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Evaluation of the Incorporation of Sheep Manure on *Pasture Panicum* maximum Cv Tanzania in a Silvopastoral System

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Abstract

The objective of the study was to evaluate the effect of sheep manure production and nutritive value of *Panicum maximum* cv. Tanzania was included in a silvopastoral system (SPS). Applied a design completely random, using three treatments: T1=Control T2=this consists in the addition of 4kg sheep manure and T3=this consists with the incorporation of 8 kg sheep manure with three replicates per treatment. The Biomass according to production of green matter (GM) and dry matter (DM) was evaluated. So also we evaluated the relationship of leaf-steam and the contribution of organic matter (OM), crude protein (CP) and neutral detergent fiber (NDF) of *Panicum maximum* cv. Tanzania to 112 days after its sowing. The results showed no statistically significant differences between treatments for the variables that were evaluated. The incorporation of sheep manure no significant change to the evaluated variables corresponding to production of GM and DM, the relationship of leaf-steam, content of OM, CP and NDF; however, the amount of manure that is recommended to pasture of Tanzania is 40t/ha due to there was a positive trend in CP content and relationship of leaf-steam.

Keywords: Content; Manure; Incorporation; *Panicum maximum*; Production; Silvopastoral system

Introduction

In Mexico, the cattle raising is one of the activities that from the beginning has been predominantly extensive, the pasture represent the base of the feeding of ruminants, such as gramineae that are produced naturally occurring, which allows producers decrease meaningfully the production costs in feeding systems [1].

Feeding cattle during different times of the year is one of the problems facing the producer, because forage production is seasonal and dependent on the rainfall; In addition, producers do not have sufficient management techniques and forage conservation, economic resources and infrastructure that allow them to maintain sustainable productivity Crespo [2]. One of the most obvious characteristics of the grazing areas is the high degree of soil deterioration that is associated with reduced forage production and short shelf life, lowering levels of productivity and increasing costs for recovery of grasslands, the low nutritional value of pastures is one of the limiting factors in tropical regions, mainly due to the pasture inadequate management.

The application of inorganic fertilizers in tropical pastures has favorable results on yield and forage quality; however, the current trend is the increase its cost and negative long-term effects due to accumulation of toxic substances in soil and acceleration of acidification thereof. For another way require reduce the application of these sources of nutrients during extended periods [3].

Because of this, the producer has as the primary challenge the search for alternatives to minimize these problems for the slightest cost; that is why to counteract these effects, now incorporating leguminous trees is recommended how forage potential, allowing enrich one hand the diet of the animals as a source of complementary N and on the other hand improve the physicochemical characteristics of the soils for livestock use [4].

Due to this situation a feasible alternative when integrated into grasslands is the incorporation of animal manure as a source of organic fertilizer in the production medium, because it is considered a local resource and of inexpensive handling [5].

The sheep manure, is one of the organic amendments rich nutrient for pasture because usually the faeces are mixed with urine and are of easily mineralization by microorganisms, but large amounts are required to obtain significant increases in performance and pasture quality due to low concentration of the main macronutrients [6], this research was aimed at evaluating the effect of sheep manure application in production and nutritive value of *Panicum maximum* cv. Tanzania in a silvopastoral system.

Materials and Methods

Location of the study area

The experimental work was developed in the Sustainable Agriculture and Development Training Center S.P.R. DE R.L., during the months of June to October 2015. The center is located in the municipality of Chiapa de Corzo, Chiapas; the geographic location is latitude 16° 42' north and longitude 93° 01', with more than 1100mm annual rainfall.

