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FOLIAR FERTILIZATION AT THE ESTABLISHMENT OF MARANDU, MAVUNO, MULATO AND YPYPORÃ GRASSES

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Abstract

Foliar fertilization with macro and micro minerals for the forage grasses establishment can be a less costly alternative for the farmer, however the possible benefits of this management technique still need to be better studied. The objective with this work was to evaluate the physiological, productive and structural responses of grasses of the *Urochloa* genus, depending on the application or not of foliar fertilizer during the plant establishment. Four experiments were carried out, in each of which one of the following forage grasses was evaluated: *Urochloa brizantha* cv. Marandu, *Urochloa* spp. Mulatto II, *Urochloa* spp. Mavuno and *Urochloa* spp. Ipyporã. All the experiments were carried out from November 2018 to March 2019, in a completely randomized design, with four replications. The experimental area of each experiment consisted of four plots with 12.25 m², where half the area of the plots received foliar fertilizer (FH PASTAGEM FOLIAR, with 14% N; 12% P; 12% K; 0.38 % Mg; 10.2% S; 0.24% Cu; 0.18% Mn and 0.63% Zn) and the other half did not. The response variables were evaluated: spad index, leaf area index, canopy light interception, forage production and root density. In all experiments, the foliar fertilizer application during the establishment of Marandu, Mulato II, Mavuno and Ipyporã grasses did not influence (P>0,05) the spad and leaf area indexes, forage production and root density.

Keywords: Root Density, Leaf area index, Spad index, Forage production, *Urochloa*.

Introduction

The inadequate forage establishment and management practices, such as the lack of periodic fertilization of pastures established in soils of low natural fertility, are the main causes of degradation and low productivity, in relation to the potential of pastures in Brazil (DIAS-FILHO, 2011). In general, ranchers are resistant to the use of fertilization for pastures because they believe, among other factors, that the investment is high and without economic return. In this context, foliar fertilization in pastures, being less expensive than conventional fertilization, appears as an alternative to increase the productivity of forage grasses.

Foliar fertilization consists of the application of nutrients on the aerial part of the plants, so that these nutrients are absorbed, mainly via the cuticle and leaf stomata. With this, there is a rapid availability of nutrients for the plant, which can be efficient and supplement to the soil fertilization (DEUNER et al., 2008). Indeed, the practice of foliar fertilization, as a complement to traditional fertilization, is very common for the supply of micronutrients in perennial crops. In these situations, the macronutrients are applied to the soil and the micronutrients are applied to the leaves, saving the product and money (ROSOLÉM, 1984).

According to Gazola et al. (2014), foliar fertilization is complementary to soil fertilization, with regard to the supply of nitrogen, phosphorus and potassium for crops, as in recent years the supply of some isolated nutrients for corrective foliar application or for prevent deficiencies (BORKERT; SFREDO; MÍSSIO, 1987). However, the efficiency of nutrient absorption by leaves depends on external factors such as weather conditions; as well as factors inherent to mineral nutrients and solutions. Furthermore, the plant species and development stage are also determinants for the efficiency with foliar fertilization.

In this sense, there is still a gap in knowledge about the effects of foliar fertilization during the establishment of tropical grasses. There is a possibility that foliar fertilization increases the initial pasture growth rate, promoting faster soil coverage and less weed appearance in the area during pasture formation. In addition, the benefits of foliar fertilization can reduce pasture formation time, enabling the first grazing anticipation and, in effect, faster recovery of the investment used for pasture formation.

We tested the following hypothesis: foliar fertilization in the establishment of marandu, mavuno, ipyporã and mulatto II grasses increases spad and leaf area indices, forage production and root density. The objective of our work was to quantify the effects of foliar fertilization during the establishment of four forage grasses on their physiological, productive and structural responses.

Development

The experiment was conducted from November 2018 to March 2019, in the Experimental Farm Capim-branco area, at the Faculty of Veterinary Medicine, Federal University of Uberlândia, in Uberlândia, MG. The geographic coordinates of the site are 18°30’ south latitude and 47°50’ west longitude of Greenwich, and its altitude is 776 m. The climate of the Uberlândia region, according to the classification by Köpen (1948), is of the Aw type, tropical savannah with a dry winter season. The average annual temperature is 22.3ºC. The average annual precipitation is 1,584 mm.

