17*
L3				-3.78
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

From the post hoc results (table 4.4), it was found that there were statistically significant difference between control 213 (L1) and L3 and between L1 and L4 while there was no significant difference between control (L1) and L2 and between L2 and L3.

The results on the number of tillers conformed to those of Allah & Bello, (2019) found out that application of nitrogen fertilizer significantly increase the number of tillers per plant of guinea plant. Also Arshad et al., (2016) reported that increase in the levels of nitrogen had significant effect on number of tillers per plant .

Different findings were obtained by Arshad et al., (2015). The author recorded the lower tillers per plant in Rhodes grass when applying 100 kg / acre of nitrogen could be due to the difference in the types of fertilizers used at the establishment, varying dosage of fertilizer applications and plant management level. From earlier reports, applying high or low NP levels declined Rhodes grass yield and yield components. Rapid tiller production, mainly during establishment time, is an expected feature for high DM production, tolerance and weed control (Arshad et al., 2016).

4.3 Effects of fertilizer combinations on number of leaves for Rhodes grasses

The number of leaves was counted on the three tagged plants of each variety per plot as a way of determining the productivity of the two varieties. Then the average number of leaves/ plant was obtained.

Table 4.5

Effects of different levels of combination of fertilizers on number of leaves

Leaf per plant	Rhodes grass Varieties	
Treatments	Bhoma.R	Katambora.R
L1	107	93
L2	109	109
L3	156	110
L4	184	138

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

In application of all treatments, Bhoma Rhodes grass had more number of leaves than Katambora variety while Bhoma had more number of leaves in treatment L4.The number of leaves ranged from 93-138 and 107-184 for Katambora and Bhoma Rhodes varieties respectively.

Table 4.6

ANOVA table for number of leaves

Source	Sum of Squares	Df	Mean Square	F	Sig.
Blocks	36140.278	8	4517.535	4.843	.000
Treatments	41213.944	3	13737.981	14.728	.000
Varieties	12587.556	1	12587.556	13.494	.001
Error	55035.500	59	932.805		
Total	144977.278	71			

a. R Squared = .620 (Adjusted R Squared = .543)

The analysis of variance ((ANOVA) showed that there was statistically significant difference ($P<0.05$) on number of leaves at different levels of fertilizer combination but between varieties, there was significant difference in the number of leaves. A post hoc test was then conducted to determine where the differences were.

Table 4.7

Post hoc test for number of Leaves

	L1	L2	L3	L4
L1		-9.00	-33.78*	-61.56*
L2			-24.78*	-52.56*
L3				-27.78*
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

From the post hoc results (table 4.7), it was found that there were statistically significant difference ($P<0.05$) between control (L1) and L3, control (L1) and L4 while there was no significant difference ($P>0.05$) between control (L1) and L2.

The increase in the number of leaves enables plant to trap more sunlight to be used in photosynthesis, a process by which a plant manufactures its own food through use of sunlight and carbon dioxide.

The results on the number of leaves obtained in this study conformed to those of Arshad et al., (2016) who reported that increase in the levels of nitrogen let to significantly more number of leaves of Rhodes grass. Brima & Abusuwar, (2020) on their study on influence of seed rate and NPK fertilizer on yield and quality of Rhodes grass (*Chloris gayana* L. kunth) observed from the results of growth attributes that fertilizer increased number of leaves per plant.

Brima, (2007) indicated that the mean number of leaves / Rhodes grass plant had been ominously affected by NPK.

In other analysis by Nadaf et al., (2004), the number of leaves in the main tillers of pure Rhodes grass was 4.5 to 7.0 in the summer and 4.0 to 5.0 in the winter, whereas in the Rhodes grass portion the number of leaves in mixtures was 4 to 7 in the summer compared to 2-4 in the winter leaf period. However, Saad, (2010); Arshad et al., (2019) & Arshad, (2015), when researching on various Rhodes grass varieties, reported higher figures. The difference could be due to variation in varieties of Rhodes grass that were used during the experiment and the part of the grass the number of leaves were counted from, for this study the whole number of leaves per plant were counted. Research have shown that higher leaf quantity is anticipated quality in fodder species because the leaves have higher nutritive quality thereby, making them more digestible and increase animal dry matter intake (Adam, 2004). Higher leaf number will also give the plant the chance to trap adequate sunlight for photosynthesis to take place. Ismael, (2007) reported that application of manure in forage increased the yield of different types of fodder plant significantly.

4.4 Effects of fertilizer combinations on number of nodes for Rhodes grasses

Number of nodes per plant was counted on the three tagged plants of each variety per plot. The parameter also indicates productivity of a given fodder.

Table 4.8

Effects of fertilizer combinations on number of nodes

Nodes/Plant	Rhodes grass Varieties	
Treatments	Bhoma.R	Katambora.R
L1	6	6
L2	8	6
L3	9	7
L4	10	8

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3=100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

The highest number of nodes was recorded with treatment L4 for both varieties of grass.

Table 4. 9

ANOVA table for number of nodes per plant

Source	Sum of Squares	Df	Mean Square	F	Sig.
Blocks	170.250	8	21.281	3.208	.004
Treatments	120.153	3	40.051	6.038	.001
Varieties	28.125	1	28.125	4.240	.054
Error	391.347	59	6.633		
Total	709.875	71			

a. R Squared = .449 (Adjusted R Squared = .337)

The analysis of variance ((ANOVA) showed that there was statistically significant difference (P>0.05) on number of nodes at different levels of the fertilization while there was no significant difference in the number of nodes between the two varieties.

Table 4.10

P*ost hoc test for number of nodes*

	L1	L2	L3	L4
L1		-.56	-2.11^{*}	-3.28^{*}
L2			-1.56	-2.72^{*}
L3				-1.17
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2= 75 kg CAN + 5 T FYM, L3=100 kg CAN + 10 T FYM L4 =125 kg CAN + 15 T FYM

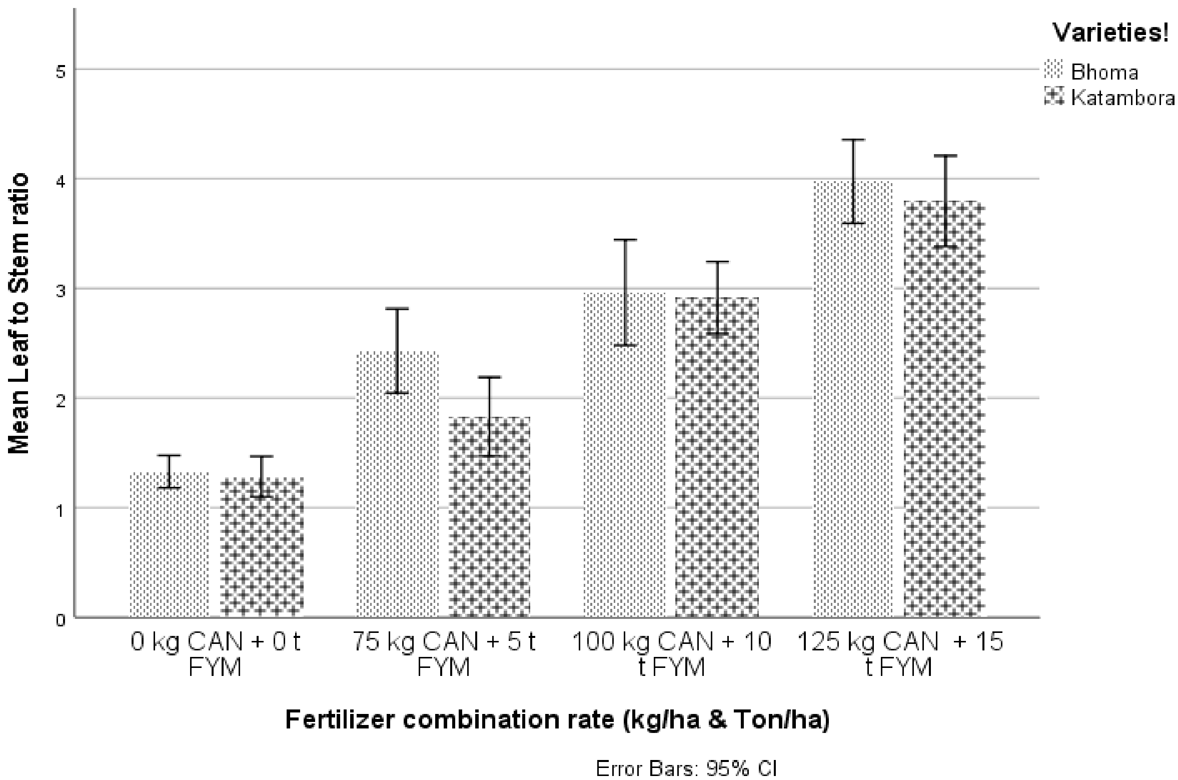
From the post hoc results (table 4.10), it was found that there were statistically significant difference (P<0.05) between control (L1) and L3, control (L1) and L4 while there was no significant difference (P>0.05) between control (L1) and L2, L2 and L3, L3 and L4.The number of nodes were positively affected by treatment L3 and L4 when compared to L1 while L4 did not have any significant effect in relation to L3.

The increase in the number of nodes as fertilizers are increase is attributed to adequate nutrients obtained by the plant leading to elongation of the stem and consequently the number of nodes. The number of nodes ranged from 5-10 from control to highest level of 125 kg CAN/ha and 15tons/ha FYM for both varieties.

4.5 Effects of fertilizer combinations on leaf to stem ratio

Figure 4.3

Effects of fertilizer combinations on leaf to stem ratio



The highest leaf to stem ratio was recorded with the application of the highest level of fertilizer combination for both varieties with Bhoma variety recording a higher leaf to stem ratio. The leaf to stem ratio ranged from 1-3.4 from control to highest level of 125 kg CAN/ha and 15tons/ha FYM for both varieties. This is contributed by adequate nutrients obtained by the plant leading to more growth of leaves than stems number of leaves than the stems.

Table 4.11

ANOVA table for leaf to stem ratio

Source	Sum of Squares	Df	Mean Square	F	Sig.
Blocks	5.304	8	.663	4.342	.000
Treatments	65.814	3	21.938	143.679	.000
Varieties	.854	1	.854	5.591	.021
Error	9.009	59	.153		
Total	80.980	71			

a. R Squared = .889 (Adjusted R Squared = .866)

The analysis of variance (ANOVA) showed that there was statistically significant difference ($P<0.05$) of applying a combination of farmyard manure with CAN fertilizer at different rates on the leaf to stem ratio for the two varieties of Rhodes grass. Between the two varieties there was significant difference in leaf to stem ratio.

