Herbage accumulation and mass in Massai grass plots mixed with forage peanut and fertilized with nitrogen

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Abstract. The objective of this work was to evaluate herbage accumulation and mass during the growing season of Massai grass mixed with peanut forage and fertilized with nitrogen. The work was carried out at Federal Rural University of Rio de Janeiro, Brazil, from 11/2021 to 03/2022. A randomized block experimental design was used, in plots of Massai grass *Megathyrsus maximus*, in a factorial arrangement, with seven replications. Four treatments formed by the combination of the presence or absence of *Archis pintoi* and nitrogen fertilization (0 and 50 kg ha^{-1} of N). Canopy heights of the plots were evaluated weekly and when they reached values of about 50 cm two samples were collected and the total herbage accumulation and mass were calculated. The treatments without nitrogen fertilization and legume had the lowest herbage accumulation and mass (5,080 and 2,060 kg ha^{-1} of DM, respectively), when compared to the plots that had nitrogen fertilization and legume. The treatments with or without legume but with nitrogen fertilization had the same herbage accumulation and mass (9,775 and 2,630 kg ha^{-1} of DM, respectively). Thus, the presence of the legume resulted in greater herbage accumulation and mass in relation to those plots without legume and nitrogen fertilization. However, when nitrogen fertilization was performed no additive effect with the presence of the legume was observed, indicating that the nitrogen fertilization somehow inhibited the benefit of the legume on forage production. So, based on the short-term results obtained, the use of nitrogen fertilization or the use of forage peanuts should be done separately.

Introduction

Nitrogen is considered the most important nutrient for forage production. In a pasture, nitrogen fertilization and biological nitrogen fixation (BNF) are the main ways to supply this nutrient. The use of forage legumes in pastures is standing out for its potential for BNF, increase the yield and improvement of the nutritional value of forage (Homem *et al.* 2021). Among the legumes with the greatest potential for use in tropical condition, forage peanut has stood out for their persistence in pastures and the annual BNF from 80 to 120 kg ha^{-1} (Lira *et al.* 2006; Marques *et al.* 2019). For most of the forage grasses used in Brazil, which belong to the genus Urochloa, this fixed amount is sufficient to meet the demand and reach the yield potential. However, when working with more demanding forages and, consequently, with greater yield potential, such as forages of the *Megathyrsus* genus, this fixed amount may not be enough to explore the productive potential. Therefore, a strategy that adds more nitrogen to pasture is necessary, but the use of nitrogen fertilization in mixed pastures can limit the BNF process. However, there is scientific evidence that some legume species and also the lineage within a species are less sensitive to the availability of soil nitrogen for symbiosis with nitrogen-fixing microorganisms to occur (Forrester and Ashman 2018; Reinprecht *et al.* 2020). In addition, the amount of nitrogen available is crucial to limit the nodulation process, so a small amount has little potential to limit the BNF process. Therefore, we hypothesized that nitrogen fertilization, in small amounts, will have an additive effect on forage production if the potential limitations on BNF are small or null in mixed pastures of *Megathyrsus maximum* cv. Massai and forage peanut.

Methods and Study Site

The work was carried out in an experimental area of the Animal Science Institute of the Federal Rural University of Rio de Janeiro, from November 2021 to March 2022. The climate in the region is type AW,

tropical warm humid, with a dry period in the winter and a rainy period in the summer, according to the Köppen climate classification. The average annual precipitation is 1200 mm, with an average annual temperature of 26 °C. The region is located at 22°45' South latitude and 43°41' West longitude and at an altitude of 33 meters. Average soil chemical characteristics for the 0-20 cm layer were: pH $CaCl_2$: 4.9; P (Mehlich-1) = 14.1 mg dm^{-3}; Ca = 1.1 $cmol_c$ dm^{-3}; Mg = 0.3 $cmol_c$ dm^{-3}; K = 0.14 $cmol_c$ dm^{-3}; H+Al = 2.05 $cmol_c$ dm^{-3}; sum of bases = 1.51 $cmol_c$ dm^{-3}; base saturation = 41.8%. A randomized block experimental design was used, in 8 m^2 plots of Massai grass (*Megathyrsus maximus*) implanted in 2014, in a factorial arrangement, with seven replications. Four treatments formed by the combination of the presence or absence of *Arachis pintoi* cv. Belomonte, established in January of 2021, and nitrogen fertilization (0 and 50 kg ha^{-1} of N), using urea in a single application in November 2021. The criterion for defining the moment to harvest the plots was determined based on the height at which the canopy reaches 95% of light interception, which was determined in work conducted by Silva *et al.* 2018. Canopy heights were evaluated weekly in the plots and when they reached values between 50 and 55 cm two areas of 0.25 m^2 each (1 x 0.25 m) were sampled by cutting at 15 cm from the ground. The samples were processed in the laboratory, dried in a forced air oven at 55 ºC until constant weight and weighing of green and dry materials to estimate their botanical composition to calculate the total of herbage accumulated in the experimental period (herbage accumulation) and the average of forage mass by harvest (herbage mass) in the warm season of the year. The data were analyzed using the linear model of SAS® OnDemand and the means were estimated using the LSMEANS command and comparisons made with the Tukey test ($p<0.05$).

