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EFFECTS OF CUTTING INTERVAL ON MORPHOLOGICAL PARAMETERS, BIOMASS YIELD AND CHEMICAL COMPOSITION OF PARA (*Brachairia muticastapf*), NAPIER (*Pennisetum purpureum*) AND DESHO (*Pennisetum pedicellatum*) GRASSES GROWN UNDER IRRIGATION CONDITION IN MECHA *WOREDA*, WEST GOJJAM ZONE, ETHIOPIA

MSc THESIS

BY

TOBIYAW TSEGAYE DEMLEW

JUNE 2021

BISHOFTU, ETHIOPIA

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In Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN ANIMAL PRODUCTION

BY

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As MSc research advisors, we hereby certify that we have read and evaluated this Thesis prepared under our guidance by **Tobiyaw Tsegaye Demlew**. Title: **"Effects of Cutting Interval on Morphological Parameters, Biomass Yield and Chemical Composition of Para (*Brachairia muticastapf*), Napier (*Pennisetum purpureum*) and Desho (*Pennisetum pedicellatum*) Grasses Grown under Irrigation Condition** ", and recommend that it be accepted as fulfilling the thesis requirement for the degree of **Master of Science in Animal Production**.

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DEDICATION

This thesis paper is dedicated to my father Tsegaye Demlew and my mother Enkuayehush Alebachew for their unreserved partnership and love in the success of my life.

STATEMENT OF AUTHOR

First, I declare that this thesis is my original work and that all sources of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for an MSc degree in Animal Production at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University/College library to be made available to borrowers under the rules of the Library. I surely declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author was born in Yismala Jankit Kebele, North Achefer Woreda, and West Gojjam zone on October 19, 1996, from her father Ato Tsegaye Demlew and her mother W/ro Enkuayehush Alebachew. She completed her secondary and preparatory education at Yismala Secondary and Preparatory School. Then, from October 2016 to June 20, 2018, she joined Debre Tabor University and graduated with a Bachelor of Science in Animal Science. In September 2019, she joined the Ethiopian Institute of Agriculture and served as a junior researcher at Werer agricultural center. Subsequently, in September 2020 she joined Addis Ababa University, College of Veterinary Medicine and Agriculture, Department of Animal Production for MSc Program in Animal Production.

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LIST OF ABBREVIATIONS

ADF	Acid detergent fiber
ADL	Acid detergent lignin
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
Cm	Centimetr
CP	Crude protein
CSA	Central statistical agency
DAP	Di Ammonium Phosphate
DM	Dry matter
DOA	Department of agriculture
FAO	Food and agricultural organization of the United Nations
GLM	General linear model
IVOMD	*In vitro* organic matter digestibility
M	Meter
M.a.s.l	Meter above sea level
NDF	Neutral detergent fiber
SAS	Statistical analysis system
TDN	Total digestible nutrient

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ABSTRACT

Livestock feed resources in Ethiopia are mainly obtained from natural pasture and crop residues. This study was aimed to study the effects of cutting interval on plant height, number of tillers per plant, number of leaves per plant and leaf to stem ratio of the grasses, and to study the effects of cutting interval on dry matter yield and chemical composition of the grasses under irrigation condition at Mecha, Ethiopia; with three kinds of grasses namely Para (Brachiaria mutica Stapf.), Napier (Pennisetum purpureum), and Desho (Pennisetum pedicellatum) at three harvesting dates (60, 90,120). The experimental design was RCBD (Random Complete Block Design) with three replications giving a total of nine plots. The area of each unit plot was three m x four m and plant to plant distance and row to row distance was 0.5m. Data on morphological parameters of the grasses were recorded at each harvesting dates. The grasses were first harvested after 60 days of regrowth; second and third harvests were done after consecutive 30 days of re-growth. All harvested data were laid open to GLM ANOVA procedures of SAS version 9.0. Based on the data collected, harvesting age was significantly affected the morphological parameters of the grasses; Plant height (PH), the number of tillers per plant (NTPP), and the number of leaves per plant (NLPP) were increased with increasing harvesting age, whereas cutting interval showed a non-significant effect on a leaf to stem ratio (LSR) of the grasses. Although cutting interval had a significant effect on dry matter yield (DMY), ash content, crude protein, neutral detergent fiber, acid detergent fiber and acid detergent lignin content of the grasses. It was concluded that Napier grass produces a higher forage yield among the three grasses and longer harvesting intervals result in increased forage yield and decrease nutrient composition in all the studied grasses. Further research is needed to be conducted over much longer periods to determine to what extent these findings relate to performance over the life of a permanent pasture.

Keywords: Chemical composition, cutting interval, dry matter yield, morphological parameters

1. INTRODUCTION

Livestock feed resources in Ethiopia are mainly obtained from natural and improved pastures, crop residues, agro-industrial by-products, and non-conventional feeds (Zereu and Lijalem, 2016). The contribution of these feed resources, though, depends upon the agro-ecology, the type of crop produced, and accessibility and production system. More than 90% of livestock feed is crop residues and natural pasture in Ethiopia. Both of which are either unavailable in sufficient quantities due to fluctuating weather conditions or are accessible but in poor quality that they do not provide adequate nutrition for sustainable animal production. Animal feed shortage remains the main constraint on herd size and productivity in both the lowlands and high lands of Ethiopia (Asmare, 2016).

The shortage of feed can be solved through the introduction and utilization of adaptable and high-yielding cultivated forage crops with better nutritional values than the current feed resources in the country (Kefyalew *et al*., 2020). Using improved forages would decrease the burden on natural pastures; improve soil fertility and reduce erosion. Therefore there is a need to evaluate suitable forage species or cultivars to address the feed shortage challenge. Among the improved forage species recommended in Ethiopia; Para, Napier and Desho grasses play a significant role (Mengistu, 2004; Kefyalew *et al*., 2020; Zemene *et al*., 2020).

For most forage cutting interval has been shown to influence the morphological parameters, biomass yield, and nutritive value of herbage (Ansa *et al*., 2019). According to the same source, cutting interval affects forage production, re-growth potential, and species survival; and shorter cutting intervals result in weak and thinner stands because of reduced carbohydrate reserves for regrowth.

Farmers do not have enough information on optimal management practices for Para grass Zemene *et al*. (2020), Napier grass Rambau *et al*. (2016) and Desho grass (Kefyalew *et al*., 2020). Although the potential of those grasses for increasing pasture and animal productivity is well known, it is important to understand the effects of cutting intervals on morphological parameters, biomass yield, and chemical composition of Para, Napier and Desho grasses. The optimization of productivity and nutritive value of grasses can be achieved by forage management (Mengistu *et al*., 2016). The previous study reported that cutting interval affecting morphological parameters, dry matter yield, and chemical composition of para and Napier grasses under rain-fed conditions (Tilahun *et al*., 2017; Zemene *et al*., 2020). On the other hand, Kefyalew *et al*. (2020) reported that cutting intervals affect morphological parameters, dry matter yield, and chemical composition of Desho grass under irrigation condition. However, scientific evidence regarding plant height, the number of tillers per plant, the number of leaves per plant, and the dry matter yield, and chemical composition of Para, Napier and Desho grasses in response to different cutting intervals is limited. Therefore, the present study was carried out with the following specific objectives;

- To study the effect of cutting interval on plant height, number of tillers per plant, number of leaves per plant, and leaf to stem ratio of Para, Napier and Desho grasses under irrigation conditions; and
- To study the effect of cutting interval on biomass yield and chemical composition of Para, Napier and Desho grasses under irrigation conditions.

2. LITERATURE REVIEW

2.1. Overview of Feed Resources in Ethiopia

According to Kebede *et al*. (2016) livestock feed resources in Ethiopia are pasture, crop residues, improved forages, agro industrial byproducts, and other by-products like food and vegetables refusal are major livestock feed resources of which the first two contribute the largest feed type. Natural grazing land is a predominant feed source for livestock in Ethiopia. Very little land is planted to introduce pasture both within and outside urban areas that have forage crops (Negash, 2018). Grazing areas are usually equally part-owned. Crop-residue and agro-industrial by-products represent a large proportion of feed resources in the mixed crop-livestock system. Reliance on a crop residue for animal feed is ever-increasing or more land is cropped to feed the fast-growing human population (Mengistu *et al.*, 2017).

2.1.1. Natural pasture and browse

According to (Mengistu, 2004.) in most areas of sub-Saharan Africa, the major even the only feed source available for large parts of the year in smallholder production systems are natural pastures. Despite the continued expansion of croplands into the grasslands and the resultant decline in the size of grazing areas, native pastures remain the major providers of livestock feed in the densely populated highlands of Ethiopia (Getachew and Asfaw, 2003). Natural pastures mostly suffer from seasonal spells of dry periods during which they drop in quality, which is characterized by high fiber content, low digestibility, and low in nitrogen, very low protein and energy content (Creemers and Aranguiz, 2019). According to the same source the yield, as well as quality of pasture, is very low due to poor management and overstocking. In general, grazing land productivity is declining at a higher rate because of temperature stress and scarcity of rainfall, which is favored by deforestation that denies a humid environment to the area. In addition to this, the transfers of grazing lands to cultivation for cropping and poor grazing land management are some of the reasons for dry matter reductions from grazing land. Natural pastures are suitable for live weight maintenance and weight gain through wet seasons, but would not support maintenance for the rest of the year. Natural pastures in the highlands of Ethiopia are rich in species composition, particularly indigenous grasses and legumes (Yadessa, 2015). Preserving of forage means of distributing forage throughout the year and is usually in excess during spring and early summer and in deficient for the rest of the year (Birhan and Adugna, 2014). So forage conservation is needed to provide feed during the dry season. Conserved pasture forage can be categorized into standing hay, harvested hay and silage (Jalč *et al.*, 2009).

Shrubs and fodder trees play a significant role in livestock production in all agro-ecological zones of tropical Africa. The fodder tree foliage is commonly browsed directly on trees, or after lopping by livestock herders. They are also offered as cut-and-carry feed install-fed situations (Mengistu *et al*., 2017). The importance and availability of fodder trees in tropical Africa are influenced by several factors such as the natural distribution of trees within the agro-ecological zones, the distribution, types, and importance of livestock, the integration and role of livestock within the farming system, and the availability of alternative sources of fodder in livestock feeding in the agro-ecological zone (Mengistu *et al*., 2017). Productivity of the fodder trees in terms of foliage production per unit area is linked with habitat and soil texture. Some fodder trees in humid and sub-humid climate were reported to produce 2.3 to 4.69 tons of forage DM/ hectare/year Fodder trees contain medium to a high level of CP ranging from 120-250 g per kg, indicating that they are a valuable source of protein in livestock feeding in the tropics. Mengistu *et al*. (2017) reported that fodder trees contain 26-95% DM and 10-30% CP. Perennial fodder trees retain high CP content for a longer period than annual shrubs. However, the CP digestibility of certain fodder species was found to be low and several cases of livestock death have been associated with their high tannin content in foliage. The role of fodder trees in ruminant nutrition has not been truly defined and is likely to be different depending on whether they are used as a strategic supplement or basal feed source (Gulilat *et al*., 2018). According to the same source, Indigenous fodder trees and shrubs are important feeds of ruminant animals due to their appreciable nutrient content that is deficient in ordinary feed resources such as crop residues and natural pasture. Most browse plants are high in crude protein content, ranging between 10 and 25% on a dry matter basis.

