DISEASE INCIDENCE AND GROWTH LEVELS OF SELECTED BRACHIARIA CULTIVARS IN SELECTED AGRO- ECOLOGICAL ZONES OF WESTERN REGION IN KENYA

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DECLARATION

This research is my original work and has not been presented for the award of any certificate degree in any university or for any other award.

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance of Masinde Muliro University of Science and Technology a thesis entitled, **"Disease Incidence and Growth Levels of Selected Brachiaria Cultivars in Selected Agro-Ecological Zones of Western Region in Kenya".**

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DEDICATION

I dedicate this thesis to my late father Richard Sitienei, my mother Leah Sitienei, my husband Josephat Nairutia Kemei, my children; Blessing Jepkoech Achua Nairutia, Japhet Kiprotich Longilai Nairutia, and Jasper Kiprono Ewoi Nairutia, and my other siblings whom without their support, understanding, and encouragement, I would not be able to have such an academic journey.

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ABSTRACT

Brachiaria is a new forage grass that has been introduced in Kenya and other nations with a big potential of enhancing the productivity of livestock. Its small seed size is however a major limitation to mass adoption. Pasture production in Western Kenya is facing the pathological and physiological issues which are caused by the Biotic and abiotic stressors and this poses negative impact on the performance of livestock more so in dairy industry. Although its use has gained increased significant, little information is available on the tolerance of the disease, seed viability and agronomic performance of Brachiaria cultivars in dissimilar agro-ecological settings, particularly its LM1 (Alupe) and LM2(Kakamega) cultivars. The current research was prompted by this research gap, as well as growing need to find a sustainable substitute to Napier grass. The overall aim of the research was to compare levels of disease incidence, growth and yielding potential of some Brachiaria cultivars in some ecological areas of Western Region, Kenya. In addition, the study had the objectives of assessing the disease tolerance, growth performance, light interception, leaf area index (LAI), and yield potential of selected Brachiaria cultivars Xaraes (Brachiaria brizantha cv. Xaraes), Piata (Brachiaria brizantha cv. Piata), MG4 (Brachiaria brizantha), Basilisk (Brachiaria decumbens), and Mulatto II (Brachiaria ruziziensis) with Mulatto II being used as a control. The split-plot design was adopted, where cultivars were the primary plot factor and defoliation regime (no defoliation, single defoliation, and constant defoliation since week 12) was the subplot factor. Three repetitions of the experiment were done at two agro-ecological sites, namely KALRO Kakamega (LM2) and KALRO Alupe, Busia (LM1), which were housed in a factorial design of 3x5x2. Planting material was in form of root splits obtained in KALRO Kakamega. At the planting stage, phosphate fertilizer, (40 kg/ha P2O5) was applied and nitrogen topdressed at the rate of 100 kg/ha N. Data was recorded after every four weeks and involved plant height, number of tillers, biomass yield, incidence of pest and disease, number of infloescences, seed yield, and germination rates. Mulatto II grew to the highest and Basilisk the lowest in LM1; the same occurred in the reverse in LM2. Basilisk had the most number of tillers in both regions. False smut (58%), and ergot (69.33) had the greatest impact in LM2 on Basilisk. MG4 had the lowest ergot incidence rate (41%), and Xaraes had the lowest false smut incidence rate (32%). LM1 showed no cases of disease. Most cultivars intercepted more light in LM2 than in LM1. The maximum interception of light penetration was higher in Mulatto II with the lowest light interception in Xaraes in LM1. Basilisk was the light interception leader in LM2, and Xaraes was the lowest. The same trend was observed with LAI, with exception of MG4 which registered the lowest LAI in LM1. All cultivars had the potential to high forage yield. Basilisk was the most profitable in LM1 and Piata was the least. In LM2 this trend was inverted. The cultivars were also divided according to flowering time Basilisk, MG4, and Mulatto II were early flowering and Xaraes and Piata were late flowering. Cultivar had no significant effect on seed weight with Xaraes and Mulatto II recording the highest seed weights at 100 seeds (0.38 +- 0.019 g) with Basilisk recording the lowest (0.32 +- 0.019 g). But the germination of the seeds failed and fungus of a dark sooty soil appeared probably an outcome of contamination with disease. The importance of the findings is that cultivars such as MG4 and Basilisk have been identified having high forage yield, improved disease resistance, and early flowering characteristics which are useful in breeding, pasture enhancement, and sustainable seed production plans in Kenya. The findings are particularly useful to small-scale dairy farmers, researchers, extension workers, and seed producers in search of resilient, high-yielding forages to fit the local aspect of the environment. The present study gives the background data of the performances of the specific Brachiaria cultivars and outlines disease as a significant factor that reduces seed viability. Cultivar-specific disease response, defoliation response and light-use efficiency were created and can inform future breeding programs and pasture management practices. The results enhance the comprehension on improving the quality and availability of Brachiaria seeds, hence the use of the results to support the process of upscaling Brachiara production and increasing the yield of dairy in smallholder agricultural systems in Kenya.

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ABREVIATIONS AND ACRONYMS

CIAT	Centro International de Agricultural Tropical
DM	Dry Matter
EMBRAPA	Brazilian Agricultural Research Corporation
GDP	Gross Domestic Product
IPCC	Intergovernmental panel to climate change
KALRO	Kenya Agricultural Livestock and Research Organization
KEPHIS	Kenya Plant Health Inspectorate service
NSD	Napier Stunt Disease
FAO STAT	Food and Agriculture Organization Statistics
MAS	Marker Assisted Selection
SIMLESA	Sustainable Intensification of Maize-Legume systems for food security in Eastern and Southern Africa
LAI	Leaf Area Index
LI	Light Interception

DEFINATION OF TERMS

Cultivar Refers to a plant variety that has been produced in cultivation by selective breeding

Defoliation Refers to harvest the top part of the grass for herbage yield.

Diseases Refers to a disorder of structure or function in plant, especially one that has a known cause and a distinctive group of symptoms, signs, or anatomical changes.

Incidence Refers to the occurrence, rate, or frequency of a disease.

Inflorescence Refers to a complete flower head of a plant.

Leaf area index Refers to the total leaf area per unit ground area.

Light interception Refers to the amount of solar radiation absorbed by a canopy.

Plant height Refers to the shortest distance between the upper boundary of the leaf on a plant and the ground level.

Stool Refers to the grass cover per plant

Tillering Refers to the production of side shoots

CHAPTER ONE

INTRODUCTION

This chapter covers the background information, problem statement, objectives (general and specific), research questions and justification, providing a comprehensive foundation for the research.

1.1 Background information

Production of dairy cattle is a very important agricultural business in Kenya and both the national and the county government have very high value of this produce. Small-scale farmers also prioritize it because it contributes 14 percent to the agricultural GDP (Janetrix, 2019). The dairy industry is a part of six pillars of Kenya vision 2030 and the bottom-up economic systems. This area is one of the sectors that the government plans to develop agricultural initiatives by establishing projects that would enhance better food security, raise the income of rural households and allow young people to get jobs. Moreover, dairy farming enhances the ability of sustainable agriculture to produce manure (Maina et al., 2020).

Although it is important, milk production per cow is low in many occasions less than 10 liters per day in better dairy cows primarily because of the low quality of available feeds (Mudavadi et al., 2020). To this, the government has focused on conducting research and marketing of on-farm production technologies on high yielding forage to cut the cost of production of milk. Smallholder dairy farmers are also faced with the threat of Napier stunt disease that leads to a 40-80 percent decrease in forage yield (Asudi et al., 2015). Tolerant or resistant cultivars development and acceptance is the most promising solution since there is no effective control method currently.

Over the last few years, Kenya Agricultural and Livestock Research Organization

(KALRO) in partnership with others has introduced high yielding hybrid Brachiara brizantha cultivars that have been sourced at CIAT in South America. The cultivars are known to be highly productive in different agro-ecological regions in Kenya (Njarui et al., 2016). More so, they have presented some other advantages of managing stem borers with the push-pull technology, as well as suppressing soil erosion (Sobhy et al., 2022). Brachiaria is an African species, but during the 1960s and 1970s when grassland research were at their highest point, the species were not much utilized as pasture in Eastern Africa (Namazzi et al., 2020).

The limited availability of quality seeds is considered to be one of the key limitations to the implementation of these cultivars which may help resolve the problem of the feed shortages that take away 55-70% of the total cost of dairy production. The other major challenge is the post-harvest handling processes during the process of harvesting and storing (Batello et al., 2008). At the moment, farmers use root splits to propagate. They are costly to transport and their set up is so much weather-dependent. Also, the seed yield of such Brachiaria varieties has not been sufficiently examined. The general objective of the project is to provide knowledge based information on the production of high quality Brachiaria on the early growth parameters such as height, numbers of tillers, light interception leaf area index, herbage and seeds in the view of increasing their availability and accessibility to smallholder dairy farmers.

1.2 Statement of the problem

Brachiaria grass is a tropical agricultural and environmental agricultural forage that is native to Africa (Njarui et al., 2020). Over the last couple of years, Napier grass, which forms the main forage crop among smallholder dairy farmers in Kenya, has been getting progressively affected by Napier stunt and head smut diseases, which cause a 40-80% reduction in forage yields (Negawo et al., 2017). The few successful control measures of these diseases exist in the recent past. The Government of Kenya, in its turn, launched sourcing and screening of high-yielding Brachiaria cultivars, as alternative forages. Although, there is a paucity of data about disease tolerance, field performance and growth properties of these Brachiaria cultivars under various agro-ecological conditions in Kenya. It is necessary to understand the disease potential and agronomic performance of such cultivars, so that there is no introduction of replacement forage, which may also be susceptible to biotic and abiotic stressors. Also, this information is required to breed desirable germplasm that produces high yield and has resistance to diseases which can be used long-term as a forage crop (Sandhu et al., 2015).

Despite the fact that Brachiaria may be grown by both seeds and root splits, Kenyan farmers at the moment use nearly all root splits, where root splits are obtained at research stations or through their acquaintances. The seed quality is not produced locally and it has to be imported at very high prices, say KSh 6,000 per kilogram, which is not affordable by the majority of smallholder farmers. Moreover, root splits are logistically difficult: they are very heavy, expensive to carry, and their installation largely relies on the good weather conditions. In dry soil or hot weather there is usually a poor establishment. Pathological and physiological issues are also likely to occur in root splits, which affect productivities in the long run (Ghimire et al., 2019). The research, therefore, fills two important gaps, namely, the absence of local information on disease tolerance and growth performance of the Brachiaria cultivars under field conditions in Western Kenya, and access to quality, locally-produced Brachiaria seed. The results will be used to come up with better disease tolerant cultivars with high yield potential that can be used to supplement informal and formal seed systems to increase forage production by the smallholder farmers.

1.2 Justification of the Study

Most of the people in the western part of Kenya are mixed farmers where small scale farmers grow crops and farm cows (Musotsi et al., 2008). Low quality forage feeds of livestock which is cost-effective to produce dairy is a problem that most livestock farmers in western Kenya have. NSD threatens the use of napier grass that has been in use over the years by lowering the yields by 40 -80 percent. Despite the fact that other elements (rainfall, agronomic practices, soil fertility, and pest management) play an equally critical role, seed quality plays a critical role in achieving a good crop stand and quick growth of plants even in unfavorable conditions (Assefa et al., 2012).

To sustain the small holder dairy system in western Kenya, there is need to develop high yielding fodder grasses that resist the pests and diseases of the tropical pasture. Brachiarya hybrids have been found to have the potential to offer quality forage in a broad agro ecological area. Brachiaria grass is a climate smart crop that can reduce climatic changes by preventing release of nitrous oxide and thus greenhouse gases thus alleviate feed shortage that will ultimately increase the income of a resource constrained farmer (Njarui et al., 2020).

Thus, the study has been pegged to sustainable development goals (SDGs) number 1 on poverty reduction by provision of job opportunities, 2 zero hunger as state by Njarui et al., 2020 and 15 lives on land by planting Brachiaria it supports the eco-system (Morton, 2007). Current root splits used as planting materials are heavy and are costly to transport and also, establishment is poor in high temperature and low moisture soils. Thus, access to good quality of Brachiaria that are disease-resistant and high in growth should increase the availability of forages and consequently more milk, as well as profits, as well as profitability of small-scale farmers in Western Region, Kenya.

1.3 Objectives

1.3.1 General objective

The general objective of the study was; to evaluate disease incidence levels, growth and yielding potential of selected Brachiaria cultivars in selected ecological zones of Western Region, Kenya.

1.3.2 Specific objectives

The specific objectives that guided the study were:

i. To determine the growth and disease levels of ergot and false smut of selected Bracharia cultivars in selected agro-ecological zones of Western Region, Kenya.

ii. To determine the light interception and leaf area index under field conditions of the selected Brachiaria cultivars in selected agro-ecological zones of Western Region, Kenya.

iii. To determine the herbage and seed yielding levels of selected Brachiaria cultivars in selected agro-ecological zones of Western Region, Kenya.

1.3.3 Research Questions

The research questions that addressed the above specific objectives were as follows:

i. What are the growth and disease levels of ergot and false smut of selected Brachiaria cultivars in selected agro-ecological zones of Western Region, Kenya?

ii. What was the light interception and leaf area index under field conditions of the selected Brachiaria cultivars in selected agro-ecological zones of Western Region, Kenya?

iii. What are the herbage and seed yielding levels of selected Brachiaria cultivars in selected agro-ecological zones of western Region, Kenya?

1.4 Significance of the study

This research was required because of the desperate condition of alternative forage options in Kenya where Napier grass is the crop of forage and has been hit hard by disease like Napier stunt and head smut resulting in the loss of large quantities of yield. Although indigenous in Africa, previously Brachiaria was a major part of the local forage system until it was reintroduced in research programs in recent years. However, its efficiency in the Kenyan field conditions has not been widely reported. This research paper fills that gap by assessing the adaptability, growth performance, and disease tolerance of various types of Brachiaria growing in the LM1 (agro-ecological region of western Kenya Alupe) and LM2 (Kakamega) agro-ecological regions.

The practical uses that the findings have are especially to the smallholder farmers, who are given evidence-based suggestions on high yielding, disease resistant cultivars that would be used to substitute or supplement Napier and Rhodes grasses. Through the measurement of light interception and leaf area index, the research also determines cultivars that can be used in the agroforestry systems, which are becoming a significant land-use approach in Kenya.

In addition, the paper presents major ailments that restrict Brachiaria seed yield and recommends ways of managing them, which could advance the production of local seed systems. On the whole, this study will help Kenya to produce more resilient, productive and sustainable forage production, which will benefit livestock farmers, researchers and agricultural policy-makers directly.

CHAPTER TWO

LITERATURE REVIEW

This chapter offers the review of several issues regarding Brachiaria beginning with the description of the livestock production and the description of Brachiaria including its origin, the morphology of Brachiaria and its reproductive development. The chapter also discusses how Brachiaria is a suitable resilient forage crop. It looks at the influences on the growth and seed yield of the Brachiaria cultivars including insect pests, pathogens, climatic conditions, defoliation, and light interception. Also, the review explores the quality of the seeds and the differences that the harvesting stage and storage have on the seed yield and quality providing substantial background to the context of the research.

2.1 Livestock production

The rural population of Sub-Saharan Africa depends on livestock production as a source of food and income (Enahoro et al., 2019). In the Kenyan economy, livestock has been a vital ingredient and in the agricultural industry (Herrero et al., 2013; Alila et al., 2006). Records indicate that the industry has as many as 50 to 80 percent of all the populace who rely on Agriculture (FAOSTAT 2005). Livestock keeping leads to numerous advantages with increase in consumption and demand of red meat, as well as milk. These include nutritional food security, creation of employment opportunity, growth and development of household incomes and can make the agricultural industry a major contributor to the 10% per year economic growth rate envisaged under the economic pillar as is in Agricultural Sector Development Strategy 2010-2020 and Kenya Vision 2030.

A long-term drought in the East African Humid Highlands has placed a pressure on cattle feed supply (Bryan et al., 2013). Overall, rising temperatures with a prolonged period of drought have affected the fodder quantity and quality severely; reducing the level of cattle production (Giridhar et al., 2015). Other factors that have led to poor milk and meat production in the Sub-Saharan countries especially Kenya include lack of quality and quantity of feed. The lack of climate-smart fodder types, irregular and prolonged droughts, pests and diseases are the primary factors that lead to the lack of quality and quantity of feed (Alemu et al., 2019; Zougmore et al., 2018). The increasing adoption of Brachiaria in eastern Africa has been slowed due to the inability to find seed and the commercial industry not willing to cater to an unorganized and diffuse demand of seeds (Ghimire et al., 2019).

To address this issue, farmers should be advised to integrate forage in crop-livestock systems in a frequent manner to ensure that cattle meals are present (Paul et al., 2020). Due to the reduction in land size per household, bad management and overstocking, natural pastures have been grossly overgrazed and therefore they have become highly degraded, useful species extinct, and the undesired species having taken over (Busso et al., 2018).

2.2 Description of Brachiaria

2.2.1 Origin of Brachiaria

Brachiaria is a genus of grass commonly referred to as Brachiaria and used as forage in Latin America, Asia, South Pacific, Australia and Africa (Miles et al., 2004). Most Brachiaria are of African origin, America is the center of Brachiaria variety (Mutimura and Ghimire, 2021). Even though Brachiaria species are African and diverse, they have not been identified as the choice to be used to expand pastures in eastern Africa in the 1960s and 1970s when grassland research was at its zenith (Reid et al., 2005). Due to the favorable agronomic and environmental characteristics suggested by other authors and access to better cultivars via research provided by CIAT and EMBRAPA in South America, Brachiara was chosen as a potential forage in its home country, east Africa (Maass et al., 2015).

