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The Effect of Shading Conditions and Mowing Frequency on Plant Diversity, Productivity, Soil Nitrogen and Mineral, and Mineral Profiles of Dominant Forages of Grazing Pasture

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ABSTRACT

The research aimed to study the effect of three different paddock management systems on nitrogen and mineral status of soil, plant diversity, and biomass production and to discuss the potential nutritional effects of macro mineral profiles of dominant forages on grazing cattle. The research was conducted in a Completely Randomized Design (CRD) 3x4, consisting of 3 paddocks as treatments and four plots as replicates. The pasture was divided into three paddocks based on shading conditions and mowing frequency: P1: unshaded by trees and rarely mowed; P2: unshaded but regularly mowed; and P3: shaded by numerous trees and never mowed. Each paddock was divided into four plots based on plant density, with plant and soil samples collected at 17 sampling points per plot. Measured parameters included botanical composition, dominant species, dry matter, and macro mineral concentration of calcium, sodium, phosphorus, sulfur, magnesium, and potassium in the soils and dominant forages. The grazing pasture was inhabited by around 110 native plant species, dominated by *Imperata cylindrica* (19.6%), *Axonopus compressus* (16.8%), *Mimosa pudica* (12.1%), *Digitaria sanguinalis* (10%), *Elephantopus mollis* (9.0%), and *Euphorbia hirta* (8.5%). Biomass production ranged from 110–135 kg/ha/day, with a carrying capacity of 2.5–3.0 AU/ha (significant at $p<0.05$). Different mowing frequency and shading conditions influenced soil nutrient concentrations, forage diversity, and productivity. Considering requirements for growing cattle, the dominant species had a favorable content in Mg, K, and S but was deficient in P, Na, and Ca. In conclusion, the grazing pasture was populated by diverse native forage plants, and the dominant species were poor in several essential minerals of P, Na, and Ca, which are most likely to limit cattle productivity.

Keywords: botanical composition, dominant species, grazing cattle, macro minerals, pasture.

INTRODUCTION

The campus area of Andalas University, located at Kubu Gadang Subdistrict, Payakumbuh Utara District, Payakumbuh City, has approximately 3 hectares of grazing pasture adjacent to the lecture buildings. About 12 beef cattle are grazed or tethered daily on the pasture. The mini pasture is overgrown with wild plants and dominated by low-quality and productive species. The wild forages grow irregularly and unevenly due to unregulated grazing and irregular plant-mowing. Irregularly distributed shade tree plants grown in the pasture also affect the diversity and development of vegetation. Seasonal factors also influence the productivity and quality of forage. Forage production decreases significantly during the dry season (May–September), resulting in low carrying capacity and poor cattle performance (Fitri et al., 2024).

The mini pasture is potentially designed and developed into a well-managed and sustainable grazing pasture for a field laboratory to support students' and faculty's academic activities and research projects. The first step in transforming the currently underutilized pasture into a sustainable grazing pasture is to assess the vegetation diversity, nitrogen and macro mineral status of soil, and macro mineral content of forage plants. This data is essential for designing improvements in soil fertility and the productivity and quality of forages through fertilization, rehabilitation, supplementation, and introduction of more productive forage species.

Essential macro minerals, including calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sulfur (S), and sodium (Na), are critical for soil fertility and the growth of forage plants. These minerals influence plant development by supporting structural integrity, enzymatic activity, and nutrient uptake (Maathuis, 2009; Nadeem et al., 2018). Adequate macro mineral levels in soil enhance forage yield, quality, and nutritional value, directly impacting livestock health and productivity (Soetan et al., 2010). Imbalances or deficiencies in soil macro minerals can reduce plant vigor, limit biomass production, and lead to poor forage mineral content.

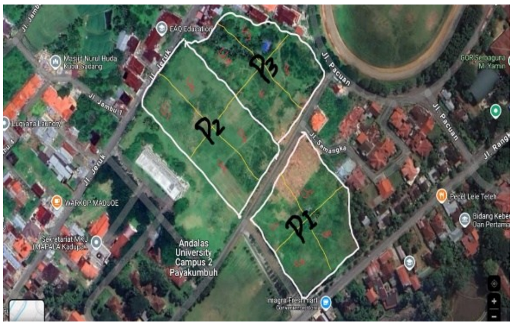
Forage plants serve as a primary dietary source of these nutrients, influencing animal growth, reproduction, and overall physiological function of grazing cattle. The mineral content of forages varies depending on soil quality, plant species, and growth stage. Providing macro minerals in appropriate amounts ensures optimal growth, reproduction, and production in grazing cattle while preventing deficiencies and associated health issues (McDowell, 1985). Adequate macromineral content in forage supports bone development, enzymatic reactions, electrolyte balance, and metabolic processes (Wu, 2018; Suttle, 2010). Conversely, deficiencies or imbalances can lead to disorders such as hypercalcemia, grass tetany, or reduced fertility (Yasothai, 2014; Sharma et al., 2007). Understanding and managing macro mineral concentration in soil and forage systems ensures sustainable pasture productivity and optimizes grazing cattle performance (McDowell et al., 1993).

