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Agronomic Yield And Nutritive Value Of Brachiaria Reclining Under Different Fertilization Strategies In The North Of The Ecuadorian Amazon

Hilter Farley Figueroa-Saavedra[1,2] ,
Santiago Alexander Guamán-Rivera[2]

[1]Universidad Politécnica Estatal del Carchi (UPEC)
Tulcán-Ecuador; http://orcid.org/0000-0002-7395-8944
[2]Escuela Superior Politécnica de Chimborazo,
(ESPOCH) Sede Orellana, El Coca 220150, Ecuador;
https://orcid.org/0000-0001-8699-0655
Corresponding author: Hilter Farley Figueroa-Saavedra

Abstract

Cattle farming in tropical conditions claims low yields due to a low soil fertility gradient, grass species with limited productive potential, as well as local breed animals with low genetic merit. In addition, under these conditions, it has been widely evidenced that the use of nitrogenous (N) chemical fertilizers is a common practice, but without technical criteria. Faced with the fight against climate change, the study aimed to study the use of organic fodder as an alternative to replace chemical fertilizer (N) inBrachiaria reclining. A randomized complete block design was applied as a methodology, a study was carried out to compare three treatments; with or without fertilizer, T1, 100% urea (45% N) and T2, Urea + biol 50:50. The results showed higher canopy height and grass mass when 50:50 Biol + Urea (P = 0.04 to 0.05) than other fertilization plans. Regarding the chemical composition, the crude protein was slightly higher in T1 than in T2 (84 vs. 80 ± 0.1 g DM^{-1}), but the latter had ADF contents lower than T1 (412 vs. 423 ± 3.3 g DM), concluding that the substitution of 50% organic fertilizer instead of chemical N positively affected agronomic yields and chemical composition, the Brachiaria reclining. Therefore, more long-term studies should be performed to confirm these results.

Keywords: Fertilizers, Climate change, Fodder, Small livestock.

Introduction

In tropical areas, most beef and dairy cattle production is pasture-based (Nascimento et al., 2021). In this context, nitrogen fertilization (N) is crucial to maintain the productivity and protein levels of pastures necessary for satisfactory animal performance (Free &Mccune, 1974). The three most important greenhouse gases (GHGs) in the atmosphere are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (NorsuzilaYa'acob et al., 2018). Livestock production systems contribute about 42% of the total GHG production from agriculture, of which 28% is associated with direct emissions from enteric fermentation (CH_4) and 14% (CH4 and N_2O) related to handling, storage and its use as manure fertilizer (Menardo et al. 2021). Thus, pollution derived from agricultural activities has become a serious problem throughout the world, especially in less developed countries (Vasco et al., 2021).

Plants are sensitive to temperature and grow differently in the tropics. This difference could be reflected in total nutritional requirements, in the types and proportions of nutrients needed, or in a combination of quantity and quality of nutrients (Free &Mccune, 1974). Rao (2001) states that tropical grasses, due to the C pathway$_4$ of photosynthesis, they are more efficient than legumes in the use of N, Ca and P. Although better N management is essential, i.e. the use of adequate amounts of fertilizers, forms and formulations of N and timing and method of application. Being essential to promote rapid plant growth and improve the performance and quality of forage, ensuring sustainability, while minimizing negative effects on the environment.

The practice of nitrogen fertilization considerably increases the cost of pasture production, since its synthesis requires fossil fuel sources and most of the input is currently imported (Da Costa Leite et al., 2019). In addition, the benefits of nitrogen fertilization are only short-term in tropical soils, with accelerated losses by leaching and volatilization, along with the risk of soil and water contamination by nitrate additions (Hungria et al., 2016; Pedreira et al. al., 2017). For this reason, it is important to develop agricultural practices to maintain or even increase production with greater sustainability (Di Salvo et al., 2018). In this context, the use of organic inputs to improve the efficiency of nitrogen fertilizers is an alternative to growing grasses in tropical regions, in addition to reducing environmental risks.

