environmental sciences proceedings

MDPI

Proceedings Paper

Influence of the arboreal component in the productive and nutritional parameters of *Brachiaria mutica* grass in northeastern Peru†

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† Presented at the 3rd International Electronic Conference on Forests — Exploring New Discoveries and New Directions in Forests, 15–31 Oct 2022.

Abstract: The objective of this study was to evaluate growth (cm), yield (kg/m^2), crude protein (CP %), crude fiber (CF %), ether extract (EE %), NDF (%), ADF (%), gross energy (GE kcal/kg), ELN (%), Ash (%) and in vitro digestibility (IVD %) of *Brachiaria mutica* grass; under three silvopastoral systems, guava (*Inga edulis*), poplar (*Populus alba*) and eucalyptus (*Eucalyptus globulus labill*) and a treeless system (TS) in the northeastern of peru. Were analyzed under a completely randomized design (CRD) with four treatments and four repetitions and the results were analyzed by analysis of variance ($\alpha = 0.05$ %) and Tukey's means test ($p \leq 0.05$). The SPS with guava showed higher growth at 30 days (59.57 cm), and the there was no difference between systems at 45 (98.43-107.14 cm), 60 (138.86-146.57 cm) and 75 days (159.81-165.67 cm); the highest yield at 30 days was for SPS with guava (0.41 kg/m2), at 45 and 60 days there was no difference (1.01-1.15 and 1.57-1.76 kg/m2) and for 75 days was for TS (2.88 kg/m2); the nutritional composition was evaluated in two cut-off frequencies (30 and 75 days); for 30 days, the SPS with guava has a higher value for CP (16.03%), IVD (68.13%) and GE (4502 kcal/kg), the SPS with eucalyptus has a higher percentage for CF (21.08), NDF (33.17), FDA (56.42), and ash (7.74), the highest EE content was in the SPS with poplar (2.46%) and the TS presented the highest percentage of ELN (50.88); for 75 days, the SPS with guava presented a higher value for CP (13.61%), FDA (36.78) and GE (4504.33 kcal/kg), the SPS with eucalyptus had a higher percentage for CF (23.51) and ash (6.42), and the highest percentage of EE (2.24), ELN (59.18) FDN (62.67) and IVD (56.59) was for the SPS with poplar..

Keywords: Sustainable production, silvopastoral systems, productivity and nutritional composition

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Environ. Sci. Proc.* **2022**, *4*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Published: date

1. Introduction

The livestock activity is of fundamental importance for the rural area and the food security of Peru since it generates employment for 1.8 million families (7.6 million people), represents 40.2% of the Gross Value of the production of the Agricultural sector and in the period 2007 to 2016, showed an annual growth rate of 5.2% [12]. However, most of the country's livestock systems are developed under extensive conditions, where monoculture of grasses predominates and the absence of the tree component; there will be environmental problems such as soil degradation, water pollution, loss of biodiversity, social inequity and greenhouse gas emissions [8].

The low productivity of grasslands is one of the most important limitations in the Peruvian livestock feeding system [2], the researchers mentioned that forage species such as *Brachiaria humidicola*, for example, have limitations in productivity, adaptability and persistence in these environments; they present susceptibility to pasture spittlebugs caused by *Aeneolamia* spp and foliar fungi such as *Rizoctonia solani*, which significantly reduce yield values [3]. On the other hand, livestock systems under monocultures lacking the tree component also affect the performance of the animal, since they are subjected to strong heat stress that can negatively affect their milk and meat production and their reproduction [14].

In the Peruvian Amazon, it is estimated that around 16% of the area has been intervened, 40% of this area is "purma" or secondary forest and more than 70% of this area is degraded with low-productivity native pastures, degraded improved pastures and areas of variable degree of "empurme" (soil nutrients are recovered). These pasture areas, for the most part, are used without adequate management techniques, and there is animal overload and overgrazing, which causes negative effects such as compaction, also hinders root development and reduces the drainage capacity of the porous space, producing loss of nutrients [1].

In this context, silvopastoral systems (SPS) are a livestock production option where trees and shrubs interact with traditional components, represented by pastures and livestock under an integrated management system [7]. The use of trees within livestock production systems has multiple benefits, since they will represent a source of animal feed, they will contribute to recovering the natural fertility of the soil, they will participate in the regulation of the water balance, they will increase the net benefit of the system, they will decrease the negative effects of climatic factors on pastures and livestock, diversify the outputs of the livestock system and are carbon dioxide fixers [14].