The research aimed to analyze the soil nitrogen and minerals, forage diversity and productivity, and nutrient and mineral content of dominant species growing in the pasture in different mowing frequencies and shading conditions and to discuss the potential nutritional effects on grazing cattle. The results of the present study might help provide recommendations for optimizing the utilization of the grazing pasture to support academic activities at Campus II Payakumbuh.

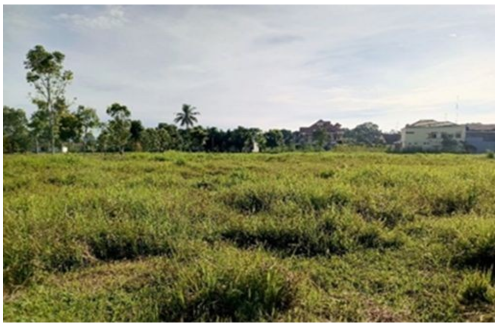
MATERIALS AND METHODS

The determination of sampling points and the collection of forage and soil samples

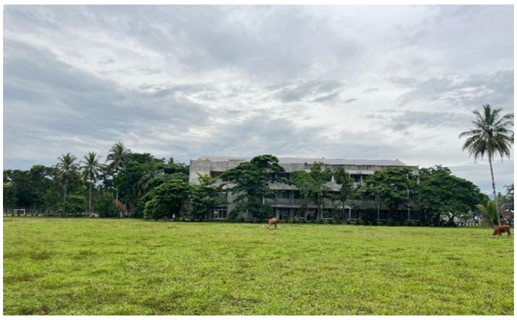
The study was conducted in a Completely Randomized Design (CRD) 3x4, consisting of 3 paddocks as treatments and four plots as replicates. The pasture was divided into three paddocks based on differences in vegetation characteristics and management practices: paddock 1 (P1 (tree-free shaded paddock and rarely mowed) paddock 2 (P2 (tree-free shaded paddock but regularly mowed), and P3 (tree-shaded and never mowed. Due to uneven forage distribution and density, each paddock was further proportionally divided into four plots based on the distribution and density of plant growth: very dense, dense, sparse, and very sparse plots. Forages and soil samples were collected from 17 sampling points per plot using the Stratified Random Sampling method described by Berutu et al. (2014), resulting in 204 samples (3 paddocks × 4 plots × 17 sampling points).



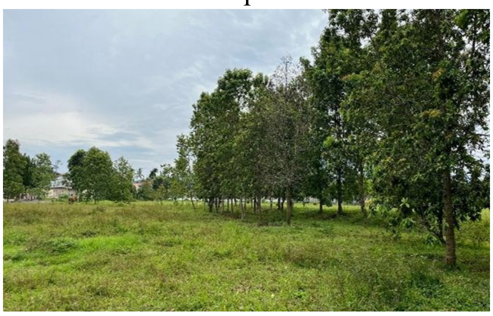
Pasture and paddocks



Paddock 1: Tree-free, shaded, and rarely mowed paddock



Paddack 2: tree-free, shaded, but regularly mowed paddock



P3: tree-shaded and never mowed paddock

Fig. 2. Determination of paddocks, plots, and sampling points

Plant sampling was conducted using a plate meter measuring 0.5 x 0.5 meters. The plate meter was placed randomly at the selected sampling points, and all forage plants within the plate meter were cut 5–10 cm above the ground surface or at the grazing height of cattle (Khalil et al., 2015). The samples were stored in pre-labeled plastic bags and then sealed.

The soil samples (topsoil) were collected from the same sampling points as the plant samples. The soil surface was cleared of plant residues and other foreign materials, then loosened using a small hoe to a depth of approximately 10–15 cm. Roots and other plant debris were removed. Approximately 1000 g of clean soil was collected from each sampling point. The soil samples were then placed in labeled plastic bags and sealed.

Analysis of botanical composition and identification of dominant plants

The forage samples were weighed for their fresh weight, separated by species, and identified using their local and scientific names through the PlantSnap open software. Each plant species was weighed to calculate the botanical composition, identify the dominant species, and estimate biomass production. The botanical composition was calculated by dividing the weight of each plant species by the total weight of the sample and then multiplying by 100%. Dominant plants have a botanical composition of ≥ 5% (Khalil, 2016). Calculations of botanical composition, biomass production, and carrying capacity were performed using the formula provided by Infitra and Khalil (2014).