The Amazon Basin is considered one of the world's biodiversity hotspots (Bass et al., 2010). For this reason, this region has been the object of considerable attention by researchers and professionals due to the high rates of deforestation and the increasing pressure on natural resources. To the best of our knowledge, much less attention has been paid to the investigation of alternatives to the excessive use of nitrogenous chemical fertilizers in livestock systems. Therefore, the present essay had as objective to evaluate the inclusion of organic fertilizers in the agronomic and chemical composition ofBrachiaria reclining in Ecuadorian conditions. to promote more sustainable tropical livestock practices, reducing environmental impacts.

Materials and methods

The experiment was carried out in Joya de losSachas, Ecuador (0°18′ 37′′S, 76°55′07°W and 270 m elevation) where the topography of the experimental area was gently sloping. The climate in the region is characterized by humid tropical forests (Holdridge, 1967; Inzunza, 2007). The pasture was established in 2016 withBrachiara reclining at a sowing rate of 3 kg/ha. The physicochemical properties of the soil were 7% organic matter, 15.1 ppm phosphorus (P), 0.26 meq potassium (K) and 57% base saturation. The experimental area was fertilized with 195 kg N/ha applied at the time of planting. During the experimental period, the total precipitation was 2942 mm, and the average temperature was 29.7°C (INAMHI, 2021).

Analysis and discussion of results

Treatments and design of the experimental field

Before the application of the treatments, the grassBrachiaria reclining it was cut to 15 cm for standardization in September 2017 and kept until mid-December (pre-experimental period). Subsequently, in January 2018, three treatments according to a randomized complete block design with three repetitions were established. For this study, 0.25 ha of total experimental area was used, which was divided into nine plots of 127 m^2 (experimental units). All plots were separated by 2 m to avoid mixing of nutrients from adjacent treatments. The treatments were: WITH, without fertilizer, T1, 100% urea (45% N) and T2, 50% urea + 50% biol. The biol was previously prepared (3 months ago) on the farm itself, using (bovine manure (43%), Gliricide hedges (15%), commercial yeast (5 g/L), raw milk (2%), cane molasses (10 g/L) and water (40%). The different fertilizer treatments were applied to supply a total amount of N, equivalent to 150 kg ha-1/year, according to the requirements of the grass (Berça et al., 2021), except the Control, which did not receive fertilizer. The cutoff frequency atBrachiaria reclining It was done every 5 weeks. Therefore, the total amount of N to be applied was divided throughout the experimental period (that is, after each cut-off frequency), as shown in Table 1.

Treatments	N Applied by plot (127 m^2)			Total N Applied ($kg \cdot ha^{-1}$)
	Urea	Biol	No fertilizer	
WITH	0	0	0	0
T1	4.2	0	0	150
T2	2.1	28.3	0	150

Table 1. Amounts of natural and synthetic organic N fertilizers applied in each experimental unit.

WITH, no fertilizer; **T1**, 100% urea; **T2**, 50% urea + 50% boil.

Pasture measurements

Canopy height was controlled in each treatment with a 1-m ruler graduated in centimeters, through systematic readings made along five transect lines (eight measurement points per transect) in all plots (Euclides-Batista et al. 2016). In addition, the tiller population density (m^2 of tillers) was measured in each cut by direct count in a sampling frame of 0.15 × 1.0 m (0.15 m^2), assigned to the average height of the plot (De Sousa et al. 2019). The estimated population density of the tillers represented the mean of the three plots per treatment. The scoring of the plants of the plots was carried out to determine the degree of coverage by the forage. For this, a five-point scale was used, as suggested by Onyango and Asiegbu (2013) for the subjective evaluation. Where the degree of coverage was evaluated as, 1 (<20%) = very low; 2 (20 to 39%) = low; 3 (40 to 59%) = medium; 4 (60 to 79%) = high and 5 (80 to 100%) = very high.