Soil characterization and sheep manure

Sheep manure was collected in the holding pens animal management, place these roost overnight, allowed to stand in a cool shady spot for a month before starting the experiment, a representative sample was taken. In the case of soil, he proceeded to take five samples in the plot where the experiment was developed at a depth of 30cm. pH were measured in a 1:10 (w/v) aqueous extract [7]. Moisture content was obtained by drying at 105°C for 24h. Carbon (C) and Organic matter (OM)/ ash content were determined by a muffle furnace at 550°C [8]. Total nitrogen (N) was analysed by Kjeldahl method (Method 928.08, [9,10]. P contents were analyzed by colorimetric analysis in a spectrophotometer using the molybdate reagent ascorbic acid-ammonium. K content was evaluated with a spectrophotometer after extraction with ammonium acetate, as established by Shamim et al [11]. Cation exchange capacity (CEC) was measured according to the method proposed by Cely et al [12], using 1 M NH4+ OAc as saturating agent. The soil type according to the particle size (clay<2μm; silt 53-2μm and sand >53μm) was determined according to Yang et al [13].

Experimental site

A meadow of an area of approximately 1 ha, established with *Panicum maximum* cv was used. Tanzania associated with *L. leucocephala* in an array of pasture in alleys, where *L. leucocephala* was set at 7m distance between rows and 2m between trees; rows of trees were established from east to west in order to allow greater entry of sunlight to the grass during the day.

Cages exclusion

In the experimental plot nine exclusion cages were established of 1x1x1m, these were built with wood and mesh; same that was properly identified. The cages were distributed randomly in the experimental plot based on the particularities of the experimental design.

Experimental design

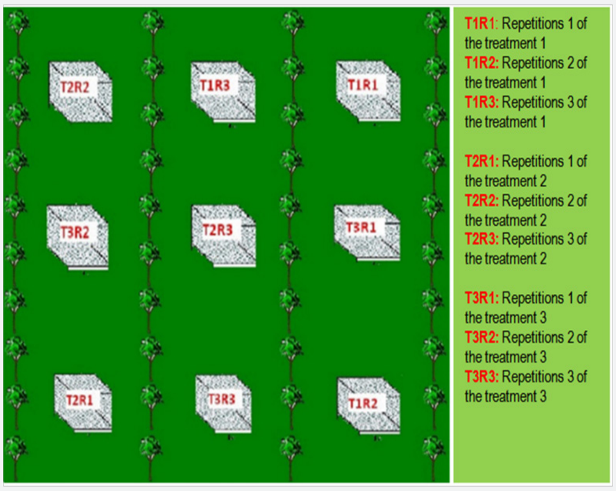

Figure 1: Distribution of treatments: Completely randomized design, using three treatments, three repetitions, making a total of nine experimental units

Applies a design completely random, using three treatments (4 and 8kg sheep manure, respectively) and three repetitions, making a total of nine experimental units (Figure 1).

Crop management

Prior to the development of the experiment, the prairies were homogenized at a height of 15cm from the ground, and then the manure was applied at three concentrations (0, 4 and 8kg, respectively). After being applied manure, the grass was harvested at 112 days of age, taking into account the particularities of the experimental design.

Statistical model

The linear model design is represented as follows:

$$Yij = \mu + Ti + Eij$$

Where:

Yij = Feature ij study in the experimental unit (variable treatment response and repetition).

μ = Characteristic common to all experimental (population mean) units.

Ti = Treatment effect i.

Eij = Effect of experimental error in the ij experimental unit.

Variables evaluated

Production of green matter: Green matter (GM) production was obtained from the values of the productive potential reached by P. maximum cv. Tanzania during the 112 days of the re-growth under the conditions mentioned above. The vegetative material was cut into the exclusion cage 15cm from the ground and weighed on a granataria balance [14].

Dry matter production: Dry matter (DM) was determined by three representative samples of plant material of each of

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the treatments (2kg) and their repetitions were analyzed, being heavy and deposited in bags on kraft paper properly identified. The samples were introduced to a forced air oven at a temperature of 60 °C for 48h until they reached a constant weight (DM, AOAC [15] Method 934.01).

Relationship leaf-stem: For obtaining of the variable of the relationship leaf-stem, the components of the plant (leaf, stem and dead material) were separated. Then the structures were weighed on a scale granataria individually; taking into account the results obtained, the average was calculated in relation to the above components (leaf and stem) [16].