The general objective of this research was to evaluate the production and nutritional value of *Brachiaria mutica*, under different silvopastoral systems in the Huayabamba Valley - Amazon region, whose specific objectives were to determine the biomass of *Brachiaria mutica* in terms of growth (cm), yield (kg/FV m^2) with the different open field systems and tree species such as guava (*Inga edulis*), poplar (*Populus*) and eucalyptus (*Eucalyptus globulus* L.) at different cutting frequencies (30, 45, 60 and 75 days) and also the nutritional value in protein (%), crude fiber (%), ash (%), ether extract (%), nitrogen free extract (%), acid detergent fiber (%), neutral detergent fiber (%), digestibility (%) and gross energy (kcal/kg) of *Brachiaria mutica* with the different SPS at different cutting frequencies (30 and 75 days).

2. Materials and Methods

2.1. Study area

The study was carried out in the districts of Huambo (1,636 masl), Longar (1,595 masl) and Mariscal Benavides (1,600 masl) in the province of Rodríguez de Mendoza, Amazonas region, with average annual rainfall of 800 to 1,300 mm/year. In these districts, farmers use continuous and rotational grazing systems under a treeless system (TS) and silvopastoral systems (SPS) using different tree species, both natural and installed.

2.2. Silvopastoral Systems

SPS Guaba. This system was characterized by being distributed as a live fence, in dry season the soils of this type of system have a bulk density of 1.20 g/cm3, a pH of 5.8, 10.1 % of organic matter, 7.8 ppm of phosphorus, 165 ppm of potassium and a loamy texture [24].

SSP Poplar. In this system the forest species was dispersed in the pasture, in dry season the soils associated with this system have a bulk density of 1.18 g/cm3, a pH of 6.7, 7.7% of organic matter, 24.3 ppm of phosphorus, 166 ppm of potassium and a loamy texture [24].

SSP Eucalyptus. In this system, as in the SPS Guaba, the forest species is used as a live fence. During the dry season, these soils are characterized by a bulk density of 1.19 g/cm3, pH of 5.2, 15.3% organic matter, 14.1 ppm of phosphorus, 282 ppm of potassium and a loamy texture [24].

2.3. Population

Made up of farmers from the districts of Huambo, Longar and Mariscal Benavides of the Province of Rodríguez de Mendoza in the Amazon region, Peru. Applying the formula to calculate the size of the quantitative finite population sample, a sample size of 7 Livestock Units that manage cattle for each district was determined.

2.4. Sampling

A stratified sampling was used with allocation proportional to the size of the stratum, and the livestock units were chosen following a simple random sampling procedure.

2.5. Evaluation of productive variables

To evaluate the growth and yield of green forage of *Brachiaria mutica* in the different systems evaluated, the pasture was cut at 30, 45, 60 and 75 days of age.

2.6. Nutritional assessment

To determine the nutritional value of *Brachiaria mutica* in the different systems evaluated, samples were taken according to the square meter methodology, which consisted of throwing a frame at random and where it fell, the forage was cut [13]. A representative sample of 0.5 kg was collected for each silvopastoral system and treeless, which was placed in duly identified paper bags and later sent to the laboratory of animal nutrition and food bromatology of the Toribio Rodríguez de Mendoza National University. The methodologies used for the bromatological analysis were those used by the AOAC [22] and Van Soest [23].

2.7. Statistical design and data anlysis

It was used under a DCA random square design with 4 treatments (Treeless system: TS, Silvopastoral System with Guaba (*Inga edulis*): SPS Guaba, Silvopastoral System with Poplar (*Populus*): SPS Poplar, Silvopastoral System with Eucalyptus (*Eucalyptus globulus* L.): SPS eucalyptus, with 4 observations per treatment. It began by checking the assumptions of normality and homogeneity of the variances. Then, an analysis of variance was carried out in order to see significant differences between treatments and Dunnet's multiple comparisons test in order to consider the Treeless System as a control to compare the mean of the treatments for each of the parameters evaluated. We worked with a significance level of 0.05 and the software R v. 4.2.1.

