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Agronomic behavior and chemical composition of three varieties of grasses at different harvest ages

Comportamiento agronómico y composición química de tres variedades de pastos en diferentes edades de cosecha

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Abstract

The study investigated the impact of age (E) and variety (V) on several plant characteristics, including plant height (AP) in centimeters, forage biomass (FB) in kilograms of dry matter per hectare, stem weight (PT), leaf number (LH), leaf area (LA), leaf-stem ratio (LSR), and the chemical composition of three grass species: Axonopus micay, Axonopus scoparius, and Melinis minutiflora. The grasses were harvested at five different stages of maturity (30, 45, 60, 75, and 90 days). A randomized complete block design with a factorial arrangement (3 x 5) was employed, resulting in a total of 75 plots. Notably, the purple Gramalote grass (Axonopus scoparius) outperformed the other varieties in terms of AP, PT, LH, AH, PH, and H:T ratio, with specific measurements of 168,46 cm, 97,24 g, 64,02 cm, 3,72 cm, 32,39 g, and 0,37, respectively. Additionally, at 90 days, the highest values were observed for AP (138,83 cm), PT (58,96 g), LH (41,74 cm), AH (2,94 cm), PH (15,69 g), and biomass (1 682,5 kg MS ha-1). Furthermore, the dry matter content (%) of the purple Gramalote grass (33,16) exceeded that of the Gordura grass (32,38) and Micay grass (21,97). In terms of ash and crude protein content, the Gramalote morado variety exhibited higher values (9,65 and 9,09 respectively).

Keywords: Axonopus micay, Axonopus scoparius, Melinis minutiflora, cutting age, variety, forage.

Resumen

El estudio investigó el impacto de la edad (E) y la variedad (V) en varias características de la planta, incluida la altura de la planta (AP) en centímetros, la biomasa del forraje (FB) en kilogramos de materia seca por hectárea, el peso del tallo (PT), el número de hojas. (LH), área foliar (LA), relación hoja-tallo (LSR) y la composición química de tres especies de gramíneas: Axonopus micay, Axonopus scoparius y Melinis minutiflora. Los pastos se cosecharon en cinco estados diferentes de madurez (30, 45, 60, 75 y 90 días). Se empleó un diseño de bloques completos al azar con arreglo factorial (3 x 5), resultando un total de 75 parcelas. Cabe destacar que el pasto Gramalote morado (Axonopus scoparius) superó a las demás variedades en cuanto a AP, PT, LH, AH, PH y relación H:T, con medidas específicas de 168,46 cm, 97,24 g, 64,02 cm, 3,72 cm, 32,39 g y 0,37, respectivamente. Además, a los 90 días, los valores más altos se observaron para AP (138,83 cm), PT (58,96 g), LH (41,74 cm), AH (2,94 cm), PH (15,69 g), y biomasa (1 682,5 kg MS ha-1). Además, el contenido de materia seca (%) del pasto Gramalote morado (33,16) superó al del pasto Gordura (32,38) y al pasto Micay (21,97). En cuanto al contenido de cenizas y proteína cruda, la variedad Gramalote morado presentó valores más altos (9,65 y 9,09 respectivamente).

Palabras clave: Axonopus micay, Axonopus scoparius, Melinis minutiflora, edad de corte, variedad, forraje.

Introduction

On the Ecuadorian coast, livestock systems rely on dual-purpose approaches. These systems primarily utilize forage as the main source of food for the animals. The forage consists of numerous grazing and cutting grasses, which are abundant during the rainy season but scarce during the dry season. In Ecuador, the total surface area dedicated to pastures exceeds that of any other crop. Within this agricultural land of 5 381,383 has, cultivated pastures cover 42,68%, while natural pastures account for 14,85%. When considering only pasture areas, the proportion becomes 73% cultivated pastures and 27% natural pastures. Additionally, across the entire national surface with pastures, 56.64% corresponds to the Coastal Region, 28,43% to the Sierra Region, and 14,94% to the Eastern Region and Undelimited Zones. Notably, the key pastures in Ecuador, based on area, include Saboya (1 147,091 has), other pastures (639,915 has), Honey grass (182,532 has), Gramalote (167,519 has), Brachiaria (132,973 has), and Raigrás (104,475 has) (León *et al.,* 2022).