Grass mass (HM) was estimated by direct (destructive) sampling every 35 days. For this, 12 samples were collected in each plot using a 0.25 m metal frame.^{2} (Barbero et al., 2015). The bulk density of the grass (DBH) was calculated as the quotient of MH and the height of the canopy at the time of measurement (kg DM ha^{-1} cm^{-1}), according to (Nascimento et al., 2021). Next, the grass ration (kg DM/100 kg BW) was determined by dividing the usable grass mass by the live weight of the animals (Jerry and Holechek, 1988; Berça et al., 2021). Nitrogen fertilizer efficiency (NUE) was estimated according to the methodology described by Zanine et al. (2020) as follows: (total production of dry matter with fertilization kg- total production of dry matter without fertilization kg/ nitrogenous fertilizer kg). Finally, samples were cut fromBrachiararecliningat 15 cm from the ground level of four 0.25 m grids^2 per plot with manual scissors according to each treatment to determine the chemical composition.

Chemical composition

fresh samples ofBrachiaria reclining they were placed in a forced-air dryer at 65°C until constant weight was reached. After drying, the samples were ground through a 1 mm sieve (Retsch SM2000, Retsch, Haan, DE). Dry matter (DM) and ashes were determined at 105°C for 24 h and at 550°C for 4 h, respectively AOAC (2000). While the organic matter (OM) was calculated as 100 - % ash. In addition, neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin were determined sequentially (Van Soest et al. 1991). Total nitrogen (N) content was determined by the Dumas combustion method using an N analyzer (Leco FP-2000 N Analyzer; Leco

Instruments Inc., St. Joseph, MI, USA), and crude protein (CP) was calculated as N × 6.25.

Statistic analysis

Analysis of variance was performed using the mixed procedure SAS v.9.4 (SAS Institute Inc., Cary, NC, EU). Previously, the normality and homogeneity of the variance residuals were checked using PROC UNIVARIATE. The statistical model considered the treatments, the period and their interaction as fixed effects, while the residual error and the blocks were considered random terms. Means were calculated using the LSMEANS statement and compared using Dunnett's test. The differences were declared significant atP ≤ 0.05, and trends toP ≤ 0,10.

agronomic performance

In Table 2 the agronomic performance data of Brachiariadecumbens are summarized.

Table 2. Least squares mean of the main agronomic data of Brachiariadecumbens (Control, no fertilizer; T1, Urea 100%; Urea + Biol 50:50%).

Item	Treatments			WHICH	P = Effect		
	WITH	**T1**	**T2**		Treat	Period	T × P[1]
Canopy heigh, cm	62[b]	67[a]	63[b]	1.9	0.05	0.001	0.17
Tiller population, m^2 tiller	37	39	42	1.9	0.30	0.001	0.81
Plant cover, % m^2	67	73	70	4.7	0.17	0.001	0.98
Herbage mass, kg ha^{-1}	4770[b]	6580[a]	6025[a]	683	0.04	0.001	0.72
Herbage bulk density, kg cm^{-1} ha^{-1}	81	118	98	15	0.27	0.05	0.82
DM, kg ha^{-1}	1263[and]	1806[x]	1626[x]	186	0.084	0.001	0.68
Total usable herbage, kg DM ha^{-1}	884[and]	1264[x]	1138[xy]	130	0.084	0.001	0.68
Herbage allowance, kg DM/100 kg BW[2]	3.54[and]	5.07[x]	4.56[xy]	0.52	0.080	0.001	0.67

[1]Treatment × period interaction;[2]Calculated as tropical livestock unit (an animal ruminant of 250 kg BW) according to Hans (1983); SEM, standard error of the mean. [a-b] Means with different letter in the same row, differ at P ≤ 0.05. [x y] Means with different letter in the same row, tend at P ≤ 0.10.