3. Results

3.1. Productive evaluation

The variables of height and yield at 30, 45, 60 and 75 days, presented a normal distribution of the data and a homogeneous variance. The analysis of variance showed significant differences at 30 and 75 days for both variables ($p<0.05$). The height increased at higher cutting frequency in all the systems evaluated, with the SPS eucalyptus, TS and SPS poplar systems registering the highest averages at 75 days of evaluation with 165.67 ± 7.27, 160.00 ± 6.78 and 159.81 ± 1.64 centimeters respectively. Regarding the yield variable, it also increased in each evaluation, presenting the highest averages for TS and SPS poplar at 75 days of evaluation with 2.88 ± 0.08 and 2.86 ± 0.09 kg/m^2 respectively.

3.2. Nutritional assessment

All the variables evaluated presented a normal distribution and fulfilled the assumption of homogeneity of variances of the data at 30 and 75 days of evaluation. The analysis of variance only showed significant differences for the digestibility and gross energy variables at 30 days ($p<0.05$).

The percentage of protein had a tendency to decrease and was higher at 30 days and for the SPS guaba with 16.04 ± 2.12%. Crude fiber also increased between evaluations, being higher at 75 days for the SPS guaba with 23.08 ± 2.28%. The percentage of ashes decreased in the second evaluation, the highest percentage was obtained in the SPS eucalyptus at 30 days with 7.74 ± 0.57%. The percentage of ethereal extract also showed a decrease in the evaluation at 75 days, the highest percentage corresponded to SPS poplar with 2.45 ± 0.63% at 30 days.

In relation to the acid and neutral detergent fibers, they also obtained the highest percentages in the second evaluation, with 36.78 ± 2.82% ADF in the SPS guaba and 62.67 ± 1.31% NDF in the SPS poplar. On the contrary, the digestibility had a tendency to decrease in the second evaluation, the highest percentage was obtained in the SPS guaba with 68.13 ± 1.75% and being significantly different from the other systems. Finally, regarding gross energy, the increase between evaluations was minimal, however, the highest averages were observed in the SPS guaba in both evaluations with 4502.01 ± 30.10 Kcal/kg at 30 days and 4504.33 ± 30.10 Kcal/kg at 75 days.

4. Discussion

Regarding the height variable at 30 days, the highest value was recorded within the SPS guaba with 59.57 cm, this value is lower than that reported by Mier and Rojas [10] who obtained an average of 79.5 cm with the application of island guano fertilizer in conditions of San José de Cúcuta, Colombia. On the other hand, Sosa and Espinoza [19] found lower values than those of this research for their three evaluations of *Brachiaria mutica* at 30, 45 and 60 days, being its maximum height 61.09 cm at 60 days and with application of 50% Biol fertilizer, under Nicaraguan conditions. The differences found in grass growth may be associated with edaphoclimatic differences in each study area [4].

The height variable at 60 days was higher in the poplar SPS with an average of 146.57 cm similar to that obtained by Castrejón [6] with his control treatment without fertilizer application with an average of 151 cm for conditions of the Nueva Esperanza annex, Jalca Grande, Chachapoyas, this place has climatic characteristics similar to those of this research since it is located at an altitude of 1600 m above sea level. The height values found exceeded the range established by Olivera et al. [25] who state that *Brachiaria decumbens* is characterized by being a perennial herbaceous plant 30 to 100 cm high.

The green forage yield at 75 days was higher in the Treeless System with an average of 2.88 kg/m^2, this value is lower than that obtained by Castrejón [6] in his different treatments with fertilizer application since he obtained averages between 4 and 6 kg/m^2, obtaining the best results with the application of island guano, this shows the importance of fertilizer application for the productive improvement of the pasture [20].

In addition, it was possible to observe a direct relationship between plant height and green forage yield, since the greater the plant height, the higher the yield values, thus corroborating López et al. [9] who mention that the increase in plant height is accompanied by an increase in structural (stems) and foliar (leaves) biomass.

The protein percentages at 75 days fluctuated between 12.52 and 13.62%, these values were higher than those obtained by Ospina et al. [17] in low Tropic conditions of Colombia obtaining protein percentages of 8.82% for *Brachiaria mutica* grass with the near infrared spectroscopy (NIRS) method.

With respect to protein, it was also observed that this has a tendency to decrease as plant maturity increases, as mentioned by Brenes-Gamboa [26].