Proximal chemical analysis: In preparation of samples for chemical analysis proximal, the matters were dried in a forced air oven at a temperature of 60 °C for 48h. Having determined the dry matter, samples were ground using a sieve of 2mm for the determination of chemical components present in the pasture.

Crude protein (PC) were analysed by Kjeldahl method (CP, AOAC, 1996, Method 954.01); Neutral detergent fiber (NDF) was analyzed with heat-stable amylase and without Na-sulfite, were determined according to the sequential method of Van Soest et al [17] by an ANKOM fiber analyzer (ANKOM220 Technology, Macedon, NY, USA), and expressed inclusive of residual ash.

Statistical analysis

One way ANOVA was used at $p<0.05$ level of significance, with the Info Stat statistical program. Data are presented as mean±standard deviation, with a comparison of Tukey ($p\leq0.05$).

Results and Discussion

Soil characterization and sheep manure

Table 2 shows the results of soil analysis of the site where the present work (Silvopastoril System) was performed. According to the results, the soil is a silt loam in which a high content of N Total (0.23%) and P (0.27%) is appreciated. For pH and OM content, this soil is slightly alkaline, having an average percentage of OM; while a good indication of the cation exchange capacity. The bulk density reflects the degree of soil compaction; for this study it presents the silt loam soil bulk density low, considering very porous of good quality. The Table 3 shows the results of the chemical analysis of sheep manure that was applied in this study. Results that differ to that observed in Table 1. It is important to mention that the contribution of OM and the total N is high.

Table 1: Chemical composition of sheep manure.

C (%)	N (%)	P (%)	K (%)	OM (%)	C/N (%)	References
ND	0.89	0.48	0.83	30.7	ND	Naranjo, 1982.
35	1	0.9-1.8	2.1	ND	35/1	Varnero, 1991.
46.08	1.44	0.74	1.65	82.94	32/1	Paschoal, 1995.
47	1.83	1.13	1.27	ND	25.7/1	Álvarez et al., 2010.
16	0.89	0.48	0.83	30.7	20/1	Sierra & Rojas, 2010.
ND	0.45	0.71	3	13.8	ND	Flores et al., 2012.

C, carbon N, nitrogen; P, phosphorus; K, potassium; OM, organic matter; C/N, relation of carbon nitrogen. ND: not determined

Table 2: Physicochemical characteristics of the soil where it is established grass P. maximum cv. Tanzania.

N Total (%)	P (%)	K (%)	pH	OM (%)	C.I.C. Cmol/kg	Sand (%)	Clay (%)	Silt (%)	Texture	Da g/mL
0.23	0.27	0.02	7.82	3.42	25.91	1.64	26.36	72	Silt loam	1.02

N, nitrogen; P, phosphorus; K, potassium; OM, organic matter; C.I.C, cation exchange capacity; pH, hydrogen potential. N = High (0.16- 0.25%), P = High (>11mg de P/Kg of soil), OM = Medium (1.6-3.5%), C.I.C. = High (25-40Cmol/kg). According to: NOM-021-RECNAT-2000.

Table 3: Chemical composition (%) of the sheep manure.

N Total (%)	P (%)	K (%)	pH	OM (%)
1.53*	0.51*	0.47*	9.64*	59.79*

N, nitrogen; P, phosphorus; K, potassium; OM, organic matter; pH, hydrogen potential.

*The values are average of three replicates (n=3).

The soil N content is reflected in the expected redeeming potential of Tanzania grass (Table 2). As for the content of P high concentrations in the soil were observed, this result ensure a good assimilation by the plant [18].

The pH is related in some way with the percentage of P observed in this study, since when pH changes from acid to neutral or slightly alkaline an increased rate of mineralization P is achieved, allows for greater solubility and use of this nutrient [19,20]. For this study the apparent density is an indicator of quality, a low value (<1.3g/mL) indicates higher porosity, aeration, soil permeability, filtering, water dynamics, this allows better crop growth, development roots and improves the production of agro ecosystems [21]. In this sense, legumes have a positive effect on the maintenance and restoration of soil fertility (Crespo, 2008). They can also modify the physical characteristics

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of the soil and its structure (by the addition of leaves, roots and stems) and increase the values of OM, the cation exchange capacity and the availability of N, P and K.

