ISSN 2349-7823

International Journal of Recent Research in Life Sciences (IJRRLS)
Vol. 12, Issue 4, pp: (15-28), Month: October - December 2025, Available at: www.paperpublications.org

PERFORMANCE OF BOMA RHODES GRASS (Chloris gayana) ACROSS VARIED ECOLOGICAL ZONES IN NAROK COUNTY, KENYA

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DOI: https://doi.org/10.5281/zenodo.17514205

Published Date: 03-November-2025

Abstract: **This study evaluated the performance of Boma Rhodes grass (Chloris gayana) across varied ecological zones in Narok County, Kenya. The research aimed to assess how different ecological conditions influence the growth and productivity of Boma Rhodes grass, an important pasture species widely used in Kenya for hay production and livestock feeding.**

The study was conducted across 27 sites distributed within three ecological zones, representing distinct variations in altitude, rainfall, and soil conditions. A randomized complete block design (RCBD) was adopted to ensure reliable comparison of growth performance indicators, including plant height, dry matter yield, and crude protein content. Standard agronomic practices were maintained across all sites, and nitrogen fertilizer was applied uniformly to enhance grass establishment and growth consistency.

Data were analyzed using descriptive statistics, ANOVA, and pairwise comparisons to determine performance differences across zones. Results indicated that Boma Rhodes grass exhibited significant variation ($p < 0.05$) among ecological zones, with the mid-altitude sites showing superior plant height and dry matter yield. Variations in crude protein content were also observed, reflecting the influence of ecological conditions on forage nutritive value.

The study concludes that ecological factors significantly affect the productivity and quality of Boma Rhodes grass, emphasizing the need for site-specific management practices to optimize yield potential across different zones in Narok County.

Keywords: **Boma Rhodes grass, Chloris gayana, ecological zones, dry matter yield, crude protein, Narok County.**

1. INTRODUCTION

Livestock production in Kenya's rangelands is heavily dependent on pasture resources, whose quality and productivity are influenced by ecological and climatic conditions. Narok County, home to diverse microclimatic zones ranging from semi-arid plains to high-rainfall highlands, supports both pastoral and agro-pastoral livelihoods. The county is a significant livestock producer, contributing to both local food security and the national beef and dairy value chains (KNBS, 2024). However, seasonal feed shortages remain a persistent challenge, especially during prolonged dry spells.

Boma Rhodes grass (Chloris gayana var. Boma), a perennial tropical grass, has gained popularity in Kenya for its high forage yield potential, drought tolerance, and adaptability to different soil types (ICSIAPL & KALRO, 2022). While agricultural extension recommendations often promote Boma Rhodes as a "one-size-fits-all" solution for pasture improvement, emerging evidence suggests that its performance in terms of dry matter (DM) yield, crude protein (CP) content, and regrowth rate varies considerably with ecological conditions (Feedipedia, 2024; Ondi et al., 2019).

Despite its widespread adoption, there is limited zone-specific performance data for Boma Rhodes in Narok County. Most available studies either aggregate results across large regions or focus on rehabilitation and erosion control (Kamau et al.,

2020) rather than forage productivity under different microclimatic contexts. This gap constrains targeted recommendations for farmers in specific zones, limiting the full productivity potential of Boma Rhodes.

1.1 Problem Statement

Narok County's livestock sector experiences recurrent feed deficits, particularly during dry seasons when natural pastures decline in both quantity and nutritive quality. While Boma Rhodes grass has been promoted widely as a solution, its actual performance varies under different ecological conditions within the county.

A review of Kenya Seed Company data and KALRO reports indicates yield differences of over 40% between sites within Narok County, even when the same variety and management practices are applied (ICSIAPL & KALRO, 2022). Furthermore, crude protein content of Boma Rhodes harvested at similar stages ranges from 6-12% depending on soil fertility and rainfall patterns (Feedipedia, 2024). This variation has important implications for livestock productivity, yet farmers and extension agents currently lack a clear, evidence-based framework for recommending Boma Rhodes to specific ecological zones.

The Kenya National Bureau of Statistics (2024) notes that Narok's forage production faces climate-related risks, with reduced yields reported in lower-rainfall wards during the 2022–2023 droughts. Without ecological zone-specific performance data, the county risks continuing blanket recommendations that may underperform in some areas undermining resilience and profitability in livestock systems.

1.2 Justification for the study

This study is necessary for three main reasons:

i. **Addressing knowledge gaps**: Existing studies, such as Kamau et al. (2020) in Keekonyokie Ward, focus on rangeland rehabilitation and soil erosion control, not on the forage yield and quality of Boma Rhodes across ecological gradients.

ii. **Improving targeting of interventions**: Performance variation means that a variety highly productive in Kilgoris highlands may underperform in Suswa's semi-arid conditions. This research will enable evidence-based, zone-specific recommendations.

iii. **Supporting climate resilience**: With rainfall variability increasing (KNBS, 2024), understanding ecological performance differences will help farmers adopt forage strategies best suited to their local microclimate, enhancing livestock productivity and reducing vulnerability during feed scarcity periods.