In relation to crude fiber, the percentages were increasing between evaluations and the highest percentages were obtained in the SPS eucalyptus with an average of 23.52% at 75 days of evaluation, a value lower than the average obtained by Lopez et al. [9] who reported an average of 29.3% for *Brachiaria mutica* in its seed maturation stage in conditions of Oxapampa, Peru.

The ash content decreased as the days progressed with values between 5 and 7%, being the SPS eucalyptus the one that presented the highest averages, contrary to what was reported by Reyes-Pérez et al. [18] for *Brachiaria decumbens* at 42 and 61 days of evaluation in conditions of Guayas, Ecuador; since they observed a slight increase from 15.36 to 16.15%, values higher than those of this research.

Regarding the ethereal extract for *Brachiaria mutica* this was decreasing as the grass grew, as suggested by Mojica-Rodríguez et al. [27] who found an inversely proportional relationship between regrowth age and ethereal extract content. The ethereal extract was higher at 30 days and in poplar SPS with 2.45%, this average is slightly lower than that obtained by Avella [28] for *Brachiaria brizantha* which obtained an average of 2.64% in climatic conditions of Meta, Colombia.

The free nitrogen extract was higher at 75 days for poplar SPS with 56.94%, this value is higher than those reported by Cedeño et al. [29] for grasses such as Kudzu and Crotalaria evaluated at 60 days with values of 37.09 and 51.90 respectively under conditions of the Ecuadorian subtropics.

The acid detergent fiber was higher at 75 days with values between 33.53 and 36.78 %, which are below the average obtained by Milla-Luna et al. [11] who reported 48.55% NDF for *Brachiaria mutica* in the tropical zone of southeastern Mexico.

In relation to Neutral Detergent Fiber at 75 days of evaluation the highest value was recorded in SPS poplar with an average of 62.67%, this average is similar to that obtained by Ospina et al. [16] who reported an average of 62.6% for this grass in conditions of the Andes of Colombia.

In vitro digestibility presented a tendency to decrease as grass growth progressed, as mentioned by Castrejón et al. [5]. The highest value was observed at 30 days for SPS guaba with 68.13%, this value is similar to that obtained by Ortega-Ramirez et al. [15] for *Brachiaria brizantha* grass with an average of 64.19% in Nayarit, Mexico at 120 days of evaluation.

Finally, regarding gross energy there were no noticeable differences between the two evaluations and also between systems, the highest value was observed for the SPS guaba at 75 days with an average of 4504.33 Kcal/kg, this average is higher than that obtained by Valles et al. [21] in Veracruz, Mexico for *Brachiaria insurgente* grass that obtained an average energy of 2140 Kcal/kg.

5. Conclusions

In conclusion, good energy contributions of *Brachiaria mutica*, good energy-protein balance and good yield values were evidenced under systems such as SPS guaba and SPS poplar, representing good options for the development of sustainable livestock in the study districts. It is recommended to extend the investigation to other districts of the province and the region where livestock systems are managed in order to explore other species that serve for the establishment of silvopastoral systems, taking into account edaphoclimatic aspects of each zone.

Author Contributions: For this articles the authors made the following contribution: "Conceptualization, L.V. and E.L.L.; methodology, L.V., E.L.L. and H.V.P.; software, L.V., L.G.B., C.N.V., and L.V-V.; validation, C.A.L., and H.V.P.; formal analysis, L.V., L.G.B., C.N.V., and L.V-V.; investigation, L.V., L.G.B., C.N.V., and L.V-V.; resources, C.A.L and H.V.P.; data curation, L.V., L.G.B. and C.N.V.; writing—original draft preparation, L.V., E.L.L., L.G.B., C.N.V., and L.V-V.; writing—review and editing, C.A.L. and H.V.P.; visualization, L.G.B. and C.N.V.; supervision, H.V.P.; project administration, C.A.L.; funding acquisition, H.V.P. All authors have read and agreed to the published version of the manuscript.

Funding: Funding: This research was funded by the National Institute of Agrarian Innovation (INIA), and the Toribio Rodríguez de Mendoza National University (UNTRM).

Institutional Review Board Statement: Not applicable.
Informed Consent Statement: Not applicable.
Data Availability Statement: Not applicable.
Acknowledgments: We thank the farmers of the districts of the study area for their collaboration in collecting data for this research.
Conflicts of Interest: The authors declare no conflict of interest.

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