Disease Tolerance Levels and Growth Potential of Selected Brachiaria Cultivars in Selected Agro-Ecological Zones of Western Region, Kenya

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ABSTRACT

Brachiaria is a newly introduced forage grass in Kenya and other countries that has potential for improving livestock productivity but there is limited availability of seed this has become a major constraint. Pastures in western Kenya faces both pathological and physiological problems associated with both biotic and abiotic factors that leads to poor livestock production especially in the dairy industry. This research study focused on evaluating disease tolerance and growth potential of selected Brachiaria cultivars Xaraes (Xaraes palisade), Piata (Piatã palisade), MG4 in the selected agro-ecological zones of Western Region, Kenya. Mulato II grass was included as a control. The experiment was replicated three times at two different agro-ecological zones namely KALRO Kakamega LM2 and KALRO Alupe, Busia LM1 agro ecological zones therefore this study was a 2×3×5 factorial laid in a split plot. Root splits used as planting material were sourced from KALRO Kakamega farm. Phosphate fertilizer at the rate 40 kg/ha P2O5 were used at planting and the crop was top dressed with Nitrogen fertilizer at the rate 100 kg/ha N. Data collected included number of tillers, plant height at different stages, light interception, leaf area index and diseases incidence on the seeds. In LM1 Mulatto II had the highest height and Basilisks had the lowest height and vice versa for LM2. In both agro-ecological zones Basilisks had the highest number of tillers. In terms of disease establishment, in LM2 (KALRO-Kakamega); Basilisks was the most affected cultivar by both false smut and ergot diseases at 58% and 69.33% incidences respectively. MG4 had the least ergot incidence at 41%, while Xaraes had the least incidence for false smut at 32%. In LM 1 (Alupe Busia), no cultivar exhibited disease. Most cultivars intercepted light higher in LM2 and lower in LM1. Mulatto II and Xaraes had the highest and lowest light interception respectively in LM1 (Alupe Busia), while Basilisks and Xaraes had the highest and lowest interceptions respectively in LM2 (KALRO-Kakamega). The trends were the same in terms of LAI though MG4 had the lowest LAI in LM1. Through this study Basilisks, Xaraes, Mulatto II and Piata were moderately tolerant to ergot disease while MG4 was highly tolerant. Basilisks and MG4 were moderately tolerant to false smut disease while Xaraes had high tolerance levels This research serves as a baseline for future research on Brachiaria forage yield and provide knowledge-based information on production of high quality Brachiaria seeds with the view of enhancing their availability scaling-up Brachiaria forage production to enhance dairy productivity in smallholder farm.

Keywords: Brachiaria, Cultivar, Diseases, Plant Height, Number of Tillers, Percentage Dry Matter, Yield

I. INTRODUCTION

Dairy cattle production in Kenya is highly ranked by both National, County Government and by small-scale farmers as an important enterprise that contributes 14% of agricultural GDP (Odero-Waitituh, 2017). In recent years, Napier grass which has been the main forage feed has been under threat from Napier stunt and head smut diseases which can reduced forage yields by 40% - 80% (Negawo et al., 2017). Improved Brachiaria cultivars developed through breeding by increasing diversity through germplasm introductions to the Kenyan environment to boost the forage resource base for livestock programs are now commercially available to farmers in tropical regions worldwide

(Nguku et al., 2015). These cultivars offer advantages such as higher forage yields, better nutritional quality, and enhanced sustainability in livestock production systems (Maass et al., 2015). Except in Africa, Brachiaria has been widely grown as a pasture plant across the tropics (Ghimire et al., 2019).

Research has shown that reproductive process in Brachiaria is highly influenced by agronomic practices. Sword typically grows in an inflorescence slowly, sparsely, and with poor synchronization (Smith, 2011). The growth of tillers inside the sword serves as the beginning of reproduction. It is advised that Brachiaria grow best on moist soils that have enough nitrogen and a mean daily temperature of about 23°C (Gobius et al., 2001). Depending on specific photoperiodic requirements, tillers grow into separate bursts that initiate flowering (Loch & Ferguson, 2004). Currently farmers depend on root splits as planting materials, which are expensive to transport to their farms and their establishment is greatly affected by weather conditions. Their potential to produce seed totally has not been adequately evaluated. Although other factors such as rainfall, agronomic methods, soil fertility, and pest control are equally important, high-quality seed has a vital role in attaining a good crop stand and rapid plant development even under bad conditions (Assefa et al., 2012).

To support the smallholder dairy system in western Kenya, it is necessary to establish high-yielding fodder grasses that are resistant to tropical pasture pests and diseases. Brachiaria hybrids have shown the potential to provide high quality forage in a wide range of agro ecological zones. Brachiaria grass is a climate smart crop that has the potential to mitigate climate change by inhibiting the release of nitrous oxide therefore reducing greenhouse gas emissions, also improve feed shortage which will eventually improve income for a resource constrained farmer (Njarui et al., 2020). Therefore, this research was anchored to sustainable development goals (SDGs) number 1 on reducing poverty through creating job opportunities, 2 zero hunger through commercialization of Brachiaria Grass, 13 climate action as stated by Njarui et al. (2020) and 15 lives on land by planting Brachiaria it supports the eco-system (Morton, 2007). Therefore, availability of high-quality Brachiaria seed will enhance forage availability and thus increased milk production and profitability for small-scale farmers in western Kenya, as well as the Kenyan dairy industry. This research focused on the growth potential and disease tolerance levels affecting selected Braicharia cultivars in selected agro-ecological zones of western Kenya.

1.1 Statement of the Problem

Brachiaria grass is a tropical pasture of agricultural and environmental significance that is indigenous to Africa (Njarui et al., 2020). In recent years, Napier grass which has been the main forage feed has been under threat from Napier stunt and head smut diseases which can reduced forage yields by 40% - 80% (Negawo et al., 2017). To date there is no efficient control method of the diseases and these prompted the Government through KALRO and partners to source and evaluate alternative high yielding Brachiaria cultivar. The fodders are extremely palatable to livestock, resulting in high consumption whether fed fresh or grazed in the field (Barry et al., 2021; Nguku et al., 2015).

Seeds and vegetative splits can both be used to propagate Brachiaria, however in Kenya farmers can only access the splits either from research Centre's or neighboring farmers. The seed available is imported hence too expensive (retailing at approximately KSh 6,000 per kg) for resource constraint farmers to afford. Root splits, on the other hand, face significant pathological and physiological obstacles, resulting in a significant drop in production over time (Ghimire et al., 2019).

The root splits are also bulky hence expensive to transport and also their establishment is dependent on weather condition which results in poor establishment whenever low soil moisture and high temperatures are experienced. As a result, developing and deploying cost-effective technologies for Brachiaria herbage and quality seed production system with minimal disease incidences will go a long way in making quality seed available through informal and formal seed systems. Availability of quality seed will encourage farmers to plant high yielding Brachiaria cultivars and thus solve the constraint of feed shortage for dairy cattle in the smallholder farms.

1.2 Research Objective

The research objective is to; determine disease tolerance levels and growth potential of selected Brachiaria cultivars in selected agro-ecological zones of Western Region.

II. LITERATURE REVIEW

Brachiaria is an important tropical forage grass that originated in Africa. Different restrictions, such as diseases, have an impact on its performance. In sub-Saharan region, common diseases affecting pasture ranges from specie to species based on the susceptibility. Leaf blight, leaf rust, leaf spot and NSD have been documented among others. Pests are also major causes of low productivity of pasture. For instance, spittlebugs are the most damaging pest of tropical Brachiaria pasture. Red spider mites and leaf cutting aunts have also been documented as major threats for the survival of Brachiaria cultivars (Brigitte et al., 2014).

Root-knot nematodes infect practically every species of plant, causing microscopic to large galls on root knots (Moens et al., 2009). For instance, Nacobbus aberans is a root knot nematode that affects fodder crops. The physiology of the plant is affected, resulting in a reduction in yield and product quality. Infected field contain number of juveniles which penetrates young plants; become established within the root tissues. Species of nematodes like Meloidogyne, on the other hand, have been detected in vegetative planting materials such as splits, but not in seeds (Moens et al., 2009). It's worth noting, though, that resistant rootstocks or splits can have an impact on the microbial populations in the soil around the roots. Authors have documented grass cyst nematodes such as *Puctodera puctata*, implying that the species infects most grasses which serve as a good nematode host (Bacon et al., 2003).