Native Brachiaria species have been used to graze animals by native people in Africa and Latin America. Traditionally, such grasses were chosen according to the following characteristics: drought resistance, palatability, and resistance to grazing pressure (Machogu, 2013). The 20 th century saw the emergence of scientists who started appreciating the potential of the Brachiaria grasses in enhancing livestock production in the tropical areas. Attempts were made to locate and harvest different germplasm in their natural habitats to be evaluated and bred. The development of formal breeding programs of Brachiaria species started in the mid-20 th century, mostly in tropical countries and Brazil (Gordon, 2017).

The objective of these programs was to come up with better cultivars, which had a higher forage yield, better nutrition quality, resistance to diseases and adaptation to these geographical areas. Breeders used the conventional selection and hybridization procedures to come up with new cultivars. This included picking individual plants whose characteristics are desirable, e.g. fast growth or resistance to diseases, and hybridizing them to produce new genetic formations (Sandhu et al., 2015). Hybridization has been very important in the breeding of Brachiara in the recent decades. In some cases, such as hybrid cultivars, which are usually the product of a cross between two or more species or ecotypes, the new hybrids sometimes have superior characteristics over their parents, with an increased productivity, flexibility and pest resistance.

However, more recently, there have been successes in biotechnology and genomics to elicit the creation of superior Brachiaria cultivars (Gupta et al., 2021; Varshney et al., 2021). Such methods as the molecular marker-assisted selection (MAS) and the genomic selection enable breeders to identify and select plants that have the desired characteristics more effectively. Better breeds of Brachiara varieties were breed to enhance diversity by the introduction of germplasm to the Kenyan environment to make the forage resource stronger in livestock programs, which are now commercially marketed to farmers in the tropical parts of the world (Nguku et al., 2016). The benefits of these cultivars include increased yields of forage, improved nutritional value, and improved livestock production system sustainability (Maass et al., 2015). With the exception of Africa, Brachiaria was a common pasture crop cultivated in the tropics (Ghimire et al., 2019).

2.2.2 Morphological characteristics of Bracharia

The interactions between biological factors, abiotic factors, and the physiological processes, anatomy, and morphology are used to alter the distribution of species, the rate of growth, the time of production, and the quality of the forage. Piata (Brachiaria brizantha) is the grass usually has medium to tall growth habit, fine stems and leaves, the leaves are normally narrow and may be either light to dark green, it grows faster after grazing or cutting and has a variety of species making it well to be utilized in livestock forage due to its high productivity.

Basilisk (Pennisetum purpureum) is a high growth rate with thick stems and broad leaves, and in most cases, the leaf is lengthy and may have a slightly serrated margin, a drought-tolerant plant, and can be used to provide high livestock forage, particularly in tropical areas (Wassie et al., 2018).

Brachiaria hybrid, Mulato II (Brachiaria hybrid) is a hybrid type which is formed through cross breeding of various species of the Brachiaria genus, It has generally fine stems and leaves and has a dense growth habit, the leaves of Mulato II may be of variable width, but they are generally narrower than some other Brachiaria variety and this grass type is known to have high forage quality, palatability, and fast regrowth and hence it is used in intensive grazing systems.

MG4 (Megathyrsus maximus x Megathyrsus infestus) is a cross between Megathyrsus maximus (previously Panicum maximum) and Megathyrsus infestus (previously Urochloa brizantha) it is generally medium to tall in growth habit and has wide leaves, has high yield potential, particularly under favorable soil and management conditions and is well adapted and persists well to a variety of soils and climates making it suitable to pasture and forage production in diverse environments (Nguku et al., 2

Xaraes (Brachiaria brizantha cv. Xaraes) or Brachiaria brizantha cv. MG-5 is an excellent example of a cultivar grew due to its very good forage properties and its variety of use in tropical climates. Morphologically, Xaraes is characterized by high biomass production by tall growth habit, robust tillering and wide and dark green leaves. It boasts of a strong rooting system and this increases its drought resistance and low-fertility soils resilience (Odiko et al., 2021). The grass has semi erect growth form and foliage is very dense hence it is suited to rotational grazing systems. Xaraes is quite palatable to livestock and has a high nutritional content especially the crude protein and digestibility, relative to the older Brachiaria varieties. It grows fast after grazing or pruning and thus allows frequent harvesting and indefinite forage supply.

In addition, Xaraes has been observed resisting spittlebugs (or Brachiaria classic pest), which leads to its survival in pasture systems (Valle et al., 2009). These characteristics render Xaraes a significant aspect in sustainable livestock production particularly in the tropical areas of Africa, Latin America and Southeast Asia.

It has been found that the availability of forage can change according to environmental response of forage. The morphology of the plant is directly related to maturity of the plant in a certain environment (Arzani et al., 2004). Morphological characterization of plants shows good attributes in both farmers and breeders (Mwenda, 2019, Wassie et al., 2018).

2.2.3 Brachiaria reproductive growth

The quality of Brachiaria seeds is greatly affected by dormancy and vitality (Liu et al., 2022). Energy is determined by seed maturity at time of harvest. Dormancy in the genus is developed, and at least is maintained in most species. Brachiaria species can be reproduced in two methods, vegetative reproduction that is quite simple and not practical in large scale whereas seed reproduction is recommended in commercial practices (Miles, 2007). The studies have revealed that agronomic practices have a significant effect on reproduction process in Brachiaria. Sword is usually inflorescent and it grows at a slow rate, very sparsely and synchronously (Smith, 2011).

The reproduction starts with the growth of tillers within the sword. It is recommended that Brachiaria performs optimally in moist soils that contain sufficient nitrogen and average daily temperature of approximately 23degC (Gobius et al., 2001). Based on particular photoperiodic needs, the tillers develop into distinct bursts triggering flowering (Loch et al., 2004). After spikelet differentiation and inflorescence, it could require six days or more to induce floral initiation. At this phase, anthesis on a single head is made. Seeds have to be pollinated at least in part whether they develop sexually or apomictically, there may also be a failure in seed formation during the anthesis phase because of biotic processes like drought. The caryopsis in Brachiaria would reach a certain size which is predetermined by the size of the husk. In plants, once the seeds are full, their caryopsis is fully grown to keep out external bodies such as water or fungus hyphae (Loch et al., 2004).

Maturation of a population of pure seeds is easily assessed in this case, through a measure of average pure seed spikelet weight and consistency of spikelet sizes. A low amount of less than 450mg/100 seeds signifies low maturity status, moderate amount of 450-500 and high amount of 500 or more (Mwangi et al., 2003).

2.2.4 Suitability of Brachiaria as a resilient forage crop

Brachiaria grass is also healthy and very high biomass producer; hence, it can be used to increase the cattle productivity (Wassie et al., 2018). The definition of seed quality entails all the physical, biochemical, pathological, and genetic factors leading to the ultimate production of forage crops. Brachiaria grass is an increasingly dependable blend feed either as a mixture with Panicum (Megathyrsus maximum) or as a pure stand (Peters et al., 2021).

It has a vast root system capable of enhancing the efficiency of nitrogen uses as well as capturing carbon (Rao et al., 2016). Various experimental field trials have shown that Brachiaria can be incorporated in different agro-ecological zones and increase the productivity of cattle (Maina et al., 2020). It was demonstrated that Brachiaria increases the milk production by 3-5 liters per day (SIMLESA, 2015). Brachiaria is a nutritious and tasty fodder and it will keep the dairy and meat industries active as well as reducing the carbon footprint of livestock production (Gadissa et al., 2020).

It has been found that Brachiaria could yield a dry matter of between 21 and 28 t/ha/year and crude protein at 16% in studies conducted in various agro-ecological areas of Kenya (Njarui et. al., 2016). In most cases, Brachiaria cultivars have been found to have low yields in terms of seeds (Esteban et al., 2013; Hare et al., 2007). Esteban et al., (2013) found the yield of seeds at 150 kg ha-1 of Mulato II and Cayman. Previous research by Hare et al., (2007) had presented less than 200 kg/ha seed of Mulato II hybrid in Mexico and attributed the low seed yields to be due to sterility of pollen and lack of caryopsis maturation.

The variation in the amount of seeds that the various Brachiaria cultivar produce is credited to the dissimilarity in the genetic aspect and environmental factors. Deep roots and stomatal control were found to be the basis of drought resistance in Brachiaria in response to varying water availability (Habbermann et al., 2021). Besides, provided statement on push pull-technology, restoration of damaged lands and prevention of soil erosion (Ndayisaba et al., 2023). As such, the presence of Brachiaria seeds will assist the farmer to realize these with ease as the transportation of the seeds, planting and adapting them is less challenging.

2.3 Factors affecting Brachiaria cultivars on growth and seed yield

2.3.1 Effect of Insect pests and pathogens on growth and seed yield of Brachiaria species

Brachiaria is a valuable tropical forage grass which is of African origin. Its performance is affected by various restrictions like diseases. In sub-Saharan region, some of the diseases that often attack the pastures are specie to species depending on their susceptibility. Among others, leaf blight, leaf rust, leaf spot and NSD have been reported. Low productivity of pasture is also caused by pests. An example would be the spittlebug that is the most destructive pest of Brachiaria pasture in the tropics. It has also been recorded that red spider mites and leaf cutting aunts are the most significant threats to the survival of Brachiaria cultivars (Brigitte et. al., 2014).

Root-knot nematodes infest all plant species and result in microscopic to massive galls to root knots (Moens et al., 2009). As an example, Nacobbus aberans happens to be a root knot nematode, which afflict fodder crops. It affects the physiology of the plant leading to decrease in yield and quality of the products. The amount of juveniles infecting field contain penetrates the young plants; establishes itself in the root tissues. Nematode species such as Meloidogyne have, however, been found in vegetative planting material like splits, but not in seeds (Moens et al., 2009). It is worth adding, however, that resistant rootstocks or splits may affect the microbial population of the soil surrounding the roots. Grass cyst nematodes like puctodera puctata have been reported by the authors meaning that the species infects the majority of grasses that are a good host to nematodes (Bacon et al., 2003).

Root infection by lesion nematodes is characterized by the grass seeming brown to reddish necrotic parallel to the axis of the root and subsequent secondary decay. Symptoms of infected plant may be seen above the soil and may include, but is not limited to, suppressed shoot growth and a sample decrease in the shoot -root ratio, nutritional deficiencies that manifest in the foliage (chlorosis), temporary wilting and reduced yields in plant. Only certified nematode -free plants in reputable nurseries are therefore recommended. The most significant diseases that have occurred in Brachiaria cultivars in Kenya are; Leaf spots, which are defined by black to brown spots on the Brachiaria leaves. The infested leaves develop brown to black elevated spots on their leaves that changed to rough and irregular in extreme cases that made the leaf die. The disease has been reported in the following areas Nairobi, Ithookwe, Katumani and Mtwapa, where the disease was observed in orange or yellowish-orange raised pustules primarily on leaf blades.

The disease spreads to upper parts and is characterized by leaf blight that is characterized by appearance of long elliptical gray or tan lesions first on lower leaves. When severely infected, the result would be premature death and gray appearance similar to drought or frost damage Leaf blight has been reported in the following locations Ithookwe, Katumani, Nairobi, Mariakani, Msabaha and Mtwapa. False smut is the one in which single grains of Brachiaria are substituted with smut sori. They have registered the disease at Ithookwe. Another disease that impact brachia cultivar its first symptoms include a white soft ball of tissue on affected florets that yielded a sweet honeydew which later developed into a hard dry sclerotium and this disease has been reported in Nairobi (Nzoiki et al., 2016; Kamidi et al., 2016 and Njarui et al., 2016). Thus, the study contributes to the impression of the influence of these diseases and pests on Brachiaria cults in Western region and agro-ecological zones.

2.3.2 Effect of climatic condition on growth and seed yield of Bracharia cultivars

Brachiaria grass performs well in a broad climatic condition in Kenya. It thrives in regions where there are rainfall of more than 700mm and temperatures exceeding 19oC and well drained soils with pH of 5-8. The production of Brachiaria grass is ideal in the altitude above 1800mm above the sea level. In Kenya, Mulatto II, Cayman, Cobra, Piata, Xaraes, MG4 and Basilisks are majorly grown Brachiaria grasses. The average yields of the Brachiaria seeds vary between 1000kg/ha of pure seed and less than 100kg/ha but the quality depends on the dormancy and vitality.

A case in point is that Mulato II produced almost twice as many pure seeds per m 2 compared to Mulato I (161 kg/ha), and thus grew the seed production by 60 percent (Bakur et al., 2008). This has been proved before that the viability of the seeds is directly proportional to their maturity during harvesting. The average or weak water table influences the development of the root system of the grass (Taiz and Zeiger, 2009). Although the Brachiaria grass may be subjected to the stress but display growth potential of root towards the soil regions that were not as dry because during low water levels the top surface layer of soil is dry earlier.

Thus, this is viewed as a defensive process of the grass (Carrilho et al., 2012). The lack of light impacts the photosynthesis as well as reduces the uptake of carbon to grow plants (Lee et. al., 2007). Although, the yield of Brachiaria grass seed is high when cultivated in the partial light and partial shade (Carrilho et al., 2012). As such, the study aims at establishing the quantity of light that different Brachiaria cultivars absorb.

The Brachiaria seed yields an average of 1000 kg/ha of pure seed to less than 100 kg/ha but the quality depends upon the dormancy and vitality. An example is that Mulato II produced almost 2 times the amount of pure seeds per M2 when compared to Mulato I (161 kg/ha), which produced the seed more than 60 percent (Bakur et al., 2008). It has been established that the maturity of the seeds during the time of harvest is directly proportional to the viability of the seeds.

2.3.3 Influence of defoliation on growth and seed yield of Brachiaria cultivars

Defoliation is the untimely extraction of grass components via either ether grazing or cutting. The defoliation of the grasses and the variety of individual grasses posed a controversy more than a decade ago. Defoliation may either have positive or negative effect on growth and even seed production (Ferraro and Oesterheld, 2002).

Photosynthesis Reduction Leaves The major location of photosynthesis is found here. Defoliation causes a decrease in the photosynthetic capacity of the plant, which may retard growth. The level of growth loss is usually dependent on the amount and repetition of defoiliation (Wohlfahrt & Gu, 2015). In general, Brachiaria cultivars that have been subjected to defoliation develop quite resilience and growth. Nonetheless, extreme or continuous defoliation may reduce the stores on the plant and lead to a decrease in the strength of the regrowth. The recovery of the plant is also dictated by the genetic characteristics and general well-being of the plant (Low, 2015). Over-defoliation may cause low growth of roots. This may additionally affect the health and growth of plants as roots are important in the uptake of water and nutrients (Landhausser and Lieffers, 2012).

Defoliation has the ability to cause stress effect on Brachiaria such as growth patterns and nutrient distributions. Repeated defoliation may cause chronic stress that leads to the occurrence of detrimental effects on plant growth in the long run. Defoliation may have an effect on the reproductive stage of the plant. The plant may end up having fewer seeds because it lacks leaves and thus the photosynthetic capacity during flowering and seed development stage is lower, (Parra-Tabla et al., 2004). Different timings of the process of defoliation also have an influence on the yield of the seed. An example is that, defoliation at the reproductive stage is worse compared to defoliation at the vegetative stage (Emine & Sema, 2007). The capacity of the plant to regain manufacturing capacity and generate seeds following defoliation may vary. Other cultivars of Brachiaria might be more resilient to defoliation by enhancing seed production when given ample time to remerge than others do. Defoliation of plants may result in nutrient diversion to recovery and regenerate vegetation. It may produce reduced seed yields because the plant may favor growth and not production, (Ferraro

& Oesterheld, 2002). It influences the morphogenetic elements with regard to the frequency of defoliation and the intensity via physiological and environmental mechanisms (Francos and Gilles, 2015). Certain grasses such as total production suffer defoliation (Diego and Martin, 2002).

2.3.4 Effects of Light Interception on Growth, Forage, and Seed Yield of Brachiaria

Intercepting light is a major factor that determines the growth of plants, forage and seed yield especially in Brachiaria species. Guenni, Gil, and Guedez (2005) study gives a detailed examination of five Brachiaria species in the tropical environment with special focus on comparing the correlation between light interception and biomass production. They found that there were great differences in light-interception between the species, with those species with high light-interception getting high forage yields. The capacity to convert intercepted light into biomass was also a key consideration and certain species would have been more effective use of the available light to grow.

Light is a significant resource to the plant life and is extremely important in obtaining both the carbon and mineral nutrients. Shade tolerance is a trait, which would not have been predicted to evolve. Plants however vary in their ability to adapt to a low light environment which is a meritorious quality in grasses that are cultivated within other canopies (Zdravko and Orlando, 2007). Contrasting results have been published in regards to response of grasses to irradiance. In other reports, a greater biomass production was recorded under shade and a lesser production was recorded under non shade, accompanied or not with an augmentation of leaf N levels.

In a similar important research, Guenni, Seiter, and Figueroa (2008) examined the adjustments of three Brachiaria species to different levels of light and nitrogen levels.

This study has indicated that the light intensity, as well as nitrogen availability, is a significant factor in maximizing the growth of Brachiaria and its yield. The maximum yield of forage and seed was obtained due to high light and sufficient nitrogen levels. The differences in photosynthetic activity of the species in different light conditions on their overall growth performance and yield were also observed in the study. All these findings reinforce the need of light interception in the planting of Brachiaria. This is because there is efficient light interception that promotes photosynthesis which contributes to the production of more biomass and yield. The researches also demonstrate the multi-factorial interaction that exists between light and the other parameters like nitrogen supply that, when combined with light, control the growth and productivity of Brachiaria species.