Preparation and analysis of forage and soil samples

There were six dominant plant species: *Imperata cylindrica, Axonopus compressus, Mimosa pudica, Digitaria sanguinalis, Elephantopus mollis*, and *Euphorbia hirta*. Samples of each dominant plant were collected from each paddock, resulting in 18 samples (6 plant species x 3 paddocks). The plant samples were chopped into 2-3 cm pieces, mixed and composited. Composed samples of approximately 150 g were taken and weighed for their fresh weight (FW). The sample was then placed in a pre-labelled aluminium foil box and dried in an oven at 60 ± 5°C for 48 hours. The air-dried samples were cooled, weighed for their air-dried weight (ADW), and ground into a meal form. The sample was analyzed for dry matter (DM) and macro minerals (calcium, phosphorus, magnesium, potassium, sodium, and sulfur).

The soil samples of plant root remnants, gravel, and foreign matter were cleaned. The clean samples were weighed and sun-dried until they were dry and suitable for grinding. The dried soil samples were manually ground using a glass bottle and sieved through a mesh. Samples with coarse particles were re-grounded and re-sieved until all samples were finely ground. The soil samples were then ground using a blender to a powder-like consistency. Soil samples from the same plot were combined and composited, resulting in 12 soil samples (3 paddocks x 4 plots). The samples were analysed for DM, nitrogen, and macro-minerals: phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), and sulfur (S). DM and nitrogen analysis were performed according to the procedures of the AOAC (2016). Preparation of soil samples and mineral analysis of soil and forage samples were conducted by following the procedures described by Eviati and Sulaeman (2012) and ISRIC (2002).

Statistical analysis

Biomass production data, plant carrying capacity, and soil mineral content were statistically analyzed using Analysis of Variance (ANOVA) with a Completely Randomized Design (CRD) 3x4, consisting of 3 paddocks as treatments and 4 plots as replicates. Data on the nutrient and mineral content of dominant plants were analyzed using a Randomized Block Design (RBD) with 6 treatments and 3 replicates (6x3). Further analysis was conducted using Duncan's Multiple Range Test (DMRT) if significant differences were observed among treatments. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 18.0.

RESULTS AND DISCUSSION

Soil nitrogen and mineral concentration

Table 1 presents the nitrogen and macro mineral concentrations in soils derived from three distinct paddock management systems. The critical levels for each parameter, defined by McDowell (1985) and Rhue and Kidder (1983), are also provided for reference. The total nitrogen content (N-total) was highest in paddocks 1 (0.37% DM) and 3 (0.38% DM), both of which exceeded that of paddock 2 (0.32% DM). This indicates that the frequency of mowing without fertilization drained soil nitrogen and reduced nitrogen retention, with Paddock 2 showing a significantly lower nitrogen level than the others.

For total phosphorus (P-total), paddock 3 demonstrated the highest concentration (807.45 ppm), significantly ($p<0.05$) exceeding those of paddocks 1 (565.98 ppm) and 2 (579.85 ppm). This trend suggests that reduced mowing or the absence of mowing might allow for greater phosphorus accumulation, potentially due to limited nutrient removal from plant biomass. Total potassium (K-total) concentrations varied considerably, with paddock 2 showing the highest level (4087.43 ppm) compared to paddocks 1 (830.27 ppm) and 3 (1556.56 ppm). This could indicate differential nutrient cycling or external inputs specific to paddock 2. The calcium concentrations (Ca-total) were not significantly different among the paddocks, suggesting minimal influence of mowing or shading on calcium levels. However, paddock 1 displayed slightly higher variability (431.19 ppm).

Magnesium (Mg-total) and sodium (Na-total) levels showed significant variation. Paddock 2 exhibited the highest magnesium concentration (609.67 ppm), while paddocks 1 and 3 had significantly lower values. For sodium, paddocks 2 and 3 were similar and significantly higher than paddock 1, suggesting possible differences in soil salinity or nutrient leaching. Total sulfur (S-total) exhibited the most variability among the paddocks, with paddocks 2 (1456.81 ppm) and 3 (2059.02 ppm) greatly exceeding paddock 1 (287.47 ppm). This high variability might be due to differences in organic matter decomposition or external nutrient inputs.

The data indicates that mowing frequency and shading conditions influence soil nutrient concentrations. Shading lowers soil temperature by reducing solar radiation. Shading alters soil's mineral content by modifying temperature, moisture, organic matter accumulation, microbial activity, and nutrient cycling. Cooler soils experience slower microbial activity, which can affect nutrient mineralization and availability. Increased moisture retention under shaded conditions can enhance the leaching of mobile nutrients like nitrogen (N) and potassium (K) (Laclau et al., 2004).