The grass may appear brown to reddish necrotic lesions parallel to the root axis and eventual secondary decomposition characterize root infection by lesion nematodes. Above ground symptoms observed on infected plant may include but not limited to; suppressed shoot growth and accompanying decreased shoot -root ratio, nutritional deficiencies showing in the foliage (chlorosis), temporary wilting and suppressed plant yields. It is therefore recommended to use only certified nematode –free plants from reliable nurseries. The major diseases that have affected Brachiaria cultivars in Kenya are; Leaf spots which are characterized by black to brown spots on Brachiaria leaves. Infected leaves have brown to black raised to flat rough irregular spots which in severe cases coalesced and killed the entire leaf. This leaf disease has been noted in Ithookwe, Katumani, Msabaha, Mtwapa, Mariakani and Ol Joro Orok, Leaf rust Symptoms consisted of orange or yellowish-orange raised pustules mainly on leaf blades; the disease has been noted in the following areas Nairobi, Ithookwe, Katumani and Mtwapa.

Brachiaria grass does well in a wide range of climatic conditions in Kenya. It does well in areas with rainfall above 700mm and temperature beyond 19ºC with well drained soils with a pH of 5-8. The altitude above 1800mm above the sea level is ideal for the production of Brachiaria grass. Majorly grown Brachiaria grass in Kenya are Mulatto II, Cayman, Cobra, Piata, Xaraes, MG4 and Basilisks. Brachiaria seed yields range from about 1000 kg/ha of pure seed to less than 100 kg/ha whereas the quality is influenced by dormancy and vitality.

For instance, Mulato II generated nearly twice as many pure seeds per m2 as Mulato I (161 kg/ha), resulting in a 60 percent higher seed output (Bakur et al., 2008). Previous study has demonstrated that the viability of the seeds is directly proportional to their maturity at harvest. The moderate or low water levels affect the growth of the root system of the grass (Taiz & Zeiger, 2009). Though brachiaria grass can be exposed to the stress but show growth potential of root towards the soil areas that remained wetter since during low water levels the superficial soil layer dry first.

Therefore, this is considered a defensive mechanism of the grass (Carrilho et al., 2012). Low light availability affects the photosynthesis and diminishes the capture of carbon for plant growth (Lee et al., 2007). Though, Brachiaria grass seed production is high when grown under partial light and partial shade (Carrilho et al., 2012). Therefore, the research seeks to find out the amount of light intercepted by various Brachiaria cultivars and their Photosynthetic Active Radiation.

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III. METHODOLOGY

3.1 Study Site

The study locations were purposefully chosen to represent dairy production areas in Western Kenya's sub-humid and mid-altitude agro-ecological zones. The study site were KALRO Kakamega in agro ecological zone Low Midlands 2 (LM 2) and Alupe, representing the Low Midlands 1 (LM 1) agro ecological zone within an altitude of approximately 1430m and 1330m above the sea level respectively (Jaetzold et. al., 2005).

The mean annual minimum and maximum temperature is 13ºC and 29^0C for Kakamega and 15.3ºC and 31.4ºC for Alupe. The soils in Alupe are classified as moderate organic carbon and the texture is clay loam while that for Kakamega is classified as highly organic carbon and they are sandy loam. The soil pH for both Alupe and Kakamega are slightly acidic (Okalebo et al., 2002). Kakamega represent smallholder farming systems on mixed farming, it is predominantly a crop farming county with livestock farming taking a small portion of the available arable land. However, with the increasing land demarcation from population pressure, it is important to improve on animal feeding style. Through ministry of Livestock and veterinary service and KALRO the government has embarked in hay/pasture improvement.

Livestock production department is also engaged in various extension services where farmers are trained on animal feeds. Majorly the combination of subsistence and industrial crops with the predominance of sugarcane crop and other crops live maize, tea, sweet potatoes, cassava, sorghum and millet. Busia also represent a small holder farming with the combination of food crops and animal production, majorly coffee, rice, fish and livestock production. Other crops include groundnuts, sorghum, maize and millet grown in small scale. Furthermore, the agro-ecological zones of interest are on latitude 00 30' N, longituted 350 00' E and located 50km north of Lake Victoria for Kakamega and latitude N00 29' 50', longitude E 340 7' 31' and 9km from Busia town for Alupe.

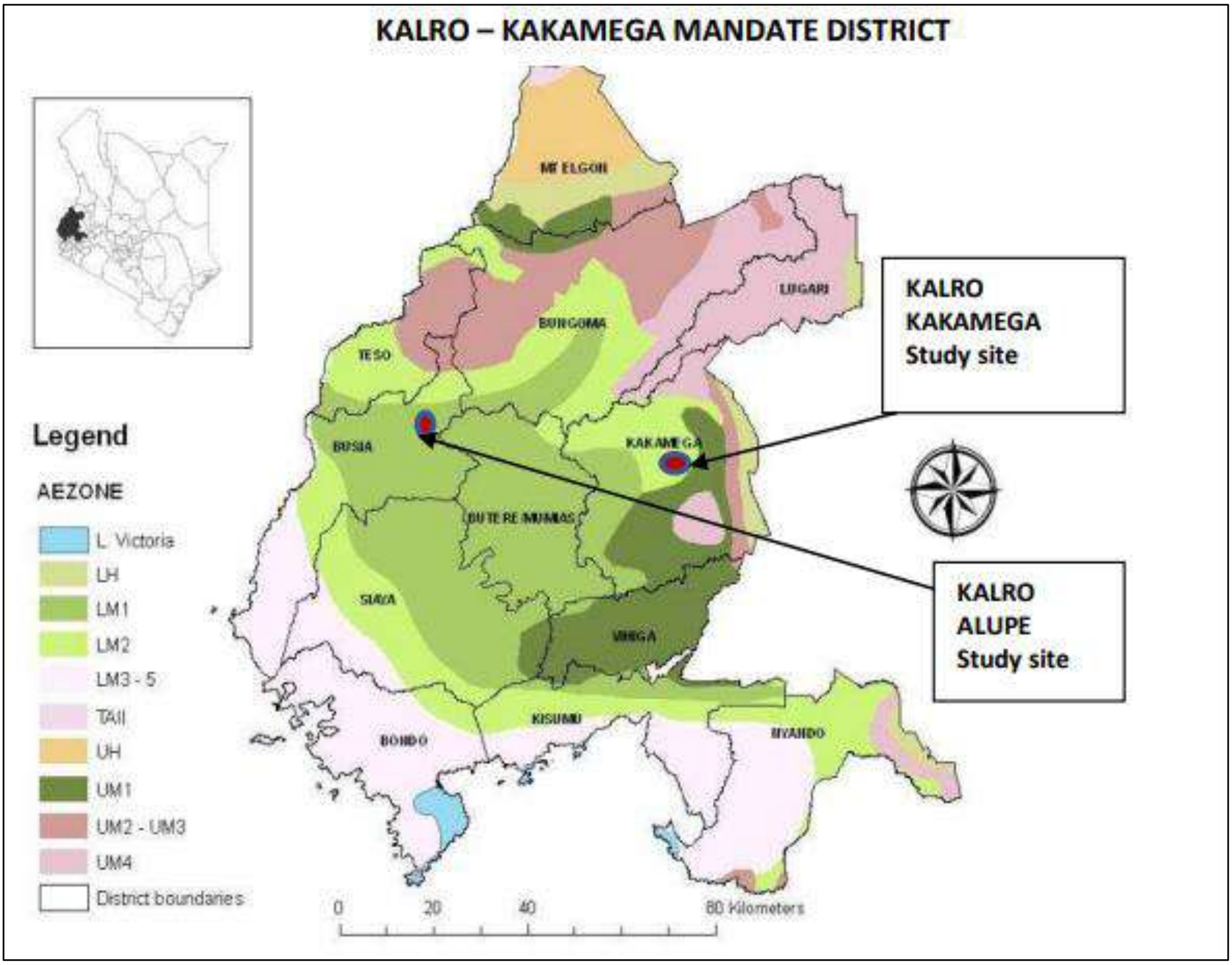

Figure 1
Map Showing Experimental Sites

3.2 Experimental Design

The experiment in this study was a 2×3×5 factorial experiment which was laid in a split plot design. The factors included cultivars at five levels namely Xaraes (*Xaraes palisade*), Piata (*Piata palisade*), MG4 (*Brachiaria brizantha*), Basilisk (*Brachiaria decumbens*) and Mulatto II (*Brachiaria ruziziensis*) as control. The second factor was defoliation at three levels namely non-defoliation (Control), defoliated once after three months of growth, and defoliated continuously after every 60 days from week twelve throughout the growth period. The first two defoliation treatment growth parameters and disease tolerance were determined, while in the continuously defoliated treatment only dry matter was determined. The third factor was agro-ecological zones at two levels Low Midland 2 (LM2) at KALRO (Non-ruminant Research Institute) Kakamega and Low Midland 1 (LM1) at Alupe (Food crop research centre) Busia. The three factors helped in determination of their effects on growth, herbage and seed yield. The three factors made up the 30 treatments and the treatments were replicated three times which gave 90 experimental units. The defoliation factor was meant to test the synchronization of flowering and seed set by the tillers. The main plot measured 9m by 5m, sub plots measuring 3m by 5m and the spacing between plots and between replicates was 2m.