Table 4.12

Post hoc test for Leaf to stem ratio

	L1	L2	L3	L4
L1		-.82*	-1.63*	-2.58*
L2			-.81*	-1.76*
L3				-.95*
L4				

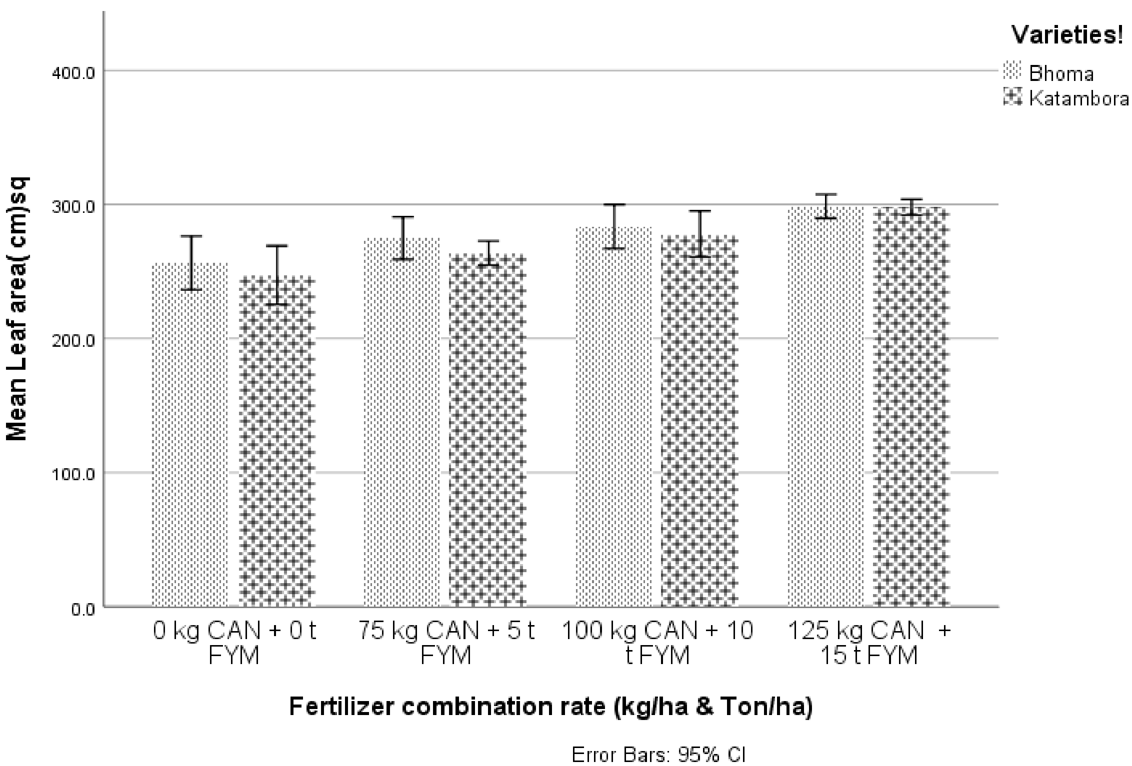
*. The mean difference is significant at the 0.05 level

There were statistically significant difference ($P<0.05$) between control (L1) and L2, L1 and L3, L1 and L4. The results indicated that the increase in leaf to stem ratio was influenced by all the treatments. These results of leaf to stem ratio were in agreement with those of (Brima & Abusuwar, 2020) who reported that increase in the fertilizer levels led to higher leaf to stem ratio. The results were also similar to those of Yossif & Ibrahim, (2013) who subjected Rhodes grass on different types of farm yard manure with urea combination.

4.6 Effects of fertilizer combinations on leaf area

Figure 4.4

Effects of fertilizer combinations on leaf area for Rhodes grass varieties



The highest leaf area was recorded with the application of fertilizer combination level 4 while the lowest was recorded with the control for both varieties. The leaf to leaf area ranged from 148.0 -198.6 from control to highest level of 125 kg CAN/ha and 15 tons/ha FYM for both varieties. This is contributed by adequate nutrients obtained by the plant leading to more growth of leaves. This parameter of leaf area is good for plant growth since the more surface of leaf is exposed to sunlight hence photosynthetic process takes place.

Table 4.13

ANOVA table for Leaf area (cm^2)

Source	Sum of Squares	Df	Mean Square	F	Sig.
Blocks	5933.216	8	741.652	2.209	.039
Treatments	20504.862	3	6834.954	20.354	.000
Varieties	801.267	1	801.267	2.386	.128
Error	19812.091	59	335.798		
Total	47051.436	71			

a. R Squared = .579 (Adjusted R Squared = .493)

The analysis of variance ((ANOVA) showed that there was statistically significant difference ($P<0.05$) of applying a combination of farmyard manure with CAN fertilizer at different rates on the leaf area for the two varieties of Rhodes grass.

Table 4.14

Post hoc test for Leaf area (cm^2)

	L1	L2	L3	L4
L1		-17.372*	-28.848*	-46.332*
L2			-11.476	-28.959*
L3				-17.484*
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM L4 =125 kg CAN + 15 T FYM

From the post hoc (table 4.14 above), it was found that there were statistically significant difference ($P<0.05$) between control and L2, control and L3, control and L4. The results indicated that increase in leaf area was affected by application of the three levels of the combination of fertilizers in comparison to control while there was no significant difference (P>0.05) between L2 and L3.

For leaf area, results in this study were in conformed to those of Arshad et al., (2016) who reported a significant effect on leaf area with increasing level of nitrogen. (Brima & Abusuwar, 2020) on their study on Influence of seed rate and NPK fertilizer on yield and quality of Rhodes grass (*Chloris gayana* L. kunth) observed from the results of growth attributes that fertilizer increased leaf area. Mirza et al., (2002) reported high results than those obtained in this study. The disparity in the leaf area of Rhodes grass with different rates of fertilizer applications in this study and other authors may be due to the genetic variation of Rhodes grass or different dosages of fertilizers and fertilizer types used at establishment level.

4.7 Effects of fertilizer combinations on biomass yields of two varieties of Rhodes grass

The fresh and dry weights of the two varieties were measured and recorded as shown in tables 4.15 and 4.16.

Table 4.15

Effects of fertilizer combinations on Green matter yields

Fresh matter t/ha	Varieties of Rhodes grass	
Treatments	Bhoma.R	Katambora.R
L1	20.0	17.3
L2	22.2	18.8
L3	23.6	21.0
L4	24.8	22.3

Key L1=0kg CAN + 0 T FYM, L2= 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

Highest green matter yield was recorded by treatment L4 in both varieties.

Table 4.16

ANOVA table for fresh weight (t/ha)

Source	Sum of Squares	Df	Mean Square	F	Sig.
Blocks	9.082	8	1.135	.228	.984
Treatments	247.076	3	82.359	16.536	.000
Varieties	139.445	1	139.445	27.998	.000
Error	293.856	59	4.981		
Total	689.459	71			

a. R Squared = .574 (Adjusted R Squared = .487)

The analysis of variance ((ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had significant effects (P<0.05) on green matter yields of both varieties of Rhodes grass .Between varieties, there was significant difference in the fresh weight. The results are shown in table.

Table 4.17

Post hoc test for Fresh weight (t/ha)

	L1	L2	L3	L4
L1		-1.86*	-3.64*	-4.91*
L2			-1.78*	-3.05*
L3				-1.27
L4				

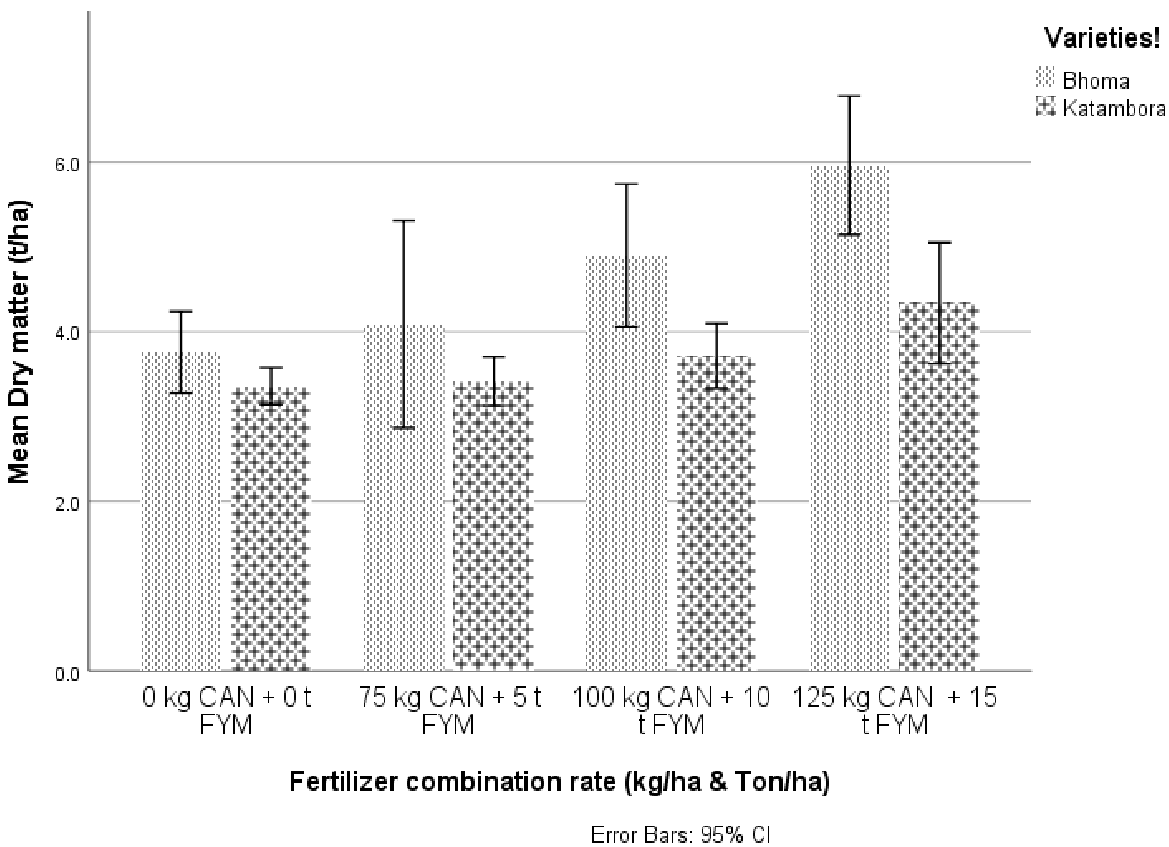
*. The mean difference is significant at the 0.05 level

From the post hoc (table 4.17), it was found that there were statistically significant difference (P<0.05) between control (L1) and L2, control (L1) and L3, control (L1) and L4. The results indicated that increase in leaf area was affected by all the treatments in comparison to control while there was no significant difference (P>0.05) between L3 and L4.

