UNIVERSITY FOR DEVELOPMENT STUDIES

EFFECTS OF `HARVESTING AGE AND INTENSITY ON BIOMASS YIELD, CHEMICAL COMPOSITION AND *IN VITRO* DIGESTIBILITY OF BRACHIARIA GRASS IN NORTHERN GHANA

BY

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THIS THESIS IS SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCE, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN ANIMAL SCIENCE.

(ANIMAL PRODUCTION OPTION)

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DECLARATION

This is to affirm that this thesis has been authored by me and has neither been submitted for a degree nor any aspect published by another person elsewhere.

All cited literature in the text has been well referenced and any assistance received in writing this thesis has been duly acknowledged.

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ABSTRACT

The study was conducted to investigate the effect of harvesting age and intensity on biomass yield and the effect of harvesting age and botanical fraction on chemical composition and *in vitro* dry matter true digestibility (IVDMTD) of *Brachiaria mulato II* grass. Experimental design for the chemical analysis was 2 ×2 factorial. The experimental design for the *in vitro* Digestibility analysis was 2 ×2 factorial. The agronomic data was analyzed with ANOVA in a 2×2 factorial using GenStat. The chemical composition and fiber digestibility data were analyzed with ANOVA in 2×2 factorial using GenStat. The interactive effect of harvesting age and intensity was significant for tiller number only at location one. Grasses harvested 100 days after planting produced the highest average tiller numbers of (107.1 cm) and (98.9cm) for location one and two respectively. Grasses harvested 80 days after planting produced the highest average plant height of (47.57cm) and (47.45cm) for location one and two respectively. The interactive effect of harvesting age and intensity was not significant for both initial and regrowth harvest for both locations. Grasses harvested at 100 days after planting produced the highest average initial biomass yield of (1532kgDM/ha) and (2536.5kgDM/ha) for location one and two respectively whiles that of the regrowth is (856.5kgDM/ha) and (918.5kgDM/ha) for location one and two respectively. For the chemical analysis of *Brachiaria mulato* II, the interactive effect of harvesting age and botanical fraction was significant on Ash, OM, NDF and ADF at the initial harvest for location one. On the other hand, the interactive effect of harvesting age and botanical fraction was significant on CP and ADF in the regrowth for location one. Botanical faction affected all the parameters except HM whiles harvesting age was significant on Ash, OM, CP and NDF in the regrowth for location one. The interactive effect of harvesting age and botanical fraction was significant on ADF and HM at the initial harvest for location two. On the other hand, the interactive effect of harvesting age and botanical fraction was significant on Ash, OM and ADF in the regrowth for location two. Botanical faction affected all the parameters whiles harvesting age was significant on CP, NDF and HM in the regrowth for location two. The interactive effect of harvesting age and botanical fraction was significant for all *in vitro* digestibility parameters except dNDF in the initial harvest in location one. Also, the interactive effect of harvesting age and botanical fraction was significant for only NDFD in the regrowth harvest for location one. However, the botanical fraction's main effect was only significant on NDFD and dNDF in the regrowth in location one. The botanical fraction's main effect was significant on all parameters except NDFD in the initial harvest in location two. However, botanical fraction and harvesting age main effect was significant on all parameters except NDFD in the regrowth in location two. In conclusion, harvesting age and intensity has an effect on biomass yield, plant height and tiller number. Beside these, harvesting age and botanical fraction has an effect on chemical composition and *in vitro* dry matter true digestibility (IVDMTD) of *Brachiaria mulato II* grass in this research.

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DEDICATION

I dedicate this thesis to my mother Janet Ayibatu and my late father Josephe Ayibatu Apuri; I wish you were alive to see the fruits of your efforts and to have helped me climb faster in my academic ladder. God knows best, rest well Baba!

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LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
BF	Botanical Fraction
CP	Crude Protein
CSIR	Council for Scientific and Industrial Research
DIGDM	digestible dry matter
DM	Dry Matter
dNDF	digestible Neutral Detergent Fibre
GDP	Gross Domestic Product
HA	Harvesting Age
HM	Hemicellulose
iNDF	insoluble Neutral Detergent Fibre
IVDMTD	In vitro Dry Matter True Digestibility
ME	Metabolizable Energy
NDF	Neutral Detergent Fiber
NDFD	Neutral Detergent Fibre Digestibility
OM	Organic Matter
PH	Plant Height

CHAPTER ONE

1.0 Introduction

Livestock production plays very important roles in the lives of people all over the world especially the rural poor livestock farmer. Some of these significant contributions are contribution to global GDP which stands at about 40% to the agricultural gross domestic product (GDP) and constitutes about 30% of the agricultural GDP in the developing world (World Bank, 2009). Livestock products account for almost 30% of human protein consumption (Steinfield *et al.*, 2006). Livestock production is an important component of the farming systems and plays a vital role in the livelihood of many people (Tekliye *et al.*, 2018). In most African countries, 60 – 80% of rural households keep livestock as easily liquid assets, insurance in time of need, food and nutrition. Besides these, livestock also provide organic fertilizer (manure) serves as source of transportation for human and farm produce and also provides animal traction which the rural poor farmer uses to till the land for crops cultivation. In marginal areas with harsh environments, livestock provide a means of reducing the risks associated with crop failure and a diversification strategy to resource poor small-scale farmers and their communities (Thornton, 2006). According to Agyare *et al.* (2002), livestock has been shown to increase the stability and resilience of agricultural enterprises, act as store of wealth, offer quick cash, lower the chance of crop failure and assist farmers in buying inputs for farm growth.

Through improved energy and nutrient cycling, livestock help to achieve more sustainable and effective use of agricultural resources. The present estimated population of 7.6 billion people on Earth is predicted to increase to 8.6 billion by 2030, 9.8 billion by 2050, and 11.2 billion by 2100 (UN, 2023). Naturally, the demand for livestock and its products will rise in tandem with the rise in the need for food. Between 1997/99 and 2030, annual meat consumption in developing countries is projected to increase from 25.5 to 37 kg per person, compared with an increase from 88 to 100 kg in industrial countries. Consumption of milk and dairy products will rise from 45 kg/ person/p.a. to 66 kg in developing countries, and from 212 to 221 kg in industrial countries (FAO, 2023). According to FAO, (2023), consumption of food from terrestrial animals (including eggs, milk and meat) varies widely around the world. For instance, someone living in Democratic Republic of the Congo consumes on average 160 g of milk per year whiles someone in Montenegro consumes 338 kg, the average meat consumption by person per year in Burundi is 3kilograms compared to 136 kg for someone in Hong Kong. In sub-Saharan Africa, livestock play a significant role in agriculture, accounting for almost 27% of the region's gross agricultural product (FAO, 2010). Due to inadequate feed supplies and poor feeding practices, livestock productivity is below the average for Africa (Shapiro *et al.,* 2015; Gelayenew *et al.,* 2016). Over the past thirty years, Africa has become increasingly dependent on the importation of basic cattle products to meet the demands of its expanding population (Rakotoarisoa *et al.,* 2012). Naturally occurring pastures, which vary in quantity and quality throughout the year, provide the majority of the nutrition for ruminants worldwide (Wanapat, 2000). Furthermore, a lot of farmers who raise livestock rely on agricultural wastes, which are a valuable source of feed during the dry season (Teferedegne, 2000). According to Njarui *et al.* (2016), these feed resources are deficient in nutrients, particularly during the dry seasons. It is advised to employ enhanced forage plants as a feed source to help address the lack of livestock feed (Shapiro *et al.,* 2015; FAO, 2016). There has been a number of research papers published on forages by researchers in Ghana, (Ansah *et al*., 2018) a lecturer at the Department of Animal Science, University for Development Studies (UDS) worked on Napier grass, pigeon pea*,* just to mention a few. Besides these, (Panyan *et al*., 2021) and (Konlan *et al.,* 2016) who are with Animal Research Institute of Ghana have also worked on *Brachiaria ruziziensis*, *Sorghum almum,* just to mention a few. Besides all these publication on various forages ruminants in Ghana are still suffering from feed gabs and under nutrition during certain parts of the year. To address this feed problem, we need forage grass which is high yielding, high rejuvenating ability, can thrive well on poor soils with low fertility and can withstand drought/dry spell which is characterized by the climate of the hub of ruminant production in Ghana. One of the candidates of forages that has potentiated itself and can help to alleviate ruminant feed shortage or gabs and thereby enable Ghana as a country especially the northern part which is the hub of livestock production to exploit livestock production to the highest level is *Brachiaria mullato* II grass. *Brachiaria* grass is the most extensively grown tropical forage in Latin America and East Asia (FAO, 2015). In recent times, *Brachiaria* grass has garnered significant attention in Africa and other tropical regions of the world. Numerous projects have been launched to support the growing livestock business in the region, particularly during the dry season (Maass *et al.,* 2015). The reason for this is that *Brachiaria* has a high capacity for biomass production and yields nutrient-rich herbage, which raises animal output (Holmann *et al.,* 2004). Besides these, the widespread use of *Brachiaria* is attributed to several of advantageous characteristics: the capacity to adapt to low fertility and acid soils; the resistance to drought or dry spells, shade, and flooding; the potential for high biomass production; the capacity to store carbon in soils; the capacity to efficiently use nitrogen (via biological nitrification inhibition); and the capacity to reduce the emissions of greenhouse gases and contaminants in groundwater (Subbarao *et al.,* 2009; Rao, 2014). This study was therefore conducted to evaluate the agronomic characteristics, fodder yield, nutritional quality and digestibility of *Brachairia mulato* II in the guinea savannah ecological zone of Ghana to solve the seasonal nutritional challenges where ruminant production forms a major part of the people of Northern region of Ghana, most especially in the peri urban and rural regions.

1.1 Objectives of study

1.1.1 Main objectives of study

1. To investigate the effects of harvesting age and intensity on the biomass yield, chemical composition and in vitro digestibility of *Brachiaria mulato II* grass.

1.1.2 Specific objectives of study

1. To determine the effects of harvesting age and harvesting intensity on biomass yield of *Brachiaria mulato* II grass.
2. To determine the effect of harvesting age and botanical fraction on chemical composition and *in vitro* digestibility of *Brachiaria mulato* II grass.

1.2 Research questions of study.

1.2.1 General research questions of study

1. What are the effects of harvesting age and intensity on the biomass yield of *Brachiaria mulato* II grass?

2. How do harvesting age and intensity influence the chemical composition and in vitro digestibility of *Brachiaria mulato* II biomass?

1.2.2 Specific research questions of study

1. Does increasing harvesting age affect the biomass yield of *Brachiaria mulato* II grass?
2. How does varying harvesting intensity impact the chemical composition and in vitro digestibility of *Brachiaria mulato* II grass biomass?
3. Is there an interaction between harvesting age and intensity on the chemical composition and *in vitro* digestibility of *Brachiaria mulato* II grass biomass?
4. What is the optimal harvesting age and intensity for maximizing biomass yield while maintaining desirable chemical composition and in vitro digestibility of *Brachiaria mulato* II grass biomass?

1.3 Hypothesis

1. Increasing harvesting age will decrease biomass yield but improve chemical composition and *in vitro* digestibility.
2. Higher harvesting intensity will reduce biomass yield and alter chemical composition, but may not affect *in vitro* digestibility.
3. There will be an interaction between harvesting age and intensity on biomass yield, chemical composition and *in vitro* digestibility.

CHAPTER TWO

2.0 REVIEW OF LITERATURE

2.1 Description and growth characteristics of *Brachiaria spp.*

Improved *Brachiaria* grasses are commonly grown in Latin America (Cezário *et al.,* 2015) and these include *Brachiaria brizantha* cv. MG-4, *B. brizantha cv. Piatá, B. brizantha cv. Marandú, B. brizantha cv. Xaraes, B. humidicola cv. Llanero, B. humidicola cv. Humidicola and B. decumbens cv. Basilisk* which are in general well adapted to other tropical agro-ecologies. Their physiology and root systems enable them to adapt to a wide range of ecologies, particularly tropical grasses. According to Malinowski and Belesky (2000), the majority of photosynthetic pathways are tropical grasses which are classified as C4 plants that promote effective water usage and increased resistance to pests, diseases, and droughts through symbiotic relationships with fungal endophytes. Perennial grasses are crucial to smallholder farms because they reduce erosion and provide feed for ruminants that are fed on stalls. The tufted perennial bread grass, or *Brachiaria brizantha*, is typically 60–120 cm high (up to 200 cm) with short rhizomes and deep roots (down to 2 m). Its bright green leaves are backed by sturdy, erect or slightly decumbent culms. An inflorescence is a panicle that is 4–20 cm long and has 2–16 racemes. Typically, a single row of elliptical, 4-6 mm long spikelets with a sub-apical fringe of long, purplish hairs surround the tip. The yield; hairiness, leafiness, and habit of *Brachiaria brizantha* vary greatly. Though a little more tufted, with somewhat different spikelets and shorter roots, it is similar to *Brachiaria decumbens* (Cook *et al.,* 2005; FAO, 2010).

With softer leaves than *Brachiaria brizantha, Brachiaria mullato II* is a more productive, multipurpose pasture that can tolerate large stocking rates and maintain strong persistence under rotational or continuous grazing. Additionally useful for hay, silage, and cut-and-carry feeding include bread grass (Cook *et al.,* 2005). In addition, it's grown for erosion control and as decorative hedges (Ecocrop, 2010). Numerous commercial cultivars have been created.

2.2 Distribution of *Brachiaria spp.*

Brachiaria grasses are among the most important tropical grasses that originated from Africa and improved in Americas through agronomic selection and breeding (Miles *et al.,* 2004). They have demonstrated to be highly productive, nutritive and socially acceptable in Asia and Africa for different livestock production systems (Vendramini *et al.,* 2014). *Brachiaria* is a drought- and low-fertility soil-adapted plant that also increases nitrogen usage efficiency, reduces eutrophication and greenhouse gas emissions, and stores carbon through its extensive root system (Subbarao *et al.,* 2009; Arango *et al.,* 2014; Moreta *et al.,* 2014; Rao *et al.,* 2014). *Brachiaria* species have long been an important part of seeded pastures in humid lowlands and savannas of tropical America, spanning an estimated 99 million hectares in Brazil alone (Jank *et al.,* 2014). Since *Brachiaria* grasses originated in Africa, they are adaptable in Kenya and can be successfully incorporated into the current agricultural systems. Among the most significant tropical grasses, *Brachiaria* grasses are native to Africa. They were developed in the Americas by breeding and agronomic selection (Miles *et al.,* 2004), and they have since been shown to be extremely productive, nutrient-rich, and socially acceptable in Asia and Africa for use in a variety of livestock production systems

(Mutimura and Everson, 2012a; Pizarro *et al.,* 2013; Vendramini *et al.,* 2014). Inyang *et al.* (2010a) reported that *Brachiaria* grasses are a productive warm-season perennial grass that has a higher nutritional content than more warm-season grasses (Vendramini *et al.,* 2014). Additionally, *Brachiaria* grasses can be harvested and stored for future use as feed (Vendramini *et al.,* 2010). Due to their extreme adaptability and widespread cultivation, *Brachiaria* grasses, which are native to eastern, central and southern Africa have completely transformed the livestock business since they are the most commonly grown and adaptive to animals in South America (Miles *et al.,* 2004). Originating in Africa, *Brachiaria* grasses have undergone genotype improvement in Latin America and have been suited to various local circumstances prevalent in tropical regions (Miles *et al.,* 2004). A very thriving beef sector is supported by the millions of hectares of *Brachiaria* species that have been sown as better pastures throughout South and Central America, with an estimated 99 million hectares in Brazil alone (Jank *et al.,* 2014).

