

**INFLUENCE OF NITROGEN AND HARVESTING TIME ON YIELD AND  
QUALITY OF FORAGE PEARL MILLET AND RHODES GRASS IN  
KIAMBU COUNTY, KENYA**

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AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRONOMY.**

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## DECLARATION

I hereby certify that this work belongs to me and has never been presented for any award in any other university.

Sign.....

Date.....

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## Supervisors' Approval

We confirm that the work reported in this thesis was carried out by the candidate under our supervision and has been submitted with our approval.

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## **DEDICATION**

This thesis is devoted to my lovely parents Mr James Nyakwana Oricho and Mrs Alice Kwamboka Nyakwana who raised me. My siblings, for their encouragement and inspiration. My wife Naomi Mogere Nyambega and my son Aiden Ty Dukes who have been my constant source of motivation.

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## TABLE OF CONTENTS

<b>DECLARATION .....</b>	<b>ii</b>
<b>DEDICATION .....</b>	<b>iii</b>
<b>ACKNOWLEDGEMENT .....</b>	<b>iv</b>
<b>TABLE OF CONTENTS .....</b>	<b>v</b>
<b>LIST OF TABLES.....</b>	<b>viii</b>
<b>LIST OF FIGURES.....</b>	<b>x</b>
<b>ABBREVIATIONS AND ACRONYMS .....</b>	<b>xi</b>
<b>ABSTRACT .....</b>	<b>xii</b>
<b>CHAPTER ONE: INTRODUCTION.....</b>	<b>1</b>
1.1 Background information .....	1
1.2 Problem statement.....	4
1.3 Research objectives.....	5
1.3.1 General objective .....	5
1.3.2 Specific objectives were to; .....	5
1.4 Research hypotheses .....	5
1.5 Justification of the study. ....	6
1.6 Significance of the study.....	7
1.7 Conceptual framework.....	8
<b>CHAPTER TWO: LITERATURE REVIEW .....</b>	<b>9</b>
2.1 Introduction.....	9
2.2 Pearl millet.....	9
2.2.1 Depiction .....	9
2.2.2 History and distribution of pearl millet .....	10
2.2.3 Growth habits and requirements .....	10
2.2.4 Establishment, management and utilization.....	11
2.3 Rhodes grass .....	13
2.3.1 Description .....	13
2.3.2 History and distribution of Rhodes grass .....	14
2.3.3 Rhode grass adaptation to environmental conditions.....	14
2.3.4 Establishment, management and utilization.....	15

2.4 Harvesting time influence on performance and nutritional value of fodder....	17
2.5 Impact of nitrogen rates on the forage yield and quality fodder.....	19
<b>CHAPTER THREE: METHODOLOGY .....</b>	<b>22</b>
3.1 Study area .....	22
3.2 Study design.....	24
3.4 Agronomic management.....	24
3.5 Data collection .....	25
3.5.1 Soil sampling.....	25
3.5.2 Soil analysis .....	25
3.5.3 Growth parameters .....	29
3.5.4 Yield.....	29
3.6 Data analysis .....	31
<b>CHAPTER FOUR: FINDINGS AND DISCUSSION .....</b>	<b>32</b>
4.1. Soil chemical properties.....	32
4.2 Influence of nitrogen levels on growth of pearl millet and Rhode grass. ....	33
4.2.1 Plant height.....	33
4.2.2 Number of tillers. ....	36
4.2.3 Stem diameter.....	39
4.2.4 Above-ground biomass fresh weight .....	41
4.2.5 Above ground biomass dry weight .....	45
4.2.6 Root fresh weight .....	48
4.2.7 Root dry weight.....	51
4.3 Influence of harvesting time on biomass yield and quality .....	54
4.3.1 Effect of harvesting time on yield .....	54
4.3.2 Quality as affected by harvesting time .....	58
4.4 Impact of nitrogen rates on nutrient quality and yield of pearl millet and Rhodes grass .....	62
4.4.1 Nitrogen levels influence on yield .....	62
4.4.2 Quality as affected by nitrogen levels .....	69
<b>CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS.....</b>	<b>74</b>
5.1 Conclusions.....	74
5.2 Recommendations.....	74
<b>REFERENCES .....</b>	<b>76</b>

<b>APPENDICES</b> .....	104
Appendix 1: Experimental stages of fodder in the field .....	104
Appendix 2: Data collection and a visit by my supervisors .....	105
Appendix 3: Research Approval from Graduate School .....	106
Appendix 4: Research Authorisation from Graduate School .....	107

## LIST OF TABLES

Table 3.1. Experimental treatments .....	24
Table 4.1 Initial chemical properties of soil (0-30cm) for the study site .....	32
Table 4.2: Effect of nitrogen levels on plant height (cm) of pearl millet during short and long rains growing seasons .....	33
Table 4.3: Plant height (cm) of Rhodes grass as affected by nitrogen levels.....	33
Table 4.4: Number of tillers of pearl millet as affected by nitrogen levels.....	36
Table 4.5: Number of tillers of Rhode grass as affected by nitrogen levels .....	37
Table 4.6: Mean pearl millet stem diameter (cm) as affected by nitrogen levels .....	39
Table 4.7: Mean Rhodes grass stem diameter (cm) as affected by nitrogen .....	40
Table 4.8: Mean pearl millet above ground biomass fresh weight per plant (g) as affected by nitrogen levels.....	42
Table 4.9: Mean Rhodes grass above ground biomass fresh weight per plant (g) as affected by nitrogen levels.....	42
Table 4.10: Mean pearl millet above ground biomass dry weight per plant (g) as affected by nitrogen levels .....	46
Table 4.11: Mean Rhodes grass above ground biomass dry weight per plant (g) as affected by nitrogen levels.....	46
Table 4.12: Pearl millet root fresh weight per plant (g) as affected by nitrogen levels .....	49
Table 4.13: Rhodes grass root fresh weight per plant (g) as affected by nitrogen levels .....	49
Table 4.14: Mean pearl millet root dry weight per plant (g) as influenced by nitrogen levels .....	52
Table 4.15: Mean Rhodes grass root dry weight per plant (g) as influenced by nitrogen levels .....	52
Table 4.16: Quality of forage pearl millet and Rhodes grass as affected by harvesting time during the short rains.....	59
Table 4.17: Quality of forage pearl millet and Rhodes grass as affected by harvesting time during the long rains.....	59
Table 4.18: Quality of forage pearl millet and Rhodes grass as affected by nitrogen levels during short rains.....	70



Table 4.19: Quality of forage pearl millet and Rhodes grass as affected by nitrogen levels during long rains.....	73
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## LIST OF FIGURES

Figure 1.1 Conceptual framework .....	8
Figure 4.1: Mean yield of millet as affected by harvesting time during short rains (A) and long rains (B). H1, H2, and H3 denotes 30, 44, and 58 days after germination respectively .....	55
Figure 4.2: Yield of Rhodes grass as affected by harvesting time during short rains (A) and long rains (B). H1, H2, and H3 denotes 30, 44, and 58 days after germination respectively .....	57
Figure 4.3: Mean yield of pearl millet as affected by nitrogen levels during short rains (A) and long rains (B). N0 – 0 kg/ha, N50 – 50 kg/ha, N100 – 100 kg/ha .....	63
Figure 4.4: Regression analysis on pearl millet forage yield and nitrogen rates, (A) short rains, and (B) long rains .....	66
Figure 4.5: Mean yield of Rhodes grass as affected by nitrogen levels during short rains (A) and long rains (B), N0 – 0 kg/ha, N50 – 50 kg/ha, N100 – 100 kg/ha .....	67
Figure 4.6: Regression analysis on Rhode grass forage yield and nitrogen rates, (A) short rains, (B) long rains.....	69

## **ABBREVIATIONS AND ACRONYMS**

<b>ANOVA</b>	Analysis of Variance
<b>AOAC</b>	Association of Official Analytical Chemists
<b>asl</b>	above sea level
<b>CP</b>	Crude Protein
<b>DAG</b>	Days After Germination
<b>DAP</b>	Di Ammonium Phosphate
<b>DM</b>	Dry Matter
<b>EDTA</b>	Ethylenediaminetetraacetic acid
<b>ESGPIP</b>	Ethiopia Sheep and Goat Productivity Improvement Program
<b>FAO</b>	Food and Agriculture Organization
<b>FeSO<sub>4</sub></b>	Iron (II) sulphate
<b>HCl</b>	Hydrochloric acid
<b>HT</b>	Harvesting Times
<b>ILRI</b>	International Livestock Research Institute
<b>ME</b>	Metabolizable Energy
<b>NaOH</b>	Sodium hydroxide
<b>N</b>	Nitrogen
<b>NPK</b>	Nitrogen Phosphorous Potassium
<b>NRCS</b>	National Resource Conservation Service
<b>OM</b>	Organic matter
<b>RCBD</b>	Randomized Complete Block Design
<b>S</b>	Species
<b>TDN</b>	Total Digestible Nutrients
<b>TSP</b>	Triple superphosphate

## ABSTRACT

Pearl millet (*Pennisetum glaucum*) and Rhode grass (*Chloris gayana*) are among the fodder crops of great eye-catching in Kenya. They have multiple cutting nature and high tillering ability. They do not contain poisonous acid and do well when managed properly. Nitrogen is an obligatory nutrient for plants to growth including fodder crops. Inadequate nitrogen leads to poor growth and grasses develop fewer tillers, hence leading to low biomass yield, which impacts on livestock production negatively. This research was carried out to examine the outcome of different nitrogen rates and harvesting periods on the growth, yield and quality of forage pearl millet and Rhode grass. The nitrogen rates were 0 (control), 50 and 100 kg N ha<sup>-1</sup>, while harvesting times were 30, 44 and 58 days after germination. The pearl millet cultivar was ICMV-22, Boma for Rhodes grass. The experiment was set up in a split-plot design using an RCBD arrangement with three replications. Data collected included the height of plants, tiller number, stem thickness, fresh foliage yield, herbage weight, the content of ash, and organic matter. All the growth parameters and quality data were subjected to analysis of variance using the software. Means separated using Least Square Difference at a five per cent level of probability. The results indicated that the differences were important ( $p < 0.05$ ) on plant heights, number of tillers, stem thickness, foliage weight, yield, dry matter percentage, ash content and organic matter when nitrogen fertilizer was supplied compared to the control. The rate of 100 kg N ha<sup>-1</sup> was superior while control recorded the lowest values in all parameters. Biomass dry weight significantly ( $p < 0.05$ ) increased with nitrogen application. The maximum biomass dry weight was observed in 100 kg N ha<sup>-1</sup> having a dry weight of 74.63g and 58.49g per plant in pearl millet and Rhodes grass respectively. The effect of nitrogen on dry matter percentage was pronounced more in pearl millet (33.53, 36.47) as compared to Rhodes grass (30.34, 34.01) in short and long rains respectively. Harvesting at 58 days after germination recorded a high forage yield (25.74t/ha, 41.32t/ha) in pearl millet, (18.86t/ha, 26.4t/ha) in Rhodes grass during short and long rains respectively. The effect of interaction between fodder species and nitrogen rates on quality parameters was significant in both seasons. Dry matter and organic matter consistently increased up to the final harvest, while ash content decreased with delaying harvest. Based on these results, the rate of 100 kg N ha<sup>-1</sup> was recorded to produce more superior growth parameters for both pearl millet and Rhode grass, implying that additional nitrogen would further increase growth. It can be concluded from the results that in order get a higher yield of pearl millet and Rhodes grass they can be fertilized at the rate of 100 kg N ha<sup>-1</sup> and harvested 58 days after germination.

## **CHAPTER ONE: INTRODUCTION**

### **1.1 Background information**

Livestock farming is an intrinsic section of the mixed crop and livestock production in Kenyan plateaus. It is the main means of transport, and animal waste acts as manure to support crop production. Its contribution to dietary nutrition, income and acts as assets for the communities in rural areas serving as insurance in the event of crop failure thus an important contributor to total food production (Sansoucy, 1995). Even though the influence of livestock in boosting crop production has been recognized all along, its efficiency in Kenya is decreasing to an extent that will affect the sustainability of the synergistic relationship between the livestock and crop production sectors. The major challenge affecting dairy production is inadequate feeds, in terms of quantity and quality (Amede *et al.*, 2005). Animal feed in most developing countries is practically based on grazing, stubble grazing, natural pastures and the use of crop residues (Tahir *et al.*, 2018).

Crop remains are low in quality and avail less energy, crude protein, and required minerals (Keftasa, 1987). This, therefore, implies that the available sources of feed do not supply the required nutritional rations for animal growth. Similarly, Kitabe and Tamir (2005), recorded that nutritional quality and forage yield of natural pastures is low. The forage makes faster growth of reasonable quality in the early rainy season but in the dry season only matured forage of low quality is may be available. A larger portion of the animal feed in Kenya constitutes natural pastures and crop residues (Njarui *et al.*, 2011). This reserve consists of an extensive array of natural grasses, fodder legumes and other palatable herbaceous species (Owen and Jayasuriya, 1989, Dubeux Junior *et al.*, 2017).

High-quality fodder cultivation is vital for economical large and small ruminant production. Quality and quantity of fodder forage are affected by crop species (Khan *et al.*, 2007), climatic conditions, imbalanced soil fertility (Yar and Waheed, 1991), water supply (Rashid and Salim, 1989), harvesting frequency (Bilal, 1998), stage of growth and management practices (Kim *et al.*, 2001). The stage of growth is among the crucial factors that influence the nutritional value of fodder (Fariani *et al.*, 1994).

Pearl millet (*Pennisetum glaucum*), a native of the West region of Africa. It blew out from the place of origin and spread to Eastern parts of Africa and then to parts of India. Got embraced early and later became an essential crop (National Research Council, 1996). The farming of pearl millet for forage purposes has lately been emphasized due to its multi-cut nature, profused tillering, absence of poisonous 'prussic acid' and good performance even on poor soils and performs well if managed optimally. Its productivity depends on the physiological growth stage and cutting at an optimum stage during the growing season (Rajendra and Gumaste, 2010). Rhodes grass (*Chloris gayana*) is a common grass in the tropics of Southern and East Africa. It originated from Eastern Africa, it is valued for its ease to establish and as a potential ground cover, and ability to set seed, drought tolerance and it is suitable for intercrop with legumes (Ponsens *et al.*, 2010).

Nitrogen is required for a plant to grow successfully. Even though inorganic nitrogen compounds ( $\text{NH}_4^+$ ,  $\text{NO}_3^-$  and  $\text{NO}_2^-$ ) contribute to about 4% of soil nitrogen (Brady and Weil, 2008), Nitrates and ammonium are the key forms of nitrogen taken up by the majority of the crops (Gweyi-Onyango *et al.*, 2009). Synthetic and organic fertilizers are used to sustain the soil nutrients of cropping cycles. Nitrogen occupies a conspicuous place in the plant metabolism system. All-

important processes in plants are related to protein, of which nitrogen is a vital constituent. Therefore to get more crop production, nitrogen application is crucial. It plays an important role in agriculture in that it increases crop yield (Massignam *et al.*, 2009).

Nitrogen is a vital element essential for plants to grow particularly for forages. It is significant in so many physiological processes such as nutrient uptake, protein synthesis, chlorophyll, vitamin production, photosynthesis, utilization of sunlight, amino acid synthesis, and together with the use of phosphorus in energy systems, it has a positive effect on the variables defining the forage plant quality like herbage digestibility (Cruz and Boval, 2000). If forages lack adequate nitrogen, they may appear stunted with very slow growth, developing fewer tillers and consequently a farmer ends up with less pasture or hay. Low or suboptimal levels of nitrogen will increase early growth but when nitrogen is exhausted, the resultant pasture or hay will be low in proteins (measured as total digestible nutrients – TDN). Fertilized grass matures faster and contains more fibre than unfertilized grass at late development stages (Keftasa, 1996).

Nitrogen management is vital from the viewpoint of herbage production and herbage quality. The nutritional quality of all pastures is the key function of the vegetative growth stage and species composition, which can be affected by climatic factors that influence mineral content, botanical composition, and forage re-growth potential (Whiteman, 1980). The growth stage of the fodder crop during grazing or cutting to feed fresh is attributed as an important management strategy that influences the nutritional value of cultivated and fallow pastures. In many instances, grasses in the tropics will not meet the feed requirement of livestock because they are utilized at a late stage of growth (Beyene *et al.*, 1977).

## **1.2 Problem statement**

Several limitations lead to the low productivity of livestock in Kenya. The major one is feed shortage which derives from low forage quality and scarcity. Shortage of fodder can be caused by a combination of factors that include; shrinking grazing lands due to competition for land for other crops, limited and erratic rainfall and shifting land-use patterns that favour urbanization and settlement (Ayele *et al.*, 2012). The main feed resources being crop residues and natural pastures. Feed produced from natural pasture is declining due to numerous factors that include land degradation, overgrazing, population pressure among other factors (Hassen *et al.*, 2010). The nutritional content of crop residues is integrally low. Moreover, the quality of the natural pastures, especially in the dry periods is low. These resources of feed have less crude protein and metabolizable energy (ME). Therefore these feed resources need strategic supplementary feedstuff such as agricultural industrial wastes and cultivated improved forages.