Specifically, the lack of mowing in paddocks 1 and 3 enhances nitrogen and phosphorus retention, possibly through reduced biomass removal and enhanced organic matter accumulation. Conversely, the significantly higher potassium levels in paddock 2 may reflect fertilization practices or other management interventions unique to this paddock. The variability in sulfur and other nutrients suggests complex interactions between management practices and nutrient-cycling processes (Sharma et al., 2024). Further research is needed to isolate the specific mechanisms driving these differences, including the roles of plant uptake, microbial activity, and external nutrient inputs.

Table 1. Nitrogen and mineral concentration in the soils derived from three paddocks

Parameter	Paddock:			Critical levels*)
	1	2	3	
	free, shaded, and rarely mowed	free shaded but regularly mowed	shaded and never mowed	
N-total (% DM)	$0.37^a \pm 0.03$	$0.32^b \pm 0.02$	$0.38^a \pm 0.04$	< 10 ppm
Minerals (ppm):				
P-total	$565.98^b \pm 80.89$	$579.85^b \pm 67.63$	$807.45^a \pm 152.63$	< 10
K-total	$830.27^c \pm 113.78$	$4087.43^a \pm 283.89$	$1556.56^b \pm 657.28$	< 59
Ca-total	431.19±281.69	354.77±58.17	395.01±211.25	< 70
Mg-total	$380.53^b \pm 16.86$	$609.67^a \pm 36.00$	$416.18^b \pm 41.50$	< 30
Na-total	$193.01^b \pm 8.63$	$218.26^a \pm 14.63$	$225.05^a \pm 6.38$	< 62
S-total	287.47±112.32	1456.81±2330.43	2059.02±3186.34	< 10

*) McDowell (1985), Rhue and Kidder (1983)

Forage diversity and dominant species

Table 2 presents the detailed botanical composition of pastures in three paddocks with varying management practices. Vegetation is categorized into four groups: grasses, herbaceous broad-leaved plants, shrubs, and legumes, listing individual species along with their percentage contributions to the overall composition in each paddock. Grasses dominate botanical composition across all paddocks, with ***Imperata cylindrica*** as the most prominent species. The percentage of this grass varies significantly across the paddocks: 33.1% in Paddock 1, 13.6% in Paddock 2, and 12.0% in Paddock 3. Paddock 1 has a more diverse composition of less abundant grass species than the other paddocks, with notable contributions from ***Digitaria sanguinalis*** and ***Pennisetum setaceum***.

Herbaceous and broadleaved species exhibit a wide range of diversity. ***Euphorbia hirta*** is the dominant herbaceous species, contributing 7.8%, 8.8%, and 8.8% in Paddocks 1, 2, and 3, respectively. The regular mowing in Paddock 2 is associated with a broader representation of secondary herbaceous species like ***Paederia Florida*** (0.6%) and ***Centratherum punctatum*** (1.3%). Shrub composition varies, with ***Mimosa pudica*** and ***Elephantopus mollis*** consistently representing significant portions. ***Mimosa pudica*** has the highest prevalence in Paddock 2 (16.8%) compared to Paddock 1 (8.9%) and Paddock 3 (10.7%). Regular mowing in Paddock 2 may promote certain shrubs' growth, as evidenced by the higher percentage of this species. Legume diversity is low, represented solely by ***Centrosema pubescens***, with its presence limited to Paddock 1 (1.8%) and Paddock 2 (0.4%).

The dominant species composition highlights significant ecological variation. *Imperata cylindrica* is prevalent in Paddock 1 (33.11%) but less dominant in Paddocks 2 and 3 (13.57% and 12.04%, respectively). Conversely, *Axonopus compressus* thrives in Paddocks 2 and 3 (21.61% and 24.16%, respectively) but is less prominent in Paddock 1 (4.58%). As summarized in Tabel 3, other dominant species, such as *Mimosa pudica, Digitaria sanguinalis, Elephantopus mollis*, and *Euphorbia h*irta, exhibit a more balanced distribution across paddocks, contributing between 8% and 13% on average.

The botanical composition of the pastures reflects the influence of mowing and shading on species diversity and abundance. The regularly mowed Paddock 2 shows a balanced distribution of grasses and shrubs, while the rarely or never mowed Paddocks 1 and 3 exhibit greater dominance of specific grass species such as *Imperata cylindrica*. The absence or low proportions of legumes in all paddocks indicate limited nitrogen-fixing species in these pastures. The observed variations may provide insights into pasture management strategies and their impact on botanical diversity and ecosystem health.

