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Analysis of the productive behavior of gramalote (Axonopus scoparius) subjected to three levels of organic plus chemical fertilization

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Abstract

This project aimed to evaluate the agro-botanical performance of gramalote (Axonopus scoparius), subjected to three different treatments of a fertilizer composed of urea plus cuyasa. This project was developed under a randomized block design, and analyzed through the statistical package InfoStat with Tukey's test at 0.05 significance. Four treatments with five replications were used; the incorporation of the guinea pig was 0% (T0), 100% (T1), 75% (T2) and 25% (T3), adding a standard base of urea (0.125 kg/Ha) and lime (4.55 kg/Ha). At the end of the statistical analysis, T1 was the best; in plant height, 124 cm were obtained at 90 days; in the number of leaves with 8, in the production of green matter and dry matter with 16.6 and 2.84 T/Ha respectively, in protein with 0.21 T/Ha, in the production of neutral detergent fiber 1.26 T/Ha was obtained, in acid detergent fiber 0.94 T/Ha was obtained, and in acid detergent lignin 0.12 T/Ha, This could have been produced by greater availability of vegetative material to provide nutrients to the crop for a longer time, supporting the washing by the rains, and making up for the low availability of natural soil nutrients that do not allow a good crop production under natural conditions. It is concluded that the application of fertilizers is productive in this pasture because they allow better development of the crop, as well as to increase the quality of the pasture, so it is recommended the use of this material as fertilizer for the crop, at the levels evaluated in this work.

Keywords: Urea. Organic matter, Axonopus scoparius, Gramalote, Fertilization.

Introduction

Cattle feeding is based on the production of pasture and forage; according to Ortiz (2015), grass is the most widespread plant in the world and is the main form of feed used by farmers in the production of meat and milk. This criterion is relevant because analysis shows that, in general, meat production and, marginally, milk production are the most widespread production systems in the Ecuadorian Amazon.

However, according to Saca (2021), the nutritional content of gramalote (Axonopus scoparius) produced under normal conditions, i.e., without any fertilizer, is significantly low compared to the nutritional requirements demanded by the livestock so that they can express their genetic potential.

Based on these criteria, this research seeks to generate alternatives different from those commonly generated in our rurality's daily productive systems. In this sense, it seeks to incorporate organic matter (cuyasa) as a fertilizer potentiator and to determine its effect on the production of biomass and nutritional content of this grass, for which the following objectives are proposed, the following objectives are proposed:

• To evaluate the effect of using urea plus cuyasa as a potentiator of the productive parameters of gramalote grass (Axonopus scoparum).

• To analyze the nutritional content of the pasture under different levels of combined fertilization.

Characteristics of the gramalote (Axonopus scoparum)

Gramalote is a warm climate grass with high hardiness that adapts easily to humid soils, so it is used in the Amazon region from 6 months of age in the lowlands of the Amazon, while in the foothills of the Cordillera, it can be grazed from 8 months of age, it is described as a perennial plant, densely bushy, formed by large clumps, reaching heights of 1 to 1.5 meters, with pubescent leaves and blunt tip, tolerant to high and low temperatures; it adapts to acid soils and low or medium fertility, its ecological environment is located at altitudes ranging from 600 - 2000 m. It is not tolerant to drought, contains 5.3 to 10.8% protein in dry matter, and its forage yield is 10 to 20 t/year (Ortiz, 2015).

Another important aspect to analyze within the characteristics of the forage under study is to determine its quality, which according to Buelvas, 2009), in tropical pastures varies according to age, soil fertility, time of year, plant part, parameters that determine the amount of fiber contained in the feed and therefore the nutritional contribution that it can provide, in this sense the quality of the pasture will depend on the proper combination of these parameters.

Nutritional value

At a nutritional level, pastures in livestock production systems represent approximately 90% of the animals' daily feed, providing 2.5 % and in green forage, between 12 and 13 % of the daily consumption about the live weight of the animals. Thus, the average percentage of protein provided by pastures can vary between 5% and 20%, neutral detergent fiber between 30% and 50% and acid detergent fiber between 20% and 30%. These values are strictly related to the vegetative state of the grasses associated with plant maturity, weather conditions, edaphology factors, soil fertility and most importantly, tillage and crop management (MackDonald, 2013).

For Gonzales (1987), this pasture has good palatability for the animals, fundamentally in the tender state, since they are succulent due to the high water content and they mean an important contribution of crude protein, phosphorus, to the animal diet. These characteristics are potentiated since this pasture at 12 weeks of age has a lower content of fiber, this undoubtedly has an effect on the increase of digestibility. In the case of the Amazon, this forage resource is usually used months after grazing, that is to say, at approximately 6 months, which means that its nutritional value has decreased, which undoubtedly affects the productive cycle of animals of zootechnical interest.

The following table shows approximate values for the nutritional content of the grass, which are detailed below.

Table 1. Nutritional composition (pre-flowering)

Nutritional content	Unit	Value
Dry matter	%	13,99
Protein	%	5,6
Calcium	%	0,22
Phosphorus	%	0,02
Grease	%	1,11
Ash	%	0,12
Fiber	%	5,6

Source: Galvez (2020).

This forage resource can be used through direct grazing or by cutting; however in direct grazing, up to 80% of waste can be generated because the animals tend to feed on the tips of the leaves, and the excess vegetative material is incorporated in the form of organic matter to the soil favoring its fertility and therefore the sustainability of the prairie (Alvarez, 2009).

Finally, the nutritional value of a pasture cannot be evaluated by measuring the content of a single element; on the contrary, it must be the sum of all the nutrients that this resource contains and contributes to the daily diet of animals, as well as its effect on the productive behavior of the animal.