In the areas where trials for improved nutritional fodder species have been done, some farmers have not utilized them optimally, yet this can enable a suitable equilibrium between nutritive content and forage yield to meet the livestock nutritional requirements and ensure sensible animal production (Bayable, 2004). Feed source improvement by considering management practices that boost nutrient value and forage yield is, one of the significant actions that have to be put in place to reciprocate the scenario of low livestock productivity.

Although the climatic condition of a region could be favourable for pearl millet production, its yield per hectare can be very low. The low forage yield of millet can be caused by many constraints but the fertilizer is considered the major factor. Nitrogen is an important element for plant rigorous growth. To improve the forage



yield and nutritional value it is so crucial to determine the fertilizer requirement of the crop. Appropriate and judicious use of fertilizer increases yields and improves the nutritional quality of fodder particularly protein contents (Ayub *et al.*, 2007).

Another significant factor that affects the nutrient content and forage yield of fodder crops is harvesting time. The chemical composition and yield of forage are affected more by the harvesting time than the cultivars grown. Fresh forage yield of pearl millet goes on increasing up to a certain growth stage and after that starts decreasing (Keshawa and Yadav, 1989). Nutritional value in most tropical grasses decreases as they grow old because of fibre content with increasing maturity (Keftasa, 1988).

### **1.3 Research objectives**

#### **1.3.1 General objective**

To improve yield performance and nutritional quality of forage pearl millet and Rhodes grass in Kiambu County through specific harvesting times and nitrogen levels.

#### **1.3.2 Specific objectives were to;**

- i. Determine how nitrogen rates affect growth of pearl millet and Rhodes grass
- ii. Determine the influence of harvesting on biomass yield and forage quality of pearl millet and Rhodes grass.
- iii. Evaluate the impacts of nitrogen on yield and nutritional value of pearl millet and Rhodes grass.

### **1.4 Research hypotheses**

- i. Nitrogen levels and harvesting time have no effect on growth of pearl millet and Rhodes grass.

- ii. Harvesting stages have no significant effect on forage yield and quality of pearl millet and Rhodes grass.
- iii. Nitrogen has no influence on biomass yield and quality of Rhodes grass and pearl millet.

### **1.5 Justification of the study.**

Nitrogen is an essential constituent of protein and chlorophyll. It promotes vegetative growth, imparts dark green colour to plant, and rapid early growth. It improves the quality and metabolizable energy besides improving the succulence and palatability of fodder crops (Bhoya *et al.*, 2014). Protein content in grass forage can be improved with nitrogen application, but there is a risk of accumulation of nitrogen residues and downward movement of nitrates in the soil, and the increase of toxic levels of nitrates in the forage when nitrogen is applied more than crop requirements (Malhi *et al.*, 2004). Therefore this study incorporated the determination of the influence of nitrogen fertilizer application on forage yield and quality.

The viable and modest mediations to mitigate an intensive shortage of feed is to focus on how to increase the forage quality by using essential agronomic and utilization practices. More especially harvesting the fodder crops at earlier stages of growth to obtain more nutrients. In addition, there is need for appropriate management of the crop when it is in the field for improved qualitatively and quantitatively productivity of cultivated fodder (Sileshi *et al.*, 1995). Information and knowledge on nitrogen fertilizer application and the proper stage of harvesting fodder as a way for boosting pasture and fodder productivity for small-scale farmers in Kiambu County is scanty.

## **1.6 Significance of the study**

The present agricultural engagement across the world is to ensure productive, eco-friendly and maintainable cropping system by employing improved ways of crop management that include; proper nutritional supply to the crop, appropriate planting methods and right harvesting stage (Crew and Peoples, 2004). An increase in production faces an array of challenges due to the rapid increase in population which exerts more pressure on the cultivated land. Time for harvesting is a crucial aspect influencing the forage quality. Previous work has proved that the stage of cutting affects both forage yield and nutritional quality, which is a significant feature in fodder growing. Ram and Singh, (2007) found out that cutting times influence chemical constituents of harvested herbage. According to Joshi *et al.* (2004), forage increases by delaying the time of harvesting though nutritional content reduces. This study examined whether harvesting stages and nitrogen levels affect the nutritional content of forage pearl millet and Rhodes grass.

## 1.7 Conceptual framework

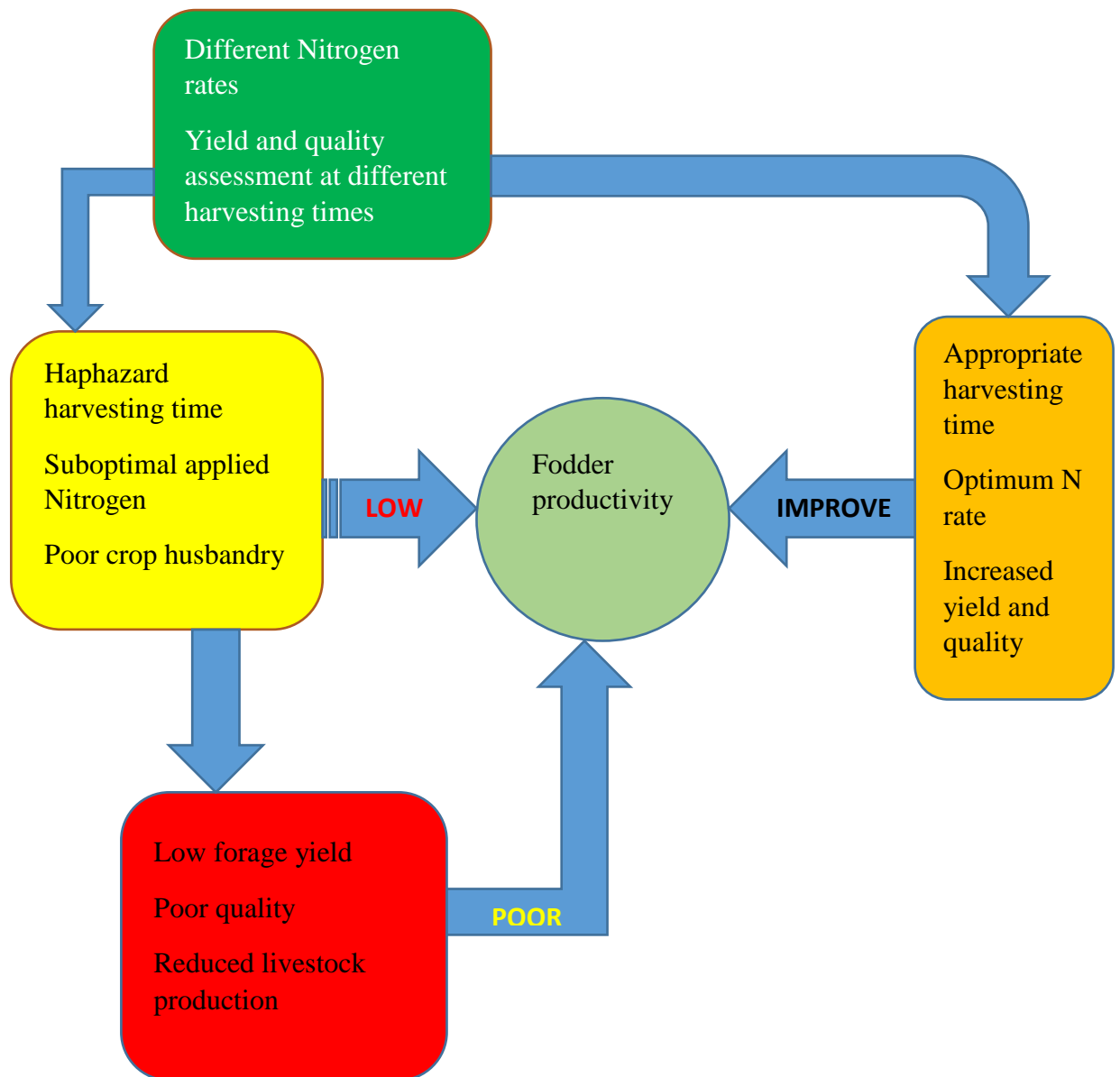


Figure 1.1 Conceptual framework

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 Introduction**

### **2.2 Pearl millet**

Fodder crops are plant species that are usually cultivated and harvested for feeding animals in different forms of forage; cut green and fed fresh, hay, (which is dehydrated green fodder) and silage, (which is fodder preserved under anaerobic conditions). In Africa, fodder grasses have been greatly endorsed for animal production because they have high nutrients and more dry matter yield (Onyeonagu and Asiegbu, 2013). Among the fodder species which have attracted much attention include Rhodes grass (*Chloris gayana*) and pearl millet (*Pennisetum glaucum*).

#### **2.2.1 Depiction**

Pearl millet is erect, grows up to 3 metres high with an extreme growing system of roots and has slender culms, 1 to 3 centimetres in diameter. Leaves are pubescent, blade is linear, simple, alternate and serrated. It has a panicle inflorescence, 12 to 30 centimetres in length. Stems are often heavily hairy and usually 0.65 to 2.8 centimetres in diameter. Leaves and stems may vary in colour from green to light yellowish to deep purple. The shape of grains differs with cultivars. It utilizes C4 carbon fixation (Andrews and Kumar, 1992). A good stand will produce plants with profuse leaf growth and fairly fine stems. It contains considerably high ratio of leaf to stem compared to different fodder crops such as foxtail millets, Sudan grass and sorghum-Sudan hybrid. It has a profuse tillering under favourable climatic conditions which can thrive in patchy stand establishment. Prop roots may develop at the lower nodes of the stem to support the plant as it matures. The potential of it to regrow after harvesting is comparable to Sudan grass but greater than foxtail

millet. For fodder it is majorly grown for silage, hay, cut green or grazed directly in the field (FAO, 2009).

### **2.2.2 History and distribution of pearl millet**

Pearl millet (*P. glaucum*) is indigenous to the regions of Sahel (Andrews and Kumar, 1992). It grows in extreme low rainfall tropical areas. It performs better in regions other C4 cereals grasses like sorghum and maize will not grow due to drought and heat. The crop is mostly found in areas that receive annual rainfalls of 200 to 800 mm. The temperatures ideal for its growth falls in the range of 22°C to 36°C. In Kenya, it is grown in dry parts of the country like Tharaka and Mbeere in Mwingi (Maundu *et al.*, 1999). Forage millet has been observed and considered to be tolerant to sandy acidic soils and salinity (FAO, 2009).

### **2.2.3 Growth habits and requirements**

Pearl millet can grow in most of the areas that usually experience regular periods of dry weather conditions during vegetative and reproductive phases. Pearl millet can grow in different geographical areas, including those with very stressful to suitable conditions (Yadav and Bhatnagar, 2001). It is more tolerant to acidic and sandy soils than other grain crops (Kretzschmar *et al.*, 1991). In addition, it has deep roots which can be used to utilize the residual soil nutrients such as nitrogen, potassium and phosphorus, and therefore can moderately do well in sub-optimal to optimal soil fertility conditions (Sammauria and Yadav, 2010). These characteristics enhance its resilience and boost its popularity in dry land and lower input production systems. On-farm experiments and research demonstrations have indicated that pearl millet can dependably produce high yields per hectare if well managed, although extreme droughts reduce its yields the plant can withstand periods of drought that might

cause crop failure or more yield reductions in other crops (de Rouw, 2004). In Kenya it grows well on sandy and clay soils, but in certain occasions has been reported to thrive in poor soils, since it is a drought-tolerant crop that grows in semi-arid regions below 1,500m above sea level. The crop requires rainfall ranging from 450mm to 850mm annually (Maundu *et al.*, 1999).

Pearl millet germinates well in soil temperatures of 20°C to 32°C, emergence occurs in two to four days when conditions are favourable. Development of seedlings occurs during the first four weeks then stalk development occurs rapidly soon after (Lee *et al.*, 2009). Tillering might be more in sparse crop stands, especially if there is adequate soil moisture content. Flowering begins 50 to 60 days after emergence, and the plant attains physiological maturity within 80 to 90 days after crop emergence. Forage accumulation is influenced by cumulative intercepted solar radiance and rainfall (Santos *et al.*, 2017). It can extract nitrogen from degraded sandy soils, hence the high ability to supply high-quality fodder in areas experiencing water shortage (Pandey *et al.*, 2011).

#### **2.2.4 Establishment, management and utilization**

Even though pearl millet is considered a crop that requires low inputs, it responds to fertile soils and good management practices. The management of pearl millet is very similar to sorghum whereby intercropping with legumes can enhance resilience to climate variability (Hausmann *et al.*, 2012). The crop should be planted in a well-tilled field to evade competition from weeds and optimize germination. Seeds germinate quickly within four to seven days after sowing when the temperature is favourable for growth (Masters *et al.*, 2004). The seeds are small in size, hence shallow sowing 1.5 to 2.5 cm deep in a firm field to get good soil-seed contact is

crucial (Sedivec and Schatz, 1991), seed germination is best when there is adequate soil moisture content and temperature is 20°C or higher. Two weeks after planting pearl millet sets a rapid growth phase. The broad fibrous roots that it produces can grow both downward and laterally into the soil profile (Passot *et al.*, 2016).

Pearl millet is an annual drought-tolerant forage. It prefers well-drained soils and does not tolerate waterlogging (Ismail, 2012). Late planting may hinder forage production, therefore used for hay production, short-term grazing or forage production for an emergency. Yield decreases if the date of planting is delayed (Hancock and Greg, 2010). Pearl millet seeds vary depending on the utilization. Seed rates of 7 to 13 kg per hectare are recommended when planting by drilling in a prepared seedbed, 15 to 20 kg per hectare when broadcasting. Both drilling and broadcasting are suitable planting methods, although drilling uses seeds more proficiently, hence reducing the number of seeds required (Newman *et al.*, 2010). Seeding rates depending on region and use, the lighter seed rate is recommended when pearl millet is to be used for grazing to allow more tiller production per plant, while a heavier seed rate is recommended in a hay production system to increase tiller competition and obtain thinner and fine stems that reduce the drying time (Hanna *et al.*, 2004).

Pearl millet can grow on soils with a pH of less than 5.5, but liming is recommended at least six months before planting to allow reaction of lime and neutralization of the soil acidity. Potassium and phosphorus should be applied as per the soil test recommendation report. Phosphorus may be applied during planting while potassium can be applied in split (Noman *et al.*, 2010). Fertilizer can be used at the rates of 20 to 25 kilograms per hectare when the plants have reached 7 cm in height. Then the second application did one month after the first application at the same



rate. It should be ready for grazing or cut green and fed fresh 40 to 60 days after germination when managed properly it can provide 90 to 120 days of grazing depending on soil fertility, growing conditions, variety and grazing management strategy (Teutsch, 2009). Pearl millet requires uniform defoliation to maintain the quality on the stand (Hannaway and Larson, 2004).

Pearl millet produces high-quality fodder especially when defoliated frequently, the digestibility of millets ranges from moderate to high when the plant biomass has a large leaf to stem ratio (Ferraris and Norman, 1973). Leaf concentration contains high digestible nutrients, protein and low fibre concentration. The percentage of crude protein ranges from 10 to 12 under unfertilized conditions to 14 and 16 under well nitrogen applications. The main advantage of pearl millet is that it does not have hydrocyanic acid and does not contain tannins compared to other fodder species such as sorghum/Sudan hybrids, sorghum and sudangrass (Harinarayana *et al.*, 2005). Pearl millet can produce good forage, but there are key factors that determine yields, including; length of the growing season, planting date, time of forage utilization and growing conditions such as optimal nitrogen fertilizer application that guarantees satisfactory benefits for farmers (Rostamza *et al.*, 2011).

## **2.3 Rhodes grass**

### **2.3.1 Description**

Rhodes grass (*Chloris gayana*) is a grass that belongs to the plantae kingdom, poales order, poaceae family, genus chloris, and species C. gayana (Ponsens *et al.*, 2010). The grass is leafy that grows from 1 to 2 meters in height and is highly capricious. Its culms are usually creeping, it has deep roots, linear leaf shape, having flat blades,

10 to 50 centimetres long, 10 to 20 millimetres wide, tapered at the apex (Cook *et al.*, 2005).

### **2.3.2 History and distribution of Rhodes grass**

*Chloris gayana* is native to Kenya and many other sub-Saharan countries. It is both summer and spring fodder grass that can be found on the roadsides. Can be grown on planted fodders and terraces that are irrigated (Quattrocchi, 2006). It grows in a latitude ranging from 20 to 35° N and S. The grass grows well in areas experiencing temperatures of 17°C to above 27°C. Rainfall of between 650 to 800 mm (Ecocrop, 2014).

### **2.3.3 Rhode grass adaptation to environmental conditions**

Rhode grass can grow in many types of habitats, but in most areas it is grown for grazing, as a ground cover to reduce soil erosion and rapidly reclaim denuded soil. It is fairly tolerant to saline and alkaline soils (Suttie, 2000). It secretes salts on its leaf surfaces, can grow in harsh environmental conditions and thus widespread in many parts of the world as pasture plant and hay production (Kobayashi and Masaoka, 2008). Rhodes grass is adapted to a varied range of ecological conditions. It can thrive in a variety of soils ranging from poor soils to saline and alkaline soils (Rogers *et al.*, 2003). It also grows on poorly drained soils, provided fertility is adequate.