The present data reveals that mowing appears to reduce the dominance of certain grasses like ***Imperata cylindrica*** while promoting the presence of diverse herbaceous species. In contrast, the absence of mowing in Paddocks 1 and 3 allows grass to dominate, likely due to reduced competition and disturbance. The limited diversity of legumes suggests potential implications for soil fertility, as legumes are important for nitrogen fixation. Their low presence might be attributed to competitive exclusion by grass and shrubs (Spehn et al., 2002). Overall, the findings underscore the importance of management strategies in shaping botanical diversity and composition in pastures. Further studies should evaluate the ecological and productive implications of these variations for grazing systems.

Biomass production and carrying capacity

Table 3 summarizes land area, biomass production, and carrying capacity. The total land area across the three paddocks is 2.91 hectares, each covering nearly equal areas of approximately 0.95 to 0.99 hectares. The paddocks collectively host 110 species, with Paddocks 1 and 3 being more diverse (60 species each) than Paddock 2 (48 species).

Grasses dominate the botanical composition in all paddocks, comprising 53.81% to 57.39% of the vegetation, with an overall mean of 55.6%. Herbaceous and broadleaf plants represent 16.20% to 18.18%, shrubs account for 25.98% to 26.40%, and legumes are sparse, contributing only 0% to 1.80%. These variations may reflect the mowing regimes and shading conditions that influence species competition and growth dynamics (Bomanowska et al., 2019).

Biomass production and carrying capacity vary significantly among the paddocks. Paddock 3, shaded and never mowed, exhibits the highest annual biomass production (47.79 t/y) and daily biomass production (130.94 kg/d). Paddock 1, despite being rarely mowed, also maintains high productivity (46.10 t/y and 126.30 kg/d), whereas Paddock 2 shows reduced productivity (38.41 t/y and 105.24 kg/d), likely due to the frequent mowing. The carrying capacity reflects this trend, with Paddocks 1 and 3 supporting higher values (2.81 and 2.91 AU/ha, respectively) than Paddocks 2 (2.34 AU/ha). Carrying capacity, measured in animal units per hectare (AU/ha), mirrors the biomass production trends. Paddocks 1 and 3 have significantly higher carrying capacities (2.81 ± 0.09 and 2.91 ± 0.11 AU/ha, respectively) than paddock 2 (2.34 ± 0.31 AU/ha). This highlights the impact of management practices on the ability of pastures to support grazing cattle. The pasture can only supply forage