Fertilization

The term fertilization refers to the artificial supply of nutrients to the soil so plants can reach their optimum productive and reproductive development. However, to achieve efficiency in this task, it is essential to know soil properties such as texture, ion exchange capacity and nutrient absorption, and organic matter content, which are fundamental factors determining fertilization processes' efficiency. In this sense, the presence of organic matter in the soil is fundamental for the macro and macro minerals it provides, in addition to the microflora that allows a balanced action of the soil and optimal levels of nutrient absorption by the plants (Traxco, 2015).

For Cruz (2012), within pasture production, nitrogen is a primary element that is important because its main function is to stimulate rapid plant growth and increase leaf area, a factor that is important in the forage yield of a plot. In general, fertilization is a factor that stimulates rapid plant growth and is important in its nutritional content.

Another important aspect of the fertilization process is to determine the correct amount of fertilizer to apply, which will start in the first instance of the physical-chemical analysis of the soil that tells us what its content is and, from this information, determine the most effective formula of fertilization to apply, a factor that should also consider the requirement of nutrients that the plant to be planted needs (Contexto Ganadero, 2017)

For the gramalote grass (Axonopus scoparius) is quite rustic and grows relatively well in acid soils of low fertility. Its production can be increased notably with the application of chemical fertilizers, especially with nitrogen and potassium, although its response to the application of nitrogen fertilizers is less favorable than that of most of grasses. The effect of phosphorus is much smaller and generally less significant on yield. However, its relatively low response to fertilizer application seems to respond well to the application of stable manures and organic matter such as poultry manure and pig manure (Timber Forestry, 2019).

In Cartago, Costa Rica, in a trial, a yield of 146% was recorded, for the control without fertilizers, with the application of 99 kg/ha of nitrogen plus 132 kg/ha of P2O5; with the application of 38.6 ton/ha of stable fertilizers the yield was 132%, but with the combined application of nitrogen, P2O5, and stable fertilizers in the same quantities, the yield was 210%. Therefore, it is concluded that stable fertilizers should not be less than 28.6 ton/ha to obtain a high yield from the latter combination. Other trials carried out to the south of the former location, on worn soils with low organic matter content, report that the application of 198 kg/ha of complete fertilizers of 20-10-10 or 15-15-15 grade, provided significant increases in forage production, but not enough to justify the cost of the fertilizer. Likewise, it is highlighted that there were no responses to the application of phosphorus and potassium in the absence of nitrogen, and low recovery of the latter, only 28.9%, applying 90 kg/ha with urea as a nitrogen source (Forestal Maderero, 2019).

In conclusion, for fertilization requirements, the contribution of nutrients to the soil will depend on the forage species, nutrient content of the substrate, and organic matter content, because, according to the tests reported by Forestal Maderero (2019), gramalote responds efficiently to combined fertilization of chemical fertilizers and organic fertilizers.

Urea and its importance in pasture production

Urea, by definition, is a fertilizer that contains only nitrogen, and of the solid fertilizers, it is the one that contains the most nitrogen as analyzed above, it actively participates in the growth of the plant and the formation of tissue, in the specific case of Axonopus scoparius as well as plants whose fruit or harvest are the leaves are demanding in this element and according to Novoa et al. (2021), require doses of 100 kg/ha of urea and 500 kg of phosphorus/ha.

Regarding the availability of this fertilizer, urea is freely available and perhaps is the most widely used nitrogen fertilizer in the world, especially in Latin American countries. Its chemical structure contains 46% nitrogen, with a pH of acid reaction,hich means that it can be used in slightly acidic and alkaline soils (Morales, 2019).

Action of organic matter on soil fertility

Soil organisms of all shapes and sizes, from microbes to macrofauna, are of great importance for plant health and nutrition as they interact directly in the biogeochemical cycles of nutrients. They influence moisture and nutrient availability, and mobility in the soil profile; it is important to analyze that certain species can also become pests and pathogens due to population imbalance, resulting in a loss of critical interactions in the soil food web. Microorganisms are responsible for the mineralization and immobilization of nitrogen, phosphorus and sulfur, among others, through the decomposition of organic matter and contribute to the gradual and continuous release of nutrients to plants. Therefore, agronomic practices that influence nutrient recycling, especially mineralization and immobilization, contribute to an immediate increase or loss of productivity, which is reflected in the profitability of the agricultural system (Complutense University, n.d.).

Organic fertilizers can come from vegetable or animal sources and, through the process of mineralization (rotting), are transformed into elements that can be absorbed by plants and establish an important balance in the functionality of the soil. It has the following properties:

• Increases cation exchange capacity, which increases its fertility.

• It favors soil neutrality, i.e., it acts on acid and alkaline soils.

• Increases the water retention capacity favoring the availability of water, especially in times of lack of rainfall.

• Decreases the effect of erosion by leaching

• Maintains soil heat favoring microbial activity and nutrient absorption.

• Increases soil microbiology since organic fertilizers, in their mineralization process, release energy that is used by microorganisms.

• It favors soil aeration through the promotion and production of aerobic microorganisms.

• Improves soil texture in soil.

Observing what has been described above, it can conclude that the addition of organic matter to the soil generates more advantages than disadvantages since it widely favors soil fertility, achieving decontamination processes that chemical fertilizers generate (Montalvan, 2018)

Guinea pig manure (cuyasa)

According to (Borrero, 2001), manure is the result of the digestion of food consumed by animals (approximately 60 to 70% of the food consumed is excreted), its average chemical content is 1.5% of N, 0.7% of P, and 1.7% of K, and its function is to improve the physical, chemical and biological properties of the soil with the particularity that it should be used in an amount not less than 10Kg/Ha/year. Its quality depends on the food consumed, the management given to the manure, and its best use is obtained by adding it to the soil after decomposition and fermentation (Caiza, 2018).