Axonopus scoparius, commonly known as carpet grass, is a perennial grass species. It typically grows to a height of 0,6–2 meters, forming tufts with succulent stems. This grass is often used in the rope grazing system, where animals remain in an assigned area until all the forage is consumed, after which they are moved to a different location (Parra *et al.*, 2023; Huebla Concha *et al*., 2021; Lajús *et al*., 2014). Its species grow mainly below 1,000 m altitude, although some species can reach 3,000 m. Livestock readily accept *Axonopus scoparius*, especially when it is in its tender state. The nutritional value of this grass depends on its growth stage (Giraldo-Cañas, 2014). Unlike some other grasses, it does not produce roots at the nodes. The spike of A. *scoparius* resembles that of imperial grass, but it has a greater number of spikelets. This species thrives in areas situated between 400 and 2 200 meters above sea level, with an annual rainfall ranging from 1 000 to 4 000 mm and an average temperature around 20 °C The spike of A. *scoparius* resembles that of imperial grass, but it has a greater number of spikelets. This species thrives in areas situated between 400 and 2 200 meters above sea level, with an annual rainfall ranging from 1 000 to 4 000 mm and an average temperature around 20 °C (Saha *et al*., 2024 ; Velasco *et al*., 2023). In summary, *A. scoparius* is a valuable forage grass, particularly in humid tropical regions. Its succulent stems and nutritional quality make it a preferred choice for livestock grazing.

According to León *et al.* (2022) , Gordura grass (*Melinis minutiflora*) exhibits the following characteristics: The stems and leaves of Gordura grass are pubescent, covered with tiny hairs. When touched, it feels viscous and gives the sensation of being resinous. It grows to a medium height and forms compact bushes. Abundant basal stems extend from the crowns. Gordura grass can reach a height of 90 – 150 cm. It is suitable for grazing. It can be hayed and ensiled. When cutting, aim for 5 or more cuts per year. Avoid cutting below 10 cm or during the dry season, as insufficient humidity may lead to the loss of many bushes. Gordura grass, with its unique properties, serves as a valuable resource for various agricultural practices (Ortiz Pilacuan, 20152015; Motta-Delgado *et al.*, 2019 ; Andrade-Yucailla *et al*., 2016).

Currently, this plant is widely distributed in fertile and well-drained soils, thrives in poor soils and grows at altitudes between 200 and 2,500 meters above sea level in warm and temperate climates. (Vacacela Ajila *et al*., 2023). Most livestock farmers are unaware of the agronomic behavior and chemical composition of grasses at different stages of maturity. Consequently, they do not treat grasses as crops that require cultural and phytosanitary practices, resulting in underutilization of their full production potential (Motta-Delgado *et al.*, 2019). Recognizing the importance of understanding tropical forage species, this study aims to evaluate the agronomic behavior and nutritional quality of three grasses: *A. micay, A. scoparius,* and *Melinis minutiflora*. This investigation will shed light on growth patterns and chemical composition, providing valuable insights for effective agronomic management of these grasses. Farmers engaged in forage grass production can benefit from this knowledge to optimize their practices and enhance overall productivity.

Materials and methods

Location of the experiment

The research was conducted at the San Lorenzo Technical Educational Unit School in the San Lorenzo - Esmeraldas canton, as well as at km 12 via Ibarra, San Lorenzo - Esmeraldas canton. This location is situated to the north of the Esmeraldas province, with geographical coordinates at WGS 84: Latitude S 1° 28’ 33” and Longitude W -78° 83’ 33”. The investigation spanned five months, from June to November 2014. The altitude of the area is 785 meters above sea level, and the average temperature during the study period was 23 °C.

Annual precipitation in the region amounted to 1 800,70 mm/year, with the rainy season occurring from December to April. The soil in the experimental area is classified as loam. Prior to sowing pastures, a chemical analysis of the soil revealed the following results as shown in Table 1.

Study distribution, experimental design and statistical analysis

For this study, 25 experimental plots measuring 3 x 4 m were established for each pasture, resulting in a total of 75 experimental plots. We evaluated the agronomic behavior and chemical composition of three grass species: Micay Grass (*A. micay*), Gramalote Morado (*A. scoparius*), and Gordura Grass (*M. minutiflora*). These evaluations were conducted at five different harvest ages (maturity stages): 30, 45, 60, 75, and 90

days. The experimental design employed was a Randomized Complete Block Design (DBCA) with a factorial arrangement (3 x 5). Statistical analysis of the results was performed using the SAS 201 software.