The results of green matter yields were agreement to those recorded by Arshad et al., (2016) that nitrogen fertilizer treatments differed significantly for green fodder yield in all eight cuts of Rhodes grass in Nigeria. Ogedegbe & Ewansiha, (2016) noted that fresh weight yields of Rhodes grass differed significantly with different rates of applied fertilizers. The results were also similar to those of (Brima & Abusuwar, 2020) who stated that forage fresh weight was significantly increased with increasing level of application of chemical fertilizer and manure.

Figure 4.5

Effects of fertilizer combinations on dry matter yields for Rhodes grass varieties



Highest dry matter yield was recorded with treatment L4 while control recorded the lowest for the two varieties of Rhodes grass respectively. The higher production resulting from high of fertilization of Rhodes grass could be due to increase amount of nutrients in the soil.

Table 4.18

ANOVA table for Dry matter (t/ha)

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	27.410	3	9.137	12.023	.000
Varieties	16.927	1	16.927	22.274	.000
Block	11.802	8	1.475	1.941	.070
Error	44.836	59	.760		
Total	100.974	71			

a. R Squared = .556 (Adjusted R Squared = .466)

The analysis of variance ((ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had significant effects (P<0.05) on dry matter yields of both varieties of Rhodes grass .The varieties also varied significantly in the dry matter production with Bhoma Rhodes variety producing higher amounts .

Table 4.19

Post hoc test for Dry matter (t/ha)

	L1	L2	L3	L4
L1		-.193	-.748*	-1.589*
L2			-.556	-1.397*
L3				-.841*
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3=100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

From the post hoc (table 4.19), it was found that there were statistically significant difference (P<0.05) between control (L1) and L3, control (L1) and L4. The results indicated that dry matter yields were positively affected by L3 and L4 in comparison to control while there was no significant difference ($P>0.05$) between L1 and L2 and between L2 and L3.

The results on dry matter (herbage yield) was similar to those of Delevatti et al., (2019) who reported significant effect ($P < 0.05$) while evaluating effects of adding more nitrogen in Marandu grass (*Brachiaria brizantha).* Nemera et al., (2017) also reported that dry matter production was of the natural grassland was significantly influenced by the use of both organic and inorganic fertilizers. Both manure and nitrogen increased dry matter yields of Rhodes grass. Patil et al., (2016) noted that an increase in the nitrogen level significantly increased production of Rhodes grass from 6.74 to 7.76 t ha-1 5.13% increase) in the first harvest, and from 7.98 to 8.52 t ha-1 (i.e. 6.77%) in the second harvest. The production of dry matter of the natural grassland was significantly influenced ($P<0.01$) by the use of both organic and inorganic fertilizer (Mabu et al., 2019). This is attributed to the fact that nitrogen increases the photosynthetic capacity of growing plants, which enhances growth to produce adequate dry matter. This is because animal manure produced a lot of oil and a relatively small percentage of plant food during the decomposition of farm yard manure. Some of the Ismael, (2007) related results revealed that dry weight forage was significantly affected by higher NPK fertilization rates. Manure has reportedly considerably increased the yield of various forages. In their study, the maximum plant population and dry matter yield was achieved by application of chicken manure but the minimum fresh yield was attained by farm yard and chicken manure (Yossif & Ibrahim, 2013; Adam, 2004; Olanite et al., 2014). Similarly, findings from Kunene et al., (2019) showed that the highest growth rate and production of green matter was achieved from plants treated with chicken manure.

Rhodes grass herbage yields generally vary with cultivar size, plant age, environmental factors and different types of fertilizers used. Production of the second year may double those of the first year of establishment, but this also relies on crop husbandry and weather conditions (Ojo et al., 2015).

4.8 Effects of fertilizer combinations on chemical qualities of Rhodes grass

The two varieties of Bhoma Rhodes grass varied significantly ($P<0.05$) in their Invitro-Dry matter digestibility, % CP, % CF,% EE,% NFE and % DM content except metabolizable energy.

4.8.1 Effects of fertilizer combinations on % dry matter content

Table 4.20

Effects of fertilizer combinations on % dry matter content

%DM	Varieties of Rhodes grass	
Treatments	Bhoma.R	Katambora.R
L1	26.5	26.3
L2	27.0	26.8
L3	27.4	27.0
L4	27.8	27.4

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

Bhoma Rhodes grass produced higher % dry matter content in all treatments than Katambora variety. The treatment L4 produced highest % dry matter in both varieties in relation to other treatments**.**

Table 4.21

ANOVA table for % Dry Matter

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	4.370	3	1.457	27.935	.000
Varieties	.603	1	.603	11.565	.003
Block	2.289	2	1.144	21.949	.000
Error	.886	17	.052		
Total	8.148	23			

a. R Squared = .891 (Adjusted R Squared = .853)

The analysis of variance ((ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had significant effects (P<0.05) on % dry matter yields .The was also significant difference between the two varieties of Rhodes grass with Bhoma Rhodes grass producing more than Katambora variety. The post hoc test was carried out to determine where the differences were.

Table 4.22

Post hoc test for % Dry Matter

	L1	L2	L3	L4
L1		-.483*	-.784*	-1.167*
L2			-.301*	-.683*
L3				-.383*
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

From the post hoc (table 4.22), it was found that there were statistically significant difference (P<0.05) between control (L1) and L2, control (L1) and L3, control (L1) and L4. The results indicated that increase in % dry matter was affected by application of the three levels of the combination of fertilizers in comparison to control.

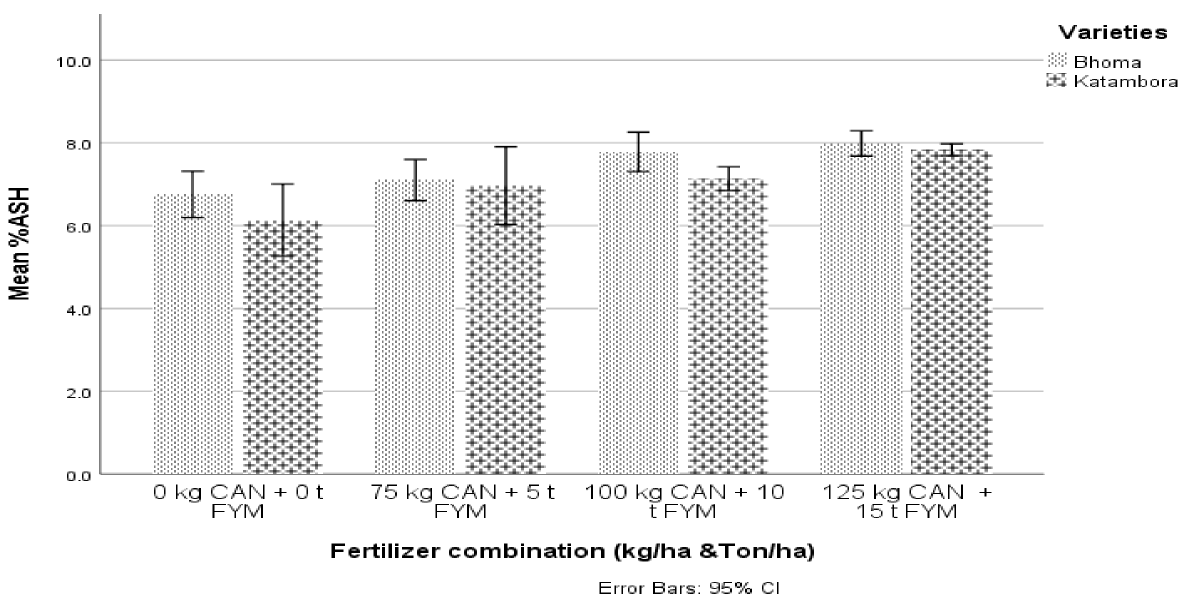
The results on dry matter (herbage yield) was similar to those of Delevatti et al., (2019) who reported significant effect ($P < 0.05$) while evaluating effects of adding more nitrogen in Marandu grass (*Brachiaria brizantha).* Nemera et al., (2017) also reported that dry matter production was of the natural grassland was significantly influenced by the use of both organic and inorganic fertilizers. Both manure and nitrogen increased dry matter yields of Rhodes grass

4.8.2 Effects of fertilizer combinations on % Ash content for Rhodes grass varieties

Ash is an organic carbon free substance which remains at 60^{o}C. It is has essential and nonessential minerals along with plant silica. Minerals are acid soluble material while plant silica is acid insoluble. Ash has essential minerals that help in the normal physiological functions of the animal's body (Nemera et al., 2017).

Figure 4.6

Effects of fertilizer combinations on % Ash content



Bhoma Rhodes grass produced higher % Ash content in all treatments than Katambora. The treatment L4 produced highest % Ash in both varieties in relation to other treatments**.**

Table 4.23

ANOVA table for %   Ash

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	7.015	3	2.338	55.379	.215
Block	.904	1	.904	21.420	.130
Varieties	.496	2	.248	5.877	.021
Error	.718	17	.042		
Total	9.133	23			

a. R Squared = .376 (Adjusted R Squared = .156)

The analysis of variance (ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had no significant effect ($P<0.05$) on % Ash of both varieties of Rhodes grass.