Respect to guinea pig manure, Molina (2012) states that it has multiple benefits, especially for the preparation of organic fertilizers, due to its high nutrient content, it does not emanate odors after the mineralization process, its presentation is a powder which facilitates its application, which is why, together with horse manure, it is considered one of the best, since, as described in the previous paragraphs, it has multiple benefits in the physical and chemical properties of the soil.

The following table shows the nutritional value of guinea pig manure:

Table 2. Mineral contents of guinea pig manure.

Minerals (ppm)	%
Nitrogen	0,7
Phosphorus	0,05
Potassium	0,31

Source: Caiza 2018

For Guaman (2010), the use of guinea pig manure is important in improving soil fertility, as described below:

• Maintains soil fertility,

• It does not contaminate the soil.

• Healthy harvests are obtained

• Good yields are achieved

• Improves the physical, chemical and biological characteristics of the soil.

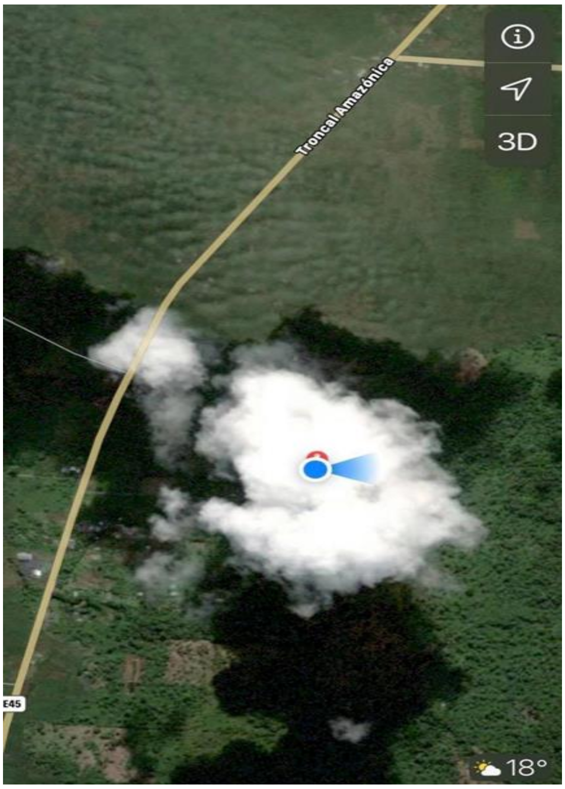
• It does not have bad odors and therefore does not attract flies.

MATERIALS AND METHODS

Location

The present investigation was carried out in the Sinai parish, Morona canton, Morona Santiago province, located 22.5 km from the city of Macas on the road to Puyo, bordered to the north by the Chiguaza parish, to the east by the Shuar federation, to the west by the Upano river and Sangay national park, and the south by the Sevilla "Don Bosco" parish, at an altitude of 1200 masl, at a temperature that fluctuates between 12 - 18 °C, with an average rainfall of 500 to 3000 mm. Its coordinates are 0828425 E; 9768452 N; latitude 02°05'31,5" S; longitude 78°03'52,4" W, (Pan cantonal Morona , 2020)

Figure 1. Location of the study site



Source: Google maps 2022.

Description of the experimental scenario

The research was carried out in a gramalote (Axonopus scoparius) pasture, approximately 20 years old, 25 m2 plots established the experimental units, four treatments were applied, with five replications each, the same that were delimited and identified, separating each plot at distances of 1 m to avoid possible edge effects, the total experimental area was 775 m2.

Experimental design.

Table 3. Description of treatments

Treatments	Urea	Cuyasa	Cal
T0			
T1	**0.125 Kg**	**100 Kg**	**4.55 kg**
T2	**0.125 Kg**	**75 kg.**	**4.55 kg**

T3	**0.125 Kg.**	**25 kg.**	**4.55 kg**

Source: Own elaboration.

Variables under study

• Plant height at 90 days.

• Number of tillers at 90 days.

• Number of leaves per tillers at 90 days.

• Percentage of flowering at 90 days.

• Biomass production at 90 days

• Nutritional value of grass (protein, dry matter, cell walls) at 90 days.

Experimental procedure

The research was carried out on an established crop of gramalote (Axonopus scoparius) approximately 20 years old.

It started with an equalization cut of the entire area at 10 cm from the soil level. Then a soil sample was taken to determine its chemical composition and to find possible nutrient deficiencies in the soil.

All the plots (5m x 5m) where the treatments were located were measured, leaving separations (1m). At the same time, the paths were cleaned, and all weeds found within the plots were removed.

Posts, poles and identification labels were placed to separate and differentiate the plots. It weighed the urea, quassia and lime to be placed in the corresponding plots.

The variables above were measured from 10 plants per plot. After 90 days, the biomass of each of the plots was weighed. Finally, the bromatological analysis of four different treatments was carried out.

Evaluation methodology

Green forage production/ha and dry matter

This variable was evaluated by weighing the biomass for which the forage was cut after 90 days. Subsequently, a subsample (1 kg) of each treatment was taken to determine the percentage of dry matter of the grass under analysis.

Nutritional value of gramalote (protein, ashes, cell walls)

It proceeded to take 1 kg of grass from each treatment to perform a bromatological analysis in the laboratory.

Height at 90 days

For the evaluation of this variable, it was measured at the indicated times, from the soil surface to the tip of the highest leaf of the average plant shoot; this process was carried out with 10 plants chosen at random from each of the plots.

Number of tillers

Five plants were taken randomly from each plot, and the tillers were counted to obtain an average for each treatment.

Number of leaves per tillers

From the tillers obtained in the measurement of the previous variable, the number of leaves was counted to determine the means for each treatment.

Percentage of inflorescence

For the measurement of this variable, the quadrant method was used, pitching twice per plot, and the number of flowers per plant was counted to obtain an average for each treatment.

RESULTS AND DISCUSSION

The following table shows the results achieved in the variables proposed for evaluation:

Table 4. Results achieved in the variables for evaluation.