2.1.2. Crop residues

The high dependency on crop residues as livestock feed is expected to be higher and higher, as more and more of the grazing lands are cultivated to satisfy the grain needs of the rapidly growing human population (Gulilat *et al*., 2018). The contribution of crop residues to the national feed resource base is significant (Zewdu, 2008). Since the available evidence tends to indicate that Gulilat *et al*. (2018), under the current Ethiopian condition, crop residues provide 40-50% of the annual livestock feed requirement. According to Gulilat *et al*. (2018), in most parts of the central highlands of Ethiopia, crop residues account for about 27% of the total annual feed supply during the dry periods. On average, crop residues provide 10-15% of the total feed intake in the mixed crop-livestock-producing area in the central highlands of Ethiopia. It has been reported that, most intensively cultivated areas rely on crop residues and aftermath grazing more than 60-70% of ruminant animal’s basal diet. The general tendency is that the role of crop residue as livestock feed is increasing from time to time at the expense of shrinkage of grazing lands. Teff, barley, wheat, and pulse straws are stacked after threshing for animals during the dry season, when the quality and quantity of natural pasture decline dramatically in different parts of the Ethiopian highlands (Kebede *et al*., 2016).The supply of these crop residues is directly proportional to the land area used for cropping the grains. Cereals account for more than 75% of the total crop residue yield in the central highlands of Ethiopia. Crop residues are increasingly becoming the major basal feed for livestock in the crop-livestock mixed farming systems of Ethiopia. The optimum utilization of crop residues is constrained by their low feed quality as measured in terms of protein content and digestibility (Gulilat *et al*., 2018).

Moreover, most of the crop residues used as livestock feed are subjected to seasonal fluctuation in availability and used without any treatment and/or strategic supplementation (Gulilat *et al*., 2018). Crop residues are of very poor feeding value attributed to low metabolizable energy, available protein, and a serious deficiency in minerals and vitamins. Crop residues vary greatly in chemical composition and digestibility depending on varietal differences and agronomic practices. The feeding value of crop residues is also limited by their poor voluntary intakes and low digestibility. The crude protein content of crop residues ranges between 2.4 and 7%

and their IVDMD ranges between 34 and 52%. Cereal straws have mean CP, NDF, and IVDMD values of 4.5, 79.4 and 51.1%, respectively compared to pulse straws, which have mean CP, NDF and IVDMD values of 7, 62.9 and 63.5%, respectively. Straws of oil crops have CP and NDF values of 5.4 and 66.4%, respectively (Zewdu, 2008). Crop residues are generally characterized by high fiber content and low digestibility and intake (Asmare, 2016). Most cereal straws and Stoves are known for their lower nutritive value compared to haulms of grain legumes and vines from root crops such as sweet potato. In the highland mixed crop-livestock farming systems of the Ethiopian highlands, the cereal crop residues provide approximately 50% of ruminant livestock's total feed source is plants. During the dry seasons, crop residues can contribute up to 80%. Further increased dependence on crop residues for livestock feed is expected, as more and more of the native grasslands are cultivated to satisfy the grain food needs of the rapidly increasing human population in the country (Tesfaye and Chairatanayuth, 2007). The total annual production of crop residues in Ethiopia is estimated to be 30 million tons of dry matter Kebede *et al*. (2016), of which 70% is utilized as livestock feed. Based on the existing trend of conversion of grazing land into cropping land, the crop residues-based livestock production system is expected to increase proportionally.

2.1.3. Agro-Industrial By-products

Agro-industrial by-products include by-products of flour mills, oil-processing plants, breweries, and sugar factories. Wheat bran is the main by-product of flour mills used as animal feed in Ethiopia (Negash, 2018). According to the same source, other by-products of the flour mill industry include wheat middling, wheat short, rice bran, bean bran, bean hull, lentil bran and lentil hull. These by-products have a substantial contribution to the livestock feed supply, particularly in the urban and peri-urban areas. The by-products of the oil processing plants are oilseed cakes, which contain cottonseed cake, *noug* cake, linseed cake, sunflower cake, sesame cake, and rapeseed cake (Tolera *et al.*, 2012). The main by-product of the sugar factories is molasses although bagasse and sugar cane tops are also other byproducts that can be used as roughage sources. Molasses is a source of available energy to enrich microbial fermentation in the reticulo-rumen of ruminant animals (Bartholomew *et al*., 2003). The annual production of wheat milling by-products and oilseed cakes is estimated to be 269,238 and 102,225 tons, respectively (Bartholomew *et al*., 2003). The flour mills and oil processing plants are operating at less than 50% of their capacities due to shortage and the high price of raw materials and non-competitiveness of the products, particularly oil, in the market. The supply and price of oilseeds are affected by competition from other uses such as export and direct use of the seeds locally. Depending upon accessibility and fee, cereal grains and grains injured during handing out could be used as sources of high-energy feeds (Tesfaye and Chairatanayuth, 2007). A substantial amount of screenings and damaged grains are produced during grain processing and seed cleaning. Cereal grains are usually highly digestible (80-85%), rich in energy and have a protein content of about 8-12% of DM. Maize grain has a high potential in this respect because of its high energy content, relative abundance and reasonable (Tolera *et al*., 2012).

2.1.4. Improved pastures

Introduction, popularization, and utilization of improved multipurpose forage crops and trees such as *Sesbania spp.*, *Leucaena leucocephala, Calliandra spp.* and *Chamaecytisus palmensis* through integration with food crops cultivation in the mixed crop-livestock system in Ethiopia started in the 1970s aimed at supplementing the widely available roughage feed resources (Mengistu, 2006). Unsatisfactory and limited success rates have been reported from the attempts made in the establishment of improved forages with less than one- percent aid which calls for further work in extension and research activities in the area (Atnaf *et al*., 2015). In the highland of Ethiopia, immediate response to population pressure is targeted towards an expansion of the cultivated area to maintain per capita crop output (Mengistu *et al*., 2017). Thus, livestock and crop activities may become competitive for land resources. Although the demand for feed may increase under these conditions, competition with food crops is unfavorable to forage adoption, particularly because farmers tend to be unwilling to sacrifice food production to produce fodder for animals (Mengistu *et al*., 2017). Some potential contribution of indigenous multipurpose plants such as *Vernonia amygdalina, Buddleja polystachya, Maesa lanceolata, Ensete ventricosum*, and *Bambusa spp*. as a livestock feed resource in the smallholder traditional farming systems has been reported in different parts of the country noted that Farmers showed more interest for multipurpose indigenous fodder trees than exotic ones. This indicates that the potential of improved forage adoption is limited under subsistence-oriented livestock production as the economic incentives are low. In contrast, the potential for adoption of improved forages could be higher under market-oriented livestock production systems, such as dairying with crossbreds or improved breeds, and fattening of large and small ruminants (Kefyalew *et al*., 2020).

2.2. Pasture Improvement in Ethiopia

East Africa is recognized as the Centre of origin and distribution of 8-10 of the most economically important tropical and sub-tropical grasses, contributing 20-25% of sown pasture (Jahnke, 1982). In Ethiopia research on cultivated pasture and forage-crop species was initiated in the late 1960s. Cultivated pastures and forage crops, except for alfalfa and Rhodes grass, have not been used on significant areas outside government stations, state farms and farmer's demonstration plots. Due to land scarcity and a crop-dominated farming system, there has been no significant introduction of cultivated species into traditional grazing areas (Mengistu, 2006a). The leading organizations conducting research were the Institute of Agriculture Research (IAR), Arsi Rural Development Project (ARDP, ex-CADU), and lately the International Livestock Center for Africa (ILCA) and the Forage Network in Ethiopia (FNE). The development programs were partially executed by the Extension Promotion and Implementation Department (EPID) and the Livestock and Meat Board (LMB), but since 1979 the Ministry of Agriculture, Animal and Fisheries Resources Development, Main Department, has been responsible for the execution of the national programs. Within the same Ministry, the Department of Soil and Community Forests and the Third Livestock Project are also running development programs. The Ministry of State Farms, especially the Animal Resources Development Department, has large-scale dairy and beef farms (Mengistu, 2006a).

In Ethiopia, forage development strategies have been introduced and popularized for about five decades (i.e., starting in the 1970s) in the mixed crop-livestock production system (EARO 2002; Mengistu, 2006a; Mengistu and Assefa, 2012). This integration of improved forage species into a farming system is a promising option and /or strategy in solving the prolonged feed shortages in the country (Mengistu and Assefa, 2012). However, the adoption of improved forages at the farmers’ level has remained very low due to shortage of forage seed, the reluctance of most smallholder farmers (Mengistu and Assefa, 2012), and the lack of well-organized extension services. Identification of limitations to improved forage technologies in a given agricultural system aids to design suitable interventions. Beshir (2014) observed that since the adoption of improved technologies is dynamic having information with regards to the current technologies being accepted by farmers is very important.

2.3. Role of Grass Pasture in Livestock Production

Grass is the main source of nutrition for domesticated ruminants during a large part of the year Herrera (2004) and Taweel *et al.* (2005) argued that pasture turns out to be an appropriate source of food for ruminants, mainly in countries of tropical climate. According to the same source, this is due to the high number of species that can be used, the possibility of cultivating them throughout the year, the capacity of ruminant using fibrous foods, does not compete as food for humans and tends to be a cheap economical source. Grasses are more easily available, better in taste, and more rapid in digestion than shrubs and trees. Different grass species are digestible in different ways and are affected by many factors, such as temperature, light intensity, total rainfall, soil type, fertilization level, and stage of maturity, and preservation method (Huhtanen *et al.*, 2006; Jalč *et al.*, 2009).
Ganskopp and Bohnert, (2003) observed that the mineral composition of grasses changed seasonally, particularly in a dry climate. In the production of grazing livestock, both the excess and deficiency of minerals are the major constraints.