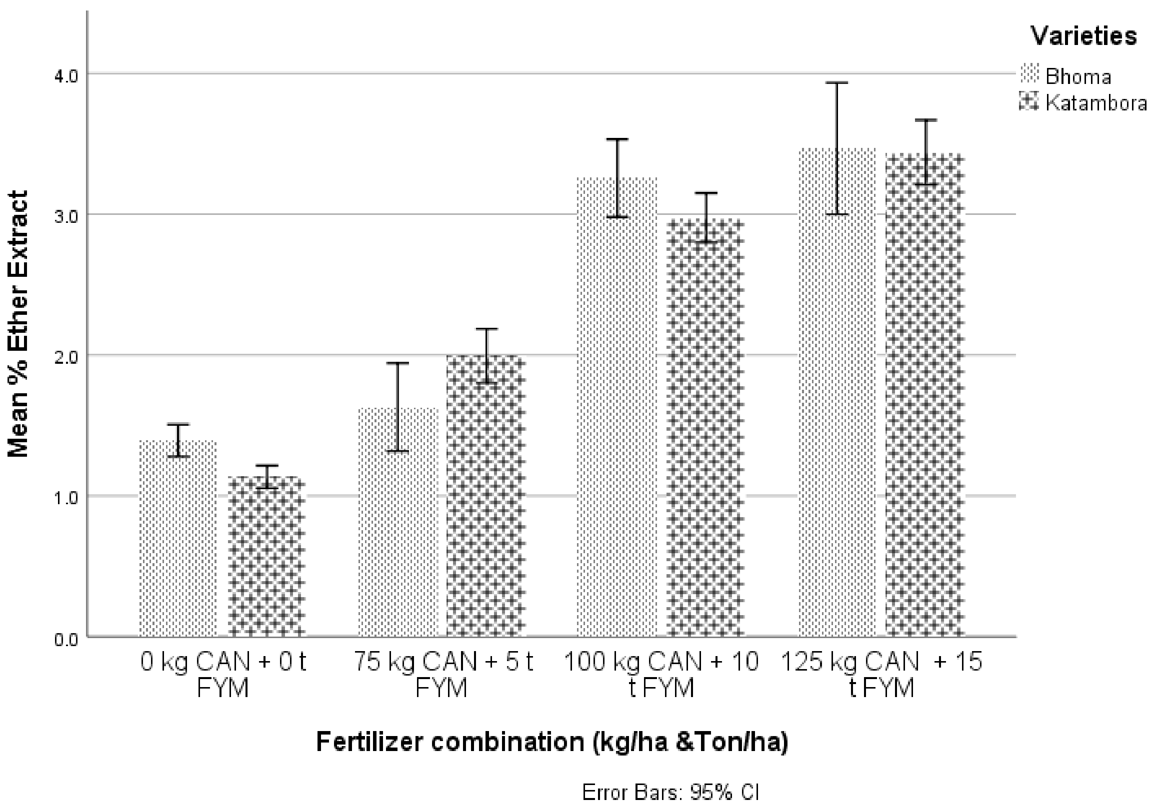
The results conformed to those of Arshad et al., (2016) who reported that nitrogen had no significant effect in ash content of Rhodes grass(*Chloris gayana*). Yossif, & Ibrahim, (2013) while studying on effect of Organic and inorganic fertilizers on quality of Rhodes Grass (Chloris gayana L. Knuth) also noted that fertilizers did not have significant effect on crude fibre.

4.8.3 Effects of fertilizer combinations on % ether extract for Rhodes grass varieties

The ether extract contents include of fats, oils, waxes, organic acids, pigments, sterols and vitamins A, D, E and K. Vitamins are of great importance in animal breeding.

Figure 4.7

Effects of fertilizer combinations on % ether extract for Rhodes grass varieties



The % ether extract increased with levels of fertilizers while the variety Bhoma Rhodes had higher levels of ether extract in all fertilization levels as compared to Katambora variety.

Table 4.24

ANOVA table for % Ether Extract

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	11.452	3	3.817	13.095	.000
Block	.468	1	.468	1.607	.222
Varieties	2.667	2	1.333	4.574	.012
Error	4.955	17	.291		
Total	19.542	23			

a. R Squared = .746 (Adjusted R Squared = .657)

The analysis of variance ((ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had significant effect ($P<0.05$) on % ether extract of both varieties of Rhodes grass.

Table 4.25

Post hoc test for % ether extract

	L1	L2	L3	L4
L1		-.332	-1.381*	-1.648*
L2			-1.049*	-1.315*
L3				-.267
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2= 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

The post hoc results indicated that there was a statistically significant difference between L1 and L2, L3 and L4.There was also significant difference between L2 and L3 and L2 and L4 and between L3 and L4 ($P>0.05$).

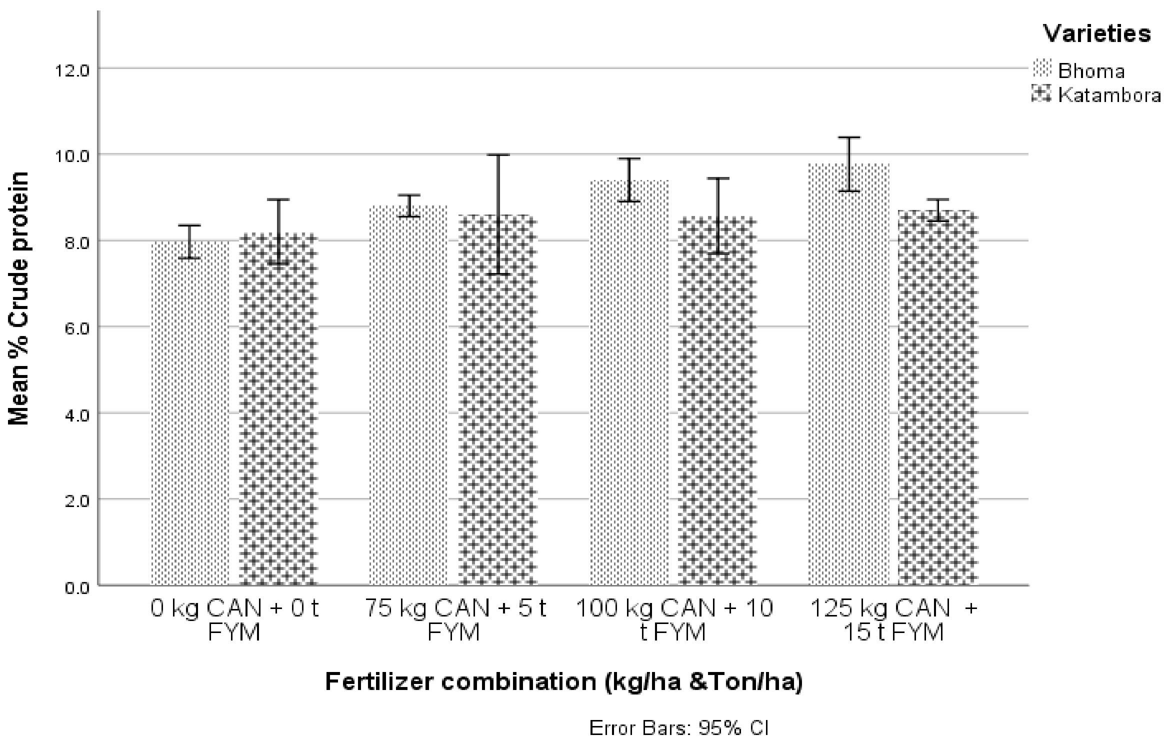
The results were within the range of tropical grasses as reported by Ahmed & Suliman, (2015) to be between 1.00 to 4.00.

4.8.4 Effect of fertilizer combinations on % crude protein content for Rhodes grasses

Crude protein is the amount of protein of animal feed. CP depends on the nitrogen levels of the food proteins. It is calculated as mineral nitrogen x 6.25. The mineral nitrogen value is obtained by the Kjeldahl method (Delevatti et al., 2019).

Figure 4.8

Effect of fertilizer combinations on % crude protein content for Rhodes grasses



Bhoma Rhodes grass produced the highest % crude protein content in all fertilizer combination than Katambora Rhodes grass variety.

Table 4.26

ANOVA table for % crude protein

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	4.410	3	1.470	10.981	.000
Block	1.307	1	1.307	9.761	.006
Varieties	.648	2	.324	2.418	.119
Error	2.276	17	.134		
Total	8.640	23			

a. R Squared = .737 (Adjusted R Squared = .644)

The analysis of variance ((ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had significant effect (P<0.05) on % crude protein but between the two varieties, there was no significant difference.

Table 4.27

Post hoc test for % crude protein

	L1	L2	L3	L4
L1		-.617*	-.900*	-1.150*
L2			-.283	-.533*
L3				-.250
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

The post hoc results indicated that there was a statistically significant difference between L1 and L2, L1 and L3 and L1 and L4. There was no significant difference between L2 and L3, and L3 and L4.

Use of farm yard manure and nitrogen affected the CP in the two varieties. The amount of CP increased with increasing fertilizer levels. This is caused by high rate of synthesis of amino acids and proteins. In this study, CP increased linearly ($P < 0.05$), from the lowest to the highest with fertilizer application rate (figure 4.8 above). The results agreed with those of Delevatti et al., (2019) who reported significant effect of nitrogen in CP content of Marandu grass. The results also concurred with those of Allah & Bello, (2019) who reported that nitrogen increased the CP of Rhodes grass by 15% at the early stage of growth.

On the other hand, CP of unfertilized plants showed that the soils have not had sufficient nutrients to support optimal growth of Rhodes grass. Hence, the CP depends on nitrogen and manure which, in turn, relies on the level of organic matter in the soil. Nitrogen influence plant growth and physiological processes, as it enters all enzymes composition and enhances vegetative growth and production. Abate et al., (2020) on their study on effect of different levels of nitrogen on biomass, seed yield and CP of Rhodes Grass found out that there was significant effect of increasing levels of nitrogen on the CP content of Rhodes grass.

4.8.5 Effect of fertilizer combinations on % crude fibre content for Rhodes grasses

Crude fiber mainly consists of cellulose, hemi cellulose and lignin. The lignin contents reduce the digestibility of forage.

Table 4.28

Effects of fertilizer combinations on % crude fibre content for Rhodes grasses

% CF	Varieties of Rhodes grass	
Treatments	Bhoma.R	Katambora.R
L1	34.9	36.6
L2	34.7	35.7
L3	33.9	35.2
L4	33.3	34.0

Katambora Rhodes grass produced higher % crude fibre in all fertilizer combination compared to Bhoma. The zero fertilization level produced the highest % crude fibre content in both varieties in relation to other treatments**.**

Table 4.29

ANOVA Summary for % Crude fibre

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	14.445	3	4.815	84.059	.000
Block	.961	2	.480	8.387	.003
Varieties	8.760	1	8.760	152.942	.000
Error	.974	17	.057		
Total	25.140	23			

a. R Squared = .961 (Adjusted R Squared = .948)

The analysis of variance ((ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had significant effect ($P<0.05$) on % crude fibre of both varieties of Rhodes grass.

Table 4.30

Post hoc test for % crude fibre

	L1	L2	L3	L4
L1		.533*	1.167*	2.083*
L2			.633*	1.550*
L3				.917*
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

The post hoc results indicated that there was a statistically significant difference between L1 and L2, L1 and L3 and L1 and L4. There was also significant difference between L2 and L3, L2 and L4 and L3 and L4.

The results indicated that crude fibre decreased linearly with increasing levels of nitrogen. The results were similar to those of Delevatti et al., (2019) who found out that increase in levels of nitrogen had significant effects on NDF. (Brima & Abusuwar, 2020; Yossif & Ibrahim, 2012) in their studies also found out that increased nitrogen level led to lower levels of fiber content of Rhodes grass. This is linked to the quality of the fodder because with increase in quality, the crude fibre content is reduced.