Figure 2 show how all experimental plots were split into three sub plots the defoliated once, continuously defoliated and non-defoliated and also shows how the plots were replicated:

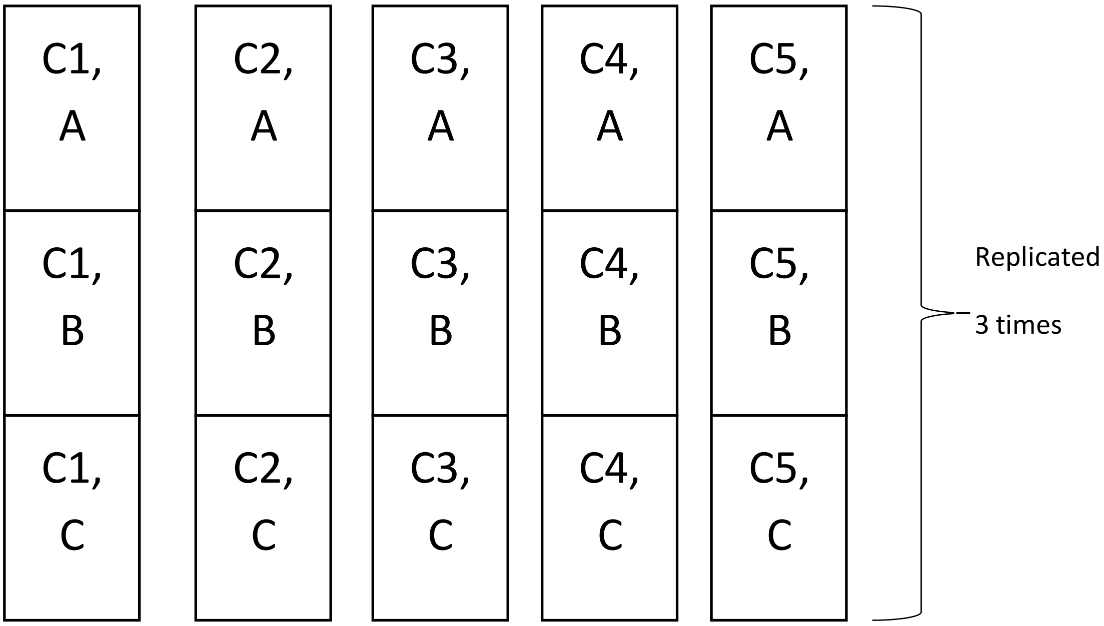

Figure 2
Field Experimental Layout Plot
The experimental plots are identified as follows from the figure above:

C - Defoliated continuously
B - Defoliated once
A - non-defoliated
C1 – Piata
C2 – Basilisks
C3 – MG4
C4 – Xaraes
C5 – Mulatto II

Planting and Agronomic Management

The samples of soils were collected in both fields at KALRO Kakamega and Alupe, and then taken to the laboratory to test all the soil chemical properties. The land was ploughed using tractor and harrowed through hand harrowing and removal of any plant debris and plant remains from the field. The measurements as described above were demarcated into 5 plots per replicate and there were 3 replicates to give a total of 15 plots. The planting holes were made at a distance of 50cm by 50cm whereby there were 19 holes by 11 holes per plot at a deep of about 10cm.

The cultivars were planted from root splits of clean planting material from KALRO Kakamega. Three root splits were planted per hole for all the cultivars including the control. Phosphate fertilizer at a rate of one bottle top per hole representing a rate of 40kgs P2O5 per hectare was used. The selected Brachiaria cultivars were planted in the plots by randomly choosing them, this was achieved by writing the names of the selected Brachiaria cultivars in small pieces of paper then fold, mix them well and picked one by one, the first cultivar to be picked was planted in the first plot and the rest followed in that pattern to the fifth plot. Weeds were controlled as they emerge through manual weeding.

Disease Tolerance Levels and Growth Potential

The data collected included; plant height, number of tillers, disease effect and incidence, light interception and leaf area index as described:

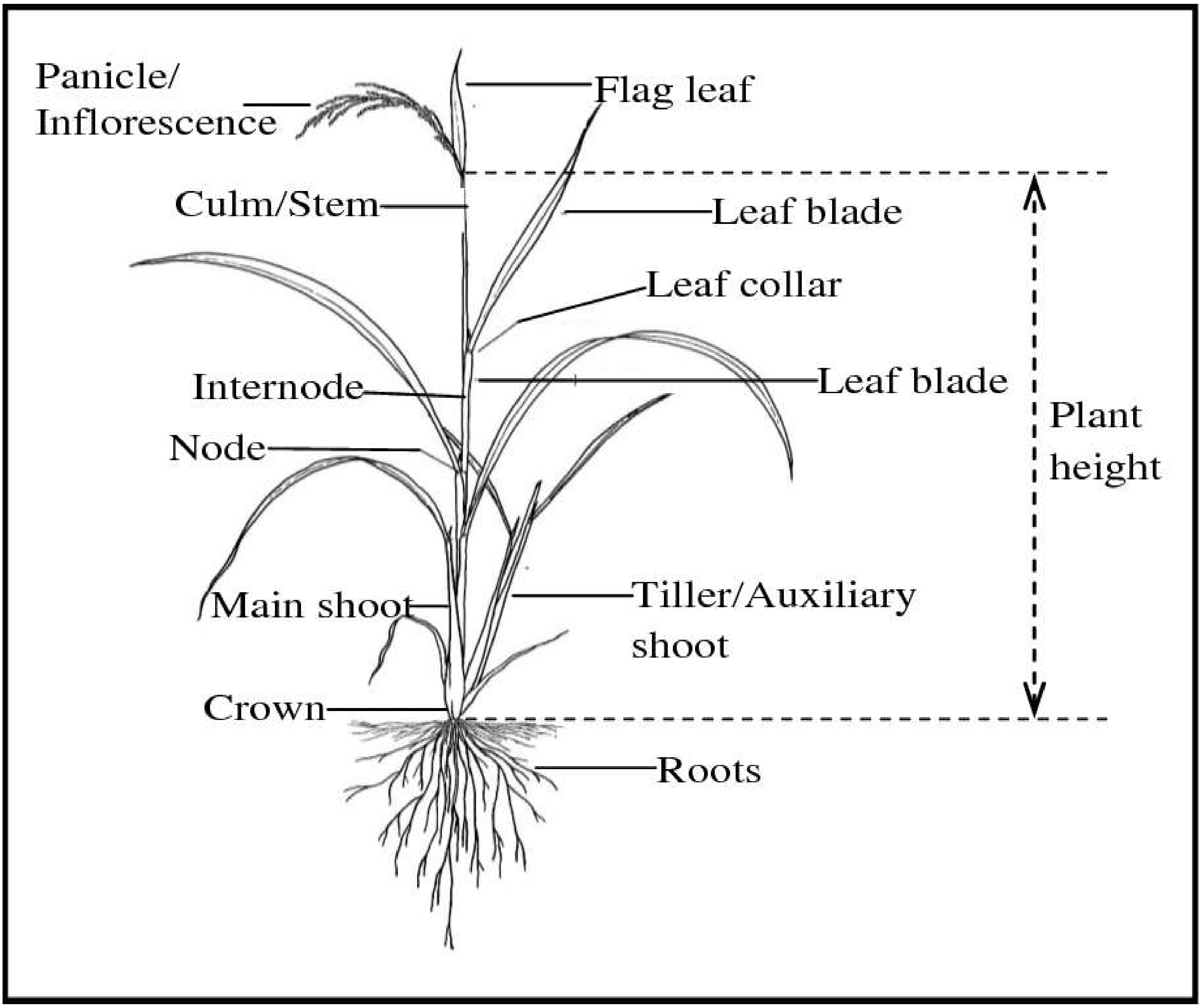

Figure 3
Shows the Various Parts of a Grass Plant that were used in this Study for Various Data Collections

Estimation of Number of Tillers and Plant Height

The number of tillers per plant were physically counted from 35 plant stools in each sub plot and the plant height was measured physically using a meter rule from the 35 plant stools in each sub plot, the non-defoliated and defoliated treatments, this add up to 105 plant stools per plot, at every after four weeks after planting and continuously after every four weeks interval consistently. Two guard rows were left from all sides of the plot to avoid biasness. This data was collected after standardization and before defoliation. Standardization was done by ensuring the number of tillers were three by removing the extra tiller on stools that had more than three and the stubble height at 5cm to make it uniform to avoid biasness. The purpose of this data was to help describe the growth of the selected Brachiaria cultivars in the selected agro-ecological zone LM1 KARLO Alupe and LM2 Kakamega.