Grasses are the most dominant plants in most forage-based enterprises throughout the world. They afford energy and nutrients for animal growth and maintenance. Their leaves are more palatable than stems and re-growths more nutritious than old tissues (Briske, 1996). Cattle and sheep feed on grass which forms their major diet and can convert the vegetative matter into products such as milk and meat. There are many genera of grasses and numerous species ranging from short leafy grasses to tall coarse fibrous grasses. During the early stages of growth at the onset of the rains, the plants put out soft leaves which are very rich in protein and sugar. At this stage, the contents within the cellulose cell wall are readily available to the animal (Barett and Larkin, 1974). As the grass plant matures, the leaves reach their full size and contain less digestible protein and carbohydrates which in turn are less available to the animal. Grasses are most negatively affected when grazed during their reproductive period and least affected during dormancy. According to Briske (1996), plant species do not grow or respond to grazing as isolated individuals, but rather as members of a population and community. Individual grass plants consist of an accumulation of phytomers and tillers. Grass populations reflect the number of plants per unit area and the number of tillers per plant.

2.3.1. Para grass (Brachairia muticastapf)

Para grass is an invasive, lasting grass that belongs to the Poaceae family. It is also known as buffalo grass, Dutch grass, California grass, Carib grass, scotch grass and water grass (Wassie *et al*., 2018. Approximately 79% of effluent nitrogen was removed by Para grass resulting in excellent forage quality consisting of 13% protein content and caloric value of 4,000 Kcal/kg (Kanak *et al*., 2013). Although Para grass is considered a problematic weed, it can be beneficial in certain environments. It is an effective means for reducing the nitrate content in groundwater by irrigating with secondary treated domestic manure waste (Kanak *et al*., 2013). Para grass has allopathic and toxic compounds (phenolic and unidentified ninhydrin positive) which inhibit the germination and growth of other plants. Para grass could be an alternative grass to improve the existing natural grasslands in Ethiopia and enhancing the availability of feed to the livestock sector (Zemene *et al*., 2020). Para grass is being cultivated throughout tropical world due to its ability to grow in low rainfall and acidic soil for sustainable fodder production (Rivas *et al*., 2005). A vigorous plant, individual stolon's can be up to 5 meters long.

2.3.2. Napier grass (Pennisetum purpureum)

Napier grass has been highlighted as one of the most important tropical forages for dairy grazing system improvement in the tropics. Its productive potential, associated with other desirable forage traits, such as vigor, persistence, carrying capacity and nutritional quality have stimulated the cultivation and the genetic improvement of the species (Snijders *et al*., 2011). Napier grass is a very essential forage crop in the cut-and-carry system of dairy production, for example in Kenya. It is high yielding; good palatability; good nutrient content; easy to establish and persistent; drought tolerant; very good for silage making; inhibits soil erosion and can serve as a wind-break.

Higher herbage yield of elephant grass was recorded at Debre Zeit than at Holetta, indicating that elephant grass better expressed its genetic potential relatively under warmer than cooler environmental conditions (Gelayenew *et al*., 2020).

2.3.3. Desho grass (Pennisetum pedicellatum)

Desho is an indigenous grass of Ethiopia belonging to the family of Poaceae (Leta *et al*., 2013). It is a perennial grass that has an extensive root system that anchors well with the soil. It has a high biomass production capacity of 30–109 t/ha. It grows upright with the potential of reaching 90–120 cm based on soil fertility (Shiferaw *et al*., 2011). It can grow anywhere from 1500–2800 m.a.s.l with optimum elevation over 1700 m.a.s.l on medium to low soil fertility. Desho grass has a crude protein content of 9.6% on DM basis at an early stage and 1.6% at a straw stage, respectively. The digestibility and voluntary intake decrease with an increase in the stage of maturity which indicates that the grass should be fed at an early stage of maturity (Kefyalew *et al*., 2020). Mature Desho grass must be well supplemented with protein sources to sustain growth and/or milk production. The nutritive value of late-stage Desho grass hay is low to support the maintenance nutrient requirement of adult rams of 17-25 kg, even if supplementation with nitrogen and energy improves performances. Desho grass is widely used as green fodder for cattle (Asmare, 2016). This grass is one of the indigenous potential forage species which needed comprehensive research in Ethiopia (Kefyalew *et al*., 2020). Currently, it is utilized as a means of soil conservation practices and animal feed in the highlands of Ethiopia. The grass is popular, drought-resistant plant, used as feed for ruminants (FAO, 2019). It has the potential of meeting the challenges of feed scarcity since it provides more forage per unit area and ensures regular forage supply due to its multi-cut nature (Kefyalew *et al*., 2020).

2.4. Effect of Cutting Interval on Morphological Parameters of Para, Napier and Desho Grasses

2.4.1. Plant height (PH)

In forage plants, plant height is an important factor contributing to yield and also Plant height is an important component which helps determining the growth attained during the growing period (Zewdu *et al*., 2002). Early stage of growth showed a low mean plant height, but harvesting after 120 days showed an enhanced growth in Desho grass (Tilahun *et al*, 2017). As reported by Zemene *et al*. (2020) Para grass recorded the highest mean plant height at late stage of maturity. According to Nguku *et al*. (2016) shows that at week 16, Napier recorded the highest mean plant heights (103.8cm) and Llanero lowest at 6cm. Among the Brachiaria cultivars MG4 (63.4cm) recorded higher plant heights and although second after Napier (103.8cm), it's height was not significantly different from C.gayana cv. Kat R3 (52.8cm). According to Kanak *et al*. (2012), there is no significant effect on plant height was observed among para, germen and dhal grasses at different harvesting.

2.4.2. Number of tillers per plant (NTPP)

According to Zemene *et al*. (2020) mean tiller number of Para grass was higher at later harvesting date than the first and the second harvesting dates. According to Musimba *et al*. (2016) mean tiller numbers were highest for Marandu, MG4 and Basilisk at week 4. At week 16, Llanero (30.5tillers/plant) recorded highest tiller numbers but Marandu (16.8 tillers/plant) was among the lowest in tiller recruitment. MG4 (24.5tillers/plant), Piata (25.5tillers/plant), Xaraes (25.5tillers/plant), Mulato II (23.8tillers/plant) and Basilisk (20.5tillers/plant) also recorded high and similar tiller numbers with Llanero at week 16 Wangchuk (2015) mentioned that percentage of effective tillers was higher in the younger seedlings. Number of tillers per plant was significantly affected by harvesting date, rather than altitude of Desho grass (Tilahun *et al*, 2017).There was no significant effect in number of tiller per plant during the establishment year determines density of Napier grass but there was effect in the second year (Zewdu, 2008).

2.4.3. Number of leaves per plant (NLPP)

The maximum number of leaf per plant (50.20, 65.83 and 75.20 at 30 DAP, 60 DAP and 90 DAP, respectively) of Napier grass was recorded in V3N1 and minimum (40.10, 52.10 and 60.80 at 30 DAP, 60 DAP and 90 DAP, respectively) was recorded in V2N3. However, the maximum length of leaf (90.20cm, 97.10 cm and 105.23 cm at 30 DAP, 60 DAP and 90 DAP, respectively) was recorded in V1N1 and minimum (56.00 cm, 59.20 cm and 78.10 at 30 DAP, 60 DAP and 90 DAP, respectively) was in V3N3 (Rahman *et al*., 2016).There was no significant effect in total leaves and leaf length per plant of Napier grass. The density of plants during establishment results in Napier grass was significantly affected by plant density in the second year (Zewdu, 2008). According to Kefyalew *et al*. (2020) and Zemene *et al*. (2020) the mean number of leaves was higher for later harvesting days for Desho and Para grass, respectively.

2.4.4. Leaf to Stem Ratio (LSR)

Leaf to stem ratio reflected the variety of leaf stem mass with harvest and year stem mass with harvest and year and is a trait that can affect preference during grazing. According to Tilahun *et al*. (2017), Early harvesting (90 days and 120 days) resulted in higher leaf-to-stem ratios than late harvesting in Desho grass. Furthermore, plants harvested at intermediate harvest dates had a higher leaf-to-stem ratio than those harvested at 150 days. Napier grass planted at 50 cm*50 cm spacing produced a 1.49 leaf to stem ratio (Bayable, 2007) compared to plant spacing of 100 cm*50 cm with 1.91 LSR (Zewdu *et al*., 2002). Chlorisgayana KATR3 on the other hand has a higher proportion of stem relative to leaf by week sixteen which could be the reason for lower dry matter yields (Nguku *et al*., 2016). Leaf to stem ratio values of p*anicumcoloratum* were significantly affected by the age of regrowth (Geleti and Tolera, 2013). Table 1 below shows the effects of cutting interval on morphological parameters of Para, Napier and Desho grasses under different scholars.

Table 1: Review on effects of cutting interval on morphological parameters of Para, Napier and Desho grasses

Grasses	Cutting interval	Spacing (cm)	PH(m)	NT	NL	LSR	References
Para	60(days)	15	1.14	35.2	20.1	1.37	Zemene
		30	1.11	37.1	19.6	1.14	*et a*l., 2020
		45	0.91	48.5	17.4	1.31	
	90(days)	15	1.92	38.7	23.9	0.998	
		30	1.71	47.4	22.4	1.03	
		45	1.84	57.9	21.4	1.08	
	120(days)	15	2.48	44.4	25.4	0.92	
		30	2.60	57.8	26.5	1.005	
		45	2.57	67.4	26.7	0.974	
Napier	4wks	_	27.7	9.4	70.6	_	Rambau
	8wks	_	42.8	11.0	88.9	_	*et al*., 2016
	12wks	_	58.5	12.9	104.5	_	Kefyalew
Desho	90(days)	_	37.19	38.50	187.7	1.76	*et al.*,2020
	120(days)	_	40.48	52.06	300.9	0.87	
	150(days)	_	45.43	44.60	430.4	0.79	
	75(days)	_	46.2	36.4	249	_	*Tilahun*
	105(days)	_	69.8	93.1	554	_	*et al., 2017*
	135(days)		83.1	106.4	710	_	

Where, PH (m) = plant height in meter, NT= number of tillers per plant, NL = number of leaves per plant and LSR= Leaf to steam ratio

2.5. Effect of Cutting Interval on Biomass Yield and Chemical Composition of Para, Napier and Desho Grasses

According to Kanak *et al*.(2012) the Nutritive value of Para (*Brachiariamutica Stapf.*), German (E*chinochloacrusgalli* L.) and Dhal (H*ymenachnepseudointerrupta* C. Muell) grasses at different stages of maturity shown that fresh biomass highly significant difference and dry biomass yield less significant difference of three fodder germplasm differed significantly. Crude proteins and organic matter yield were significant only in the second cutting. German grass was showed significantly higher in CP and OM yield at second cutting than other grasses.