According to Naranjo [22], Varnero [23], Paschoal [24], Álvarez et al [1], Sierra & Rojas [25] and Flores et al. [26] indicate that the results of this study are due to conditions that were given to manure before being applied to the soil. In this regard, Pozo [27] mentions that moving the manure every third day and apply enough water to increase microbial activity after 34 days, this stabilizes and improves its nutrient supply (2.72% N, 1.71% P, 1.54% K and pH 8.4). Moreover, the direct application of manure is due to that animals in natural environments deposited its manure on the ground, which is degraded and slowly adding to it. According to the results presented by Flores et al. [26], depending on the chemical properties of soil fertilized for 4 times a year with sheep manure, these authors obtained significant differences ($P \leq 0.05$) in the content of the OM (2.25 to 6.34%), N (0.17 to 1.46%), P (0007-0009%) and pH (5.6 to 6.7) when they applied an amount of 28.1t ha-1, superior results to those found in this work, however, this may be that even when sheep manure has been applied for 10 years at the site where the study was conducted, doses applied are variables. For these reasons, trees as *L. leucocephala* have the ability to release in a short time, more than 50% of the total content of nutrients such as N, P and K when incorporated into the soil [4], which indicates the excellent quality of the biomass, for these reason that this species has to be used in the recovery of soil fertility, also they used as a source of shade, as they can achieve sustainability in tropical grasses and are an attractive and viable alternative in the tropics [28]. So it is also important to mention that the rate of disappearance of manure in the pasture depends on the time of year when it is deposited on the ground. In tropical areas of Veracruz in Mexico, where the fauna of beetles Coleoptera is abundant and diverse [29], the further degradation of cattle manure during the rainy season was held in the first 4 and 8 days after its deposition.

Production of green matter in *P. maximum* cv. Tanzania fertilized with sheep manure in an SPS

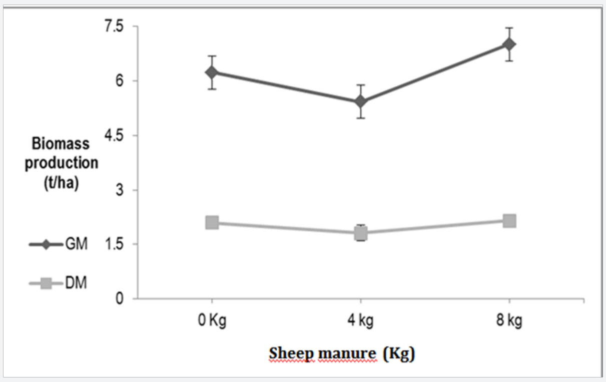

Figure 2: Production of green matter (GM) and dry matter (DM) of P. maximum cv. Tanzania fertilized with sheep manure in a SPS

The analysis of variance made to the data of biomass according to the production of green matter in the present work, determined that there were no significant differences, observing in the T3 (70.16t/ha) an increased production of green matter, followed by T1 (62.4 t/ha) and a lower production in T2 (54.36 t/ha) (Figure 2).

In the silvopastoral systems, total biomass production is usually higher than in monoculture systems. In addition, the interactions that occur between the components of these systems during their use can determine their productive capacity; this varies depending on the mode of SPS. Because the incorporation of sheep manure caused no effect on the quality and productivity of pasture Tanzania by lack of moisture in the soil, these yields can be considered optimal for producers who manage pasture in monoculture system (Figure 2).