Rhodes grass prefers loam and clay soils, but not suited for heavy clays. It grows well on soils with pH range of 5.5 to 7.5, but can grow in pH of 4.5 up to 10 (Cook *et al.*, 2005). The grass bears deep roots which enables it to withstand up to 15 days of flooding and lengthy dry periods and also responds well to irrigation (FAO, 2014). This grass may be of great benefit to poor farmers in the tropics since

it has a moderate tolerance to aluminium, and is able to survive on low rainfall and less labour is required to maintain it (ILRI, 2013). It requires optimal rainfall of about 600 to 700 mm per annum, however not suitable in extreme dry areas or humid conditions particularly where the soils do not permit draining. Rhode grass grows well where temperatures range between 18°C to 27°C. It is often grown to increase productivity and decrease erosion in infertile sandy soils (Moore *et al.*, 2014; Cook *et al.*, 2005). Rhodes grass proficiently utilises available soil moisture and solar radiation to rapidly produce more herbage (Valenzuela and Smith, 2002).

#### **2.3.4 Establishment, management and utilization**

Rhodes grass can be established from seeds or vegetative propagation. It has fluffy seeds that may need to be mixed with a carrier (sawdust) or coated to improve the flow when sowing mechanically using a seeder (Moore, 2006). Direct drilling and conventional sowing are reliable methods, where the use of rollers and wheels greatly enhance the contact between the seed and soil resulting in better germination. The grass can be established with the seeds at the rate of 4 to 6 kg per hectare, where the seedbed should be well prepared to a fine tilth and compact since the seeds are small. Compaction helps to ensure uniformity and preventing seeds from going far deep. Rhodes grass can dominate if planted in a mixture because it has a good seedling vigour and can spread through runners (McGufficke and McCormick, 2010).

Before ploughing, weeds and trees should be cleared from the land (ESGPIP, 2008) and it should be ploughed two or three times to attain the fine tilth and well-levelled seedbed. Since the seeds are so tiny, they need a well-prepared seedbed (Feyissa,

2000), such a seedbed will favour germination and seedling emergence and growth in general. Rhode grass is suitable for both irrigated and rainfed fodder production systems. Pure stands require proper management and fertilizer addition, more especially nitrogen, to improve the nutritional value of the grass (Cook *et al.*, 2005). For haymaking, the grass to be used should be cut once a month. Cattle should not be allowed to graze on the stand during the first year of cultivation until the root system has become intensive to allow well soil anchorage of grass. Failure to ensure exclusion of grazing cattle can lead to stand damage by the livestock if they uproot the grass (Cook *et al.*, 2005).

Fertilizer application improves biomass and enhances both yield and nutritive value. The grass responds well to nitrogen supply primary when the basal application of phosphorus has been done (Brima, 2011). It responds to phosphorus in some areas and gives a remarkable liner response to nitrogen when potassium and phosphorus are adequate, which are critical in improving both crude protein content and yield. Application of nitrogen fertilizer in splits is known to be beneficial (Gweyi-Onyango *et al.*, 2021) and in this case particularly after every grazing cycle or each cut is better compared to the basic application. In general, more maintenance inputs are required when cutting and feeding fresh to livestock compared to open grazing. If sown pastures are maintained with fertilizers and well utilized, they will produce more biomass yield up to four years (ESGPIP, 2008).

Rhode grass is recommended for harvesting at 50 % flowering to obtain high-quality feed. Harvesting the grass at an early stage guarantees high levels of crude protein in the harvested material. Harvested forage can be fed to livestock while fresh or dehydrated to form hay which can be used for later feeding. When splits are used as planting material, the first cut or harvest can be done from 2 to 3 months if there is

sufficient moisture and adequate nutrients (Abebe *et al.*, 2015). Rhodes grass is very palatable and contains high nutrient levels. If cut at the onset of flowering or a little bit earlier the grass makes good hay. Late harvesting gives low-quality hay. It does not give high-quality silage due to low contents of soluble carbohydrates and high moisture which makes it difficult to ensile (Parvin *et al.*, 2010). Appropriate haymaking procedures should be followed to make sure the forage is well utilized. The grass can be grazed 2 to 5 months after sowing. It tolerates heavy cutting and grazing, but very frequent defoliation reduces its production (Abebe *et al.*, 2015).

#### **2.4 Harvesting time influence on performance and nutritional value of fodder**

Among the significant factors influencing the foliage yield and nutritional content of fodder crops is the stage of harvest during maturation. Time of harvesting affects chemical contents and forage yield of fodder more than the effect of the variety grown. Pearl millet fodder yield increases up to a certain stage of growth and later starts declining (Keshwa and Yadav, 1989). Ayub *et al.* (2002a) reported that the green fodder of sorghum and dry matter yield, acidic and neutral detergents fibre increased with delaying the harvest, but crude protein, total ash contents and extractable fat decreased.

Delaying harvest increased dry matter yield but decreased crude protein contents (Malai, *et al.*, 1980). Bukhari (2009) reported that ash and protein contents decrease when delaying harvest, for dry matter percentage and crude fibre were increased with progressive maturity, On the contrary, Beck *et al.* (2007), observed an increase in the acid detergents fibre and a decrease in the crude protein at advanced maturity. Ayub *et al.* (2003) harvested maize at 40, 50 and 60 days after sowing and reported

that dry matter, dry matter yield, and crude fibre contents significantly increased with late harvesting.

The nutritional value of fodder depends on physiological and morphological changes. When the crop matures, cell cytoplasm reduces this, in turn, reduces the number of soluble minerals, lipids, proteins and carbohydrates (Sullivan, 1973). Lipid and the protein contents of fodder are negatively related to fodder growth maturity (Cleale and Bull, 1986). For dry matter (DM) it increases as the crop advances in age (Azim *et al.*, 1989). The cell wall components increase hence making the cell wall to be rigid as the fodder crop matures (Kim *et al.*, 2001).

The fodder nutritional value is high during the early growth stages, but dry matter yield is lower (Fariani *et al.*, 1994). To obtain more core nutrients, proper time of harvesting, in the viewpoint of nutritive quality and dry matter yield should be explored. Maize for forage should be harvested between the 7th to 8th week after planting to obtain highly digestible and nutritious livestock feed (Firdous and Gilani, 1999). Firdous and Gilani (2001) recorded the optimal cutting stage for forage sorghum is the flowering stage. Grewal *et al.* (2003) showed that pearl millet for forage can be cut before the booting stage.

Failure to consider the defoliation height and frequency of harvest might affect the re-growth of the remaining parts during harvesting of fodder. Previous reports have shown a disparity in crop species in response to defoliation intensity and frequency of harvesting due to rooting systems differences and growth habits (Onyeonagu and Asiegbu, 2013). Harvesting time is an essential aspect that influences both the quality and herbage yield of fodder species. In other studies, optimal harvest time increased the yield and crude protein content with increased nitrogen rates while delayed harvesting decreased the contents of available protein (Siddique *et*

*al.*, 1989). Hence, the information on the harvesting stage and frequency of cutting is essential since the nutritional value and yield of fodder crops for livestock feed is partly affected by these aspects (Ball *et al.*, 2001).

To capitalize on forage production, suitable harvesting management practices have to be considered. Harvest management of forage essentially means the timely cutting of forages from the field for delayed consumption as hay or silage or instant feeding to livestock while still fresh (NRCS, 2006). Management of harvest is geared towards not only improving the economic yield of forage but also desired quality enhancement (NRCS, 2006). Forage harvest management puts into consideration the following parameters; an average number of cuttings for maximum yields i.e. cutting or harvest intervals, the stage of forage maturity at harvest, residual stubble height for plant health and vigour among other parameters (NRCS, 2006). Detailed information of the influence of harvesting time on fodder yield and nutritional quality is therefore very important in optimising forage productivity.

## **2.5 Impact of nitrogen rates on the forage yield and quality fodder**

Nitrogen is a critical nutrient that aids plant growth and development. To improve potential forage and increase the nutrient content of fodder, it is much important to assess the individual fertilizer rates for the specific crop. Appropriate and judicious use of fertilizer increases yields and boosts the quality of fodder particularly protein contents (Ayub *et al.*, 2007). High yields cannot be attained without adding substantial amounts of actual nitrogen. When a fertility program is managed, it leads to improved plant vigour and the development of roots in growing conditions of abundant soil moisture and cooler temperatures. A less stressed plant can reinstate essential plant reserves after grazing or harvesting. Swift regrowth from healthy

plant crowns advances the opportunity for second cuttings. If moisture levels are standard and temperatures remain optimal, the application of nitrogen after the first cutting in most fodder species will result in the production of high forage dry matter and quality yields (Jacobs *et al.*, 1998).

Nitrogen being the constituent of protein and protoplasm, naturally increases the yield of the fodder crop primarily through the formation of greater potential sites of ear head formation, as a result of enhanced growth. Adequate nitrogen supply has the potential of producing an extra protein that allows the leaf tissues to grow larger, thereby providing a larger surface area for the photosynthetic activity to take place (Zerbini and Thomas, 2003; Yadav *et al.*, 2014).

Nitrogen is a key element needed by pearl millet and Rhodes grass since it shows variability in growth and a greater influence on yield (Gascho *et al.*, 1995). Normally, pearl millet has been considered to grow in low nitrogen fertilizer (Gascho *et al.*, 1995) but, some research has shown that nitrogen inputs may lead to more pearl forage significantly (Singh *et al.*, 2010). Vast differences exist when nitrogen is used in getting a greater forage yield of pearl millet. More dry matter in pearl millet was achieved when fertilized at a rate of 120 kg N per hectare. (Mesquita and Pinto, 2000).

Nitrogen is the macronutrient that commonly hinders yield and has a key role in the nutritional quality of fodder crops (Munene *et al.*, 2017). A positive impact of nitrogen application has been recorded by Gasim (2001) and Omer (1998). Gasim (2001) recorded higher plant heights in nitrogen fertilizer addition was because nitrogen encourages vigorous growth, increased internodes length, which eventually resulted in increased plant heights Koul (1997), observed that nitrogen led to bigger values height, leaf number, leaf area of forage maize.

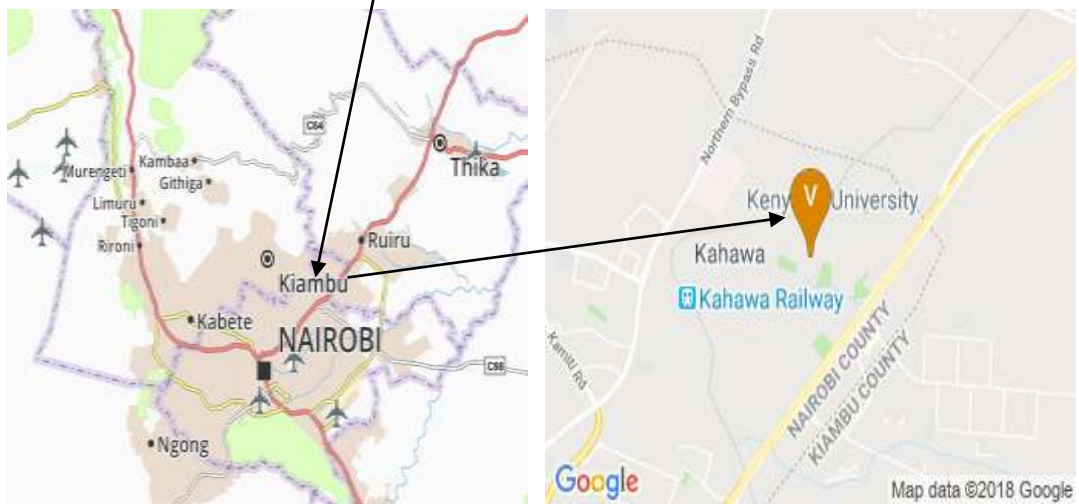


Different varieties might respond differently to fertilizer application under changing soil and environmental conditions. Plant nutrition affects forage production and improves quality. Fertilizers are essential in the present system of agriculture. Scientific use of fertilizer is important in sustainable agriculture, whereby they pay back more profit per unit of investment. Judiciously using fertilizer is an important management practice to increase fodder production. Nitrogen is an essential nutrient needed by forage crops, which is required in large amounts to improve the herbage yield (Balasubramanian *et al.*, 2010).

## **CHAPTER THREE: METHODOLOGY**

### **3.1 Study area**

The study was conducted at Kenyatta University in Kiambu County (Figure 3.1). The campus is situated about 20km from Nairobi city along the Nairobi-Thika superhighway. The farm is within coordinates 1.1767° S, 36.9365° E (Latitude: - 1.1876; Longitude: 36.9318), has an elevation of 1720 metres above sea level (ASL) and temperature range of between 18° C to 24° C. The rainfall pattern is bimodal with an average of 989 mm. Long rains occur between mid-March and May while the short rains occur between October and December. Trials were carried out during the 2017 short rains (October - December) and 2018 long rains (March-May) cropping season.



**Figure 3.1 Map of Kenya showing the experimental trial site**

### 3.2 Study design

The experimental design was Randomized Complete Block Design (RCBD) with split-split plot arrangement where the fodder crops (Rhodes grass and pearl millet) were the main plots, nitrogen fertilizer levels constituted the sub-plots, and the harvesting times the sub-sub plots (Table 3.1). The treatments were replicated three times. Individual plots measured 3 m by 3 m, blocks were spaced 1 m apart while the plots within the blocks were separated by 0.5 m.

**Table 3.1: Experimental treatments**

Main plot	Sub plot	Sub – sub plot
Fodder species	Nitrogen rates (kg ha <sup>-1</sup> )	Harvesting times (DAG)
Pearl millet	0(C)	30
	50	44
	100	58
Rhode grass	0(C)	30
	50	44
	100	58

**C - Control**

**DAG - Days after germination**

### 3.4 Agronomic management

The seeds of Rhodes grass and pearl millet were planted on a well-tilled field by using a hand drill in 30 cm apart rows and 30 cm from plant to plant. Triple superphosphate (TSP) was applied at 60 kg ha<sup>-1</sup> during seedbed preparation. After crop emergence, a faster release nitrogen fertilizer (Urea) was applied as per the

treatment rates. Weeding was done by hand after every two weeks to reduce weed competition with grass, in the case of dry periods, supplemental irrigation was done accordingly.

### **3.5 Data collection**

#### **3.5.1 Soil sampling**

Before the start of the experiment, samples were collected from the field using the auger at a depth of 0-30 cm following a zig-zag pattern and the samples mixed carefully to form a representative portion which was spread on paper and left to air dry for three days in the laboratory. Then ground using a miller and passed through a 2 mm sieve, thereafter analysed for chemical properties at National Agriculture Research Laboratory.

#### **3.5.2 Soil analysis**

Soil samples were analysed for following properties;

##### **3.5.2.1 Soil pH**

The soil pH was determined using the method outlined by (Adamchuk *et al.*, 1999), soil sample obtained from sieving (2mm) was weighed at approximately 10g, and 10 ml of 0.01 M calcium chloride solution (1:5; soil: solution) was added then thoroughly mixed and left to stand for one hour. Two standard buffers of pH 4.00 and 7.00 were used to calibrate the pH meter. Then the temperature of the suspended soil samples was measured and the temperature on the pH meter was set to match with it. The probes were rinsed with distilled water, with the pH meter on the electrodes were placed in the partially settled suspension then the reading was recorded once the meter stabilized.

### **3.5.2.2. Available phosphorus**

Phosphorus available in the soil was determined by use of Olsen and Sommers (1982) method, whereby 5g of the air-dried soil sample was weighed into a 250ml conical flask, 50 ml of 0.5N sodium bicarbonate solution (soil: solution, 1:10) was added then shaken and the contents filtered by the aid of Whatman no. 1 filtering paper. 5 ml filtrate was put into a 25ml volumetric flask then 5 ml of ammonium molybdate solution and mixed well until the evolution of carbon dioxide ceased. Then 10 ml of deionized water was added washing the neck of the flask to remove the adhering molybdate, 1 ml of working stannous chloride was added and volume increased to the mark by distilled water, the intensity of the blue colour was read at 730 nm after 10 minutes and a standard curve was prepared by plotting the absorbance against phosphorus concentrations.

### **3.5.2.3. Mineral nitrogen**

Soil total nitrogen was determined by the Kjeldahl method (Sáez-Plaza *et al.*, 2013). The procedure involved digestion, distillation and titration, 50g of the processed soil sample was weighed using an electric balance then placed in a 500 ml flask, 1g copper sulphate, 10g potassium sulphate and 30 ml of concentrated sulphuric acid were then added. Then the contents of the flask were shaken well until a complete solution resulted and allowed to stand for 30 minutes. The contents were digested until a greenish colour appeared, a blank digest was run with the same quantities of the reagents and then the blank value was subtracted from the value of the soil digest because sometimes reagents contain impurities. Digestion was effected on a digestion rack with low flame for 10 to 30 minutes until further frothing stopped and then more strongly until the sample was completely scorched. The heat was slowly

raised until the acid reached one-third way up the digestion flask. The content was then cooled and diluted to about 100 ml using distilled water. The flask was shaken for 2 minutes and the fluid was transferred to a 1000 ml flask. The residue was cleaned with 50 ml deionized water and then decanted into the flask and glass beads were added to avoid bumping. The flask was fitted with two neck joints whereby one neck joint was connected for adding 40% sodium hydroxide while the other was used to trap the sodium hydroxide coming with the distillate. Then the trap was connected to a condenser with a delivery tube that dipped into 50 ml of 0.1 N HCl in a conical flask with 2 drops of methyl red indicator, 125 ml of 40% NaOH solution until the content was alkaline in reaction. Ammonia formed was absorbed by HCl, and the end of the tube was washed down into a conical flask and then 150 ml of distilled water was added. When ammonia formation ceased (red litmus paper turned blue), distillation was stopped. The excess acid was titrated with 0.1 N NaOH until the colour changed from pink to yellow. Then the multi equality of the acid that participated in the process of ammonia absorption throughout digestion was calculated using the titrate value.