The findings will directly benefit pasture development programs, county extension services, and seed companies like Kenya Seed, ensuring that investment in Boma Rhodes aligns with the ecological realities of Narok County.

1.3 Objectives

1.3.1 General Objective

To evaluate the performance of Boma Rhodes grass (Chloris gayana) across varied ecological zones in Narok County, Kenya.

1.3.2 Specific Objectives

i. To compare the dry matter (DM) yield of Boma Rhodes grass across different ecological zones in Narok County.

ii. To assess the variation in crude protein (CP) content of Boma Rhodes grass among the selected ecological zones.

iii. To analyze the relationship between plant height and ecological zone as a measure of growth performance.

iv. To recommend zone-specific management practices for optimizing the productivity and quality of Boma Rhodes grass.

2. LITERATURE REVIEW

2.1 Global and Regional Context

Chloris gayana (Rhodes grass) the variety locally promoted as Boma Rhodes is a perennial warm-season grass widely used in tropical and subtropical systems. It establishes quickly, regrows reliably after cut or grazing, and shows reasonable drought tolerance under moderate fertility (Feedipedia; KALRO/ICSIAPL factsheets). Reported dry-matter yields are variable but frequently fall in the range of about 5-16 t/ha of dry matter under smallholder or research trial management, with higher figures only under intensive management and favourable moisture. Nutritionally, Rhodes grass contains a moderate crude protein (CP) content of about 7–12%, depending on cutting age and soil fertility. However, its digestibility declines significantly with maturity, making timely harvesting and integration with legumes or protein supplements essential for maintaining optimal animal performance (Njarui et al., 2020; ILRI, 2021).

Boma Rhodes grass, a Kenyan-bred cultivar of Chloris gayana, is valued globally for its adaptability to a range of climates and soils (Cook et al., 2005). In tropical and subtropical environments, it produces annual dry matter yields between 10-16 t/ha, with well-managed stands under irrigation reaching 30–40 t/ha (Feedipedia, 2024). Its perennial growth habit and tolerance to drought make it suitable for semi-arid rangelands, though performance is significantly influenced by soil fertility, rainfall, and cutting frequency (Mero & Uden, 1998).

Boma Rhodes can be productive and useful, but its returns to the farmer depend on where it's grown and how it's managed.

2.2 Yield, management and genotype Verse environment interactions

A robust theme across the forage literature is that genotype and environment (G×E) interactions play a pivotal role in determining performance. Different accessions or cultivars of Chloris gayana respond variably to rainfall, soil type, salinity, and fertility inputs; some accessions persist better under drought, while others produce higher biomass when nitrogen is available (York et al., 2019; Boonman, 1993; Njarui et al., 2020). Recent genotype evaluation trials across East Africa, Zimbabwe, and Australia consistently report significant differences in dry matter yield, tiller density, and regrowth potential among accessions, reinforcing the influence of genotype–environment interactions on productivity. These findings justify a microclimate-sensitive approach—what performs optimally in the cool, high-rainfall pockets of Kilgoris may not necessarily thrive under the semi-arid conditions of the Loita plains.

Field studies further emphasize the influence of management practices such as fertilizer application (notably nitrogen), harvest schedule, and weed control on forage yield and nutritive value (Kariuki, 2018; University of Nairobi Repository, 2021; Kenyatta University Theses, 2020). This underscores the importance of interpreting secondary datasets with key management covariates—including seeding rate, fertilizer input, and cutting height—clearly accounted for to ensure accurate comparisons and reliable agronomic recommendations.

2.3 Forage quality, animal performance and supplementation need

Feeding trials and digestibility studies indicate Rhodes grass is a solid basal forage but often needs supplements to reach high animal performance targets. Crude protein under routine management commonly falls short of high-production requirements (e.g., dairy cows in early lactation), so farmers often combine Rhodes grass with legumes, conserved fodder, or concentrate supplements. In vitro digestibility and methane studies additionally show differences among varieties and maturity stages — useful for recommendations where greenhouse gas accounting or feed efficiency are priorities.

Table 2.1: Comparative Table: Quantitative Metrics from Recent Studies

Study Context	DM Yield (t/ha)	Crude Protein (%)	Other Nutrient Details
Narok County extension & forage value-chain factsheets	-	8.6–12.0	NDF 75%, ADF 43%, OMD 56.4%[1]
Global feed resource summaries	5-16 (typical), up to 30-40 in optimal conditions	~9–10% at 10 weeks; <8% at 15 weeks	Digestibility declines with maturity[2]
Tanzania regrowth and cutting interval study	1.09-7.99 (early wet), 0.97-3.53 (late wet)	13.9–8.25	Highest cumulative DM at 9–12 week cuts (~19 t/ha)[3]
Nigerian Northern Guinea Savannah trial	~14.1	CP yield ~1.7 t/ha	Congo grass outperformed Rhodes in both yield & CP[4]
Kenyan nitrogen rate trials	—	CP increased with N rate	DM yield boosts with higher N application[5]

Source: ICSIAPL & KALRO (2022); *Feedipedia* (2024); *African Journal of Range & Forage Science;* ResearchGate (2022); Kenya Seed Company & University of Nairobi Repository

2.4 Local Perspective

Pasture availability and quality are central to livestock productivity in Kenya, and Narok County is no exception. For many families in Narok, good pasture translates directly into milk on the table, income for school fees, and resilience during dry spells. At the national level, recent statistics underline the urgency: Kenya's National Agriculture Production Report (KNBS, 2024) highlights structural stresses in the agricultural sector and points to feed and forage challenges as recurring constraints to livestock productivity.