Table 1. Chemical analysis of the soil of the localities at the beginning of the study

Parameters	Worth	Interpretation
pH	5,02	Moderately Acid
Nitrogen ppm	38,12	Half
Phosphorus ppm	2,56	Low
Potassium meq/100 m L	0,26	Half
Ca meq/100 m L	4,36	Half
Mg meq/100 m L	1,83	Half
S ppm	8,01	Half
Zn ppm	2,88	Low
Cu ppm	0,86	Low
Fe ppm	198,3	Half
Mn ppm	51,34	High
B ppm	0,53	High
M.O (%)	3,58	Half
Ca/Mg	2,38	Optimum
Mg/K	7,04	Optimum
Ca+Mg/K	23,81	Half

Note. (Ortiz Pilacuan, 2015).

Variables evaluated

Plant height (measured in centimeters) was determined by using a tape measure. The measurement started from ground level and extended to the beginning of the last shoot of five randomly selected plants within each plot, per treatment and cutting frequency. Additionally: The number of leaves and number of stems were counted for all five plants in each experimental unit, and the average value was recorded. The yield (expressed in kilograms of dry matter per hectare) was calculated based on the dry weight of leaves and stems. These plant parts were dried in a forced air oven at 65 °C for 48 hours. To determine the leaf-stem ratio, the dried leaves and stems were individually weighed using an analytical balance.

Results and discussion

Variety effect

In the study of various grass varieties, the plant height (cm) showed significant statistical differences. Specifically, the Gramalote Morado species (*A. scoparius*) achieved the greatest height (168,46 cm), surpassing the Micay grass (*A. micay*) and Gordura grass (*M. minutiflora*) which reached heights of 121,97 cm and 95,12 cm, respectively. This variation can be attributed to the distinct growth habits of these species. The Gramalote Morado grass forms dense bushes with numerous erect, leafy, unbranched, and succulent stems that contribute to its taller stature. These stems typically reach heights between 80 cm and 150 cm and have an elliptical cross-section. Additionally, the Gramalote Morado grass exhibits broad leaves measuring 40-60 cm in length (León *et al.,* 2022). Furthermore, when considering stem weight (measured in grams), the Gramalote Morado grass (97,24 g) significantly (p<0,05) outweighed the Micay grass (28,66 g) and Gordura grass (13,55 g) as shown in Table 2. Researchers have noted that the Gramalote Morado grass's stems are unbranched and contribute to its robust weight (León *et al.,* 2022; Arias Hernandez y Delgado Floreano, 2022).

In terms of leaf characteristics, the Gramalote Morado grass also excelled as it forms numerous erect, leafy, unbranched stems that reach heights of 80-150 cm. It had the longest leaf length (64,02 cm) and the widest leaf width (3,72 cm), followed by the Micay Grass (37,98 cm and 2,48 cm, respectively) and Pasto Gordura (21,85 cm and 2,54 cm, respectively) (Table 2). These findings highlight the diversity in growth patterns and physical attributes among the studied grass varieties.

Table 2. Effect of the varieties on the agronomic behavior of the three grasses

Varieties	Effect of varieties			
	Micay pasture	Purple Gramalote	Gordura pasture	EEM
Height (cm)	121,97 b	168,46 a	95,12 c	0,34
Stem Weight (g)	28,66 b	97,24 a	13,55 c	0,16
Blade length (cm)	37,98 b	64,02 a	21,85 c	0,23
Blade width (cm)	2,48 b	3,72 a	2,54 b	0,05
Blade weight (g)	6,37 b	32,39 c	3,94 a	0,11
Biomass (kg MS ha-1)	1 454,16 b	1 420,00 b	1 041,66 a	0,15
Leaf stem ratio (g)	0,22 c	0,37 a	0,28 b	1,03

Averages in each row with equal letters do not differ statistically (Tukey p≤0,05).

According to the research by (Murillo I. *et al*., 2012), the gramalote is a perennial crop characterized by its dense, bushy growth habit. It forms large clumps and can reach a height of 1-1,5 meters. The leaves of gramalote are wide, pubescent, and have a blunt tip. Furthermore, the leaf weight (measured in grams) of the Gramalote Morado grass was significantly greater (p<0,05) compared to that of the Micay grass and Gordura grass. Specifically, it was 32,39 g for Gramalote Morado, 6,37 g for Micay grass and 3,94 g for Gordura grass.