These results obtained after the canicular period may be due to the shade of leguminous trees because they reduce leaf temperature, resulting in less transpiration, increasing water use efficiency of the grass. Biomass production in GM grass Tanzania obtained at 112 days of age, in treatments 1 and 3 (62.4 and 70.16 t/ha) are very similar to the results obtained by Reyes & Santos [30], in a silvopastoril system, reporting a production of 71.83 t/ha to 112 days old pasture and 65.56 t/ha at 84 days old. However the biomass production compared to the treatment 2 (54.36 t/ha) may be due to more loss of senescent leaves was observed that treatment 1 and 3 during the canicular period; result similar was obtained by Reyes & Santos [30], in monoculture, reporting a production of 51.23 t/ha in 112 days old pasture. In this regard, Hernandez & Guenni [31] mention that tropical pastures are better able to take advantage of solar radiation, so that they reach their maximum production with the presence of greater leaf area, allowing the interception of high levels of light intensity. The above mentioned can be related to the production of biomass in GM as observed in treatment 1 (62.4 t/ha). Due to mode the SSP (alley cropping) and distribution of treatments, during the course of daily the treatment 1 received less shadow that the treatment 2 and 3, enabling take advantage of the solar radiation, so that influenced that the production approaching to treatment 3 (70.16 t/ha). Moreover Hernández et al. [32] and Baldelomar [33] obtained lower yields of biomass in GM (32 t/ha), *P. maximum* cv. Massai and cv. Tanzania at 90 and 100 days of age of regrowth, respectively, in monoculture. The results mentioned above are lower than those obtained in the present study, due to the canicular period of 38 days exactly, a condition that limited the grass Tanzania, since he suffered a strong dehydration, loss of height, poor turgor, leaves in senescence and changing color of the leaves in all treatments evaluated, this phenomenon can be attributed that the sheep manure has not caused a significant effect on the grass, due to lack of moisture in soil. However, despite the conditions presented in this experiment, a few days of subsequent rain and the association of trees Leucaena presented in this silvopastoral system, meant that the grass Tanzania will get recover, thus

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obtaining good yields of green biomass, that can be considered acceptable to the producers.

Production of dry matter of *P. maximum* cv. Tanzania fertilized with sheep manure in an SPS

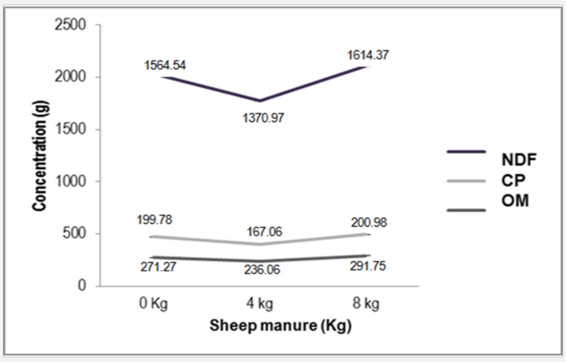

Figure 3: Content of organic matter (OM), crude protein (CP) and neutral detergent fiber (NDF) of P. maximum cv. Tanzania fertilized with sheep manure in an SPS

In the Figure 2 the production of biomass in relation to the dry matter of Tanzania grass is presented, shows that there were no significant differences between treatments. Production of DM in treatment 3 were of 21.61 t/ha when applied 80 t ha^{-1} manure of sheep, followed by treatment 1 (21.02 t ha-1), the lower DM production was obtained in the treatment 2 (18.15 t/ha) when applied 40 t/ha of manure.

The fluctuation observed in the 3 treatments, is likely to be attributable in part to climatic factors demonstrated in the experiment; such as precipitation, which presented an atypical distribution throughout the experiment; to address this problem should be noted that the deficit of soil moisture inhibited the uptake of CO_2 due to stomatal closure and thus decreased photosynthetic activity, with reduced pasture growth and development. In addition to this, after the canicular period the T2 and T1 showed a higher synthesis of structural carbohydrates due to pasture age, increasing the production of DM. In this regard, Ramirez et al. [34] believe that increased DM yield with age of grass, is related to the increase in the photosynthetic process that occurs in the plant and thus the synthesis of structural carbohydrates, which increases the DM of pasture, influencing the soil and climate factors directly. However, as age increases of pasture progressively decreases the nutritional value (chemical composition, intake and digestibility).