2.3 Soil requirements of *Brachiaria spp.*

The Australian-developed signal grass (*Brachiaria decumbens cv. Basilisk)* thrives at a variety of altitudes and is adaptable to an array of soil types and situations 500–2300 meters above sea level. This tropical grass is quite productive and can be found all throughout South America, Australia, Indonesia, Vanuatu, and Malaysia (Low, 2015). Brachiaria grasses produce high biomass, enhance soil fertility and reduce greenhouse gas emission (Peters *et al.,* 2012) and contribute to carbon sequestration (Djikeng *et al.,* 2014). This can enhance soil productivity and nutrient cycling while reducing greenhouse gas emissions (McLaughlin and Kszos, 2005; Vagen *et al.,* 2005). *Brachiaria* grasses have the ability to slow down climate change since they can grow in a variety of 38 different types of environments and are suited to low soil fertility (Miles *et al.,* 2004). Deep, well-drained soils are necessary for *Brachiaria* (Njarui and Wandera, 2004). According to an on-farm study (Mutimura and Everson, 2012) on the adaptability of improved *Brachiaria* grasses in low rainfall and areas of Rwanda susceptible to aluminum toxicity, farmers preferred cv. *mulato* II despite it not being the most productive grass because of its year-round production of green forage and its ability to withstand acidic soil stress and low rainfall. While the genera of *Andropogon* and *Brachiaria* are suited to infertile and acidic soils, Cenchrus ciliaris is suitable to dry, fertile soil (Pitman, 2001). *Brachiaria* grows on a broad spectrum of soil types, including light to heavy textures, pH 4–8, a wide variety of soil nutrients, and more. However, when soil nutrients rise, so does production. Depending on the cultivar, flood tolerance is typically poor (Cook *et al.,* 2005; FAO, 2010). Their ability to adapt to the severe environment was the basis for any genetic improvement they may have had, and forage breeders can increase their persistence under biotic and/or abiotic stress circumstances (Vogel and Lamb, 2007). Furthermore, the modification suggests an improved method for reproduction. *Brachiaria's* resistance to fire, shade, and successive cutting are additional advantageous qualities (Ghebrehiwot, 2004). Taking into account all of these adaptation factors, their growth in various conditions will be a significant accomplishment (Kretschmer and Pitman, 2001) for improving the standard of living for smallholder farmers using crop-livestock agricultural systems.

2.4 Response of *Brachiaria spp* to draught.

In many parts of the world, particularly the arid and semi-arid ones, drought is one of the most restrictive environmental factors on plant productivity (Fischlin *et al.,* 2007).

Numerous metabolic and physiological processes are hampered by drought stress, which results in decreased plant growth, decreased chlorophyll and water content, and altered fluorescence (Souza *et al.,* 2004; Li *et al.,* 2006; Yang *et al.,* 2006). Forage grass output is substantially limited by drought (Knapp *et al.,* 2001). By the year 2100, the land area under extreme drought will have increased by up to 30% due to an increase in the frequency and intensity of droughts brought on by global warming (Fischlin *et al.,* 2007; Dai, 2013). According to Yoshida *et al.* (2014), plants have developed intricate drought-adaptive mechanisms spanning from individual plant physiological processes and ecological levels to genetic molecular manifestations and biochemical metabolism. The most common methods used by plants to withstand drought are: i) brief life cycles or developmental plasticity—for example, some annual plants flower before a severe drought sets in (Manavalan *et al.,* 2009); ii) drought resistance via desiccation tolerance, antioxidant capacity, and osmotic adjustment (Yue *et al.,* 2006); iii) drought prevention involves increasing water availability and lowering water loss, such as by growing root systems or reducing stomata and leaf area/canopy cover. (Luo, 2010; Tardieu, 2013). Compared to other grasses, *Brachiaria* grasses can grow productively in places that experience extended dry spells (Cardoso *et al.,* 2015). *Brachiaria brizantha cv mulato* II, cultivated locally and developed by CIAT, can withstand temperatures exceeding 30°C and extended droughts lasting up to two months without water (Pickett *et al.,* 2014). According to Guenni *et al.* (2002), certain species of *Brachiaria* adapt their growth and biomass distribution under moderate drought circumstances, resulting in comparatively unchanged overall plant production. In dry, high-irradiance environments, like those seen in tropical grasslands and savannas, C4 plants like

Brachiaria are more competitive than their C3 counterparts (Edwards *et al.,* 2010; Taylor *et al.,* 2011, 2014). The capacity of C4 species to sustain higher photosynthetic rates per unit of water loss than C3 species gives them a competitive advantage (Sage and Kubien, 2003; Taylor *et al.,* 2014). However, the highest yields that C4 plants like *Brachiaria* may produce are still determined by the availability of water. Water availability is still a major factor in influencing the productivity of C4 grasses, such as *Brachiaria*, even though these grasses exhibit significant resilience to water stress situations. Wide variations have been observed in these grasses' responses to extended droughts (Wedin, 2004). Prior research has documented the significant impact of drought stress on *Brachiaria* biomass production, primarily pointing to a reduction in plant growth in *Brachiaria* genotypes (Guenni *et al.,* 2002; Araujo *et al.,* 2011; Santos *et al.,* 2013; Cardoso *et al.,* 2015). Compared to other grasses, some enhanced *Brachiaria* grasses (such as cultivar *Mulato* II) can maintain productive growth in regions with extended dry periods (Cardoso et al., 2015). Plants of *B. decumbens* have a vast root system which have suggested being responsible for their capacity to react to light rains that fell during the dry season (Guenni *et al.,* 2000).

2.5 Climate requirement of *Brachiaria spp.*

Compared to grasses in other genera, *Brachiaria* grasses are more suited to withstand drought and poor soil fertility. They can also store carbon, improve nitrogen utilization efficiency by inhibiting biological nitrification, and stop greenhouse gas emissions. According to Ghimire *et al*. (2015), *Brachiaria* thrives best in Kenya in regions with annual rainfall of more than 700 mm and temperatures over 19°C. Unlike other tropical grasses, *Brachiaria brizantha* can endure dry seasons and less than 1000 mm of rainfall lasting three to six months during which it stays green. It thrives best with a yearly rainfall of 1500 to 3500 mm (Heuze *et al.,* 2016). These weather patterns are comparable to those found in the research location, which is located in Ghana's Guinea Savannah Ecological Zone.

2.6 Response of *Brachiaria spp* to fertilizer application

Teixeira *et al*. (2011) found that the highest yearly biomass was produced in Brazil by applying nitrogen in the late summer (100 kg N/ha) and delaying grazing for 95 days. Fast-growing pasture species have been shown by Mganga (2009) and Nguku *et al.* (2016) to be more resource-efficient, making them more competitive and likely to produce greater biomass. Because it plays a part in photosynthesis and affects the chlorophyll molecule, nitrogen is a crucial component in the growth of grass (Oliveira *et al.,* 2010). Forage grasses may respond quickly to the application of N fertilizer if the amount of N available in the soil is insufficient for forage production (Batista *et al.,* 2014). For maximum productivity N fertilizer needs to be sprayed following each cut in cut-and-carry systems (Batista *et al.,* 2014). According to Oliveira *et al.* (2007), grasses respond favorably to nitrogen fertilization. This is probably because nitrogen stimulates plant cell growth and multiplication, as it is a nutrient that makes up proteins and cellular nucleic acids. When fertilizing *B. decumbens* with a dose of N equivalent to 371 mg dm-3 of soil, Bonfim-Silva and Monteiro (2006) found a maximum value of 17 g dry mass of leaf. Regardless of the kind of grass, there was a quadratic influence on fodder production in response to the N dose. Other investigations also noted the quadratic response and the beneficial effect of N fertilization (Johnson *et al.,* 2001). According to Santos *et al.* (2013), nitrogen produced in a given amount of time. According to Johnson *et al.* (2001), there is a point at which more N fertilizer does not result in higher forage production. Despite not having nutritional quality on par with temperate grasses, tropical forages have a high potential for producing dry matter (DM), which could lead to high animal productivity.

2.7 *Brachiaria spp.'s* reaction to defoliation.

The time between grass harvests influences the amount of herbage produced, as well as the nutritional value and capacity for regrowth. Ball *et al.* (2009) state that soil fertility, climate, forage species, and maturation stage at harvest all affect fodder quality. Good protein, low lignin and cellulose, and good digestibility are the hallmarks of young regrowth (Wijiphans *et al.,* 2009). Studies on the intensity and intervals of grass harvesting have shown that the sward's persistence, yield, and growth are impacted by the cutting (Probst *et al.,* 2011). After pruning, the forages grew slowly again since the plants didn't have many leaves to capture light for photosynthesis. According to Onyeonagu *et al.* (2005a), there were more tillers when there were frequent cutting intervals. According to Vinther (2006), the grasses that are harvested at eight-week intervals have developed stems and leaf photosynthetic area, which leads to a higher output of dry matter. Vinther (2006) discovered that harvest interval influences productivity, partially by altering their morphological development since harvest frequency is correlated with dry matter (DM) production. According to Bruinenberg *et al.* (2002), variations in the phenological stage may be the cause of variations in the digestibility of DM of grasses at a certain harvesting date. The impact of harvesting intervals on the growth of grass herbage has yielded inconsistent results in most parts of the world. Working with *mulato* II and *Cayman* in Florida, Vendramini *et al.* (2014)

discovered that there was no variation in the herbage accumulation between the regrowth intervals of the first and second periods of three and six weeks, but that the second period's regrowth interval of three weeks was greater than the first. Working with *Brachiaria* hybrids in Thailand, Hare *et al.* (2013) discovered that although cutting intervals were extended to 90 days, DM production was significantly boosted while crude protein (CP) contents were decreased. He added that compared to cutting at 45 and 60-day intervals, cutting would result in 3-4% greater CP levels at 30-day intervals. Longer renewal intervals cause more herbage formation in many grass species (Interrante *et al.,* 2009). Tillering ability enhances grass stand resilience and yield under defoliation, according to Mganga (2009). Wolfson (2000) noted that in areas where grass has grown and covered the ground, shoots or tillers that do not shed their leaves for an extended period of time may experience a reduction in growth and eventually stop producing new stems. According to Mutimura and Everson (2012), *Mulato* II generated a large production of primary DM. Moreover, Guiot and Melendez (2003) noted that the large size leaves (15.2-1.5-inch long and thick stems 1-1.5-inch wide) contributed to the high DM yield of *Mulato* II. A crucial management factor that influences grass productivity and nutritional value is cutting interval. It is commonly known that seeded pasture responds differently to defoliation regimes in various situations in terms of growth rate and productivity. The effects of cutting management on grass productivity and quality have been the subject of numerous studies (Tessema *et al.,* 2010; Hare *et al.,* 2013a and 2013b). At a cutting frequency of 30 days, Hare *et al.* (2013a) observed the highest CP content of the hybrid *Brachiaria cvs. Cayman* and *mulato* II, while a cutting frequency of 90 days produced the maximum yield. Conversely, Tessema *et al.* (2010)

discovered that longer harvest intervals resulted in higher fiber content and decreased Napier grass quality, while increasing cutting frequency decreased output. According to Riet-Correa *et al.* (2011), *B. decumbens* grows back quickly after fire in Papua New Guinea. This is because the indigenous villagers use fire to hunt animals or to manage standing grass by slashing and burning it to make way for new food gardens.

2.8 *Brachiaria spp.* biomass yield.

Large leaf diameters are thought to be the cause of *Brachiaria mulato* II's high dry matter output, according to Mutimura and Everson (2012) and Nguku *et al.* (2016). According to Nguku *et al.* (2016), testing conducted in the semi-arid eastern Kenya revealed that *Brachiaria mulato* II had a dry matter yield of (4.1 t/ha). In Thailand, Hare *et al.* (2013b) also noted that when the regrowth period lengthened from 30 to 90 days, *Mulato II*, herbage accumulation rose from about 11 to 20 t/ha. For the *mulato II*, Inyang *et al.* (2010b) observed reduced herbage buildup at two weeks of regrowth compared to pruning at six-week intervals. In the same region, a study by Njarui and Wandera (2004) revealed that basilisk yield increased with longer cutting intervals as opposed to shorter ones. Vendramini *et al*. (2014) found that harvesting *mulato* II at 6 and 8 weeks resulted in 13–16% CP. Across a three-year period, Hare *et al*. (2009) measured the average CP of different *Brachiaria* grasses, including *Brachiaria mulato* II, *Marandu, Xaraes,* and *Basilisk*. The results ranged from 9.8 to 11.8% (leaf) and 6.7 to 7.3% (stem). When *Brachiaria* grass *cv. mulato* was interplanted with perennial peanut in Madagascar, it produced significant DM in the first cuts but showed no change in the third (Rahetlah *et al.,* 2012). The interplanted plants were assessed in 20 mono cultures. The total plant CP content of *mulato* II and hybrid BR02/1485 was 14% and 15%, respectively. Both the native *Brachiaria decumbens* and the cultivar *Toledo* of *Brachiaria brizantha* had high DM levels (Mutimura and Everson, 2012a). Both throughout the wet and dry seasons, the DM yield of naturalized *Cenchrus ciliaris* was lower than that of improved *Brachiaria* grasses including *Toledo, Marandú, mulato* II, and indigenous *Brachiaria*. *Brachiaria* grasses, particularly varieties Toledo, *mulato,* and *Decumbens*, are widely cultivated in Latin American nations like as Honduras. They are collected for hay throughout the six- to seven-month-long dry season. (Reiber *et al.,* 2012). According to Hare *et al.* (2013b), the DM production of guinea grass cv. Mombasa rose from 9.8 to 12 t/ha if the cutting interval was extended from 30 to 60 days; however, at 9 days, the DM yield in Thailand did not increase. Previous research on the adaptability of *Brachiaria* cultivars in semi-arid locations, as reported by Njarui and Wandera (2004) and Nguku *et al.* (2016), revealed that some *Brachiaria* cultivars produced more dry matter than Rhodes grass, which is typically planted. In Kiboko, Kenya, it was discovered that *cv. mulato* II outperformed native range grasses including Buffel (*Cenchrus ciliaris*) and horsetail grass (*Chloris roxburghiana*) in terms of initial dry matter production and later regrowth under irrigation (Machogu, 2013). *B. decumbens* may yield 15–27 mt/DM/ha/year (Abdullah, 2015), which is more dry matter than most tropical grasses can produce during the dry season. At 70 days following establishment, the *Brachiaria brizantha* cultivar *Piatá*, when combined with sorghum, yielded high levels of crude protein, biomass, and *in vitro* digestibility of organic matter (Quintino *et al.,* 2013). When *Brachiaria* hybrid cultivars *mulato* and *mulato* II were analyzed in Thailand, it was discovered that *mulato* possessed more crude protein (17.5%) in its leaves during the first seed harvest than *mulato* II (14.6%). *Brachiaria mulato* II had a high dry matter of 2,337 kg/ha, in contrast to *mulato*, which had 1,971 kg/ha (Hare *et al.,* 2007). In northern Thailand, cultivars *mulato* and *mulato* II produced more dry matter during the dry season than cultivars *Brachiaria brizantha cv. Toledo, Paspalum atratum*, and *Panicum maximum* (Hare *et al.,* 2009). Both the native *Brachiaria decumbens* and the cultivar *Toledo* of *Brachiaria brizantha* had high DM levels (Mutimura and Everson, 2012a). Both throughout the wet and dry seasons, the DM yield of naturalized *Cenchrus ciliaris* was lower than that of improved *Brachiari*a grasses including *Toledo, Marandú, mulato* II, and indigenous *Brachiaria*. When *Brachiaria* grass cv. *mulato* was intercropped with perennial peanut in Madagascar, it produced significant DM in the first cuts but showed no change in the third (Rahetlah *et al.,* 2012). The intercropping was assessed in 20 mono-cultures. *Brachiaria* grasses, particularly varieties *Toledo, mulato,* and *Decumbens*, are widely cultivated in Latin American nations like as Honduras. They are collected for hay throughout the six- to seven-month-long dry season. (Reiber *et al.,* 2012).