	Treatments									
Variables	T0		T1		T2		T3		Prob.	E. E.
Plant height at 90 days (cm)	0,74	c	1,24	a	1,04	b	0,90	bc	2,4E-05	0,04
Number of tillers at 90 days (cm)	14,24	a	15,00	a	15,16	a	13,96	a	0,93	1,49
Number of leaves at 90 days	7,08	b	8,32	a	8,12	ab	7,96	ab	0,04	0,28
Inflorescence at 90 days	3,81	a	3,99	a	3,63	a	3,99	a	0,96	0,57
Production of green matter /m².	0,83	b	1,66	a	1,64	a	1,39	a	7,9E-04	0,11
Green matter production T/Ha	8,32	b	16,64	a	16,40	a	13,92	a	7,9E-04	1,15
Dry matter production T/Ha	1,42	b	2,84	a	2,79	a	2,37	a	7,9E-04	0,20
Protein Production T/Ha	0,10	b	0,21	a	0,20	a	0,17	a	7,9E-04	0,01
Production of FDA T/Ha	0,47	b	0,94	a	0,93	a	0,79	a	7,9E-04	0,06
NDF production T/Ha	0,63	b	1,26	a	1,24	a	1,04	a	1,4E-03	0,09
Production of LDA T/Ha	0,06	b	0,12	a	0,11	a	0,10	a	7,9E-04	0,01

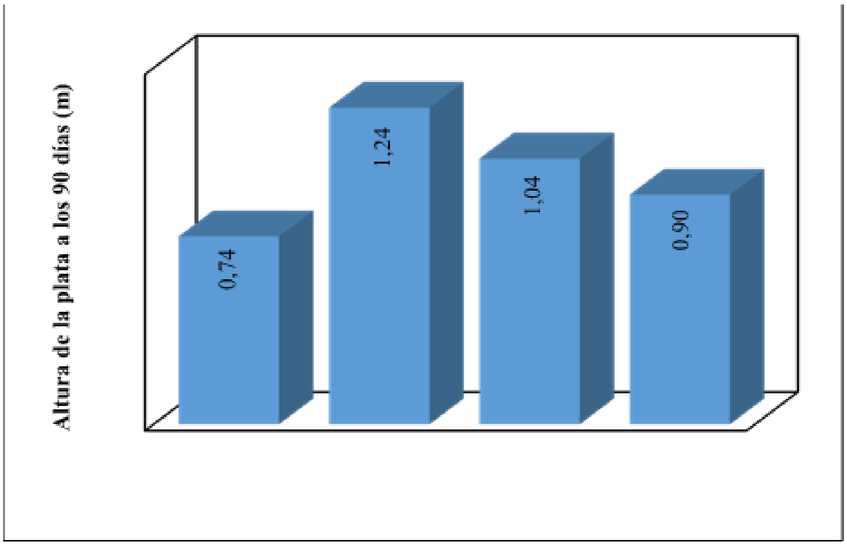
Source: Own elaboration.

Height of Axonopus scoparius, according to the age of evaluation.

When analyzing this variable, it was determined that there were differences between fertilization levels that statistically affected plant height, as described below:

An average height of 98 cm was found, showing highly significant differences (P>0.05) between the treatments used, obtaining in the separation of means by Tukey the highest height of 124 cm for treatment T1, followed by significant differences by treatment T2 with 104 cm. Conversely, the lowest heights were reported by treatments T3 and T0 with 90 cm and 74 cm, respectively, with no differences between these two treatments.

Figure 1. Height at 90 days of Axonopus scoparius plants under the different treatments.



Source: Own elaboration.

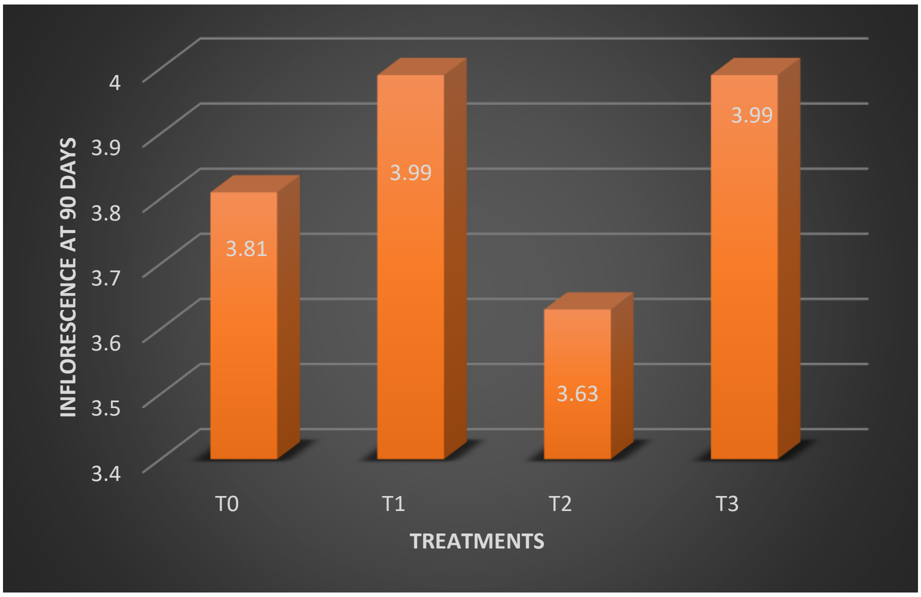
The differences found in this parameter indicate that as time elapses, the availability of nutrients in the soil allows the plant a greater absorption and a more accelerated growth, evidenced by showing the highest values with the use of the highest amounts of fertilizer and the lowest when less was used, including the control with the lowest value and without application of fertilizer, which also confirms the usefulness of the application of this fertilizer, as Noboa et al. (2021) state, who also found in their work at 90 days, that reports a greater increase in this parameter when using cuyasa (88.33 cm) and other organic fertilizers for the control without fertilizer (84.27 cm).