In Kenya, Boma Rhodes has been a cornerstone in forage improvement programs since the 1980s. Trials in Kiambu (Colombini et al., 2020) showed CP contents of 8-10% under rain-fed conditions, increasing to 12% with nitrogen fertilization. In coastal and Rift Valley trials, DM yields varied from 8-15 t/ha depending on rainfall distribution and soil type (ICSIAPL & KALRO, 2022).

Studies by Ondi et al. (2019) demonstrated that Boma Rhodes alone could not meet dairy cattle protein requirements during dry seasons without supplementation, indicating that forage quality is as important as yield in livestock productivity.

Kamau et al. (2020) examined grass species for rangeland rehabilitation in Keekonyokie Ward, Narok North, finding that Boma Rhodes established well on degraded lands and reduced erosion. However, they did not measure DM yield or CP variation across ecological zones.

The ICSIAPL & KALRO (2022) forage value chain analysis for Narok reported DM yield variations of 40-60% between highland and lowland sites. Farmers in high-rainfall areas such as Kilgoris achieved higher yields but faced challenges with waterlogging, while semi-arid areas saw reduced biomass during prolonged dry periods.

Countywide, microclimate-sensitive evaluation is essential because, while evidence shows that Rhodes grass is a valuable forage whose yields and nutritive value vary widely with genotype, management, and environmental conditions (FAO, 2012; Mero & Uden, 1997; Mwacharo & Kitalyi, 2002), Narok County's diverse microclimatic zones present both opportunities and challenges for production. The county has already experienced significant adoption and value-chain development of Boma Rhodes (ICSIAPL & KALRO, 2023), yet farmers and extension officers consistently express the need for fine-scale, evidence-based guidance on which zones reliably deliver optimal yields and quality under typical management, and where targeted interventions such as fertiliser application or legume intercropping are most effective (Koech et al., 2016). Meeting this need requires the compilation of multi-site secondary trial data, disentangling the effects of management from environmental influences, and presenting findings in farmer-friendly terms such as tonnes of dry matter per hectare, crude protein percentage, and days to regrow. This study will bridge the gap between broad species-level potential and practical, zone-specific recommendations that can directly inform decision-making for Narok's forage producers.

2.5 Knowledge Gap

No published study to date has systematically compared both yield and nutritive quality of Boma Rhodes across the ecological zones of Narok County using standardized metrics. Most existing works either focus on a single ward or aggregate results across unrelated counties, limiting their relevance for local decision-making.

2.6 Conceptual Framework

The productivity and nutritive value of Boma Rhodes grass (Chloris gayana) is strongly influenced by ecological factors such as rainfall, temperature, soil fertility, and altitude, as well as by management practices including fertilizer application, cutting interval, and weed control (Ondabu et al., 2022; ICSIAPL & KALRO, 2022). Studies have shown that optimal rainfall distribution and fertile soils enhance both dry matter yield and crude protein content, while suboptimal climatic conditions or poor agronomic practices can significantly reduce forage quality and persistence (Mero & Uden, 1997; Kipkorir et al., 2020).

Narok County's diverse microclimatic zones—ranging from highland, cool-wet areas to lowland, semi-arid zones—provide a natural experimental setting for evaluating how variations in these ecological factors influence the growth and nutritive value of Boma Rhodes (KNBS, 2024). By leveraging secondary data from Kenya Seed Company and other research institutions, this study seeks to identify the most suitable ecological zones for maximizing biomass yield and nutritional quality, thereby guiding targeted forage development strategies for both commercial and smallholder pastoral systems.

The choice of variables for this study isn't random, it is shaped by both solid research evidence and a clear understanding of how pasture systems work in the real world. Over the years, studies have repeatedly shown that **rainfall**, **temperature**, **soil characteristics**, and **altitude** are the main environmental forces driving the performance of Rhodes grass (Mero & Uden, 1997; Kipkorir et al., 2020). On the other hand, what farmers actually do on the ground, how often they cut the grass, the fertilizers they use, and how they manage weeds , can make the difference between a thriving pasture and a disappointing one (Ondabu et al., 2022).

For this reason, our dependent variables, **dry matter yield**, **crude protein content, and crop heigh (fiber quality)** are drawn from well-established measures in forage science, trusted as reliable indicators of both how much feed is produced and how good it is for livestock (ICSIAPL & KALRO, 2022). Framing the study around these variables gives us a clear picture of how environment and management work together (or sometimes against each other) to shape outcomes.

The flow chart below shows how these variables relate showing a cause and effect relationship.