Identification of Diseases of Brachiaria Grass

At the field the major diseases that affected the Bachiaria cultivars were identified and their incidence established by counting the number of affected tillers then converted to percentages.

Light Interception and leaf Area Index

Light Interception and Leaf Area Index data was collected as follows; this data was collected 12weeks after planting. The data was collected after every two weeks from 11am to 2pm and it was collected from non-defoliated sub plots to maintain consistency. At week 12 after planting were the first data on Leaf Area Index (LAI) and Light Interception (LI) followed by week 14 which was collected after two weeks and it continued consistently to week 18.

Light Interception (LI)

This was measured using an LP- 80 ceptometer. A ceptometer is an instrument used to measure photosynthetically active radiation (PAR) within a plant canopy. It typically consists of sensors that quantify the amount of light intercepted by the canopy (Pokovai & Fodor, 2019). The ceptometer measured the amount of light intercepted by the canopy, by subtracting the ceptometer reading from the incident light. Incident light is the total light above the canopy. The result represented the proportion of light intercepted by the grass canopy. In this study formula 1 was used.

Formula 1; Light Interception=Incident Light (Upper canopy)- Ceptometer Reading (lower canopy)

Therefore:

Formula 2:

$$\text{Photosynthetically Active Radiation (PAR)} = \text{Incident PAR} \times \left(1 - \frac{\text{Light Interception}}{\text{Incident Light}}\right)$$

In Formula 2 is used to show how light interception can affect the photosynthesis and henceforth, affect the herbage yield. Though in this study Formula 2 was not used

Leaf Area Index (LAI)

The leaf area index of a plant was read directly from the screen of LP-80ceptometer and recorded. This was done at specific points in a plot that were randomly chosen and the chosen points were marked for the subsequent data collected on Leaf Area Index (LAI) and Light Interception (LI).

3.3 Data Analysis

In the data analysis, descriptive and comparative statistics (means, percentages, and cross tabulations) were used. Growth parameter data were analysed by generating ANOVA using SPSS Software. The means were separated using Least Significant Difference (LSD).

IV. FINDINGS & DISCUSSION

4.1 Response Rate

Soil Chemical Analysis

Figure 4 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.

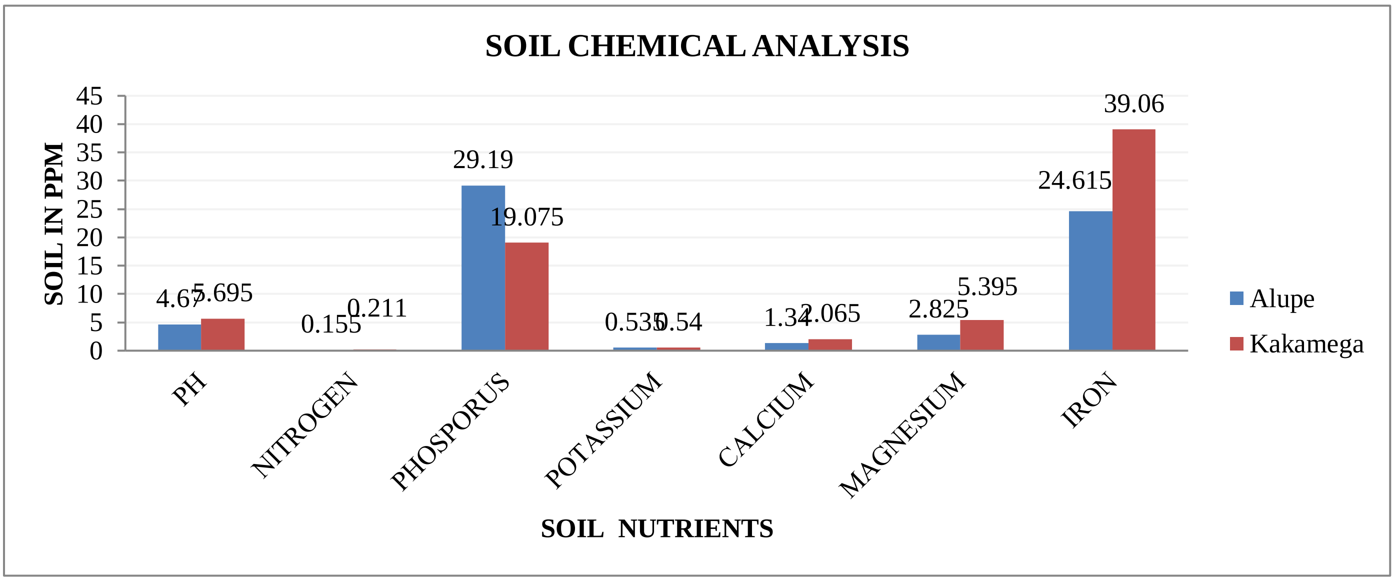

Figure 4

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 phosphorus, calcium, magnesium and iron in Kakamega compared to Alupe.

Plant Height

Table 1 and 2 shows the analyzed data on plant height collected at 4, 8 and 12 weeks. The mean height for the different cultivars was significantly different ($p<0.05$) across all the observations as shown in Tables 1 and 2. At 4 weeks Xaraes was significantly the tallest in LM 2 (Kakamega) while Piata was the tallest in LM1 (Alupe). Basilisks was the shortest among all the cultivars in both sites. Piata was significantly taller than MG4 but there was no difference between Mulatto II and MG4 in LM2 (Kakamega) while in LM1 (Alupe) Mulatto II was significantly taller than MG4. At 8 weeks Basilisks and Xaraes were the tallest with MG4 being intermediate while Mulatto II and Piata were significantly the shortest in Kakamega but in Alupe Mulatto II was the tallest followed by Piata.

The performance of Basilisks on height at week 12 was significantly high followed by Xaraes, Piata and MG4 while the shortest was Mulatto II in Kakamega but in Alupe Mulatto II and Piata were significantly the tallest followed by Xareas while Basilisk was the shortest. Generally according to the observation of this research both sites had potential to grow and attain the expected height for pasture that can be cut and carry and Mulatto II can do much better in Alupe than in Kakamega and Basilisk does well in Kakamega than Alupe.

Table 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 ± 0.71a	69.80 ±1.08a	106.05 ±1.32b
PIATA	35.80 ± 0.75b	62.10 ± 1.12c	104.04 ±1.34b
MULATTO II	33.93 ± 0.65bc	63.08 ±1.14c	85.25 ±1.12c
MG4	32.21 ± 0.75c	64.77 ±1.28bc	106.53 ±1.85b
BASILISKS	29.18 ± 0.72d	69.48 ±1.09ab	117.84 ±1.62a
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 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 ± 1.2bc	69.5 ± 1.0bc	100.34 ± 2.3b
PIATA	55.95 ± 0.9a	82.0 ± 1.1ab	118.79 ± 2.8a
MULATTO II	51.25± 1.4b	91.0 ± 7.8a	122.9 ± 3.7a
MG4	46.37 ± 1.1cd	64.6 ± 1.1c	78.66 ± 2.1c
BASILISKS	43.25 ± 1.1d	60.2 ± 1.2c	64.32 ± 1.5d
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**

Tiller Numbers

Table 3 and 4 shows the analyzed data on number of tillers collected at 4, 8 and 12 weeks. This data was collected after standardization and before defoliation. The purpose of this data was to help in description on growth of the selected Brachiaria cultivars in the selected agro-ecological zone LM1 (Alupe) and LM2 (Kakamega). Number of tillers increased progressively for all cultivars and their values were significantly different ($p<0.05$) (Tables 3 and 4). Basilisks had significantly the highest number of tillers followed by MG4 at all stages of observation in both ecological sites. Although, Piata had low production of tillers in Kakamega site it performed better in Alupe compared to Xaraes and Mulatto II which had little difference in both sites across the three observation stages.