Most studies have been done on a short-term basis and aimed at a specific environment, whereas the existing literature argues that the importance of light interception in Brachiaria growth and yield is important. The number of long-term studies analyzing the stability of these effects on the basis of several growing seasons is lacking. Besides, the interplay between light interception and other abiotic elements has not been properly examined like the soil moisture and soil temperature. The other gap is the genetic variation of the Brachiara species with regard to their ability to utilize and intercept light. This research was an attempt to fill these gaps by identifying how genetic enhancement can be made to increase light interception efficiency in Brachiaria species.

2.4 Seed quality

Brachiaria is a wide genus of approximately 100 species that are distributed throughout the tropics (especially in Africa) (Schiek et al., 2018). The use of many species to grow tropical pastures has generated agronomic attention to this genus. The

Brachiaria species, which contains Cayman, Mulato II, and Cobra, was introduced in Kenya in 2015 (Mwendia et al., 2021).

The selection of these grasses in South America is based on the fact that they are more resistant to pests, disease, and drought as compared to legumes. Consequently, it follows that forages can be readily modified to suit diverse climates (Annicchiarico et al., 2015). Three apomictic hybrids have been introduced (cvv). Mulato, Mulato II and Cayman) because the breeding program was launched in 1988 at CIAT. Studies have revealed that Mulato has agronomic potential of high herbage but low seed yields. An excellent grass that was found superior during trials in Central America was Mulato II, which is a deep-rooted grass with a high level of branched roots that makes it highly tolerant to drought situations in the Brazilian Cerrado and Mexico and has excellent nutritional content (Pizarro et al., 2013). Mulato II is non-fertilized all year round to yield green forage, palatable with a high yield of DM of 10-15t/ha (Ndung'u et al., 2016), drought-resistant, quick re-growth, persisting, perennially, and easy to cut and carry.

2.5 Effects of harvesting stage and storage on seed yield and quality

Good quality brachiaria grass seeds are very significant because the good quality seed has high yield per unit area because the genetic potentiality of the grass can be maximized, the infestation of land with weed seed/other crop seeds is low, disease and insect problem is low (Gbenou et.al., 2018). Reduced seed rate, quick and even germination of seed they are vigorous, able to self-adapt to extreme climatic and cropping system of the area, the quality seed was responsive to the applied fertilizers and nutrients, even population of the plant and maturity, good seed protracts life of a variety, their germination was easy, their marketability was easy (Mirza, 2015).

The spoilage of the seeds can start at any stage of growth of the plant starting at the fertilization stage. The quality of seeds relies on the physical environments under which the mother plant is grown or genetic or on the harvesting, processing, storage and planting. Seed growth is also influenced by temperature and other environmental factors, and this has an impact on seed quality (Rong et al., 2017). The hormone balance may cause seeds to be dormant over a long period, and hence early germination of seeds in adverse environments is restricted (Mirza, 2015). In the case of species dispersal given the field conditions in the context of survival, the germination events are spaced over a long time (Carneiro. 2014).

In Kenya, Nguku et al. (2016) and Kamidi et al. (2016) have mentioned the impact of harvesting stage and storage on seed yield and quality in Boma Rhodes grass and Brachiaria grass. Nguku et al. (2016) pointed out that Boma Rhodes grass seeds collected at full maturity gave higher germination and seedling vigor as opposed to those collected earlier. Kamidi et al. (2016) reported the same with Brachiaria grass in which the seeds collected at the optimal stage and those stored under cool and dry conditions maintained the best quality over time.

Nonetheless, there was a major gap in the research that was not filled on the way forward in illustrating the findings to enhance farming practices in Kenya. Little information is available concerning the long term economic effects of these streamlined harvesting and storage approaches on the smallholder farmers in Kenya. So, this study sought time to elapse to cause Brachiaria to bloom and how productive it was in terms of production.

2.6 Ecological principle

Principles of ecology are key, guiding principles that help us in the understanding of how ecosystems operate, interact and react appropriately to changes. Energy Flow explains the entry of energy into ecosystems which is through the process of photosynthesis where the plants convert sunlight into chemical energy. This energy is passed through the ecosystem through food chains and food webs and is passed to the producers, consumers and decomposers.

Energy is lost at every trophic level which is mostly in the form of heat. Nutrient Cycling describes the movement of such Nutrients as carbon, nitrogen and phosphorus through ecosystems as biogeochemical cycles. These cycles entail the circulation of nutrients among the living (biotic) and non-living (abiotic) parts of ecosystems, which makes the existence of vital elements to life possible (Rumble et al., 2019).

Succession is a process of changing ecosystems with time. Primary succession is the first one that takes place in the previously unoccupied regions, whereas secondary succession takes place in the regions where the disturbance has already taken place but still the soil remains. A mature and stable ecosystem is created as a result of succession. Ecosystems can also be changed significantly by also human activities which include deforestation, pollution and climate change. Being aware of some of such ecological principles can reduce the bad effects and enhance sustainable activities (Dale et al., 2000).

CHAPTER THREE

MATERIALS AND METHODS

In this chapter, the materials and methods that were to be used in the study are outlined including the site where the study was to be conducted and the different treatments that were to be used. It explains the experimental design as well as agronomic management practice in planting Brachiaria grass. It also expounds on data collection methods such as rainfall, tiller and plant height, Leaf Area Index (LAI) and Light Interception (LI), herbage dry matter yield, and flowering and inflorescence production. It is also about seed harvesting, tests of seed germination, and insect pests and diseases of Brachiaria. Lastly, the chapter describes the data analysis procedures to explain the findings. It has been discussed as follows:

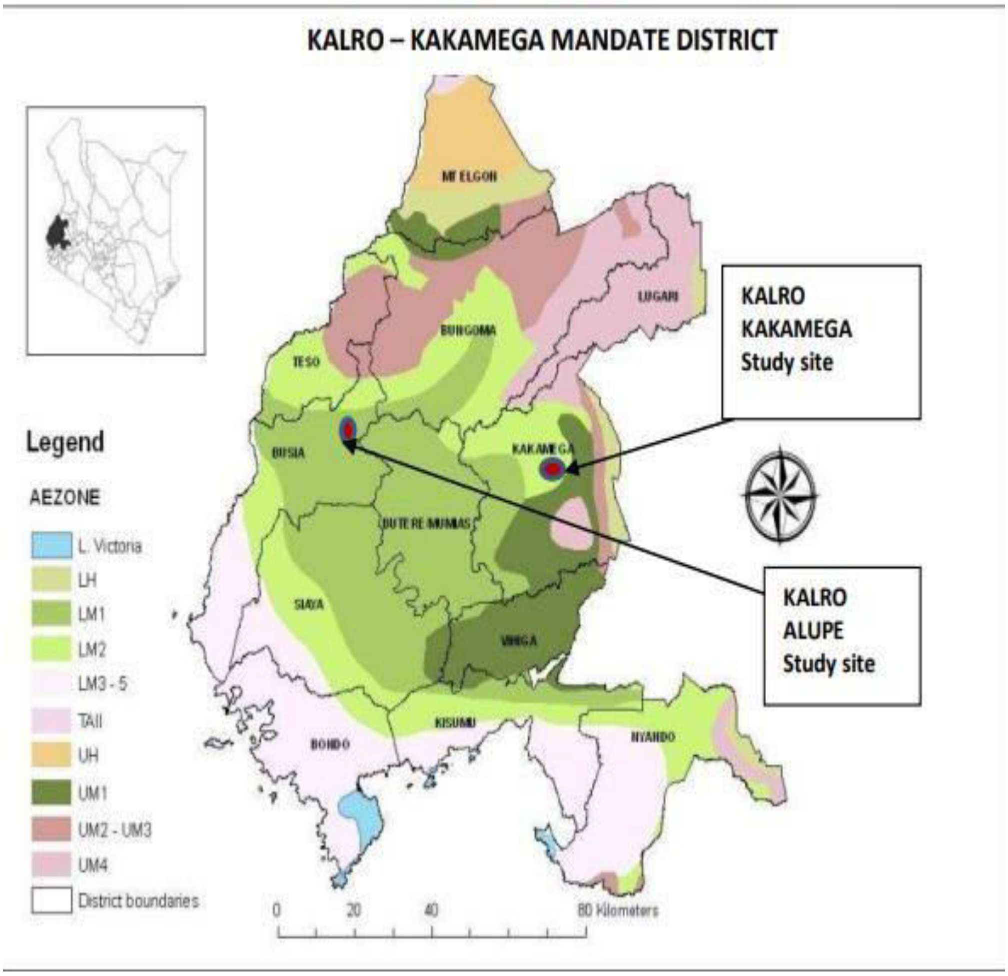
3.1 Study site

The sites of the study were strategically selected to capture the dairy production regions in the sub-humid and mid-altitude agro-ecological regions of Western Kenya. The sampling areas were KALRO Kakamega, agro ecological zone Low Midlands 2 (LM 2) and the Alupe which is a Low Midlands 1 (LM 1) agro ecological zone within an altitude of about 1430m and 1330m above the sea level respectively (Jaetzold et. al., 2005).

Kakamega has a rainfall range of 1,800-2,000 mm annually whereas Busia (Alupe) has slightly higher p-values of 2,300-2,350 mm per annum. The increased rainfall received in Busia can be explained by the fact that the area is close to the Lake Victoria which increase the level of precipitation through convectional rains. The two areas have a bimodal rainfall distribution which sustains mixed crop livestock agricultural systems. Busia has relatively better rainfall, which supports pasture and crop diversity hence making it an ideal location in terms of integrated agricultural production (Nomad Season, 2025).

Kakamega and Alupe have an average temperature of 13oC and 15.3oC per year as the lowest and highest minimum and maximum temperature respectively. Alupe soils are rated as moderate organic carbon and the texture is Clay loam and Kakamega soils are rated as highly organic carbon and their texture is sandy loam. Both the soil pH of Alupe and Kakamega are slightly acidic (Okalebo et al., 2002). Kakamega are the smallholder varieties of farming systems on mixed farming and is essentially a crop farming county with some small interest of the arable land being utilized in livestock farming. Nevertheless, as the land demarcation to population pressure grows, animal feeding style should also be enhanced. Government through ministry of Livestock and veterinary service and KALRO has taken up hay/pasture improvement.

It is also involved in livestock production department which deals with different extension activities like training of farmers on animal feeds. Primarily the subsistence and industrial crops combined with the domination of sugarcane crop and other crops alive maize, tea, sweet potatoes, cassava, sorghum and millet. Busia are also a small holder farm that comprises both the food crops and the production of animals, primarily the production of coffee, rice, fish and livestock. Other crops are the grown under small scale; groundnuts, sorghum, maize and millet. Moreover, Kakamega and Alupe are located at agro-ecological zone of interest 00 30' N, 350 00' E and 50km north of lake Victoria and 00 29 50' N, 340 7 31' E 9km north of Busia town respectively (Munyasi et al., 2015).



Source Munyasi *et al*., 2015

Figure 3.1: Map showing experimental sites

3.2 Experimental design and treatments

The experiment in this paper was designed as 5 x 3 x 2 factorial experiment in a split-plot design, to allow the multifaceted interactions among the treatment factors. The first was the Brachiaria cultivars, whose five levels were Xaraes (Brachiaria brizantha cv. Xaraes), Piata (Brachiaria brizantha cv. Piata), MG4 (Brachiaria brizantha), Basilisk (Brachiaria decumbens) and Multo II (Brachiaria ruziziensis), where Mulato II was used as a control. The second one was the defoliation which was performed on three levels, namely no defoliation (control), defoliation once after 3 months of growth, and constant defoliation every 60 days starting week twelve. Early development parameters, dry matter, and seed output were determined during first and second defoliation treatments; with the continuously defoliated treatment the yield of the dry matter only was determined because the flowers did not substantially develop at the usual defoliation stress (Cook et al., 2005). The third factor was the agro-ecological zone whereby two areas were Low Midland 2 (LM2) at KALRO Kakamega and Low Midland 1 (LM1) at Alupe based on varying levels of rainfall and soil. All three factors were used to produce 30 treatments which were repeated three times to create 90 experimental units.

The plots were 9 m x 5 m overall, 3 m x 5 m subplots with 2 meter separating the plots and replicates. This was essential to reduce edge effects, allow sufficient light and air circulation and to limit chances of cross-contamination of treatments, especially on above-ground pests and disease vectors (Gomez, 1984). Also, effective management practices like weeding, data collection and defoliation can be easily practiced without the interference of other plots owing to the buffer spacing.

The phosphate fertilizer was sprayed at 40kg P2O5 per hectare at the rate of one bottle top per planting hole. This application rate was guided by the past forage productivity literature and the agronomic recommendations of growing Brachiara on phosphorus deficient soils of the tropics. Sufficient phosphorus helps in active root development and early plant establishment, which is key in tillering and biomass accretion (Gichangi et al., 2020; CIAT, 2013). Most tropical soils contain low levels of phosphorus and this moderate application rate has proved to be agronomical and also environmentally sustainable in smallholder conditions. Fig. 3.2 depicts the way all the experimental plots were divided into three sub plots which were defoliated once, continuously defoliated and non-defoliated and also indicates how the plots were replicated:

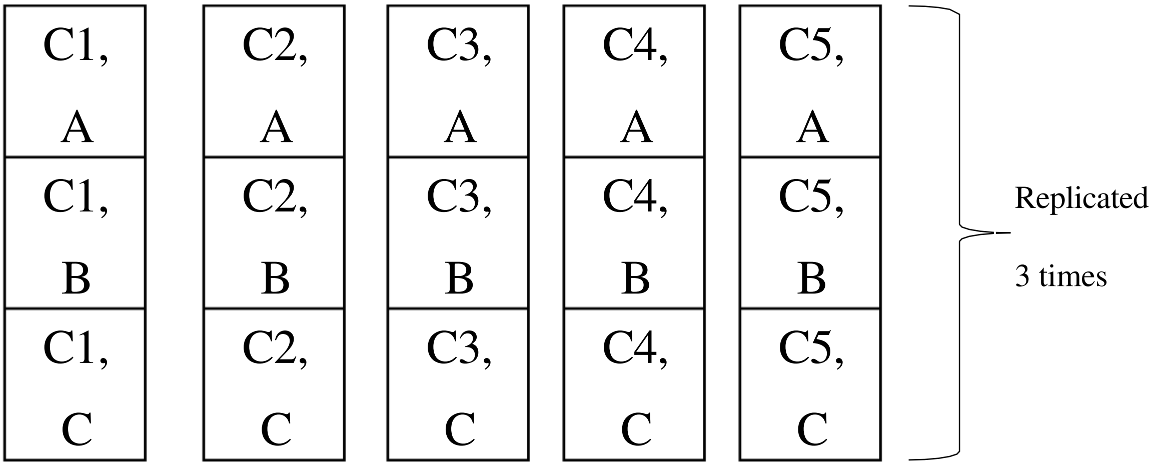


Figure 3.2: Field Experimental Layout plot

The experimental plots are identified as follows from the figure above:

C - Defoliated continuously C2 – Basilisks

B - Defoliated once C3 – MG4

A - non-defoliated C4 – Xaraes

C1 – Piata C5 – Mulatto II

3.3 Planting and agronomic management

The samples of the soils were taken then to the laboratory for analysis of the chemical properties of soil at both fields of KALRO Kakamega and Alupe using routine methods of soil sampling and testing (Okalebo, et al., 2002). Ploughing was done first with a tractor and then harrowing was done by hand harrowing and all plant debris and leftovers seen in the field were cleared up to provide even conditions of establishment (FAO, 2010). The experimental plots were marked into 3 plots under the randomized complete block design (RCBD) and there were five plots per replicate thus, 15 plots in total (Gomez, 1984). Holes were formed at a distance of 50 cm x 50 cm and at the depth of the holes, an average of 10 cm deep, making 19 holes in total that made 11 holes per plot.

Brachiaria cultivars were planted with clean root splits that were acquired at KALRO Kakamega and three root splits planted in each hole in all the cultivars including the control. The phosphate fertilizer was added which was equivalent to one bottle top per hole, which corresponds to 40 kg P2O5/hectare which was found to stimulate the optimum early root development in tropical grasses (Gichangi et al., 2020). Plots received randomly selected cultivars, by writing their names on folded pieces of paper, mixing these names, and picking the names at random, which gives randomness and less biasness to the plot assignment process (Montgomery, 2017). Manual weeding was applied to the grasses that appeared during the period of the experiment (Woomer and Muchena, 1996).