The information regarding the climatic conditions during the experimental period were monitored at the meteorological station of the Federal University of Uberlândia, located at the Experimental Farm Capim Branco, approximately 100 m away from the experimental area (Table 1).

Table 1 – Monthly averages of mean daily temperatures, average solar radiation, monthly rainfal and evapotranspiration from November 2018 to February 2019.

Month	Mean air tempeture (°C)			Solar radiation (Mj/dia)	Rainfall (mm)	Evapotranspiration (mm)
	Mean	Minimum	Maximum			
November	22,39	19,22	27,28	16,33	251,10	77,01
December	23,59	19,09	29,21	21,19	226,60	81,56
January	24,15	19,05	30,22	21,53	138,40	107,71
February	23,79	19,42	30,16	18,79	203,40	84,60

Source: Federal University of Uberlândia meteorological station.

At the beginning of the experiment and according to the recommendations of Arruda et al. (2014), soil samples were taken from the 0 to 20 cm layer to analyze the fertility level, whose results were: pH in H_2O: 5,6; P: 1,4 (Mehlich-1); K: 250 mg/; : 3,3 $cmol_c$/; : 0,9 $cmol_c$/e : 0,0 cmolc/. Based on these results, it was not necessary to carry out liming or potassium fertilization (CANTARUTTI et al., 1999). Phosphate fertilization was carried out via soil in the seed furrow, in November 2018, at a dosage of 50 kg ha^{-1} of P_2O_5, using simple superphosphate.

The four experiments were conducted from November 2018 to March 2019, separately. Each experiment was conducted in its own experimental area, but adjacent to the experimental areas of the other experiments. In each experiment a forage grass of the *Urochloa* genus was evaluated separately, namely: *Urochloa brizantha* cv. Marandu, *Urochloa* spp. Mulatto II, *Urochloa* spp. Mavuno and *Urochloa* spp. Ipyporã. The experimental area of each experiment consisted of four plots, each with 12.25 m², where half the area received foliar fertilizer and the other half did not. In each experiment, the design used was completely randomized, with four replications. Therefore, repetitions consisted of half the area of each experimental plot. Thus, forage grasses were not compared, as each one of them was evaluated in a different experiment. Only a single factor (foliar fertilization) was compared in each experiment.

All forage grasses were established on November 27, 2018, with a sowing rate of 6.0 kg ha^{-1} of pure and viable seeds with a cultural value of 64% and a sowing depth of 3 cm. The foliar fertilizer used was FH PASTAGEM FOLIAR (Fertilizantes Heringer S/A, Paulínia, SP, Brazil), with 14% nitrogen; 12% phosphorus; 12% potassium; 0.38% Mg; 10.2% S; 0.24% Cu; 0.18% Mn and 0.63% Zn. This foliar fertilizer was applied at a dose of 2 kg ha^{-1}, diluted in 0.5 liter of water and sprayed with a manual pump, in order to ensure a more uniform distribution. This application of foliar fertilizer took place 42 days after plant emergence and at the coolest time of the day (close to 8 am). In the half of the area of the plots that did not receive the foliar fertilizer, 0.5 liter of water was applied, but without the foliar fertilizer, in a similar way as described above. The portion of the plots that did not receive the foliar fertilizer was also covered with plastic tarpaulin during the application of the foliar fertilizer, to avoid interferences caused by drift or spraying. The terrain in the area of the experiments had a flat relief and, in addition, the reduced amount of solution used for foliar fertilization (0.5 L) ensured conditions for the low occurrence of water percolation in the soil.

After 15 days from foliar fertilizer application, the fertilized and non-fertilized plants of all plots were cut at a height of 30 cm, due to the high growth of forage canopies. All evaluations took place on the day of application of the foliar fertilizer and after 15 and 45 days of application.

Leaf area index and light interception (%) by forage canopies were determined using the AccuPAR canopy analyzer (model LP-80). In each plot, a reading was performed above and one below the forage canopy.