According to Gemiyo *et al*. (2017) the dry matter yield of the accessions No. 16815 and local were higher than the accession No.16794 and 16819 but similar to the accession No.16783, 16902, 16913, 15743, 16817 and 16791. Mean dry matter yield of Napier accessions at 2 months age (12.77 tons DM/ha). The high dry matter recorded for accession16815, local, 16902, 16817, 16791, 15743, 16913and 16783 suggested that these accessions are competent with local accession and less moisture is present in the grass and will therefore reduce the rate at which the grass deteriorate when stored. The CP, OM, NDF, ADF, lignin and organic matter digestibility (OMD) were not different among accessions. The overall mean in CP and OMD obtained at 18 months age (5.42 and 40.04%), respectively. The highest CP (6.66%) in Napier accession No. 16902 whiles the lowest CP (4.23%) in accession No. 16794. However, the CP content of all the Napier accessions in this study was below the minimum level (7%) required for optimum rumen function. The overall mean in NDF and lignin obtained at 18 months in this study (80.98 and 8.16%), respectively. the highest NDF (83.61%) was found for accessions No.16794 while the lowest NDF in turn (78.64%) for accession No.16913. The highest lignin determines the intake and animal performance. 8.80% was found for accessions No.16817 while the lowest lignin (7.83%) for accession No.16913. However the quality of all Napier accessions in the present with respect to NDF content was lower than the recommended medium and higher quality roughage feeds of 45-65 and below 45%, respectively.

Hare *et al*. (2013) reported that the effect of cutting interval on yield and quality of Mulato II, Cayman and BRO2/1794 in Thailand shown that Mulato II produced significantly more leaf dry matter than Cayman at 30, 45 and 90-day cutting intervals and more than BRO2/1794 at all four cutting intervals. Mulato II had a greater percentage of leaf than Cayman and BRO2/1794, and Cayman had a greater percentage of leaf than BRO2/1794 at all four cutting intervals Increasing cutting intervals significantly reduced crude protein levels and increased ADF and NDF levels in stems and leaves. Cayman and BRO2/1794 had higher stem crude protein levels than Mulato II at 30 and 45-day cutting intervals and both had lower levels than Mulato II at 60 days cutting intervals. BRO2/1794 had lower leaf crude protein levels than both Cayman and Mulato II at all cutting intervals. Overall, Mulato II had higher leaf ADF and stem and leaf NDF levels than both Cayman and BRO2/1794 at all cutting intervals at four cutting intervals (30, 45, 60, 90 days).

Manyawu *et al*. (2003) reported that effect of harvesting interval on herbage yields and nutritive values of two Napier accessions (SDPP 8 and SDPP 19) and four hybrid Pennisetum (SDPN 3, SDPN 29, SDPN 38 and Bana grass) compared at five harvest intervals (2, 4, 6, 8, and 10 weeks) shown that, the stage of growing had significant effects on fodder yield, WSC content and nutritive value of the Pennisetum. Herbage yields increased in a gradually linear manner, with age. Nutritive value declined as the harvesting date increased. In particular, crude protein content declined rapidly from 204 g kg-1 DM at 2 weeks to 92 g kg-1 DM at 8 weeks of growth. In vitro dry matter digestibility decreased from 728 to 636 g kg-1 DM, whilst acid and neutral detergent fiber contents increased from 360 and 704 to 398 and 785 g kg-1 DM, respectively. Rapid variations in nutritive value arisen after 6 weeks of a growth period.

According to Epifanio *et al*. (2019) report the nutritional characteristics of three Brachiariabrizantha cultivars (Marandupalisadegrass, Xaraespalisadegrass, and Piatapalisade grass) at three cutting intensities (10, 20, and 30 cm) sward height showed that the Piatapalisade grass had the best chemical composition compared to the Marandupalisadegrass and Xaraespalisadegrass. The management of Brachiariabrizantha cultivars at the lowest residual height (10 cm) affected the nutritional value of these feed grasses. Vélez-Santiago *et al*. (1985) reported that the effect of three Harvest intervals on yield and nutritive value of seven Napier grass at the effect of 30-, 45-, and 60-day harvest intervals on green forage (GF), dry forage (OF), and crude protein (CP) yields, leaf/stem ratio, and chemical composition showed that as the grasses advanced in maturity from 30 to 45 and from 45 to 60 days, GF, OF, and CP yields increased in all cultivars. Significant differences occurred among cultivars as to GF, OF, and CP yields during the 2 years. The highest yields were obtained by cultivars 13079, 13078, 7353, and 7350. Significant differences also occurred among cultivars as to GF and OF yields during the short-day and dry-month periods of the year.

Rusdy (2014) reported that the dry matter yield and nutritional quality of Panicum maximum centrosemapubescens mixtures at Proportions of guinea grass – Centro grown at 100: 0%, 75: 25%, 50: 50%, 25: 75% and 0: 100% and with cutting intervals 30, 45 and 90 days shown that, the dry matter yield of inter crops was significantly higher than that their monocultures and sole guinea grass produced higher dry matter yield than sole Centro. The highest yield advantage achieved when guinea grass - Centro at the ratio of 50: 50%. As an increasing proportion of Centro in the mixtures and decreasing cutting intervals, crude protein, calcium contents and digestibility were increased. With exception of sole guinea grass cut at an interval of 45 and 90 days, crude protein and IVDMD values of all sole crops and intercrops of guinea grass – centro are above the minimum requirements for maintenance of ruminant animals.

According to Serra *et al*. (1996) report the monthly variation in crude protein, fiber fractions and mineral composition of para grass (B*rachiariamutica Stapf*) and star grass (C*ynodonplectostachyusPilger*) has shown that month differences in CP and different fiber fractions were observed for the two forage species. Specie effects were observed in various nutrient fractions including some minerals (Ca, P, Cu and Zn). Month differences were also observed in mineral elements Ca, P, K, Cu and Zn but not in Mg.

Table 2: Review on effects of cutting interval on chemical composition of Para, Napier and Desho grasses

Grasses	Cutting Intervals	Spacing (cm)	DM (%)	ASH (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)	References
Para	60(days)	15	94.36	14.65	13.44	68.22	34.56	4.15	Zemene *et a*l., 2020
		30	94.21	14.67	13.69	69.43	34.41	4.42	
		45	94.14	14.60	13.41	68.24	33.58	3.95	
	90(days)	15	94.42	12.75	10.16	66.33	35.97	4.13	
		30	94.55	12.59	9.85	66.91	36.02	4.06	
		45	94.43	12.05	8.37	68.21	36.4	4.15	
	120(days)	15	94.75	10.69	6.59	70.83	35.91	4.38	
		30	94.72	10.39	6.2	71.14	36.26	4.44	
		45	94.62	10.40	5.7	70.96	36.56	4.47	
Napier	8wks	_	277.9	77.1	140.4	68.56	37	3.52	Rambau *et al.*, 2016
	12wks	_	330.5	75.4	131.6	69.67	38.1	39.1	
Desho	90(days)	_	94.25	15.77	13.78	55.76	43.16	11.34	Kefyalew *et al.*,2020
	120(days)	_	94.25	14.41	9.23	57.52	45.17	12.11	
	150(days)	_	95.25	13.56	7.58	59.74	46.72	13.2	
	75(days)	_	88.2	9.16	10.9	45.2	33.1	17.3	*Tilahun et al.*,2017
	105(days)	_	88.4	7.89	10.2	46.2	37.6	18.3	
	135(days)	_	89	7	9.3	51.7	42.6	20.7	

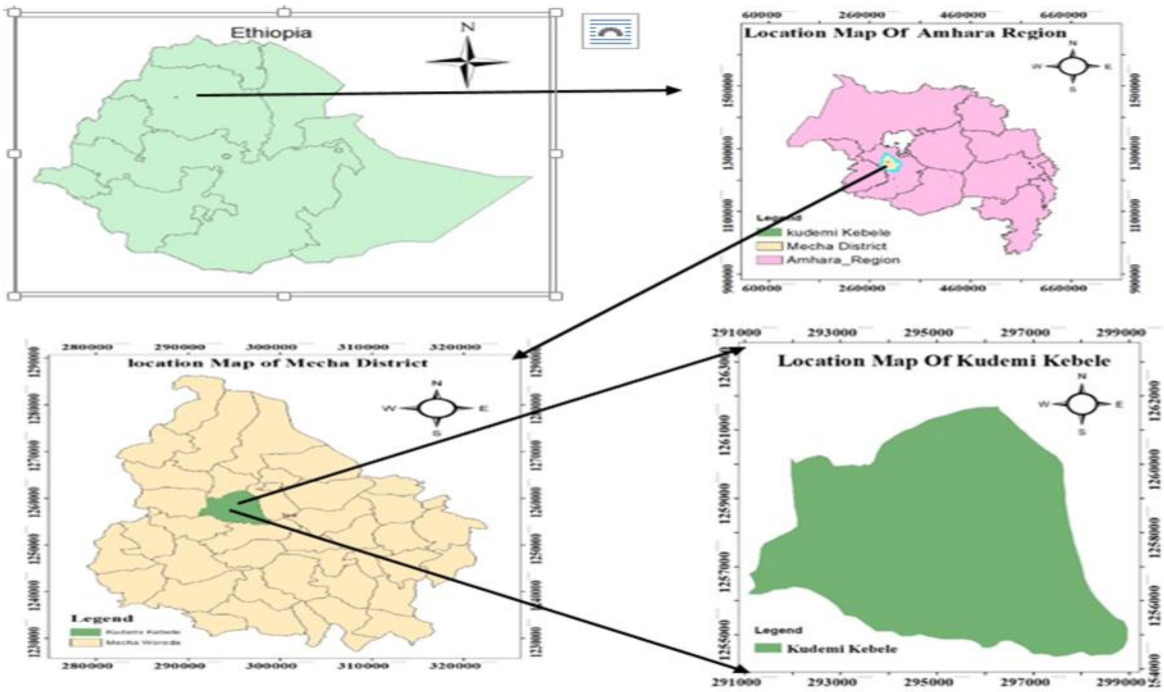
Where DM = stands for Dry matter, CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, ADL= Acid detergent lignin

3. MATERIAL AND METHODS

3.1. Description of the Study Area

The study was conducted at Koga irrigation site in Kudemi *Kebele*, Mecha *Woreda* of West Gojjam zone in Amhara Regional State (Figure 1). It is located about 525 kilo meters northwest of Addis Ababa and 34 kilo meters southeast of Bahir Dar, the capital city of the Amhara Region. In Mecha *Woreda*, the climatic condition alternates between summer rainfall and dry season with mean annual rainfall ranging between 1500 and -2200 mm. The mean temperature ranges between 24 and -27 ^{0}C and the altitude range from 1800 to 2500 m.a.s.l. Agriculture is the main economic activity in the study area. The main agricultural activities at present practiced include irrigation (modern and traditional) and mixed farming. The major crops grown in the area includes maize, teff, wheat and other legume groups. In this *Woreda*, there are 192, 556 cattle, 148, 971 ovine, 23, 106 equine and 204, 181 poultry (Mecha *Woreda* Agriculture Office unpublished report).