#### **3.5.2.4. Total carbon**

Organic soil carbon was determined by Walkey and Black oxidation method described by Black *et al.* (1965). One gram (1 g) of dried soil was sieved at (2mm) and weighed into a 500 ml conical flask, 10 ml 1 potassium dichromate was then added and the flask swirled gently to allow the soil to disperse in the solution, 10 ml of sulphuric acid was added while directing the stream into the suspension and the flask immediately swirled till the soil and the suspension mixed. A 200°C thermometer was then inserted and the flask was heated on a gas burner and gauze

while swirling it until the temperature reached 135°C then set aside to cool down slowly on an asbestos sheet in a fume chamber. Two blanks (without soil) were run to standardize the FeSO<sub>4</sub> solution. After cooling for about 30 minutes the content was diluted to 200 ml using deionized water read for FeSO<sub>4</sub> titration. Three (3) drops of Ferroin indicator were added and contents titrated with 0.4 N FeSO<sub>4</sub>, as the endpoint approached the solution took a greenish colour and then changed to dark green, at that point ferrous sulphate was added drop by drop until the colour changed sharply from blue-green to reddish grey.

#### **3.5.2.5 Potassium.**

Available potassium in the soil was determined by flame photometry method described by (Pratt, 1965), where a sample of the air-dried soil was sieved and weighed (5g) and put in a 100 ml polyethylene bottle, the 50 ml of ammonium acetate/acetic acid solution and the bottle was stoppered and transferred to a shaker, and mixed for 35 minutes, the liquid was decanted through a dry Whatman no. 2 filter paper potassium standard solutions were made from 0 and 100 ppm. The photometer was set at 100 using 100 ppm solution the successfully aspirated at 20, 40, 60 and 80 ppm potassium solutions and a calibration graph was prepared.

#### **3.5.2.6 Extractable nutrients**

The available trace elements in the soil were determined using ethylenediaminetetraacetic acid (EDTA) as described by Mergel and Kirkby, (1982). Whereby 1% of EDTA was prepared by dissolving 10g of di-sodium and diluting it to 1000ml in a volumetric flask using distilled water, 5g of air-dried soil passed through 2 mm sieve was placed into 250ml plastic bottle fitted with an airtight cap then 50 ml of 1% of EDTA was added and the suspension was mixed on a



reciprocating shaker for one hour. The suspension was filtered using standard filtering paper, supernatant filtrate solution was analysed using atomic absorption spectrophotometer.

### **3.5.3 Growth parameters**

Five plants in the treatment plot were selected randomly and tagged for growth attributes recording. Data were collected in two weeks intervals starting from the second week after crop emergence up to the 12th week for the following parameters; plant height (cm) was measured using a tape measure whereby the plants were recorded from the base to the tip of the tallest tiller, Number of tillers were counted in each tagged plant and recorded, stem diameter (cm) was measured using a digital Vanier Caliper. For above-ground biomass (fresh and dry) weight, root (fresh and dry) weight, two plants were uprooted from each treatment plot and then cut to separate the roots and weighed while fresh using an electric weighing balance and the mean fresh weight was calculated and recorded, thereafter oven-dried at 100 °C for 48 hours, then the samples weighed again and their mean dry weights recorded.

### **3.5.4 Yield.**

Forage was harvested from a 1.0 m<sup>2</sup> area from each treatment plot at 30, 44, and 58 days after germination since that was the period of active vegetative growth, using a sickle and then chopped and weighed and later extrapolated to yield per hectare. Then 500 g from each harvested treatment sample was dried using the oven, 60°C for 72 hours (until the weight was stable) for quality analysis.

### **3.5.5 Quality parameters.**

#### **3.5.5.1 Dry matter**

Dry matter is the portion in forages that is not water. It is an important aspect of animal nutrition and feeding since the concentration of other nutrients is usually expressed as a percentage of dry matter (on a dry matter basis). Dry matter percentage was determined using Methods of official chemists. (1990). Plant tissues dried overnight at 70°C in air-circulation to obtain air-dried samples. Dry samples were then ground using the laboratory blender to 2mm particle size and stored in airtight ziplock bags away from heat and light. Empty porcelain crucibles were dried for 2 hours at 135°C, then put in the desiccator to cool to room temperature for about 20 minutes. Oven-dried crucibles were weighed (W<sub>4</sub>) one at a time from the desiccator and kept closed between crucible removal. Approximately 2g of ground samples were then added to the crucibles and then weighed (W<sub>5</sub>), then shaken gently to evenly distribute the sample and render maximum surface area for drying. Samples were then inserted into the already heated oven at 135°C for 2 hours. The samples were moved to the desiccator and the desiccator was sealed to allow the samples to cool to room temperature. The crucibles plus the dried sample was then weighed and recorded (W<sub>6</sub>).

Calculations: **% Dry matter** =  $\{(W_6 - W_4) / (W_5 - W_4)\} \times 100$

#### **3.5.5.2 Ash and Organic matter**

Ash is the fraction of forage or animal feed that contains all the mineral elements mixed. It would be important to know the exact amount of individual elements, it also provides the estimate of contaminants. Ash can be endogenous or exogenous, endogenous ash consists of the mineral nutrients within the plant e.g Calcium,

Magnesium, and potassium which are nutritious to lactating dairy cows. Exogenous ash consists of materials exterior to the plant associated with soil such as soil particles and silica. Ash and organic matter were determined by AOAC (1990) Official method of analysis 942.05. Samples taken from each experimental plot from the field were dried at 65°C for 24 hours in the lab to obtain air-dried samples. The dry samples were then ground using a blender to 2mm particle size then kept in airtight containers away from light and heat. Empty porcelain crucibles dried at a temperature of 135°C. Crucibles were placed in the desiccator and left to cool to room temperature for about 20 minutes. The oven-dried crucible was weighed using a precision balance and recorded as W<sub>0</sub>. Approximately 3g of ground sample was added to the dried crucible and weighed (W<sub>2</sub>). The crucibles with the samples were then placed in a furnace at a temperature of 600°C for 3 hours, temperature was set to 135°C and let to drop to 135°C. The crucibles were then transferred to the desiccator and cooled to room temperature for 20 minutes. The crucible with the ashed samples was weighed immediately and recorded as W<sub>3</sub>.

Calculations: **% Ash =  $\{(W_3 - W_0) / (W_2 - W_0)\} \times 100$**

**% Ash DM =  $(\% \text{ Ash} \times 100) / \text{sample DM}$**

**% OM =  $100 - \% \text{ Ash DM}$**

### **3.6 Data analysis**

Collected data was entered and cleaned in Microsoft excel 2013, then analysed using a statistical software (GenStat 15<sup>th</sup> Edition).

## CHAPTER FOUR: FINDINGS AND DISCUSSION

### 4.1. Soil chemical properties

Soil in the study site was slightly acidic (pH 5.54), low in available phosphorus (7 ppm), total nitrogen (<0.18%) and total organic carbon (<1.53%) (Table 4.1).

**Table 4.1 Initial chemical properties of soil (0-30cm) for the study site**

Measurement	Value	Class
Soil pH	5.54	Medium acidic
Phosphorus ppm	7	Low
Nitrogen %	0.18	Low
Total Org. carbon %	1.53	Low
Potassium me%	1.64	Adequate
Magnesium me%	3.96	High
Calcium me%	7	Adequate
Copper ppm	1.48	Adequate
Zinc ppm	8.56	Adequate
Iron ppm	41.3	Adequate
Sodium me%	1.23	Adequate

As shown in above, nitrogen levels in the study site soils were low considering a moderate range of 3 to 4% in tropical soils (Kader *et al.*, 2010; Sakha *et al.*, 2019;

Miriko *et al.*, 2018). This indicated that addition of nitrogen was essential for fodder crop production.

## 4.2 Influence of nitrogen levels on growth of pearl millet and Rhode grass.

### 4.2.1 Plant height

Plant height of both fodder crops differed significantly ( $P \leq 0.05$ ) according to nitrogen levels in both seasons (Tables 4.2 and 4.3)

**Table 4.2: Effect of nitrogen levels on plant height (cm) of pearl millet during short and long rains growing seasons**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	18.86 <sup>a</sup>	26.69 <sup>c</sup>	46.69 <sup>c</sup>	20.14 <sup>c</sup>	41.97 <sup>c</sup>	58.8 <sup>c</sup>
50	20.28 <sup>a</sup>	35.67 <sup>b</sup>	62.78 <sup>b</sup>	42.42 <sup>b</sup>	70.53 <sup>b</sup>	97.9 <sup>b</sup>
100	22.30 <sup>a</sup>	47.31 <sup>a</sup>	97.25 <sup>a</sup>	79.61 <sup>a</sup>	135.97 <sup>a</sup>	187.0 <sup>a</sup>
LSD	3.45	6.89	10.65	2.99	6.69	7.78

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), N - nitrogen**

From the data in Table 4.2, the lowest plant height (18.86 cm) was recorded during the short rains under the control in week 4, while the highest plant height (187 cm) was recorded during long rains when nitrogen was applied at 100 kg/ha in week 12.

With the increase in nitrogen rates, plant height increased in both seasons. However, the differences in plant height under the three nitrogen rates were not statistically significant during short rains in week 4. These results could partially be explained by nitrogen fertilization which may have enhanced the growth of pearl millet by increasing the number of internodes and internode length (Shahin *et al.*, 2013). A similar trend was observed by Pathan and Bhilare, (2009) who showed that nitrogen supplied at 90kg/ha had higher values of growth parameters including plant height, and plant population per metre row. The higher plant heights with increased doses of nitrogen were due to the contribution of nitrogen to rapid growth, which led to an increase in the internode length and thus plant height (Nirmal *et al.*, 2016a).

Results by Chaudhary *et al.* (2018) showed higher plant height at harvest with 100 kg/ha of nitrogen application, this increase in height resulted from more supply of nitrogen to plant leading to the quick synthesis of carbohydrate and subsequently into protoplasm and thus reduced portion accessible for cell wall formation. One of the consequences is an increase in the cell size which is morphologically expressed through an increase in plant height, these results correlate with those of Agarwal *et al.* (2005)

According to (Joshi *et al.* 2018; Ntinyari *et al.*, 2018; Gweyi-Onyango *et al.*, 2018), nitrogen fertilizer application increased plant height throughout the crop growth period, the increase was due to a positive influence of nitrogen on plant growth, resulting from enhanced cell division and expansion. These outcome agreed with the work of different researchers (Khateek *et al.*, 1999; Gupta *et al.*, 2008; Rajput, 2008; El-Sarag and Abuo Hashem, 2009; Meena *et al.*, 2012; Patel, 2014; Raval *et al.*, 2014). According to Shivprasad and Singh (2017), higher plant height with increased rates of nitrogen was due to additionally available nitrogen for uptake by

the plant which led to more vigorous growth and an upsurge in protoplasm constituents and hastening the cell division process, differentiation and expansion hence resulting to luxuriant growth, these findings were in line with those of (Tiwana and Puri, 2005; Ngetich *et al.*, 2018).

**Table 4.3: Plant height (cm) of Rhodes grass as affected by nitrogen levels**

Table 10.1 Plant height (cm) of Rhodes grass as affected by nitrogen levels						
	Short rains			Long rains		
	Weeks after planting					
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	18.76 <sup>a</sup>	28.50 <sup>b</sup>	45.36 <sup>c</sup>	15.76 <sup>c</sup>	29.72 <sup>c</sup>	51.53 <sup>c</sup>
50	19.33 <sup>a</sup>	38.61 <sup>a</sup>	54.75 <sup>b</sup>	30.61 <sup>b</sup>	54.94 <sup>b</sup>	78.97 <sup>b</sup>
100	21.22 <sup>a</sup>	39.78 <sup>a</sup>	74.28 <sup>a</sup>	48.28 <sup>a</sup>	95.97 <sup>a</sup>	135.83 <sup>a</sup>
LSD	2.84	5.31	7.61	1.83	4.75	5.39

**Means followed by the same letter in the same column do not differ significantly ( $p \leq 0.05$ ), N - nitrogen**

As shown in (Table 4.3) the Rhodes grass plant height was lowest (15.76cm) during the short rains season at week 4, while the tallest plant (135.83cm) was obtained using 100 kg/ha fertilizer during the long rains season in the twelfth week after planting. However, the differences in plant height under the three nitrogen rates were not statistically significant during the short rains season in week 4. The long rains season recorded high plant heights compared to the short rains season because there was more precipitation during that period which made sufficient moisture available for the plants to utilize nitrogen fully hence resulting in taller plants. An

increase in nitrogen fertilizer application led to increased plant height due to vigorous growth, the same was recorded by Eltelib *et al.* (2006) who observed that additional nitrogen rates boosted the plant height due to the positive effect of nitrogen that led to a progressive increase in internode length resulting to stem elongation hence taller plants, similar results were obtained in the previous studies by Keskin *et al.* (2005). Findings in Table 4.3 compared with the observation of Koul, (1997) who reported that increase in nitrogen application led to superior values of plant height in fodder maize.

#### 4.2.2 Number of tillers.

Number of tillers of pearl millet and Rhodes grass differed significantly ( $P \leq 0.05$ ) according to nitrogen levels for both seasons (Tables 4.4 and 4.5).

**Table 4.4: Number of tillers of pearl millet as affected by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	2.00 <sup>b</sup>	3.00 <sup>b</sup>	3.89 <sup>c</sup>	3.00 <sup>c</sup>	3.78 <sup>c</sup>	4.44 <sup>c</sup>
50	2.33 <sup>ab</sup>	4.00 <sup>a</sup>	6.00 <sup>b</sup>	4.67 <sup>b</sup>	6.44 <sup>b</sup>	8.56 <sup>b</sup>
100	2.78 <sup>a</sup>	4.89 <sup>a</sup>	8.44 <sup>a</sup>	8.00 <sup>a</sup>	12.56 <sup>a</sup>	18.44 <sup>a</sup>
LSD	0.63	0.75	1.05	0.58	0.96	1.31

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), N - nitrogen**



There were more tillers (18) when nitrogen was supplied at a rate of 100 kg/ha during long rains in week 12 compared to when fertilizer was used at 50 kg/ha (8) and the least number of tillers (2) were recorded during short rains under zero nitrogen in week four after sowing ((Table 4.4)). However differences in the number of tillers were not statistically significant during short rains in week 4 and week 8 when nitrogen was supplied 50 kg/ha and 100 kg/ha, this was due to insufficient precipitation, whereby moisture was inadequate for the plants to utilize the supplied nitrogen efficiently. Tiller number increase with nitrogen rates was also reported by several workers (Prasad *et al.*, 2014a; Njinju *et al.*, 2018) they recorded that growth and yield parameters differed significantly with nitrogen fertilizer, application of 90 kg N/ha showed significantly taller plants, a high number of tillers and number of leaves per plant compared to when nitrogen was applied at lower rates. Nitrogen is the constituent of the protoplasm which is involved in various metabolic activities such as the stimulation of cell division and elongation, and photosynthesis (Ali, 2010). This leads to an increase in the number of tillers per plant (Ayub *et al.*, 2009). Nitrogen augments the development of sturdy cell walls hence more rigid straw which results in profuse tillering (Joshi *et al.*, 2018) and these results were in conformity with those obtained by (Pathan *et al.*, 2010; Njinju *et al.*, 2018).

**Table 4.5: Number of tillers of Rhode grass as affected by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	2.89 <sup>a</sup>	4.78 <sup>b</sup>	8.78 <sup>c</sup>	5.33 <sup>c</sup>	7.11 <sup>c</sup>	9.11 <sup>c</sup>
50	3.22 <sup>a</sup>	7.33 <sup>a</sup>	17.89 <sup>b</sup>	9.44 <sup>b</sup>	15.44 <sup>b</sup>	21.78 <sup>b</sup>
100	3.56 <sup>a</sup>	9.44 <sup>a</sup>	29.33 <sup>a</sup>	17.78 <sup>a</sup>	29.11 <sup>a</sup>	45.00 <sup>a</sup>
LSD	0.98	1.93	3.19	1.29	2.17	2.84

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), N - nitrogen**

The number of tillers of Rhodes grass increased at each increased rate of nitrogen in the long rains season and week 12 during the short rains, with the highest number of tillers (45 tillers) recorded during long rains in week 12 at a rate of 100 kg/ha, followed by 50 kg/ha (21 tillers) and then lowest (2 tillers) in short rains under the control in the fourth week after planting. During short rains in week 4, the number of tillers was comparable in the three nitrogen rates, in week 8 the difference between the number of tillers when 50 and 100 kg/ha of nitrogen were applied was not statistically significant although both were more than the control. These findings agree with those obtained by Jemberie, (2008), who reported that an increase in the number of tillers was due to the associated constant increment in the photosynthetic rate of the grass. Kizima *et al.* (2014) also found out that the optimal rate of nitrogen fertilizer increases the dynamics of *Cenchrus ciliaris* tiller population and affects their appearance. In addition, these results are corroborated by those of

Mushtaque *et al.* (2010) who ascertained that nitrogen fertilizer prompts dormant buds by activating them thus increasing vegetative filling with the utmost tiller multiplication, that yields a greater percentage of younger tillers per plant, eventually resulting in more of tillers and subsequently increases herbage. Isa *et al.* (2020) also recorded an increase in the mean number of tillers which was influenced by inter-row spacing and an increase in nitrogen fertilizer levels. These results correlate with Aderinola *et al.* (2011), who observed that boosted *Andropogon tectorum* yield was due to nitrogen fertilizer application that resulted in the increased number of tillers.