Results and Discussion

There was an interaction effect ($p<0.05$) between the factors studied on herbage accumulation and mass (Table 1). The treatments that did not receive nitrogen fertilization and did not have the legume had the lowest forage accumulation when compared to the plots that had the presence of the legume or that received nitrogen fertilization (5,073; 7,668 and 9,630 kg ha^{-1} of DM, respectively). The treatments with or without legume and that were applied nitrogen had the same herbage accumulation (9,881 and 9,630 kg ha^{-1} of DM, respectively), but they presented greater values than those that did not receive nitrogen fertilization. Also, in the plots that had forage peanut and receive nitrogen fertilization was observed an increase in herbage accumulation than the plots that just had the legume (9,881 and 7,668 kg ha^{-1} of DM, respectively). Regarding the herbage mass, the treatments that did not receive nitrogen fertilization and did not have the legume had the lowest herbage mass when compared to the plots that had the presence of the legume or that received nitrogen fertilization (2,060; 2,883 and 2,676 kg ha^{-1} of DM, respectively). The plots that had legume and receive nitrogen fertilization had the similar herbage mass that the plots that had only legume or just received nitrogen fertilization (2,835; 2883 and 2,676 kg ha^{-1} of DM, respectively).

Table 1. Herbage accumulation and mass and proportion of legume in plots of Massai grass mixed with forage peanut and fertilized with nitrogen

Arachis pintoi	Nitrogen fertilization (kg ha^{-1})		SEM*
	0	50	
Herbage accumulation (kg ha^{-1} of DM)			
With	7,668 Ba	9,881 Aa	1,125
Without	5,073 Bb	9,630 Aa	
Herbage mass (kg ha^{-1} of DM)			
With	2,883 Aa	2,835 Aa	305
Without	2,060 Bb	2,676 Aa	
Proportion of legume (% of DM)			
With	22.4 a	13.9 b	4.1
Without	0	0	0

Means followed by the same letters, uppercase in columns and lowercase in rows, are not diferente by test Tukey ($p>0.05$). *SEM: standard error of mean.

These results evidence the importance of nitrogen, through nitrogen fertilization or by BNF, to increase

forage production. The presence of the legume or nitrogen fertilization resulted in an increase of 50 and 90% in the herbage accumulation, respectively. It is clear how fertilization is more effective to increase forage yield, but is important to mention that forage peanut was in the establishment process, the planting was in January of 2021 and the data collected was from November 2021 until March 2022. In the establishment phase the proportion of forage peanut in the forage mass and, consequently, NBF is low (Longhini *et al.* 2021). Also, the most important pathway to transfer fixed nitrogen from legume to the companion grass is by recycled nitrogen in pastures, by litter or by livestock excretion (Dubeux *et al*. 2007). In this trial, there was no livestock excretion because the animal was not used to harvest the forage. Another point to highlight is how the BNF is not enough to explore the yield potential of forage grass like Massai grass, because nitrogen fertilization increased the herbage accumulation by around 30% when compared with treatments that had just forage peanut. The lowest herbage mass was registered for treatments without forage peanut and nitrogen fertilizer (Table 1). Less variation in herbage mass is expected because of the management to hasted that was used in this trial. The use of the height of 50 cm as a target to harvest the plots of Massai grass was because at this height is when the canopy intercepts 95% of the light (Silva *et al*. 2018).

No difference in herbage accumulation and mass was registered between the treatments that had forage peanut and were fertilized with nitrogen and those only fertilized. These results indicate that, in the short term of the evaluation that was made, no addictive effect of nitrogen fertilization on mixed plots was registered, indicating a negative effect of N fertilization on BNF observed in other crops (Santachiara *et al.* 2019). However, it is possible that in the long term of the evaluation the addictive effect can be detected. The dynamics of nitrogen in the soil as a result of nitrogen fertilization is fast (Janke *et al.* 2020), so in the first cycles of evaluations, after nitrogen fertilization, an inhibition process of BNF may have occurred, but with advancing time and the cycles of harvest the concentration of nitrogen in the soil should decrease and the BNF occurs again, generating the additive effect of the combination of legume use and nitrogen fertilization.

Another effect of nitrogen fertilization was the reduction of the proportion of forage peanut in the herbage mass ($p<0.05$). Nitrogen fertilization decreases the proportion of forage peanut in herbage mass from 22 to 14 (Table 1). Probably, when nitrogen fertilization was performed the Massai grass had more competitive ability than to legume. This may have occurred due to the positive effect of N on forage grass tillering (Caminha *et al.* 2010), causing an increase in light competition in the canopy, even if the plots were kept at the same harvest height, which, in turn, led to a reduction in the proportion of the legume in the forage mass. Therefore, with the evaluations carried out, it was recorded that nitrogen fertilization in mixed plots of Massai grass with forage peanut did not generate an additive effect on forage production. However, evaluations for a long-term and, perhaps, greater control of competition for light may generate results different from those presented. The cutting height used in the present experiment was the same in all plots, and the height used was obtained in previous work of Silva *et al* (2018) who, in turn, worked with light interception. However, nitrogen fertilization may have increased light interception for the same cutting height between treatments and the lower luminosity in the lower canopy strata may have resulted in a reduction in the proportion of forage peanuts and, consequently, in the possible additive benefits of the use of fertilizer nitrogen in mixed plots.

Conclusions

The use of legume or nitrogen fertilization increases the forage production, but no additive effect was observed when mixed plots of Massai grass and forage peanut were fertilized with nitrogen, indicating that somehow the benefit of the legume on forage production was limited. So, based on the short-term results obtained, the use of nitrogen fertilization or the use of forage peanuts should be done separately.

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