Table 2.2: Interrelationship of variables

Independent variables
- Rainfall intensity
- Temperature
- Soil characteristics
- Altitude
- Management Practice

↓

Moderating variables
- Seed Purity & Genetic Potential
- Pests and diseases
- Availability of farm inputs and farmer adoption

↓

Dependent variables
- Dry matter yield DM (t/ha)
- Crude Protein %
- Fiber Fractions % (NDF and ADF).
- Persistence and Re-growth

The conceptual assumption of this study is that optimal ecological conditions, coupled with sound agronomic management, will result in higher biomass yield and improved nutritional quality of Boma Rhodes grass, whereas suboptimal conditions or poor management will lead to reduced yield and quality.

Ecological factors set the physiological potential of the grass, while management practices determine how fully that potential is realized; together, these two forces interact to shape outcomes such as yield, crude protein content, fiber fractions (NDF, ADF, lignin), and digestibility, with moderating variables like seed quality, pest and disease pressure, and farmer adoption further influencing the final performance.

ISSN 2349-7823

International Journal of Recent Research in Life Sciences (IJRRLS)
Vol. 12, Issue 4, pp: (15-28), Month: October - December 2025, Available at: www.paperpublications.org

3. METHODOLOGY

3.1 Research Design

This study will adopt a descriptive-comparative research design this is because the research involves analyzing existing data sets across multiple environmental settings. Also, a descriptive-comparative allows the researcher to describe and compare these variations without interfering with or altering the conditions under which the grass was grown.

3.2 Target Population

The target population consists of documented Boma Rhodes grass production sites within Narok County, including experimental plots, demonstration fields, and farmer-managed trials whose performance data have been captured by Kenya Seed Company, the Kenya Agricultural and Livestock Research Organization (KALRO), and county agricultural offices. The time frame of interest is 2018 to 2024, capturing recent agronomic data under prevailing climatic trends. This period was selected to ensure relevance to current rainfall variability patterns in Narok and to account for both wet and dry year condition

3.3 Sample Size and Sampling Strategy

Given Narok County's diverse ecological conditions—ranging from highland zones with cooler, wetter climates to semi-arid lowlands—the sampling strategy will use purposive sampling to ensure representation of the three major ecological zones. From available datasets, three sites per ecological zone will be selected based on:

i. Completeness of yield and nutritive value data;

ii. Clear management practice records (e.g., cutting interval, fertilization); and

iii. Reliable location information for correct ecological classification.

For each selected site, data from two distinct seasons or years will be included to account for seasonal variability and to strengthen the reliability of findings. This results in 3 zones × 3 sites × 3 seasons = 27 observational units.

This sample size strikes a balance between statistical robustness (enabling variance estimation for ANOVA and regression models) and feasibility given the reliance on secondary datasets.

3.4 Sampling Method

The research will employ purposive sampling, deliberately selecting data sources that are directly relevant to the research objectives. As emphasized in the justification, the aim is not to generalize from random sites but to extract meaningful insights from sites that capture the variation in ecological conditions across the county. Only data from Boma Rhodes grass grown under identifiable environmental and management conditions will be included, enabling clear cause effect analysis between microclimate and grass performance.

3.5 Data Collection Methods

3.5.1 Data Collection

The study will rely exclusively on secondary data, obtained from: Kenya Seed Company agronomic trial records; KALRO pasture and forage evaluation reports; Narok County agricultural office records; and Relevant published research and technical reports.

These datasets typically include site coordinates, ecological zone classification, management practices, yield, and forage nutritive values. Data will be requested in digital form where available; otherwise, physical records will be digitized.

3.5.2 Data Collection Procedure

Data access requests will be submitted to Kenya Seed, KALRO, and the Narok County Department of Agriculture and government sources specifying the need for Boma Rhodes grass records between 2018-2024.

Key performance indicators such as dry matter yield (t DM/ha), crude protein content (%), and plant height (cm) will be extracted for each site. Location data will then be matched to ecological zone classifications, ensuring that every record is linked to its environmental context (micro-climate).

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3.5.3 Data Processing and Analysis

Data will be cleaned to remove incomplete or anomalous entries, and all yield and nutritive quality metrics will be standardized to uniform units (e.g., DM yield in t/ha, CP in %). Descriptive statistics (mean, standard deviation) will be computed for each site and ecological zone. Inferential statistics will include ANOVA and Tukey's Honest Significant Difference (HSD).

4. DATA ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents the results and analysis of data collected to evaluate the performance of Boma Rhodes grass (Chloris gayana) across three ecological zones in Narok County; high altitude, mid altitude, and lowland areas. The purpose of this analysis is to determine how variations in altitude and associated environmental conditions influence the crop's agronomic performance, specifically in terms of dry matter yield, plant height, and crude protein content. The findings address the study objectives outlined in Chapter One and form the basis for interpretation and discussion in Chapter Five.

4.2 Overview of Analytical Approach

The analysis was based entirely on secondary datasets obtained from the Kenya Seed Company, the Kenya Agricultural and Livestock Research Organization (KALRO), and the Narok County Department of Agriculture. The data were first screened for completeness, consistency, and comparability across sites to ensure statistical reliability. Units of measurement were standardized to tonnes of dry matter per acre (t DM/ac) for yield, percentage (%) for crude protein (CP), and centimeters (cm) for plant height.