4.8.6 Effects of fertilizer combinations on % nitrogen free extract

Nitrogen free extract represents soluble carbohydrates and other digestible and easily utilizable non-nitrogenous substances in feed. %NFE = 100-(% moisture + % CF + %CP + %EE + %Ash).

Table 4.31

Effects of fertilizer combinations on % nitrogen free extract

% NFE	Varieties of Rhodes grass	
Treatments	Bhoma.R	Katambora.R
L1	48.1	45.9
L2	48.9	47.5
L3	49.3	48.9
L4	50.3	49.3

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

Bhoma Rhodes grass produced higher % nitrogen free extract in all treatments than Katambora.

Table 4.32

ANOVA table for % Nitrogen free extract

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	25.930	3	8.643	10.484	.006
Varieties	9.375	1	9.375	11.372	.018
Block	10.973	2	5.487	6.655	.007
Error	14.015	17	.824		
Total	60.293	23			

a. R Squared = .317 (Adjusted R Squared = .076)

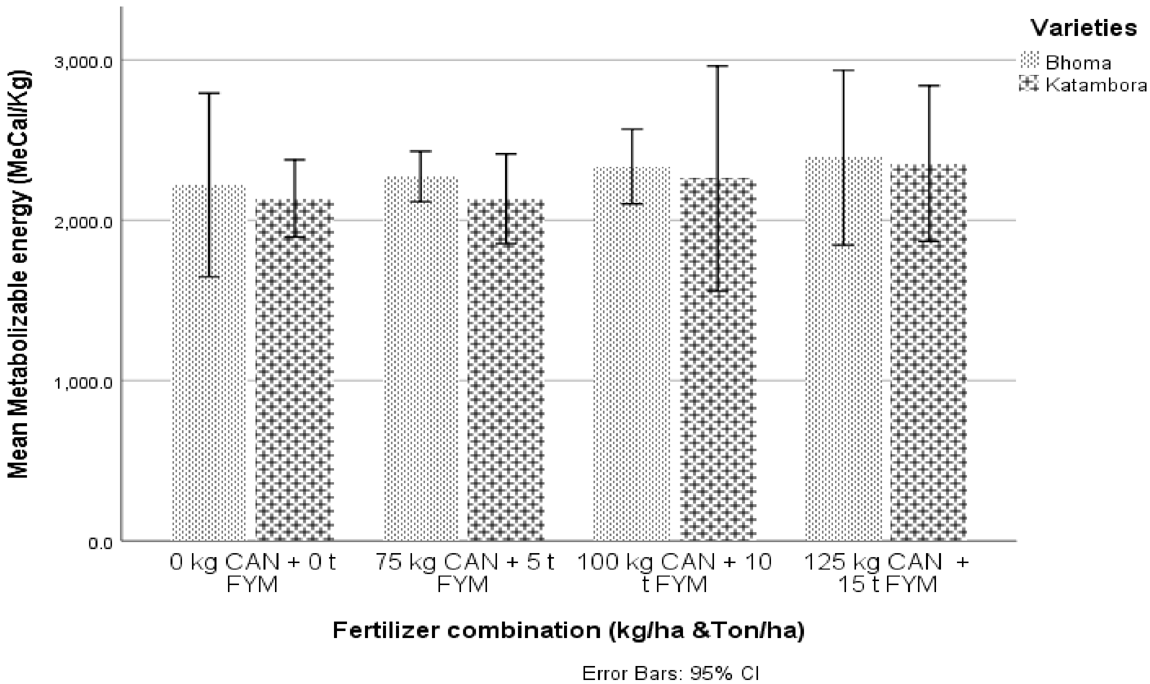
The analysis of variance (ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had no significant effect ($P<0.05$) on % nitrogen free extract of both varieties of Rhodes grass. The results were in agreement with those of Arshad et al., (2016) who stated that nitrogen had no significant effect on the nitrogen free extract of Rhodes grass.

4.8.7 Effects of fertilizer combinations on metabolizable energy for Rhodes grass

Metabolizable Energy (ME) is the net energy that remains after digestible energy has been used. It represents the energy of a feed available for growth or reproduction and for supporting metabolic.

Figure 4.9

Effects of fertilizer combinations on metabolizable energy for Rhodes grass



Bhoma Rhodes grass produced higher metabolizable energy content in all treatments than Katambora variety. The treatment L4 produced the highest metabolizable energy content in both varieties in relation to other treatments.

Table 4.33

ANOVA table for Metabolizable energy (MeCal/Kg)

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	144180.667	3	48060.222	1.511	.248
Block	4121.906	2	2060.953	.065	.938
Varieties	12640.758	1	12640.758	.397	.537
Error	540819.804	17	31812.930		
Total	701763.136	23			

a. R Squared = .229 (Adjusted R Squared = -.043)

The analysis of variance (ANOVA) showed that different rates of application of combined farmyard manure with CAN fertilizers had no significant effect (P>0.05) on metabolizable energy of both varieties of Rhodes grass.

Table 4.34

Post hoc test for Metabolizable energy (MeCal/Kg)

	L1	L2	L3	L4
L1		195.393*	74.874	168.362*
L2			-120.519*	-27.031
L3				93.488
L4				

*. The mean difference is significant at the 0.05 level

Key L1=0kg CAN + 0 T FYM, L2 = 75 kg CAN + 5 T FYM, L3 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

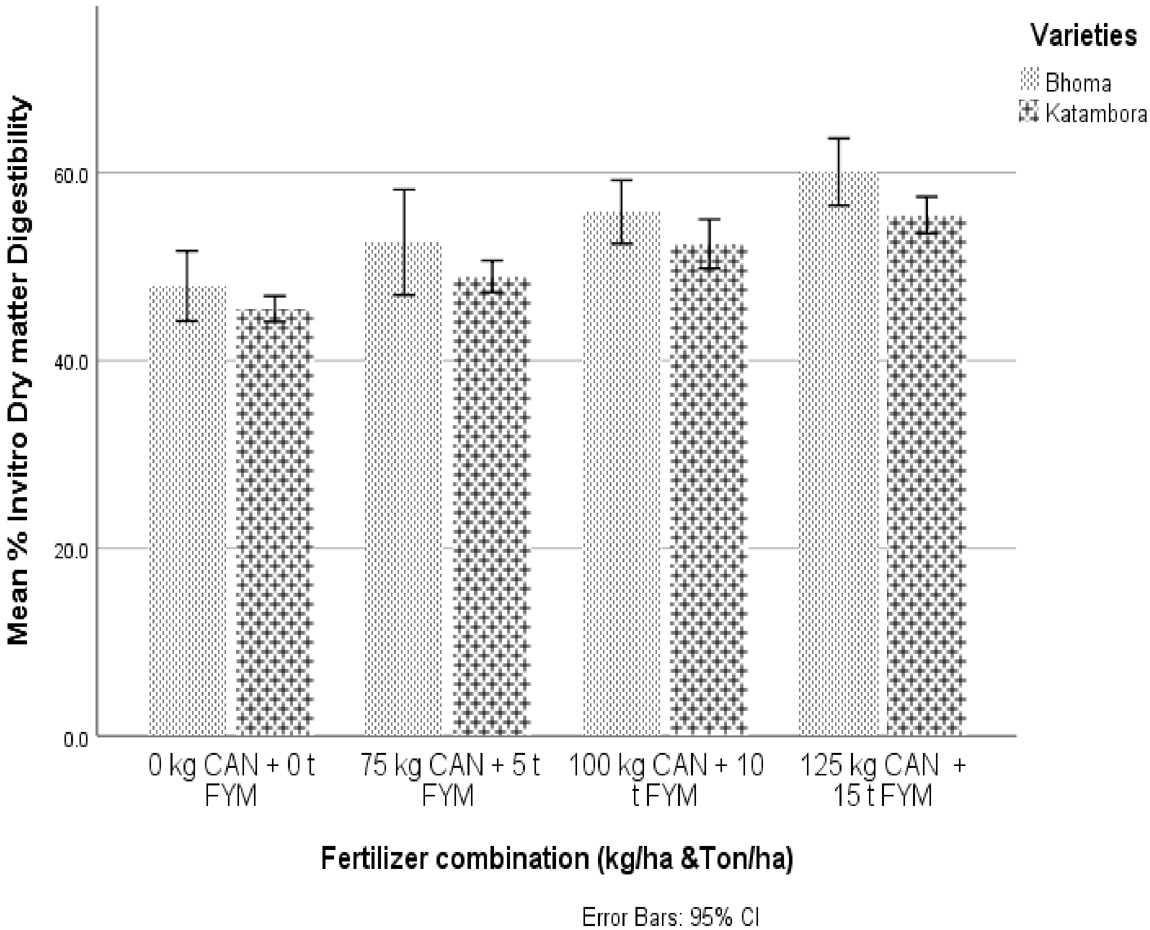
The post hoc results indicated that there was a statistically significant difference between L1 and L2, L1 and L4. There was also significant difference between L2 and L3, while there was no significant difference between L1 and L3 and L2 and L4.

4.8.8 Effect of fertilizer combinations on % Invitro Dry matter Digestibility

Invitro Dry matter Digestibility **(**IVDMD) is used to estimate what would be digestible in animal feeds fed mainly to ruminants. High IVDMD was recorded with Bhoma Rhodes grass (60.5g/100g) compared with Katambora Rhodes grass (56.2g/100g) respectively.

Figure 4.10

Effects of fertilizer combinations   Invitro Dry matter Digestibility



The treatment L4 produced the highest % Invitro Dry matter Digestibility in both varieties in relation to other treatments. The Bhoma Rhodes variety exhibited higher invitro dry matter digestibility than Katambora variety.

Table 4.35

ANOVA table for % Invitro Dry matter Digestibility

Source	Sum of Squares	Df	Mean Square	F	Sig.
Treatments	3.310	3	1.103	.131	.940
Varieties	171.735	1	171.735	20.468	.000
Block	732.111	2	366.055	43.628	.000
Error	142.637	17	8.390		
Total	1049.793	23			

a. R Squared = .864 (Adjusted R Squared = .816)

The analysis of variance (ANOVA) showed that the two varieties varied significantly ($P<0.05$) on % Invitro Dry matter Digestibility but the different levels of fertilization did not have any significant effect ($P>0.05$). The lower the IVDMD, the better is the quality of a fodder since the consumed amount will be utilized well in the normal body processes of the animal.

The results were in agreement with those reported by Ahmed & Suliman, (2015) that invitro digestibility of Rhodes grass ranges from 40.00 to 60.00. The IVDMD of different varieties of Rhodes grass was reported to range from 40 to 80 percent, almost the same as in this report (Ullah et al., 2012).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter gives the conclusion of the research and recommendation for further research on the study.