2.9 Nutritional composition of *Brachiaria spp.*

In addition to genetics, a number of other factors, such the temperature, can affect how nutritious forages are (Keba *et al.,* 2013), soil nutrition (Tessema *et al.,* 2011), season and grazing pressure (Henkin *et al.,* 2011), management (Okwori and Megani*,* 2010; Keba *et al.,* 2013), and fertilizer application (Hasyim *et al.,* 2015). Cutting intervals can significantly affect the nutritional quality and yield of most forage, which is an important factor to consider (Okwori and Megani*,* 2010). Wanghchuck *et al.* (2015) suggested a 60-day cutting interval during the ideal growth season in order to preserve a high yield without significantly altering the composition of nutrients. Cutting intervals can significantly affect the nutritional quality and yield of most forage, which is an important factor to consider (Okwori and Megani, 2010). Wanghchuck *et al.* (2015) suggested a 60-day cutting interval during the ideal growth season in order to preserve a high yield without significantly altering the composition of nutrients. Early-stage harvesting of forages is thought to result in comparatively larger crude protein content (Mirza *et al.,* 2002; Keba *et al.,* 2013). When *mulato* II is harvested at the two-week mark rather than the six-week mark, Inyang *et al.* (2010b) indicate a better nutritious value.

2.9.1 Crude Protein (CP)

When *Brachiaria* hybrids cultivars *mulato* and *mulato* II were assessed in Thailand, it was discovered that *Brachiaria mulato* had greater crude protein content. When *Brachiaria* hybrid cultivars *mulato* and *mulato* II were analyzed in Thailand, it was discovered that *mulato* possessed more crude protein (17.5%) in its leaves at the first harvest than *mulato* II (14.6%). When *mulato* II is harvested at the two-week mark rather than the six-week mark, Inyang *et al.* (2010b) indicate a better nutritious value. When *mulato* II was harvested or cut at 30-day intervals, the CP level was 3–4% higher than when it was cut at 45–60-day intervals (Hare *et al.,* 2013a). Because temperatures affect the quality of grasses, high temperatures can cause plants to have lower CP than anticipated (Ghimire *et al.,* 2015). As the cutting interval increased from 6 weeks (CP 9.8 - 12.9% of DM) to 12 weeks (6.1 - 8% of DM), the CP decreased. According to Njarui *et al.* (2016), *Mulato* II exhibited the most CP content at both the 6- and 8-week cutting intervals. Certain enhanced *Brachiaria* grasses were also assessed in Rwanda's low-rainfall and acidic soils. The entire plant of *Mulato* II and hybrid BR02/1485 exhibited a CP level of 14% and 15%, respectively. When *mulato* II was cut at 30-day intervals, the CP level was 3-4% higher than when it was cut at 45–60-day intervals (Hare *et al.,* 2013a). Working with *Brachiaria* hybrids in Thailand, Hare *et al.* (2013) discovered that while lowering CP concentrations, increasing cutting intervals to 90 days resulted in a considerable rise in DM production. He went on to state that compared to cutting at 45- and 60-day intervals, cutting at 30-day intervals would elevate CP levels by 3-4%. The CP and digestibility of all the *Brachiaria* cultivars were generally rather high when they were chopped at 6 and 8 weeks of growth, which is advantageous for ruminant production. *Mulato* II had the highest CP at 6 and 8 weeks (9.8–12.9%), but it was lower than the 13–16% values reported by Vendramini *et al*. (2014) and similar to values reported by Hare *et al.* (2009). Hare *et al.* (2009) measured the average CP of numerous *Brachiaria* grasses, such as *mulato* II, *Marandu*, *Xaraes*, and *Basilisk*, over a three-year period. The results ranged from 9.8-11.8% (leaf) and 6.7 to 7.3% (stem). One of the main factors used to assess a feed's nutritional quality is its crude protein content. This is due to the fact that rumen microbial growths and cattle DM intake will both rise with an increase in CP level (Chanthakhoun *et al.,* 2012). According to Baluch-Gharaei *et al*. (2015), conventional feed resources should be the source of any rise in the CP content in a feed. The CP content decreased in most grasses as the plants grew older. *Brachiaria* species are comparable to *Napier* grass, with the added benefit of inhibiting biological nitrification, which prevents nitrous oxide production from soil nitrogen (Pickett *et al.,* 2014 and Subbarao *et al.,* 2009). According to Mutimura *et al.* (2017), chemical investigations that have evaluated the nutritional quality of *Brachiaria* grass and *Napie*r grass have consistently ranked the two forages. Increased cutting or harvesting intervals considerably decreased the CP and raised the concentration of fibers in guinea grass, according to research by Hare *et al.* (2013b). According to Inyang *et al.* (2010), cutting frequency is a crucial management technique that influences the persistence, nutritional value, and herbage buildup of warm-season grasses. After comparing *Brachiaria mulato* II, *Cayman*, and BR02/1794 in Thailand, Hare *et al.* (2013) discovered that while herbage accumulation would be 20% lower, cutting at 30-day intervals would provide CP levels that were 3-4% higher than cutting at 45 and 60-day intervals. The effects of stubble height and regrowth interval on the accumulation of herbage, nutritional worth and endurance of *mulato* II were investigated by Inyang *et al.* (2010b). Herbage accumulation was lower for 2-week regrowth intervals than for longer intervals, despite the fact that herbage taken at these intervals had higher nutritional content. These findings are consistent with those found for other warm-season grasses. According to Nguku *et al.* (2015), *Brachiaria* grasses in the semi-arid eastern Kenya have a mean CP content of 7–10. While the content of CP was falling, the frequency of seed collection was increasing DM. When compared to *Brachiaria ruziziensis*, *Paspalum atratum*, and *Panicum maximum, Brachiaria brizantha cv. Toledo*, cultivars *mulato* and *mulato* II had a high output of dry matter during the dry season in northeastern Thailand (Hare *et al.,* 2009). On *Brachiaria* hybrids, Vendramini *et al.* (2014) reported a decrease in CP with increasing cutting interval. However, the nutritional values were higher than those that Paulino *et al.* (2011) found elsewhere, most likely as a result of the site's unique geographic location and environmental circumstances. Good markers of forage quality include high mineral concentrations, low levels of acid and neutral detergent fibers (NDF and ADF), and high levels of crude protein (CP). Pasture grasses, such as *Brachiaria* grasses, have demonstrated their significance in numerous facets of agriculture. At 70 days following establishment, the *Brachiaria brizantha* cultivar *Piatá*, when combined with sorghum, yielded high levels of crude protein, biomass, and *in vitro* digestibility of organic matter (Quintino *et al.,* 2013).

2.9.2 Acid Detergent Fiber (ADF)

The cellulose and lignin components of forages, which depend on how digestible the feed is, make up ADF. Because they pertain to the feed's digestibility when ingested by ruminants, the values of ADF are significant to farmers. Forages with high ADF values have a reduced rate of digestion, according to Costa *et al.* (2005). According to Van Saun (2006), grasses with ADF levels under 50% are regarded as high-quality forage, whereas those with levels over 60% are regarded as low-quality forage. According to Albayrak *et al.* (2011), when the ADF rises, the forage's digestibility often decreases, which results in a decrease in the amount of forage consumed by the animals.

2.9.3 Neutral Detergent Fiber (NDF)

Feed intake is influenced by NDF; reduced intake is caused by foods with NDF levels exceeding 72%. According to Lima *et al.* (2002), dry matter consumption falls as NDF percentages rise Schroeder (2012). Additionally, during later harvests, the structural components of the plant (lignin, ADF, and NDF) rise, which lowers the digestibility of dry matter (Mirza *et al.,* 2002; Keba *et al.,* 2013). Additionally, Hare *et al.* (2013b) demonstrated that when cutting intervals increased, the dry matter digestibility (DMD) decreased and the CP and fiber content both considerably decreased. According to Albayrak *et al.* (2011), as the ADF rises, the forage's digestibility often decreases, which results in a decrease in the amount of forage consumed by the animals. However, the quality may be positively or negatively impacted by the stage at which the grass is picked. According to Bruinenberg *et al.* (2002), variations in the phenological stage of guinea grass may result in variations in the digestibility of DM of grasses at a certain harvesting date. However, due to actual or perceived palatability and superior animal reaction to the grass, *Brachiaria* grass was chosen by both farmers and animals over *Napier* grass, according to a few feeding trials and farmers' opinions (Mutimura and Everson, 2012a; Rao *et al.,* 2015). The nutritional quality of plants is influenced by both species and age (Särkijärvi *et al.,* 2012; Waramit *et al.,* 2012 and Tikam *et al.,* 2015). At 60 days following planting, the majority of the assessed grasses had superior nutritional qualities. But ninety days after planting, there were still high dry matter, gas production, potential degradable percentage, and rate of degradability seen *in vitro* because of the meal's available energy contents, microbial growth affects how easily the feed degrades in the rumen (Yahaghi *et al.,* 2014). The significant *in vitro* degradability of these grasses, observed 90 days after planting, may be attributed to their low fiber and high crude protein concentrations, which are responsible for energy production and rumen microbial development. *Brachiaria brizantha cv. Piatá,* cv. *Marandú* and *Brachiaria decumbens cv. Basilisk* exhibited superior methane concentrations and degradability properties. Approximately 10% of *Brachiaria brizantha's* DM and 66% of its NDF are protein when it is in the vegetative state.

2.9.4 Lignin

The primary factor limiting the digestibility of organic matter and nutritional availability in forages is lignin, an essential component of plant secondary cell walls, which functions as a physical barrier to microbial enzymatic activity (Agbor *et al.,* 2011; Jung, 2012). At a 12-week cutting interval, the highest lignin content was found in *Mulato* II (5.30%), whereas *Marandu* (3.0%) had the lowest. (Njarui *et al.,* 2016). High protein content, low lignin and cellulose content, and high digestibility are characteristics of young plants (Tekletsadik *et al.,* 2004; Wijitphan *et al.,* 2009).

2.9.5 Minerals

Any feed's amount of ash is a good sign of how many inorganic (mineral) ingredients it contains. Njarui *et al.* (2016) reported that while Ca and P levels increased with cutting intervals between 6 and 8 weeks, depending on the cultivar, they either remained the same, increased, or decreased at 12 weeks. In tropical regions, the attributes most susceptible to management and environment in terms of phenology, soil fertility, moisture conditions, light intensity, and temperature are metabolizable energy (ME), crude protein contents, and macro- and micro-minerals (Campos *et al.,* 2013; Danes *et al.,* 2013).

2.9.6 Hemicellulose (HM)

The soluble part of the feed that the animal can digest from the forage is known as HM. Mulatsih (2003) discovered that when a plant is defoliated after 60 days, there is an increased amount of cellulose and hemicellulose, which are components of the cell wall that increase the levels of crude fiber and DM.

2.10 How digestible are *Brachiaria* species?

2.10.1 Digestibility of Dry Matter

The grass *Brachiaria* hybrid 36061 cv. *mulato* has excellent nutritional quality; its *in vitro* digestibility ranges from 550 to 620 g/Kg DM, and its crude protein concentrations range from 90 to 170 g/Kg DM. Inyang *et al.* (2010). In the *Marandu* and *Xaraés* grasses, similar findings were made by Flores *et al.* (2008), who observed that pastures managed at 15 and 25 cm high had the highest values of CP and *in vitro* digestibility of organic matter. Additionally, Marcelino *et al.* (2006) observed that a longer defoliation interval was linked to a higher population of stems and senescent material, which decreased the grass's nutritional value. *Mulato* grass assays showed a decrease in CP content of 9–16% and in vitro digestibility of 62–55% when the plant was aged from 23 to 30 days (Argel *et al.,* 2005). Regarding this, Clavero and Razz (2009) discovered that raising the cutting age of *maralfalfa* grass from 3 to 9 weeks resulted in a 10.35 unit fall in digestibility, but in *B. brizantha*, harvesting at 21 and 42 days resulted in a decrease in digestibility from 61.0 to 47.7% (Rodríguez *et al.,* 2004). According to Flores *et al.* (2008), as plants get older, the nutritional value of grasses decreases due to changes in their structural components. The CP content significantly decreased with plant age in both native grasses such as *Aristida longiseta, B. gracilis, C. incertus, H. Berlangeri, P. hallii,* and *S. macrostachya,* and cultivated grasses such as *Panicum coloratum, ciliaris, Cynodon dac-tylon,* and *Dichanthium annulatum*. This decline may have been caused by a relative increase in the cell wall and a decrease in the cytoplasm (Ramírez *et al.,* 2003a, b; Ramírez *et al.,* 2004).

2.10.2 Digestibility of Neutral Detergent Fiber (NDFD)

In 2002, Hernández *et al.* observed that pastures that experience severe and frequent defoliation exhibit a greater rate of digestibility, a greater quantity of young leaves with a higher CP content, and digestible dry matter that has a lower concentration of NDF and ADF. By the end of the growing season, grasses had more neutral detergent fiber (NDF), according to Skládanka *et al.* (2008). Seasonal fluctuations had a significant impact on the digestion of feed or forages. According to Kallah *et al.* (2000) and Megersa *et al.* (2017), an average digestibility of 450 g/Kg forage/fodder was found to be enough for sustaining an animal's peak performance. The indigestible neutral detergent fiber (iNDF) in ruminants will not be available for microbial digestion, even if the total tract residence of fibers was prolonged to an infinite amount of time Huhtanen *et al.* (2006). The cross-links between the hemicellulose and lignin in the cell wall of the iNDF are what cause its indigestibility, according to Van Soest (1994).