The different forms of fertilization influenced canopy height and grass mass between treatments (P = 0.04 to 0.05). In general, and on average, T1 (67 ± 1.9 cm) presented canopy height values higher than those obtained for Control and T2 (63 ± 1.9 cm;P< 0.05), as shown in Table 2.

Although the herbaceous mass values were higher in T1 and T2 (6302 ± 638, on average) than those observed for the Control (4779 ± 638), the other measurements only showed statistical trends (P = 0.804 to 0.080), as shown in Table 2. On the contrary, no differences were observed in the other agronomic variables between treatments (P = 0.30 to 0.17; Table 2), being their averages for the tiller population (40 ± 1.9 tillers/m^2), vegetation cover (67 ± 4.7 %/m^2) and bulk density of grass (94 ± 15 kg cm^{-1} ha^{-1}). Regarding the effect of the period, the height of the plant, the population of tillers and the total useful grass showed positive linear responses (P< 0.001), while the bulk density of the grass had a positive polynomial response (P< 0.001), as shown in Figure 1. No differences were observed in the treatment × period interaction (P = 0.98 to 0.17; Table 2).

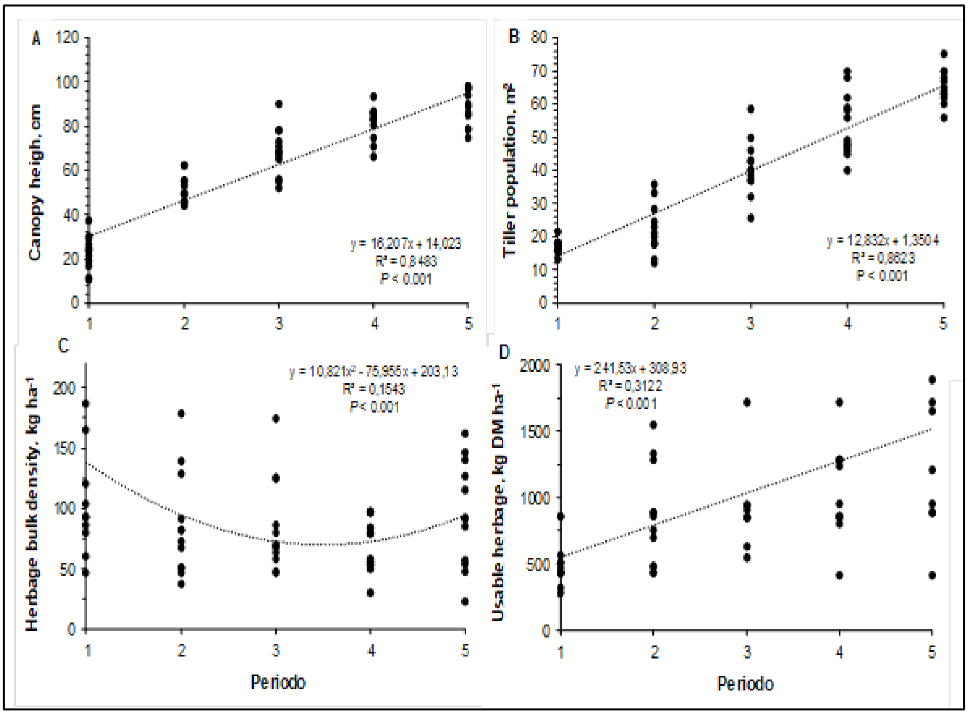

Figure 1. Responses of the canopy height (A), the tiller population (B), the apparent density of the grass (C) and the total useful grass (D) according to the effect of the period (5 grazing cycles).