5.1 Summary

The research took place at Kenya Methodist University Farm, Kithoka in Meru County and the objectives of the study were to determine growth, biomass yield and quality of Rhodes grass varieties as animal fodder.

Application of different fertilizer combination levels had significant effect ($P < 0.05$) on all agronomic parameters. Fertilizer combination did not have significant effect on ash content ($P=0.215$), nitrogen free extract ($P= 0.006$), metabolizable energy ($P= 0.248$) and invitro dry matter digestibility ($P = 0.940$) while there was significant effect on % dry matter, ether extract, crude protein and crude fibre.

The growth and biomass yield of the two varieties were affected positively by the different levels of the fertilizer combination since the plant height, number of leaves and number of tillers increased with increase in the levels of fertilization. These parameters led to improved growth as well as biomass yield of the of the Rhodes grass. The quality of the two varieties of grass was improved by application of higher levels of combined fertilizers.

In this report, the CP content of Bhoma Rhodes grass variety and Katambora Rhodes grass variety was above the minimum range of 6.5–8.0 percent recommended for optimum tropical ruminant output. Additionally in this study, the protein composition of Rhodes grass varieties was within the range of tropical grasses as reported by Bogdan, (1977).

5.2. Conclusion

From the research findings, all the agronomic parameters were significantly affected by variation of fertilizers. The attributes of the parameters increased with increase in the level of combined fertilizers. The chemical components of the two varieties were significantly influenced by change in fertilizer combination except Ash content, ether extract, invitro dry matter digestibility and metabolizable energy. The application of 125 kg CAN/ha and 15 tons of Farmyard Manure/ha resulted to better response in most of the agronomic parameters such as plant height and proximate parameters. The study conclude that maximum plant height, tillers per plant, leaves per tiller, leaf to stem ratio and leaf area were produced in treatment 125 kg CAN/ha + 15 manure/ha. These factors contributed towards maximum green fodder yield, dry matter yield and quality of both Bhoma Rhodes and Katambora Rhodes grass. Bhoma Rhodes grass variety responded better on the treatments than Katambora Rhodes grass variety. The Bhoma Rhodes grass variety is best suited to be grown in Kithoka climatic conditions.

5.3. Recommendations

Based on the findings of this study the following can be recommended; application of 125 kg of CAN combined with 15 ton of farm yard manure gave the best results, hence the regime is recommended to be used by the livestock farmers in order to obtain maximum tonnage of green and dry matter with good quality of crude protein contents in Bhoma Rhodes grass and Katambora Rhodes grass varieties under favorable environmental conditions of Kithoka, Meru County, Kenya. This level of application of fertilizer combination should be practiced for higher pasture yield and feed quality parameters. The Bhoma Rhodes grass variety performed better in dry matter yield and it is therefore recommended to be grown by the livestock producers of Kithoka. Further investigation is essential to find out the performance of the two varieties when harvested at different heights and frequency, to check on the performance of the two varieties with application of nitrogen and farm yard manure separately and to check on the performance of the two varieties at slightly higher and lower levels of nitrogen than the levels used in this research.

REFERENCES

Abass, E.A.H. (2007). Effect of Chicken and Farmyard Manure on Growth and Yield of Forage Sorghum Cultivars (Sorghum bicolor (L.) Moench and Sorghum sudanense). M.Sc. Thesis. Faculty of Agriculture, University of Khartoum, Sudan.http://khartoumspace.uofk.edu/bitstream/handle/123456789/13003

Abdo, M., & Kefyalew, G. (2018). On-farm performance evaluation of selected perennial grass under rain-fed conditions at Deghabour District, Cherer Zone, Ethiopian Somali Region. *Poultry, Fisheries & Wildlife Sciences, 6*(2), 2-5. https://www.omicsonline.org/open-access/ 2375-446X-1000202-106541.html

Abebe, Y., Molla, T., Shiferaw, D., Mekonen, T., Yihenew, G., Selassie, A. A. & Dessalegn, M. (2015). Best fit practice manual for Rhodes grass (Chloris Gayana) production. https://scholar.google.com/

Adam, M.Y. (2004). Effect of seed rate and nitrogen on growth and yield of teff grass (Eragros tisteffzucc.) Trotter. (Master's Thesis, University of Khartoum) Sudan. https://pdfs.semanticscholar.org/6a67/0b96145a36a3019531d3b35a210b0e7a0d27.pdf

Adzemi, M. A., Haruna, Y. R., & Wan, Z. Wan, S. (2017). The potential impact of different organic manure sources and Arbuscular Mycorrhizal Fungal Inoculation on growth performance of sweet corn grown on Bris Soil**.** *International Journal of development and sustainability, 6* (8), 641-649.

Ahmed, A. Bakhashwain, (2010).Fodder Yield and Quality of Rhodes Grass-Alfalfa Mixtures as Affected by Sowing Rates in Makkah Region.JKAU: Met., *Env. & Arid Land Agric. Sci.,* 21(1), 19-33. DOI: 10.4197/met.21-1.2

Ali, M., I.A. Qamar, A. Ali, M. Arshad & J. Iqbal, (2001).Evaluation of tropical grasses for forage yield and crude protein content in the Pothowar plateau of Pakistan. *On line J. Biol. Sci.,* 1;466–7. DOI: 10.3923/jbs.2001.466.467

Allah, Y (2015). Comparative evaluation of productivity of native and introduced forage grasses and legumes in the semi-arid zone of Nigeria. A PhD thesis submitted to the postgraduate school, Usmanu Danfodiyo University, Sokoto, Nigeria. https://www.researchgate.net/publication/268689153

Allah, Y. N., & Bello, A. (2019). The Potentials of Rhodes Grass (ChlorisGayanaKunth) as Drought Resistant Perennial Forage Grass in Nigeria. DOI: 10.34297/AJBSR.2019.06.001025.

Arshad I. , Medani, K.M ,& Khan, Z.A. (2014) "Effect of manual and artificial application of NPK fertilizers on the growth and yield of Rhodes Grass (Chlorisgayana L. Kunth.) by using central pivot irrigation technology". *Int. J. of Res.* 1(7)2348-6848. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.686.4800&rep=rep1&type=pdf

Arshad, I. (2012). "Green Fodder-A Critical Resource" Published in SGS Pakistan Pvt. Ltd. News Letter. 03.

Arshad, I. (2015). Performance of Different Rhodes Grass Varieties under the Agro-Climatic Conditions of Sindh, Pakistan. *Int. J. Res. Appl. Sci. Engin. Technol*, *3*(7), 36-41. https://www.researchgate.net/publication/304347241

Arshad, I., Ali, W., Khan, Z.A., & Bhayo, W.A., (2016). Effect of Water Stress on the Growth and Yield of Rhodes Grass (Chlorisgayana. L. Kunth.). *PSM* Biol. Res., 01(2): 58-61. https://www.researchgate.net/publication/308608726.

Arshad, I., Medani, K. M., & Khan, Z. A. (2016).Integrated Impact of Nitrogen And Phosphorus On Rhodes Grass Under Ghotki Environment. *J. Agric. Res*, *54*(4), 687-695. https://www.researchgate.net/publication/314081561

Arshad, I., Shah, N. H., & Vallejera, C. A. E. (2019).Effect of different levels of Irrigation on the Growth and Yield of Rhodes Grass (Chlorisgayana L. Kunth.) under the Agro-Climatic Conditions of Multan, Pakistan. *International Journal of Alternative Fuels and Energy*, *3*(1), 13-21. https://psmpublishers.org/issues

Association of official analytical chemists (AOAC). (1995), Revision March 1998. Official methods of analysis. Arlington, Virginia. https://law.resource.org/pub/us/cfr/ibr/002/aoac.methods.1.1990.pdf

Bogdan AV (1977) Tropical Pasture and Fodder Plants. London: Longman. Crowder LV and

Borhan, H., &Hago, T. E. (2000).Principle of crop production.*University of Khartoum printing press, Sudan.(Arabic edition).*

Brima .A & O. Abusuwar (2020). Influence of Seed Rate nd NPK Fertilizer On Yield And Quality Of Rhodes Grass (*Chloris Gayana* L. Kunth.) *International Journal Of Agricultural And Applied Sciences 1 (1)*, 80-86. Https://Www.Agetds.Com/Ijaas.

Brima, F. I .A. (2011). Effect of Seed Rate and NPK Fertilization on Growth, Yield and Forage Quality of Rhodes grass (Chlorisgayana L. Kunth). M.Sc. Thesis. Faculty of Agriculture, University of Khartoum, Sudan. https://www.researchgate.net/publication/323469773

Brima, F. I. A. (2007). *gayana L. kunth* (Doctoral dissertation, Department of Agronomy, Faculty of Agriculture, University of Khartoum).

Capacity building for Scaling up of evidence-based practices in Agricultural Production in Ethiopia CASCAPE, (2015).

Cook, B. G., Pengelly, B. C., Brown, S. D., Donnelly, J. L., Eagles, D. A., Franco, M. A., ... &Schultze-Kraft, R. (2005). Tropical Forages: an interactive selection tool. *Tropical Forages: an interactive selection tool.* https://cgspace.cgiar.org/handle/10568/49072

Dawit, A., Girma, C., & Daniel W. (2020). Effect of Different Levels of Inorganic Nitrogen Fertilizer on Biomass, Seed Yield and Crude Protein Content of Rhodes Grass Journal of Natural Sciences Research 10(10) https://iiste.org/Journals/index.php/JNSR/article/view/52652 DOI 0.7176/JNSR/10-10-01

Dev I (2001). Problems and prospects of forage production and utilization of Indian Himalaya. ENVIS Bulletin: *Himalayan Ecology and Development* 9 (2): 1-13.

Duke, J. A. (1983). Handbook of energy crops. *Handbook of Energy Crops.*

EARO, (Ethiopian Agricultural Research Organization) (2004).Directory of released crop varieties and their management. Addis Ababa, Ethiopia.

Edokwe, R. E. (1991). Influence of guinea grass density, under sowing date and N-fertilizer on the performance of guinea grass-maize mixture. *B. Sc. Project Report submitted to the faculty of Agriculture University of Nigeria, Nsukka 51p*.

Edwards, D. R., Daniel, T. C., Scott, H. D., Murdoch, J. F., Habiger, M. J. & Burks, H. M. (1996). Stream quality impacts of best management practices in a northwestern Arkansas basin. *Water Resour. Bull,* 32: 499-509.