The behavior observed in this experiment of P. maximum, based on their performance is similar to the results obtained by García [35], who achieved the greatest redeeming after 75 days of re-growth ages but lower than those obtained by Ramirez et al. [34] and Verdencia [36], with a production of biomass in DM 7.23t/ha (cv. Likoni at 90 days of regrowth) and 12.7 t/ha (cv. Tanzania 105 days of re-growth) without fertilization and monoculture. In addition to this, the results of the SPS are satisfactory if one takes into account the benefits, despite the factors that negatively influenced, in addition to good production and create an optimal environment for grazing animals inside.

Relationship of Leaf-stem of *P. maximum* cv. Tanzania fertilized with sheep manure in an SPS

Table 4: Leaf-stalk ratio of P. maximum cv. Tanzania fertilized with sheep manure in a SPS.

Treatment	L (kg)	S (kg)	L:S
T1	1.08*	1.31	0.82
T2	0.71	0.84	0.84
T3	0.91	1.2	0.75
L, leaf; S, stalk; T1 = 0kg of manure, T2 = 4kg of manure and T3 = 8kg of manure			

*The values are average of three replicates (n=3).

Table 4 presents the results for the variable leaf-stalk of grass Tanzania, the analysis shows no significant differences between treatments evaluated, observing a trend in T2 (0.84), followed by T1 (0.82) and being the lowest in T3 (0.75). However, there was some interaction between the production of biomass in relation to the dry matter of grass Tanzania and leaf-stem ratio (L:S), finding a lower ratio L: S in the T3 (0.75), where he obtained an increased production of biomass in relation to the green stuff (70.16t/ha) and a higher ratio L: S in T2, less production of green matter (54.36 t/ha), in a way, the age of cutting in this experiment was important in the ratio L: S in each of the treatments evaluated.

In order to know the amount of leaves Tanzania grass produced in relation stem it is vital, since the nutritional value of the plant focuses on higher production of leaves; being this of greater palatability for consumption of ruminants. The results obtained in this study, may be attributable in part to canicular period where senescent leaves loss it was evident as increased production of stems was observed with respect to leaves. Meanwhile, Izurieta [37] scored higher, with a ratio L: S of 2.2 to 70 days old, with Pasto Savoie (Panicum maximum) in monoculture. Moreover Verdecia et al. [36] mention that any variation that exists in the physiological processes of tropical grasses as a result of the thermal regime, rainfall and its distribution, directly influence the production of DM, which is why the leaf-stem ratio decreased in response to weather conditions that occurred in the experiment, so these changes were reflected in the productivity and quality of grass Tanzania.

OM content of *P. maximum* cv. Tanzania fertilized with sheep manure in a SPS

In the Figure 3 results obtained from organic matter (OM) are presented, the analysis of variance indicates that there was no significant difference between treatments, obtaining a content of 12.98% in T1, 13.04% for T2 and 13.53% T3.

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The results obtained in this study are lower than those obtained by Reyes & Santos [30], who observed a higher content in the same silvopastoral system with 17.50% at 112 days of age, without fertilization; values that can possibly be attributed to increasing the amount of plant cover was found; which plays an important role in the incorporation of nutrients to the soil, taking into account any variation that may arise from soil and climate factors. Various studies using these systems indicate improvements in soil fertility, efficient recycling of nutrients and increased biomass production base grass, to improving the nutritional quality of the associated pasture Crespo [2].

CP content of *P. maximum* cv. Tanzania fertilized with sheep manure in an SPS

Regarding the content of CP (Figure 3) it can be seen that no significant differences, the results were values of 9.5% in T1, 9.2% for T2, and 9.3% in T3, content acceptable to a monoculture.