2.10.3 Botanical Fractions' Digestibility

According to Arcanjo *et al.* (2022), *Ruziziensis* grass has superior invitro digestibility for dry matter in both the leaf and the stem compared to *Marandu* grass. The regrowth age had no effect on the leaves' dry matter (DM) or neutral detergent fiber (NDF) *in vitro* digestibility (ivD). The two kinds of grass have identical ivDNDF in their leaves, when the regrowth age was 21 days; there was a rise in the stem's ivDDM.

2.11 Pest and diseases of *Brachiaria* grasses

Spider mites have been identified as the primary pest of *Brachiaria* grasses in sub-Saharan Africa, according to (Maass *et al.,* 2015 and Njarui *et al.,* 2016). Experiments conducted in Kiboko, *Brachiaria mulato* II had higher rates of spider mite attacks (Machogu, 2013).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 The Study Area

The University for Development Studies experimental field at Nyankpala, in the Tolon district, and Pong – Tamale Senior High School, in the Savelugu Municipality, both in the northern region, were the sites of the experiments. The study locations are located in the agro-ecological zone of the Guinea savanna. Nyankpala lies 16 kilometers to the west of Tamale, the capital of Ghana's northern region, whereas Pong-Tamale is situated 32.1 km to the north of Tamale. Nyankpala is situated at an elevation of 183 meters above sea level, with latitudes of 9° 30'' N and 9^{o} 35'' N, and longitudes of 1° 20'' and 1^{o} 04'' Whereas, Pong- Tamale is placed at a coordinate system of 9^{o} 41'6'' N and 0^{o} 49' 57'' W in degrees, minutes, and seconds (DMS). These regions experience a monomodal rainfall pattern that starts in April and ends in October, with an average annual rainfall of 800 to 1200 mm (SARI, 2014). The mean annual minimum and maximum temperatures are 25˚C and 38˚C respectively. The region is influenced by the cold, dry North-East Trade winds, often known as the "Harmattan" winds, December and January (SARI, 2014).

3.2 Climatic conditions of the study area

According to GIS's (2012) classification, Ghana is broadly divided into seven agro-ecological zones: Moist evergreen, wet evergreen, coastal savanna, Guinea savanna, Sudan savanna and deciduous woodland. The Guinean forest-savanna mosaic ecosystem is found in the Northern Region. Out of the three savanna ecological zones, the Guinea Savanna has the most rainfall. The majority of the vegetation is made up of grasslands and forests. April through October is the wet season, and January through March is the dry season. The mean annual rainfall is 800–1200 mm with a unimodal distribution (SARI, 2014). At the conclusion of the dry season in March, the greatest temperatures are recorded. Harmattan is caused by trade winds blowing from the northeast from late November to March. Temperatures can range from 14 °C (59 °F) at night to 40 °C (104 °F) during the day during this period (Lyngsie *et al.,* 2011).

3.3 Procurement of Seeds, Land Preparation and Propagation

Brachairia mulato II seeds were purchased from Semanhyia farms in the Eastern Region of Ghana. The experimental sites were ploughed with a tractor; weeds were cleared and leveling was manually done using a hoe. *Brachiaria mulato* seeds were planted two seeds per hole at a depth of 2–5 cm and spacing inter and intra plants to be 0.5 m.

3.4 Experimental Design and Treatment

A plot size of 3m × 2m (6m^2) was used and spacing inter and intra plants was 0.5m and a total of 27 experimental plots per location. The grasses were harvested at two different ages (80 and 100 days) and two harvesting intensities (Light [15cm], Severe [8cm]) stubble and replicated twice in a 2×2 factorial in a Randomized Complete Block Design. Agronomic and morphological data such as tiller number were visually counted and plant height were measured using a classic steel self-retracting measuring tape starting from the sixth week after planting and on the same day of any other week till the end of sixteen weeks of data collection. Soil moisture of all the experimental plots in the two experimental fields were measured diagonally and at the middle of the plot given five readings per experimental plot, using SM 150T Delta-T Devices Ltd UK soil moisture sensor kit.

Table 1: Random field layout for location one (Nyankpala field)

80S	**100L**	**80L**
100L	**80S**	**100S**
80L	**100S**	**80S**
100S	**100L**	**100L**
80S	**80L**	**80L**
100L	**100S**	**100S**
80L	**100S**	**80S**
80S	**80L**	**100L**
80S	**100L**	**80L**

80 days Sever (80S), 80 days Light (80L), 100 days Sever (100S) and 100 days Light (100L)

Table 2: Random field layout for location two (Pong-Tamale field)

100S	**80S**	**100L**
100S	**100S**	**80L**
100L	**80L**	**100S**
80L	**100L**	**80S**
100S	**80S**	**100L**
80S	**80S**	**80L**
80L	**80L**	**100S**
80L	**100L**	**80S**
100S	**100L**	**100L**

80 days Sever (80S), 80 days Light (80L), 100 days Sever (100S) and 100 days Light (100L).

3.4 Management Practices

The experiment was conducted from the month of June to October, where sulphate of ammonia was applied at a rate of 40kg/ha to all experimental plants six (6) weeks after germination and were repeated immediately after each harvesting regime to supply nitrogen to the grass. Weeds were cleared using a hoe at any time the fields were weedy. The experimental grasses were not irrigated any time there were dry spell. This is because the researcher wants to find out how the *Brachiaria mulato* II grass would perform in the guinea savannah agroecological zone which is characterize by dry spells. The few pests such as caterpillars and grasshoppers which were found on the plants towards the end of the experiment were hand-picked because application of pesticides might affect the growth of the experimental grass. There was no any visible sign of diseases observed on the *Brachiaria mulato* II grass.

3.5 Data Collection

For the purpose of measuring plant height and tiller counts, six plants were chosen at random, omitting those that were near the boundaries of each experimental plot because of the influence of external factors such as more sun light, wind, water and wash fertilizers from nearby fields on those grasses. From the sixth week following planting and every other week until sixteen weeks of data collection, morphological characteristics such as plant height (PH) were measured using a classic steel self-retracting measuring tape to measure from the base of the plant to the tip of the leaves. Tiller numbers were also visually counted from the same plants whose height were measured from the sixth week after sowing/planting seeds and every other week by visual counts till the end of data collection. Soil moisture of each of the fifty-four (54) experimental plots (27 in each location) was measured diagonally and at the middle of the plot to have comprehensive moisture distribution of the experimental plots, given five readings per plot immediately after sowing/planting and every other week using SM 150T Delta-T Devices Ltd UK soil moisture sensor kit till the end of data collection. Standardized cutting or harvesting at 8 cm and 15 cm above ground level were performed using a sickle because with the nature of the *Brachiaria* grass, it is the sickle that is able to cut the grass in bundle with ease and accurately at the measured point. The harvested biomass was transported to the Forage Evaluation Unit of University for Development Studies` where the biomass yield of each plot was weighed using TITAN-C EAGLE table top electronic weighing scale. In order to calculate the dry matter, the biomass was oven dried for 48 hours at 60°C according to Donnelly, *et al*. (2018). The collected biomass was separated into the midrib and leaf blade sections for *in vitro* dry matter digestibility testing and chemical analysis for the researcher thinks the midrib might affect digestibility and chemical composition.

3.6 Chemical Analysis

The experimental design for the chemical analysis was 2 ×2 factorial where the factors are leaf and midrib. A Full Circle Screen Hammer Mills was used to grind the dried samples (leaf and midrib) separately so they could pass through a 1 mm sieve. The milled samples were examined for crude proteins (CP) and ash according to AOAC (2000) procedure. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were found to be limited in residual ash through the use of sodium sulfite and alpha-amylase, following the method of Van Soest *et al.* (1991). This was accomplished using an Ankom

(2000) fiber analyzer (method 5 for ADF and method 6 for NDF) at the University for Development Studies' Forage Evaluation Unit.

3.7 *In vitro* Digestibility procedure

The experimental design for the *in vitro* digestibility analysis was 2 ×2 factorial.
The batch *in vitro* gas production technique of Theodorou *et al*. (1994) was adopted and Ansah *et al*. (2016) source of rumen fluid modification method was used. Four (4) slaughtered Sanga cattle (weighing 300 ± 15 kg) at the Tamale abattoir provided the rumen fluid. The cattle were raised on native pastures that naturally grew heterogamous plants. The rumen fluid was collected from the rumen after the animals have been slaughtered and rumen taken out. The rumen fluid was collected into a thermos flask that had been pre-warmed to a temperature of 39°C. The rumen fluid was squeezed through a four layer of cheesecloth. McDoughal's buffer was made and maintained at 39°C in a water bath. Treatment samples (0.45-0.55 g per bag) were weighed into the fiber filter bag; heat sealed and placed in 50 ml digestion tubes. About 30 ml of the warm and anaerobic incubation media (rumen fluid + buffer) was dispensed into the digestion tubes and incubated for 48-h in water bath (39°C). After 48-h, the incubation process was terminated, and samples washed in distilled water and oven dried (102°C) for 3-4 h. Neutral detergent fibre was determined on the incubated samples using Ankom (2000) fibre analyses (Method 6) to get the residual NDF.

The following parameters were calculated according to the equations of Mertens, (2002).

1. IVDMTD (%DM) = 100*(DMwt – NDFres / DMwt).
2. iNDF (%DM) = 100 – IVDMTD.

3. dNDF (%DM) = NDF – iNDF.
4. NDFD (%DM) = 100* dNDF/NDF.

Where:

IVDMTD: *In vitro* Dry Matter True Digestibility.

iNDF: Indigestible Neutal Detergent Fiber.

dNDF: Digestible Neutal Detergent Fiber.

NDFD: Neutral Detergent Fiber Digestibility.

DMwt: Dry Matter weight.

NDFres: Neutral Detergent Fiber residue.

3.7 Data Analysis

The agronomic data (plant height, tiller number and biomass yield) was analyzed with ANOVA in a 2×2 factorial using GenStat (11th edition). The factors are harvesting age and harvesting intensity. The ANOVA equation model used was; Yijk=U+Ai+Si+ (AS) ij+ϵijk

Where:

Yijk=Observation (Plant height, tiller number and biomass yield)

U=Overall mean.

Ai=Effect of Harvesting age

Si= The fixed effect of the i-th level of factor S.

As=Effect of harvesting intensity.

E=Error mean.

(AS)ij= The interaction term between factors A and S.

ϵijk (Epsilon)= The random error term.

The chemical composition and fiber digestibility data were analyzed with ANOVA in 2×2 factorial using GenStat (11th edition). The factors were harvesting age and botanical fractions. Means were separated using LSD at 5% significance level.

CHAPTER FOUR

4.0 RESULTS

4.1 Weekly moisture variations of the experimental plots.

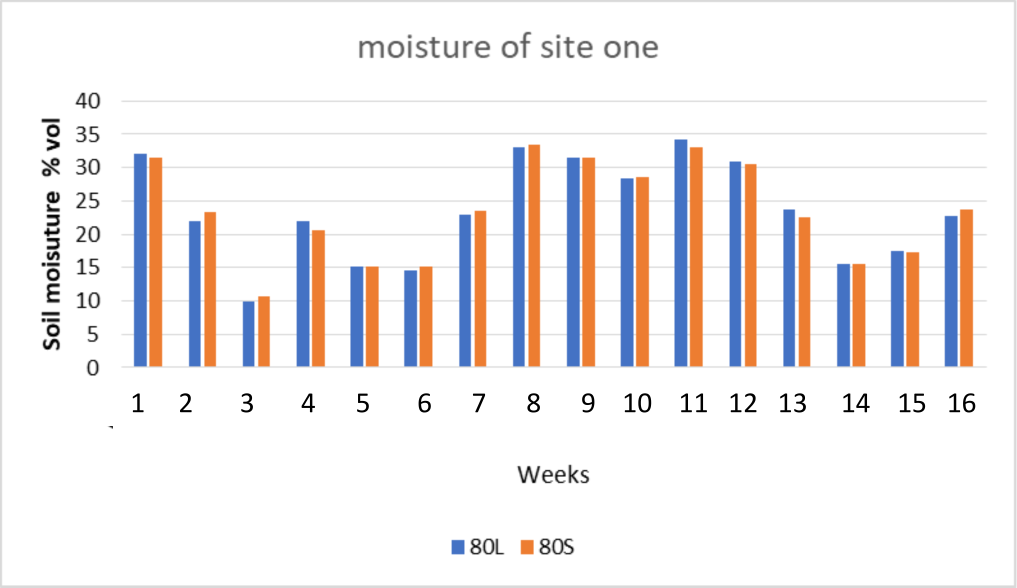

Figure 1: Soil moisture content (% vol) of 80 days experimental plots for location one.

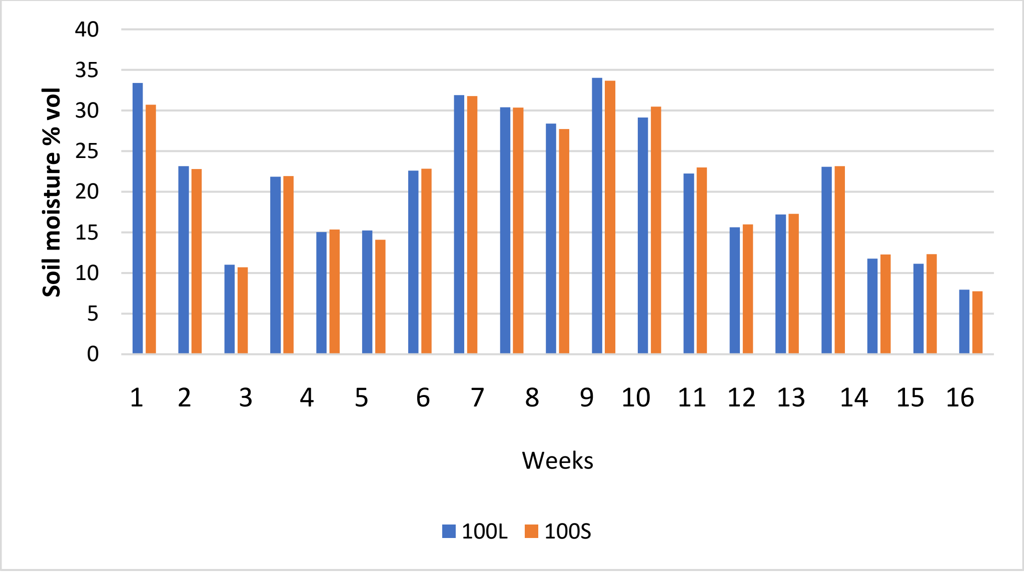

Figure 2: Soil moisture content (% vol) of 100 days experimental plots for location one.