#### 4.2.3 Stem diameter

Nitrogen rates led to significant differences ( $P \leq 0.05$ ) in stem diameter of pearl millet and Rhodes grass (Table 4.6 and 4.7).

**Table 4.6: Mean pearl millet stem diameter (cm) as affected by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	0.71 <sup>b</sup>	0.81 <sup>c</sup>	0.82 <sup>c</sup>	0.54 <sup>c</sup>	0.67 <sup>c</sup>	0.94 <sup>c</sup>
50	0.82 <sup>b</sup>	1.01 <sup>b</sup>	1.25 <sup>b</sup>	0.86 <sup>b</sup>	1.18 <sup>b</sup>	1.41 <sup>b</sup>
100	0.99 <sup>a</sup>	1.37 <sup>a</sup>	1.79 <sup>a</sup>	1.23 <sup>a</sup>	1.74 <sup>a</sup>	2.28 <sup>a</sup>
LSD	0.11	0.11	0.08	0.06	0.08	0.07

Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), N - nitrogen

Pearl millet stem diameter was positively influenced by nitrogen whereby the increase in nitrogen rates resulted in a significant increase ( $P \leq 0.05$ ) in stem diameter in both short and long rains seasons (Table 4.6). Thicker stems were observed during short rains as compared to short rains, maximum stem diameter (2.28cm) was recorded when fertilizer application was done at 100 kg/ha, followed by (1.41cm) at 50kg/ha in week 12 and minimum (0.54cm) under the control in week 4 during the long rains season. An increase in stem diameter with an increase in the nitrogen levels can be attributed to better growth due to a stable supply of nutrients at higher rates of nitrogen. Similar findings were also reported by Ayub *et al.* (2002b and 2007). These results also correlate with those of Cho *et al.* (2001), they also reported a significant effect on pearl millet stem diameter with nitrogen application. Ibrahim *et al.* (2014) also reported that additional nitrogen doses resulted in thicker stems. These results confirm the findings of Saruhan and Şireli (2005), and Ayub *et al.* (2009).

**Table 4.7: Mean Rhodes grass stem diameter (cm) as affected by nitrogen**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	0.23 <sup>c</sup>	0.38 <sup>c</sup>	0.54 <sup>c</sup>	0.24 <sup>c</sup>	0.42 <sup>c</sup>	0.58 <sup>c</sup>
50	0.51 <sup>b</sup>	0.69 <sup>b</sup>	0.78 <sup>b</sup>	0.43 <sup>b</sup>	0.69 <sup>b</sup>	0.89 <sup>b</sup>
100	0.64 <sup>a</sup>	0.99 <sup>a</sup>	1.39 <sup>a</sup>	0.77 <sup>a</sup>	1.25 <sup>a</sup>	1.69 <sup>a</sup>
LSD	0.07	0.08	0.09	0.03	0.04	0.06

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), N - nitrogen**

The output obtained indicates there was an increase in stem diameter of Rhodes grass with additional doses of nitrogen across the weeks (Table 4.7), Maximum stem diameter (1.69cm) was recorded during the long rains in week 12 when the application rate was 100 kg/ha, followed by (0.89cm) at 50 kg/ha and minimum (0.23cm) during short rains season under the control in the fourth week. The increase in stem diameter due to nitrogen application might have resulted from the high photosynthetic activities which produced more photosynthates thus supplying food to growing parts hence improving growth. These results correlate well with those of Mohammed, (1990) who found out that nitrogen fertilizer increased stem diameter, plant density and number of leaves of both grasses and legumes.

#### **4.2.4 Above-ground biomass fresh weight**

Statistical analysis of data showed that nitrogen fertilizer doses had an effect ( $P \leq 0.05$ ) in biomass fresh mass of both fodder species (Table 4.8 and 4.9)

**Table 4.8: Mean pearl millet above ground biomass fresh weight per plant (g) as affected by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	10.96 <sup>b</sup>	20.14 <sup>b</sup>	55.9 <sup>b</sup>	18.73 <sup>c</sup>	37.4 <sup>c</sup>	69.0 <sup>c</sup>
50	35.47 <sup>b</sup>	56.70 <sup>b</sup>	126.1 <sup>b</sup>	53.02 <sup>b</sup>	91.9 <sup>b</sup>	148.7 <sup>b</sup>
100	81.76 <sup>a</sup>	184.00 <sup>a</sup>	428.5 <sup>a</sup>	90.20 <sup>a</sup>	187.2 <sup>a</sup>	452.9 <sup>a</sup>
LSD	29.99	43.14	94.3	9.72	18.32	46.06

**Means followed by the same letter in the same column do not differ significantly ( $p \leq 0.05$ ), N - nitrogen**

Pearl millet above ground biomass fresh weight was significantly influenced ( $P \leq 0.05$ ) by nitrogen levels whereby during long rains the effect of nitrogen was statistically significant in all the nitrogen rates, highest biomass fresh weight (452.9g) was recorded in week 12 in 100 kg/ha, followed by (148.7g) at 50 kg/ha and the lowest (10.96g) during short rains under the control (Table 4.8). During the short rains season, biomass fresh weight at 50 kg/ha was higher than at 0 kg/ha though not significantly different in week 4, week 8 and week 12. The difference in biomass fresh weight can be attributed to an increase in the availability of nutrients due to a balanced supply by high nitrogen fertilizer rates. Similar results were reported by Afzal *et al.* (2012) who recorded an increase in fresh weight per plant in multi-cut forage sorghum with an increase in nitrogen levels. These findings concur with those of others (Awan, 1999; Ammaji and Suryanarayana, 2003; Devi, 2002;

Shivran and Pareek, 2001; Chaurasia *et al.*, 2006) who reported that nitrogen application increased the shoot fresh weight of grasses.

According to Khinchi *et al.* (2017), nitrogen levels led to a significant increase in pearl millet green forage, this was due to the favourable effect of nitrogen on the formation of co-enzymes and nucleotides, and cell elongation which led to the increased photosynthetic area and meristematic activity and thus more accumulation of photosynthates, resulting to more number of tillers and high plant height hence increased biomass. These results confirm those of Sheoran and Rana, (2006) and Mohan *et al.* (2015) who reported that shoot fresh weight of pearl millet increased with nitrogen rates increase. The assimilatory system of the plant is measured by its leaf area which is a product of leaf breadth and length thus affecting the plant biomass. Application of nitrogen fertilizer at the of 150 kg/ha produced more significant leaf area than the other treatments hence more biomass fresh weight, the rates of 50 and 100 kg/ha differed significantly and produced a high surface area of leaves than in plots of zero nitrogen (Ayub *et al.*, 2007).

The higher number of leaves led to an increase in fresh biomass weight at each increased rate of nitrogen fertilizer. Ahmad *et al.* (2011) recorded more leaves per crop in forage sorghum in the application of nitrogen fertilizer which eventually resulted in fresher biomass weight. The findings of this study agree with those of Backiyavathy *et al.* (2007) who reported that high fresh biomass yield in forage sorghum was due to an increase in nitrogen rates. Chaudhary *et al.* (2018) reported that in higher nitrogen levels plant leaf area increased as a result of the increase in leaf expansion rate due to quicker cell division and more cell expansion which concurrently increased photosynthate formation hence high leaf width and leaf length resulting in high leaf area per plant and thus more biomass fresh weight in

forage sorghum, these findings were in conformity with those of different workers (Devi and Padmaja, 2007; Nadeem *et al.* 2009; Khan *et al.* 2014).

**Table 4.9: Mean Rhodes grass above ground biomass fresh weight per plant (g) as affected by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg ha <sup>-1</sup>						
0	3.38 <sup>b</sup>	10.90 <sup>b</sup>	36.90 <sup>b</sup>	10.81 <sup>c</sup>	23.99 <sup>c</sup>	46.4 <sup>c</sup>
50	16.32 <sup>ab</sup>	39.40 <sup>b</sup>	74.80 <sup>b</sup>	26.46 <sup>b</sup>	58.82 <sup>b</sup>	94.7 <sup>b</sup>
100	27.41 <sup>a</sup>	84.12 <sup>a</sup>	203.4 <sup>a</sup>	49.73 <sup>a</sup>	118.95 <sup>a</sup>	253.7 <sup>a</sup>
LSD	10.91	25.3	91.6	4.86	14.65	20.01

**Means followed by the same letter in the same column do not differ significantly ( $p \leq 0.05$ ), N - nitrogen**

Nitrogen fertilizer levels had significant effects ( $P \leq 0.05$ ) on Rhodes grass above ground biomass fresh weight during long rains, highest biomass fresh weight (253.7g) was recorded at 100 kg/ha rate in week 12, while the lowest (3.38g) was recorded in the plots where no nitrogen fertilizer was applied during short rains (Table 4.9). There were no statistical differences in biomass fresh weight between nitrogen applied at 50 kg/ha and 0 kg/ha in week 8 and week 12 during the short rains season. The increase in biomass fresh weight with increased levels of nitrogen was probably due to a high ratio of leaf to stem with an increase in nitrogen because of rapid extension of the foliage which captures and use the sun rays to produce photosynthates and hence resulting in increased meristematic activities and high leaf



to stem ratio per plant which is referred to as biomass. An increase in nitrogen might have favourably influenced the processes of cell division and elongation which led to the production of more functional leaves for a long period. Leaves play a crucial role in manufacturing food by the process of photosynthesis and supplying the food material to other parts of the plant. Hence an increase in the number of leaves has an impact on plant biomass which affects the herbage yield of fodder crops (Shivprasad and Singh, 2017). These results were in line with the findings of Ahmad *et al.* (2003), who reported that leaf area is a key morphological determinant of forage yield, increase in nitrogen levels led to a significant increase in the leaf area index, whereby the minimum leaf area was recorded in the control plots, plots with zero nitrogen. Olanite *et al.* (2010) found out that for all growth parameters, maize plants that received nitrogen fertilizer at different levels performed well than the control. These findings were in conformity with those of Yagoub and Abdelsalam, (2010) who reported that forage sorghum fresh weight increased with nitrogen application.

#### **4.2.5 Above ground biomass dry weight**

The findings obtained indicated there were statistical differences ( $P \leq 0.05$ ) in above ground biomass dry weight of both fodder species when supplied with different levels of nitrogen fertilizer during both short and long rains (Table 4.10 and 4.11)

**Table 4.10: Mean pearl millet above ground biomass dry weight per plant (g) as affected by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	1.38 <sup>b</sup>	2.70 <sup>b</sup>	9.73 <sup>b</sup>	2.49 <sup>c</sup>	4.61 <sup>c</sup>	12.32 <sup>c</sup>
50	4.31 <sup>b</sup>	6.90 <sup>b</sup>	18.84 <sup>b</sup>	6.12 <sup>b</sup>	11.34 <sup>b</sup>	25.90 <sup>b</sup>
100	8.99 <sup>a</sup>	22.32 <sup>a</sup>	62.74 <sup>a</sup>	11.56 <sup>a</sup>	25.15 <sup>a</sup>	74.63 <sup>a</sup>
LSD	2.96	4.96	13.5	1.51	2.86	4.77

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), N - nitrogen**

Pearl millet above ground biomass dry weight increased significantly ( $P \leq 0.05$ ) with additional nitrogen fertilizer rates zero to 100 kg/ha during long rains in week 4, week 8, and week 12 (Table 4.10). During short rains nitrogen supplied at 100 kg/ha led to higher dry weight 8.99g, 22.32g, and 62.74g in week 4, week 8, and week 12 respectively than the rates of 0 and 50 kg/ha. Even though biomass dry weight when fertilizer was applied at 50 kg/ha was higher than 0 kg/ha during short rains, the values were not statistically significant. An increase in plant dry weight with an increase in nitrogen doses was due to an increase in photosynthetic products such as leaf weight, leaf area and stem length. These results were in conformity with those Tiwana *et al.* (2003) who recorded an increase in dry weight as the levels of nitrogen were increased. Chaudhary *et al.* (2018) reported that high biomass dry weight per plant with nitrogen application was due to increased plant height, leaf width and leaf

length as a result of increased photosynthetic rates. Therefore, more availability of metabolites, photosynthates and nutrients led to more biomass dry weight per plant, these observations agreed with those of previous researchers (Aslam *et al.*, 2011; Shahid, 2012; Ayub *et al.*, 2013) who reported that increase in biomass weight in grasses was positively related to nitrogen application.

**Table 4.11: Mean Rhodes grass above ground biomass dry weight per plant (g) as affected by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	0.63 <sup>b</sup>	1.72 <sup>b</sup>	7.15 <sup>b</sup>	1.73 <sup>c</sup>	3.26 <sup>c</sup>	10.01 <sup>c</sup>
50	2.38 <sup>ab</sup>	5.17 <sup>b</sup>	16.37 <sup>b</sup>	3.23 <sup>b</sup>	7.69 <sup>b</sup>	20.52 <sup>b</sup>
100	4.02 <sup>a</sup>	10.36 <sup>a</sup>	51.68 <sup>a</sup>	6.44 <sup>a</sup>	15.48 <sup>a</sup>	58.49 <sup>a</sup>
LSD	1.71	3.21	17.81	0.75	1.44	3.47

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), N - nitrogen**

The nitrogen rates led to ( $P \leq 0.05$ ) increase in Rhodes grass above ground biomass dry weight during long rains, whereby the highest dry weight per plant (58.49g) was recorded in the twelfth week after planting in 100 kg/ha, followed by 50 kg/ha (20.52g) and then the lowest (0.63g) during short rains in week 4 under the control (Table 4.11). In the short rains season, the rate of 100 kg/ha led to higher dry weights in weeks 8 and 12 than the rates of 50 kg/ha and 0 kg/ha. Even though dry weights at the rate of 50 kg/ha were more than the control, they were not

significantly different. Low moisture content due to low rainfall during season 1 might have affected the effective utilization of nitrogen applied. Increased dry weight with nitrogen application can be due to the essential role of nitrogen in initiating photosynthetic activities in the plant, which enhanced more growth and hence leading to higher biomass dry weight per plant. These findings were in line with those of Ziki *et al.* (2019) who reported that increased nitrogen levels led to highly significant differences in Sudan grass dry weight per plant, was due to an increase in growth attributes such as leaf area, many shoots and plant height, therefore leading to more biomass weight (g)/plant and ultimately more dry weight per plant. These results were in conformity with those of Khair *et al.* (2007), Yagoub and Abdelsalam (2010). Nirmal *et al.* (2016b) reported significant increases in biomass dry weight per plant in forage sorghum with higher nitrogen rates compared to lower rates, this correlates with the findings of Moghimi and Maghsoudi, (2015), Somashekar *et al.* (2015) and El Zubair *et al.* (2015)

#### **4.2.6 Root fresh weight**

Analysis of variance results indicated differences ( $P \leq 0.05$ ) in root fresh weight of both pearl millet and Rhodes grass with nitrogen application (Table 4.12 and 4.13).

**Table 4.12: Pearl millet root fresh weight per plant (g) as affected by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg ha <sup>-1</sup>						
0	4.47 <sup>b</sup>	6.48 <sup>b</sup>	26.52 <sup>c</sup>	6.52 <sup>c</sup>	13.90 <sup>c</sup>	27.23 <sup>c</sup>
50	10.42 <sup>b</sup>	14.35 <sup>b</sup>	77.49 <sup>b</sup>	12.47 <sup>b</sup>	29.18 <sup>b</sup>	80.63 <sup>b</sup>
100	20.90 <sup>a</sup>	38.97 <sup>a</sup>	155.37 <sup>a</sup>	30.37 <sup>a</sup>	71.17 <sup>a</sup>	167.91 <sup>a</sup>
LSD	7.36	9.14	23.69	3.08	5.78	10.38

**Means followed by the same letter in the same column are not significantly different (p≤0.05), N - nitrogen**

During short rains, the nitrogen rate of 100 kg/ha resulted in higher pearl millet root fresh weight than the rates of 50 kg/ha and 0 kg/ha in week 4, week 8 and week 12 (Table 4.12). Even though the rate of 50 kg/ha led to more root dry weight than the control (0 kg/ha), the difference was not statistically significant in weeks 4 and 8. In long rains the influence of nitrogen application was highly significant throughout the growing period whereby the maximum root dry weight per plant (167.91g) was recorded in season 2 at 100 kg/ha in week 12, followed by 50 kg/ha (80.63g), minimum (4.47g) in short rains season under the control during the fourth week after germination. An increase in root fresh weight with nitrogen application can be attributed to high root proliferation, enhanced root hair formation and additional

secondary root growth. These recordings were in conformity with those of Razaq *et al.* (2017) who reported that optimum nitrogen fertilization had a positive impact on root growth, root biomass, and root elongation at each increased rate, which were similar to the observations of López-Bucio *et al.* (2003), and De Giorgio and Fornaro, (2012).