Figure 1: Map of the study area



Source: DOA, 2019

3.2. Experimental Design and Treatments

The experiment was conducted under irrigation from November 2020 to February 2021 after two years of establishment. During establishment year the experimental land was first ploughed and cleared of weeds and then back-hoed, three times before subdividing it into blocks and plots, this was done before planting of grasses. After planting, DAP and Urea fertilizers were applied to each grass species based on the recommendation of (Cameron and Lemcke, 2008). Weeds were controlled by hand weeding to avoid intervention by interspecific competition. Weeding was done early and then two times per month until the final harvesting was accomplished, to eliminate regrowth of undesirable plants and removal of the dry root to stimulate fodder re-growth by increasing soil exposure to air. The experiment was arranged using a randomized complete block design (RCBD) with three replications. The total area of the experiment was 108m² (9m *12m). The plot size of each grass species was 12 m² (3 m x 4 m) by excluding the outer row on both sides of each plot row length 0.25 m and 0.5 m row width were subtracted during planting on both ends of the rows to avoid probable border effects. With a 1m path between blocks, a 0.5 m path between the plots and plants. There were three blocks; resulting in nine plots from nine plots each grass species has three plots, each plot had six rows and in each row, there were eight plants. The experiment has a total of three grass species namely Para; Napier and Desho grasses were compared at three harvesting dates (60, 90 and 120 days). During the experimental periods, the field was irrigated with furrow two times per week throughout the growth period and weeding was done once per week.

Table 3: Treatments allocated in different plots for field experiment

Replication	plot number	Treatment
1	1	P
1	2	D
1	3	N
2	4	D
2	5	P
2	6	N
3	7	D
3	8	N
3	9	P

Where: P= Para grass, D= Desho grass, N= Napier grass

❖ The randomization is made by Generate Basic Design application

3.3. Data Collection and Sampling Procedure

The data were collected after 60 days of regrowth. Data on morphological parameters and forage yield were recorded at each cutting interval. Six randomly selected plants in each species were randomly selected to record Plant height (PH), the number of tiller per plant (NTPP), the total number of leaves per plant (TLPP), and leaf to stem ratio (LSR).

Data collected from 6 representative samples plants were randomly taken and properly record as follows.

Plant height: Plant height was measured on the primary bud from the soil surface to the base of the top-most leaf using a meter designated by (Rayburn *et al*., 2007). This was done on the same for plants tagged. Measurement of plant height was undertaken immediately before the time of biomass harvest, at the end of each of the three cutting intervals. From the total of six rows within each plot, an entire of four rows was selected by eliminating the two border rows and then six tillers were randomly selected for the measurement of plant height at an interval of 30 days from 60 days after regrowth to upto120 days of harvesting date.

The number of tillers: The number of tillers was counted from the sample of six plants at 60, 90 and120 days of cutting intervals of the experimental plot area. Mean was calculated and then the total number of leaves per plant was estimated from the tiller number per plant and leaf number per tiller. The main stem was not included to calculate the total tillers per plant.

Leaf to stem ratio (LSR): Sample taken from each harvesting date was properly weighed and the fresh leaves and stems of each of the six harvested plants were separated by using hand and weighed by sensitive balance. After individual plant measurements, stems and leaves were bulked separately, then leaf to stem ratio (LSR) was estimated by dividing fresh leaf weight to fresh stem weight.

*Dry matter yield (*DMY*):* After harvesting the middle four rows, the total biomass yield was determined using a spring balance from each plot at each harvesting date. The dry matter yield (DMY) was determined at the end of every harvesting day. Based on DM % and fresh biomass yield from the sample area of each plot were used to calculate total dry matter yields for each plot, thereafter, converted to metric tons per hectare (Gelayenew *et al*., 2019).

The dry matter yield (DMY t/ha) was calculated using the following formula.

DMY (t/ha) = TFW*(DSW/HA*FSW)*10 where, TFW = total fresh weight kg/plot, DSW = dry sample weight in grams, FSW = fresh sample Weight in grams, HA = Harvest plot area in square meters and 10 is a constant for conversion of yields in kg/m^2 to t/ha.

During sampling, the four rows at the middle of each plot were cut five Cm above the ground from each block, excluding border rows then freshly harvesting plant samples were chopped into small pieces up to 1-2 cm to facilitate drying and weighed for their fresh weight right in the field. Sample taken from each harvesting stage were thoroughly mixed and 400 g sample was taken and dried under open air until constant dry matter weight is attained. After drying, all samples were ground to pass a 1-mm Wiley mill screen and stored in an airtight container for different chemical analyses.

3.4. Analytical Procedures

Samples of each treatment were subjected to chemical analysis for determination of dry matter following the methods of (AOAC, 2004). Forage quality measurements such as determination of crude protein (Kjeldhal-N×6.25), acid detergent fiber (ADF) and neutral detergent fiber (NDF) were analyzed using (Van Soest *et al*., 1991). Ash was determined by igniting at 550 ^oC overnight, total DM by drying at 105^oC and N by the auto-analyzer (Chemlab, 1984). All the chemical analyses were done in continuous (at Bahir Dar University Animal Nutrition Laboratory).

3.5. Statistical Analysis

The collected data were managed and organized with MS-Excel 2010. All data collected were statistically analyzed using General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 2004) for least square one way analysis of variance. Differences among treatment means were considered statistically significant at a 0.5% significance level using Duncan's Multiple Range Test (DMRT). The following statistical model was used for the analysis of data.

$Y_i = \mu + CI_i + e_i$

Where, Yi = the observed morphological characteristics (Plant height, Number of tillers/plant, Number of leaves/plant, Leaf to steam ratio), biomass yield and chemical composition of the grass species in the i^{th} cutting interval

μ = overall mean

CI_i = the effect of i^{th} cutting interval (i = 60, 90 and 120 days)

e_i= standard error of the mean

4. RESULTS

4.1. Effect of Cutting Interval on Morphological Parameters of Para (*Brachairia muticastapf*), Napier (*Pennisetum purpureum*) and Desho (*Pennisetum pedicellatum*) Grasses Grown under Irrigation Condition

In the present study, the effect of cutting interval on plant morphological parameters of Para, Napier and Desho grasses are presented in Table 4. The finding indicated that except for Leaf to stem ratio (LSR) (P>0.05); Plant height (PH), Number of tillers per plant (NTPP), and Number of leaves per plant (NLPP) of Para, Napier and Desho grasses were significantly affected by cutting interval. The overall results of the study show that a maximum number of PH, NTPP and NLPP were recorded for later cutting intervals (120 days) than for the shorter cutting interval (60 days and 90 days). Desho grass recorded generally higher tiller numbers than Para and Napier throughout the growth period. Mean tiller numbers were highest for Para, Napier and Desho at 120 days. At 120 days Desho (236 tillers/ plant) recorded the highest tiller numbers followed by Para (183 tillers/ plant) but Napier (46 tillers/ plant) was among the lowest in tiller number. The Para grass recorded generally higher leaf numbers than Desho and Napier grasses throughout the growth period. Mean leaf numbers were highest for Para, Desho and Napier at 120 days of cutting interval. At 120 days Para grass (2366.7 NLPP) recorded the highest leaf numbers, Desho (1588.4 NLPP) but Napier (414.88 NLPP) was the lowest in leaf number.

Table 4: Effects of cutting interval on morphological parameters of Para, Napier and Desho grasses

		Grasses		
Parameters	Cutting interval	Para	Napier	Desho

PH (cm)	60	43.15^{c}	101.99^{b}	28.95^{b}
	90	60.4^{b}	107.5^{b}	39.2^{ab}
	120	75^{a}	151.9^{a}	45.3^{a}
	SEM	1.74	6.49	4.42
	Sig.	***	**	**
NTPP	60	148.8^{b}	40.48^{b}	149^{b}
	90	153.2^{b}	43.7^{ab}	181^{b}
	120	183^{a}	45.88^{a}	236^{a}
	SEM	6.35	1.32	10.35
	Sig.	*	*	**
NLPP	60	1336^{c}	267.5^{b}	894.8^{c}
	90	1563.7^{b}	325^{ab}	1199.4^{b}
	120	2366.7^{a}	414.88^{a}	1588.4^{a}
	SEM	9.6	3.8	3.5
	Sig.	**	*	**
LSR	60	1.15^{a}	2.4^{a}	1.37^{a}
	90	1.1^{a}	2.3^{a}	1.2^{a}
	120	1.1^{a}	2.3^{a}	1.2^{a}
	SEM	0.15	0.27	0.22
	Sig.	NS	NS	NS

*Note: *=significant at 0.05; **=significant at 0.01; ***=significant at 0.001 and Ns stands for non-significant means with in column followed by the same letters are not significantly different, and SEM stands for standard error of the mean; PH = plant height; NTPP = number of tillers per plant; NLPP = number of leaves per plant; LSR = Leaf to Stem Ratio*

4.2. **Effects of Cutting Interval on Chemical Composition and Yield of Para, Napier and Desho Grasses Grown under Irrigation Condition**

Table 5 below shows the chemical composition of three different harvesting days of Para, Napier and Desho grasses. In the current study the dry matter yield, Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) increased with an increase in harvesting days (60<90<120days) whereas the crude protein showed a decreasing trend with increase in harvesting days (60>90>120days). The CP content of Para, Napier and Desho grasses were 13.1%, 10.5%, 8.0%; 13.2%, 9.5%, 7.9% and 13.4%, 9.16%, 7.73% in the first, second and third cuttings, respectively. The average ash contents of Para, Napier and Desho grasses were 15.1, 15.24, 13.92 % in the first cutting; 13.9, 13.2, 13 % in the second cutting, and 12.8, 11.3 and 12.16% in the third cutting, respectively.

Table 5: The effects of cutting interval on chemical composition and dry matter yield of Para, Napier and Desho grasses.