Table 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	$12.52 \pm 0.38_a$	$39.82 \pm 1.40_a$	$71.44 \pm 2.65_a$
MG4	$12.13 \pm 0.51_a$	$29.80 \pm 1.22_b$	$54.88 \pm 1.98_b$
XAREAS	$8.33 \pm 0.30_b$	$18.96 \pm 0.60_{cd}$	$34.64 \pm 1.92_c$
MULATTO II	$8.15 \pm 0.58_b$	$23.01 \pm 1.65_c$	$30.04 \pm 0.90_{cd}$
PIATA	$5.80 \pm 0.17_c$	$14.58 \pm 0.48_d$	$25.92 \pm 0.88_d$
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

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	$15.57 \pm 0.8_b$	$50.12 \pm 1.8_a$	$77.55 \pm 2.8_a$
MG4	$20.7 \pm 1.02_a$	$47.7 \pm 1.8_a$	$53.71 \pm 2.4_b$
XAREAS	$11.89 \pm 0.6_c$	$31.92 \pm 1.5_b$	$42.89 \pm 2.7_c$
MULATTO II	$12.77 \pm 0.8_{bc}$	$28.08 \pm 1.3_b$	$31.87 \pm 2.1_d$
PIATA	$15.71 \pm 0.5_b$	$33.9 \pm 1.03_b$	$48.74 \pm 1.9_{bc}$
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**

Diseases Incidences and Number of Tillers Affected

The diseases of Brachiaria were observed in accordance to what Nzioki *et al. (*2016) described through morphological observation. This observation was made only on the flowering stage since there was no disease of significance at the vegetative state. Ergot affected the nine stools of all the selected cultivars but not all tillers were affected as shown in Table 5. Data collected from the nine stools of the cultivars affected by false smut disease were as shown in Table 6 below. The disease incidence of false smut was high in Basilisk compared to MG4 and Xaraes. Therefore this showed that the effect of Ergot was high compared to the effect of false smut among the cultivars affected by false smut. The disease tolerance levels were determined by the tool described by Omayio and Tavasi (2022) on estimating tolerance in plants. Therefore, through this study Basilisks, Xaraes, Mulatto II and Piata were moderately tolerant to ergot disease while MG4 was highly tolerant. Basilisks and MG4 were moderately tolerant to false smut disease while Xaraes had high tolerance levels.

Table 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	$50.33 \pm 1.9_a$	$72.33 \pm 2.9_a$	$69.33 \pm 1.6_a$	30.67%
MG4	$22.67 \pm 1.9_b$	$55.00 \pm 2.9_b$	$41.00 \pm 1.6_c$	59.00%
XAREAS	$17.00 \pm 1.9_c$	$26.00 \pm 2.9_c$	$65.33 \pm 1.6_b$	34.67%
MULATTO II	$20.00 \pm 1.9_c$	$32.00 \pm 2.9_c$	$62.67 \pm 1.6_{bc}$	37.33%
PIATA	$22.67 \pm 1.9_b$	$35.00 \pm 2.9_c$	$65.33 \pm 1.6_b$	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 5
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± 2.1a	72.00 ± 3.5a	58.00 ± 2.1a	42.00%
MG4	27.67 ± 2.1b	55.00 ± 3.5b	50.33 ± 2.1b	49.67%
XAREAS	11.33 ± 2.1c	35.00 ± 3.5c	32.00± 2.1c	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**	

Disease Progression on a Monthly Basis
Ergot (Claviceps Purpurea)

The disease was observed from November, December 2023, January, February, March and April 2024 as shown in Figure 5. The early symptoms of the disease were observed immediately after the falling of the pollen therefore a white soft spherical tissue on infected florets that was sugary honeydew and later transformed into a hard dry sclerotium as shown in the plate 1 below.

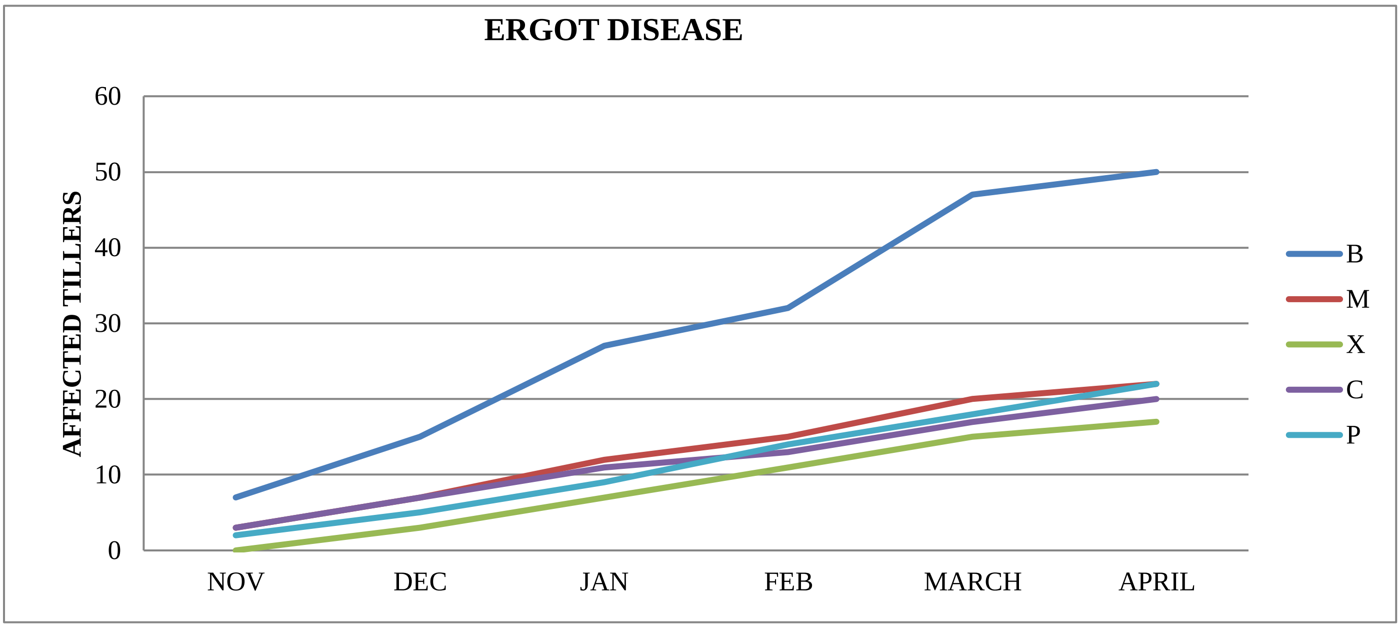

Figure 5
Showing the Ergot Diseases on Number of Tillers affected Monthly in Kakamega
B - Basilisks
M – MG4
X - Xaraes
C – Mulatto II
P – Piata

Plate 1
The Two Plates Shows How Ergot Disease affected the Inflorescence

False Smut (Ustilaginoidea virens)

The disease attacked Xaraes, Basilisks and MG4 at the months of November and December 2023, January, February, March and April 2024 as shown in Figure 6 and the incidences were increasingly high as from February to April. Basilisk was the most affected followed by MG4. The disease replaced some Brachiaria grains by smut sori as shown in plate 2. This disease occurred immediately after the fall of pollen.