The inclusion of leguminous trees in silvopastoral systems favors the occurrence of changes in the chemical composition of the associated grasses, opposite case to that observed in the present study, due to atypical rainfall and pasture re-growth age. The results obtained in this study for this variable are lower (10.5% CP) to that obtained by Reyes & Santos [30], at the same age of regrowth in silvopasture. Despite the detrimental effect of water deficit and advanced maturity, the concentration of CP in the grass Tanzania remained ≥7%, value considered as minimum level to avoid a decrease voluntary intake in grazing ruminants [38]. This allows for a tighter diet to the nutritional requirements of animals and increase livestock efficiency Cuartas et al. In this sense, the results obtained by Hernandez et al. [32] coincide with the results of this study, who reported an increase in the content of 9.5% CP in the species *P. maximum*, *Stargrass* and *Paspalum notatum*, when they were associated with Leucaena. Similarly, Reinoso [39] reported a similar CP content in the star grass (8.0-9.5%), set in a silvopastoral system, in fertile soil and without the application of chemical fertilizers. Meanwhile, Verdecia [36], Izurieta [37] and Rodriguez [40] obtained lower CP contents grass *P. maximum* cv. Savoie at 70 days of age (6.9%) in cv. Mombaza at 60 days of age (7%) and 5.3% at 105 days of age in cv. Tanzania; all handled in monoculture. For his part, Hernandez et al. [31] found a CP content of 11.3% at 90 days of age with grass *P. maximum* cv. Massai in monoculture. In this regard, Devkota et al. [6] refers to that the limited availability of light influences negatively on the photosynthetic activity of grass species in silvopastoral systems, reducing its performance. However, for the Tanzania grass associated, their growth and development was not affected by the above factors, reflecting the associative ability of this grass with the leguminous shrub (*L. leucocephala*) [41]. As noted, soil moisture determined forage quality, as during the rainy emerged canicular period. Causing significant changes in soluble and structural components of the grass, where grass tended to increase its structural carbohydrates as a measure of defense against adverse weather conditions and therefore reduce its nutritional value. During the wet season the grass remains green and its lignificación is less, being able to obtain an increase in its CP content.

NDF content of *P. maximum* cv. Tanzania fertilized with sheep manure in a SPS

The Figure 3 shows the NDF, analysis of variance determined that there were no significant differences for the three treatments.

As the forage mature NDF content increases, this determines a slower digestion rate, with a longer passage through the digestive tract. A suitable content of NDF in grasses of tropical climate ranges between 55 and 60% Chamberlain & Wilkinson. The content of NDF of grass Tanzania in this experiment is outside the proposed range, increasing as the age of the grass is prolonged; due to water stress suffered by the grass during the canicular period; besides age that was harvested (112 days). Increased NDF was observed at 112 days old of the grass, it is related to the physiological changes that occur with aging plant, which causes decreased cytoplasmic cell content; cell lumen with soluble components is reduced and fibrous components increase. For his part, Hernandez et al [30] obtained a content of 76% at 90 days of NDF in the grass *P. maximum* cv. Massai in monoculture. In practical terms, the NDF concentration is inversely proportional to the consumption capacity of the ruminants (to more NDF, less voluntary consumption of DM) [42,43].

Conclusion

Growth and nutritional potential of P. maximum cv. Tanzania is influenced by weather conditions (precipitation and temperatures) that occurred during the development work.

The incorporation of sheep manure no significant change to the evaluated variables corresponding to production of GM and DM, leaf-stem ratio, content of OM, CP and NDF; however, the amount of manure that is recommended apply to pasture Tanzania is 40t/ha because a positive trend in the CP content and leaf-stalk of grass relationship was observed.

The application of manure to pasture production in a silvopastoral system represents an important alternative to provide nutrients needed for crop development, as well as to improve the physicochemical and microbiological characteristics of the soil; even though there are few studies that report the benefits from the use and application of various amendments. Therefore their employment should be diffused by a resource available and inexpensive in rural areas. Based on this, it is recommended to continue making evaluations in order to adjust the amount and instant of applying this organic alternative at different times of year as long as there is availability of water resources, particularly in forage crops handled in monoculture, whose interaction will improve the biomass production and nutritional value towards a more friendly cattle raising environment.

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