It is important to note that there is a decrease in the speed at which height increases, which is accentuated in the last 30 days, similar to what happens in the control treatment, but this does not occur equally in all treatments, which seems to indicate that the greater volume applied allows the crop to extract sufficient nutrients for a longer period, which is reflected in the fact that the crop can grow for a longer time and show better results at the end of the period evaluated.

Inflorescence at 90 days

When analyzing the data on inflorescence at 90 days, it was found that the ANAVAR did not show significant differences among the different treatments, which was corroborated by the mean test. In this parameter, very similar values were found in all treatments, with slightly higher results for T1 with 3.99, and the lowest value corresponding to T2 with 3.63, with the control treatment showing an intermediate value, results that can be seen in the following graph.

Figure 2. Inflorescence at 90 days of Axonopus scoparius plants under the different treatments.



Source: 2022 research team.

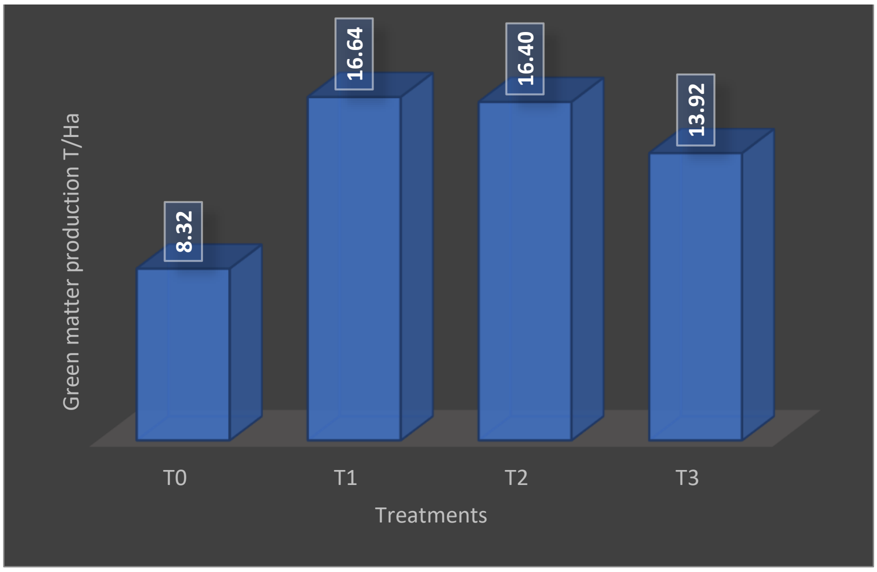
The values shown in the inflorescence at 90 days indicate that the application of compost does not significantly influence this parameter, which shows the maturity of the crop and its harvest time, showing differences from that reported by Alemán et al. (2020), who using poultry manure achieved improvements in the early physiological maturity of the crop, similar to that reported by Barcenes, (2015), for the crop of Setaria sphacelate in which there was an early maturity. This situation may be because an important part of the nutrients provided by the compost was leached by the rains and by the low capacity of the soil to retain them, considering that, in general, the soils have thin topsoil, and the amount of rainfall is important.

Green Forage Production (GF) at 90 days

The different treatments used in the fertilization of Axonopus scoparius affected in a statistically significant way the green forage production up to 90 days, from which the following analysis follows.

The average found at this age is 13.8 T/ha of VWF, with significant differences (P>0.05) among the treatments used, observing in the separation of means by Tukey that the highest productions are reported by treatment T1 with 16.6 T/ha of VWF, differing from the other treatments. On the contrary, the lowest productions are reported by the T0 treatment with an average of 8.3 T/ha, existing differences with the other treatments used, so it is assumed that to increase the production of VF fertilizers should be used, it can be observed that the result obtained by T1 is double that shown by T0, which is a clear indication of the difference between these two treatments, and also of the control treatment with T2, very similar to T1 although with a lower amount of fertilizer applied as presented in the following graph.

Figure 3. Green matter production of Axonopus scoparius under the different treatments.



Source: 2022 research team

The different treatments used in the fertilization of Axonopus scoparius affected in a statistically significant way the green forage production up to 90 days, from which the following analysis follows.

The difference shown in the production of green matter, in which the application of fertilizer caused this parameter to reach values almost double those obtained without fertilizer, is a clear indication of the good response of the grass to the application of fertilizer in different amounts since in all the treatments with fertilizer, the yield was much higher than the control. These results are different from those obtained by Alemán et al. (2020). However, it should be noted that in their work, they indicate that high amounts of fertilizer, such as those used in this work, can produce differences between a fertilized crop and another without fertilizer, as can be seen from the data presented in this work, which indicates that in soils such as those used in this case, a significant amount of fertilizer is necessary to compensate for the low supply of nutrients that the soils have, which is accentuated by the leaching caused by rain and the thin vegetative layer that they also present. The results seem to coincide with those reported by de Newton de Lucena Acosta et al. (2019), who, in a poor soil, managed to considerably increase the production of green matter by applying fertilizer, which shows that Axonopus are plants that respond to important applications of nutrients even in poor soils. To this is added the contribution of Noboa et al. (2021), who also found significant differences using different organic fertilizers in Axonopus scoparius, in the sense that the organic source of the nutrient is important, there will be a significant effect on crop yield as long as adequate doses are used, implying that the cuyasa can supply enough nutrients, especially nitrogen, to the crop and retains it in the soil despite the leaching effect of rainfall.