**Table 4.13: Rhodes grass root fresh weight per plant (g) as affected by nitrogen levels**

	Short rains			Long rains		
	Weeks after planting					
Treatment	4	8	12	4	8	12
N rates kg						
ha <sup>-1</sup>						
0	3.48 <sup>b</sup>	5.68 <sup>c</sup>	26.81 <sup>c</sup>	3.99 <sup>c</sup>	6.68 <sup>c</sup>	29.40 <sup>c</sup>
50	7.53 <sup>ab</sup>	14.49 <sup>b</sup>	52.48 <sup>b</sup>	9.93 <sup>b</sup>	23.34 <sup>b</sup>	56.75 <sup>b</sup>
100	11.23 <sup>a</sup>	26.33 <sup>a</sup>	109.30 <sup>a</sup>	20.58 <sup>a</sup>	52.16 <sup>a</sup>	118.89 <sup>a</sup>
LSD	5.59	6.91	18.79	1.64	4.54	8.99

**Means followed by the same letter in the same column are not significantly different (p≤0.05), N - nitrogen**

Root fresh weight in Rhodes grass was significantly influenced ( $P \leq 0.05$ ) by rates of nitrogen during long rains, whereby the increase in root fresh weight per plant was significant at each increased rate of nitrogen (Table 4.13). The rate of 100 kg/ha resulted in the highest fresh weight (118.89g) during long rains in week 12 and the lowest during short rains in week 4 (3.48g) under control during the same period.

During short rains root, fresh weight showed significant differences with nitrogen application except in week 4 where the weights at each rate were comparable. Nitrogen application stimulated the growth and greening of Rhodes grass by aiding shoot and root growth. Nitrogen is an essential element that has a key influence on many plant responses such as pigmentation, tolerance to cold and dry conditions, accelerated shoot and root formation, accretion of the ageing process and recovery (Alwi *et al.*, 2018). The results in Table 4.13 correlate with those of Song *et al.* (2010) and Wekha *et al.* (2016) who reported that applying nitrogen together with phosphorus led to an increase in root length, root surface area, and root to shoot weight.

#### **4.2.7 Root dry weight**

Root dry weight of pearl millet and Rhodes grass revealed significant differences ( $P \leq 0.05$ ) due to nitrogen fertilizer application in pearl millet and Rhodes grass (Table 4.14) and 4.15), During the long rains season higher values of root dry weight compared to short rains, steady increase during this period can be attributed to the favourable climatic conditions i.e. adequate rainfall which aided the utilization of the supplied nitrogen by the plants effectively. According to Waraich *et al.* (2011), plant roots are not capable of getting ideal amounts of nitrogen from the soil in drought conditions, which affects plant growth negatively by physiological metabolism disturbances, this observation correlates with findings of Saud *et al.* (2017) who observed lack of adequate precipitation severely hindered all morphological characteristics, carbon content, nitrogen utilization, leaf structure and root density of bluegrass.

**Table 4.14: Mean pearl millet root dry weight per plant (g) as influenced by nitrogen levels**

	Short rains			Long rains		
	Weeks after planting					
Treatment	4	8	12	4	8	12
N rates kg ha <sup>-1</sup>						
0	3.08 <sup>b</sup>	4.31 <sup>b</sup>	19.26 <sup>c</sup>	4.71 <sup>c</sup>	10.43 <sup>c</sup>	21.18 <sup>c</sup>
50	7.09 <sup>b</sup>	9.36 <sup>b</sup>	56.60 <sup>b</sup>	8.89 <sup>b</sup>	22.78 <sup>b</sup>	60.54 <sup>b</sup>
100	14.06 <sup>a</sup>	26.08 <sup>a</sup>	110.24 <sup>a</sup>	21.77 <sup>a</sup>	57.20 <sup>a</sup>	132.82 <sup>a</sup>
LSD	5.11	6.01	19.75	2.04	5.17	6.35

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), N - nitrogen**

Pearl millet root dry weight per plant exhibited significant differences ( $P \leq 0.05$ ) in the whole of long rains season, whereby the rate of 100 kg/ha nitrogen resulted in maximum weight (132.82g) in the 12th week after planting, followed by the rate of 50 kg/ha (60.54g) then the minimum (3.08g) during short rains season under the control (zero nitrogen) in the fourth week after planting (Table 4.14). During long rains, the rate of 100 kg/ha led to more superior root dry weight values than the other rates, during the short rains In week 12 significant differences were observed between the three nitrogen rates, while in weeks 4 and 8 the differences between the rate of 50 kg/ha and the control were not statistically significant this can be attributed to insufficient moisture which led to slow growth. According to Wang *et al.* (2014), the morphology of roots is closely linked to the maturation of plant biomass implying that more above biomass weight means more the root weight,



these findings were in line with those of Qi *et al.* (2019) who found that conventional application led to a significant increase in maize root weight density. Dry matter accumulation in pearl millet roots was significantly influenced by different planting patterns and rates of nitrogen fertilizer (Rakesh *et al.*, 2019).

**Table 4.15: Mean Rhodes grass root dry weight per plant (g) as influenced by nitrogen levels**

Short rains				Long rains		
Weeks after planting						
Treatment	4	8	12	4	8	12
N rates kg ha <sup>-1</sup>						
0	2.61 <sup>b</sup>	4.29 <sup>c</sup>	20.43 <sup>c</sup>	2.76 <sup>c</sup>	4.70 <sup>c</sup>	22.51 <sup>c</sup>
50	5.71 <sup>ab</sup>	10.78 <sup>b</sup>	39.57 <sup>b</sup>	6.63 <sup>b</sup>	16.62 <sup>b</sup>	45.99 <sup>b</sup>
100	8.24 <sup>a</sup>	18.12 <sup>a</sup>	78.93 <sup>a</sup>	15.48 <sup>a</sup>	39.23 <sup>a</sup>	85.65 <sup>a</sup>
LSD	4.26	4.40	14.14	1.29	4.36	8.68

**Means followed by the same letter in the same column are not significantly different (p≤0.05), N - nitrogen**

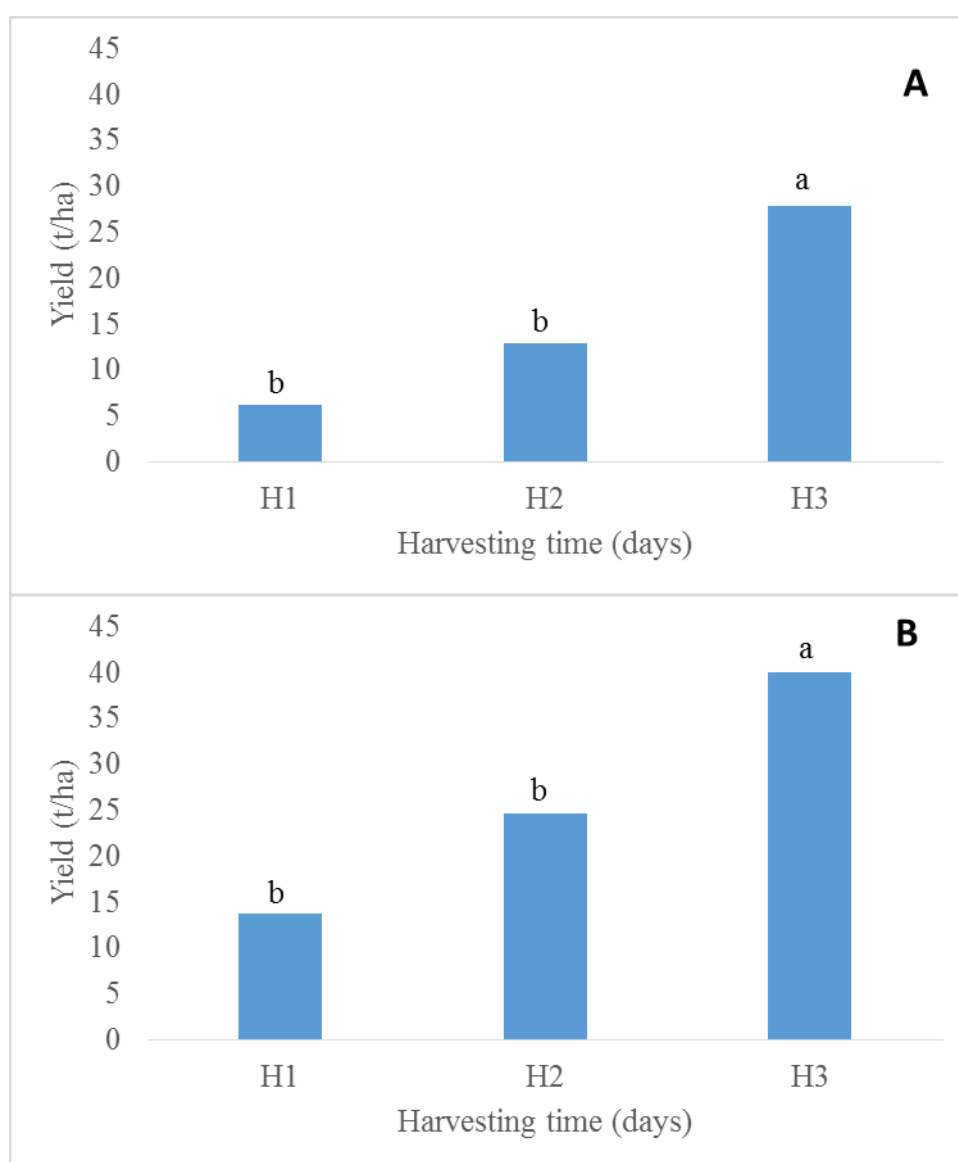
The root dry weight of Rhodes grass per plant was significantly influenced ( $P \leq 0.05$ ) by nitrogen rates in both short and long rains, though during the fourth week after planting in short rains the root dry weights were not statistically different from each other under the three rates of nitrogen (Table 4.15). Maximum root dry weight (85.65g) was recorded in long rains season under the rate of 100 kg/ha and the minimum (2.61g) under control (0 kg/ha) during short rains in the fourth week after planting. Nitrogen application led to an increase in root length and root surface area to support the high above-ground biomass. Costa *et al.*, (2002) observed that

optimum nitrogen fertilization enhanced root length and diameter. According to Wagner *et al.* (2003), response of shoot growth reflected the root growth response, which showed a significant increase in root dry matter with nitrogen supply. Inorganic fertilizers in the form of NPK and organic fertilizer (compost) gave an actual influence on the root dry weight, the number of tillers and canopy (Priyadarshani *et al.*, 2013).

### **4.3 Influence of harvesting time on biomass yield and quality**

#### **4.3.1 Effect of harvesting time on yield**

Results of this study indicated differences ( $P \leq 0.05$ ) in forage yield of both fodder species when harvested in 30, 44 and 58 days after germination (Figure. 4.1 and 4.2)



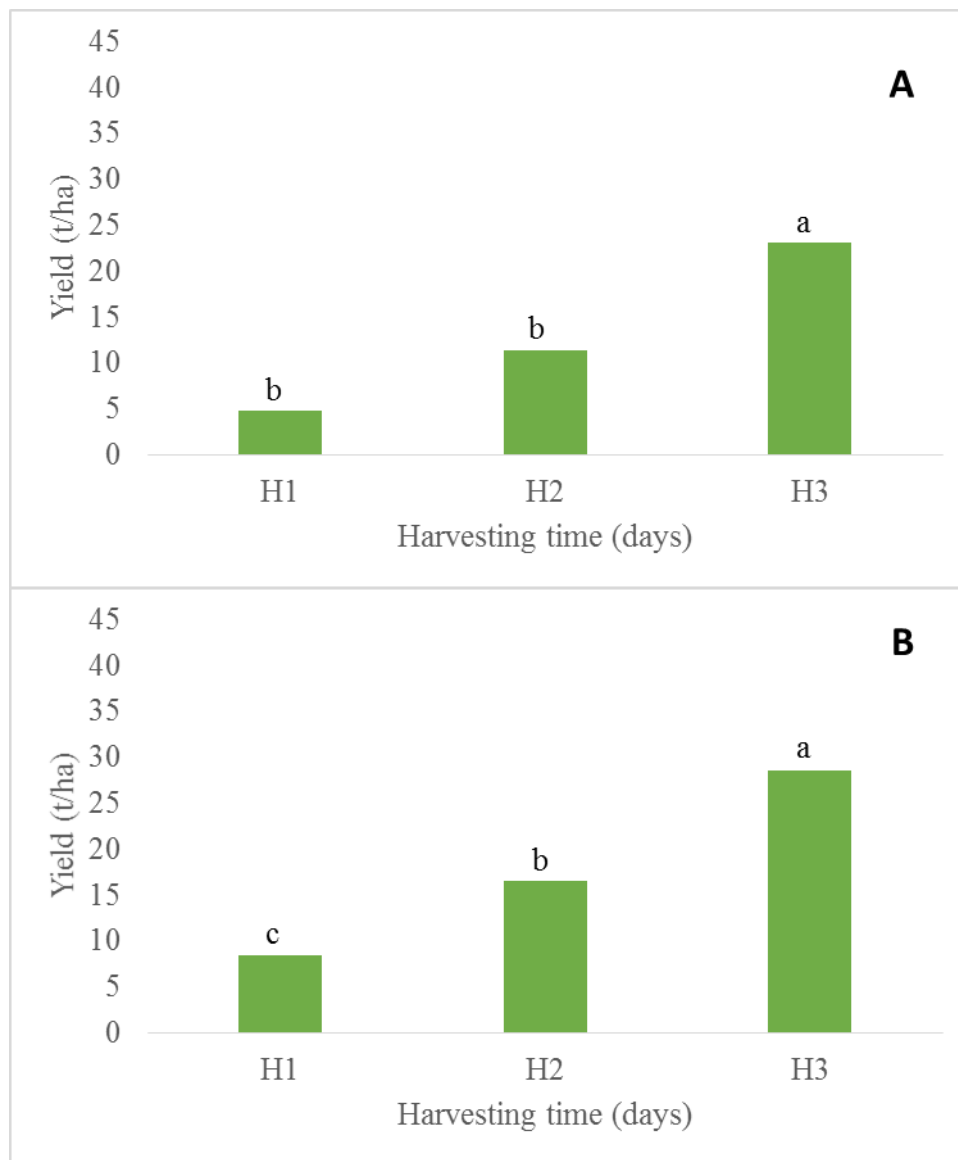
**Figure 4.1: Mean yield of millet as affected by harvesting time during short rains (A) and long rains (B). H1, H2, and H3 denotes 30, 44, and 58 days after germination respectively**

The yield of pearl millet increased with delayed harvesting during short and long rains season (Figure 4.1). The highest yield (40.04t/ha) was obtained during long rains when forage was harvested at 58 days after germination (DAG) and the lowest (6.27t/ha) during short rains when the forage was harvested at 30 days after germination. Forage harvested at 58 DAG was significantly different from the ones

harvested at 30 DAG and 44 DAG in both seasons. Though in both seasons there were no significant differences in forage harvested at 30 DAG and 44 DAG. More yield was obtained with delayed harvesting due to the increase in plant and tiller height caused by stem elongation as the millet crop matured. Similar observations were made by Amodu *et al.* (2001), who recorded high plant heights with delayed harvesting of millet leading to high more fresh forage yield. These results were in conformity with those of Musa *et al.* (1993), and Shahid, (2012).

According to Crawford *et al.* (2018), higher forage yield associated with delayed harvesting was due to the increase in growth attributes like the number of tillers, plant height, and stem diameter; findings that were in line with the results of this study and those of Ram and Singh, (2001), and Amandeep *et al.* (2010). Ayub *et al.* (2009), reported that harvesting time significantly influenced fresh forage yield thus the yield increment with delaying harvesting which was primarily due to growth parameters that increased with maturity

.



**Figure 4.2: Yield of Rhodes grass as affected by harvesting time during short rains (A) and long rains (B). H1, H2, and H3 denotes 30, 44, and 58 days after germination respectively**

Significant differences ( $P \leq 0.05$ ) were observed on Rhode grass yield during long rains as shown in Figure 4.2, during this season the increase in yield was significant as harvesting was delayed. Harvesting 58 days after germination (DAG) recorded high yields (23.09t/ha), and (28.60t/ha) in short and long rains respectively. However, during short rains, the difference in yield between harvesting at 30 DAG

and 44 DAG was not statistically significant. The increase in yield was due to the advancements in the age of Rhodes grass as harvesting was delayed, thus increasing the growth parameters.

According to Ziki *et al.* (2019), forage weight increased significantly with late harvesting of Sudan grass as compared to early cutting date, this was due to more growth attributes like leaf number as the crop matured hence resulting in more fresh forage weight per plant eventually high yield, which was quite suitable if the target of crop production was high forage yield. Dry yield in forage crops is essential since it is crucial component of carbohydrates that provide energy for livestock. These results correlate with the report by Machicek, (2018), who concluded that harvesting forage sorghum at 90 days after sowing produced a significantly high yield compared to forage harvested 30 and 45 days after planting.