Chemical composition

There were differences in all chemical determinations between fertilization plans (P = 0.030 to 0.001; Table 3). The average DM in T1 (275 g/kg DM^{-1}) was higher than T2 and CON (267 g/kg DM^{-1}, on average), although there were no differences between them (P> 0.05). Regarding the CP contents, the T1 presented higher values (84 g/kg DM^{-1}) in comparison with the other treatments (Table 3), showing the Control the lowest CP contents (68 g/kg DM^{-1}, on average). Fiber contents also differed between treatments (Table 3). Compared with the other fertilization treatments, T2 presented the lowest NDF and hemicellulose values, with FAD contents being slightly different from those observed for the Control (412 vs. 393 ± 3.2 g DM^{-1}). On the contrary, the chemical composition did not vary because of the period (P = 0.97 to 0.14) nor by the interaction treatment × period (P = 0.72 to 0.12), as shown in Table 3.

Table 3. Mean of least squares of the chemical composition ofBrachiaria reclining (WITH, without fertilizer; T1, Urea 100%; T2, Urea + Biol 50:50%).

Item	Treatments			WHICH	p =Value		
	WITH	**T1**	**T2**		Treat	Period	T × P[1]
Dry matter, g/kg DM^{-1}	265^{b}	275^{a}	269^{b}	1.9	0.001	0.50	0.23
Organic matter , g/kg DM^{-1}	913^{a}	893^{b}	887^{b}	3.5	0.001	0.34	0.12
Ash, g/kg DM^{-1}	87^{b}	107^{a}	113^{a}	3.5	0.001	0.34	0.72
Crude protein, g/kg DM^{-1}	68^{c}	84^{a}	80^{b}	0.1	0.001	0.66	0.68
CF, g/kg DM^{-1}	325^{b}	327^{b}	331^{a}	2.1	0.001	0.14	0.13
NDF, g/kg DM^{-1}	719^{b}	717^{ab}	715^{a}	2.0	0.030	0.48	0.35
Hemicellulose, g/kg DM^{-1}	326^{a}	294^{b}	303^{b}	4.6	0.005	0.85	0.25
ADF , g/kg DM^{-1}	393^{c}	423^{a}	412^{b}	3.2	0.001	0.86	0.45
Ether extract, g/kg DM^{-1}	23^{b}	26^{a}	22^{b}	0.3	0.001	0.97	0.15

[1]Treatment × period interaction; SEM, standard error of the mean. [a-d] Means with different letter in the same row, differ at P ≤ 0.05

agronomic performance

This study showed that urea alone or its combination with biol had a positive influence on the canopy height ofBrachiaria reclining, although no differences were observed in the tiller population between the treatments. However, it is important to note that canopy height and bulk density influence grazing behavior (Sollenberger and Burns, 2001). Despite this, no differences were detected in the apparent density of the grass between treatments. Although we expected that the use of N from chemical fertilization would increase both the total bulk density and the leaf density. In any case, contrary to our results, Berça et al. (2021) and Delevatti et al. (2019) reported that N stimulates tiller development in warm season pastures. Based on these results, the combination of fertilizers (ie, chemical and biol N) has a significant positive effect on height, being a potential alternative to improve forage growth.

On the other hand, according to Zanine et al. (2020) the increase in the production of forage mass is a function of nitrogen that actively participates in the synthesis of organic compounds, thus forming plant structures, such as chlorophyll molecules, proteins, vitamins, pigments and amino acids. In our study, when 50% N chemical fertilizer was replaced by biol, a similar grass mass was obtained using 100% N chemical fertilization, and 21% higher compared to CON. Therefore, these results are positive, since the leaves are the most photosynthetically active component in the plant, and have the highest nutritional values (Zanine et al., 2020). A study by Berça et al. (2021) obtained a lower grass mass (5350 kg/ha^{-1}) at a fertilization rate of 150 kg N/ha^{-1} that our study (6580 kg/ha^{-1}), but similar compared to the non-Control treatment (4600 kg/ha-1). In contrast, Delevatti et al. (2019) using a fertilization rate of 180 kg N/ha^{-1} reported a grass mass similar to that of our study at 150 kg N/ha^{-1} (6436 vs. 6580 kg/ha^{-1}). While Zanine et al. (2020) and Nascimento et al. (2021) have reported a lower grass mass inBrachiariabrizanthacv. Piatã (4415 to 2930 kg/ha^{-1}) throughout the seasons of the year.