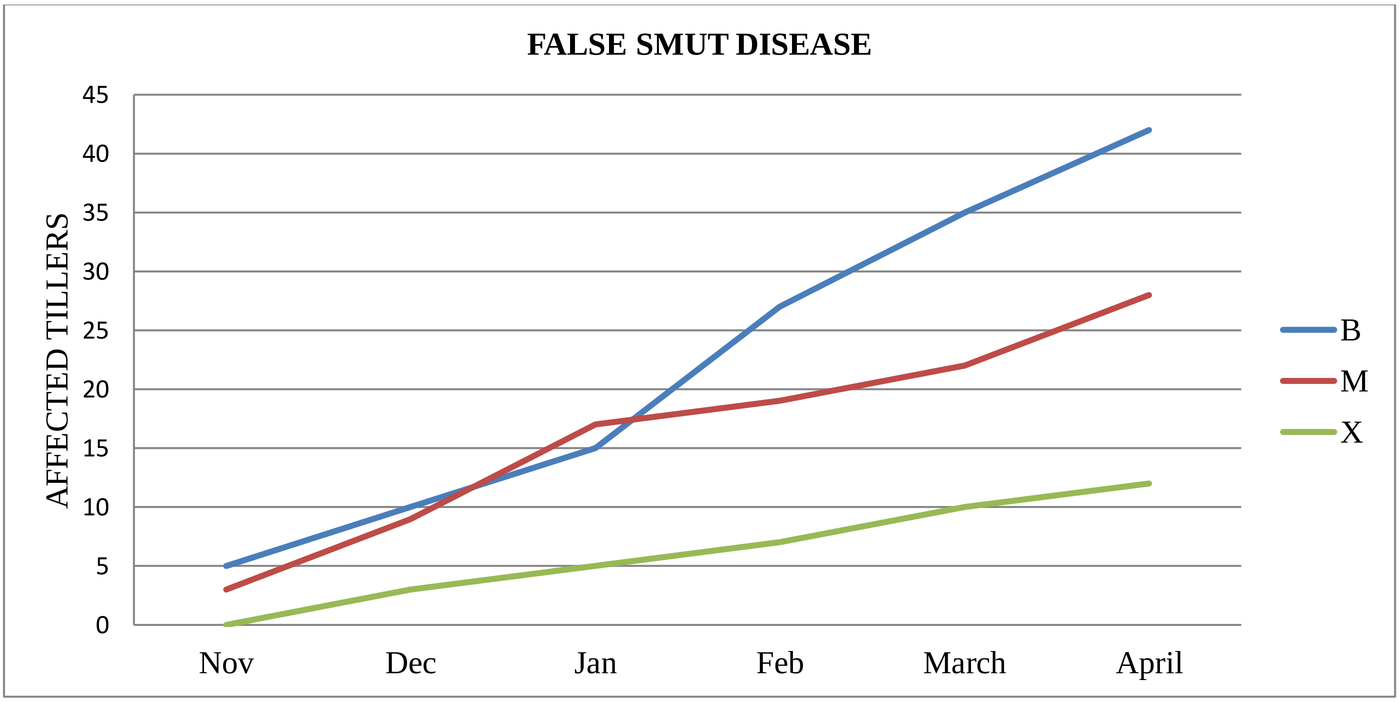

Figure 4.3: Showing the affected number of tillers by false smut disease monthly in Kakamega.
B – Basilisks
M – MG4
X – Xaraes

Plate 2
The Two Plates Shows How False Smut Disease affected the Inflorescence

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

Figure 7 to Figure 10 shows the variations in terms of light interception and leaf area index of the selected Brachiaria cultivars in the selected agro-ecological zones. Light interceptions (LI) were directly proportional with the increase in leaf area index. As the L.A.I increase there was also an increase in LI and this resulted in increased on growth rate for all the cultivars. Generally all the cultivars attained higher LAI in LM2 (Kakamega) than in LM1 (Alupe). In LM2 (Kakamega) MG 4 and Mulatto II attained the highest LAI above 0.25 week 18 while Xaraes had the lowest in LM2 during the same period. In LM1 (Alupe) all the cultivar attained a lower LAI with the cultivars than in LM2 (Kakamega). Basilisks, Xaraes and Mulatto II attaining the highest of 0.08 by week 18 compared to other cultivars. Piata and Mulatto II attained the highest light interception in of 68.33 and 69.0 respectively by week 18 while Xaraes had significantly the lowest in LM2 (Kakamega) at 29. Although MG4 had high LAI, LI was slightly lower that for Piata and Xaraes. In LM1 (Alupe), Basilisks and MG 4 had higher light interception of 20.33 and 19.33 respectively at week 18 with Xaraes having the lowest light interception of 11. This was to help understand among the selected Brachiaria cultivars how they intercept light and if leaf area index can affect light interception since it has impact on biomass production.

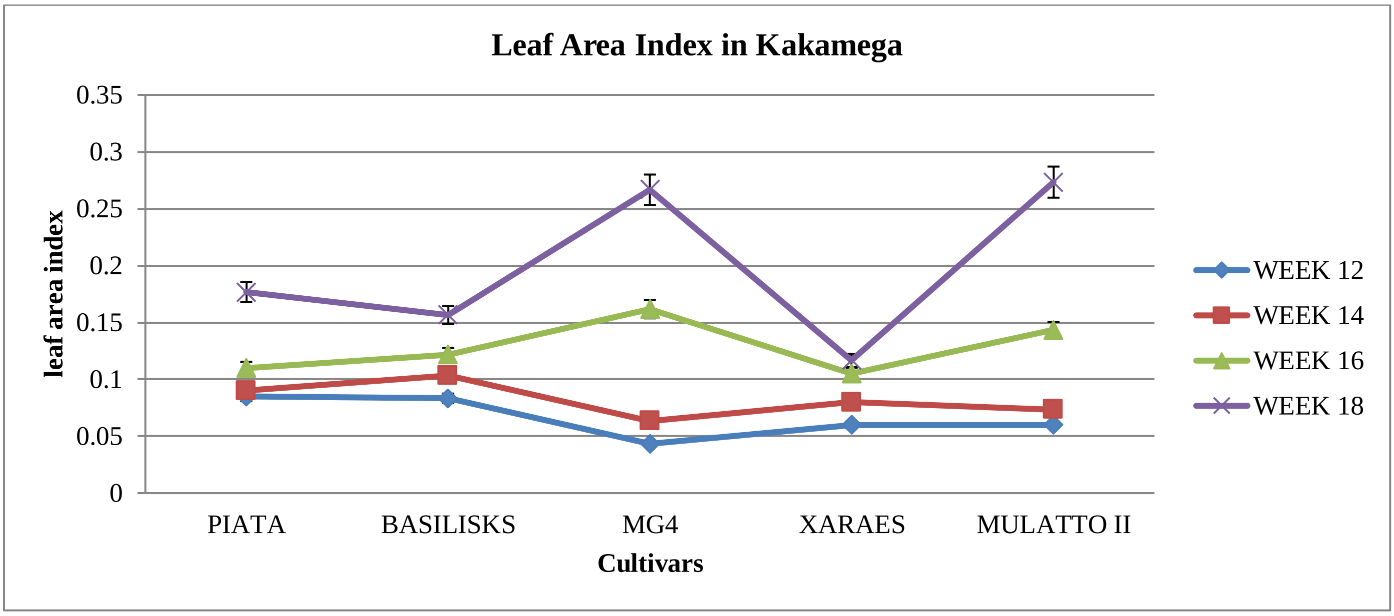

Figure 7
Leaf Area Index of Brachiaria Cultivars in Agro Ecological Zone LM 2 (KALRO- Kakamega) Kakamega County

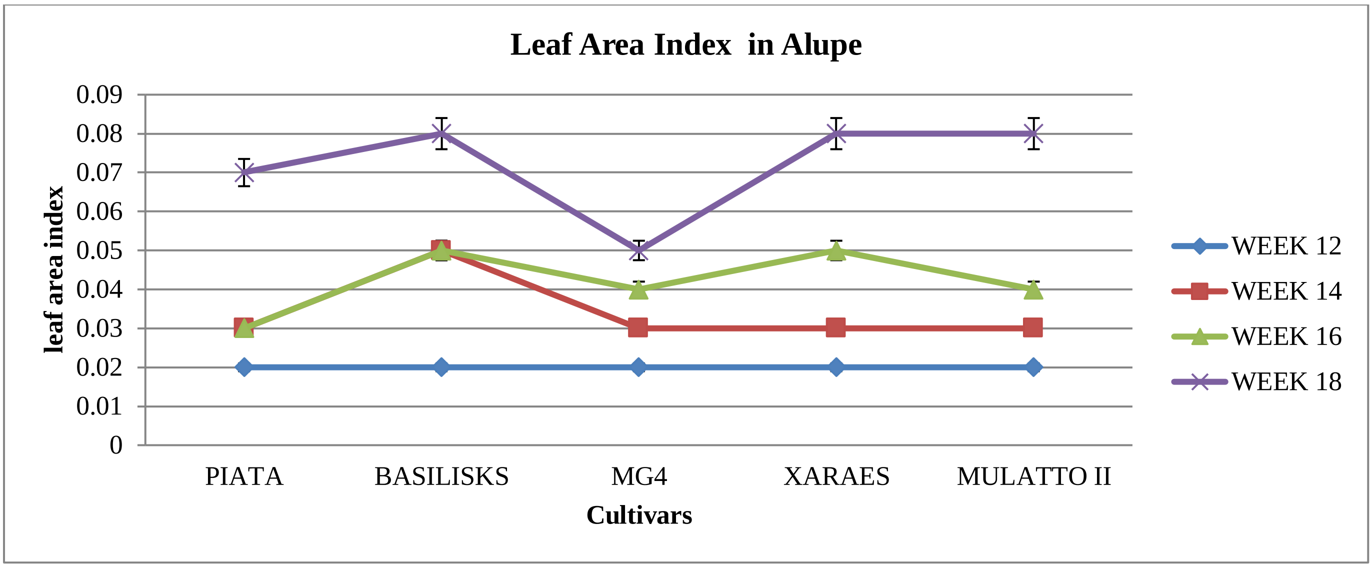

Figure 8
Leaf Area Index of Brachiaria Cultivars in Agro Ecological Zone LM 1 Alupe, Busia County