In terms of forage biomass (kg MS ha-1), Micay grass (1 454,16) exhibited significantly higher values (p<0,05) compared to Gramalote morado grass (1 420,00) and Gordura grass (1 041,66), as indicated in Table 2. Additionally, Arias Hernandez y Delgado Floreano (2022) y Benítez *et a*l. (2017) reported that gramalote, when grown in alluvial soils with a medium climate and without fertilization, produces approximately 12 to 14 t/has of dry matter per year. However, with maintenance fertilization (100 kg/has of P_2O_5 and 50 kg/ha of K_2O annually) and 50 kg/has of nitrogen after each cut, gramalote can yield 20 to 22 t/ha of dry matter. Furthermore, the best leaf/stem ratio (Nº/N°), was observed in the following order: Gramalote Morado grass (0,37), Gordura Grass (0,28), and Micay Grass (0,22), as shown in Table 2. This ratio provides insights into the relative proportions of leaves and stems in these grass species.

Effect of harvest age

At 90 days, the highest values were observed (p<0,05) in various parameters for the grasses (Table3). These values include: Plant height: 138,83 cm, Stem weight: 58,96 g, Leaf length: 41,74 cm, Leaf width: 2,94 cm, Leaf weight: 15,69 g, Biomass: 1 682,5 kg DM ha-1. In the leaf-stem relationship, the highest value (p<0,05) occurred at 30 days (0,35). This finding aligns with (Luna *et al*., 2015)the agronomic response of three varieties of Brachiaria (B. decumbens; B. brizantha and B. hybrid cultivar cv. Mulato (CIAT 36061, who observed increased values in plant height (98,57 cm), number of leaves (774,84), and number of stems (162,51) as grass age increased to 63 days. Authors León *et al.* (2022) y Ortega Mejía (2022); Valles de la Mora *et al.* (2016) emphasized that regrowth age significantly influences pasture growth and quality. Longer regrowth periods lead to higher performance but may compromise quality. Frequent defoliations are often preferred to maintain grasses with superior nutritional value.

Regarding hay dry matter content (%), the purple Gramalote grass exhibited higher values (33,16) compared to Gordura grass (32,38) and Micay grass (21,97) Arias Hernandez y Delgado Floreano (2022); Velasco *et al*. (2023) due to the country's topography, cattle farmers have a choice of the best pasture for their production. The pastures in eastern Ecuador are generally of the following types AXONOPUS SCOPARIUS (AS reported lower dry matter results (13,15) for purple gramalote grass in a study on growth rate and chemical analysis of elephant grass and purple gramalote. In terms of ash and crude protein, the Gramalote morado variety surpassed Pasto Gordura and Micay. As shown in Table 3, they were ash content for Gramalote morado (9,65) compared to Pasto Gordura (9,46) and Micay (8,50) and crude protein as Gramalote morado (9,09) compared to Pasto Gordura (6,95) and Micay (7,22). These results coincide with (Arias Hernandez y Delgado Floreano, 2022) who recorded higher values in the purple gramalote grass in both ash and crude protein (12,10; 15,26 respectively).

Effect of varieties and harvest age on chemical composition

The highest percentage of crude protein was recorded by the Gramalote morado grass with 9,09% followed by Gordura grass with 6,95% and finally the Micay grass with 7,22%. The ethereal extract percentage was significantly higher (p<0,05) for Micay grass 1,83%, surpassing that of Gramalote morado grass 1,36% and Gordura grass 1,26%. In a study by Arias Hernandez y Delgado Floreano (2022); Maderero (2019), higher values were recorded for the ethereal extract in the purple Gramalote grass 2,90%. This difference is likely due to the lignification of the stem present in the integral sample. Regarding gross energy (kcal g-1), Micay grass exhibited higher values 3,57 compared to Gordura grass 3,56 and Gramalote morado grass 3,45 (as shown in Table 4).

Table 3. Effect of harvest age on the agronomic behavior of the three pastures

Variables	Effect of harvest ages					
	30	45	60	75	90	EEM
Height (cm)	109,14 d	122,89 c	134,29 b	137,43 a	138,83 a	0,44
Stem Weight (g)	32,78 d	40,61 c	41,95 b	58,11 a	58,96 a	0,21
Blade length (cm)	39,45 a	40,72 ab	42,03 c	42,48 c	41,74 bc	0,29
Blade width (cm)	2,88 a	2,97 a	2,88 a	2,91 a	2,94 a	0,07
Blade weight (g)	13,43 a	13,58 a	13,16 a	15,32 b	15,69 b	0,14
Biomass (kg MS ha^{-1})	791,66 a	1 097,50 b	1 426,66 c	1 529,16d	1 682,5 e	0,19
Leaf stem ratio (g)	0,35 a	0,31 b	0,28 c	0,26 d	0,26 d	1,07

Averages in each row with equal letters do not differ statistically (Tukey p≤0,05).