In order to calculate the root density, two samples were taken per experimental unit, using a 5 cm diameter steel cylinder. This was introduced into the soil at the seeding line at 10.5 cm depth. The samples from the cylinders were manually torn apart to separate the roots and, at the end, washed in running water over a 300 mm mesh strainer to remove the soil still remaining in the sample. Afterwards, the root samples were dried in a forced ventilation oven at 65°C for 72 hours and weighed. By dividing the root mass and the volume of the sampling cylinder, the root density was obtained, expressed in mg/cm^3.

The SPAD index (Soil Plant Analysis Development) was measured for the indirect determination of the chlorophyll content in the leaves of the plant (BONFIM-SILVA et al., 2014). This evaluation took place in the middle third of the blade of newly expanded leaves, performing 20 readings per experimental unit.

Forage mass (kg ha^{-1} DM) was calculated by multiplying the number by the average weight of the tiller. In order to calculate the average weight of the tiller, 20 tillers were collect close to the ground per experimental unit. These tillers were dried in a forced ventilation oven at 65°C for 72 hours and then weighed. As well as to determine the tiller population density, two counts of tillers per experimental unit were made, using a rectangle of 25 cm x 50 cm.

The forage production (kg ha^{-1} of DM) was obtained by the difference in forage masses between the end and the beginning of the following periods: first 15 days after foliar fertilizer application and during the 30 days after plant cutting. The sum of the productions in these two periods corresponded to the forage production over the 45 days after the application of the foliar fertilizer.

For each forage grass, separately, the analysis of variance (F test) of the characteristics measured was performed, in a completely randomized design, with four replications (half the area of each experimental plot), at a significance level of up to 5% probability of occurrence of type I error.

All the characteristics evaluated, with the exception of the spad index at 45 days after fertilizer application, were not influenced by foliar fertilization in the establishment phase of marandu palisadegrass (Table 2).

Table 2 - Productive, structural and physiological characteristics during the establishment of marandu palisadegrass fertilized or not with foliar fertilizer*

Variable[1]	*Days after fertilization*	*Foliar fertilization*		*CV (%)*[2]	*p-value*
		Yes	*No*		
LAI	*15*	*5,12*	*5,03*	*9,47*	*0,7947*
LAI	*45*	*4,22*	*3,20*	*38,94*	*0,3579*
LI	*15*	*98,52*	*98,42*	*0,60*	*0,8197*
LI	*45*	*82,72*	*66,22*	*18,99*	*0,1501*
SPAD	*15*	*41,33*	*39,03*	*7,36*	*0,3145*
SPAD	*45*	*31,83a*	*27,26b*	*4,48*	*0,0028*
Root	*15*	*1,36*	*1,49*	*34,51*	*0,7219*
Root	*45*	*2,19*	*2,53*	*21,94*	*0,3936*
FP	*1 a 45*	*8398*	*8189*	*34,54*	*0,9210*

*2 kg ha^{-1} de FH PASTAGEM FOLIAR: 14% N; 12% P; 12% K; 0,38 % Mg; 10,2% S; 0,24% Cu; 0,18% Mn and 0,63% Zn.
[1]LAI: leaf area index; LI: light interception (%); SPAD: spad index; Root: root density (mg/cm^3 of DM); FP: forage production in 45 days after foliar fertilization (kg ha^1 of DM).
[2] coefficient of variation.

All the characteristics evaluated in Mavuno palisadegrass were not influenced (P>0.05) by foliar fertilization (Table 3).

Table 3 - Productive, structural and physiological characteristics during the establishment of mavuno palisadegrass fertilized or not with foliar fertilizer*

Variable[1]	*Days after fertilization*	*Foliar fertilization*		*CV*[2]	*p-value*
		Yes	*No*		
LAI	*15*	*4,36*	*4,58*	*19,54*	*0,7343*
LAI	*45*	*4,37*	*5,59*	*45,02*	*0,4701*
LI	*15*	*97,05*	*97,50*	*1,63*	*0,7025*
LI	*45*	*75,27*	*85,17*	*21,08*	*0,4396*
SPAD	*15*	*45,36*	*47,17*	*8,94*	*0,5605*
SPAD	*45*	*40,28*	*40,73*	*44,36*	*0,9732*
Root	*15*	*1,88*	*1,67*	*34,19*	*0,6539*
Root	*45*	*3,60*	*4,25*	*37,89*	*0,5568*
FP	*1 a 45*	*6094*	*5554*	*38,55*	*0,7442*