Table 2. Detailed botanical composition of pasture in the different paddocks

Paddock 1: free-shaded and rarely mowed	Paddock 2: free-shaded but regularly mowed	Paddock 3: shaded and never mowed
Grasses (%)		
Imperata cylndrica (**33.1**), **Digitaria sanguinalis** (**6.9**), **Axonopus compressus (4.6)**, Digitaria cilliaris (0.2), Commelina diffusa (0.2), Rungia repens (0.1), Paspalum dilatatum (0.1), Eleusine indica (0.2), Dactyloctenium agyptium (0.4), Pennisetum setaceum (5.4), Lophaterum gracila (1.5), Sporobulus diander (0.1), Cyperus cephalatos (0.1), Cyperus rotundus (0.1), Paspalum conjugatum (0.2), Paspalum scrobiculatum (0.2), Digitaria sanguinalis (0.2), Panicum repens (0.1), Comelina difusa (0.3), Comelina erecta (0.1)	**Imperata cylndrica** (**13.6**), **Digitaria sanguinalis** (**9.9**), **Axonopus compressus** (**21.6**), Dactyloctenium agyptium (2.1), Pennisetum setaceum (3.4), Lophaterum gracila (0.1), Cyperus rotundus (2.9), Digitaria sanguinalis (0.2), Carex nigra L (0.1), Cyperus esculentus (0.2), Oplimas hirtellus (0.1), Paspalum conjugatum (0.1), Axonopus fissifolius (0.4), Paspalum setaceum (0.1), Brachia mutica (0.3), Cynodon dactylon (0.6), Paspalum dilatatum (0.2), Sacciolepis indica (0.1), Carex remota L (0.6), Cyperus aromaticus (0.1)	**Imperata cylndrica** (**12.0**), **Digitaria sanguinalis** (**13.2**), **Axonopus compressus** (**24.2**), Rungia repens (0.1), Dactyloctenium agyptium (0.1), Lophaterum gracila (0.3), Sporobulus diander (0.8), Cyperus rotundus (2.1), Digitaria sanguinalis (0.6), Panicum repens (0.1), Paspalum conjugatum (0.3), Axonopus fissifolius (0.6), Paspalum setaceum (0.3), Brachia mutica (0.2), Cynodon dactylon (0.3), Paspalum dilatatum (0.3), Elymus repens (0.1), Cyperus brevifolius (0.1), Digitaria ciliaris (0.1), Triticum aestivum (0.3), Commelina diffusa (0.8), Stenotaphrum secundatum (0.3), Luzula sylvatica (0.1), Ryegrass perennial (0.1), Dichanthelium oligosanthes (0.3).
Herbaceous and Broad leaves		
Euphorbia hirta (**7.8**), Tanacetum balsamita (0.1), Asystasia gangetica (4.5), Rostellularia procumbens (0.1), Spermacoce alata (0.1), Spermacoce remota (0.1), Clinopodium vulgare (0.1), Origanum majorana (0.2), Dischidia nummularia (0.2), Hyptis capitata (1,4), Ipomoea batatas (0,3), Murdannia bracteata (0.4), Paeeria folhida (0.1), Diodia virginiana (0.1), Heliconia psitacorum (0.1), Acalipha rhombidea (0.2), Starchytarpheta cayenensis (0.4), Ruellia blechum (0.1), Echinodorus amazonicus (0.1), Andrographis paniculata (0.2), Soncuhus arvensis (0.1), Baptisia australis (0.9), Spermacoce alata (0.1), Androggraphi paniculata (0.1), Centella asiatica (0.1), Centratherum punctatum (0.1), Spermacoce latifolia (0.4).	**Euphorbia hirta** (**8.8**), Tanacetum balsamita (0.1), Asystasia gangetica (0.5), Rostellularia procumbens (0.1), Dischidia nummularia (0.3), Hyptis capitata (0.4), Paederia folhida (0,6), Diodia virginiana (0.8), Heliconia psitacorum (0.1), Androggraphi paniculata (0.5), Centratherum punctatum (0.2), Spermacoce latifolia (0.8), Stellaria media (0.1), Richardia scabra (0.1), Origanum vulgare (0.2), Arenaria serpyllifolia (0,1), Centratherum punctatum (1.3), Metha pulegium (1.0), Schoenoplectus lacustris (0.2), Spermacoce latifolia (0.2), Justicia procumbers (0.1), Alternanthera sessilis (0.3), Ocimum americanum (0.1).	**Euphorbia hirta** (**8.8**), Tanacetum balsamita (0.2), Asystasia gangetica (1.6), Rostellularia procumbens (0.3), Dischidia nummularia (0.2), Hyptis capitata (0.7), Paederia folhida (0.1), Heliconia psitacorum (0.1), Starchytarpheta cayenensis (0.8), Andrographis paniculata (0.1), Androggraphi paniculata (0.1), Centella asiatica (0.2), Arenaria serpyllifolia (0.2), Centratherum punctatum (0.1), Alternanthera sessilis (0.6), Achyranthes aspera (0.6), Artemisia dracunculus (0.4), Oxalis dillenii (0.1), Amaranthus spinosus (0.1), Ageratum conyzoides (0.1), Ruellia tuberosa (0.1), Verbena urticifolia (1.0).
Shrubs		
Mimosa pudica (**8.9**), **Elephantopus mollis** (**8.9**), Strobilanthes crispa (0.4), Gynura procumbens (1.7), Melastoma malabatricum (2.1), Alysicarpus vaginalis (0.8), Themeda gigante (2.9), Blume balamifera (0.1), Phyllantus urinaria (0.1), Chamaecrista nictitans (0.4), Vernonia amygdalina (0.1), Arundinaria gigantea (0.1)	**Mimosa pudica** (**16.8**), **Elephantopus mollis** (**8.4**), Melastoma malabatricum (0.4), Shachytapeta jamaicensis (0.1), Borrier latifolia (0.8).	**Mimosa pudica** (**10.7**), **Elephantopus mollis** (**9.7**), Gynura procumbens (3.4), Melastoma malabatricum (0.8), Blume balamifera (0.3), Phyllantus urinaria (0.1), Shachytapeta jamaicensis (0.4), Scoparia dulcis (0.3), Malvastrum coromandelianum (0.1), Calotropis gigantea (0.1), Ocimum basilicum (0.1), Hyssopus officinalis (01).
Legumes		
Centrosema pubescens (1.8)		Centrosema pubescens (0.4)

Table 3. Land area, botanical composition, biomass production, carrying capacity, and dominant species of pasture in three different paddocks