3.4 Determination of growth and disease levels of false smut and ergot of selected Brachiaria cultivars in selected agro-ecological zones in Western Region, Kenya

The data collected under this objective included; plant height, number of tillers, natural infectious disease effect and incidence as described:

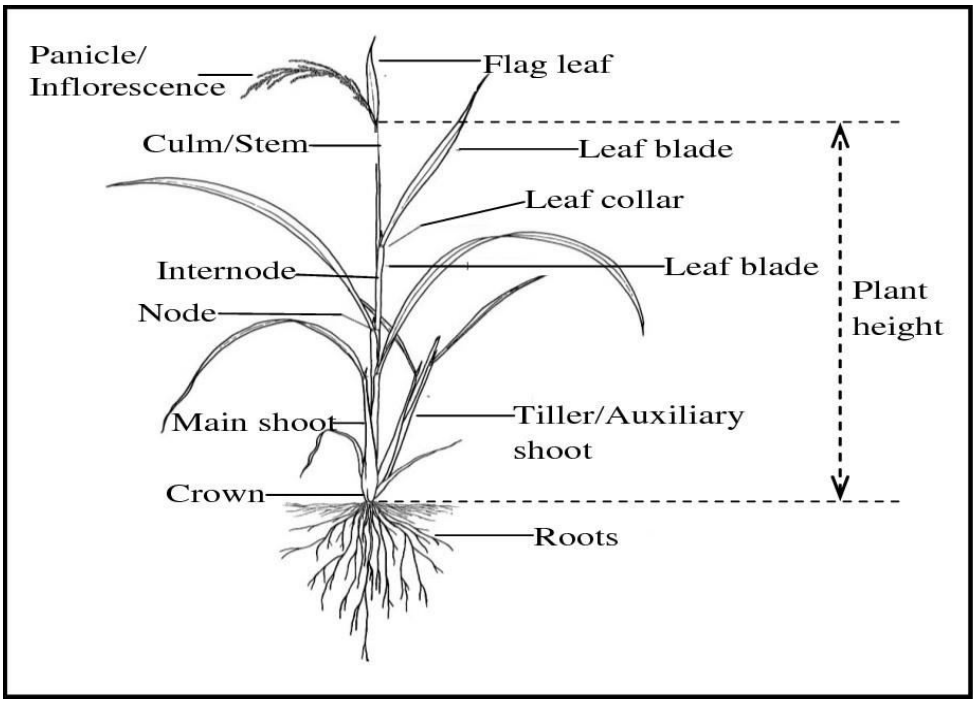


Figure 3.3: Shows the various parts of a grass plant that were used in this study for various data collections.
Source: Ogillo (2010)

3.4.1 Estimation of number of tillers and plant height

The quantification of the vegetative growth features namely the count of tillers per plant and the height of the plant, was done by means of a systematic and repetitive process of data collection. In each subplot, 35 plant stools were selected randomly with both non defoliated and defoliated treatments being represented. Each plot consisted of three such subplots hence, 105 plant stools per plot were measured in one cycle.

In the case of the count of the tillers, all the selected stool plants were manually inspected and all the tillers emerging out of the top of the stool were counted and noted manually. In the case of plant height, a meter rule was taken to measure the height of the plant at the surface of the soil through the base of the plant to the end of the longest leaf. This was also measured on the same 35 stools per subplot.

The data were collected in four weeks, four weeks after the planting date and repeated after every four weeks till the end of the growth period. Prior to data collection, standardization was done to reduce variability brought about by disproportional initial growth. Standardization entailed the removal of all the stools to a stubble height of 5cm and fitting of tillers to three per stool by removing the excess tillers in those stools with more than three. The process established a standard level on which growth could be followed and compared among treatments (FAO, 2010).

The two guard rows that were placed around each plot are to avoid the possibility of variation of edge effects due to the external environmental factors like light, wind or soil conditions. Data collection did not involve these rows, but they were used as buffers of the inner area of the experiment and enhanced reliability of measurements in line with recommended agronomic trial procedures (Gomez, 1984). This methodology allowed the accurate and objective determination of the tillering capacity and plant height which were important pieces of information to determine the growth performance of the chosen Brachiaria cultivars in the conditions of varied agro-ecological conditions: LM1 (KALRO Alupe) and LM2 (KALRO Kakamega). The different zones differ in soils, rainfall, and temperature, which affect the productivity of the forage and adjustment (Gichangi et al., 2020).

3.4.2 Identification of Diseases of Brachiaria grass

The key diseases that afflicted the Brachiaria cultivars in the field were observed directly and assessed through physical observation of apparent symptoms, the spots on the leaves, chlorosis (yellowing), necrosis, stunted growth, wilting, and dieback of the tillers. The identification of the disease involved visual diagnostic keys and symptom descriptors as provided by pasture health and forage crop pathology manual

(Cardoso et al., 2011). In order to measure the incidence of disease, 35 random plant stools per subplot were sampled (as was done with the growth parameters measurements). The total number of tillers, and diseased tillers of each stool was counted manually. The percentage of disease incidence was calculated in the formula:

Disease Incidence (%) =(Number of diseased tillers/Total number of tillers counted) x 100

Such a method gave a quantitative and uniform measure of disease pressure among treatments. The data about the disease was recorded at specific time intervals of every four weeks after planting, which was also recorded during the growth data, to record the initial infections as well as the development of the disease with time. The temporal trends and cultivar-specific vulnerability could be identified by this longitudinal data collection method.

Also, to determine the impact of disease on the plant performance, the intensity of the symptoms (e.g., damage of the leaf area or severity of dieback) was rated on a semi-quantitative scale line (0 not present, 5 severe throughout the entire plant) visually (adapted to Gerrano et al., 2019). This scale made it possible to estimate not only incidence but also the effect of it on the vitality of the plants and the possible loss of yield.

Suspected cases of the disease were confirmed by expert confirmation by plant pathologists at KALRO Kakamega and Alupe research stations to improve the accuracy. The suspected pathogens were also compared with known visual symptoms by using Brachiaria disease diagnostic guides and photographic reference materials. The attention was on widely spread pathogens in tropical Brachiaria pastures, including Puccinia spp. (rust), Drechslera spp. (leaf blight), and head smut (Ustilago spp.), which are known to have a significant impact on the forage yield and palatability (Gerrano et al., 2019). This method enabled the evaluation of cultivar resistance or susceptibility to the antagonistic agro-ecological conditions of LM1 (Alupe) and LM2 (Kakamega) to make viable information that can guide varietal choice as well as integrated disease management measures.

3.5 Determination of light interception and leaf area index of the selected Brachiaria cultivars under field conditions in selected agro-ecological zones in Western region, Kenya

According to this objective, data on Light Interception and Leaf Area Index was collected in the following way; the data was collected 12weeks after planting. Data collection was done following an interval of every two weeks between 11am and 2pm and data collection was done in non defoliated sub plots so as to ensure consistency. The first data on Leaf Area Index (LAI) and Light Interception (LI) were taken at week 12 following planting and week 14 was taken after two weeks followed by the same as the weeks progressed up to week 18.

3.5.1 Light Interception (LI) and Leaf Area Index (LAI)

This was assessed with the help of LP- 80 ceptometer. The ceptometer is a device that is used to monitor photosynthetically active radiation PAR in a vegetation canopy. It is usually composed of sensors, which measure the level of light that is captured by the canopy (Pokovai & Fodor, 2019). The ceptometer determined the amount of light intercepted by the canopy by determining the difference between the incident light and the ceptometer reading. The overall light over the canopy is called incident light. The outcome was expressed as the percentage of light that was captured by the canopy of the grass. In this research formula 1 was applied.

Formula 1;

Light Interception=Incident Light (Upper canopy) - Ceptometer Reading (lower canopy)

Therefore:

Formula 2:

Photosynthetically Active Radiation (PAR) =Incident PAR×$\{1-(\frac{Light\ Interception}{Incident\ Light})\}$

In Formula 2 is depicted that the interception of light would influence the photosynthesis and consequently, the output of the herbage.

The index of the leaf area of a plant was directly displayed on the screen of LP-80ceptometer and was recorded. It was done at certain points in a plot which were randomly selected and the selected points were indicated in the next data gathered on Leaf Area Index (LAI) and Light Interception (LI).

3.6 Determination of herbage and seed yielding levels of selected Brachiaria cultivars in selected agro-ecological zones in Western region, Kenya

The yielding levels were calculated by gathering the following information; herbage yield this were the fresh weight and dry matter percentage, seed yielding this comprised the number of days to flowering, number of inflorescence, seed weight and germination test.

3.6.1 Estimation of herbage yield

The Brachiaria grass cultivars were planted and harvested at various intervals. In order to determine the level of the yield of dry matter in continuously defoliated split plot and defoliated once plots, data was gathered after twelve weeks of planting as the grass was at the cut and carry stage. On the continuously defoliated plots this was succeeded by harvesting at the intervals of after every 8 weeks since Brachiaria regrowth attained the second cut and carry stage after 60days. The harvesting of nine (9) Brachiaria plant stools was done on the first three rows on each sub plot such that two guard rows were left on the sides of the plot. Munyasi et al., (2015) recommend that the defoliated sub plots should be cut at a basal height of 5 cm above the ground. Weight of all the harvested green material on both sampling was weighed and recorded as fresh weight and then thoroughly mixed after which a sampled 1kg was taken and placed in a bag. To ascertain the dry weight of the samples, they were dried in forced-drought incubator at 600C over 72 hours. Munyasi et al., (2015) divided the dry matter yield per hectare by 3 as shown below.

Formula 3;

% Dry weight = (Sample dry weight (kg) ÷ Whole field weight (kg))×100

3.6.2 Flowering and Inflorescence production

The days in which flowers began to bloom, and the days in which flowers had bloomed 50 per cent in each cultivar on the non-defoliated and defoliation treatments were recorded. At 50 percent flowering all the inflorescences in the 9 stools per sub plot were counted. The inflorescence percentage at the 50% flowering stage of the tillers was noted and the number of the spike per tiller was noted.

3.6.3 Seed harvest

In order to measure seed yield, the 9 stools having infloescences within the sub plots in LM2 were harvested with the help of hand harvesting. The seeds that were harvested were anaesthetically cleaned and sun dried before being stored in a sugar bag and allowed to stay in a laboratory at room temperature of two days after which germination test was performed.

3.6.4 Seed weight and germination test

The germination test was conducted on the laboratory. The seed caryopses were collected as mentioned by Munene (2006) at this point any hundred (100) seeds (caryopsis) of each cultivar were weighted out of the three replicas and the result was a weight of 100 seed weight recorded. Then 100 seed of each cultivar of the three replicates was put randomly on a double layer paper towel in a plastic dish in four replications. Sterile water was used to saturate the paper towels. The dishes were incubated in plastic at 28 degC in dark.

3.7 Data analysis

The statistical analysis of the data obtained as a result of the experiment was performed according to the descriptive and inferential statistics. General patterns in the data were summarized and compared using descriptive statistics (means, percentages and cross tabulations) that included the mean number of tillers, plant height, herbage yield and seed yield in different treatments and locations. To carry out inferential analysis, Analysis of Variance (ANOVA) was used to establish the existence of statistically significant changes in treatment means of key variables such as the number of tillers, dry matter (herbage) yield and seed yield.

The experimental design that was used to choose ANOVA was based on the experiment design; there were numerous factors (cultivar, defoliation level and agro-ecological zone) with more than two treatment levels. ANOVA is the best statistical test that should be used when comparing the means of more than one group and when trying to test the interaction effects of factors in the factorial type of experiments, which is the 5 x 3 x 2 split-plot design utilized in this study (Gomez, 1984). It enables detection of the main effects (e.g., difference in cultivars) and interaction effects (e.g., the extent to which cultivar performance varies with the degree of defoliation or location) that are essential in analyzing the complex biological responses in field trials (Montgomery, 2017).

Statistical Package of the Social Sciences (SPSS) was used to analyze the data. ANOVA results indicated that significant differences were observed and Least Significant Difference (LSD) tests were used to differentiate treatment means at 5% level of significance ($p < 0.05$). The rationale behind the use of LSD is that the test is used to compare treatments in pair wise when there are moderate number of treatments and ANOVA has already found significant differences (Steel and Torrie, 1980). The combination of these statistical methods offered a strict and trustful methodology of explaining the behavior of Brachiaria cultivars in different management and environmental conditions.

CHAPTER FOUR

RESULTS

This chapter gives the findings of the research, starting with the analysis of the soil chemicals to put in perspective the growing conditions. It involves; height, number of tillers, Leaf Area Index (LAI), and Light Interception (LI) and biomass yield and flowering features. The chapter also describes the incidence of the following diseases Ergot (Claviceps purpurea) and False Smut (Ustilaginoidea virens), and ends with the results on seed weight and germination trials. The findings substantiate the background of Chapter two and inform us about the development of Brachiaria grass in different conditions yielding and quality.

4.1 Soil chemical analysis

Figure 4.1 shows soil analysis done before planting; this was to help understand the status of the soil before planting the selected Brachiaria cultivars and also help as to understand that Brachiaria cultivars can perform in different soil status.

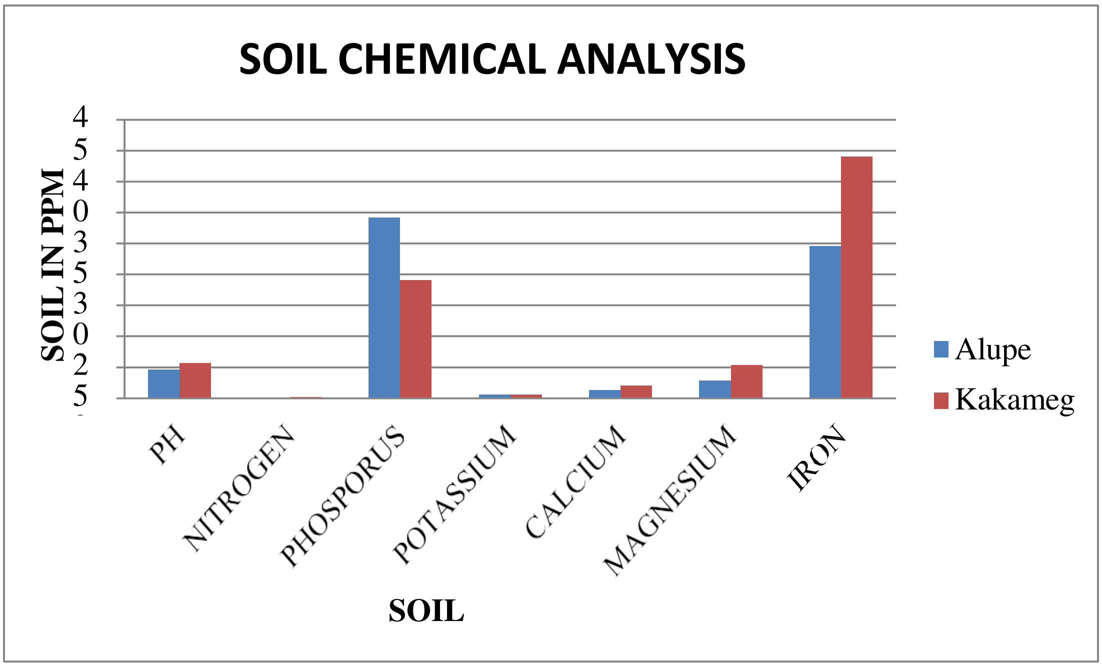


Figure 4.1: Soil chemical analysis at KARLO Alupe and Kakamega before planting in October 2022

In Alupe soils were more acidic while in Kakamega the soils slightly basic. The soils had high calcium, magnesium and iron in Kakamega compared to Alupe.

4.2 Determination of growth and disease levels of false smut and ergot of selected Brachiaria cultivars in selected agro-ecological zones in Western Region, Kenya

4.2.1 Plant Height

Table 4.1 and 4.2 present the results of analyzed data on the plant height at 4, 8 and 12 weeks. All the observations showed a significant difference ($p<0.05$) in the mean height of the various cultivars in Table 4.1 and Table 4.2. At 4 weeks Xaraes was much taller than other LM 2 (Kakamega) and Piata taller than in LM1 (Alupe). The shortest of all the cultivars in both sites was the basilisks. Piata was much taller than MG4 but there was no difference between Mulatto II and MG4 in LM2 (Alupe) and between Mulatto II and MG4 in LM1 (Alupe). At 8 weeks Basilisks and Xaraes were tallest with MG4 intermediary and Mulatto II and Piata being significantly shorter in

Kakamega but in Alupe Mulatto II was tallest with Piata being the shortest.

On height at week 12 Basilisks did very well then followed by Xaraes, Piata and MG4 but at Alupe Mulatto II and Piata significantly the tallest followed by Basilisk which was the shortest. Usually, as is seen by this study, both sites had the potential to grow and reach the desired pasture height suitable for cutting and Mulatto II may perform better in Alupe than in Kakamega and Basilisk may perform better in Kakamega than in Alupe

Table 4.1: Effect of Brachiaria cultivar on plant height at 4, 8 and 12 weeks after planting in agro ecological zone LM 2 KARLO Kakamega, Kakamega County

Brachiaria Cultivars	Height 4weeks (cm) mean ± s.e	Height 8weeks (cm) mean ± s.e	Height 12weeks (cm) mean ± s.e
XARAES	$42.75 \pm 0.71_{a}$	$69.80 \pm 1.08_{a}$	$106.05 \pm 1.32_{b}$
PIATA	$35.80 \pm 0.75_{b}$	$62.10 \pm 1.12_{c}$	$104.04 \pm 1.34_{b}$
MULATTO II	$33.93 \pm 0.65_{bc}$	$63.08 \pm 1.14_{c}$	$85.25 \pm 1.12_{c}$
MG4	$32.21 \pm 0.75_{c}$	$64.77 \pm 1.28_{bc}$	$106.53 \pm 1.85_{b}$
BASILISKS	$29.18 \pm 0.72_{d}$	$69.48 \pm 1.09_{ab}$	$117.84 \pm 1.62_{a}$
TEST VALUES	**Df=4; F=50.253; P=0.001**	**Df=3; F=8.47; P=0.001**	**Df=3; F=63.98; P=0.001**

Table 4.2: Effect of cultivar on plant height at 4, 8 and 12 weeks after planting in agro ecological LM 1 KARLO Alupe, Busia County

Brachiaria Cultivars	Height 4weeks (cm) mean ± s.e	Height 8weeks (cm) mean ± s.e	Height 12weeks (cm) mean ± s.e
XARAES	$50.68 \pm 1.2_{bc}$	$69.5 \pm 1.0_{bc}$	$100.34 \pm 2.3_{b}$
PIATA	$55.95 \pm 0.9_{a}$	$82.0 \pm 1.1_{ab}$	$118.79 \pm 2.8_{a}$
MULATTO II	$51.25 \pm 1.4_{b}$	$91.0 \pm 7.8_{a}$	$122.9 \pm 3.7_{a}$
MG4	$46.37 \pm 1.1_{cd}$	$64.6 \pm 1.1_{c}$	$78.66 \pm 2.1_{c}$
BASILISKS	$43.25 \pm 1.1_{d}$	$60.2 \pm 1.2_{c}$	$64.32 \pm 1.5_{d}$
TEST VALUES	**Df=4; F=18.5; P=0.001**	**Df=4; F=12.3; P=0.001**	**Df=4; F=92.5; P=0.001**

4.2.2 Tiller numbers

Table 4.3 and 4.4 present the data on the number of tillers gathered at 4, 8 and 12 weeks analyzed. This information was recorded until standardization and prior to defoliation. This data was meant to assist in description on growth of the selected Brachiaria cultivars in the selected agro-ecological zone LM1 (Alupe) and LM2 (Kakamega). The number of tillers also increased with time of all cultivars and their values were markedly different ($p<0.05$) (Tables 4.4 and 4.5). The highest number of tillers was significantly recorded in Basilisks, then MG4 at all the stages of observation in the two ecological sites. Although, Piata recorded low production of tillers in Kakamega site whilst it did better in Alupe than Xaraes and Mulatto II which showed slight differences among three stages of observation in both sites.