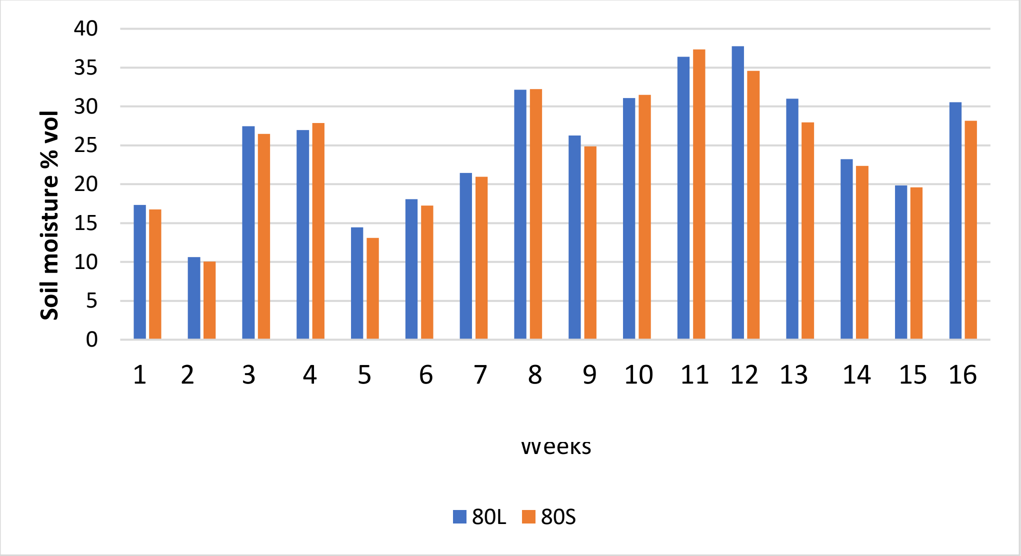

Figure 3: Soil moisture content (% vol) of 80-day experimental plots for location two.

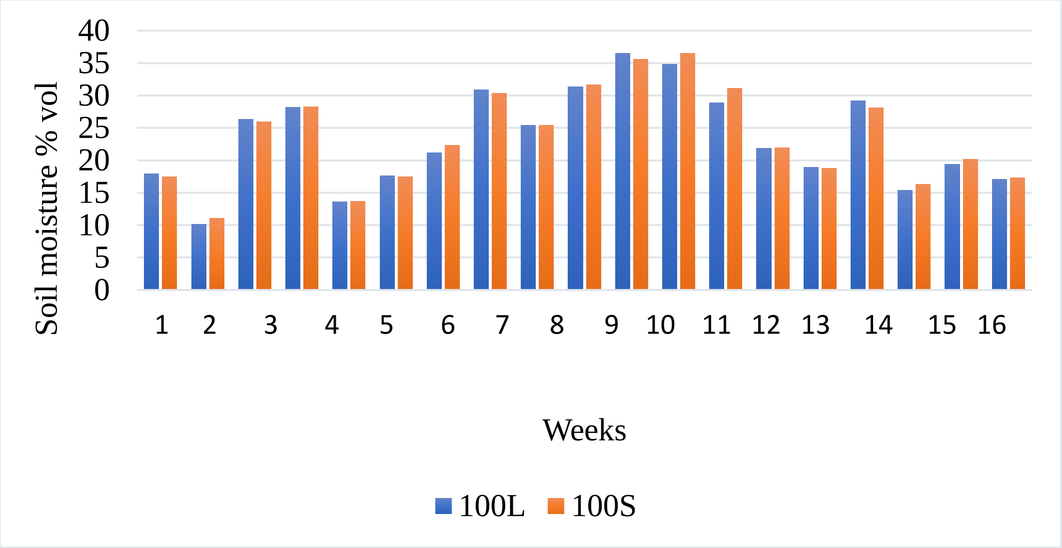

Figure 4: Soil moisture content (% vol) of 100 days experimental plots for location two

4.2 Morphological characteristics

The mean effect of harvesting age and harvesting intensity on tiller number and plant height in the initial establishment of *Brachiaria mullato* II are shown on table 3 and 4 below respectively.

Table 3: The interactive effect of harvesting age and intensity on tiller number of initial growth.

Harvesting Age	Harvesting Intensity	Tiller Numbers	
		Location I	Location II
80 days	Light	61.9^a	76.2
	Severe	80.8^a	62.7
100 days	Light	112.1^b	99.5
	Severe	102.1^b	98.3
S.e.d		7.73	8.03
	Harvesting Age	0.001	0.001
P Values	Harvesting Intensity	0.419	0.197
	Age*Intensity	0.009	0.279

S.e.d (standard error of difference)

The interactive effect of harvesting age and intensity was significant at location one only for tiller numbers. However, harvesting age main effect was significant for tiller numbers for both locations. Grasses harvested 100 days produced the highest average tiller numbers of (107.1) for location one and (98.9) for location two.

Table 4: The interactive effect of harvesting age and intensity on plant height of initial growth.

Harvesting Age	Harvesting Intensity	Plant height (cm)	
		Location I	Location II
80 days	Light	51.55	52.36
	Severe	43.40	42.53
100 days	Light	48.67	52.12
	Severe	40.33	38.51
S.e.d		1.497	2.133
	Harvesting Age (HA)	0.006	0.160
P Value	Harvesting Intensity	0.001	0.001
	Age*Intensity	0.933	0.212

S.e.d (standard error of difference)

The interactive effect of harvesting age and intensity was not significant for plant height at both locations. However, harvesting age (HA) has main effect on plant height at location one whilst harvesting intensity main effect was significant for plant height at both locations. Grasses harvested 80 days light (15cm) produced the highest plant height with averages of (47.45cm) and (47.45cm) for location one and two respectively.

4.3 Biomass yield

Table 5 and 6 shows the interactive effect of harvesting age and intensity on biomass yield of *Brachiaria mullato* II in both locations.

Table 5: The interactive effect of harvesting age and intensity on biomass yield of *Brachiaria mullato* II of location I.

Harvesting Age	Harvesting Intensity	Initial Biomass yield(kgDM/ha)	Regrowth Biomass yield(kgDM/ha)
80 days	Light	440	704
	Severe	550	671
100 days	Light	1319	908
	Severe	1745	805
S.e.d		358.3	180.9
	Harvesting Age	0.001	0.199
P Value	Harvesting Intensity	0.301	0.600
	Age*Intensity	0.540	0.787

DM (Dry Matter), S.e.d (standard error of difference)

The interactive effect of harvesting age and intensity was not significant for both initial and regrowth. However, there was significant main effect of harvesting age on initial biomass yield for location one. Harvested grasses 100 days after planting produced the highest average biomass yield at both initial (1532kgDM/ha) and regrowth (856.5kgDM/ha) for location one.

Table 6: The interactive effect of harvesting age and intensity on biomass yield of *Brachiaria mullato* II of location II.

Harvesting Age	Harvesting Intensity	Initial Biomass yield(kgDM/ha)	Regrowth Biomass yield(kgDM/ha)
80 days	Light	1034	784
	Severe	926	662
100 days	Light	1980	929
	Severe	3093	911
S.e.d		853.8	215.6
P Value	Harvesting Age	0.016	0.208
	Harvesting Severity	0.413	0.649
	Age*Intensity	0.322	0.738

DM (Dry Matter), S.e.d (standard error of difference)

The interactive effect of harvesting age and intensity was not significant for both initial and regrowth harvest for location two. However, there was main treatment effect of harvesting age on biomass yield of initial harvest for location two. Grasses harvested 100 days after planting produced the highest biomass yield at both initial (2536.5kgDM/ha) and regrowth (920kgDM/ha) for location two.

4.4 Chemical Composition

Table 7 and 8 shows the interactive effect of harvesting age and botanical fraction on chemical composition of *Brachiaria mullato* II biomass at both locations.

Table 7: The interactive effect of harvesting age and botanical fraction on chemical composition at location I.

				INITIAL ESTABLISHMENT				
		Parameters						
Harvesting age	Fraction	DM	ASH	OM	CP	NDF	ADF	HM
80	Leaf	96.75	11.63^{a}	88.37^{b}	11.14	60.13^{a}	28.57^{a}	31.56
	Midrib	95.00	13.68^{b}	86.32^{a}	7.29	59.18^{a}	26.53^{a}	32.65
100	Leaf	96.37	10.89^{a}	89.11^{b}	12.47	60.17^{ab}	26.94a	33.23
	Midrib	95.00	14.02^{b}	85.98^{a}	7.69	63.43^{b}	34.19^{b}	29.24
SED		0.838	0.305	0.305	0.577	1.167	1.479	1.853
	HA	0.755	0.352	0.352	0.047	0.017	0.009	0.514
P-Value	BF	0.016	0.001	0.001	0.001	0.177	0.022	0.282
	HA*BF	0.755	0.021	0.021	0.272	0.019	0.001	0.067
		REGROWTH						
80	Leaf	97.75	11.64	88.36^{b}	16.83^{c}	59.39	24.49^{a}	34.89
	Midrib	95.5	13.61	86.39^{a}	6.23^{a}	63.27	31.12^{c}	32.14
100	Leaf	97.75	10.74	89.26^{c}	15.86^{c}	60.73	27.86^{b}	32.88
	Midrib	95.50	13.45	86.55^{a}	9.77^{b}	66.63	31.45^{c}	35.18
SED		0.136	0.299	0.299	0.561	2.005	0.922	1.648
	HA	1.000	0.021	0.021	0.004	0.112	0.010	0.667
P-Value	BF	0.001	0.001	0.001	0.001	0.003	0.001	0.848
	HA*BF	1.000	0.100	0.100	0.001	0.485	0.031	0.052

CP (crude protein), NDF (neutral detergent fiber), ADF (acid detergent fiber), HM (hemicellulose), DM (dry matter), OM (organic matter), SED (standard error of difference), Harvesting Age (HA), Botanical Fraction (BF) and ASH

The interactive effect of harvesting age (HA) and botanical fraction (BF) was significant for ASH, OM, NDF and ADF only for initial harvest. However, botanical fraction has main effect on all parameters except NDF and HM for the initial harvest. Besides these, harvesting age have main effect on CP, NDF and ADF only for the initial harvest.

On the other hand, the interactive effect of harvesting age (HA) and botanical fraction (BF) is significant for CP and ADF in the regrowth harvest. However, harvesting age has main effect on ASH, OM, CP and ADF in the regrowth harvest. Besides these, botanical fraction had main effect on all nutritional parameters except HM in the regrowth harvest.

Table 8: The interactive effect of harvesting age and botanical fraction on chemical composition at location II.

					INITIAL ESTABLISHMENT			
		Parameters						
Harvesting age	Fraction	DM	ASH	OM	CP	NDF	ADF	HM
80	Leaf	97.96	11.55	88.45	10.90	59.31	29.29^{b}	30.01^{a}
	Midrib	95.00	13.35	86.65	5.72	65.96	27.66a^{b}	38.30^{c}
100	Leaf	97.58	10.85	89.15	12.11	57.64	24.89^{a}	32.75^{ab}
	Midrib	95.00	13.68	86.32	7.39	63.80	29.15^{b}	34.66^{b}
SED		0.548	0.414	0.414	1.085	1.266	1.371	1.283
	HA	0.634	0.532	0.532	0.076	0.045	0.148	0.623
P-Value	BF	0.001	0.001	0.001	0.001	0.001	0.192	0.001
	HA*BF	0.634	0.091	0.091	0.768	0.790	0.007	0.002
		REGROWTH						
80	Leaf	97.63	12.42^{ab}	87.58^{bc}	14.72	61.54	29.23^{b}	32.30
	Midrib	95.50	12.95^{bc}	87.05^{ab}	12.21	66.45	29.61^{b}	36.84
100	Leaf	97.67	12.12^{a}	87.88^{c}	17.80	55.28	25.21^{a}	30.08
	Midrib	95.50	13.61^{c}	86.39^{a}	14.16	63.41	31.20^{b}	32.22
SED		0.383	0.293	0.293	0.641	1.157	1.171	1.503
	HA	0.939	0.395	0.395	0.001	0.001	0.157	0.004
P-Value	BF	0.001	0.001	0.001	0.001	0.001	0.001	0.005
	HA*BF	0.939	0.029	0.029	0.223	0.063	0.003	0.272

CP (crude protein), NDF (neutral detergent fiber), ADF (acid detergent fiber), HM (hemicellulose), DM (dry matter), OM (organic matter), SED (standard error of difference), Harvesting Age (HA), Botanical Fraction (BF) and ASH

The interactive effect of harvesting age (HA) and botanical fraction (BF) was significant for ADF and HM only for initial harvest. However, botanical fraction had main effect on all nutritional parameters except ADF for the initial harvest. Besides these, harvesting age have main effect on NDF only for the initial harvest. On the other hand, the interactive effect of harvesting age (HA) and botanical fraction (BF) was significant for ASH, OM and ADF in the regrowth harvest. However, harvesting age have main effect on CP, NDF and HM in the regrowth harvest. Besides these, botanical fraction had main effect on all nutritional parameters in the regrowth harvest.

4.5 *In vitro* NDF Digestibility

Table 9 and 10 shows the interactive effect of harvesting age and botanical fraction on *in vitro* digestibility (%) of *Brachiaria mullato* II for both locations.

Table 9: The interactive effect of harvesting age and botanical fraction on in vitro digestibility (%) of *Brachiaria mullato* II for location I.

		INITIAL ESTABLISHMENT			
		Parameters			
Harvesting age	Fraction	IVDMTD	NDFD	dNDF	iNDF
80	Leaf	81.47^{b}	69.18^{ab}	41.60	18.53^{b}
	Midrib	80.56^{a}	67.15^{a}	39.74	19.44^{c}
100	Leaf	83.04^{c}	71.80^{c}	43.22	16.96^{a}
	Midrib	80.55^{a}	69.26^{b}	43.98	19.44^{c}
SED		0.232	0.742	1.232	0.232
P-Value	Harvesting age	0.001	0.001	0.003	0.001
	Botanical fraction	0.001	0.001	0.536	0.001
	Harvesting age*Botanical fraction	0.001	0.001	0.147	0.001
	REGROWTH				
80	Leaf	82.43	70.37^{ab}	41.81	17.57
	Midrib	81.65	70.91^{ab}	44.91	18.35
100	Leaf	81.22	69.09^{a}	41.95	18.78
	Midrib	81.65	72.45^{b}	48.28	18.33
SED		0.625	0.830	1.683	0.625
P-Value	Harvesting age	0.186	0.827	0.157	0.186
	Botanical fraction	0.700	0.003	0.001	0.700
	Harvesting age*Botanical fraction	0.186	0.026	0.190	0.186

In vitro Dry Matter True Digestibility (IVDMTD), Neutral Detergent Fiber Digestibility (NDFD), digestible Neutral Detergent Fiber (dNDF) and insoluble Neutral Detergent fiber (iNDF)

The interactive effect of harvesting age and botanical fraction was significant for all *in vitro* digestibility parameters except dNDF in the initial establishment. However, harvesting age main effect was significant on all *in vitro* digestibility parameters. Besides these, botanical fraction main effect was significant on all *in vitro* digestibility parameters except dNDF. The interactive effect of harvesting age and botanical fraction was significant for only NDFD in the regrowth harvest. However, botanical fraction main effect was significant for NDFD and dNDF in the regrowth.