Grasses	Cutting interval	Parameters						
		DM (%)	Ash (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)	DMY(t/ha)
Para	60	90.42^{b}	15.1^{a}	13.1^{a}	65.6^{c}	34.97^{b}	5.0^{c}	4.3^{b}
	90	90.96^{b}	13.9^{ab}	10.5^{b}	67.7^{b}	36.7^{a}	5.65^{b}	8.1^{a}
	120	92.34^{a}	12.8^{c}	8.0^{c}	69.0^{a}	37.1^{a}	5.97^{a}	9.57^{a}
	SEM	0.18	0.45	0.3	0.23	0.19	0.09	0.88
	Sig.	**	*	***	***	**	**	*
Napier	60	90.24^{b}	15.24^{a}	13.2^{a}	64.13^{c}	37.1^{c}	5.7^{b}	12.5^{b}
	90	90.57^{b}	13.2^{b}	9.5^{b}	64.86^{b}	38.43^{b}	5.7^{b}	14.6^{a}
	120	91.24^{a}	11.3^{c}	7.9^{c}	65.36^{a}	40^{a}	6.5^{a}	16.2^{a}
	SEM	0.17	0.35	0.35	0.1	0.37	0.47	0.18
	Sig.	**	**	***	**	*	*	*
Desho	60	90.42^{b}	13.92^{a}	13.4^{a}	75.12	38.15^{b}	8.89^{b}	5.5^{c}
	90	90.5^{b}	13^{b}	9.16^{b}	77.21	39.3^{ab}	9.52^{b}	6.6^{b}
	120	91.66^{a}	12.16^{b}	7.73c	78.7	40.5^{a}	10.7^{a}	8.6^{a}
	SEM	0.25	0.3	0.26	0.44	0.57	0.24	0.37
	Sig.	*	*	***	**	*	*	*

Note means with in column followed by the same letters are not significantly different; and DM = stands for Dry matter, CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, ADL= Acid detergent lignin, DMY (t/ha) = Dry matter tone per hectare, SEM= standard error of mean and Sig lev =significance level

5. DISCUSSION

5.1. Effect of Cutting Interval on Morphological Parameters of Para (*Brachairia muticastapf*), Napier (*Pennisetum purpureum*) and Desho (*Pennisetum pedicellatum*) Grasses Grown under Irrigation Condition

Plant height (PH) increased progressively with enhanced age of harvesting date and this is supported with the finding of Rambau *et al*. (2016) on Napier grass. This is because PH in grasses is greatly influenced by the developmental stage of the plant. An increase in PH at 120 days of cutting is due to substantial root development and subsequent improvement in nutrient uptake for continued increase in plant height. The estimated boost in PH at maturity is consistent with research results of Tilahun *et al*. (2017) who also reported similar results for Desho grass. The recorded plant heights for the three grasses indicated that Napier was with the highest (151.9cm) followed by Para (75cm) and the least was for Desho (45.3cm) at 120 days of cutting interval. Soebarinoto *et al*. (2014) reported greater plant height for *Brachiaria mutica* followed by *Brachiaria brizantha* and *Brachiaria Mulato* at 8 weeks of harvesting. However, the results obtained from the current study were lower than that reported by Soebarinoto *et al*. (2014); Zemene *et al*. (2020) for Para grass. This variation may be due to the difference in their species, soil fertility, maturity stage and weather condition.

More number of tillers was found in Desho (236) followed by Para (183) and the least were observed in Napier (46) at the latest harvesting age (120 days). It is supported by Rambau *et al*. (2016) who stated that as the plants approached maturity more tillers would develop. As studied by Rambau *et al*. (2016) the mean tiller number of Napier grass was lower than the current study. According to Zemene *et al*. (2020), the number of tillers for Para grass was increased with increased harvesting dates. Therefore, the results of the current study agree with the reports of Rambau *et al*. (2016); Mihret *et al*. (2018) and Zemene *et al*. (2020); for Napier, Desho and Para grasses, respectively. There was a significant effect on the total number of leaves per plant of Para, Napier and Desho grasses in all harvesting dates. Due to an increase in the tiller number of grasses the first, second and third cutting intervals significantly increased the number of leaves per plant. Greater numbers of leaves per plant were recorded for Para, Napier and Desho grasses at a late stage of maturity (120 days) cutting interval. This result was higher than the values reported by Manyawu *et al*. (2003); Tilahun *et al*. (2017) and Zemene *et al*. (2020) for Napier, Desho and Para grasses, respectively. In the current study, the cutting interval had no significant (P>0.05) effect on the leaf to stem ratio of the studied grasses. But cutting interval had a significant difference in leaf to stem ratio of the studied grasses numerically. The reason for this might be the accumulation of more cell wall components in plant tissues as a result of stem development with advancing maturity.

5.2. **Effect of Cutting Interval on Chemical Composition and Forage Dry Matter Yield of Para (*Brachairia muticastapf*), Napier (*Pennisetum purpureum*), and Desho (*Pennisetum pedicellatum*) Grasses Grown under Irrigation Condition**

In the present study, the dry matter yield increased as the grass aged, and a higher dry matter yield was observed at the late stage of maturity. This is because, as grass matures, forage yield is increased due to the rapid rise in the tissues of the plant, development of extra tillers and formation and elongation leaves, and stem development with increasing harvesting age. This idea is supported by Ansah *et al*. (2010) and Rambau *et al*. (2016), who reported that the DMY increased as Napier grass maturity increased. Similarly, as reported by Zemene *et al*. (2020) the dry matter yield of para grass was increased with increased cutting intervals. Tilahun *et al*. (2017) and Kefyalew *et al*. (2020) reported that the dry matter yield of Desho grass increased with increase cutting intervals. Therefore, the present study was in agreement with the report by Ansah *et al*. (2010); Rambau *et al*. (2016) for Napier; with Tilahun *et al*. (2017); Kefyalew *et al*. (2020) for Desho and with Zemene *et al*. (2020) for Para grasses.

In the current study, there was a significant difference on the ash content of Para, Napier and Desho grasses in different cuttings. The ash content of the grasses was reduced with an increase in age of maturity. This was due to, as grasses mature, the mineral content drops due to a natural watering process and translocation of minerals to the roots. Therefore, current result is in line with Ansah *et al*. (2010) for Napier grass; Tilahun *et al*. (2017); Kefyalew *et al*. (2020) for Desho and Zemene *et al*. (2020) for Para grass. Contrary to current findings, Rambau *et al*. (2016) found that plant maturity did not affect the ash content of Napier grass. Kitaba and Tamir (2007) also reported that ash content tended to increase as harvesting progressed. Therefore, the current study disagrees with the report by Kitaba and Tamir (2007).

As expected, CP was highest in the early stage compared with the intermediate and late stages of maturity. This was due to a growth reduction effect with an increase in structural carbohydrate content of forage materials harvested at late maturity reducing the percentage of protein in the forage. Grasses harvested at an early stage of maturity in this study had the best nutritional value, particularly highest CP content. Even forage cut at 120 days interval had CP concentrations well above 7.0%, which is the level below which voluntary intake of ruminants might be depressed. However, harvesting at the early stage resulted in low DM yields. This result is in line with the results of Tudsri *et al*. (2002); Ansah *et al*. (2010); reported for Napier grass; Tilahun *et al*. (2017) and Kefyalew *et al*. (2020) reported for Desho grass and Zemene *et al*. (2020) reported for para grass.

As would be expected, the NDF, ADF and ADL contents increased with forage maturity increases. The late-stage had the highest lignin content; this implies that forages from later stages of growth in grasses are going to be with lower quality as higher levels of lignification result in reduced digestibility. This result agrees with Rambau *et al*. (2016) for Napier grass, Zemene *et al*. (2020) for Para, Tilahun *et al*. (2017) and Kefyalew *et al*. (2020) for Desho grasses reported that the NDF, ADF and ADL content increase progressively as forage maturity increased. Similarly, the findings for ADL agree with the studies of Bayble (2007) and Aganga *et al.* (2005). Bayble (2007) and Aganga *et al.* (2005) observed increased ADL with progressive stages of maturity. Therefore, forages with lower ADL concentrations are more desired.

6. CONCLUSION AND RECOMMENDATION

From the results of the current study, it has been concluded that Napier grass produces a higher forage yield among the three grasses and longer harvesting intervals result in increased forage yield in all the studied grasses. However, forage quality as expressed in terms of crude protein value progressively declines. Therefore, under conditions where protein is not a limiting nutrient in practical feeding, letting the grass stands to regrow for a longer period would guarantee increases in forage yield. Cutting at 90 days of the grass stands yields reasonably good quantity and quality of fodder from the studied grass species. Further research is needed to be conducted over much longer periods to determine to what extent these findings relate to performance over the life of a permanent pasture. It could be advisable to be adopted by farmers who grow elephant grass as livestock feed.

7. REFERENCES

Aganga, A.A., Omphile, U.J., Thema, T. and Baitshotlhi, J.C. (2005). Chemical composition of Napier grass (Pennisetum purpureum) at different stages of growth and Napier grass silages with additives. *J. Biol. Sci*, **5**(4): 493-496.

Ansa, J.E.O. and Garjila, Y.A. (2019). Effect of cutting frequency on forage growth and yield in elephant grass in the southern rainforest of Nigeria. *Int. J. Environ. Agric. Res*, ***5***.1-5.

Ansah, T.,Osafo, E.L.K. and Hansen, H.H. (2010). Herbage yield and chemical composition of four varieties of Napier (Pennisetum purpureum) grass harvested at three different days after planting.

AOAC (2004) 'Official methods of analysis. (16th ed.) Association of Official Analytical Chemists, Washington DC.'

Asmare, B. (2016). Evaluation of the agronomic, utilization, nutritive and feeding value of Desho grass *(Pennisetum pedicellatum)* (Doctoral dissertation, Jimma University).

Atnaf, M., Tesfaye, K. and Dagne, K. (2015). The importance of legumes in the Ethiopian farming system and overall economy: An overview. *Journal of Experimental Agriculture International*.347-358.

Barrett, M.A. and Larkin, P.J. (1974). Milk and beef production in the tropics. Oxford University Press.

Bartholomew, P.W., Ly, R., Doumbia, M., Khibe, T., Kone, N.G., Traore, B. and Ba, S. (2003). Agro-industrial by-products, cowpea residues and urea-treatment of hay for supplementary dry season feeding of mature zebu oxen in Mali. *Livestock Research for Rural Development*, **15**.1-10.