Parameter	Paddock:			Total
	1	2	3	
	free, shaded, and rarely mowed	free shaded but regularly mowed	shaded and never mowed	
Land area (ha)	0.99	0.95	0.97	2.91
Total number of species (species)	60	48	60	110
Botanical composition (%):				Mean
– Grasses	53.81	56.73	57.39	55.6
– Herbaceous and broadleaves)	18.18	16.87	16.20	17.1
– Shrubs	26.21	26.40	25.98	26.2
– Legumes	1.80	0.00	1.80	0.7
Dominant species (%)				Mean
– *Imperata cylindrica*	33.11	13.57	12.04	19.57
– *Axonopus compressus*	4.58	21.61	24.16	16.78
– *Mimosa pudica*	8.9	16.79	10.72	12.12
– *Digitaria sanguinalis*	6.86	9.94	13.20	10.00
– *Elephantopus mollis*	8.93	8.35	9.66	8.98
– *Euphorbia hirta*	7.76	8.80	8.83	8.46
Biomass production and carrying capacity:				
– Biomass production, t/y	46.10^{a}±1.48	38.41^{b}±5.08	47.79^{a}±1.78	132.31
– Biomass production, kg/d	126.30^{a}±4.06	105.24^{b}±13.92	130.94^{a}±4.86	362.48
– Carrying capacity, AU/ha	2.81^{a}±0.09	2.34^{b}±0.31	2.91^{a}±0.11	8.06

feed for 8-9 cattle with a mean body weight of about 450 kg.

The results demonstrate that mowing frequency and shading conditions significantly influence pasture composition, productivity, and carrying capacity. Mowing frequency and shading conditions have profound effects on pasture composition, productivity, and carrying capacity. Gastal and Lemaire (2015) reported that frequent mowing favors low-growing, fast-regenerating species such as clover (*Trifolium* spp.) and ryegrass (Lolium spp.) while reducing dominance of tall-growing, slow-recovering species Less frequent mowing allows taller species like fescue (Festuca spp.) and weeds to establish dominance, leading to reduced pasture uniformity and lower forage quality (Briske et al., 2008). Regular mowing stimulates tillering in grasses, increasing overall forage density (Schnyder et al., 2000). While paddocks with minimal intervention (1 and 3) sustain higher biomass and carrying capacities, paddock 2's regular mowing may limit productivity. These findings underline the importance of tailored pasture management strategies to optimize biodiversity and productivity. The observed patterns suggest that management practices (mowing frequency) and environmental conditions (shading) significantly influence pasture characteristics. Less frequent mowing and increased shading, as in Paddock 3, appear conducive to higher biomass production and carrying capacity, likely due to reduced stress and enhanced resource availability. However, species diversity is also affected, as shown by the reduced diversity in Paddock 2.

Dry matter, crude ash, and mineral composition of the dominant species

Table 4 summarizes the dry matter (DM), crude ash, and mineral content of six dominant forage species: *Imperata cylindrica*, *Axonopus compressus*, *Mimosa pudica*, *Digitaria sanguinalis*, *Elephantopus mollis*, and *Euphorbia hirta*. The table also includes critical levels of minerals for cattle as a reference. These parameters are crucial for assessing the nutritional value of the forages and their adequacy in meeting the dietary needs of cattle. The dry matter content varied significantly among the species, with *Imperata cylindrica* and *Mimosa pudica* showing the highest values (32.44% and 30.15% FW, respectively).

Elephantopus mollis and *Euphorbia hirta* had significantly the lowest values (19.14% and 20.52% FW). Lower DM content in these forages could affect their palatability and livestock intake. Crude ash content, an indicator of total mineral composition, was highest in *Euphorbia hirta* (15.98% DM) and lowest in *Imperata cylindrica* (7.71% DM). Higher crude ash levels indicate better mineral availability, which may enhance forage utility for cattle supplementation.

Among macro minerals, potassium (K) levels exceeded the critical level (<0.50%) for all species, with *Euphorbia hirta* presenting the highest value (3.48%). Potassium is required to maintain fluid balance, muscle contractions, and nerve function. It also supports lactation and overall productivity. Inadequate K intake might reduce feed intake, weight loss, and decreased milk production (Wu, 2018). Similarly, magnesium (Mg) and sulfur (S) levels were adequate across species, with *Euphorbia hirta* having the highest Mg concentration (0.97% DM) and *Imperata cylindrica* showing the lowest. Magnesium (Mg) is involved in various enzyme activating, muscle contraction, and nerve function. Deficiency in Mg leads to grass tetany (hypomagnesemia), a potentially fatal condition common in cattle grazing on lush pastures (Wu, 2018). Sulphur (S) is necessary for the synthesis of sulfur-containing amino acids (methionine, cysteine) and vitamins (biotin, thiamine). S deficiency symptoms are poor growth, reduced feed efficiency, and dull coats (Wu, 2018).