The available grass followed the behavior of the amount of green forage, showing that theBrachiaria reclining fertilized either with only urea or combination with biol provided a higher supply of forage to the animals (ranged between 5.07 and 4.56 % of body weight) compared to CON (3.54 % of body weight). Normally, an animal consumes 2% of its body weight in DM; therefore, the forage ration was approximately twice the intake of the animals (Berça et al., 2021). Our results differed from those observed by Delevatti et al. (2019) in (Brachiariabrizantha) with fertilization rates of 180 to 270 kg N/ha^{-1} that oscillated between (2.55 and 2.33% PC). While Berça et al. (2021) reported higher values of grass yield in (Brachiariabrizantha cv. Marandu) fertilized with urea 150 kg N/ha (8.2% PC) and (6.2% PC) in the Control. Differences that could be explained in part, due to the hybrid cultivars of high productive potential used. As far as our study is concerned, although replacing 50% N chemical fertilizer with 50% compost did not improve any agronomic data, it is important to note that organic fertilizers rely on microbial degradation to convert organically bound nutrients into available ones. for the plant. In any case, nitrogen fertilization has been overused in several countries, resulting in high production costs and environmental impacts, such as increased greenhouse gas emissions, water pollution, and loss of biodiversity (Delevatti et al. al., 2019). Therefore, in this study, we report that forage production resulting from substitution with an organic source can help save money, earn higher profits for smallholders, and is also a low-cost grazing management strategy.

Chemical composition

According to Givens et al. (2000) forages with CP contents less than 6% based on DM, are not suitable for feeding ruminants. But, as we expected, theBrachiaria reclining fertilized with urea (45% N) had higher CP contents than other fertilization plans. The increase in CP promoted by N fertilization was also reported by Ruggieri et al. (2020) and Delevatti et al. (2019). In addition, this last author reported, on average, (151 g/kg DM^{-1}) in grassBrachiaria fertilized with 180 kg N/ha^{-1}, a result superior to those of our study. Although referential studies with tropical grasses have reported CP contents ranging between 52 and 128 g/kg DM^{-1}, Ruggieri et al. (2020) observed that the PC concentration varied according to temperature and precipitation (that is, higher and lower PC content in the rainy and dry seasons, respectively). In any case, in this study, substituting 50% of the chemical fertilizer with biol, slight differences were observed in the CP contents (84 vs 80 ± 0.1 g/kg MS-1). Consequently, the inclusion of organic fertilization should be considered to increase the CP of the grass, mainly when compared to tropical grasses without the use of any fertilizer.

Regarding cell wall content, all fertilization plans showed values higher than the minimum required for lactating cows of NDF (25-33% DM) and FAD (17-21% DM) (Van Soest, 1994; NRC, 2001). . However, other studies have observed a linear reduction of NDF and FAD when nitrogenous fertilizer is used. Studies carried out by Delevatti et al. (2019) Ruggieri et al. (2020), and Berça et al. (2021), reported that fertilizing hybrid cultivars ofBrachiaria with 180 kg N/ha^{-1} showed lower NDF (59 to 56%) and FAD (28 to 22%) contents than those obtained in this work. On the contrary, in this study, theBrachiariabrizantha fertilized with 50% Biol (that is, T2), presented cell wall contents lower than those obtained when N chemical fertilizer was used. Results that could be explained, due to the stimulation of the growth of new tissues, which reduces the concentration of structural carbohydrates in MS. Based on these evidence, the use of Biol can be considered as a potential fertilization option by farmers under Ecuadorian conditions.

Conclusion

The biol could replace at least in part the chemical fertilizer N and improve the agronomic yields, as well as the chemical composition ofBrachiaria reclining. Considering the conditions in which livestock is developed in Ecuador, it can be a potential fertilization alternative to be adopted by small farmers. Finally, we encourage further long-term studies to confirm our findings.

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