Harvesting time significantly affected the intermodal length of Bana grass thus more fresh forage yield, whereby late harvesting produced significantly longer internodes compared to intermediate and early harvesting (Melakie and Melaku, 2010). According to Zewdu, (2005), high yields were recorded with delaying harvesting in elephant grass due to its perennial nature, which allows high vegetative growth and production of more tillers as the pasture period increased. The findings of this study confirm those of Čop *et al.* (2009), and Denekew *et al.* (2005). A report by Tolera *et al.* (2006) indicated that fresh forage yield of Rhodes grass significantly increased with delayed cutting.

#### **4.3.2 Quality as affected by harvesting time**

Significant differences ( $P \leq 0.05$ ) on dry matter, ash content and organic matter of Rhodes grass and pearl millet were observed in both seasons (Table 4.16 and 4.17)

**Table 4.16: Quality of forage pearl millet and Rhodes grass as affected by harvesting time during the short rains**

Treatment	Dry matter%		Ash content%		Organic matter%	
	Pearl millet	Rhodes grass	Pearl millet	Rhodes grass	Pearl millet	Rhodes grass
<b>Harvesting time</b>						
H1	20.94 <sup>c</sup>	19.81 <sup>c</sup>	10.70 <sup>a</sup>	9.25 <sup>a</sup>	89.30 <sup>b</sup>	90.75 <sup>b</sup>
H2	26.52 <sup>b</sup>	22.14 <sup>b</sup>	9.13 <sup>ab</sup>	7.46 <sup>ab</sup>	90.87 <sup>ab</sup>	92.54 <sup>ab</sup>
H3	31.49 <sup>a</sup>	27.84 <sup>a</sup>	7.67 <sup>b</sup>	6.32 <sup>b</sup>	92.33 <sup>a</sup>	93.68 <sup>a</sup>
<b>LSD</b>	1.78	1.35	2.20	1.86	2.22	1.84
<b>SxHT</b>	*	*	*	*	*	*

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), SxHT - interaction between species and harvesting times, H1, H2, and H3: 30, 44, 58 days after germination respectively**

Dry matter percentage revealed significant differences ( $P \leq 0.05$ ) in both pearl millet and Rhodes grass during short rains season at different harvesting times (Table 4.16). Maximum percentage dry matter was recorded in forage harvested 58 days after germination (DAG), followed by 44 DAG and minimum in 30 DAG. Dry matter increase was because stem girth and plant height increased as the millet matured. According to Tariq *et al.*, (2011) dry matter production in millet hybrids was positively related to maturity. Maximum dry matter yield and fresh forage in oat were recorded at 50% flowering stage (Ashiq *et al.*, 2002). These findings corroborate with those of Ram *et al.* (2007) who reported that biomass yield of forage sorghum increased with maturity. A report by Shahid, (2012) indicated that the dry matter percentage in fodder maize significantly increased with the

advancement in maturity and the harvesting times varied significantly from each other, The author's work showed that maximum percentage of dry matter was observed in plots harvested 65 days after planting. Dry matter percentage increased with ageing due to additional deposition of fibrous materials in the plant organs (Crawford *et al.*, 2018), these results were in line with the findings of Ayub *et al.* (2009). This study agrees with the work of Bediye *et al.* (1998), who reported that the dry matter content of grass increased due to an increase in the growth and development of the plants, with long days to harvesting.

The ash content showed significant differences ( $P \leq 0.05$ ) in both pearl millet and Rhodes grass during short rains at different harvesting times (Table 4.16). Maximum ash content percentage was recorded in forage harvested 30 days after germination (DAG), followed by 44 DAG and minimum in 58 DAG. Ash reduced with delayed harvesting. A decrease in total ash was associated with lengthening the harvesting time due to high crude fibre concentration in dry matter. Crude fibre increased continuously with longer harvesting days which featured lignin deposition in cell walls with advanced maturity (Tariq *et al.*, 2011).

Ash content is the mineral nutrients phosphorus, calcium, magnesium and potassium (P, Ca, Mg, K) in total dry matter, with delayed harvesting the percentage ash content reduced due to movement of nutrients from vegetative to the reproductive parts of the crop and loss of foliage (Tariq *et al.*, 2011). These findings were confirmed in this study. According to Shahid, (2012) ash percentage was significantly influenced by harvesting times, ash decreased with maturity and all harvesting dates significantly differed from one another. These findings were in conformity with those of Kitaba, (2003) and Abate, (2008).



Significant differences ( $P \leq 0.05$ ) were observed in the percentage organic matter of both Rhodes grass and pearl millet (Table 4.16). Minimum percentage organic matter was recorded in forage harvested 30 days after germination (DAG), followed by 44 DAG and maximum in 30 DAG.

**Table 4.17: Quality of forage pearl millet and Rhodes grass as affected by harvesting time during the long rains**

	Dry matter%		Ash content%		Organic matter%	
Treatment	Pearl	Rhodes	Pearl	Rhodes	Pearl	Rhodes
	millet	grass	millet	grass	millet	grass
<b>Harvesting time</b>						
H1	23.71 <sup>c</sup>	21.82 <sup>c</sup>	11.57 <sup>a</sup>	10.36 <sup>a</sup>	88.55 <sup>b</sup>	89.75 <sup>b</sup>
H2	28.96 <sup>b</sup>	25.63 <sup>b</sup>	10.07 <sup>ab</sup>	8.45 <sup>ab</sup>	89.93 <sup>ab</sup>	91.52 <sup>ab</sup>
H3	34.82 <sup>a</sup>	32.04 <sup>a</sup>	8.68 <sup>b</sup>	7.16 <sup>b</sup>	91.32 <sup>a</sup>	92.83 <sup>a</sup>
<b>LSD</b>	2.88	2.21	2.18	1.81	2.25	1.89
<b>SxHT</b>	*	*	*	*	*	*

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), SXHT - interaction between species and harvesting times, H1, H2, and H3: 30, 44, 58 days after germination respectively**

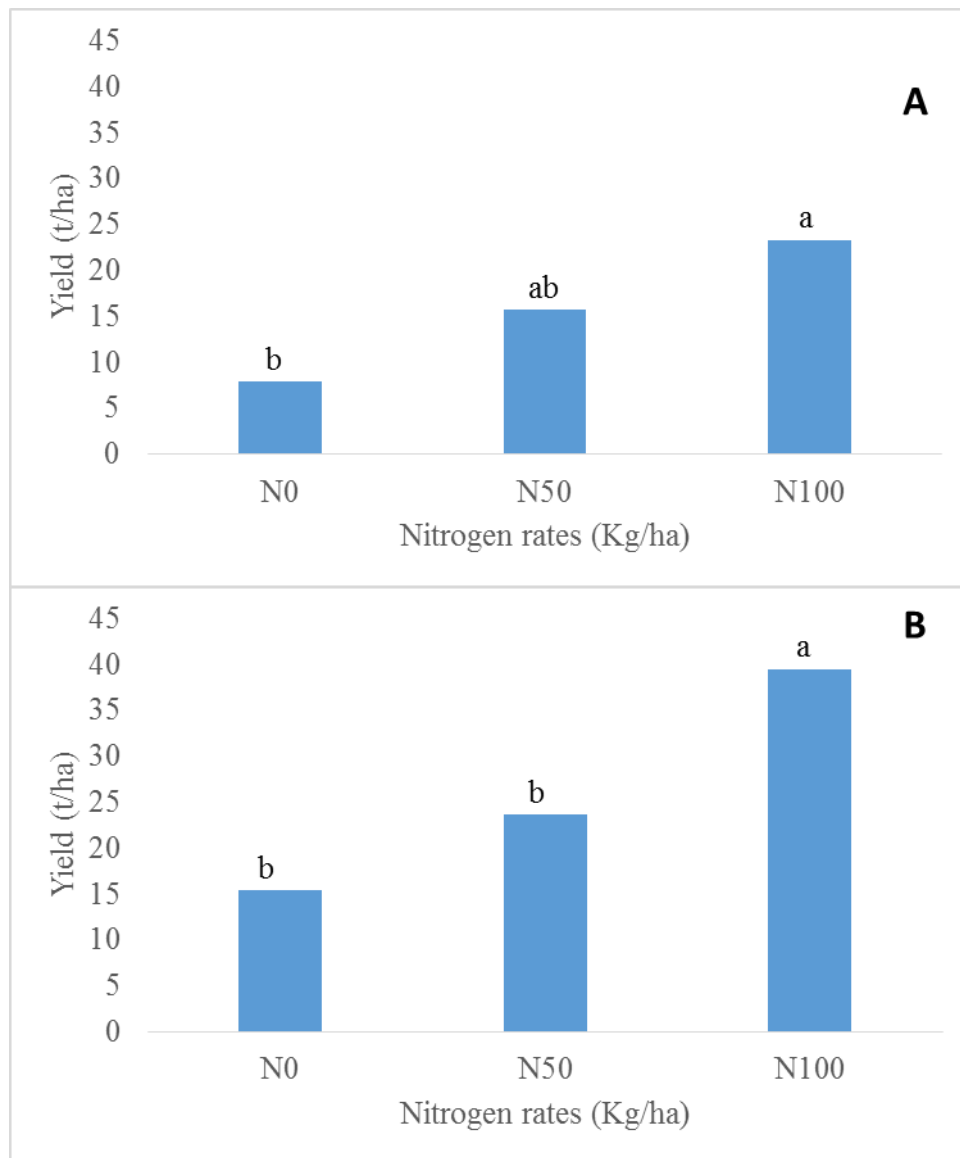
During the long rains percentage of dry matter, ash content and organic matter revealed significant differences ( $P \leq 0.05$ ) in both pearl millet and Rhodes (Table 4.17). During this period percentage of dry matter and ash content recorded higher values compared to the short rains season although the trend was the same for both parameters among the three harvesting times, this was due to a sufficient supply of moisture during the long rains with led to vigorous growth. Organic matter

percentage of both fodder species during long rains was slightly lower compared to short rains season due to difference in precipitation which affected growth. The effect of interaction between fodder species and harvesting times (SxHT) on dry matter, ash content and organic matter was statistically significant ( $P \leq 0.05$ ) during short and long rains.

#### **4.4 Impact of nitrogen rates on nutrient quality and yield of pearl millet and Rhodes grass**

##### **4.4.1 Nitrogen levels influence on yield**

Forage yield of both fodder species showed significant differences ( $P \leq 0.05$ ) when nitrogen was applied at 0 kg/ha, 50 kg/ha and 100 kg/ha (Figure 4.3 and 4.5)



**Figure 4.3: Mean yield of pearl millet as affected by nitrogen levels during short rains (A) and long rains (B). N0 – 0 kg/ha, N50 – 50 kg/ha, N100 – 100 kg/ha**

Pearl millet yield increased with an increase in nitrogen rates during short and long rains (Figure 4.3). The lowest yield (7.96t/ha) was obtained during short rains under control (zero nitrogen) while the highest yield (39.38t/ha) was recorded during long rains when nitrogen was applied at 100 kg/ha. Even though forage yield obtained under the rate of 50 kg/ha was higher than the one recorded at 0 kg/ha during both

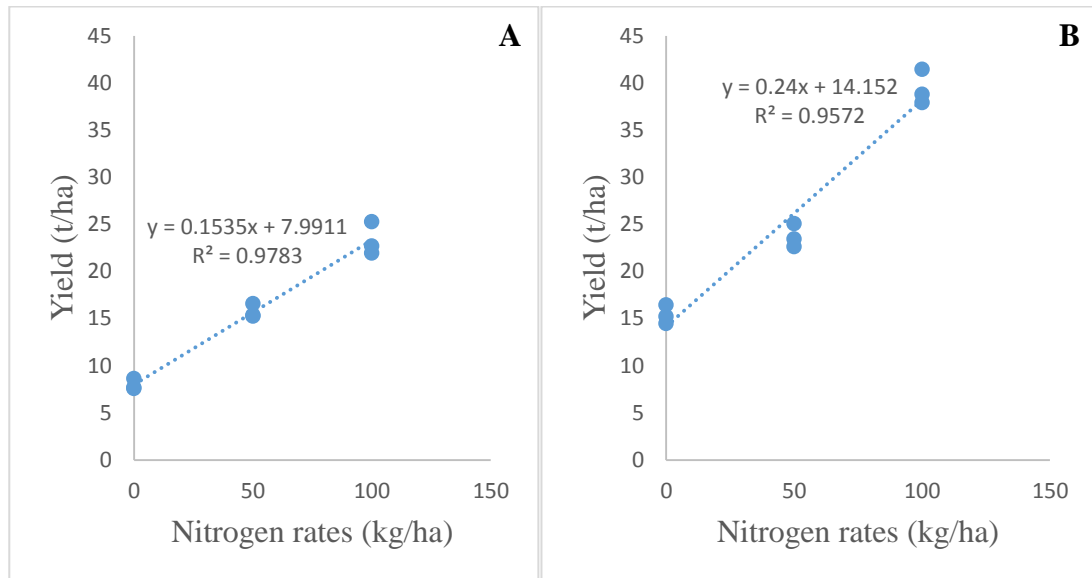
seasons the difference between them was not statistically significant increase in yield with nitrogen application can be explained by thicker stems, taller plants and additional dry matter yield per crop. Mechanisms that lead to higher yield can be due to the crucial role of nitrogen in regulating plant hormones and amino acids production which cell division. More nitrogen supply facilitates the development of chlorophyll which play a key role in capturing incident light more efficiently (Siam *et al.*, 2008).

According to Chouhan *et al.*, (2015) pearl millet's response to nitrogen fertilizer was due positive influence of nitrogen on forage yield attributes and yield. This was because nitrogen contributed to availing the nutrients that boosted plant growth and eventually leading to increased yield, this observation confirmed the findings of Prasad *et al.* (2014b), and Bhuvra and Sharma, (2015),. In another previous study by Shahin *et al.* (2013) they recorded that when increasing nitrogen application fresh yield increased, and these increases were ascribed to increments in the number of tillers per metre square and leaf number as nitrogen rates increased, similar findings were recorded by Desale *et al.* (2000) and Bhilare *et al.* (2010). Mahfouz *et al.* (2015) also suggested that both fresh and dry forage yields were influenced significantly by the application of nitrogen fertilizer in all cutting systems, these recordings agreed with those of Rakić *et al.* (2013) and Saini, (2012).

The results of this study conforms those of Crawford *et al.*, 2018 who reported that total green forage yield increased as a result of the positive effect of nitrogen fertilizer on growth parameters, this was attributed to the fact that nitrogen augmented protoplasmic components and enhanced the process of cell division and elongation which resulted to vigorous growth, similar findings were also reported by Dhar *et al.* (2006) and Trivedi, (2011).

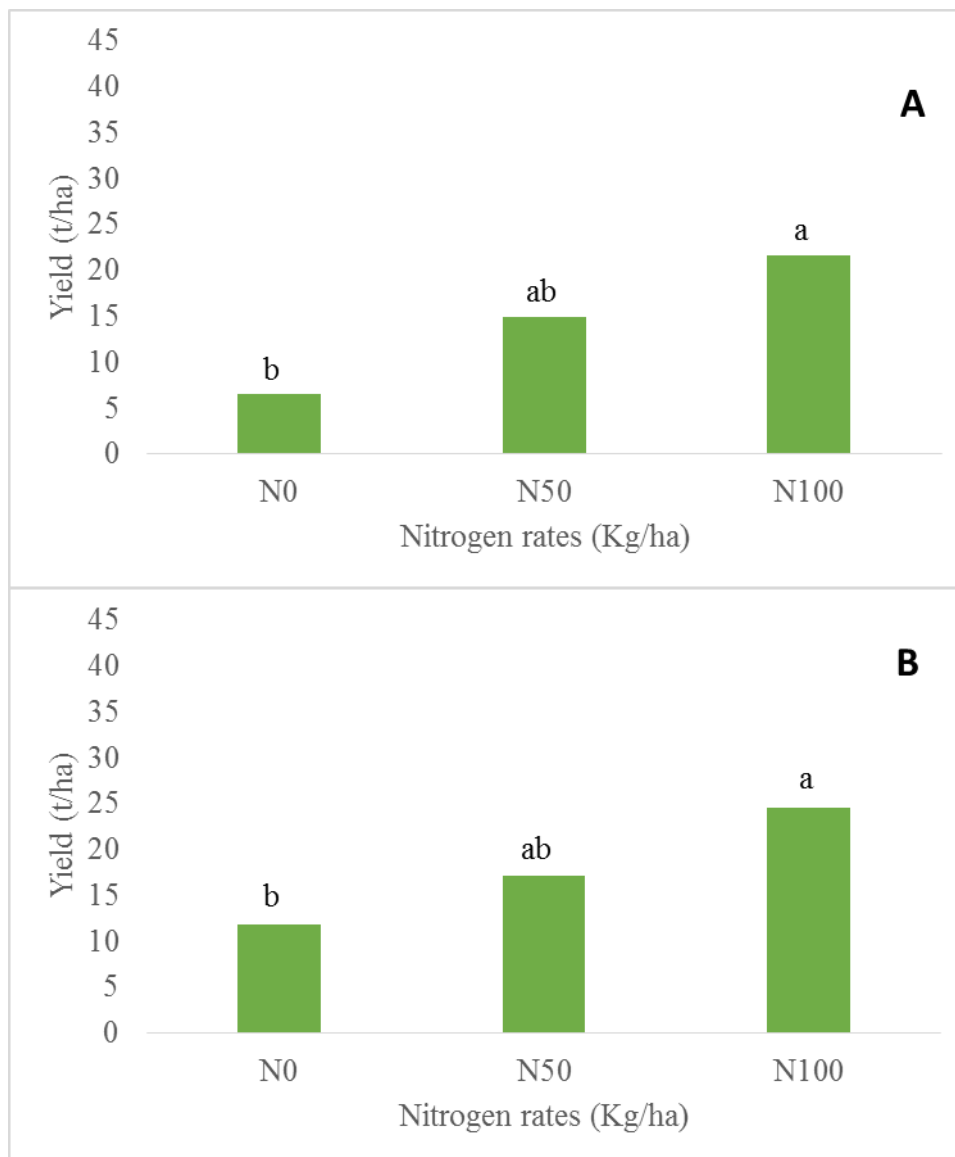
The outcome of this study conquered with that of Nirmal *et al.* (2016a) who reported that high forage yield with higher nitrogen application was due to efficient utilization of supplied nitrogen and associated environmental inputs by the forage crop that led to higher biomass production, which was in line with those reported by Karwasra and Kumar, (2006), The results this study were in line with Chaudhary *et al.* (2018) who reported that nitrogen application increased dry forage yield of sorghum, applying nitrogen at higher rates met the plant requirements at different crop growth stages resulting in higher uptake of nitrogen by plants which accelerated the meristematic activity, photosynthetic activity and vegetative growth, ultimately resulting to increased stem weight, leaf weight per plant which eventually increased green and dry forage yields

.