Bayble, T., Melaku, S. and Prasad, N.K. (2007). Effects of cutting dates on the nutritive value of Napier (Pennisetum purpureum) grass planted sole and in association with Desmodium (Desmodium intortum) or Lablab (Lablab purpureus). *Livestock Research for Rural Development,* **19**(1): 120-136.

Beshir, H. (2014). Factors affecting the adoption, intensity and use of improved forages in North East Highlands of Ethiopia. *Journal of Experimental Agriculture International*. 12-27.

Birhan, M. and Adugna, T. (2014). Livestock feed resources assessment, constraints and improvement strategies in Ethiopia. *Middle East Journal of Scientific Research*, **21**(4): 618-704.

Briske, D.D. (1996). Strategies of plant survival in grazed systems: a functional interpretation. *The ecology and management of grazing systems*. 37-67.

Cameron, A.G. and Lemcke, B. (2008). Para grass (A pasture grass for wet and flooded soils). Agnate NE30, Department of Regional Development, Primary Industry, Fisheries and Resources, Northern Territory Government, Australia.

Chemlab (1984) Continuous flow analysis system 40. Method Sheet No. CW2–008–17 (Ammonia (0–1 and 0–50 PPM. N). (Chemlab Instruments Ltd: UK).

Creemers, J. and Aranguiz, A.A. (2019). Quick Scan of Uganda's Forage Sub-Sector.

EARO (Ethiopian Agricultural Research Organization) (2002). livestock technology options for economic growth and to enhance the livelihoods of smallholder farmers. The report presented to the workshop on poverty reduction through transforming smallholder systems from subsistence to market orientation, June 3-7, 2002, Addis Ababa, Ethiopia.

Epifanio, P.S., de Pinho Costa, K.A., da Costa Severiano, E., de Souza, W.F., Teixeira, D.A.A., da Silva, J.T. and de Moura Aquino, M., 2019. Productive and nutritional characteristics of Brachiaria brizantha cultivars intercropped with Stylosanthes cv. Campo Grande in different forage systems. *Crop and Pasture Science*, **70**(8): 718-729.

Food and Agriculture Organization of the United (2019) The future of livestock in Opportunities and challenges Ethiopia in the face of uncertainty.

Ganskopp, D.C. and Bohnert, D.W. (2009). Landscape nutritional patterns and cattle distribution in rangeland pastures. *Applied Animal Behavior Science*, **116**(2-4):110-119.

Gelati, D. and Tolera, A. (2013). Effect of age of regrowth on yield and herbage quality of Panicum coloratum under sub-humid climatic conditions of Ethiopia. *African Journal of Agricultural Research*, **8**(46): 5841-5844.

Gelayenew,B., Tamir, B., Assefa,G. and Feyissa, F. (2019). Effect of Harvesting Height and Nitrogen Fertilization on Herbage Yield and Nutritional Qualities of Elephant Grass in the Central Highlands of Ethiopia. *Global Veterinaria* **21** (5): 287-297.

Gemiyo, D., Jimma. A and Wolde, S. (2017). Biomass yield and nutritive value of ten Napier grass (Pennisetum purpureum) accessions at Areka, Southern Ethiopia. *World Journal of Agricultural Sciences,* **13** (5): 185-190.

Getachew, F. and Asfaw, T. (2003). Milk and dairy products, post-harvest losses and food safety in sub-Saharan Africa and the Near East. A review of the smallholder dairy sector-Ethiopia. FAO prevention of food losses program.

Gulilat, L., Temam, S. and Haile, T. (2018). Assessment of lives stock feed resources and its constraint in Farta woreda. *Moj Food Process Techno*, **6** (3): 298-301.

Hare, M.D., Phengphet, S., Songsiri, T., Sutin, N. and Stern, E. (2013). Effect of cutting interval on yield and quality of three brachiaria hybrids in Thailand. *Tropical Grasslands-Forrajes Tropicales,* **1**(1): 84-86.

Huhtanen, P., Nousiainen, J. and Rinne, M. (2006). Recent developments in forage evaluation with special reference to practical applications.

Jahnke, H.E. and Jahnke, H.E. (1982). Livestock production systems and livestock development in tropical Africa. **35**.

Jalč, D., Lauková, A., Simonová, M., Váradyová, Z. and Homolka, P. (2009). The use of bacterial inoculants for grass silage: their effects on nutrient composition and fermentation parameters in grass silages. *Czech Journal of Animal Science*, ***54*** (2): 84-91.

Kanak, A.R., Khan, M.J., Debi, M.R., Khandakar, Z.H. and Pikar, M.K. (2013). Comparison of biomass production of three fodder germplasms. *Bangladesh Journal of Animal Science*, **42**(1):35-39.

Kanak, A.R., Khan, M.J., Debi, M.R., Pikar, M.K. and Aktar, M. (2012). Nutritive value of three fodder species at different stages of maturity. *Bangladesh Journal of Animal Science*, ***41*** (2): 90-95.

Kebede,G., Assefa, G., Feyissa, F. and Mengistu, A. (2016). Review on some management and improvement practices of natural pasture in the mid and high altitude areas of Ethiopia. *International Journal of Livestock Research*, ***6*** (5): 1-14.

Kefyalew, A., Alemu, B. and Tsegaye, A. (2020). Effects of Fertilization and Harvesting Age on Yield and Quality of Desho (Pennisetum pedicellatum) Grass Under Irrigation, in Dehana District, Wag Hemra Zone, Ethiopia. *Agriculture, Forestry and Fisheries*, ***9*** (4): 113.

Kitaba, A. and Tamir, B. (2007). Effect of harvesting stage and nutrient levels on nutritive values of natural pasture in central highlands of Ethiopia. Agricultura Tropica et Subtropica, 40(1):7-12.

Leta, G., Duncan, A.J. and Abdena, A. (2013). Desho grass (Pennisetum pedicellatum) for livestock feed, grazing land, soil, and water management on small-scale farms.

Manyawu, G.J., Chakoma, C., Sibanda, S., Mutisi, C. and Chakoma, I.C. (2003). The effects of harvesting interval on herbage yield and nutritive value of Napier grass and hybrid Pennisetum. *Asian-Australasian journal of animal sciences*, ***16*** (7): 996-1002.

Mengistu, A. (2004). Pasture and forage resource profiles of Ethiopia.

Mengistu, A. (2006a). Country pasture/forage resource profiles: Ethiopia. Accessed on, **5**(01), p.2009.

Mengistu, A. (2006b). Feed resources in Ethiopia, animal and fisheries resources development, main department ministry of agriculture.

Mengistu, A. and Assefa, G. (2012). The evolution of forage seed production in Ethiopia. *Ethiopian Institute of Agricultural Research*, pp.15-20.

Mengistu, A., Kebede, G., Feyissa, F. and Assefa, G. (2017). Review on major feed resources in Ethiopia: Conditions, challenges and opportunities. *Academic Research Journal of Agricultural Science and Research*, ***5*** (3): 176-185.

Mengistu, A., Kebede, G.,Assefa, G. and Feyissa, F. (2016). Improved forage crops production strategies in Ethiopia: A review. *Academic Research Journal of Agricultural Science and Research*, ***4*** (6). 285-296.

Mihret, B., Asmare, B. and Mekuriaw, Y. (2018). Effect of fertilizer type and plant spacing on plant morphological characteristics, yield, and chemical composition of desho grass (Pennisetum pedicellatum Trin.) in Northwestern Ethiopia. *Agricultural Science and Technology*, ***10*** (2): 107-114.

Musimba, N.R.K., Nguku, S.A., Njarui, D.N., Amwata, D.A. and Kaindi, E.M. (2016). Primary production variables of brachiaria grass cultivars in Kenya dry lands.

Negash, D. (2018). Review on Dairy Cow Feed and Feeding Aspects in Ethiopia. *CPQ Nutrition*, **1** (1): 01-19.

Nguku, S.A., Njarui, D.N.,Musimba, N.K., Amwata, D. and Kaindi, E.M. (2016). Primary production variables of Brachiaria grass cultivars in Kenya drylands. *Tropical and Subtropical Agroecosystems*, **19** (1): 29-39.

Rambau, M.D., Fushai, F. and Baloyi, J.J. (2016). Productivity, chemical composition and ruminal degradability of irrigated Napier grass leave harvested at three stages of maturity. *South African Journal of Animal Science*, ***46*** (4): 398-408.

Rayburn, E.B., Lozier, J.D., Sanderson, M.A., Smith, B.D., Shockey, W.L., Seymore, D.A. and Fultz, S.W. (2007). Alternative methods of estimating forage height and sward capacitance in pastures can be cross-calibrated. *Forage & Grazing Lands*, ***5*** (1).1-6.

Rivas, L. and Holmann, F. (2005). Potential economic impact from the adoption of Brachiaria hybrids resistant to spittlebugs in livestock systems of Colombia, Mexico and Central America. *Livestock Research for Rural Development*, **17**(5). 2005.

Rusdy, M., 2014. Dry matter yield and nutritional quality of panicum maximum centrosema pubescens mixtures at different plant proportions and cutting intervals. *International Journal of Science, Environment and Technology*, **3**(6):2231-2241.

SAS (2004). Statistical Analysis System, User's Guide. Statistical. Version 7th ed. SAS. Inst. Inc. Cary. N.C. USA.

Serra, A.B., Serra, S.D., Fujihara, M., Orden, E.A., Cruz, L.C., Ichinohe, T. and Fujihara, T. (1996). Monthly nutrient variation of Para grass (Brachiaria mutica) and Star grass (Cynodon plectostachyum) collected from pastures grazed by goats. *Asian-Australasian Journal of Animal Sciences*, ***9***(2): 203-210.

Shiferaw, A., Puskur, R., Tegegne, A. and Hoekstra, D. (2011). Innovation in forage development: Empirical evidence from Alaba Special District, Southern Ethiopia. Development in Practice **21**(8):1138–1152.

Snijders, P.J., Wouters, A.P. and Kariuki, J.N. (2011). Effects of cutting management and nitrogen supply on yield and quality of Napier grass *(Pennisetum purpureum)* (544).

Soebarinoto, M.I.S. (2014). Growth Yield and Nutritive Value of New Introduced Brachiaria Species and Legume Herbs as Ruminant Feed in Central Sulawesi Indonesia. *Pakistan Journal of Agricultural Research*, ***27***(2).

Taweel, H.Z., Tas, B.M., Smit, H.J., Elgersma, A., Dijkstra, J. and Tamminga, S. (2005). Effects of feeding perennial grasses with an elevated concentration of water-soluble carbohydrates on intake, rumen function and performance of dairy cows. *Animal Feed Science and Technology*, **121** (3-4): 243-256.