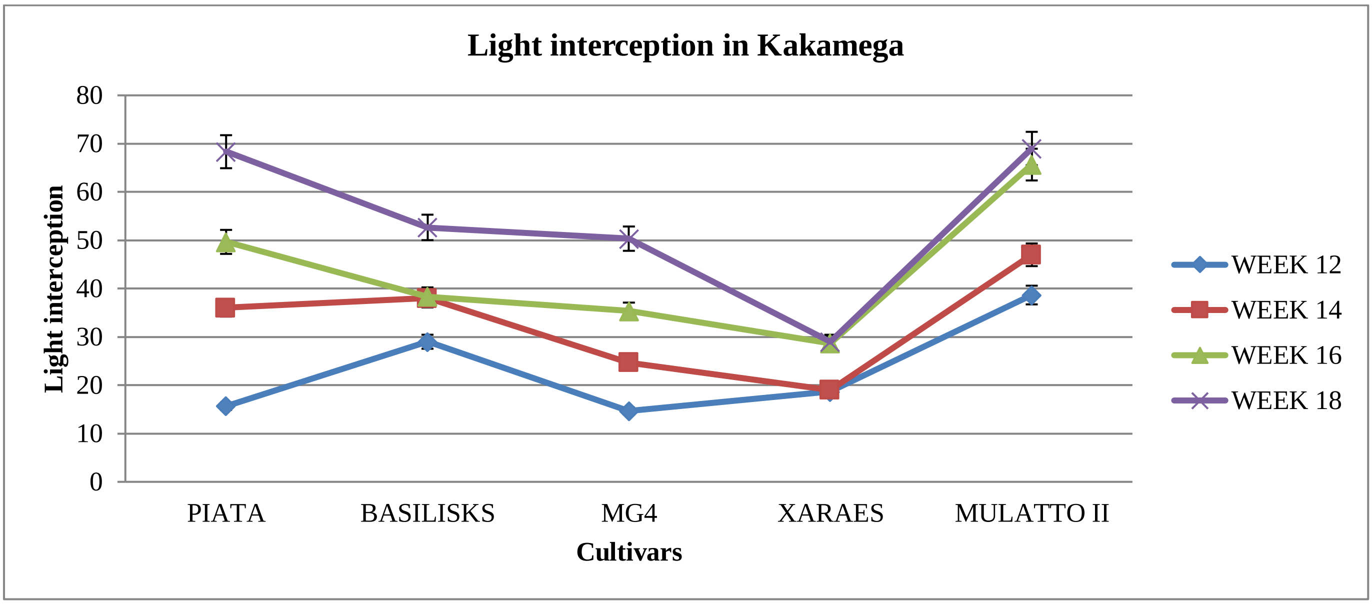

Figure 9
Light Interceptions of Different Cultivars of Brachaiaria in Agro Ecological Zone LM 2, Kakamega County

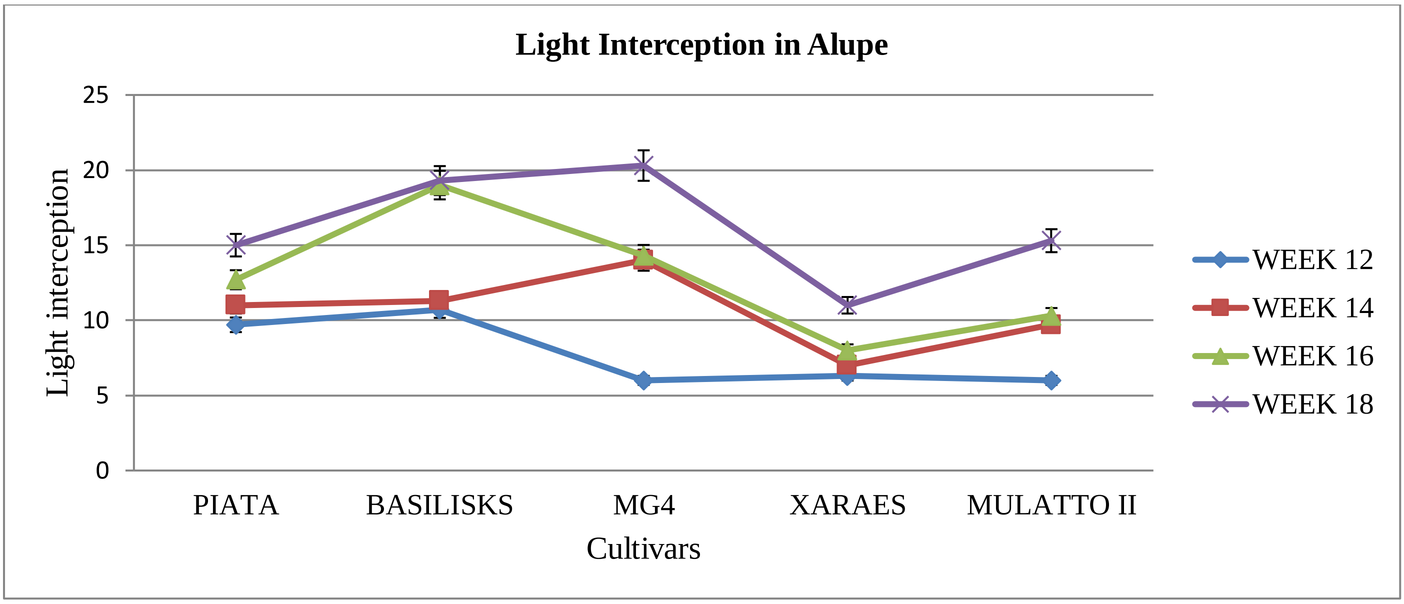

Figure 10
Light Interceptions of Different Cultivars of Brachaiaria in Agro Ecological Zone LM 1, Alupe, Busia County

4.2 Discussions

Soils

The soils in the two sites that the experiment was planted were low in Nitrogen, Calcium and Potassium. Phosphorus content was low in agro-ecological zone LM1, Alupe (Busia); this was due to the acidic soils. According to Rao et al. (2016), phosphorus is the major nutrient limiting the growth and productivity of Brachiaria pastures in acidic soils, deficiency of essential nutrients like N, P, and Ca, can be alleviated by the identification of ecotypes of Brachiaria species that are adapted to these infertile soils and can make the most use of applied nutrients. Dry matter, nutritive quality and seed production is affected by soil fertility and therefore fertilizer application and top dressing for regrowth is important. Nitrogenous and phosphate fertilizer application to the soil and good management can lead to high forage quality and high dry matter production improving the capability of the grasses to meet nutritional requirements of animals especially in the dry season (Nguku, 2015). According to Rao et al. (2016), most Brachiaria cultivars have the ability to grow in low fertility acid soils in the tropics and that the effect soil nutrients on growth and productivity depends on the physiological adaptation of the cultivar. Nguku et al. (2016) further reported that some of the characteristics that help Brachiaria cultivars to adapt include the ability to maintain root growth at the expense of shoot growth, consequently affect the biomass in acquisition and use of both nitrate and ammonium forms of nitrogen henceforth it acquire nitrogen through associative fixation and in addition acquire phosphorus through extensive root systems and association with vessicular-arbuscular mycorrhizae, and calcium through extensively branched roots with large numbers of root tips. Therefore, this informed the need of using Phosphorus fertilizer during planting of Brachiaria cultivars.

Plant Height

The mean height for the different cultivars was significantly difference ($p<0.05$) across all the observations as shown in Tables 1 and 2. The performance of Basilisks on height after 12 weeks of planting was significantly high followed by Xaraes, Piata and MG4 while the shortest was Mulatto II in Kakamega but in Alupe Mulatto II was the tallest then Piata and Xareas followed, Basilisk was the shortest. Plant morphological and physiological properties differ among the cultivars. The vertical growth habit of Xaraes and Piata explain why they are tall at the end of the establishment phase.

Pasture species which grow fast and tall are more efficient and useful resource because they are more competitive for nutrients. When these fast growing and tall pasture are planted with other species in a mixed cropping system they may outgrow the other species and suppress their growth by shading them and they may take up nutrients faster (Opiyo, 2007; Mganga, 2009 & Ogillo, 2010). Also ecological zone can affect the plant height growth of Brachiaria as it has been evident by Mulatto II and Basilisks despite Basilisks height being the tallest at agro-ecological zone LM 2 (Kakamega) it's the shortest in agro-ecological zone LM 1 (Alupe) and Mulatto II being the shortest in agro-ecological zone LM 2 (Kakamega), It's the tallest in agro-ecological zone LM 1 (Alupe).

Although plant height is considered as one of the factors determining forage yield, it was contrary to Basilisks which was found to have the least mean plant height in agro-ecological zone LM 1 (Alupe) but had significantly higher percentage dry matter in the same agro-ecological zone, also for Mulatto was the shortest in agro-ecological zone LM 2 (Kakamega) but in the same agro-ecological it produced the highest number of inflorescences. Therefore, this can be explained by other factors such as plant density per unity area, nature and number of leaves as well as number of tillers (Selemani, 2022). Generally according to the observation of this research both sites had potential to grow and attain a height that able cut and carry for pasture, in terms of height and Mulatto II can do much better in Alupe than in Kakamega and Basilisks does well in Kakamega than Alupe.