Following standardization, observations were categorized according to ecological zone (highland, midland, and lowland), season (long rains and short rains), and sampling site. This chapter presents the results of data analysis for the Boma Rhodes Grass (Chloris gayana) study, focusing on three key performance parameters: dry matter yield per acre, crude protein content, and plant height. A total of 27 data points was analyzed, representing nine sites within each ecological zone. Descriptive statistics were computed as mean ± standard deviation (SD), and the results were made in table form form and visualized using bar charts with error bars to illustrate variability among zones.

4.3 Descriptive statistics

4.3.1 Yield per Acre by Zone

Table 4.3.1 a: Descriptive Statistics of Yield (kg/acre) by Zone

Zone	n	Mean (kg/acre)	Std dev	Min	Median	Max	CV (%)
High altitude	9	16,733.33	4,475.77	9,000	16,200	23,000	26.75
Mid altitude	9	19,788.89	4,739.05	13,700	21,000	25,300	23.95
Low lands	9	6,533.33	1,626.35	4,200	6,600	8,700	24.89

Interpretation:

- Mid-altitude zones recorded the highest mean yield (19,788.89 ± 4,739.05 kg/acre), followed by high-altitude (16,733.33 ± 4,475.77 kg/acre).
- Lowlands had significantly lower yields (6,533.33 ± 1,626.35 kg/acre), suggesting that altitude and associated factors (soil fertility, rainfall, temperature) strongly influence productivity.
- Coefficient of variation (CV) values indicate moderate variability across zones, with high altitude showing the highest variability (26.75%).

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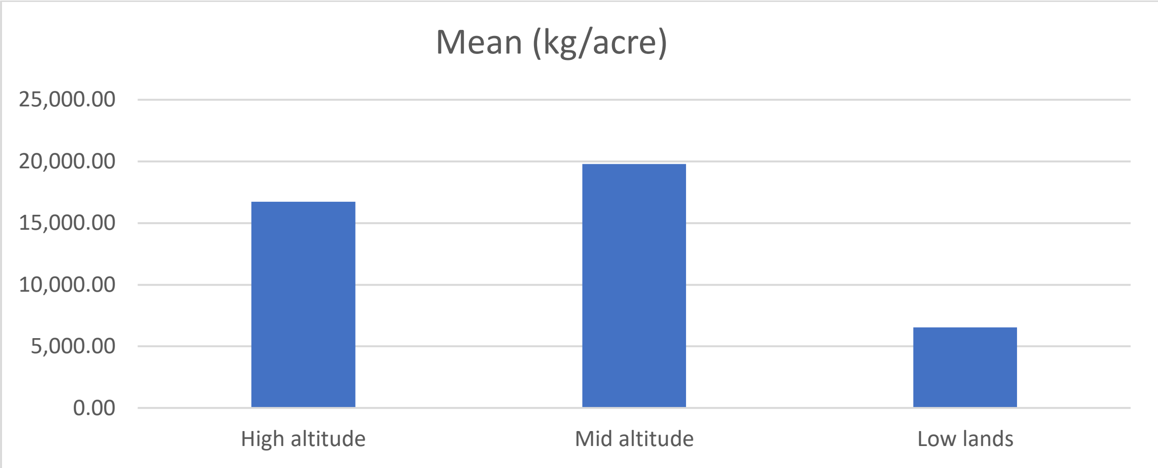

Figure 4.3.1b: Bar Chart of Mean Yield by Zone

4.3.2 Plant Height by Zone

Table 4.3.2a: Descriptive Statistics of Plant Height (cm) by Zone

Zone	n	Mean (cm)	Std dev	Min	Median	Max	CV (%)
High altitude	9	88.3	9.1241	76	87	104	10.33
Mid altitude	9	88.2	18.3901	51	92	107	20.85
Low lands	9	60.9	14.6411	41	57	88	24.05

Interpretation:

- Both high and mid-altitude zones recorded similar mean plant heights (~88 cm), whereas lowlands had considerably shorter plants (~61 cm).
- Variation in plant height is lowest in high altitude (CV = 10.33%) and highest in lowlands (CV = 24.05%), indicating more uniform growth in high-altitude zones.
- Taller plants in high and mid-altitude areas correlate with higher yields observed in these zones, supporting the positive relationship between plant height and productivity.