Table 4. Effect of the varieties on the chemical composition of the grasses under study

Variables	Micay	Purple Gramalote	Gordura pasture	EEM
Total humidity (%)	78,59 b	67,66 a	68,10 a	0,18
Dry material (%)	21,97 b	33,16 a	32,38 a	0,21
Ash (%)	8,50 a	9,65 b	9,46 b	0,09
Crude Protein (%)	7,22 b	9,09 a	6,95 b	0,09
Crude fiber (%)	38,07 b	37,54 a	37,20 a	0,13
Ethereal extract (%)	1,83 a	1,36 b	1,26 b	0,04
Gross energy (kcal g^{-1})	3,57 b	3,45 a	3,56 b	0,03

Averages in each row with equal letters do not differ statistically (Tukey $p \leq 0,05$).

Table 5. Effect of harvest age on the chemical composition of the grasses under study

Variables	Effect of harvest ages					
	30	45	60	75	90	EEM
Total humidity (%)	66,68 a	72,51 bc	72,92 c	71,73 b	73,40 c	0,23
Dry material (%)	33,87 a	27,77 bc	27,60 c	28,88 b	27,72 bc	0,27
Ash (%)	8,94 b	9,00 b	10,48 d	9,55 c	8,04 a	0,11
Crude Protein (%)	8,21 a	7,66 b	7,90 ab	7,14 b	6,83 c	0,12
Crude fiber (%)	34,99 a	35,40 a	36,84 b	37,88 c	42,90 d	0,16
Ethereal extract (%)	1,69 a	1,65 a	1,81 a	1,30 b	0,97 c	0,05
Gross energy (kcal g^{-1})	3,56 a	3,58 a	3,56 a	3,49 a	3,45 a	0,03

Averages in each row with equal letters do not differ statistically (Tukey $p \leq 0.05$).

At 30 days, the protein content reached its highest level at 8,21%. However, as the grasses aged, the protein content declined: 7,66% at 45 days, 7,90% at 60 days, 7,14% at 75 days, and 6,83% at 90 days. This trend aligns with previous studies by Avellaneda *et al*. (2008) root longitude (cm and Khuliso *et al*. (2019), which also observed a decrease in protein content as grass age increased. The decline in protein is attributed to reduced metabolic activity in the grasses during regrowth. Additionally, the ash content during the 60-day period was highly significant ($p<0,05$) at 10,48%. However, this value gradually decreased to 9,55% at day 75 and 8,04% at day 90 (Table 5).

Continuing, the fiber content exhibits significant differences ($p<0,05$) across various time points: 90 days (42,90), 75 days (37,88), 60 days (36,84), and 45 days (35,40), as compared to day 30 (34,99) (Table 5). Additionally, the highest content of ether extract ($p<0,05$) was observed at 60 days (1,81), in contrast to ages 30, 45, 75, and 90 days (1,69, 1,65, 1,30, and 0,97, respectively). In a study by (Arias Hernandez y Delgado Floreano, 2022), the purple Gramalote grass exhibited the highest levels of fiber (37,20%) and ethereal extract (2,96%) at 6 days. Gross energy did not show significant differences ($p>0,05$), but the highest energy percentage was obtained at 45 days (3,58), followed by 30 days (3,56), 60 days (3,56), 45 days (3,49), and 90 days (3,45) (Table 5). Regarding these variables, authors like Álvarez *et al*. (2015) is an alternative to the demand of grasses for feeding ruminants. four species of grass Pennisetum (elephant, purple, king grass, maralfalfa and clone Cuba CT-115 suggest that cellular content in forage species is influenced by factors such as temperature, heliophony, relative humidity, and soil microbiota. Agro-environmental conditions can either positively or negatively impact plants and soil microorganisms. If beneficial interactions occur, grasses synthesize relevant amounts of proteins, amino acids, and carbohydrates.

Conclusions

In terms of agronomic characteristics, the Gramalote Morado grass (*A. scoparius*) demonstrated superior performance compared to the Micay grass (*A. micay*) and Gordura grass (*M. minutiflora*). The impact of harvest age significantly influenced the behavior of the evaluated variables. Additionally, the chemical composition of the dry matter exhibited notable changes when compared to the other grasses. These findings suggest that *A. scoparius* is superior to the other species studied.

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