Elawad, G. E. (2004). Effect of Chicken Manure and Urea Fertilizer on Growth and Yield of Teff Grass (Eragrostisteff. zucc*)* (Doctoral dissertation, M. Sc. Thesis. Faculty of Agriculture, University of Khartoum). http://khartoumspace.uofk.edu/handle/123456789/10651

Eneji, A.E., Inanaga , S., Muranaka, S. J. Li, T. Hattori, P. A. , &Tsuji W.. (2008). Growth and Nutrient use in four grasses under drought stress as mediated by silicon fertilizers. *J. Plant Nutrition*. 31:355-365.

FAO, (2006).Fertilizer Use by Crops.Food and Agriculture Organization of the United Nations.Vol. 17.

FAO, (2009) Rhodes grass (Chloris gayana Kunth). Food and Agricultural Organization of the United Nations (FAO).

Fekadu Nemera, Kelkay Tessema & Abule Ebro, (2017). Effect of organic and inorganic fertilizer application on improvement of degraded grazing land in the central highland of Ethiopia. Livestock Research for Rural Development (29)3. http://www.lrrd.org/public-lrrd/proofs/lrrd2903/tess29059.html 1-11.

Ibrahim, M., Rafiq, M., Sultan, A., Akram, M. & Goheer, M.A. (2006) Green fodder yieldand quality evaluation of maize and cowpea sown alone and in combination, *J. Agric. Res.*, 44:15-22. https://www.academia.edu/31224408

Irshad, M., Yamamoto, S., Eneji, A. E., Endo, T., &Honna, T. (2002). Urea and manure effect on growth and mineral contents of maize under saline conditions. *Journal of Plant Nutrition*, *25*(1), 189-200. https://www.tandfonline.com/doi/abs/10.1081/PLN-100108790?journalCode=lpla20

Isa, M., Mohammed, B., Ibrahim, J. (2019). Effect of Nitrogen Fertilization and Spacing on Growth (Plant Height) of Rhodes Grass (Chloris Gayana Tan) in the Dry Sub Humid Zone of Sokoto Nigeria. www.hummingpubng.com (19).

Ishiaku YM, Hassan MR, Tanko RJ, Amodu JT, Abdu SB, et al. (2016) Effect of plant spacing on yield and quality of Columbus grass (Sorghum almum) under rain fed in Shika, Zaria, Nigeria. *Journal of Animal production Research* 28(1): 318-328. https://www.researchgate.net/publication/329815110

Ismail, F.M. (2007). Effect of Different Rate of Chicken Manure on the Growth and Yield of Forage Sorghum (Sorghum bicolor L.). M.Sc. Thesis. University of Khartoum, Sudan.

Kalawa, F. M., (2014). Developing A Suitability Model For Optimized Crops Production . A Case Study of Groundnuts In Meru County**.** A Project Study Submitted To The Department of Geospatial And Space Technology In Partial Fulfillment Of The Requirements For The Award of the Degree of Bachelor of Science In Geospatial Engineering

Karadau, Y. (2003) Effects of seed rates on forage production, seed yield and hay quality of annual legume - barley mixtures, *Turk J. Agric.* For., 27: 169-174. https://scialert.net/fulltext/?doi=ajps.2004.752.756

Kunene, T. R., Masarirambi, M. T., Wahome, P. K., &Oseni, T. O. (2019). Influence of Kraal Manure, Chicken Manure and Inorganic Fertilizer on Growth, Yield and Post-harvest Quality of Pepper (Capsicum annuum L.) in a Sub-tropical Environment. *Asian Journal of Advances in Agricultural Research*, 1-11. DOI: 10.9734/ajaar/2019/v11i130043

Loch, D. S (1980). Seed assures future of Callide Rhodes. *Queensl. Agric* J. 106: 183-187. https://agris.fao.org/agris-search/search.do?recordID=US201301356506

Loch, D. S.; Norman, F. G. & Willem A. van Neikerk. (2004). Warm season (C4) grasses. Warm season C4 grasses Agronomy Monograph No. 45: 833-871.

Lutti M, S. Cardoso,Rhaony G. Leite, P. Romanzini, C. Ruggieri & A. Reis (2019) Effect of nitrogen application rate on yield, forage quality, and animal performance in a tropical pasture http://www.nature.com/articles/s41598-019-44138-x 1-9

Marais, D., Rethman , N. & Annanda, J..(2003). Dry matter yield and water use efficiency of five perennial subtropical grasses at four levels of water availability. *Afr. J. Range Forage Sci*. 23:165-169. https://www.tandfonline.com/doi/abs/10.2989/10220110609485900

Mirza, S.N., Mohammad N., Qamar I.A., (2002). Effect of growth stages on quality of forage grasses. *Pak. J. Agric. Res.*, 17(1): 145-147. https://psmpublishers.org/issues/effect-of-different-levels-of-irrigation-on-the-growth-and-yield-of-rhodes-grass-chloris-gayana-l-kunth-under-the-agro-climatic-conditions-of-multan-pakistan/

Mohammed, H.M. (2009). Pasture in Sudan ways of support and development. Paper presented in the conference Role of Ranchers in the Development of Pastoral Sector. Jeddah, Saudi Arabia.

Muhammad, I. R., & Abubakar, S. A. (2004,). Establishment and management of sown pastures. *the proceeding of Training Workshop on Pasture and Range Management in Nigeria.Held at the National Animal Production Research Institute, Ahmadu Bello University, Zaria* (10-14).

Nadaf, S. K., AI-Khamisi, S. A., & AI-Lawati, A. H. (2004). Productivity of Alfalfa, Rhodes Grass and Their Mixtures in Arid Conditions Under Sprinklers. *Journal of Agricultural and Marine Sciences [JAMS]*, *9*(2), 23-29.

Obied, K. A. (2003).Effect of Draby Rhizobia, Chicken Manure, Sulphur, and their Residual Effect on Nodulation, Growth, Yield, and Seed Quality of Soybean and Hyacinth Bean. Ph.D. Thesis. Faculty of Agriculture, University of Khartoum, Sudan. http://khartoumspace.uofk.edu/handle/123456789/10634

Ogedegbe, S. A. & Ewansiha, S. U (2016). Effects of Fertilizers and Rates of Application on Growth and Yields of Rhodes Grass (*Chloris gayana* Cv. Callide). Nigerian Journal of Animal Science ***(1):257 – 265.*** https://www.ajol.info/index.php/tjas/article/view/162808.

Ogunlela, V. B., Masarirambi, M. T., & Makuza, S. M. (2005).Effect of cattle manure application on pod yield and yield indices of okra (Abelmoschusesculentus L. Moench) in semi-arid and subtropical environment.*J. Food Agric. Environ*, *3*(1), 125-129. https://www.researchgate.net/publication/265943148

Ojo, V. O. A., Ogunsakin, A. O., Dele, P. A., Adelusi, O. O., Olanite, J. A., Adeoye, S. A., ... & Onifade, O. S. (2015). Yield and chemical composition of Pennisetum hybrid fertilized with animal manures and harvested at different times. *Malaysian Journal of Animal Science*, *18*(2), 65-80. https://www.researchgate.net/publication/330289654

Olanite, J. A., Ewetola, I. E., Onifade, O. S., Oni, O. A., Dele, P.A. & Sangodele, O. T. (2014).Comparative residual effects of some animal manure on the nutritive quality of three tropical grasses. *Inter. J. Sci., Environ. and Tech*. 3(3): 1131-1149. http://www.ijset.net/journal/347.pdf

Onyeonagu, C. C. (2005). Reclamation of a run-down pasture through improved management. http://www.fao.org/3/x5872e/x5872e09.htm

Osman, A. A. M., Aziz, A. A. H. A., & Babiker, F. S. H. (2014). A Comparative Study between Rhodes Grass (ChlorisgayanaKunth) with Local Grass Forages. *Universal Journal of Agricultural Research*, *2*(2), 50-55. http://www.hrpub.org/journals/article_info.php?aid=1193

Osman, A. A. M., Babiker, F. S. H., & Aziz, A. A. H. A. (2013). Evaluation of Rhodes grass (Chloris gayana Kunth) with local forage legumes in the Sudan. *Advances in Environmental Biology*, *7*(1), 164-169. https://www.researchgate.net/publication/287263573

Patil, V. C., Al-Gaadi, K. A., Madugundu, R., Tola, E., Marey, S., Mulla, D., & Upadhyaya, S. (2016). Response of Rhodes grass to variable rate application of irrigation water and fertilizer nitrogen. *Pakistan Journal of Agricultural Sciences*, *53*(3). https://experts.umn.edu/en/publications

Rahman, A., 2007. Effect Seed Rate and NPK Fertilization on Growth and Yield of Forage Quality of Rhodes Grass (*Chlorisgayana*L. Kunth). M.Sc. Thesis. Faculty of Agriculture, University of Khartoum, Sudan. https://www.researchgate.net/publication/323469773

Reed, K. F. M., Nie, Z. N., Miller, S., Hackney, B. F., Boschma, S. P., Mitchell, M. L.& Kearney, G. (2008). Field evaluation of perennial grasses and herbs in southern

Australia. 1. Establishment and herbage production. *Australian Journal of Experimental Agriculture*, *48*(4), 409-423. DOI: 10.1071/EA07135.

Saad, H. H., (2010). Evaluation of Nitrogen Fertilizers on Quality and Quantity of Rhodes Grass (*Chloris gayana* L. Kunth). M.Sc. Thesis. Faculty of Agriculture Studies, Sudan University of Science and Technology, Sudan.

Suliman, A., & Hassan, A.(2016). Evaluation Of The Nutritive Value Of Some Pasture Plants Grown Under Rainfed Conditions In Western Sudan (Zalingei). Www.Irjetm.Com Doi: 10.13140/Rg.2.1.1858.5686.

Suttie, J. M.(2000). Hay and straw conservation for small-scale farm- ing and pastoral conditions. FAO plant production and protection series, no. 29. *Food and Agriculture Organization of the United Nations, Rome*. http://www.fao.org/3/x7660e/x7660e00.htm

Tewodros, M., Moseret, M., & Tesfaye, Y. (2012). Assessment of Alfalfa (Medicago Sativa) and Rhodes (Chlorisgayana) at SaddoKedidaganila district of southern Ethiopia. *Journal of Natural Science Research* 2(9): 30-35. https://www.iiste.org/Journals/index.php/JNSR/article/view/3403

Tilley, J.M.A. and Terry, R.A., (1963). A two- stage technique for the in vitro digestion of forage crops. *Grass And Forage Science*, 18(2), 104-111. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2494.1963.tb00335.x

Tolera, A., Kidane, A., & Tesfamariam, W. (2006).The effect of nitrogen fertilization and cutting age on dry matter yield and protein content of Rhodes grass at Awassa, southern Ethiopia.*Tropical Science*, *46*(2), 87-91. https://onlinelibrary.wiley.com/doi/abs/10.1002/ts.31

Trivedi, B. K. (2010). Grasses and Legumes for Tropical Pasture. Indian Agricultural Research Institute, India.