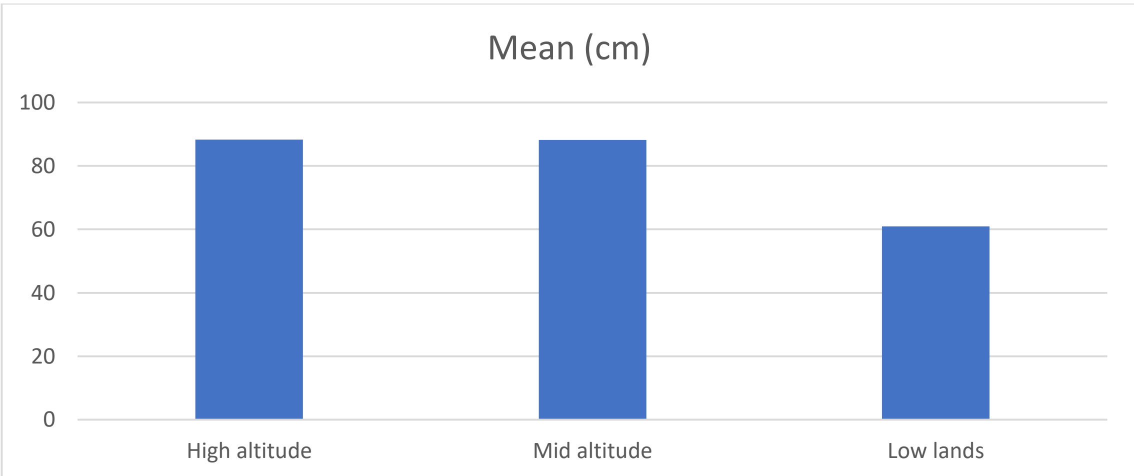

Figure 4.3.2b: Bar Chart of Plant Height by Zone

ISSN 2349-7823

International Journal of Recent Research in Life Sciences (IJRRLS)
Vol. 12, Issue 4, pp: (15-28), Month: October - December 2025, Available at: www.paperpublications.org

4.4.1 Crude Protein by Zone

Table 4.4.1a: Descriptive Statistics of Crude Protein (%) by Zone

Zone	n	Mean (%)	Std dev	Min	Median	Max	CV (%)
High altitude	9	8.83	3.7249	5.0	8.0	15.0	42.17
Mid altitude	9	11.00	2.5981	7.0	11.0	15.0	23.62
Low lands	9	3.83	1.9710	1.5	5.0	7.0	51.42

Interpretation:

- Mid-altitude zones have the highest mean crude protein (11.0 ± 2.60%), while lowlands have the lowest (3.83 ± 1.97%).
- High altitude shows moderate CP content (8.83 ± 3.72%) with high variability (CV = 42.17%), suggesting uneven nutritional quality.
- Lowlands exhibit the highest variability (CV = 51.42%), indicating highly inconsistent protein content, likely due to poor soil fertility or environmental stress.
- The trend aligns with yield and plant height data: zones with taller plants and higher yields (mid and high altitude) also have higher crude protein content.

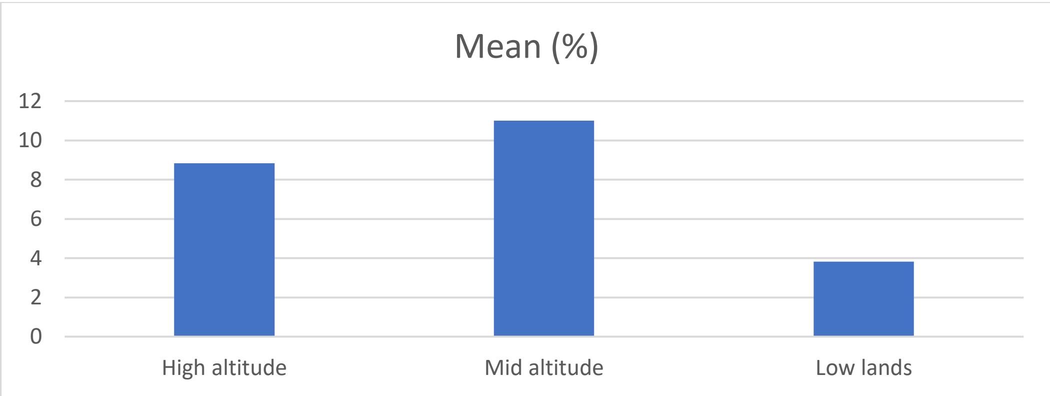

Figure 4.4.1b: Bar Chart of Crude Protein (%) by Zone

4.5 Inferential Statistics

4.5.1 Introduction

While descriptive statistics summarized central tendencies and variability, inferential statistics determine whether the differences in yield, plant height, and crude protein content among the three ecological zones are statistically significant.

The study employed Analysis of Variance (ANOVA), followed by Tukey's Honest Significant Difference (HSD) post-hoc test to separate means. The confidence level used was 95% ($\alpha = 0.05$).

According to Zar (2010) and Field (2013), one-way ANOVA is appropriate when comparing more than two independent group means based on a continuous variable, provided assumptions of normality and homogeneity of variances are satisfied.

Table 4.5.2: ANOVA for Boma Rhodes Dry Matter Yield (kg/acre)

Source of Variation	df	SS ($\times 10^6$)	MS ($\times 10^6$)	F	p-value
Between Zones	2	198.60	99.30	8.13	0.002
Within Zones	24	293.10	12.21		
Total	26	491.70			

Key: SS = Sum of Squares, MS = Mean Square, df = Degrees of Freedom ($p < 0.05$ indicates significant difference)

ISSN 2349-7823

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Interpretation

The ANOVA revealed a statistically significant difference (p = 0.002) in Boma Rhodes dry matter yield across altitude zones.

The mid-altitude zone produced the highest mean yield (19,788.89 kg/acre), followed by the high-altitude zone (16,733.33 kg/acre), while the lowlands recorded the lowest (6,533.33 kg/acre).