Table 10: The interactive effect of harvesting age and botanical fraction on in vitro digestibility (%) of *Brachiaria mullato* II for location II.

	INITIAL ESTABLISHMENT				
	Parameters				
Harvesting age	Fraction	IVDMTD	NDFD	dNDF	iNDF
80	Leaf	81.03	67.94	40.34	18.97
	Midrib	80.56	70.52	46.51	19.44
100	Leaf	82.34	69.32	39.98	17.66
	Midrib	80.54	69.47	44.36	19.46
SED		0.590	1.299	1.491	0.590
P-Value	Harvesting age	0.132	0.861	0.247	0.132
	Botanical fraction	0.013	0.154	0.001	0.013
	Harvesting age*Botanical fraction	0.132	0.201	0.406	0.132
	REGROWTH				
80	Leaf	82.49	71.53	44.03	17.51
	Midrib	80.49	70.62	46.94	19.51
100	Leaf	83.49	70.15	38.77	16.51
	Midrib	81.65	71.00	45.06	18.35
SED		0.539	1.043	1.260	0.539
P-Value	Harvesting age	0.010	0.502	0.001	0.010
	Botanical fraction	0.001	0.973	0.001	0.001
	Harvesting age *Botanical fraction	0.174	0.069	0.195	0.179

In vitro Dry Matter True Digestibility (IVDMTD), Neutral Detergent Fibre Digestibility (NDFD), digestible Neutral Detergent Fibre (dNDF) and insoluble Neutral Detergent fibre (iNDF)

The interactive effect of harvesting age and botanical fraction was not significant for all *in vitro* digestibility parameters. Harvesting age had no main effect on any of the *in vitro* digestibility parameters. Botanical fraction had main effect on all *in vitro* digestibility parameters except NDFD on initial harvest.

The interactive effect of harvesting age and botanical fraction was not significant for all *in vitro* digestibility parameters in the regrowth harvest. However, botanical fraction had main effect on all *in vitro* digestibility parameters in the regrowth except NDFD. Harvesting age had main effect on all *in vitro* digestibility parameters in the regrowth except NDFD.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Moisture variations of the experimental plots.

Though there were variations in the moisture content of the experimental plots across both locations this may be due to the dynamic nature of soil which may affects the porosity of the experimental plots. Location two experimental plots recorded slightly the highest moisture content which might have contributed to the higher biomass yield of 7033kg/ha for initial and 3286kg/ha for regrowth than in location one which recorded 4054kg/ha for initial and 3088kg/ha for regrowth. Besides these the variation in moisture content of the experimental plots did not affect the general yield requirements per hectare, the yield is higher than what Hare *et al.* (2007) reported when worked on *Brachiaria mulato* II had a high dry matter of 2,337 kg/ha, in contrast to *mulato*, which had 1,971 kg/ha. The variation in moisture across the experimental plots did not affect the height of the experimental grasses as the average plant height recorded for 80 days at both locations (66.9cm) which is far higher than what was reported by Birilie (2021) when *Brachiaria* grass was harvested at 75 days (45.78cm) while the average plant height at 100 days of harvest at both locations is (77.50cm) compared to (81.51cm) reported by Birilie. 100 days experimental plots produced plants with the highest plant height than 80 days experimental plots may be due to the higher moisture content. The variation in moisture content of experimental plots did not affect production because according to Guenni *et al.* (2002), certain species of *Brachiaria* adapt their growth and biomass distribution under moderate drought circumstances, resulting in comparatively unchanged overall plant production.

5.2 Morphological growth

Harvesting age affecting plant height at the initial establishment of *Brachiaria mulato* II in this research may be due to the uninterrupted growth of the grass with favorable soil moisture, nutrient and climatic conditions. This is consistent with the findings of Shoaib *et al.* (2013), who revealed that plant physiology is influenced by harvesting stage with respect to plant height. In addition to these, Asmare (2016) also noted that plant height rose as the plant's harvest season approached. As observed in the later stages of *Brachiaria mulato* II development from both locations, Melkei (2005) suggests that the reason for the growing plant height in the later stages of the plant could be due to huge root development and efficient nutrient uptake. The average plant height recorded for 80 days at both locations (66.9cm) which is far higher than what was reported by Birilie (2021) when *Brachiaria* grass was harvested at 75 days (45.78cm) while the average plant height at 100 days of harvest at both locations is (77.50cm) compared to (81.51cm) reported by Birilie. Harvesting or cutting intensity (sever and light) affecting regrowth plant height may be due the severity of the harvesting or cutting on the ability of the *Brachiaria mulato* II stubble to rejuvenate due to either less or no leaves left on the stubble to intercept light for photosynthetic processes. As harvesting at 15 cm (light) from the ground would leave quite a number of older leaves on the stubble which would be used for photosynthesis therefore would rejuvenate faster than 8cm (sever) treatment. Various grass harvest intervals and intensity studies, according to Probst *et al.* (2011), demonstrated that the cutting interval influences the sward's growth, yield, and persistence; slow regrowth of the forages was observed immediately after cutting because the plants had few leaves to intercept light for photosynthesis.

According to Mealor (2010), grass species' root growth declines after 40% leaf volume is removed, and aboveground productivity is negatively impacted by root system disturbance. Harvesting or cutting intensity has affected the biomass yield in both sites negatively because of the severity of the harvesting or cutting which does not leave any or enough leaves on the stubble for photosynthesis which slows the rejuvenating process of the *Brachiaria mulato* II grass as reported by Mealor (2010). According to Manske *et al.* (2001), grasses can respond favorably to pruning between the third leaf and the reproductive stages, although pruning too late in the season limits the plant's capacity to recover. Interaction effect of harvesting age and intensity did not have any influence on the initial biomass yield of *Brachiaria mulato* II in this research at both sites in that, the age at which the grass was harvested and at any intensity would not have any influence on the already biomass produced by the grass on field. Harvesting ages (80 and100 days) influences the production of more tillers, as the plants stays longer on the field with conducive climatic conditions and adequate soil nutrient and moisture before harvesting or cutting the more tillers it produces after harvesting or cutting. This is recorded in both sites which are in agreement with Onyeonagu *et al*. (2005a) report, who said tillers increased with frequent cutting interval. The higher number of tillers recorded at 100 days over 80 days aggress with the finding of Zemene *et al*. (2020) who reported that tiller number of plants increases as the grass matures. These agrees with this research observations about the *Brachiaria mulato* II grasses which produced more vegetative tillers at 100 days than reproductive tillers while 80 days harvest produced more of reproductive tillers than vegetative tillers. The researcher in this research also observed that when the grass is harvested earlier before it reaches the vegetative stage of growth, the grass tends to produce more vegetative tillers than reproductive tillers because of inadequate newly formed buds on the parent stem depending on the intensity of harvest or cutting. Harvesting intensity has not affected tiller production in both locations; it was observed that during the course of the research from both fields, new tillers sprout from the base of the grass a day or two after harvesting or cutting provided the soil is moist. This erratic rainfall pattern which influences soil moisture might have affected the biomass yield of *Brachiaria mulato* II grass. These results were supported by the findings of (Guenni *et al.,* 2002; de Araujo *et al*., 2011; Santos *et al*., 2013; Cardoso *et al*., 2015) which indicated that, there have been reports of the significant impact of drought stress on *Brachiaria* biomass output, which essentially suggests that drought stress inhibits plant development in *Brachiaria*. The two-way interactive effect between harvesting age and intensity was significant for tiller production for location one. These could be because of the prevailing soil and climatic conditions during the time of harvesting at both locations could influence the *Brachiaria mulato* II grass to adapt to a survival mechanism which either influences tiller production or inhibit it as reported by Yoshida *et al*. (2014). That plants have developed intricate drought-adaptive mechanisms as a result of drought, ranging from genetic molecular expressions to biochemical metabolism, individual plant physiological processes, and ecosystem-level responses. Wolfson (2000) noted that in areas where grass have grown and covered the ground, shoots or tillers that do not shed their leaves for an extended period of time may experience a reduction in growth and eventually stop producing new stems.

5.3 Biomass yield

According to Hare *et al.* (2013a, 2013b), cutting intervals are a crucial management factor that influence grass output and nutritional properties. It is well known that the productivity and growth rate of seeded pasture varies depending on the environment and the methods used for harvesting or cutting. Numerous research on the effects of cutting management on grass productivity and quality have been carried out, including Tessema *et al.* (2010) and Hare *et al.* (2013a, 2013b). Comparing the numerical values of the initial harvest to that of the regrowth in both locations, there is a reduction in DM yield in the regrowth biomass as harvesting frequency is reduced to 20 days. This may be because of the shorter period given to the *Brachiaria mulato* II to rejuvenate. This is consistent with the results of Inyang *et al.* (2010b), who found reduced herbage accumulation at 2 weeks of regrowth compared to pruning at 6-week intervals in *mulato* II. Njarui and Wandera (2004) also found that basilisk yield increased with longer cutting intervals as opposed to shorter ones. Machogu (2013) reported initial harvest of *Brachiaria* at 16 weeks against 8 weeks regrowth where the results were lower in biomass yield of regrowth than the initial. Moreover, Hare *et al.* (2013a) in Thailand observed increased herbage accumulation in *Brachiaria mulato* II from around 11 to 20 t/ha as the regrowth interval stretched from 30 to 90 days. At Gualaca, Panama, *Brachiaria* produced 11000 Kg DM/ha without fertilizer and 27000 Kg DM/ha when fertilized with 600 Kg N/ha per year in a rainfall area of 3997 mm per year. Both the native *Brachiaria decumbence* and the cultivar *Toledo* of *Brachiaria brizantha* had high DM content (Mutimura and Everson, 2012a). However, the low yields recorded in this research may be due to the quantity of fertilizer applied, the type of soil and soil fertility, amount and pattern of rainfall, the sun and other agro-climatic factors might have attributed to the lower biomass yield recorded in this research compared to the figures recorded by Hare *et al*. (2013a) and Mutimura and Everson, (2012a). The two-way interactive effect of harvesting age and intensity not having effect on biomass yield on both initial and regrowth at both sites could be because; the plants might have adapted to harvesting by adjusting their growth patterns, leading to similar biomass yields despite varying harvesting ages and intensities or the *Brachiaria mulato* II might be resilient to harvesting, with the ability to recover quickly and maintain biomass yields or the environmental conditions, such as climate, soil quality, or moisture levels, may overshadow the effects of harvesting age and intensity on biomass yield of the *Brachiaria mulato* II.

5.4 Chemical Composition

The CP in the various plant fractions (leaf and midrib) ranged from 5.73 – 17.80% for either harvesting or cutting regimes of 80 and 100 days after sowing and regrowth harvested 20 days after initial harvest. This range of values is within the recommended 7.0% CP levels in grasses for optimum rumen function by Van Soest, (1994) except the CP values for midribs of harvest 80day which is 5.73% which is slightly below Van Soest, (1994) recommended value of 7.0 - 7.9 CP in dry matter of *Brachiaaria bazanthis* harvested between 35-80 days after sowing from feedipedia. Also, *B. mulato* II was reported to have the highest CP levels in all the harvest intervals that ranged between 7-12.8% Nguku, *et al*. (2016). In addition to these, Vendramini *et al*. (2010) showed that crude protein levels of *Brachiaria* ranged from 10–14% in Thailand on bad soils to 12–17% in Florida, USA on better soils which also agrees with the finding of this research except the results of midrib results of 80 days harvest which is 5.73%. Nguku, *et al*. (2016) reported 12.8% CP in *mulato* II and 11.1-11.8% in *Brachairia brizantha* cultivars harvested at 22weeks at 5.8Kg N/ha nitrogen fertilizer at standardized cut which falls within the range of the results of this research which rangers from 5.73-17.80 harvested at 12 and14weeks (80 and 100 days) at 40 Kg N/ha. Certain enhanced *Brachiaria* grasses were also assessed in Rwanda's low-rainfall and acidic soils. The total plant CP content of hybrid BR02/1485 and *mulato* II was 15% and 14%, respectively (Mutimura and Everson, 2012a). This falls within the recorded percentages in this research which ranges from 5.73 - 17.80% for 80 and 100days initial and regrowth harvest. However, comparing the CP concentrations between the plant fractions of the two harvesting or cutting ages in this research, it is pretty clear that harvesting age has an effect on the CP percentages of the biomass of *Brachiaria mulato* II plant fractions harvested at 100 days than that of 80days harvest which is in agreement with the findings of Wassie *et al*. (2018) reported that CP content declined with increased harvesting date in all ecotypes [Eth. 13726 (16.33, 10.63 and 6.72), Eth. 13809 (13.87, 10.60 and 9.57) and Eth. 1377 (14.80, 10.15 and 7.86)] for 60, 90 and 120 harvesting dates, respectively for *Brachiaria* grass ecotypes in northwestern Ethiopia. Asmare *et al*. (2017) and Melkie (2005) reported similar findings (8.36, 6.90 and 7.20) respectively for 75, 105 and 135 harvesting dates in *desho* grass species. In the same vein, the CP concentrations in the regrowth biomass of *Brachiaria mulato* II which was harvested 20days after initial harvesting at 80 and 100days after sowing for both harvesting ages are higher in CP than that of the initial harvest. This finding is in agreement with the findings of Inyang *et al*. (2010b) who reported higher nutritive value of *Mulato* II when harvested at 2-week regrowth than at 6 weeks. Njarui *et al*. (2016) who also observed the decline in CP concentrations as the *Brachiaria* grasses ages on the field from 6 to 12 weeks after planting. Mutimura *et al.* (2017) also observed the decline in CP concentrations as the *Brachiaria* grasses ages on the field from 60, 90 and 120 days after planting. In a similar vein, Bayble *et al.* (2007) and Ansah *et al.* (2010) observed a declining trend of CP for Napier grass as harvesting age increased (60>90>120 days). The decline in the crude protein concentrations in the midrib of the leaf of *Brachiaria mullato* II in this research may be due to the fast lignification of the midrib compared to the other parts of the leaf. The CP concentration of the leaf (L) was high in CP at both the initial harvesting ages and regrowth's than the midrib which indicates that botanical fractions have effect on the CP concentrations of *Brachiaria mullato* II. When *Brachiaria* hybrid cultivars *mullato* and *mullato* II were analyzed in Thailand, it was discovered that *mullato* possessed more crude protein (17.5%) in its leaves during the first seed harvest than *mullato* II (14.6%). This is higher than the findings of this research which recorded 10.90 -12.11% crude proteins at 80- and 100-days initial leaf (L) biomass but lower than what is recorded in the regrowth 14.72-17.80%. The total plant CP content of *mulato* II and hybrid BR02/1485 was 14% and 15%, respectively. In multiple experiments conducted in Kenya, Toledo (Xaraés) yielded a much higher total dry matter production than *mulato* II; however, *mulato* II's forage quality (CP and NDF concentrations) outperformed *Toledo's* (Njarui *et al.*, 2016; Ondiko *et al.*, 2016; Kifuko-Koech *et al.*, 2021). Studies conducted in Ecuador revealed that *Toledo* (Xaraés) yielded considerably more total leaf DM than *mulato* II, although at lower amounts of CP (Garay *et al.*, 2017). However, a variety of factors, such as genetics and climate (Keba *et al.*, 2013), soil nutrition (Tessema *et al.*, 2011), season and grazing pressure (Henkin *et al.*, 2011), management (Okwori Megani, 2010; Keba *et al.*, 2013), and fertilizer application (Hasyim *et al.*, 2015), may have an impact on the slight variations in the nutritional qualities of *Brachiaria* forages as reported by various researchers, including this research.