Ullah, M. A., Anwar, M., Rana, A. S., Rasheed, M., & Ali, A. (2012). Assessment of promising exotic forage grasses at Faisalabad, Pakistan. *Pak. J. Agri. Sci*, *49*(2), 339-343. https://www.cabi.org/isc/abstract/20123405069

Van, S. P. J. (1994). Nutritional ecology of the ruminant. (2nd ed.). Comstock Publishing Associates/Cornell University Press.

Yesihak, K. (2008). Effect of seed proportion of Rhodes grass (ChlorisgayanaKunth) andWhite seed clover (Melilotusalba) at sowing on agronomic characteristics and nutritional quality. *Livestock Research for Rural Development*. http://www.lrrd.org/lrrd20/2/yise20028.htm

Yossif, A. M., & Ibrahim, Y. M. (2013). Effect of fertilizers (urea, farmyard and chicken manure) on growth and yield of rhodes grass (ChlorisGayana L. Knuth.). *Universal Journal of Plant Science*, *1*(3), 85-90. https://www.semanticscholar.org/paper

APPENDICES

Plant height CM

	Bhoma Rhodes Grass			Katambora Rhodes Grass		
Treatments	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3
L1	15.1	41.3	105.9	13.2	37.8	102.3
L2	20.3	48.7	129.4	18.5	40.2	118.8
L3	28.3	47.6	135.3	20.7	39.9	129.7
L4	36.2	59.5	159.8	31.0	50.7	140.0

L1= 0 Kg CAN/ha + 0 Tons Farmyard Manure/ha, L2=75 kg CAN/ha + 5 Tons Farmyard Manure/ha, L3=100 kg CAN/ha + 10 Tons Farmyard Manure/ha, L4= 125 kg CAN/ha + 15 Tons Farmyard Manure/ha

Plant tillering

	Plant Tillering			
	Bhoma Rhodes Grass		Katambora Rhodes Grass	
Treatments	Month 1	Month 2	Month 1	Month 2
L1	3.0	12.0	3.0	18.0
L2	5.0	15.0	3.0	14.0
L3	3.0	15.0	4.0	11.0
L4	5.0	20.0	5.0	21.0

L1= 0 Kg CAN/ha + 0 Tons Farmyard Manure/ha, L2=75 kg CAN/ha + 5 Tons Farmyard Manure/ha, L3=100 kg CAN/ha + 10 Tons Farmyard Manure/ha, L4= 125 kg CAN/ha + 15 Tons Farmyard Manure/ha

Leaf per plant

	Bhoma Rhodes Grass			Katambora Rhodes Grass		
Treatments	Month 1	Month 2	Month 3	Month 1	Month 2	Month 3
L1	5.0	30.0	107	8.0	64.0	93
L2	11.0	45.0	109	7.0	62.0	109
L3	7.0	52.0	156	11.0	47.0	110
L4	9.0	65.0	184	13.0	86.0	138

L1= 0 Kg CAN/ha + 0 Tons Farmyard Manure/ha, L2=75 kg CAN/ha + 5 Tons Farmyard Manure/ha, L3=100 kg CAN/ha + 10 Tons Farmyard Manure/ha, L4= 125 kg CAN/ha + 15 Tons Farmyard Manure/ha

Leaf area in 3rd month

Leaf area (cm^2)	Varieties of Grass	
Treatments	Bhoma Rhodes grass	Katambora Rhodes grass
L1	253.9	248.0
L2	274.8	265.6
L3	277.9	283.5
L4	298.6	297.8

Key L1=0kg CAN + 0 T FYM, L3 = 75 kg CAN + 5 T FYM, L2 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

Effects of fertilizer combinations on leaf to stem ratio for Rhodes grass varieties.

Leaf to stem ratio	Varieties of Grass	
Treatments	Bhoma Rhodes grass	Katambora Rhodes grass
L1	1.3	1.3
L2	1.8	2.4
L3	3.0	2.9
L4	4.0	3.8

Key L1=0kg CAN + 0 T FYM, L3 = 75 kg CAN + 5 T FYM, L2 =100 kg CAN + 10 T FYM, L4 =125 kg CAN + 15 T FYM

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **979392**

Date of Issue: **16/August/2020**

RESEARCH LICENSE

This is to Certify that Mr.. rotich KIBII kibii of Kenya Methodist University, has been licensed to conduct research in Meru on the topic: EFFECT OF DIFFERENT FERTILIZERS ON QUALITY AND YIELD OF RHODES GRASS CULTIVARS IN KITHOKA, MERU COUNTY, KENYA for the period ending : 16/August/2021.

License No: **NACOSTI/P/20/6214**

979392

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

Kenya Agricultural & Livestock Research Organization
National Agricultural Research Laboratories
P. O. Box 14733, 00800 NAIROBI
Tel: 020 2464435
Email: soil.labs@kalro.org

SOIL TEST REPORT

Name	Rotich Christopher Kibii
Address	P. O. Box 267 - 60200, Meru
Location of farm	Kithoka, Buuri, Meru
Crop(s) to be grown	Grass
Date sample received	30-08-18
Date sample reported	13-09-18
Reporting officer (through Director NARL)	A. Chek

	Soil Analytical Data							
Lab. No/2018	6192							
Soil depth cm	top							
Fertility results	value	class	value	class	value	class	value	class
* Soil pH	6.57	slight acid						
* Total Nitrogen %	0.21	adequate						
* Total Org. Carbon %	2.22	moderate						
Phosphorus ppm	85	high						
Potassium me%	1.55	high						
Calcium me%	13.2	adequate						
Magnesium me%	4.32	high						
Manganese me%	0.37	adequate						
Copper ppm	14.8	adequate						
Iron ppm	97.4	adequate						
Zinc ppm	20.8	adequate						
Sodium me%	0.28	adequate						

*** ISO/IEC 17025 accredited**

Interpretation and Fertilizer Recommendation

The soil reaction (pH) is satisfactory for grass growth. Soil organic matter content should be improved. **Grass:** Apply 2 tons/acre of well decomposed manure or compost mixed with 50 kg/acre of CAN fertilizer.

NOTE: Test results are based on customer sampled sample(s).
Methods used: Information is given out on client's request.

Page 1 of 1

Kenya Agricultural & Livestock Research Organization
National Agricultural Research Laboratories
P. O. Box 14733, 00800 NAIROBI
Tel: 020 2464435
Email: soil.labs@kalro.org

MANURE ANALYSIS REPORT

Name	Rotich Christopher Kibii
Address	P. O. Box 267 - 60200, Meru
Location	Kithoka, Buuri, Meru
Date sample received	26-Sep-18
Date sample reported	15-Oct-18
Reporting officer (through Director NARL)	A. Chek

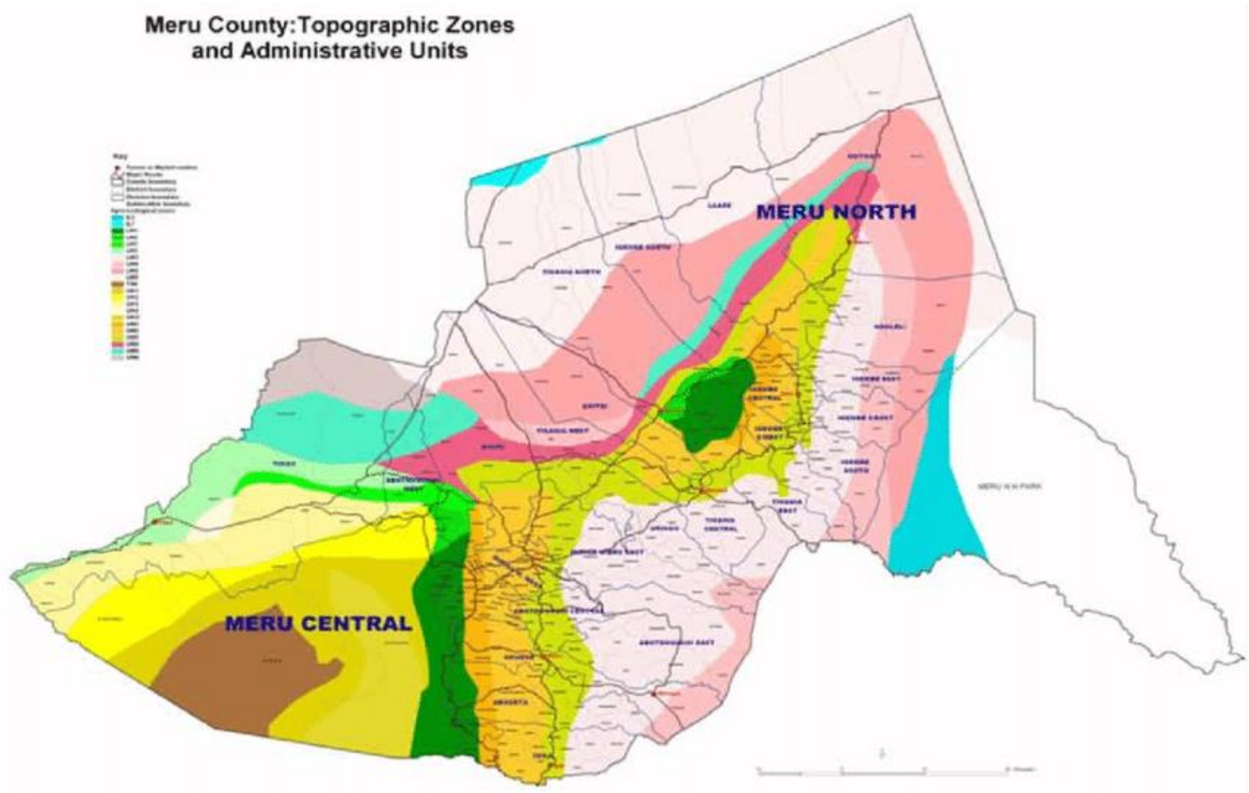
Analytical data (Test results)					
Lab No/2018	6916				
Nitrogen %	1.51				
Phosphorus %	0.34				
Potassium %	1.15				
Calcium mg/kg	167				
Magnesium %	0.23				
Iron %	8.15				
Copper mg/kg	46.7				
Manganese mg/kg	970				
Zinc mg/kg	93.3				

Interpretation of analytical data

In comparison with farm yard manure this manure sample has low calcium content. Iron and manganese are at high level. Other nutrient elements are within the normal range.

NOTE: Test results are based on customer sampled sample(s).

Page 1 of 1


Meru County: Topographic Zones
and Administrative Units
MERU NORTH
MERU CENTRAL