**Figure 4.4: Regression analysis on pearl millet forage yield and nitrogen rates, (A) short rains, and (B) long rains**

From the regression analysis (Figure. 4.4), pearl millet forage yield increased with an increase in nitrogen rates, implying that further addition increment in nitrogen will lead to more yield, these findings agreed with those of Crawford *et al.*, (2018) who reported a linear increase in forage yield of sorghum as nitrogen levels increased.



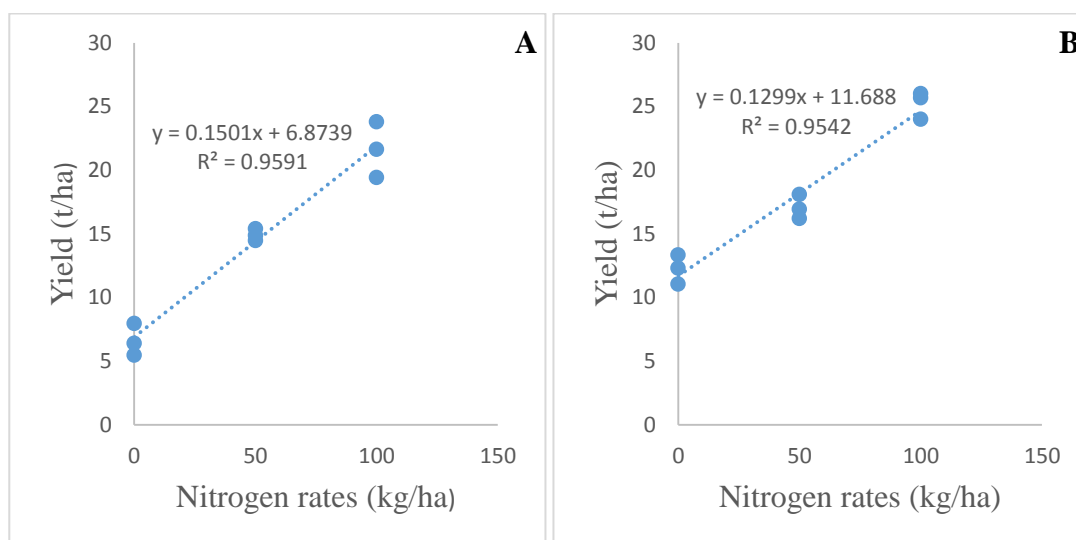
**Figure 4.5: Mean yield of Rhodes grass as affected by nitrogen levels during short rains (A) and long rains (B), N0 – 0 kg/ha, N50 – 50 kg/ha, N100 – 100 kg/ha**

The yield of Rhodes grass increased with nitrogen application in both seasons (Figure 4.5). Maximum yield (24.58t/ha) was obtained the long rains season at 100 kg/ha while minimum (6.61t/ha) was recorded under the control during short rains, nitrogen application led to vigorous plant growth and development which resulted in more above-ground biomass and hence high herbage yield. These findings were in agreement with those of Arshad *et al.* (2016), who reported that high rate nitrogen

fertilizer application produced maximum green fodder on an average basis, similar findings were recorded by Arshad *et al.* (2014), and Yossif and Ibrahim, (2013). According to Ziki *et al.* (2019), nitrogen fertilizer rates registered significant differences at all cutting dates, dry forage yield linearly increased with increasing nitrogen rates whereby the highest rate produced the highest dry yield values. Consequently, the low values of forage yield were observed with a supply of the lowest level of nitrogen. The increase in forage yield with increased nitrogen rates was ascribed to the high response by the grass crop to supplied nitrogen rates which led to luxuriant growth attributes such as more leaf area, the high number of shoots per crop, more forage weight per plant, and ultimately more forage yield, and similar observations were made by Shahrajabian and Soleymani, (2017), and Abo-Zeid *et al.* (2017).

The findings of this research agreed with those of Patil *et al.* (2016) who reported that the response of grass to nitrogen fertilizer varied from one cutting to another as well as between the agro-ecological zones. The higher nitrogen rate resulted in a higher mean yield compared to other fertilizer rates a similar trend was recorded by Yossif and Ibrahim, (2013). In another report by Shivprasad and Singh, (2017) showed that nitrogen levels significantly influenced the green yield of sorghum, this was attributed to the positive influence of nitrogen rates that led to enhanced growth parameters such as the number of leaves, leaf to stem ratio, plant population per meter and the important effects of nitrogen, cell elongation, development of co-enzymes which caused increased photosynthetic area and thus additional production and accumulation of photosynthates which yielded higher green fodder, which agreed with the past study by Dudhat *et al.* (2004).





**Figure 4.6: Regression analysis on Rhode grass forage yield and nitrogen rates, (A) short rains, (B) long rains**

The nitrogen rates had a positive influence on Rhodes grass forage yield (Figure. 4.6). An increase in nitrogen rates led to the significant increase in the yield, this can be attributed to the thicker stems, tall plants and more tillers. These findings were in agreement with those of Ausiku *et al.* (2020) who reported an increment in fresh biomass yield with additional nitrogen in pearl millet. The trend in Nitrogen rates and yield (Fig. 4.6) shows that further application of nitrogen at a higher rate will still lead to more forage yield.

#### **4.4.2 Quality as affected by nitrogen levels**

Dry matter, ash content and organic matter of Rhodes grass and pearl millet showed Significant differences ( $P \leq 0.05$ ) due to nitrogen application during both seasons (Table 4.18 and 4.19)

**Table 4.18: Quality of forage pearl millet and Rhodes grass as affected by nitrogen levels during short rains**

	Dry matter%		Ash content%		Organic matter%	
Treatment	Pearl	Rhodes	Pearl	Rhodes	Pearl	Rhod
	millet	grass	millet	grass	millet	es
						grass
<b>N rates Kg</b>						
<b>ha<sup>-1</sup></b>						
0	26.41 <sup>c</sup>	23.73 <sup>c</sup>	6.95 <sup>c</sup>	5.75 <sup>c</sup>	93.04 <sup>a</sup>	94.25 <sup>a</sup>
50	29.03 <sup>b</sup>	27.66 <sup>b</sup>	8.87 <sup>b</sup>	7.83 <sup>b</sup>	91.13 <sup>b</sup>	92.17 <sup>b</sup>
100	33.53 <sup>a</sup>	30.34 <sup>a</sup>	11.67 <sup>a</sup>	9.45 <sup>a</sup>	88.33 <sup>c</sup>	90.55 <sup>c</sup>
<b>LSD</b>	1.89	1.54	1.51	1.57	1.48	1.53
<b>SxN</b>	*	*	*	*	*	*

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), SxN - interaction between species and nitrogen, N - nitrogen**

Dry matter percentage showed significant differences ( $P \leq 0.05$ ) in both pearl millet and Rhodes grass during the short rains due to nitrogen fertilizer application (Table 4.18), for both fodder species, significant differences in the dry matter were observed at each increased rate of nitrogen. Minimum dry matter percentages were recorded in the control (zero nitrogen) while the maximum values were recorded at 100 kg/ha for both fodder species. These results were similar to the output of Shahid, (2012), who reported that the percentage of dry matter was significantly influenced by nitrogen application, dry matter increased with an increase in nitrogen whereby maximum dry matter percentage was obtained when the crop was supplied

with the higher level of nitrogen fertilizer, a similar trend was recorded by Beyaert and Roy, (2005).

According to Mahfouz *et al.* (2015), application of nitrogen fertilizer significantly affected forage quality parameters such as dry matter percentage, crude protein percentage and crude fibre percentage, applying the highest level of nitrogen gave the highest values of dry matter percentage, the increase in the dry matter as a result of nitrogen application were attributed to the fact that nitrogen increased leaf area development, maintenance and photosynthetic efficiency, this observation was in agreement with the recordings of Hugar, (2010), and Zhao *et al.* (2005). A report by Crawford *et al.* (2018) indicated that the highest dry matter percentage was recorded in the higher nitrogen level treatment, which was ascribed to higher fertility levels which increased the availability and absorption of nutrients to the fodder crop which led to more vegetative growth due to increase in tillers and plant height on the account of enlargement of cells and boosted photosynthesis, which resulted in high dry matter yield.

The results of this study (Table 4.18) were in conformity with those of Nirmal *et al.*, (2016b) who reported that dry matter accumulation increased with nitrogen fertilizer application, and that the higher nitrogen rate led to more vigorous plant growth, which subsequently led to increased herbage dry matter, and this trend was also recorded by Mahmud *et al.* (2003). According to Carpici *et al.* (2011), nitrogen rates had an important effect on the dry matter whereby the highest rate produced the highest dry matter percentage while the lowest dry matter values were plots without nitrogen

Results in Table 4.18 indicates that ash content showed significant differences ( $P \leq 0.05$ ) in both pearl millet and Rhodes grass during the short rains. Minimum ash

percentage was recorded under control (zero nitrogen) while the maximum was obtained at the rate of 100 kg/ha for both fodder species. Ash content increased significantly ( $P \leq 0.05$ ) with the increase in nitrogen levels, this was due synergistic influence of nitrogen on the uptake nutrients, this was in line with the findings of Shahid, (2012) who reported that ash percentage was statistically influenced with application fertilizer and the higher rate of nitrogen gave significantly higher ash percentage than all other nitrogen rates. A similar trend was recorded by Ayub *et al.* (2001) and Tariq, (1998). Afzal *et al.* (2012) also reported that the effect of nitrogen fertilizer application on ash contents showed significant differences on sorghum forage, nitrogen application at the rate of 100 kg/acre resulted in maximum ash content.

Organic matter percentage of pearl millet and Rhodes grass revealed significant differences ( $P \leq 0.05$ ) with nitrogen fertilizer application (Table 4.18). Maximum organic matter was obtained under the control (zero nitrogen) while the minimum was recorded when nitrogen fertilizer was applied at the rate of 100 kg/ha for both fodder species. The decrease of organic matter with an increase in nitrogen rates was due to the increase of total ash content with an increase in nitrogen levels.

**Table 4.19: Quality of forage pearl millet and Rhodes grass as affected by nitrogen levels during long rains.**

	Dry matter%		Ash content%		Organic matter%	
Treatment	Pearl	Rhodes	Pearl	Rhodes	Pearl	Rhodes
	millet	grass	millet	grass	millet	grass
<b>N rates Kg</b>						
<b>ha<sup>-1</sup></b>						
0	31.24 <sup>c</sup>	28.21 <sup>c</sup>	7.93 <sup>c</sup>	6.73 <sup>b</sup>	92.19 <sup>a</sup>	93.33 <sup>a</sup>
50	33.96 <sup>b</sup>	31.74 <sup>b</sup>	9.79 <sup>b</sup>	8.78 <sup>ab</sup>	90.21 <sup>b</sup>	91.21 <sup>b</sup>
100	36.47 <sup>a</sup>	34.01 <sup>a</sup>	12.61 <sup>a</sup>	10.41 <sup>a</sup>	87.39 <sup>c</sup>	89.58 <sup>b</sup>
<b>LSD</b>	2.19	1.84	1.42	1.65	1.39	1.63
<b>SxN</b>	*	*	*	*	*	*

**Means followed by the same letter in the same column are not significantly different ( $p \leq 0.05$ ), SxN - interaction between species and nitrogen, N - nitrogen**

During the long rains season dry matter percentage, ash content percentage and organic matter percentage of pearl millet and Rhodes showed significant differences ( $P \leq 0.05$ ) with nitrogen application. In both fodder species, significant differences in the dry matter were observed at each increased rate of nitrogen (Table 4.19). During long rains percentage of Organic matter of both fodder, species was slightly lower compared to the short rains season. The effect of interaction between fodder species and nitrogen (SxN) on dry matter, ash content and organic matter was statistically significant ( $P \leq 0.05$ ) during short and long rains periods.

## **CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS**

### **5.1 Conclusions**

- Pearl millet and Rhodes grass showed a high response to nitrogen fertilizer application as the growth parameters such as plant height, tiller number, stem diameter, biomass fresh weight and biomass dry weight were significantly increased with an increase in nitrogen fertilizer levels.
- Dry matter percentage and organic matter percentage of both pearl millet and Rhodes grass increased with delayed harvesting while ash content reduced with maturity. The highest green yield was recorded when forage was cut 58 days after germination.
- Increasing nitrogen rates significantly influenced the dry matter percentage and ash content of both pearl millet and Rhodes. Maximum green forage yield was obtained when both fodder species were supplied with a nitrogen rate of 100 kg/ha.

### **5.2 Recommendations**

- The study recommends the use of nitrogen fertilizer in forage pearl millet and Rhodes grass production to boost vegetative growth.
- Harvesting of forage pearl millet and Rhodes grass around 58 days after germination is recommended, for the farmer to obtain high yields of high quality.
- The rate of 100 kg/ha of nitrogen should be used to improve the quality and increase the quantity of pearl millet and Rhodes forage.
- This study recommends that further research should be done on the integration of inorganic with organic nitrogen source in forage pearl millet

and Rhodes grass production to gear fodder production towards sustainable agriculture.

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## APPENDICES

### Appendix 1: Experimental stages of fodder in the field



## **Appendix 2: Data collection and a visit by my supervisors**





### Appendix 3: Research Approval from Graduate School



#### KENYATTA UNIVERSITY GRADUATE SCHOOL

E-mail: [dean-graduate@ku.ac.ke](mailto:dean-graduate@ku.ac.ke)

Website: [www.ku.ac.ke](http://www.ku.ac.ke)

P.O. Box 43844, 00100  
NAIROBI, KENYA  
Tel. 020-8704150

#### Internal Memo

FROM: Dean, Graduate School DATE: 8<sup>th</sup> February, 2018

TO: Mr. Nyakwana Nyambega D REF: A144/32820/2015  
C/o Agricultural Science and Technology  
Department


SUBJECT: APPROVAL OF RESEARCH PROPOSAL


We acknowledge receipt of your Research Proposal after fulfilling recommendations raised by the Graduate School Board of 15<sup>th</sup> November, 2017.

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology & Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you

  
JOHN ODONGI  
FOR: DEAN, GRADUATE SCHOOL



CC. Chairman, Agricultural Science and Technology Department

Supervisors:

1. Dr. Joseph Gweyi  
C/o Agricultural Science and Technology Department  
Kenyatta University
2. Dr. Isaac M. Osuga  
C/o Animal Science Department  
Kenyatta University

#### Appendix 4: Research Authorisation from Graduate School



**KENYATTA UNIVERSITY  
GRADUATE SCHOOL**

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P.O. Box 43844, 00100  
NAIROBI, KENYA  
Tel. 020-8704150

Our Ref: A144/32820/2015

DATE: 8<sup>th</sup> February, 2018

Director General,  
National Commission for Science, Technology  
and Innovation  
P.O. Box 30623-00100  
**NAIROBI**

Dear Sir/Madam,



**RE: RESEARCH AUTHORIZATION FOR MR. NYAKWANA NYAMBEGA – REG. NO. A144/32820/2015**

I write to introduce Mr. Nyakwana Nyambega who is a Postgraduate Student of this University. He is registered for M.Sc degree programme in the Department of Agricultural Science and Technology.

Mr. Nyambega intends to conduct research for a M.Sc Proposal entitled, “Effect of Nitrogen and Harvesting on Yield and Quality of Forage Pearl Millet and Rhodes Grass in Kiambu County, Kenya.”

Any assistance given will be highly appreciated.

Yours faithfully,

  
  
**MRS. LUCY N. MBATIA**  
**FOR: DEAN, GRADUATE SCHOOL**

[www.ku.ac.ke](http://www.ku.ac.ke)