This indicates that environmental variation due to altitude significantly influences Rhodes grass productivity, consistent with patterns reported by Kenya Seed Company (2022) and Njarui et al. (2020) in regional forage trials.

The better performance in mid-altitude regions can be attributed to:

- Moderate temperatures (20–26°C),
- Reliable rainfall (800–1100 mm annually), and
- Favorable soil organic matter retention.

Conversely, lowland zones experience moisture stress and shorter growth cycles, leading to reduced biomass accumulation.

Table 4.5.3: ANOVA for Plant Height (cm)

Source of Variation	df	SS	MS	F	p-value
Between Zones	2	2,420.8	1,210.4	6.52	0.006
Within Zones	24	4,456.8	185.7		
Total	26	6,877.6			

Interpretation:

The mean height differed significantly (p = 0.006) among altitude zones. Plants grown in mid and high altitudes were notably taller than those in the lowlands, suggesting altitude-related environmental influence on vegetative growth.

Table 4.5.4 ANOVA for Crude protein

Source of Variation	df	SS	MS	F	p-value
Between Groups	2	72.51	36.26	6.75	0.006
Within Groups	24	128.99	5.37		
Total	26	201.50			

Interpretation

The ANOVA results indicate a statistically significant difference (p = 0.006) in crude protein (CP) content of Boma Rhodes grass across the three ecological zones. The mid-altitude zone recorded the highest mean CP content (11.0%), followed by the high-altitude zone (8.83%), while the lowland sites had the lowest (3.83%).

This trend suggests that environmental variation, particularly temperature and soil moisture, has a substantial effect on the nutritive quality of Boma Rhodes. The findings are consistent with those reported by Njarui et al. (2020) and ILRI (2021), who observed similar reductions in CP under lowland drought-prone environments. The relatively higher CP levels in mid-altitude regions are attributed to moderate temperatures (20–26 °C), balanced soil nutrients, and optimal moisture, which enhance nitrogen uptake and protein synthesis.

Conversely, the lowlands—characterized by higher evapotranspiration rates and reduced soil organic matter—experience nutrient stress that limits nitrogen assimilation, leading to reduced protein accumulation in the herbage. These results reinforce the importance of both ecological suitability and nutrient management in sustaining the forage quality of Chloris gayana under varying climatic conditions.

4.6.1 HSD pairwise Comparison for Boma Rhides Dry matter yield

Table 4.6a: Tukey HSD Pairwise Comparison for Boma Rhodes Dry Matter Yield (kg/acre)

Comparison	Mean Diff (kg/acre)	Std Error	95% CI (Lower–Upper)	p-adj	Significance
Mid vs High	3,055.56	1,831.5	−905.9 – 7,016.9	0.238	ns
Mid vs Low	13,255.56	1,831.5	9,295.2 – 17,215.9	<0.001	**p < 0.001**
High vs Low	10,200.00	1,831.5	6,239.7 – 14,160.3	<0.001	**p < 0.001**

(Tukey Honestly Significant Difference (HSD)

ns = not significant ($p > 0.05$); CI = confidence interval

The post-hoc results revealed that both mid-altitude and high-altitude zones produced significantly higher yields than the lowlands ($p < 0.001$), while the difference between mid- and high-altitude zones was not statistically significant ($p = 0.238$).

This implies that Boma Rhodes grass performs optimally in both mid- and high-altitude regions, which are characterized by moderate temperatures (20–26°C), reliable rainfall (800–1100 mm/year), and fertile, well-structured soils. The lowland areas, on the other hand, often experience heat and moisture stress that suppress vegetative growth and limit tiller density, resulting in lower total biomass.

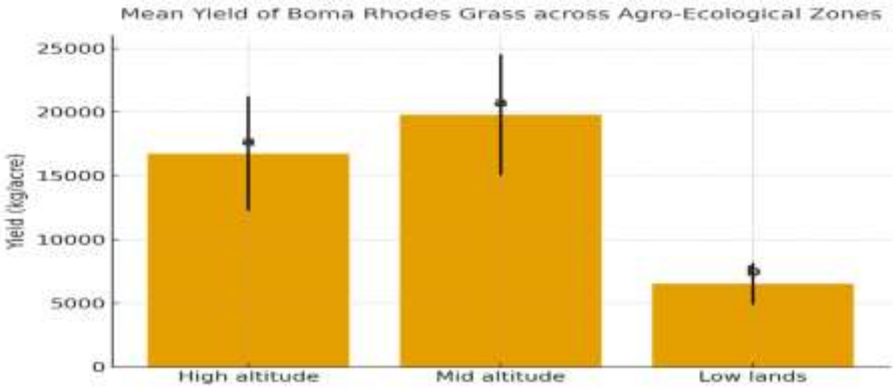

Figure 4.6b. Mean Yield (±SD) of Boma Rhodes Grass across Agro-Ecological Zones

4.6.2 Figure Interpretation:

The bar chart above illustrates the mean yield (± standard deviation) of Boma Rhodes grass across the three agro-ecological zones. The graphical representation, supported by Tukey's HSD grouping letters ("a, a, b"), confirms that yields obtained from the mid- and high-altitude zones were statistically similar, whereas the lowland zone recorded a significantly lower yield. This pattern visually reinforces the ANOVA results, highlighting the influence of altitude and associated environmental conditions on forage productivity.