Tiller Numbers

Tillering is an important attribute of forage plants because of its influence on leaf-area production and dry matter yield. The number of tillers produced by grasses allows them to attain maximum growth at early age and recover fast after defoliation (Kimidi et al., 2016). Tillering can be attributed to growth habit (Cook et al., 2005). Tiller numbers is an indicator of resource used efficiency by different grass species and that the weight of a plant's tillers determines its productivity (Laidlaw, 2005), which was contrary on Piata in agro-ecological zone LM 2 (Kakamega) since it had least number of tillers but had high percentage dry matter content in the same agro-ecological zone but was in agreement with Halim et al. (2013) who found out that taller varieties of pasture tend to have fewer tillers but produce higher DM yields.

According to Cook et al. (2005) cultivars that have many tillers can have high dry matter depending on the growth habit as evident with Basilisks in the present study. The number of tillers increased progressively for all cultivars and their values were significantly different ($p<0.05$) (Tables 4.3 and 4.4). Basilisk had significantly the highest number of tillers followed by MG4 at all stages of observation in both agro-ecological sites. Although, Piata had low production of tillers in Kakamega site it performed better in Alupe compared to Xaraes and Mulatto II which had little difference in both sites across the three observation stages. This was attributed to environmental factors and soil fertility. Temperature, humidity, and rainfall patterns vary between agro-ecological zones. In regions with optimal temperatures and sufficient rainfall, plants are more likely to produce more tillers. Conversely, in areas with extreme temperatures or limited rainfall, tiller production may be reduced as reported by Passioura and Angus (2010). Khaled and Fawy (2011) describe that nutrient content and structure of the soil influence plant growth. Soils rich in nutrients such as nitrogen, phosphorus, and potassium can support better tiller formation. In contrast, soils that are poor in nutrients or have unfavorable pH levels may limit the number of tillers. It was also noted that increase on number of tillers led to increase on Leaf Area Index and also Light Interception. Light interception (LI) by plant leaves is used in photosynthesis to provide energy for plant maintenance, to grow new leaves and roots, and to produce carbohydrates stored within cells and translocate to energy sinks. In pastures, the plant leaves needed for LI and photosynthesis are the plant part harvested by livestock for food. This conflict between leaf retention for plant growth and leaf harvest for animal production requires a balance of pasture growth and defoliation to optimize plant and animal production (Edward & Thomas, 2020). The increase in number of tillers as the number of day's increased is in agreement with the results reported by Njarui et al. (2016).

Diseases

Dairy farmers are in favor of high yielding pastures that tolerant or resistant to drought and pest/diseases. All selected Brachiaria cultivars were ranked to potential yielding in terms of biomass production and tolerance to pests in the selected agro-ecological zones since there was no pest of economic importance that was noted to affect the vegetative growth of the selected Brachiaria grass in both agro-ecological zones as Njarui et al. (2016) that Brachiaria production is influenced by a range of factors including moisture, soil fertility, pest and disease, and management options. Despite this, diseases affected the selected Brachiaria cultivars at seed setting and production stage as it was found by Demarchi et al. (2022) that disease can easily attack young seeds that area immature.

The diseases of Brachiaria were observed in accordance to what Nzioki et al. (2016) described through morphological observation. The disease incidence was high in Basilisk compared to MG4 and Xaraes for the cultivars affected by false smut. The disease incidence was high in Basilisk compared to Piata, Xaraes and Mulatto II while MG4 was least affected by Ergot disease this shows that MG4 was tolerant to False smut and Ergot. According to Selemani et al. (2022) found out that Xaraes had low ability to resist pest and disease and this was evident with the effect of Ergot on Xaraes. According to Cherunya et al. (2019) Xaraes and Basilisks are more susceptible to fungal disease and this lowers their seed yield especially in areas with humidity of 75% and above. Therefore this showed that the effect of Ergot was high compared to the effect of false smut among the cultivars affected by false smut. The early symptoms of Ergot disease were observed immediately after the falling of the pollen, Miedaner and Geiger (2015) found out that ergot disease affect grasses when they are not yet pollinated or are pollinated shortly, therefore a white soft spherical tissue infected florets that was sugary honeydew and later transformed into a hard dry sclerotium as shown in the plate 1. This result was also observe by Kimidi et al. (2016) in the North Rift Valley of Kenya that Ergot infected the inflorescence after the shedding of pollen and they also noted that the number of tiller affect in Xaraes were low and the same was found on this study. This disease was also reported in Nairobi as noted by Nzoiki et al. (2016) KALRO proceedings).The False smut disease attacked Xaraes, Basilisks and MG4 in the months of November, December 2023, January, February March, April 2024, with higher incidences in march to April. The disease replaced some Brachiaria grains by smut sori as shown in plate 2. This disease occurred immediately after the fall of pollen.

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

Light interception is a key determinant of plant growth, forage production, and seed yield, particularly in Brachiaria species. The study by Guenni et al. (2005) provides a comprehensive analysis of five Brachiaria species, Linero, Basilisks, Mulatto II and Piata under tropical conditions, emphasizing the relationship between light interception and biomass production. They discovered significant variations in light interception among the species, with those intercepting more light achieving higher forage yields. The efficiency of converting intercepted light into biomass was also a critical factor, with some species demonstrating better utilization of available light for growth.

In the present study as light interceptions (LI) increased in leaf area index increased or remained constant as shown in Figure 7 to Figure 10. In Alupe as the LAI increased there was also an increase in LI and some remained constant like MG4 at week 14 and week 16 this resulted were attributed to increase on growth for all the cultivars henceforth these results were in agreement with the findings of Marin et al. (2014), who reported that the amount of tissues in forage plant is influenced by the normal recommended cutting or grazing time, the optimum LAI occurs when the forage reaches the maximum point of mass accumulation indicating the time to start cutting or grazing.

As the LAI increase there was also an increase on growth for all the cultivars. MG4 and Mulatto II had the highest LAI, followed closely by Piata and Basilisks while Xaraes had the least in Kakamega. The performance of Xaraes in the 2 agro-ecological zones seem varying especially in terms of Leaf area index, it had high leaf area index in LM2 (Kakamega) and it was low in LM2 (Alupe) and its shows that what Oliveira et al. (2016) said is true, that water availability and soil nutritional characteristics can affect the performance of pasture. As LI and LAI increased progressively it was also noted that this was attributed to increase in plant height and number of tillers as shown in Basilisks in LM2 (Kakamega) as LAI increase with time also LI increased its height and tiller numbers increased as stated by Pedreira *et al.* (2007) who while evaluating light interception in *B. brizantha* pastures, considered that canopy height is an efficient and practical parameter to indicate the level of light interception.

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

All the new cultivars (Basilisks, MG4, Piata and Xaraes) evaluated were tolerant to diseases (ergot and false smut) during the vegetative stage and have the potential to be grown as pasture in Lower Midland 2 (LM2) Kakamega and Lower Midland 1 (LM1) Alupe agro-ecological zones in Western Region, Kenya. In agro-ecological LM2 (Kakamega) all selected Brachiaria cultivars were susceptible to ergot disease and with the effect of fungal disease the seeds cannot germinate this study concludes that for quality seed production the diseases should be control first.

More information has been added through this study regarding how the selected Brachiaria cultivars intercept light and leaf area index in the selected agro-ecological zones this helps to understand its structural and physiological modification. Therefore, this shows the survival ability of the cultivars under other canopies like trees. For Mulatto II in LM2 (Kakamega) and Basilisks in LM1 (Alupe) agro-ecological zones when grown under other canopies it may affect its growth negatively since they intercept more light

5.2 Recommendations

In LM1 (Alupe-Busia) agro-ecological zone Basilisks was recommended for growth since it had the potential to produce high dry matter percentage, high number of tillers and high plant height while LM2 (KALRO-Kakamega) agro-ecological zone apart from Mulatto II Piata and MG4 were also recommended for growth potential. MG4 was recommended in LM2 agro-ecological zone for seed production since it was tolerant to the ergot disease and false smut.

Xaraes had low levels of intercepting light in agro-ecological LM1 (Alupe) and LM2 (Kakamega) this cultivar was recommended to be planted under canopies in both agro ecological zone. Xaraes also had small Leaf Area Index in agro-ecological zone LM2 (Kakamega) therefore it means it has ability to utilize less light intensity. Therefore, it is recommended in agro-ecological zone LM1 to be grown under canopies, also apart from Mulatto II, Basilisks and Xaraes are also recommended.

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