Table 4.3: Effect of cultivar on tiller numbers at 4, 8 and 12 weeks in agro ecological zone LM 2 KARLO Kakamega, Kakamega County

Brachiaria Cultivars	Number of tillers 4weeks mean ± s.e	Number of tillers 8weeks mean ± s.e	Number of tillers 12weeks mean ± s.e
BASILISKS	12.52 ± 0.38a	39.82 ±1.40a	71.44 ±2.65a
MG4	12.13 ± 0.51a	29.80 ±1.22b	54.88 ±1.98b
XAREAS	8.33 ± 0.30b	18.96 ±0.60cd	34.64 ±1.92c
MULATTO II	8.15 ± 0.58b	23.01 ±1.65c	30.04 ±0.90cd
PIATA	5.80 ± 0.17c	14.58 ± 0.48d	25.92 ± 0.88d
TEST VALUES	**Df=3; F=47.53; P=0.001**	**Df=4; F=72.55; P=0.001**	**Df=4; F=114.22; P=0.001**

Table 4.4: Effect of cultivar on tiller numbers at 4, 8 and 12 weeks in agro ecological zone LM 1 Alupe Busia County

Brachiaria Cultivars	Number of tillers 4weeks mean ± s.e	Number of tillers 8weeks mean ± s.e	Number of tillers 12weeks mean ± s.e
BASILISKS	15.57 ± 0.8 b	50.12 ± 1.8 a	77.55 ± 2.8 a
MG4	20.7 ± 1.02 a	47.7 ± 1.8 a	53.71 ± 2.4 b
XAREAS	11.89 ± 0.6 c	31.92 ± 1.5 b	42.89 ± 2.7 c
MULATTO II	12.77 ± 0.8 bc	28.08 ± 1.3 b	31.87 ± 2.1 d
PIATA	15.71 ± 0.5 b	33.9 ± 1.03 b	48.74 ± 1.9 bc
TEST VALUES	**Df=4; F= 20.4; P=0.001**	**Df=4; F=42.15; P=0.001**	**Df=4; F=53.8; P=0.001**

4.2.3 Diseases incidences and number of tillers affected

The Brachiaria diseases were observed in compliance with what Nzioki et al., (2016) outlined using morphological observation. The observation was solely done when flowering as there was no noteworthy disease at vegetative stage. Table 4.5 demonstrates that all the selected cultivars had their nine stools affected by ergot and not all the tillers. Table 4.6 below was the result of data that was gathered in relation to the nine stools of the cultivars infected with the false smut disease. False smut was highly incarcerated in Basilisk than in MG4 and Xaraes. Hence this indicated that Ergot had a high effect than that of false smut among the false smut affected cultivars. The tool according to which Omayio and Tavasi (2022) estimate tolerance in plants was used to identify the disease tolerance levels. Thus, this study Basilisks, Xaraes, Mulatto II and Piata had moderate tolerability to ergot disease and MG4 was very tolerant. Basilisks and MG4 were moderately tolerant to false smut disease and Xaraes had high tolerant.

Table 4.5: Effects of Ergot diseases and disease incidence at flowering stage in LM2 (Kakamega)

Brachiaria Cultivars	Affected tillers mean ± s.e	Total No. of tillers mean ± s.e	Disease incidences %mean ± s.e	Disease tolerance 100 - Incidence
BASILISKS	50.33± 1.9 a	72.33 ± 2.9 a	69.33 ± 1.6 a	30.67%
MG4	22.67 ± 1.9 b	55.00 ± 2.9 b	41.00 ± 1.6 c	59.00%
XAREAS	17.00 ± 1.9 c	26.00 ± 2.9 c	65.33± 1.6 b	34.67%
MULATTO II	20.00 ± 1.9 c	32.00 ± 2.9 c	62.67 ± 1.6 bc	37.33%
PIATA	22.67 ±1.9 b	35.00± 2.9 c	65.33 ± 1.6 b	34.67%
TEST VALUES	**Df=4; F= 101.38; P=0.001**	**Df=4; F=82.02; P=0.001**	**Df=4; F=104.2; P=0.001**	

Table 4.6: Effects of false smut diseases and disease incidence at flowering stage LM 1(Kakamega)

Brachiaria Cultivars	Affected No. of Tillers mean ± s.e	Total No. of tillers mean ± s.e	Disease incidence %mean ± s.e	Disease tolerance 100 - Incidence
BASILISKS	$42.00 \pm 2.1_a$	$72.00 \pm 3.5_a$	$58.00 \pm 2.1_a$	42.00%
MG4	$27.67 \pm 2.1_b$	$55.00 \pm 3.5_b$	$50.33 \pm 2.1_b$	49.67%
XAREAS	$11.33 \pm 2.1_c$	$35.00 \pm 3.5_c$	$32.00 \pm 2.1_c$	68.00%
TEST VALUES	**Df=2;F=107.7; P=0.001**	**Df=2;F=57.17; P=0.001**	**Df=2; F=79; P=0.001**	

4.2.4 Disease progression on a monthly basis

4.2.4.1 Ergot (*Claviceps purpurea*)

Figure 4.2 indicates that the disease was observed in November, December 2023, January, February, March and April 2024. These initial symptoms of the disease were noticed on the spot just after the offing of the pollen hence the falling of a white sugary tissue which was honeydew in nature and which turned into a hard dry sclerotium as depicted in the plate 4.1 below.

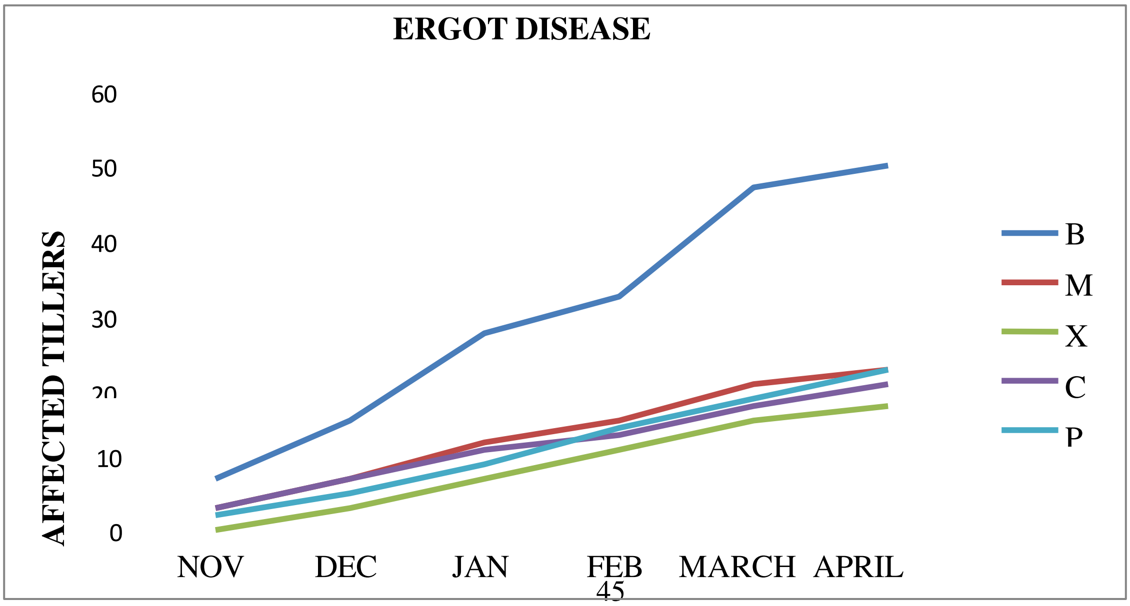


Figure 4.2: showing the Ergot diseases on number of tillers affected Monthly in Kakamega

B- Basilisks

M – MG4

X - Xaraes

C – Mulatto II

P - Piata

Plate 4.1: The two plates shows how Ergot disease affected the inflorescence

4.1.1.1 False smut (*Ustilaginoidea virens*)

The disease attacked Xaraes, Basilisks and MG4 in November and December 2023, January, February, March and April 2024 as revealed in Figure 4.3 and the incidences were high as during February to April. Basilisk was the most affected and the next one was MG4. The disease substituted some grains of Brachiaria by smut sori as indicated in plate 2. This sickness was at once following the fall of pollen.

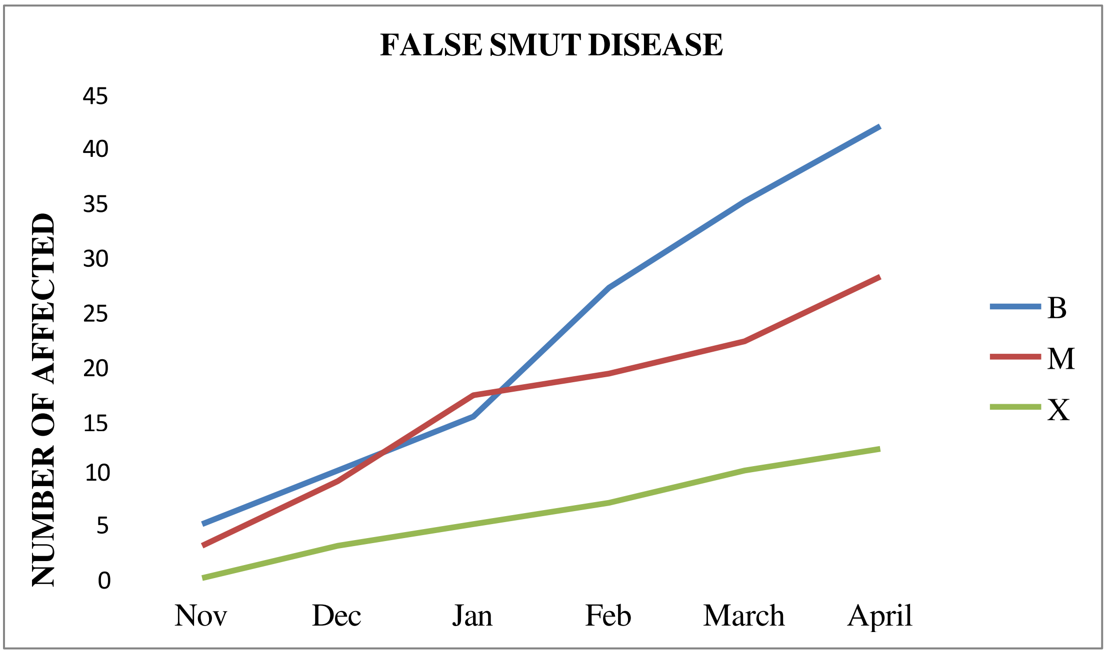


Figure 4.3: Showing the affected number of tillers by false smut disease monthly in Kakamega.

B – Basilisks
M – MG4
X – Xaraes

Plate 4.2: The two plates shows how false smut disease affected the inflorescence

4.3 Determination of light interception and leaf area index of the selected Brachiaria cultivars under field conditions in selected agro-ecological zones in Western region, Kenya.

This subsection has underscored the Leaf Area Index (LAI) and Light Interception (LI) as discussed below:

4.3.1 Leaf Area Index (LAI) and Light Interception (LI)

Figure 4.4 to Figure 4.7 reveal the changes in terms of light interception and the leaf area index of the chosen Brachiaria cultivars in the chosen agro-ecological regions. The increase in the leaf area index was directly proportional to the light interceptions (LI) (Fgure 4.4 to Figure 4.7). The higher the L.A.I increased the higher the LI increased and this led to the higher on growth rate of all the cultivars. In general all the cultivars achieved greater LAI in LM2 (Kakamega) than in LM1 (Alupe). MG 4 and Mulatto II got the highest LAI in week 18 with more than 0.25, whereas Xaraes got the lowest in LM2 during the same week. In LM1 (Alupe) all the cultivar had lower LAI with the cultivars compared to LM2 (Kakamega). Basilisks, Xaraes and Mulatto II with the highest value of 0.08 by week 18 against the other cultivars.

Piata and Mulatto II recorded the maximum light interception in of 68.33 and 69.0

respectively in week 18 and Xaraes had much lowest in LM2 (Kakamega) of 29. The LAI of MG4 was high, but the LI was a little smaller than Piata and Xaraes. Basilisks and MG 4 intercepted more light than Xaraes at week 18 with 20.33 and 19.33 respectively in LM1 (Alupe) and at 18 weeks respectively. This was to assist in the realization among the identified Brachiaria cultivars how they can intercept light and whether the leaf area index can influence the light interception as the leaf area index has consequences on biomass production.

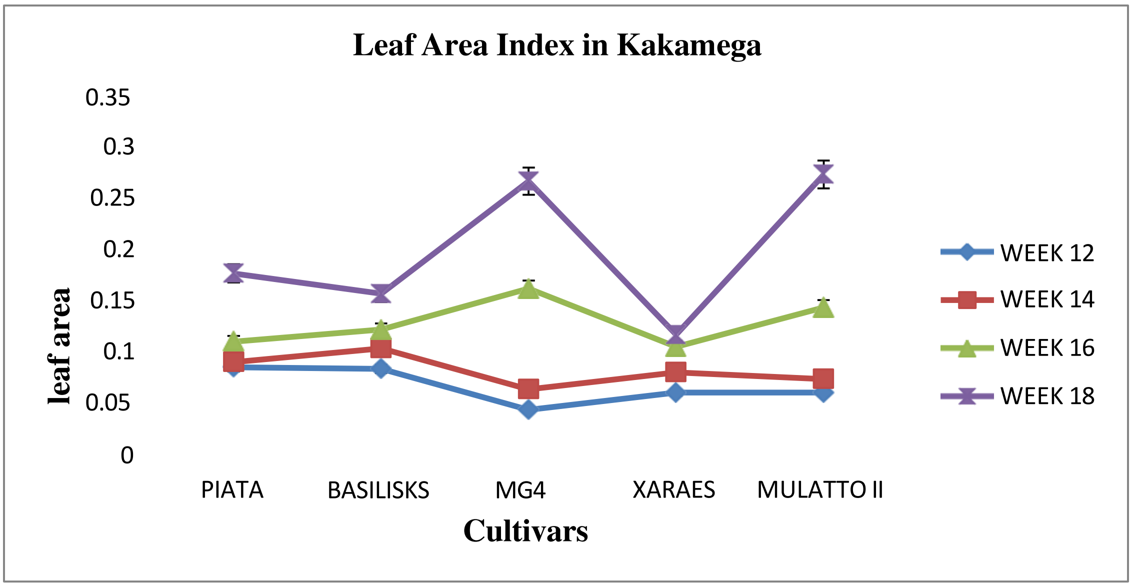


Figure 4.4: Leaf Area Index of Brachiaria Cultivars in agro ecological zone LM 2 (KALRO- Kakamega) Kakamega County.

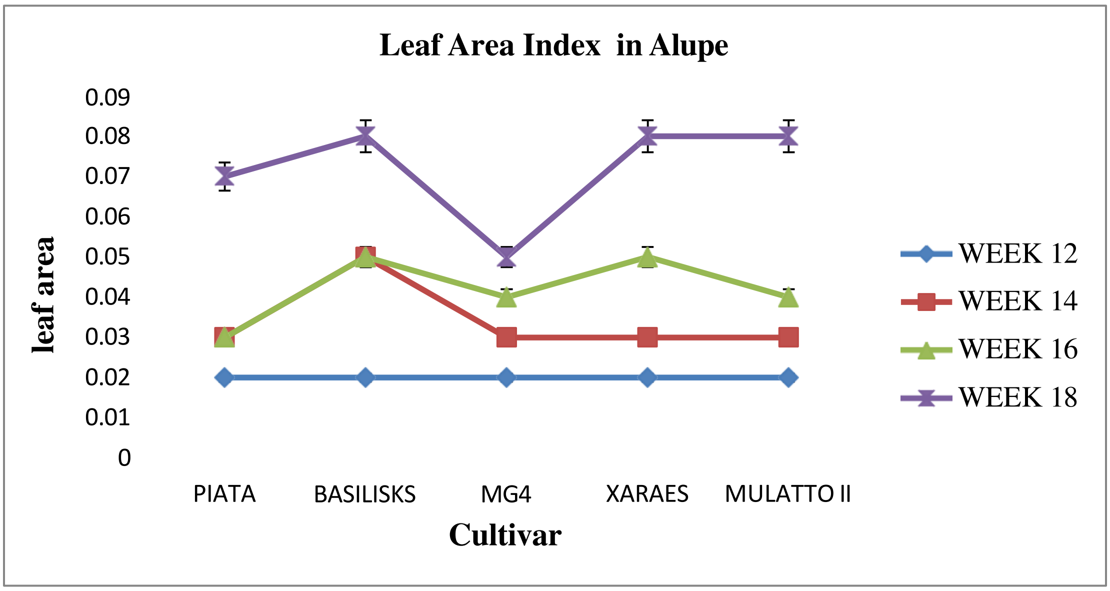


Figure 4.5: Leaf Area Index of Brachiaria Cultivars in agro ecological zone LM 1 Alupe, Busia County.