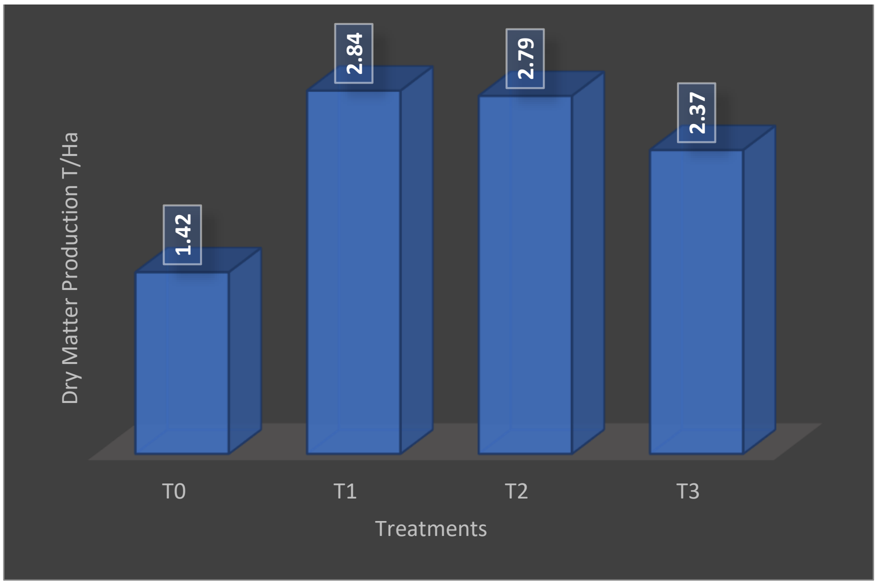
Dry Matter (DM) production at 90 days

The average DM production is 2.355 T/ha, with highly significant differences (P>0.051) among the treatments used; observing in the separation of means employing Tukey, the highest reported productions are those of treatment T1 with 2.84 T/ha of DM, followed without differences by treatment T2 with 2.79 T/ha, as shown in Table 4.

The lowest PMS were observed in the Witness treatment (T0), with a production of 1.42 T/ha of DM, with statistically significant differences with the other treatments, which corroborates the need to use fertilizer in this pasture.

The results for dry matter, as found for green matter, show a notable difference between the treatments with fertilizer and the control treatment that did not include it, with T1 doubling the yields of the T0 treatment, clearly showing the effect of fertilization on crop production, and the response of the crop to this addition of nutrients, as long as it is sufficiently abundant.

Figure 4. Dry matter production of Axonopus scoparius under different treatments.



Source: research team

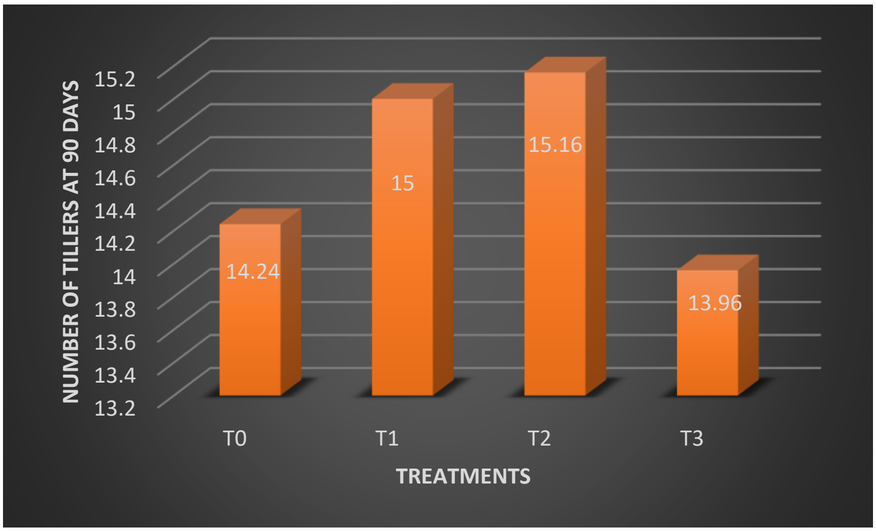
The results for dry matter, as found for green matter, show a notable difference between the treatments with fertilizer and the control treatment that did not include it, with T1 doubling the yields of the T0 treatment, clearly showing the effect of fertilization on crop production, and the response of the crop to this addition of nutrients, as long as it is sufficiently abundant.

The difference between dry matter production with the application of fertilizers and the control differs from that shown by Alemán et al. (2020), who suggest maintaining constant organic fertilization to increase and maintain yields. The results reported coincide with those shown by Hernández (2007), who obtained good results applying fertilizers to the crop and found that there were no differences between fertilization with cuyasa and cow manure, a result similar to that shown by Noboa et al,(2021), also using poultry manure and with no differences with the use of cuyasa in dry matter production. Additionally, fertilization with organic fertilizers did not show differences with chemical fertilization in dry matter production. According to Rodríguez (2018), the use of guinea pig manure provides an excellent result in the production of dry matter using Axonopus scoparius, not different from that which would be obtained by adequately using other sources of nutrients, as indicated by the different authors who have worked in this field, such as those cited above.

Number of tillers at 90 days

The average number of tillers was 14.59; there were no significant differences between the different treatments evaluated, although numerically, the highest values were still observed in treatments T1 and T2, but very close to the value shown by the control.

Figure 5. Number of tillers at 90 days of Axonopus scoparius plants under the different treatments.



Source: Own elaboration

The different treatments used in the fertilization of Axonopus scoparius statistically affected green forage production for up to 90 days, from which the following analysis follows.