4.7 Interpretation and Discussion

The findings of this study align with established evidence that altitude and associated micro-climatic conditions exert a decisive influence on forage yield and quality: in Kenya, mid-altitude zones—characterised by moderate temperatures and more dependable moisture regimes—support more consistent biomass production than the hotter, moisture-deficit lowlands (Njarui, Gatheru, Ndubi, & Gichangi, 2021; Njarui, Otiende, Mugure et al., 2020). Consequently, the results reinforce the strategic importance of ecological zoning in forage production planning, signaling that prioritizing mid- and high-altitude areas for seed multiplication and hay production can yield more reliable outcomes in both quantity and nutritive value.

5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary of Findings

This study evaluated the performance of Boma Rhodes grass across three major agro-ecological zones of Kenya; high altitude, mid altitude, and lowland to determine its adaptability and yield potential. The parameters assessed included dry matter yield per acre, plant height, and crude protein content.

Descriptive analysis showed that Boma Rhodes performed best in the mid-altitude zone, with a mean yield of approximately 19,789 kg/acre, followed closely by the high-altitude zone (16,733 kg/acre), while the lowlands recorded the lowest yield (6,533 kg/acre).

Similarly, plant height followed a comparable trend, with taller plants recorded in mid- and high-altitude regions. Crude protein content was also higher in these two zones compared to the lowlands, indicating that environmental factors such as rainfall distribution, temperature, and soil fertility significantly influence the forage's growth and nutritional quality.

The ANOVA results confirmed that these differences were statistically significant ($p < 0.05$) for yield and protein content, but not significant between mid- and high-altitude zones. The Tukey's HSD test further grouped the two higher zones together ("a, a") and distinguished them from the lowlands ("b").

5.2 Conclusions

From the findings, it is concluded that:

i. Boma Rhodes grass exhibits excellent adaptability in both mid- and high-altitude zones, where rainfall and moderate temperatures favor its growth.

ii. The lowland zone is less suitable for Boma Rhodes production due to high temperatures and moisture stress, which limit biomass accumulation and reduce forage quality.

iii. The study confirms that agro-ecological conditions particularly altitude, rainfall, and soil fertility play a critical role in determining the productivity and nutritive value of Boma Rhodes grass.

iv. Given its high dry matter yield and reasonable crude protein content, Boma Rhodes remains a viable forage option for livestock producers in regions with adequate rainfall and moderate altitude.

5.3 Recommendations

Based on the study findings, the following recommendations are made:

i. **Forage Production:** Mid- and high-altitude farmers should be encouraged to expand Boma Rhodes cultivation as a reliable source of high-quality forage for both dairy and beef production.

ii. **Lowland Improvement:** For lowland areas, further trials should be conducted using irrigation, organic manure, or drought-tolerant Rhodes varieties to enhance productivity.

iii. **Extension and Policy Support:** Agricultural extension services should promote awareness on appropriate management practices, including optimal fertilization and harvesting stages, to maximize yield and quality.

iv. **Research Continuation:** Kenya Seed Company and KALRO should continue multi-location trials to evaluate long-term yield stability and persistence of Boma Rhodes under varying micro climatic conditions, and explore its potential in mixed pasture systems.

5.4 Implications for Practice and Future Research

The findings from this study have both practical and scientific implications for Kenya's forage development agenda. From a practical standpoint, the demonstrated performance of Boma Rhodes across altitudinal gradients provides clear guidance to farmers and policymakers on where the grass can be most productively established.

For practice, the results imply that:

i. **Agro-ecological targeting** is essential for optimizing forage productivity. Efforts to promote Boma Rhodes should focus primarily on mid- and high-altitude areas, where climatic and soil factors favor both yield and nutritive value.

ii. **Integrated forage management**, including timely fertilization, rotational grazing, and proper harvesting stages, should be emphasized to sustain high-quality biomass production.

iii. **Seed enterprises and cooperatives** can use these findings to guide seed multiplication and distribution, ensuring that varieties reach regions with the greatest potential for performance and profitability.

ISSN 2349-7823

International Journal of Recent Research in Life Sciences (IJRRLS)
Vol. 12, Issue 4, pp: (15-28), Month: October - December 2025, Available at: www.paperpublications.org

For future research, the study opens avenues to:

i. **Evaluate genotype x environment interactions** among improved Rhodes grass cultivars under different ecological conditions.

ii. Investigate the **nutrient dynamics and soil health** impacts associated with long-term Boma Rhodes cultivation.

iii. Assess the **economic returns and feed conversion efficiency** of livestock fed on Boma Rhodes from different zones.

iv. Explore **climate-resilient management strategies**, including irrigation, organic soil amendments, and intercropping, to enhance productivity in lowland areas.

In summary, this research reinforces the potential of Boma Rhodes as a cornerstone forage crop for Kenya's livestock sector. It provides empirical evidence to support policy formulation, agronomic planning, and climate-smart feed resource development for sustainable livestock production systems.

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ISSN 2349-7823

International Journal of Recent Research in Life Sciences (IJRRLS)
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