Feed intake is a function of NDF, as feeds with higher NDF levels above 72% causes low intake Lima *et al.* (2002). As NDF concentrations increases, dry matter intake decreases Schroeder, (2012). The NDF percentages recorded in the biomass of *Brachiaria mullato* II in the initial and regrowth harvest rangers from 55.2 - 66.6% NDF which is far below the recommended threshold percentage of 70% by Lima *et al*. (2002), this therefore implies that there will be high intake of *Brachiaria mullato* II dry matter Schroeder, (2012). Nguku *et al*. (2016) reported 56.1% and 63.3% NDF percentages in *Brachiaria* in Kenya which agrees with the results of this research which also fall within the same range of 55.2 – 66.6%. Also, from Feedipedia, the vegetative state of *Brachiaria brizantha* contains about 66% NDF in the DM which is within the range recorded in this research which is 55.2 - 66.6%. In contrast, samples from plants that are 10–15 weeks old are thought to have 70% NDF in ordinary *Napie*r grass (Gwayumba *et al.*, 2002 and Islam *et al.*, 2003). which means *Brachairia mulato* II when harvested at almost the same age and feed to livestock (ruminants), *Brachiaria mulato* II will be more acceptable by the animals than the *Napier* grass. Harvesting or cutting age and botanical fractions have affected the NDF concentration in the various botanical fractions because of the deposition of indigestible materials in the cell walls of the various parts of the plant as the plant ages on the field. The NDF concentration in the midrib in both the initial establishment and regrowth is higher (59.15 – 66.63%) than in the leaf (55.28 – 60.73), this might be because of accumulation of lignin and other indigestible plant materials in the cell walls of the midrib than in the leaf therefore making the leaf more digestible and acceptable by ruminants than the midrib as indicated in the *in vitro* digestibility values of NDFD concentration in the results of this research where the values of the midrib are higher than that of the leaf. According to Arelovich *et al.* (2008), dietary consumption can be increased or decreased depending on the quantity and caliber of NDF. While DM intake rose with increasing dietary NDF concentration at lower NDF concentrations (7.5%–35.5%), in high-producing animals, DM intake dramatically declined as NDF concentration increased over the range of 22.2%–45.8%. ADF is the cellulose and lignin portions of forages which are a function of forage digestibility. The values of ADF are important to the farmer because it relates to the digestibility of the feed when consumed by ruminants. According to Costa *et al*. (2005) forages with high ADF values have lower digestibility rate. Van Saun, (2006) also reported that grasses with ADF levels less than 50% are considered high quality forage but those with ADF levels of above 60% are of poor-quality forage. Therefore, the ADF percentages recorded in this research which ranges from 24.5 to 34.1% in the initial harvest biomass for both sites and in the regrowth harvest biomass for both locations which are far below what Van Saun, (2006) reported. These implies that, the forage of *Brachairia mulato* II when harvested at either 80 or 100 days after sowing would produce high quality forage with high acceptability and digestibility rate for ruminant production. Nguku *et al*. (2016) also reported ADF below 40% in biomass harvested 22, 24 and 28 weeks in *Brachiaria mulato* II in Kenya. However, ADF in the midrib (M) fractions are higher than that of the leaf fractions this may be because of accumulation of lignin and other indigestible plant components in the *Brachiaria mulato* II which indicates that botanical fractions have effect on the ADF percentages. Besides this, there is a positive interactive effect between harvesting age and botanical fractions on ADF. This is because looking at the data from this research it is clear that the more the *Brachiaria mulato* II plant stays on the field the more its midrib may accumulate lignin and sclerenchyma in its cell walls, this can be seen from the results of the regrowth and the initial established plants which means the midrib will be less digestible and acceptable when separated and fed to ruminants alone than the leaf component.

Hemicellulose (HM) is the soluble component of the forage available to the animal in the feed for digestion. Mulatsih (2003) discovered that removing a plant's leaves after it has been 60 days will raise the amount of cellulose and hemicellulose, which are components of the cell wall that enhance the amounts of crude fiber and DM. Comparing this to the findings of this research which recorded 29.2- 38.3% hemicellulose percentages in both the initial and regrowth harvest for both sites shows that the biomass of *Brachiaria mulato* II when harvested at 80 and 100 days would provide high quality feed with high digestibility. However, botanical fractions have effect on the HM concentration in the botanical fractions, as the midrib has high HM percentages than in the leaf which is an indication that the leaf is more digestible than the midrib. Beside this, harvesting age and botanical fraction interaction has effect on the HM concentration of the biomass of *Brachiaria multo* II as the plant stays longer on the field the less HM concentration it will have in the plant cell wall. In accordance with the findings of these studies, which range from 84.9 to 89.3% in both initial and regrowth harvest for both sites, Nafiatul *et al.* (2018) reported the following organic matter values: Brachiaria decumbens cv. Basilisk produced the most organic matter (87.82%) compared to *Brachiaria ruziziensis cv*. Kennedy (87.34%) and *Brachiaria brizantha cv*. MG5 (85.48%). One of the primary factors influencing grass quality is its organic matter content; feeds higher in organic matter provide more nutrients that animals can use. Organic matter digestibility and dry matter digestibility are correlated; more dry matter indicates better organic matter digestion. The digestion of food items will be slowed down by a high consumption of crude fiber because it contains indigestible ingredients like lignin and silica Suryadi *et al.* (2009). The amount of dry matter generated indicates how well the plant uses the nutrients that are available. *Brachiaria decumbens cv*. *Basilisk* produced the driest matter (24.67%) compared to *Brachiaria ruziziensis cv*. (19.15%) and *Brachiaria brizantha cv*. MG5 (20.36%). Dry matter values recorded in this research at the initial harvesting or cutting age of (80 and 100 days) and regrowth harvested at 20 days after the initial harvest produced dry matter values range of 99.5 – 95.0%. This is significantly higher than what Nafiatul *et al.* (2018) reported in *Brachiaria decumbens cv*. *Basilisk which* had 78.25%, whiles *Brachiaria brizantha cv*. MG5 had matter digestibility at 64.99% harvested 45 days after sowing. A study on *Brachiaria* hybrid *mulato* II, according to Yiberkew *et al.* (2020), found a dry matter content of 90.14–90.21%, which is less than the dry matter data found in this study, which ranged from 96.37-96.75%. The difference in harvesting age and environmental conditions may be the cause of the increased DM in this study compared to values reported by Yiberkew *et al.* (2020). According to Waramit *et al.* (2011), the DM content of tropical grasses, such as blue panic grass, increased linearly with an increase in the age of the forage. Additionally, the production of more botanical fractions by the plants as they utilized the nutrients had an impact on the dry matter yield of *Brachiaria mulato* II. Any feed's amount of ash is a good sign of how many inorganic (mineral) ingredients it contains. High ash content in central midrib (14%) than leaves in this study indicates that the midrib has high lignin content which reflected in its digestibility. Crude protein (CP), hemicellulose (HM), and acid detergent fibre (ADF) were affected by interaction effect of harvesting age and botanical fraction in this study at the regrowth stage whiles except DM, CP and HM which are not affected by interactive effect of harvesting age and botanical fraction in site one. At the initial harvest in site two, ADF and HM were affected while Ash, OM and ADF were also affected by harvesting age and botanical fraction interaction effect at the regrowth. This could be because as the plant stays longer on the field the various botanical fractions accumulate indigestible plant components in the cell walls of the *Brachiaria* therefore affecting the digestibility of the various botanical fractions. As harvesting age increases the organic matter content increases. These agrees with the findings of Genet *et al*. (2017) and Asmare *et al*. (2017) that organic matter (OM) concentration increased progressively as harvesting age increases. According to report of Wubetie *et al.* (2018) organic matter of *Brachiaria brizantha* ecotypes were significantly affected by harvesting age. As harvesting age increases from 60 to 90 to 120 days the organic matter content was increased as harvesting age increases. Similarly, Zemene (2018) reported that organic matter content of *Brachiaria mutica* was affected by harvesting age.

5.5 *In vitro* NDF Digestibility

5.5.1 *In vitro* Dry Matter True Digestibility

The age of the plant on the field affects IVDMTD because, as the plant ages on the field there is accumulation of varying degrees of indigestible materials like lignin, sclerenchyma and other indigestible materials in the cell walls (primary and secondary) of the various botanical fractions. Mahyuddin, (2008) reported that as plants advance in maturity IVDMTD percentages declines which is in agreement with the findings of this research especially in the initial harvest of 80 and 100 days. Euclides, *et al.* (2007) reported that the minimum IVDMTD value to qualify a foraged as good nutritional quality and not compromise animal performance is 50%, this report affirms that *Brachiaria mulato* II forages harvested between 80 and 100 days in this research is of good nutritious quality because it recorded IVDMTD values of 80.49 to 83.49% in the botanical fractions in both initial and regrowth for both locations. When the findings of this study are compared to those of Nafiatul *et al*. (2018) who reported that IVDMTD percentages of *Brachiaria decumbens cv. Basilisk* had the highest dry matter digestibility at 78.25%, whiles *Brachiaria brizantha cv*. MG5 had the lowest dry matter digestibility at 64.99% when harvested 45 days after planting. According to Fanindi and Prawiradiputra (2017), *Brachiari*a generally has a good dry matter digestibility and can enhance average daily weight gain. The feed's nutritional content is one of the elements that influence the true digestibility of dry matter. Digestibility will also rise with higher nutrient content in feed ingredients (Hernaman, *et al.*, 2005). Beyadglign, *et al*. (2022) reported 68% IVDMTD in *mulato* I with fertilizer and 47.275% in *mutica* in red soil without fertilizer at 90 days harvest. Mupenzi, *et al*. (2017) reported that the IVDMTD difference is affected by *Brachiaria* grass cultivars. These values are also higher than dry matter digestibility values of *Brachiaria* grasses reported by (Nguku, *et al*., 2016) which range between 43.6 – 57.5% in south eastern Kenya which was harvested at 28 weeks interval. At the harvest interval of week 28, *Piata*, *Basilisk*, and *mulato* II were more digestible than the other grasses, according to Nguku *et al.* (2016).

The variations in the DMD of *Brachiaria* may be due to the age of harvest and other management and climatic factors. The interactive effect between harvesting age and botanical fraction is significant for IVDMTD for location one. This could be due to the effect of the prevailing climatic and soil conditions on the growth of the *Brachiaria* grass at location one. Aside from genetics, a variety of factors affect the nutritional characteristics of forages, such as soil nutrition and climate (Keba *et al.*, 2013; Tessema *et al.*, 2011).

5.5.2 Neutral Detergent Fiber Digestibility (NDFD)

For the majority of the year, one of the most crucial nutritional sources for domesticated ruminants is grass (Taweel *et al.*, 2005). Yan and Agnew (2004) pointed out that the nutritional content of grass silage varies greatly, even though it's a common diet for ruminants worldwide. In addition to being affected by temperature, light intensity, total rainfall, soil type, fertilization amount, maturation stage, and preservation technique, the digestibility of the various grass species can vary significantly (Huhtanen *et al.*, 2006 and Jancík *et al.*, 2009). The dNDF and iNDF feed components make up the NDFD of the *Brachiaria mulato* II dry matter. This agrees with Kendall and Combs (2004) and Ivan *et al.* (2005) who reported that a higher digestible fiber is less filling because it is retained in the rumen for a shorter period of time. The higher NDFD concentration indicates that the digestibility of the dry matter in the feed is high and intake will be greater because feed retention will be low. Diets high in easily digested fiber provide a higher intake of dry matter because they fill the rumen less. Numerical comparison of the NDFD, dNDFD and iNDFD percentages of the leaf and midrib shows that the midrib have relatively higher figure in terms of percentages in the above parameters than in the leaf which means that the leaf is more digestible than the midrib. If the botanical components are separated, animals will consume more leaf since it has a smaller retention time than the midrib, even though the midrib has longer retention duration in ruminants' digestive tracts. Studies have indicated that when given higher NDFD forages, cows consume more and yield more milk. NDFD percentages in the leaf and midrib fractions in the regrowth are higher than in the initials harvesting. This is because as plants ages on the field, the depositions of indigestible materials in the plant cell walls like lignin and other materials increases.

5.5.3 Digestible Neutral Detergent Fiber (dNDF)

Botanical fractions and harvesting age of *Brachiaria mulato* II have affected the percentages of dNDF in the initial and regrowth harvest because as the harvesting and cutting age is prolonged lignification increases in the cell walls of the botanical fractions and digestibility decreases. It has been reported by Ihsan and Syahdar (2007) that crude fiber content was affected by light intensity and temperature. High light intensity and temperature might increase plant respiration that allow a faster maturing process and lignification of cell wall plant. Mulatsih (2003) found that defoliation of an older plant (60 days) will result in higher proportion of cellulose and hemicellulose, as parts of cell wall, that leads to the increases in crude fiber and DM contents. Also, *Mulato* grass assays showed a decrease in CP content of 9–16% and *in vitro* digestibility of 62–55% when the plant was aged from 23 to 30 days (Argel *et al.,* 2005). Which falls within the NDF percentages reported in this research in both regrowth harvested 20 days after initial harvest of 80 and 100 days is 55.2 - 66.6% and that of dNDF which is also 38.77 - 48.28% therefore shows that *Brachiaria mulato* II has higher dNDF than iNDF in *Brachiaria mullato* II in this research.

5.5.4 Indigestible Neutral Digestible Fiber (iNDF)

Harvesting age and botanical fractions of *Brachiaria mulato* II has affected the percentages of iNDF in the initial harvest and regrowth because as the harvesting age is prolonged, lignification increases in the cell walls of the botanical fractions and digestibility decreases. The maturation phase is characterized by a higher buildup of stem mass in comparison to leaf material. Jung *et al*. (2011) found that the stems contain more tissue with secondary thickening, which leads to higher concentrations of cellulose, xylan, and lignin Jung *et al*. (2011). The lignin component in rumen is primarily responsible for restricting the breakdown of cell walls, and its presence also limits the breakdown of the polysaccharide fraction to which it is cross-linked (Jung *et al.*, 2015). The NDF percentages reported in this research in both regrowth and initial harvest is 55.2 - 66.6% and that of iNDF which is also 16.51 – 19.46% therefore shows that *Brachiaria mulato* II has lower indigestible components of NDF (iNDF) percentages. Tropical forages can differ greatly in iNDF despite having the same NDF content.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusions

From the results of this study, *mulato* II grass should be harvested at 100 days at maturity for higher biomass yield and light harvesting promote better regrowth. The leaves of *mulato* II are superior in terms of nutrient and digestibility than the central midrib. *Brachiria mulato* II has a big potential to provide better ruminant nutrition and solving the seasonal feed gaps if promoted in the study area.