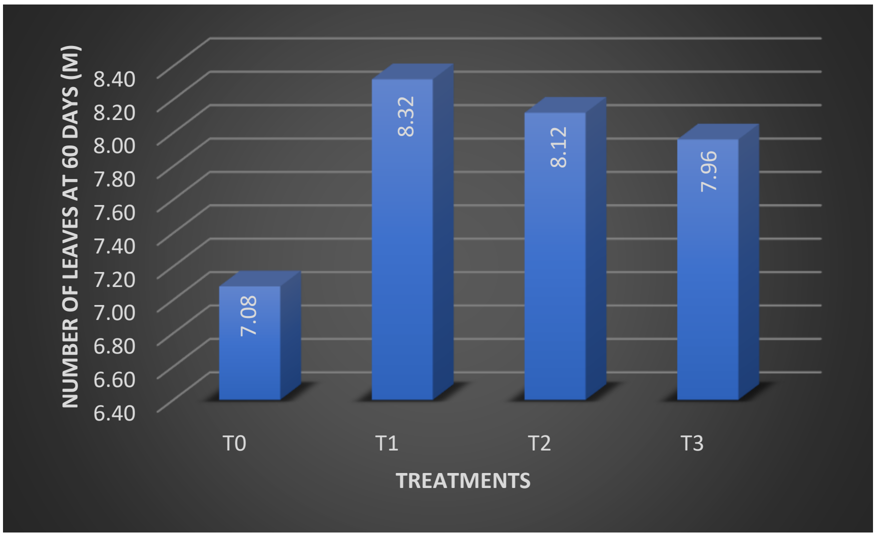
The results in several tillers differ from those found by Hernández Guevara (2007), who showed differences between treatments with and without fertilizer, using similar levels of cuyasa, which leads to thinking that there may be other factors associated with this besides the amount of cuyasa fertilizer used, who when applying cuyasa obtained a result of 29.37 being this higher than the control in which 23.32 was obtained. Another work by Newton de Lucena Acosta et al. (2019) found differences in using fertilizers on the production of tillers in Axonopus aureus.

Number of sheets

The analysis of the ANAVAR results for the number of leaves at 90 days shows significant differences between the treatments studied, which was confirmed and clearly defined in the test of means in which the highest values are found in T1 with 8.32, which differs from T0 that showed 7.08, which however appears statistically similar to treatments T2 and T3. It is interesting to note that there are two subgroups in which the treatments are statistically equal, in which the elements that differ from each other are T0 and T1, both being statistically equal to T2 and

T3, and at the same time, it is noted that the number of leaves decreases with the amount of fertilizer applied to the treatment, that is, the highest value is of T1, then T2, followed by T3 and finally the control T0.

Figure 6. Number of leaves at 60 days of Axonopus scoparius plants under the different treatments.



Source: Own elaboration.

The result shown in the number of leaves may indicate that at 90 days, the effect of the fertilizer shows significant differences, showing differences between the treatments that used fertilizer and compost, showing more leaf emission, and this number is higher the level of fertilizer applied, which is very important in this crop whose final objective is to obtain the greatest amount of leaf volume possible, and a greater leaf emission contributes significantly to achieve this. These results coincide with Barcenes (2015), who also found a greater emission of leaves when using guinea pig biol, and with Newton de Lucena Acosta et al. (2019), who found improvements in the number of leaves when applying fertilizers to the crop, which indicates that it is a crop that responds to fertilization either chemical fertilizers or organic fertilizers, so the latter represents a valid option for the supply of nutrients to the crop, and with the data obtained it can be seen that the response is direct, that is, the more fertilizer, the greater the number of leaves.

Bromatological analysis of three of the best treatments and the control

The values obtained in the parameters of the bromatological analysis of the T0 treatment are shown in Table 7, where the results of dry matter were 1.42 T/ha, crude protein 0.1 T/ha, LDA 0.06 T/ha, FDA 0.47 T/ha and NDF 0.63 T/ha.

The values obtained in the parameters of the bromatological analysis of the T1 treatment are shown in Table 7, where the results of dry matter were 2.84 T/ha, crude protein 0.21 T/ha, LDA 0.12 T/ha, FDA 0.94 T/ha and NDF 1.26 T/ha.

The values obtained in the parameters of the bromatological analysis of the T2 treatment are shown in Table 7, where the results of dry matter were 2.79 T/ha, crude protein 0.20 T/ha, LDA 0.11 T/ha, FDA 0.93 T/ha and NDF 1.24 T/ha.

The values obtained in the parameters of the bromatological analysis of the T3 treatment are shown in Table 7, where the dry matter was 2.37 T/ha, crude protein 0.17 T/ha, LDA 0.10 T/ha, FDA 0.79 T/ha and NDF 1.04 T/ha.

Figure 7. Protein production of Axonopus scoparius plants under the different treatments.

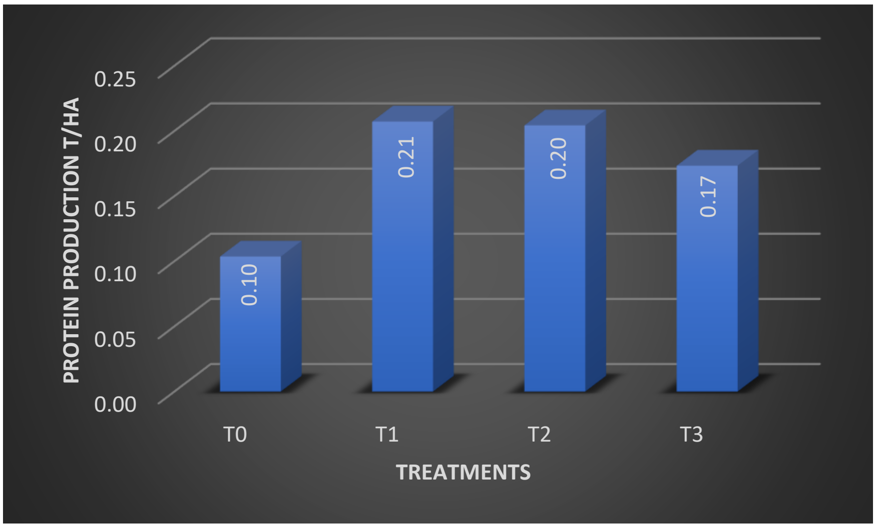


Figure 8. FDA production of Axonopus scoparius plants under the different treatments.