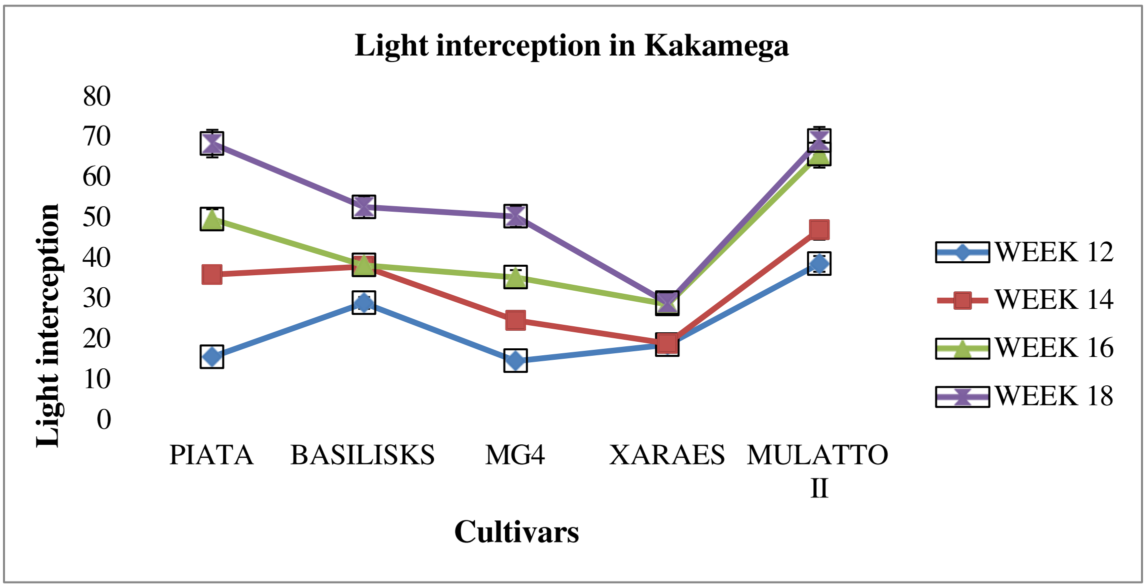


Figure 4.6: Light Interceptions of different Cultivars of Brachaiaria in agro ecological zone LM 2, Kakamega County.

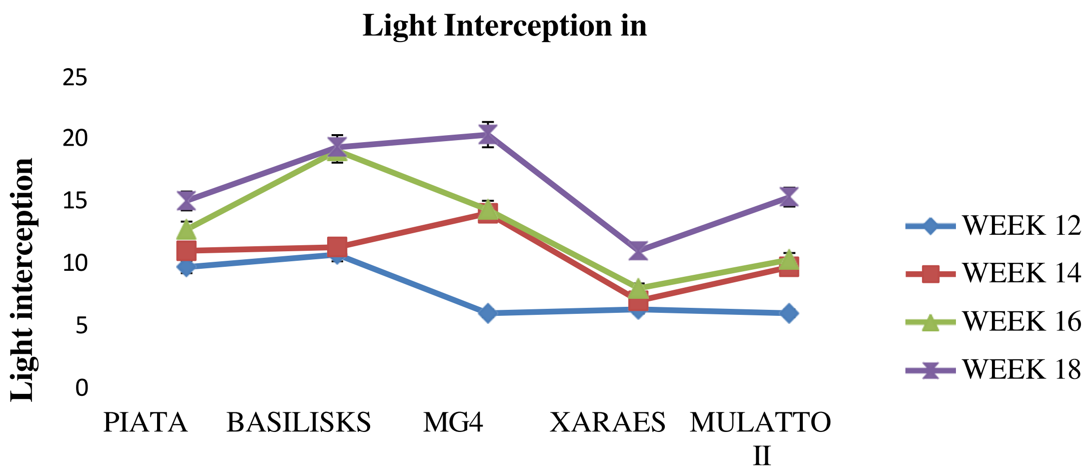


Figure 4.7: Light Interceptions of different Cultivars of Brachaiaria in agro ecological zone LM 1, Alupe, Busia County

4.4 Determination of herbage and seed yielding levels of selected Brachiaria cultivars in selected agro-ecological zones in Western region, Kenya.

This section has discussed the herbage yield, Flowering, number of inflorescences and seed yield and finally Seed Weight and Germination Test as follows:

4.4.1 Herbage yield

Figure 4.8 and 4.11 show increased yield of dry matter (DM). All cultivars differed ($p<0.05$) significantly at week 12, 20 and 28. Piata recorded the highest percentage dry matter at 12 weeks and closely followed by Xaraes and Mulatto II and MG4 whereas Basilisks failed to show any yield in Kakamega and the percentage dry matter of Xaraes, Piata and Mulatto II were almost equal. Piata recorded the highest percentage dry matter at 20 weeks at the second harvest, then Mulatto II, then Xaraes and MG4 yet Basilisks recorded the lowest percentage dry matter in both Kakamega and Fresh weight but the cultivars were in the same order.

Piata and Basilisks did not conform to the trend as Piata had low fresh weight and high percentage dry matter in Kakamega and Basilisks had high fresh weight and low percentage dry matter.

In Alupe Basilisks were the highest percentage DM with a close percentage DM of MG4, Xareas and Mulatto II, Piata recorded low percentage dry matter as illustrated in the Figure 4.8 below. In the third harvest at 28 weeks, the percentage dry matter of Piata and MG4 were highest whereas the percent dry matter of Xaraes and Basilisks were lowest in Kakamega. Whereas in Alupe Basilisks recorded the highest percentage DM followed by MG4, Xareas and Mulatto II, Piata recorded the lowest percentage dry matter.

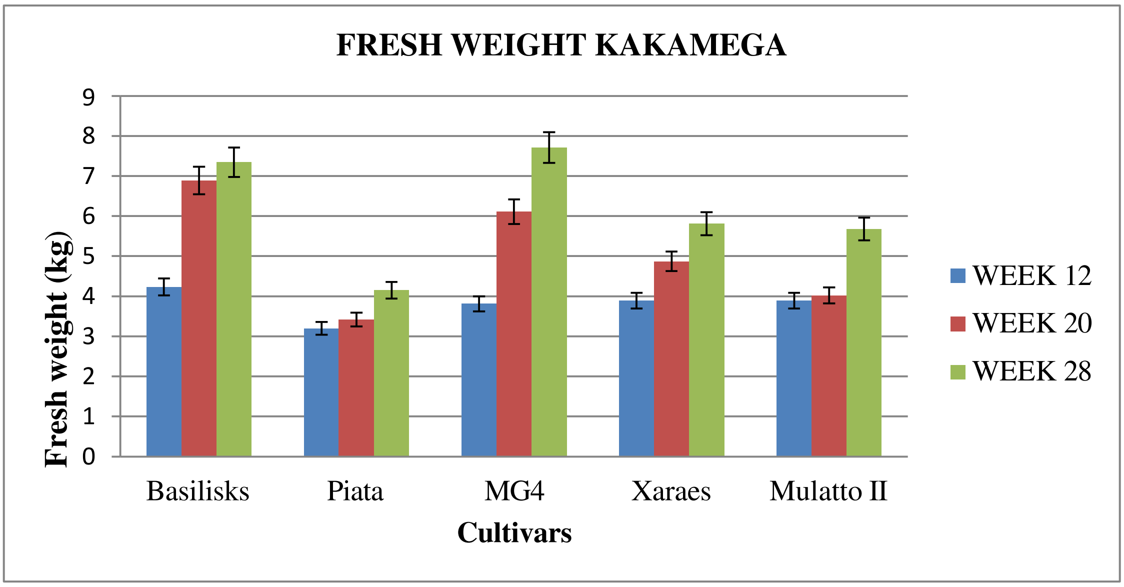


Figure 4.8: Effect of Brachiaria cultivars on Fresh Weight (Kg) in agro ecological zone LM 1 KALRO Kakamega, (Kakamega County).

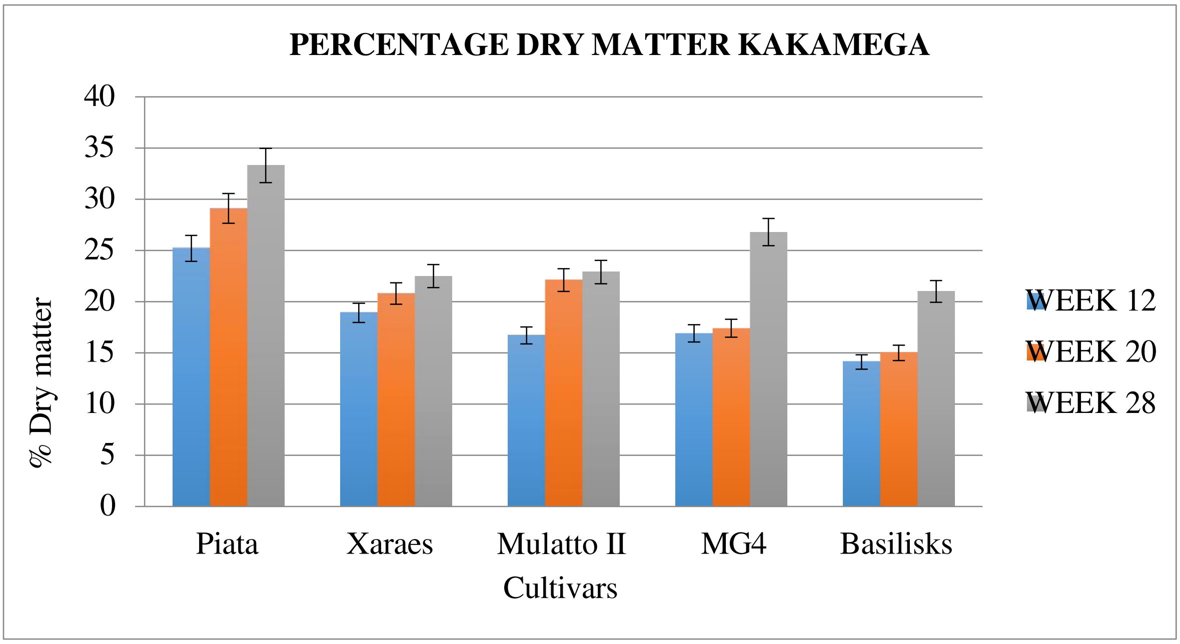


Figure 4.9: Effect of Brachiaria cultivars on percentage dry matter in agro-ecological zone LM 2 KALRO Kakamega, Kakamega County.

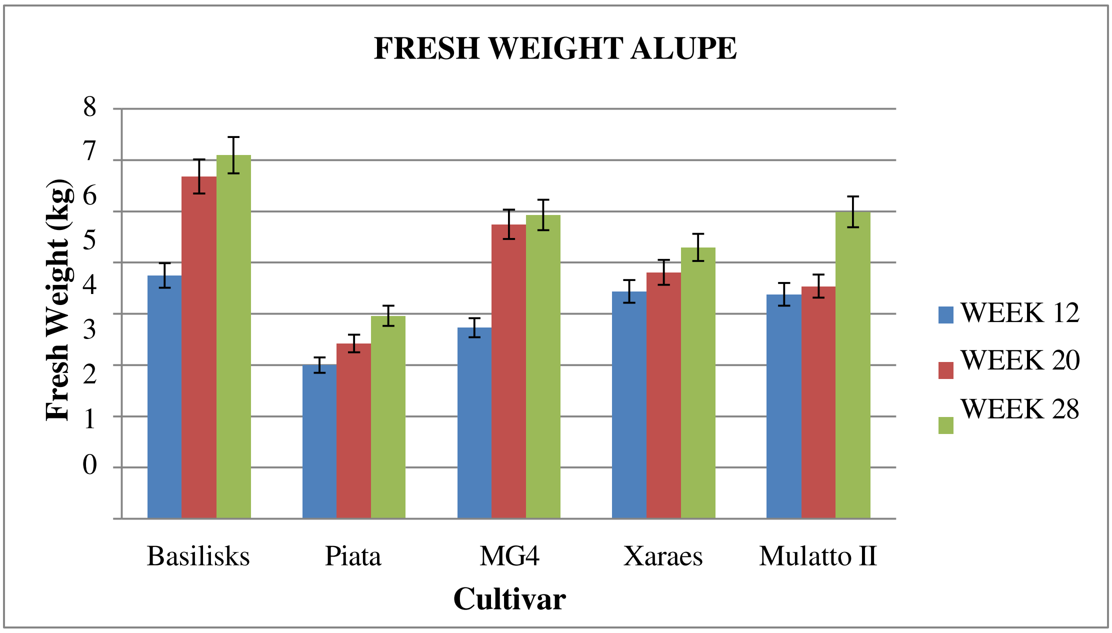


Figure 4.10: Effect of Brachiaria cultivars on Fresh Weight (Kg) in agro ecological zone LM 1 KALRO Alupe, (Busia County).

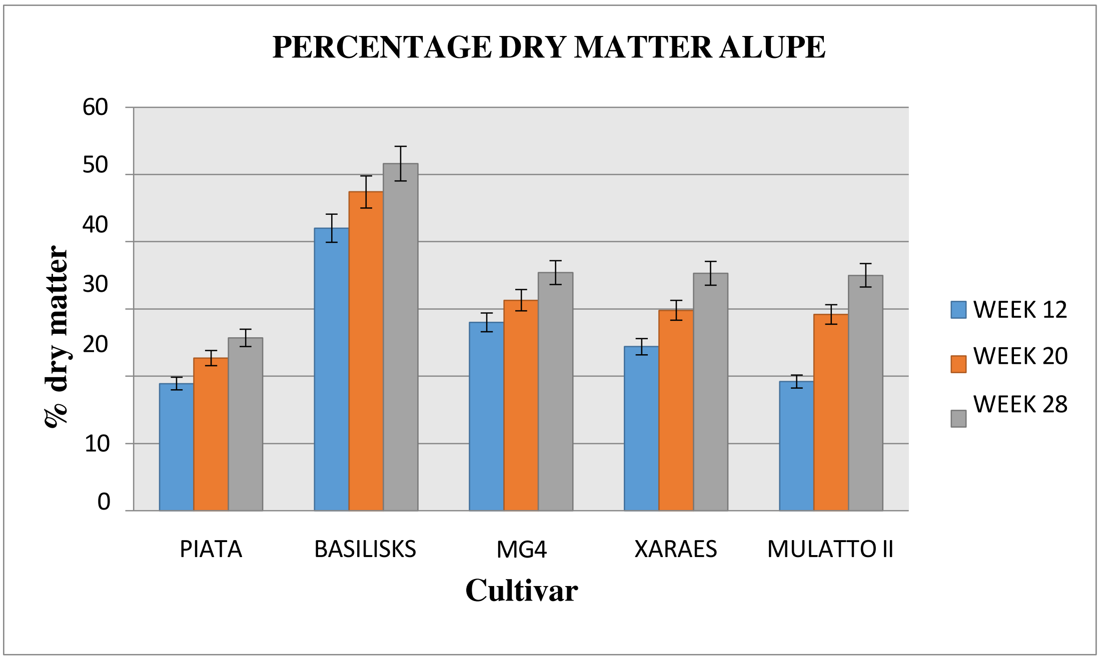


Figure 4.11: Effect of Brachiaria cultivars on percentage dry matter in agro-ecological zone LM 1 KALRO Alupe, (Busia County)

Plate 4.3 to plate 4.7 shows the pictures of Brachiaria cultivars used during the study.