6.2 Recommendation

The *Brachiaria mulato* II specie should be cultivated in different areas within the guinea savanna ecological zone without fertilizer to assess its performance.

The *Brachiaria mulato* II specie shows greater potentials as a pasture grass which is capable of solving the nutritional challenges of ruminants in the research area, feeding trials should therefore be carried out to assess its acceptability.

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APPENDIX

ANOVA OF SITE ONE INITIAL HARVEST

Appendix 1: ANOVA dry matter

Variate: DRY MATTER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	0.063	0.063	0.03	0.857
FRACTION	2	56.281	28.141	14.96	**<.001**
TRT.FRACTION	2	0.406	0.203	0.11	0.898
Residual	30	56.437	1.881		
Total	**35**	**113.18**			

Appendix 2: ANOVA ash

Variate: ASH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	4.7251	4.7251	6.66	**0.015**
FRACTION	2	40.8009	20.4004	28.76	**<.001**
TRT.FRACTION	2	3.0632	1.5316	2.16	0.133
Residual	30	21.2818	0.7094		
Total	**35**	**69.8709**			

Appendix 3: ANOVA for organic matter

Variate: ORGANIC MATTER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	4.7251	4.7251	6.66	**0.015**
FRACTION	2	40.8009	20.4004	28.76	**<.001**
TRT.FRACTION	2	3.0632	1.5316	2.16	0.133
Residual	30	21.2818	0.7094		
Total	**35**	**69.8709**			

Appendix 4: ANOVA for crude protein

Variate: CRUDE PROTEIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	3.2689	3.2689	3.32	0.079
FRACTION	2	118.0720	59.0360	59.89	**<.001**
TRT.FRACTION	2	2.3380	1.1690	1.19	0.319
Residual	30	29.5699	0.9857		
Total	**35**	**153.2488**			

Appendix 5: ANOVA for neutral detergent fiber

Variate: NEUTRAL DETERGENT FIBER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	105.733	105.733	26.90	**<.001**
FRACTION	2	8.591	4.295	1.09	0.348
TRT.FRACTION	2	56.191	28.095	7.15	**0.003**
Residual	30	117.938	3.931		
Total	**35**	**288.452**			

Appendix 6: ANOVA for acid detergent fiber

Variate: ACID DETERGENT FIBER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	27.106	27.106	3.60	0.067
FRACTION	2	54.379	27.189	3.61	**0.039**
TRT.FRACTION	2	158.651	79.325	10.54	<**.001**
Residual	30	225.682	7.523		
Total	**35**	**465.817**			

Appendix 7: ANOVA for hemicellulose

Variate: HEMICELLULOSE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	25.769	25.769	3.19	0.084
FRACTION	2	21.198	10.599	1.31	0.284
TRT.FRACTION	2	156.982	78.491	9.71	<**.001**
Residual	30	242.408	8.080		
Total	**35**	**446.357**			

ANOVA OF SITE ONE REGROWTH HARVEST

Appendix 8: ANOVA dry matter

Variate: DRY MATTER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	1.26562	1.26562	13.35	<**.001**
FRACTION	2	37.40625	18.70313	197.31	<**.001**
TRT.FRACTION	2	2.53125	1.26562	13.35	<**.001**
Residual	30	2.84375	0.09479		
Total	**35**	**44.04688**			

Appendix 9: ANOVA ash

Variate: ASH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	26.9217	26.9217	54.17	<**.001**
FRACTION	2	158.5056	79.2528	159.46	<**.001**
TRT.FRACTION	2	30.7969	15.3985	30.98	<**.001**
Residual	30	14.9105	0.4970		
Total	**35**	**231.13**			

Appendix 10: ANOVA for organic matter

Variate: ORGANIC MATTER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	26.9217	26.9217	54.17	**<.001**
FRACTION	2	158.5056	79.2528	159.46	**<.001**
TRT.FRACTION	2	30.7969	15.3985	30.98	**<.001**
Residual	30	14.9105	0.4970		
Total	**35**	**231.1347**			

Appendix 11: ANOVA for crude protein

Variate: CRUDE PROTEIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	2.4649	2.4649	2.98	0.095
FRACTION	2	440.7975	220.3987	266.22	**<.001**
TRT.FRACTION	2	41.0354	20.5177	24.78	**<.001**
Residual	30	24.8360	0.8279		
Total	**35**	**509.1338**			

Appendix 12: ANOVA for neutral detergent fiber

Variate: NEUTRAL DETERGENT FIBER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	24.741	24.741	2.66	0.113
FRACTION	2	188.961	94.480	10.17	**<.001**
TRT.FRACTION	2	14.827	7.414	0.80	0.459
Residual	30	278.602	9.287		
Total	**35**	**507.131**			

Appendix 13: ANOVA for acid detergent fiber

Variate: ACID DETERGENT FIBER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	8.972	8.972	2.54	0.121
FRACTION	2	160.723	80.362	22.76	**<.001**
TRT.FRACTION	2	26.737	13.368	3.79	**0.034**
Residual	30	105.907	3.530		
Total	**35**	**302.339**			

Appendix 14: ANOVA for hemicellulose

Variate: HEMICELLULOSE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	3.915	3.915	0.42	0.521
FRACTION	2	23.085	11.542	1.24	0.303
TRT.FRACTION	2	38.678	19.339	2.08	0.142
Residual	30	278.620	9.287		
Total	**35**	**344.298**			

ANOVA OF SITE TWO INITIAL HARVEST

Appendix 15: ANOVA dry matter

Variate: DRY MATTER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	0.7656	0.7656	1.16	0.291
FRACTION	2	95.6493	47.8247	72.15	**<.001**
TRT.FRACTION	2	4.3438	2.1719	3.28	**0.052**
Residual	30	19.8854	0.6628		
Total	**35**	**120.6441**			

Appendix 16: ANOVA ash

Variate: ASH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	0.402	0.402	0.21	0.651
FRACTION	2	91.295	45.647	23.70	**<.001**
TRT.FRACTION	2	1.109	0.554	0.29	0.752
Residual	30	57.793	1.926		
Total	**35**	**150.599**			

Appendix 17: ANOVA for organic matter

Variate: ORGANIC MATTER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	0.402	0.402	0.21	0.651
FRACTION	2	91.295	45.647	23.70	**<.001**
TRT.FRACTION	2	1.109	0.554	0.29	0.752
Residual	30	57.793	1.926		
Total	**35**	**150.599**			

Appendix 18: ANOVA for crude protein

Variate: CRUDE PROTEIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	24.361	24.361	10.13	**0.003**
FRACTION	2	167.546	83.773	34.85	**<.001**
TRT.FRACTION	2	1.106	0.553	0.23	0.796
Residual	30	72.111	2.404		
Total	**35**	**265.1**			

Appendix 19: ANOVA for neutral detergent fiber

Variate: NEUTRAL DETERGENT FIBER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	36.470	36.470	6.67	**0.015**
FRACTION	2	246.530	123.265	22.55	**<.001**
TRT.FRACTION	2	0.534	0.267	0.05	0.952
Residual	30	164.021	5.467		
Total	**35**	**447.555**			

Appendix 20: ANOVA for acid detergent fiber

Variate: ACID DETERGENT FIBER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	2.946	2.946	0.56	0.459
FRACTION	2	70.390	35.195	6.72	**0.004**
TRT.FRACTION	2	66.154	33.077	6.32	**0.005**
Residual	30	157.119	5.237		
Total	**35**	**296.608**			

Appendix 21: ANOVA for hemicellulose

Variate: HEMICELLULOSE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	18.687	18.687	5.11	**0.031**
FRACTION	2	211.083	105.542	28.87	**<.001**
TRT.FRACTION	2	78.443	39.222	10.73	**<.001**
Residual	30	109.682	3.656		
Total	**35**	**417.895**			

ANOVA OF SITE TWO REGROWTH HARVEST

Appendix 22: ANOVA dry matter

Variate: DRY MATTER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	0.1406	0.1406	0.16	0.692
FRACTION	2	33.8438	16.9219	19.22	**<.001**
TRT.FRACTION	2	0.2812	0.1406	0.16	0.853
Residual	30	26.4062	0.8802		
Total	**35**	**60.6719**			

Appendix 23: ANOVA ash

Variate: ASH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	0.9409	0.9409	1.31	0.262
FRACTION	2	53.9111	26.9555	37.51	**<.001**
TRT.FRACTION	2	0.6632	0.3316	0.46	0.635
Residual	30	21.5582	0.7186		
Total	**35**	**77.0734**			

Appendix 24: ANOVA for organic matter

Variate: ORGANIC MATTER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	0.9409	0.9409	1.31	0.262
FRACTION	2	53.9111	26.9555	37.51	**<.001**
TRT.FRACTION	2	0.6632	0.3316	0.46	0.635
Residual	30	21.5582	0.7186		
Total	**35**	**77.0734**			

Appendix 25: ANOVA for crude protein

Variate: CRUDE PROTEIN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	47.901	47.901	42.42	**<.001**
FRACTION	2	63.854	31.927	28.27	**<.001**
TRT.FRACTION	2	2.694	1.347	1.19	0.317
Residual	30	33.879	1.129		
Total	**35**	**148.328**			

Appendix 26: ANOVA for neutral detergent fiber

Variate: NEUTRAL DETERGENT FIBER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	136.425	136.425	25.98	**<.001**
FRACTION	2	429.055	214.528	40.85	**<.001**
TRT.FRACTION	2	25.743	12.871	2.45	0.103
Residual	30	157.554	5.252		
Total	**35**	**748.778**			

Appendix 27: ANOVA for acid detergent fiber

Variate: ACID DETERGENT FIBER

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	7.105	7.105	1.99	0.168
FRACTION	2	123.478	61.739	17.32	**<.001**
TRT.FRACTION	2	49.323	24.662	6.92	**0.003**
Residual	30	106.928	3.564		
Total	**35**	**286.834**			

Appendix 28: ANOVA for hemicellulose

Variate: HEMICELLULOSE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TRT	1	81.264	81.264	11.39	**0.002**
FRACTION	2	94.643	47.321	6.63	**0.004**
TRT.FRACTION	2	11.875	5.937	0.83	0.445
Residual	30	214.068	7.136		
Total	**35**	**401.849**			

Plate1. Taking plant height measurement using tape measure

Plate 2. *Brachiaria mullato* II on experimental plot. (29/08/2021)

Plate 3. Harvested *Brachiaria mullato* II. (08/10/2021)

Plate 4. ***Brachiaria mullato*** **II grass at 80-days after planting.**

Plate 5. ***Brachiaria mullato*** **II grass at 100-days after planting.**

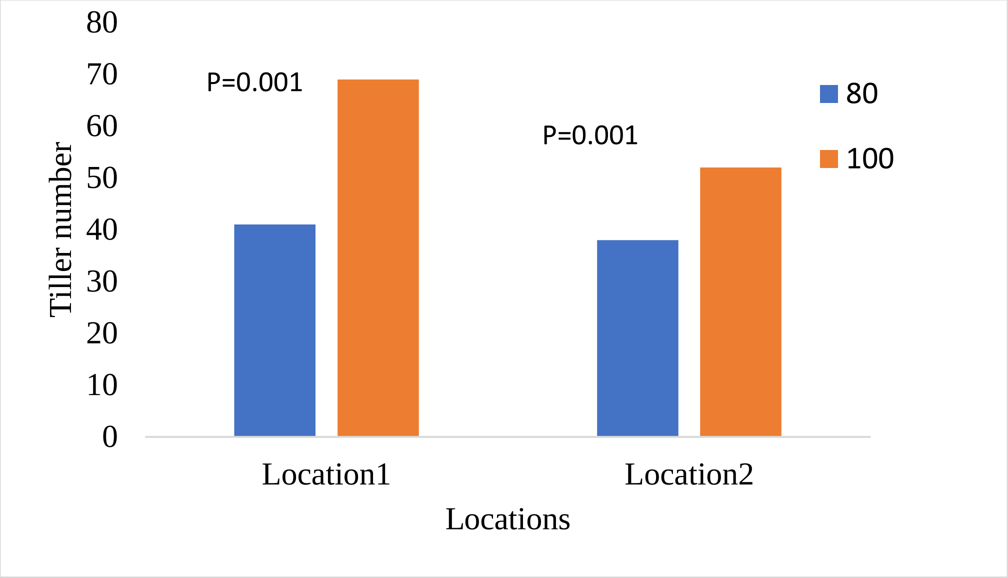

Figure 5: Tiller number of *Brachiaria mullato* II for location I & II.

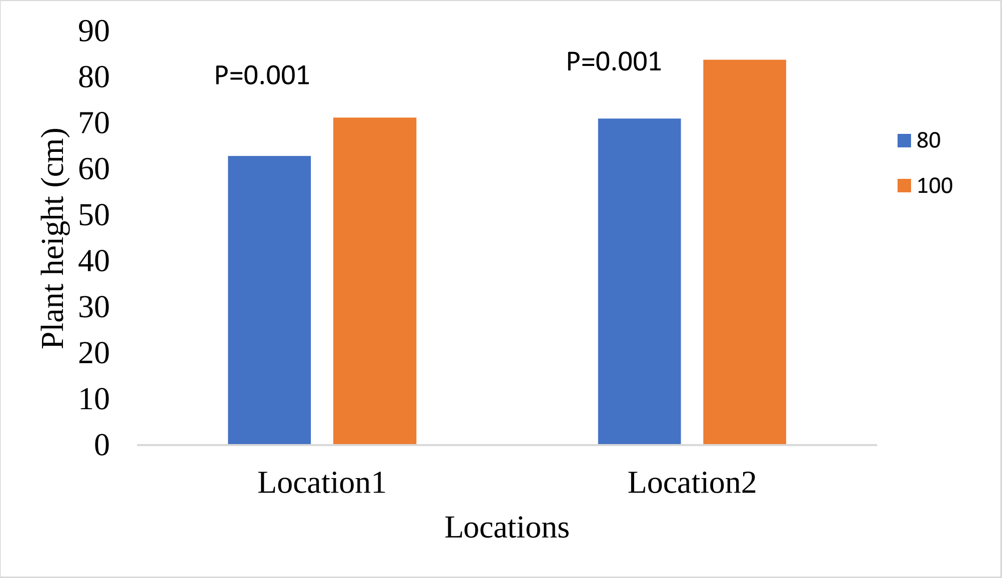

Figure 6: Plant height of *Brachiaria mullato* II for location I & II.