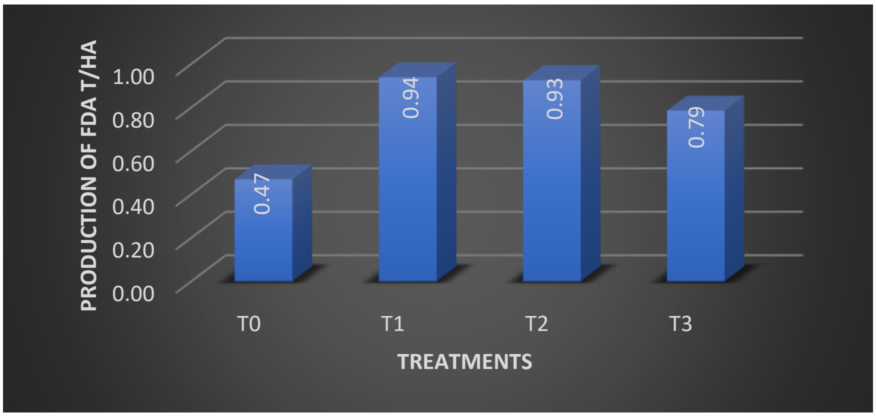
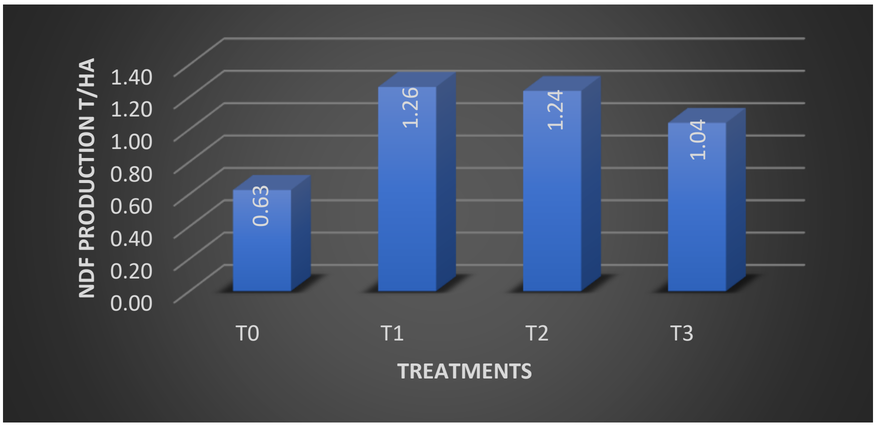


Figure 9. NDF production of Axonopus scoparius plants under different treatments.



The bromatological results found coincide with those reported by Hernandez Guevara (2007), who, in his research, found differences between production, using different types of manure and chemical fertilizers, that is, that greater quantities of these elements are produced when using organic manure, than when no type of manure is used, and there are no differences between the use of cattle, sheep or guinea pig manure, and the behavior was similar in crude protein (6.73%), lignin, cellulose and hemicellulose. These results also coincide with Noboa et al. (2021), who found no differences between the use of chemical fertilizers and chicken manure and guinea pig manure with cuttings at the same time, and also with Rodríguez (2018), who found no differences in these parameters between plants with application of organic fertilizers or chemical fertilizers. Likewise, it coincides with Gonzáles et al. (2012), who found significant differences in crude protein by adding organic fertilizers to the crop. This indicates that using cuyaza can improve the levels of these parameters, increasing the quality of the pasture and the amount of it that the animal can use. This situation may be the result of its adequate nutrient content, and the amounts used allow the crop to absorb sufficient nutrients during the time evaluated.

Conclusions

• For the beginning of the fieldwork it was essential to perform a soil analysis to measure the nutrient content and the pH of the soil; the results determined that the soil was acidic, so lime was added in the proportions described in the design of the experiment.

• When evaluating the variable plant height at 90 days, it was determined that the plants reached an average height of 98 cm, showing highly significant differences (P>0.05) between the treatments used, obtaining in the separation of means by Tukey the greatest height of 124 cm for treatment T1, followed with significant differences by treatment T2 with 104 cm. The lowest heights were reported by treatments T3 and T0 with 90 cm and 74 cm, respectively, with no differences between these two treatments.

• With respect to the variable green matter production at 90 days, it was observed that T1 generated 16.6 T/ha of FV, differing from the other treatments. On the other hand, the lowest productions are reported by the T0 treatment with an average of 8.3 T/ha, with differences from the other treatments used, so it is assumed that to increase the production of FV, fertilizers should be used in a mixture with natural fertilizers, because the result obtained by T1 is double that shown by T0, which is a clear indication of the difference between these two treatments, and also the control treatment with T2, very similar to T1 but with a lower amount of fertilizer applied.

• The average DM production is 2.355 T/ha, with highly significant differences (P>0.051) among the treatments used; observing in the separation of means using Tukey, the highest reported productions are in the T1 treatment with 2.84 T/ha of DM, followed without differences by the T2 treatment with 2.79 T/ha, as shown in Table 4. Conversely, the lowest PMS was observed in the Witness treatment (T0), with a production of 1.42 T/ha of DM, with statistically significant differences with the other treatments, which corroborates the need to use fertilizer on this pasture.

• Perhaps the most important finding of this research was to determine that fertilization, in addition to improving the physical conditions of the plant, also improves its nutritional content, a criterion that is ratified when analyzing the protein content of the grass in T1, where 21 g/kg of grass was obtained compared to T0, which obtained 10 g/kg of grass.

• In general terms, we can state that this research work determined the potential of the combined use of chemical fertilizers with organic fertilizers, especially considering that in most livestock production systems, excrement is a by-product that is permanently generated as part of the production process

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