Plate 4.3: Piata (*Piata palisade*)

Plate 4.4: MG4 (*Brachiaria brizantha)*

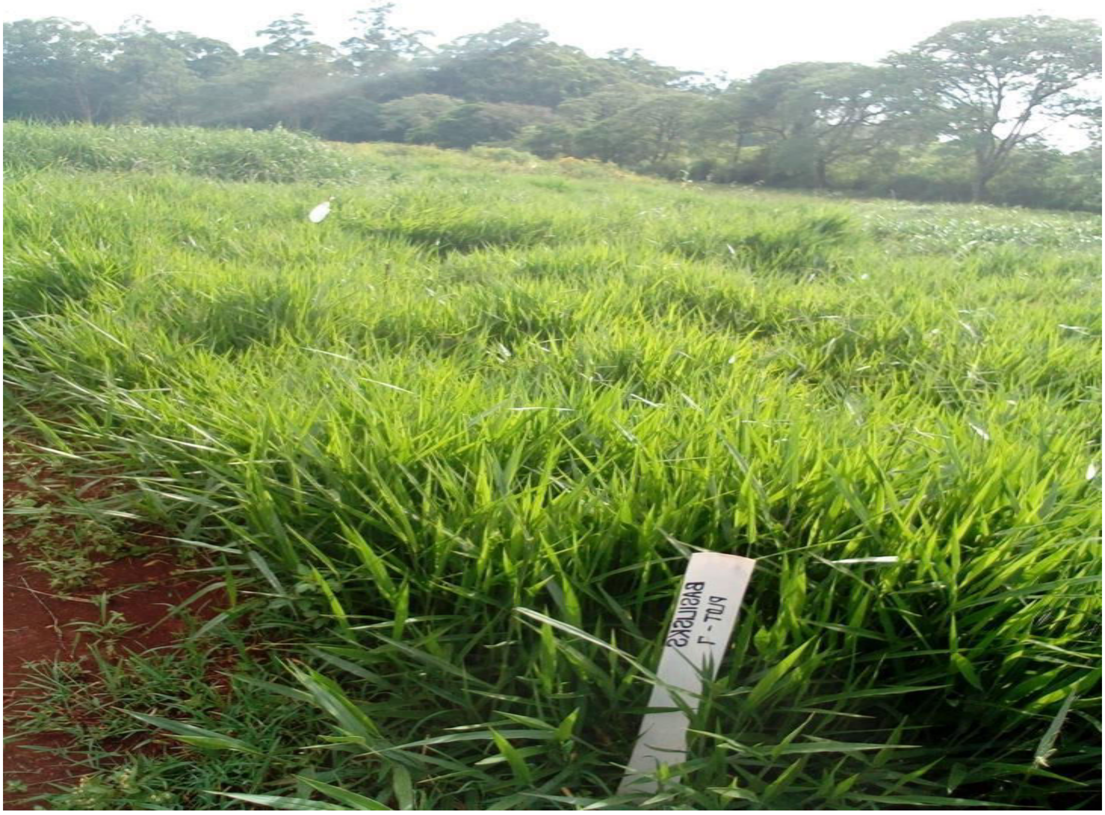


Plate 4.5: Basilisks (*Brachiaria decumbens*)

Plate 4.6: Xaraes (*Xaraes palisade*)

Plate 4.7: Mulatto II (*Brachiaria ruziziensis*)

4.4.2 Flowering, number of inflorescences and seed yield

Table 4.7: Show the influence of defoliation on the selected cultivars on their flowering, infloescence and spikes in the foliated sub plots (F) and on its defoliated once sub plots.

(D). This information aids in getting to know the impact of defoliation on seed yield.

As shown in table 4.7 above, there were differences on the effect of time on flowering of the Brachiaria grasses in LM2 (KALRO Kakamega). The foliate and the defoliated showed minimal difference in terms of time and there were considerable difference among the cultivar. Basilisk and MG4 began flowering and then Mulatto II began flowering then 50 percent as illustrated in the table above.

There were the greatest number of inflorescences in MG4 and Mulatto II followed by Basilisks and the least of them was Xareas. Though Basilisk had most of the tillers and inflorescence tillers were low as compared to MG4. Piata bore the least number of tillers and among the flowered cultivars it bore the least number of infloescences.

In LM1 (KALRO Alupe), the four cultivars; Piata, Xaraes, Mulatto II and Basilisks were in the vegetative stage since being planted in October 2022 to April 2024, which was the end of the study period as the MG4 flowered but not yet at 50% of flowering percentage.

Table 4.7: Days to flowering and number of inflorescence in LM 2 agro-ecological zone in KALRO Kakamega (Kakamega County)

Brachiaria cultivar	Mean no Days to start of flowering		Mean no Days to 50% Flowering		Inflorescence per Meter square per sub plot		No of spikes per tiller	
	F	D	F	D	F	D	F	D
XARAES	$207.33 \pm 3.6_a$	$205.32 \pm 2.9_a$	-	-	$35.00 \pm 3.0_b$	$32.67 \pm 2.8_c$	$4.00 \pm 1.1_a$	$5.00 \pm 1.2_a$
PIATA	$146.33 \pm 3.6_b$	$146.89 \pm 2.9_b$	$261.00 \pm 3.7_a$	$270.01 \pm 3.1_a$	$44.33 \pm 3.0_b$	$46.33 \pm 2.8_b$	$4.33 \pm 1.1_a$	$6.42 \pm 1.2_a$
MULATTO II	$132.67 \pm 3.6_c$	$133.02 \pm 2.9_c$	$195.33 \pm 3.7_b$	$200.87 \pm 3.1_b$	$80.00 \pm 3.0_a$	$80.33 \pm 2.8_a$	$5.00 \pm 1.1_a$	$5.00 \pm 1.2_a$
MG4	$93.67 \pm 3.6_d$	$88.67 \pm 2.9_d$	$245.33 \pm 3.7_{bc}$	$249.83 \pm 3.1_{bc}$	$75.67 \pm 3.0_a$	$79.67 \pm 2.8_a$	$6.67 \pm 1.1_a$	$7.37 \pm 1.2_a$
BASILISKS	$101.67 \pm 3.6_d$	$99.67 \pm 2.9_d$	$255.33 \pm 3.7_c$	$257.92 \pm 3.1_c$	$74.33 \pm 3.0_a$	$77.67 \pm 2.8_a$	$7.00 \pm 1.1_a$	$7.09 \pm 1.2_a$
TEST VALUES	**Df=4; F=313.95; P=0.001**	**Df=4; F=345.23; P=0.01**	**Df=3; F=133.2; P=0.001**	**Df=3; F=147.32; P=0.01**	**Df=4;F=91.14; P=0.001**	**Df=4;F=128.8; P=0.001**	**Df=4; F=2.88; P=0.001**	**Df=4; F=3.85; P=0.01**

D – Defoliated F – foliate

4.4.3 Seed Weight and Germination Test

Figure 4.12 indicates the weight of 100 seeds of the chosen Brachiaria cultivars in the agro- ecological zone, LM2, in KARLO Kakamega. Weight and germination test of the seed was done after scarification process. This was to determine the level of tolerance of the seeds to the disease.

Though all the stools were infected by the infection by ergot and false smut diseases, not all tillers were infected by them despite the infection to the seeds. None or slightly affected tillers were harvested by taking their seeds to the laboratory where they were weighed and tested on germination. Figure 4.12 indicated that Xaraes and Mulatto II were the heaviest then Piata and MG4. The least weight was basilisks. Most of the seeds were washed away as a result of rain during seed harvesting hence the separation between the defoliated regimes was not attained. There was no significant difference in the weight of 100 seeds. The germination test was performed and the seeds failed to germinate rather a dark material grew in the dishes and was assumed to be the fungal pathogen.

Table 4.8: Showing 100 seed weight (g) at KALRO-Kakamega LM2

Cultivar	**Seed weight (g) mean ± s.e**
BASILISKS	0.32± 0.019
MG4	0.37 ± .0019
XAREAS	0.38 ± 0.019
MULATTO II	0.38 ± 0.019
PIATA	0.37±0.019
TEST VALUES	**Df=4; F= 1.744; P=0.217**

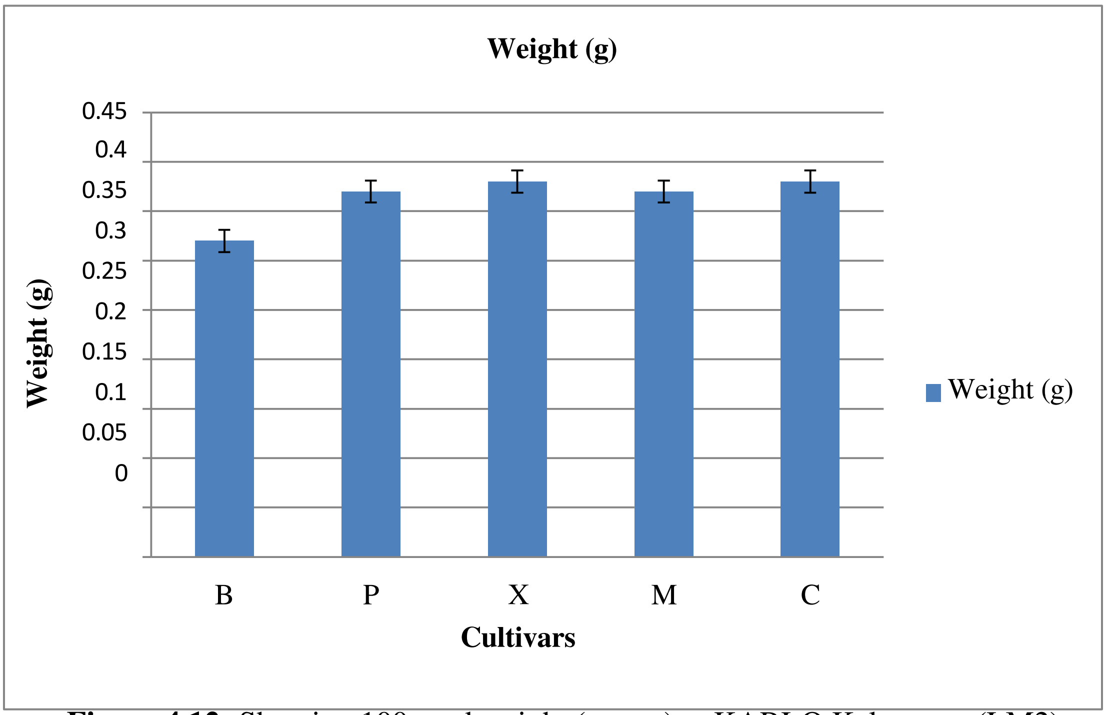


Figure 4.12: Showing 100 seed weight (grams) at KARLO Kakamega (LM2)

B – Basilisks

X - Xaraes

C – Mulatto II

P - Piata

M – MG4

CHAPTER FIVE

DISCUSSION

It is the chapter where the discussion of the findings of the study is provided and the results are analyzed in detail and compared to the previously reported works. It begins by looking at the conditions of soil and their effects on the growth of plants. It then talks about several growth parameters such as, height of plant, number of tillers, Leaf Area Index (LAI) and Light Interception (LI) and the yield of biomass. It also deals with flowering, and inflorescences and yield of seeds. The discussion is furthered to the effects of diseases on the health and productivity of plants namely Ergot (Claviceps purpurea) and False Smut (Ustilaginoidea virens). Lastly, it takes into consideration the effects of seed weight and germination test results. In addition, the chapter also frames the findings within the context of the research done in the past, their meaning, and implication.

5.1 Soils

The soils on which the experiment was planted in the two sites had low concentration of Nitrogen, Calcium and Potassium. Agro-ecological zone LM1, Alupe (Busia) had low phosphorus levels; this was as a result of the acidic soils. Rao et al., (2016) observe that phosphorus is the most significant of the nutrient that limits the growth and productivity of Brachiaria pastures in acidic soils, the deficiency of the essential nutrients such as N, P, and Ca can be relieved through identifying Brachiaria species adapted to that infertile soils and able to maximize the use of the nutrients applied. Fertility of the soil influences dry matter, nutritive quality and seed production, hence application and top dressing with fertilizer is significant in case of a regrowth. High forage quality and high production of dry matter of the soil through the application of nitrogenous and phosphate fertilizer and good management can enhance the ability of the grasses to satisfy the nutritional needs of animals particularly during the dry season (Nguku, 2015). Rao et al., (2016) hold that the majority of Brachiaria species can be cultivated in low-fertil acidic soils in the tropics and the influence of soil nutrients on growth and productivity is related to the physiological adaptability of the cultivar. Nguku et al., (2016) also reported that certain of the traits adopted by Brachiaria cultivar to help it adapt include the maintenance of root development at the cost of shoot development, and therefore, impacts the biomass in acquisition and utilization of both forms of nitrogen, nitrate and ammonium, henceforth it fixes nitrogen through associative fixation, and also fix phosphorus through large root systems and association with vessicular-arbuscular mycorrhizae, and calcium through large numbers of root tips and extensive branched roots. Thus this was an informed requirement of application of Phosphorus fertilizer when planting the Brachiaria cultivars.

5.2 Determination of growth and disease levels of false smut and ergot of selected Brachiaria cultivars in selected agro-ecological zones in Western Region, Kenya

This subsection addresses the discussions on plant height, tiller numbers and disease incidence.

5.2.1 Plant Height

Table 4.1 and Table 4.2 showed that the mean height of the various cultivars had a significant difference (p of less than 0.05) among all the observations. The height of Basilisks after 12 weeks of planting was significantly high followed by Xaraes, Piata and MG4, the shortest was Mulatto II in Kakamega, Mulatto II was tallest then Piata and Xareas next followed Basilisk being the shortest. The cultivars have varied morphological and physiological properties of plants. The growth habit Xaraes and Piata have a vertical growth habit which explains why they become high at the end of the establishment stage.

Fast and tall pasture species are more efficient and useful resource as it is more competitive in terms of nutrients. In case these fast growing and tall pasture are interplanted with other species in a mixed cropping system these pasture may out-grow the other species and shade them and they may out-compete the other species in nutrients uptake (Opiyo, 2007, Mganga, 2009 and Ogillo, 2010). Also ecological zone can influence the growth of Brachiaria in height since it has been observed through both Mulatto II and Basilisks even though Basilisks height is the tallest at agro-ecological zone LM 2 (Kakamega) it is the shortest at agro- ecological zone LM 1 (Alupe).

Even though plant height is deemed as one of the determinants of forage yield, it was the opposite with Basilisks that was found to have the lowest mean plant height in the agro-ecological zone LM 1 (Alupe) yet gave a very high percentage dry matter in the same agro-ecological zone, and Mulatto was the shortest in agro- ecological zone LM 2 (Kakamega) but gave the highest number of inflorescences in the same agro-ecological zone. Thus, it may be attributed to other variables like the density of plants per unit of area, nature and number of leaves and number of tillers (Selemani, 2022). Usually as far as is shown by the observation of this research both sites had potential to grow and reach so great a height that able cut and carry can feed on pasture, where it is found that Mulatto II can do little better in Alupe than Kakamega, and Basilisks can do little better in Kakamega than in Alupe.

5.2.2 Tiller numbers

The significance of tillering is due to some of the forage plants bearing this attribute due to the effect on the production of leaf-area and on the yield of dry matter. The quantity of tillers that the grasses produce enables them to reach optimum growth during young age and regain quickly after defoliation.

(Machogu, 2013). Growth habit can be blamed as the cause of tillering (Cook et al., 2005). The number of tillers is a measure of the efficiency of various grass species to use the resources available and the fact that the weight of tillers in a given plant is a determinant of its productivity (Laidlaw, 2005), which was not the case in Piata in agro-ecological zone LM 2 (Kakamega) because it contained the fewest number of tillers yet had the highest percentage dry matter in the given agro-ecological zone but this was congruent with the finding of friends Halim et al., (2013) who established that t

Cook et al., (2005) argue that many tiller cultivars may carry big dry matter basing on the nature of growth as observed with Basilisks in the current study. All cultivars had a progressive increment in the number of tillers and the values varied significantly ($p<0.05$) (Tables 4.3 and 4.4). In both agro- ecological sites, Basilisk and MG4 had the highest and the lowest number of tillers respectively at all the stages of observation.

Even though, Piata yielded poor production of tillers at Kakamega site, it was better at Alupe than at Xaraes and Mulatto II that had minimal disparity at the two sites in all the three stages of observation. This was credited to the environmental factors and soil fertility. There is a variation in temperature, humidity, and rainfall patterns across agro-ecological areas. The plants in areas where there is optimum temperature and enough rainfall have the likelihood of yielding more tillers. On the other hand, it could result in low levels of tiller production in regions with high temperatures or low rainfall as Passioura and Angus (2010) reported. According to Khaled and Fawy (2011), the structure and content of nutrients in the soil affect the growth of plants. The soils that contain high nutrients like nitrogen, phosphorus and potassium can enable the formation of better tiller. On the contrary, the poor soils with poor PH may reduce the number of the tillers. It was also observed that increase in the number of tillers resulted into increase in the Leaf Area Index and also Light Interception. Photosynthesis involves light interception (LI) by plant leaves which can supply energy to maintain plant, develop new leaves and roots and also generate carbohydrates stored in cells and transported to sinks of energy. The part of the plant that livestock used to feed on in pastures was the plant component required by the plant to produce LI and photosynthesis. A balance between the growth of the pasture and defoliation of the plants is necessary in this conflict between leaf retention to grow plants and leaf harvest to produce animals (Edward and Thomas 2020). The rising number of tillers with the rising number of day days is not contrary to the findings of Njarui et al., (2016) number of day days.

5.2.3 Diseases

Dairy farmers are supportive of high yielding pastures that are drought and pest/disease resistant. All the chosen Brachiara varieties were rated to potential yielding based on biomass production and resistance to pests in the chosen agro-ecological zones because there was no pest of economic significance that was observed to affect the vegetative growth of the chosen Brachiaria grass in the two agro-ecological zones as Njarui et al. introduces Brachiaria production as being influenced by various factors including moisture, soil fertility, pest and disease and management options, (2020). Nevertheless, the selected Brachiaria cultivars were susceptible to diseases during seed setting and production stage because it was discovered by Demarchi et al., (1) that the disease can easily attack young seeds that are not fully formed.

The observed diseases of Brachiaria were in accordance with the confirmed one by Nzioki et al., (2016) in terms of morphological observation. Basilisk and MG4 and Xaraes had a high incidence of the disease when affected by false smut. It was found that the disease was prevalent in Basilisk than in Piata, Xaraes and Mulatto II and the least affected by Ergot disease was MG4 this indicates that MG4 was resistant to False smut and Ergot. It was discovered that Xaraes was low in ability to resist pest and disease and this was evidenced by the effect of Ergot on Xaraes (Selemani et al., (2022). Cherunya et al., (2019) state that Xaraes and Basilisks are also prone to fungal attack and this reduces their seed production particularly in places where the humidity is 75 percent and above. Thus this, demonstrated that Ergot effect was high as compared to the Effect of false smut among the false smut affected cultivars.