Tesfaye, A. and Chairatanayuth, P. (2007). Management and feeding systems of crop residues: the experience of East Shoa Zone, Ethiopia. *Livestock Research for Rural Development*, 19(3): 6-12.

Tilahun, G., Asmare, B. and Mekuriaw, Y. (2017). Effects of harvesting age and spacing on plant characteristics, chemical composition and yield of desho grass (Pennisetum pedicellatum Trin.) in the highlands of Ethiopia. *Tropical Grasslands-Forages Tropical*, ***5***(2): 77-84.

Tolera, A., Yami, A. and Alemu, D. (2012). Livestock feed resources in Ethiopia: Challenges, Opportunities and the need for transformation.

Tudsri, S., Jorgensen, S.T., Riddach, P. and Pookpakdi, A. (2002). Effect of cutting height and dry season closing date on yield and quality of five Napier grass cultivars in Thailand. *Tropical Grasslands*, ***36***(4):248-252.

Van Soest, P.V., Robertson, J.B. and Lewis, B. (1991). Methods for dietary fiber, neutral detergent fiber, and non-starch poly saccharides concerning animal nutrition. *Journal of dairy science*, **7 4** (10): 3583-3597.

Vélez-Santiago, J., Arroyo-Aguilú, J.A. and Rodríguez-Arroyo, J.E. (1985). Response of Stargrass to fertilizer and solid cattle manure in Puerto Rico. *The Journal of Agriculture of the University of Puerto Rico*, **69**(3):323-330.

Wassie, W.A., Tsegay, B.A., Wolde, A.T. and Limeneh, B.A. (2018). Evaluation of morphological characteristics, yield and nutritive value of Brachiaria grass ecotypes in northwestern Ethiopia. *Agriculture & Food Security*, **7** (1): 1-10.

Yadessa, E. (2015). Assessment of feed resources and determination of the mineral status of livestock feed in Meta Robi District, West Shewa Zone, Oromia Regional State, Ethiopia (Doctoral dissertation, Ambo University).

Zemene, M., Mekuriaw, Y and Asmare, B. (2020). Effects of plant spacing and harvesting age on plant characteristics, yield and chemical composition of para grass (*Brachiaria mutica*) at Bahir Dar, Ethiopia. *Scientific Papers Animal Science and Biotechnologies*, **53** (2): 137-145.

Zereu, G and Lijalem. T (2016): Status of improved forage production, utilization and constraints for adoption in Wolaita Zone, Southern Ethiopia. *Livestock Research for Rural Development.* **28**

Zewdu, T. (2008). Effect of plant density on morphological characteristics, yield and chemical composition of Napier grass (Pennisetum purpureum (L.) Schumach). *East African Journal of Sciences*, **2** (1): 55-61.

Zewdu, T., Baars, R.M.T. and Yami, A. (2002). Effect of plant height at cutting, source and level of fertilizer on yield and nutritional quality of Napier grass (Pennisetum purpureum (L.) Schumach.). *African journal of range and Forage Science*, **19**(2): 123-128.

8. APPENDICES

Appendix Figures A: Photos taken during the experimental periods

Appendix Figure 1: Napier grass stands before mowing

Appendix Figure 2: Desho grass stands after mowing

Appendix Figure 3: Field pictures were management activities applied

Appendix Figure 4: Field pictures during 60 days of sampling

Appendix Figure 5: Field pictures during 90 days stand

Appendix Figure 6: Field pictures during 120 days stand

Appendix B: ANOVA tables

Appendix Table 1: ANOVA table of morphological parameters of Para grass

parameters	Source	DF	Sum of Squares	Mean Square	F-Value	p- Value
PH	Model	2	1546.8	773	85	0.0001
	Error	6	54.5	9		
	Corrected t	8	1601			
NTPP	Model	2	2074	1037	8.56	0.0175
	Error	6	727	121		
	Corrected t	8	2801			
NLPP	Model	2	1758111	879055	31	0.0007
	Error	6	167763	27960		
	Corrected t	8	1925875			
LSR	Model	2	0.05	0.02	0.42	0.6751
	Error	6	0.42	0.07		
	Corrected t	8	0.48			

Where, PH= plant height, NTPP= number of tillers per plant, NLPP= number of leaves per plant, LSR= leave to steam ratio, DF= degree of freedom

Appendix Table 2: ANOVA table of morphological parameters of Desho grass

parameters	Source	DF	Sum of Squares	Mean Square	F- Value	p- Value
PH	Model	2	416	208	3.55	0.0060
	Error	6	351	58		
	Corrected t	8	768			
NTPP	Model	2	11716	5858	18.22	0.0028
	Error	6	1929	321		
	Corrected t	8	13646			
NLPP	Model	2	727276	363638	17.36	0.0032
	Error	6	125658	20943		
	Corrected t	8	852934			
LSR	Model	2	0.0008	0.0004	0	0.9973
	Error	6	0.89	0.149		
	Corrected t	8	0.89			

Where, PH= plant height, NTPP= number of tillers per plant, NLPP= number of leaves per plant, LSR= leave to steam ratio, DF= degree of freedom

Appendix Table 3: ANOVA table of morphological parameters of Napier grass

parameters	Source	DF	Sum of Squares	Mean Square	F- Value	p- Value
PH	Model	2	4495	2247	17.76	0.003
	Error	6	759	126		
	Corrected t	8	5255			
NTPP	Model	2	44	22	4.22	0.03
	Error	6	31	5		
	Corrected t	8	75			
NLPP	Model	2	25077	12538		
	Error	6	17089	2848	4.4	0.0566
	Corrected t	8	42167			
LSR	Model	2	0.0005	0.0002	0	0.9973
	Error	6	0.61	0.1028		
	Corrected t	8	0.61			

Where, PH= plant height, NTPP= number of tillers per plant, NLPP= number of leaves per plant, LSR= leave to steam ratio, DF= degree of freedom

Appendix Table 4: ANOVA table of chemical composition and dry matter yield for para grass

parameters	Source	DF	Sum of Squares	Mean Square	F- Value	p- Value
Ash (%)	Model	2	7.47	3.73	6.14	0.0354
	Error	6	3.65	0.60		
	Corrected t	8	11.12			
CP (%)	Model	2	38.76	19.38	70.77	0.0001
	Error	6	1.64	0.27		
	Corrected t	8	40.41			
NDF (%)	Model	2	17.92	8.96	57.62	0.0001
	Error	6	0.93	0.15		
	Corrected t	8	18.86			
ADF (%)	Model	2	7.59	3.79	34.55	0.0005
	Error	6	0.65	0.11		
	Corrected t	8	8.25			
ADL (%)	Model	2	1.43	0.71	29.71	0.0008
	Error	6	0.14	0.02		
	Corrected t	8	1.57			
DMY(t/ha)	Model	2	43.96	21.98	9.31	0.0145
	Error	6	14.16	2.36		
	Corrected t	8	58.13			

Where, *CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, ADL= Acid detergent lignin, DMY (t/ha) = Dry matter tone per hectare,*

Appendix Table 5: ANOVA table of chemical composition and dry matter yield for Desho grass

parameters	Source	DF	Sum of Squares	Mean Square	F- Value	p- Value
Ash (%)	Model	2	4.65	2.32	8.38	0.0183
	Error	6	1.66	0.27		
	Corrected t	8	6.3138			
CP (%)	Model	2	52.08	26.04	126.7	0.0001
	Error	6	1.23	0.21		
	Corrected t	8	53.32			
NDF (%)	Model	2	19.09	9.55	15.84	0.004
	Error	6	3.62	0.61		
	Corrected t	8	22.72			
ADF (%)	Model	2	8.49	4.24	4.32	0.05689
	Error	6	5.9	0.98		
	Corrected t	8	14.41			
ADL (%)	Model	2	5.22	2.61	14.49	0.005
	Error	6	1.08	0.18		
	Corrected t	8	6.31			
DMY(t/ha)	Model	2	16.75	8.37	19.79	0.0023
	Error	6	2.54	0.42		
	Corrected t	8	19.29			

Where, *CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, ADL= Acid detergent lignin, DMY (t/ha) = Dry matter tone per hectare,*

Appendix Table 6: ANOVA table of chemical composition and dry matter yield for Napier grass

parameters	Source	DF	Sum of Squares	Mean Square	F- Value	p- Value
Ash (%)	Model	2	23.25	11.63	31.74	0.0006
	Error	6	2.19	0.36		
	Corrected t	8	25.45			
CP (%)	Model	2	45.41	22.71	62.11	0.0001
	Error	6	2.19	0.36		
	Corrected t	8	47.6			
NDF (%)	Model	2	2.39	1.15	49.48	0.0002
	Error	6	0.14	0.02		
	Corrected t	8	2.45			
ADF (%)	Model	2	12.64	6.32	15.63	0.0042
	Error	6	2.42	0.41		
	Corrected t	8	15.06			
ADL (%)	Model	2	1.45	0.72	1.10	0.03908
	Error	6	3.93	0.65		
	Corrected t	8	5.38			
DMY (t/ha)	Model	2	19.81	9.91	16.28	0.0038
	Error	6	3.65	0.61		
	Corrected t	8	23.46			

Where, *CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, ADL= Acid detergent lignin, DMY (t/ha) = Dry matter tone per hectare,*

Appendix C: Ethical clearance certificate

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ADDIS ABABA UNIVERSITY
College of Veterinary Medicine
and Agriculture
Bishoftu

Animal Research Ethical Review Committee

Ethical clearance certificate

Certificate Ref. No: VM/ERC/21/06/13/2021

Name of Applicant: **Tobiyaw Tsegaye (BSc in animal Science, MSc fellow)**

Address: Department of Animal Production Studies, College of Veterinary Medicine and Agriculture, Addis Ababa University

Title of the project: *Effecs of cutting interval on morphological parameters, biomass yield and chemical composition of para (Brachairia multicastapf), Napier (Pennisetum purpureum) and Desho (Pennisetum pedicellatum) grasses grown under irrigation condition in Mecha Woreda, West Gojjam Zone, Ethiopioa*

Date of application:	**December, 2020**
Nature of the project:	**Animal feed study**
Target animal species:	**None**
Number of animals involved:	**None**
Study area:	**Mecha Woreda, Ethiopia**

Minutes No. and date of review: **VM/ERC/06/13/021, 28/03/2021**

The above indicated research project has no ethical issues involved. Hence it can be executed without any condition.

Getachew Terefe (DVM, PhD, Professor of Vet. Parasitology) Signature
Chairman

The Federal Democratic Republic of Ethiopia
Addis Ababa University College of Veterinary Medicine and Agriculture

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Please quote Our Ref. No. When replying

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