In contrast, all species showed sodium (Na) and phosphorus (P) levels below the critical level. Sodium concentrations were notably low (0.01 ppm) for all species, far below the critical level (0.06%), suggesting a potential need for Na supplementation in cattle diets. Sodium is required to maintain fluid balance, nerve function, and muscle contractions. Na also influences appetite and feed intake. Na deficiency reduces appetite, poor growth, and low feed efficiency (Wu, 2018). Phosphorus (P) levels in the forages ranged from 0.14% DM in *Imperata cylindrica* to 0.23% DM in *Euphorbia hirta*. All species showed P levels below the critical level of 0.25%. Phosphorus is important in energy metabolism (ATP), bone development, reproduction, and feed efficiency. Poor growth, weak bones, and reduced fertility are deficiency symptoms of P (Wu, 2018). Moreover, as shown in Table 4, three dominant species contained relatively low calcium, close to the critical level (<0.30%). They were *Imperata cylindrica* (Ca: 0.33%), *Axonopus compressus* (0.34%), and *Digitaria sanguinalis* (0.37%). The other species surpassed the critical level. *Elephantopus mollis* had the highest calcium content (0.94%). Calcium (Ca) is essential for bone and teeth development, muscle function, nerve transmission, and blood clotting. Inadequate Ca intake causes weak bones, reduced milk production, poor growth, and disease susceptibility (Yasothai, 2014; Wu, 2018).

The forage species analyzed in Table 4 reveal variable nutritional profiles with implications for cattle feeding. While the dry matter content of *Imperata cylindrica* and *Mimosa pudica* makes them attractive as forage, the low crude ash in *Imperata cylindrica* suggests limited mineral availability. Conversely, *Euphorbia hirta* demonstrated high crude ash and superior concentrations of key minerals like K, Ca, and Mg, making it a nutritionally robust forage option.

Table 4. Dry matter (DM), crude ash, and mineral content of dominant forages

Parameter	Name of the dominant species: *Imperata cylindrica*	*Axonopus compressus*	*Mimosa pudica*	*Digitaria sanguinalis*	*Elephantopus mollis*	*Euphorbia hirta*	Critical level for cattle*)
Dry matter (% FW**)	32.44^{a}±3.65	22.97^{b}±0.70	30.15^{a}±2.06	24.50^{b}±2.45	19.14^{c}±1.89	20.52^{bc}±1.34	
Crude ash (% DM)	7.71^{d}±0.83	10.32^{c}±0.58	14.79^{b}±0.57	13.48^{b}±1.14	14.88^{b}±1.03	15.98^{a}±0.07	
Macro minerals (% DM):							
P	0.14±0.03	0.22±0.04	0.20±0.02	0.20±0.04	0.21±0.08	0.23±0.11	< 0.25
K	1.29^{b}±1.05	2.02^{b}±0.23	1.84^{b}±0.46	1.82^{b}±0.42	1.99^{b}±0.51	3.48^{a}±1.25	< 0.50
Ca	0.33^{b}±0.09	0.34^{b}±0.05	0.88^{ab}±0.15	0.37^{ab}±0.06	0.94^{a}±0.63	0.88^{ab}±0.55	< 0.30
Mg	0.44^{b}±0.18	0.53^{ab}±0.04	0.62^{ab}±0.08	0.53^{ab}±0.11	0.60^{ab}±0.28	0.97^{a}±0.45	< 0.10
S	0.19±0.18	0.24±0.04	0.24±0.08	0.24±0.11	0.24±0.28	0.36±0.45	< 0.08
Na (ppm)***	0.01	0.01	0.01	0.01	0.01	0.01	< 0.06

*) McDowell (1997) and NRC (2000); **) FW = fresh weight; ***) [Na]: very low concentration for all species (0.01 ppm) (critical level: 0.06%).

The mineral analysis indicates that all species meet or exceed critical levels for Mg, S, and K, with potassium levels particularly high across the board. However, the low sodium, phosphorus, and calcium levels highlight a potential deficiency that might need supplementation in cattle diets. These findings highlight the variability in nutritional quality among dominant forage species. They align with previous research on beef cattle fed on wild forages in the Payakumbuh region by Khalil et al. (2015).

CONCLUSION

Management practices (mowing frequency) and environmental conditions (shading) affected soil nutrient concentrations, pasture composition, productivity, and carrying capacity differently. The lack of mowing enhances nitrogen and phosphorus retention, possibly through reduced biomass removal and enhanced organic matter accumulation. On the other hand, paddocks with minimal intervention sustained higher biomass and carrying capacities. The pasture is covered with various types of wild plants that are dominated by *Imperata cylindrica* (19.6%), *Axonopus compressus* (16.8%), *Mimosa pudica* (12.1%), *Digitaria sanguinalis* (10%), *Elephantopus mollis* (9.0%), and *Euphorbia hirta* (8.5%). Concerning the mineral requirements for cattle, the dominant plants contain relatively high levels of Mg, K, and S but are deficient in Na, P, and Ca, which are most likely to limit cattle productivity. It is suggested that pasture should be rehabilitated by selecting more productive forage species and mixing with leguminous plants to improve biomass production, carrying capacity, and the content of essential minerals.

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