Miedaner and Geiger (2015) discovered that the early symptoms of Ergot disease occurred right after the falling of the pollen and found that the grasses were affected before they were pollinated or shortly afterwards resulting in a white soft sphere-like tissue infected with honeydew and then hard dry sclerotium as seen in the plate 4.1. The same result was also realized by Kimidi et al., (2016) in North Rift Valley of Kenya where Ergot infected the inflorescence following the shedding of pollen, and they also found that the number of tiller affect in Xaraes was low as was done in this study. Nairobi reports that this disease struck Xaraes, Basilisks and MG4 in November, December 2023, January, February March, April 2024 with the greatest incidences in the months of March to April 2024 (Nzoiki et al., (2016 KALRO proceedings). As indicated in plate 4.2, the disease substituted part of Brachiaria grains with smut sori. This disease came up right after the drop of pollen.

5.3 Determination of the light interception and leaf area index of the selected Brachiaria cultivars under field conditions in selected agro-ecological zones in Western region, Kenya

This subsection addresses the discussion on Leaf Area Index and Light Interception to give information on how selected cultivars intercepted light and how leaf area index affect light interception.

5.3.1 Leaf Area Index (LAI) and Light Interception (LI)

The interception of light is one of the major determinants of plant growth, forage production, and seed yield especially in Brachiaria species. Guenni, Gil, and Guedez (2005) performed an in-depth study of five Brachiaria species, Linero, Basilisks, Mulato II and Piata in tropical environment paying special attention to the correlation between light interception and biomass production. They found that there were tremendous differences in the light interception between the species with those intercepting more light yielding high forage. A factor that was also crucial was the efficiency of converting intercepted light into biomass, which was shown to be more effectively used by some of the species to grow.

In the current research where the light interceptions (LI) rose in the leaf area index rose or held steady as Figure 4.4 to Figure 4.7 exhibits. In Alupe as LAI was rising there was also the rise in the LI and some were constant such as MG4 at week 14 and week 16 this was as a result of rise on growth of all the cultivars henceforth these findings matched the results of Marin et. al., (2014) who showed that amount of tissues in forage is affected by the normal recommended cutting or grazing time, the optimal LAI is the time when the forage reaches a maximum point of mass accumulation.

Since the LAI increase there also increased on growth of all the cultivars. In Kakamega, MG4 and Mulatto II were the best in LAI closely followed by Piata and Basilisks and Xaraes was the least. The behaviour of Xaraes in the 2 agro- ecological zones appear different particularly on the measurement of Leaf area index where it exhibited high Leaf area index in LM2 (Kakamega) and low in LM2 (Alupe) and its indicates that Oliveira et al., 2016 were correct when they said that Leaf area index can be influenced by water availability and soil nutritional characteristics. As LI and LAI rose gradually it was also observed that it was also attributed to increase in plant height and the number of tillers as observed in Basilisks in LM2 (Kakamega) as increase in LAI with time also caused increase in the height of canopy and increase in the number of tillers as stated by Pedreira et al. (2007) when he was also assessing light interception in B. brizantha pastures, it was taken that canopy height is a viable and efficient parameter to represent the degree of light interception.

5.4 Determination of the yielding levels of selected Brachiaria cultivars in selected agro-ecological zones in Western region, Kenya

5.4.1 Herbage yield

The yield of dry matter rose gradually as it is shown in Figure 4.11 and Figure 4.8. All cultivars had significant difference ($p<0.05$) at week 12, 20 and 28. In LM1 (Alupe) Basilisks had the highest percentage dry matter and in LM2 (Kakamega) Piata had the highest percentage dry matter, furthermore the plant height could be due to their morphological and physiological dissimilarity among the cultivar. Thus, works by Opiyo, Francise and Ogillo 2005 who postulated that pasture which grows faster and taller are more efficient to resource users and hence they are quick in accumulating dry matter yield and are more competitive with the works of other authors were consistent with what the authors described: in the case of Piata in LM2 (Kakamega) but not in the case of Basilisks in LM 1 (Alupe). The percentage dry matter of Piata and MG4 was the highest then Xaraes and Basilisks and Mulatto II had the least percentage dry matter in Kakamega.

The results align with the finding of Rodrigues et al. (2014), who stated that pasture with increased leaves will have a higher leaf blade and stem length, which in this study were indicated in the LAI, the number of tillers and height, thus, leading to the high production of biomass. Basilisk and MG4 were the ones with the highest number of tillers and taller yet low dry matter in Kakamega whereas the number of tillers and heights in Alupe Basilisks and MG4 were the best in terms of percentages dry matter. This is unlike the results of Njurui et al., (2015) who found that the foliage height was raised, and biomass yield was higher. The variation in the yields of the cultivars in terms of dry matter can be explained by the genotypic variation as explained by Cook et al. Typically, the growth in the yield of herbage in the grass is accelerated by high levels of increase in the plant tissues (Nguku and Susan 2015). Hence, the present research aligns with what other previous researchers had already reported such as Mganga and Kevin (2009) and Ondiko et al., (2017).

5.4.2 Flowering, number of inflorescences and seed yield

The reproductive capacity of the forage grass is crucial in the conservation of biodiversity and in livestock nutrition as genotypic factors influence seed production and the environmental conditions (Machogu, 2013; Gitari et al., 2016). In this research, despite having a high number of Brachiara varieties with profuse flowering, disease pressure in most cases reduced the yield of seeds. Maturity and harvest Rainfall or dry spells during flowering and seed production also play a major role in maturity and harvest as observed by Kamidi et al., (2016).

Basilisk and MG4 flowered first at KALRO Kakamega (LM2), then Piata and finally Xaraes flowered and not anthesis 50 at all within the timeframe of the experiment (Table 4.7). Therefore, the cultivars were classified into two flowering groups, early flowering (Basilisk, MG4, Mulato II) and late flowering (Xaraes, Piata). These results are in agreement with those found in other studies in Embu and northern Kenya (Gitari et al., 2016; Kamidi et al., 2016), but also with field data in the Cameroon study (Ojong et al., 2024).

A count of inflorescence showed MG4 and Mulato II were the most followed by Basilisk, Xaraes had the least. Although Basilisk had the greatest tiller density, it had fewer infloescences per tiller than MG4. Piata, which had the lowest number of tillers, had the lowest number of infloescence of flowering cultivars. These findings are in line with the findings of Kamidi et al., (2016), who found that the inflorescence and production of seeds are favored in high tiller density and low population density of the plants.

The infloescence counts had been boosted by continuous defoliation, especially in MG4 and Basilisk at Kakamega which was also supported by Hare et al., (2007) who noted that the increase in spikes, panicles, or racemes depended on the abundance of tiller-rich grasses. Interestingly, the Mulato II, with its low tiller density, had high numbers of infloescence, which is in agreement with Monteiro et al., (2016) who have found out that tiller count and seed production are not necessarily positively correlated in tropical grasses.

But flowering was dissimilar: Mulato II came into flower later than MG4 and Basilisk; Piata came into flower later still; Xaraes never came into flower at all.

Machogu, (2013) also reported that Mulato II also requires more time to flower and set seeds. Only MG4 flowered under LM1 (Alupe) conditions in the October 2022 to April 2024, and antheised on day 112--more days than a 94 days anthesis specified at Kakamega. Climatic and soil data would provide context: Kakamega has 1,280-2214 mm annual rainfall, with the temperature of 13-29 degC at Kakamega and 15.3-31.4 degC at Alupe, and soils were different (sandy loam and high organic carbon at Kakamega and clay loam and moderate carbon at Alupe respectively, and were slightly acidic).

The reduced flowering at Alupe could be explained by a slower reproductive development caused by the lower temperatures and moisture or by nutrient uptake--in line with Oliveira et al., (2016), who suggested that the water level and soil fertility had a strong influence on pasture performance. Also, although Busia can get a greater amount of rainfall, it might not be distributed in the right areas and at the right time as per the reproductive requirements of the cultivars planted.

5.4.3 Seed Weight and Germination Test

The seed weight is also a significant characteristic of the quality of seed and its potential germination. Xaraes and Mulato II gave the highest weight of 100 seeds with an average of 0.38 grams each, followed by Piata and then MG4, and Basilisk with the least average of 0.32 grams. These are slightly lower than the range mentioned by Kamidi et al., (2016), who found that weight of 100-seed of Brachiaria cultivar averages of 0.35 g to 0.40 g, depending on genotype and environment in which they are grown. In addition, Njehoya et al., (2021) indicated a 1,000-seed weight interval of 1.538 g to 5.685 g in Basilisk, which also indicated that the weights obtained in this study lead on the lower side of the expected standards.

This might be explained by the fact that the lower seed weights were caused by biotic stress (especially fungal infections) that influenced the seed development in the reproductive stage. It was observed in the field that dark fungal growth was present on some seed samples; particularly those seeds that had been harvested in cultivars which were showing leaf blight and rust foliar diseases. Such pathogens probably infiltrated growing seeds with compromised tissue and impaired the formation of endosperm and the integrity of the seed as a whole (Cardoso et al., 2011). This consequently led to discolored and light seeds with low viability. These findings were also supported by the germination tests that were done under controlled conditions after harvesting of the seeds. The seeds with the best weights (Xaraes and Mulato II) exhibited the best germination percentages whereas Basilisk seeds which were most infected exhibited low germination percentages. The trend is similar to the previous results of Machogu, (2013) and Oliveira et al., (2016) who reported that seed-borne pathogens have a critical role in decreasing the rate of germination and seedling vigor in Brachiaria grassings. These findings underscore the value of disease management during flowering and seed-setting phases since the pressure of pathogens reduces seed yield besides impairing the quality of seeds and subsequent potentials of establishing pastures in the future.

CHAPTER SIX

CONCLUSION, RECOMMENDATION AND SUGGESTION FOR FURTHER RESEARCH

6.1 Introduction

This chapter provides the conclusion and recommendations based on the study's findings. It finalizes by providing the suggestions for further studies. It has been addressed as follows:

6.2.1 Conclusion

Regarding the initial specific aim, which was to establish tolerance to vegetative-stage disease in the agro-ecological zones of the West of the Western Region, Kenya, the research comes to the conclusion that all the tested cultivars Basilisk, MG4, Piata and Xaraes were tolerant to vegetative-stage disease like ergot and false smut. Nevertheless, in the reproductive phase of LM2 (Kakamega), the entire cultivars were sensitive to the ergot and this adversely influenced the seed viability. Basilisk was found to excel in LM1 (Alupe) in terms of height, tillering capacity and dry matter yield whereas Piata and MG4 had been found to have the best growth characteristics in LM 2. These findings indicate that Brachiaria cultivars can be well cultivated in the two zones when appropriately managed.

The second specific objective used was to identify the light interception and the leaf area index (LAI) of the selected Brachiaria cultivars under field conditions and the study concludes that the light interception capacity of different cultivars varied between agro-ecological regions. Xaraes had the lowest light interception and lowest LAI which means that this crop is cultivable in areas that are under the canopy of trees or other shaded areas. Mulatto II in LM2 and Basilisk in LM1 on the other hand collected more light and hence might not be adapted to low light situations as their productivity can be affected adversely by low light levels.

Based on the third specific objective, which was to establish the level of herbage and seed yielding of the Brachiara cultivars selected, the study revealed that Piata yielded the greatest amount of DM in the LM2, then MG4, Xaraes and Basilisk. Basilisk was the most productive in LM1 and MG4, Xaraes, and Mulatto II. In terms of seed production, MG4 and Basilisk flowered earlier and had the highest count of infloescences and spike counts which showed a great potential in seed production in LM2. Nonetheless, fungal diseases led to loss in soakedness of plant seeds highlighting the need to manage the disease early enough.

Thus, the generalized study conclusion is that the specific Brachiaria species, especially MG4 and Basilisk, demonstrate high disease resistance, possible forage and seed production, and the ability to adapt to diverse agro-ecological environments in Western Kenya, which is an alternative to Napier grass and may help to create affordable and quality seed production systems among smallholders.

6.2.2 Recommendation

As per the first specific objective, Basilisk will be suggested to be planted in LM1 (Alupe) because it has better performances in terms of tillering, plant height, and herbage. Piata and MG4 are also suggested in LM2 (Kakamega) because of good vegetative growth. In addition, MG4 was more resistant to ergot and false smut during the reproductive phase thus making it the best forage and seed production. Disease control strategies in particular at the flowering stage are necessary to enhance the seed viability and successful production of Brachiaria.

Answering the second specific objective, it is suggested that the planting of Xaraes with the minimum light interception and LAI will be done in the shaded environment or under trees in LM1 and LM2 areas. The feature predisposes Xaraes to be easily incorporated in agro forestry systems. Mulatto II and Basilisk on the other hand should not be planted in the shade, at least in LM2 and LM1 respectively, since they have large light interception demands that would lead them to perform best in the open-field environment.

In accordance with the third specific objective, it is suggested that Piata should be implemented in LM2 (Kakamega) to produce the dry matter, especially to store the hay. Basilisk can be applied in LM1 (Alupe) because it has high fresh and dry biomass production. In the case of seed production, MG4 is strongly suggested as it was an early flowering cultivar that has a fairly elevated amount of infloescences and spikes. In LM2, farmers have been motivated to cultivate MG4 to produce seeds in their farms, in order to increase availability of planting materials in the area. It should also focus on proper seed harvesting and post harvesting to maintain quality of the seeds.

6.2.3 Suggestions for Further Research

Assessment of the nutrient gain efficiency of the soils and the quality of forage of Brachiaria cultivars in specific agro-ecological areas in Western Kenya is one of the potential areas of future research. Although this study involved growth, disease tolerance and yield performance, it did not determine the effect of individual cultivars to absorb and utilize soil nutrients and the nutritional value of the resultant forage. The study of these characters would be beneficial in determining cultivars that would not only be productive, but also fit in the low-input farming systems, which is common with smallholder farmers.

The other important area of research is Development of integrated management strategies of fungal diseases that affect seed production in Brachiaria in LM2 agro-ecological zone (KALRO-Kakamega). The research discovered that fungal infections such as the ergot and false smut had a devastating effect on the seed viability, but there is little information available about their effective management. More studies are needed in understanding the chemical and cultural means of controlling the disease and the environmental and physiological determinants that precondition the cultivar to be infected.

There is also a requirement of an in-depth Evaluation of germination percentage and seed viability of domestically grown Brachiaria growing in various storage and field conditions. Since the majority of Kenyan agriculturalists at the present use vegetative propagation, given the high price of the seed and the unavailability of local produce, describing the protocols of germination and the viability would aid in the creation of a cheap, high-quality local seed system.

Even though the interception of light and leaf area index have been examined, the recommendations of future studies are to include the role of Photosynthetically Active Radiation (PAR) on growth and productivity of the selected Brachiaria cultivars in Western Kenya. The actual PAR values will be used to give more accurate information on the influence of light quality and intensity on physiological performance and forage yield particularly when the canopy is not stable.

Finally, it was also noted that the cultivar of Brachiaria that was selected in LM1 (Alupe-Busia) were late flowering with some still wholly under vegetative phase during the study period. Thus, one of the studies that can be suggested is Impact of Extended Growth Duration on Flowering and Seed Set in Brachiaria Cultivars Grown in LM1 (Alupe-Busia) Agro-Ecological Zone. The study would investigate whether lengthening of growing seasons would cause flowering and increase seed yields in slower maturing cultivars, and hence increase their viability as a seed-based forage source in the area.

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APPENDICES

Appendix I: Sample of data collection sheet from plant number 1 to plant number 105

	1st data collection		**2nd data collection**		**3rd data collection**	
PLANT NO.	**Height**	**no. tillers**	**height**	**no. tillers**	**height**	**no. tillers**
P1						
P2						
P3						
P4						
P5						
P6						
P7						
P8						
P9						
P10-105						

Appendix II: MMUST Directorate of Postgraduate Studies Approval Letter

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

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Kenya

Directorate of Postgraduate Studies

Ref: MMU/COR: 509099

20th September 2023

Rono J. Lydia
SCP/G/01-53906/2019
P.O. Box 190-50100
KAKAMEGA

Dear Ms. Rono

RE: APPROVAL OF PROPOSAL

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your Masters proposal entitled: "***Growth Potential, Seed Pests and Pathogens, Affecting Selected Bracharia Cultivars in Selected Ecological Zones of Western Region, Kenya***" and appointed the following as supervisors:

1. Dr. Dennis omayo - MMUST
2. Prof. Francis Muyekho - MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director of Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Natural Sciences Graduate Studies Committee; Chairman, Department of Biological sciences & Departmental Graduate Studies Committee. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of two years from the date of registration to complete your Master's thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours Sincerely

Prof. Stephen O. Odebero, PhD, FIEEP
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR
SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **987441** | Date of Issue: **15/December/2023**

RESEARCH LICENSE

This is to Certify that Miss.. LYDIA JEPCHIRCHIR RONO of Masinde Muliro University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Busia, Kakamega on the topic: GROWTH POTENTIAL, PEST AND PATHOGENS OF SELECTED BRACHARIA CULTIVARS IN SELECTED AGRO-ECOLOGICAL ZONES OF WESTERN REGION, KENYA for the period ending : 15/December/2024.

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Appendix III: NACOSTI PER