* 2 kg ha-1 de FH PASTAGEM FOLIAR: 14% N; 12% P; 12% K; 0,38 % Mg; 10,2% S; 0,24% Cu; 0,18% Mn and 0,63% Zn.
[1]LAI: leaf area index; LI: light interception (%); SPAD: spad index; Root: root density (mg/cm^3 of DM); FP: forage production in 45 days after foliar fertilization (kg ha^{-1} of DM).
[2] coefficient of variation.

Likewise, all the characteristics evaluated in mulatto II palisadegrass were not influenced (P>0.05) by foliar fertilization (Table 4).

Table 4 - Productive, structural and physiological characteristics during the establishment of mulato II palisadegrass fertilized or not with foliar fertilizer*

Variable[1]	*Days after fertilization*	*Foliar fertilization*		*CV*	*p-value*
		Yes	*No*		
LAI	*15*	*4,99*	*4,79*	*5,00*	*0,2920*
LAI	*45*	*5,01*	*6,29*	*44,46*	*0,4970*
LI	*15*	*98,20*	*98,10*	*0,38*	*0,7216*
LI	*45*	*78,12*	*91,22*	*20,50*	*0,3270*
SPAD	*15*	*39,89*	*41,56*	*14,61*	*0,7052*
SPAD	*45*	*31,48*	*32,48*	*22,52*	*0,8508*
Root	*15*	*1,37*	*1,37*	*22,76*	*0,9998*
Root	*45*	*3,65*	*3,19*	*16,23*	*0,2836*
FP	*1 a 45*	*7817*	*8175*	*56,69*	*0,9147*

** 2 kg ha-1 de FH PASTAGEM FOLIAR: 14% N; 12% P; 12% K; 0,38 % Mg; 10,2% S; 0,24% Cu; 0,18% Mn and 0,63% Zn.*
[1]LAI: leaf area index; LI: light interception (%); SPAD: spad index; Root: root density (mg/cm³ of DM); FP: forage production in 45 days after foliar fertilization (kg ha^{-1} of DM).
[2] coefficient of variation.

The characteristics evaluated in Ipyporã palisadegrass were also not influenced (P>0.05) by foliar fertilization (Table 5).

Table 5 - Productive, structural and physiological characteristics during the establishment of ipyporã palisadegrass fertilized or not with foliar fertilizer*

Variable[1]	*Days after fertilization*	*Foliar fertilization*		*CV*	*p-value*
		Yes	*No*		
LAI	*15*	*4,53*	*4,49*	*8,70*	*0,8834*
LAI	*45*	*4,84*	*5,20*	*41,51*	*0,8127*
LI	*15*	*97,62*	*97,42*	*0,83*	*0,7413*
LI	*45*	*83,50*	*83,72*	*20,79*	*0,9860*
SPAD	*15*	*54,66*	*47,17*	*18,20*	*0,2670*
SPAD	*45*	*32,45*	*33,48*	*17,85*	*0,8123*
Root	*15*	*1,25*	*1,86*	*33,18*	*0,1424*
Root	*45*	*3,56*	*5,28*	*36,82*	*0,1857*
FP	*1 a 45*	*6420*	*7184*	*33,03*	*0,6474*

** 2 kg ha-1 de FH PASTAGEM FOLIAR: 14% N; 12% P; 12% K; 0,38 % Mg; 10,2% S; 0,24% Cu; 0,18% Mn and 0,63% Zn.*
[1]LAI: leaf area index; LI: light interception (%); SPAD: spad index; Root: root density (mg/cm³ of DM); FP: forage production in 45 days after foliar fertilization (kg ha^{-1} of DM).
[2] coefficient of variation.

Oliveira et al. (2004) also did not obtain increases in forage mass production in their work with Panicum maximum cv. Tanzania irrigated and fertilized via leaves. However, during the evaluation period, there was no decrease in production or mineral nitrogen deficiency in the plant.

Despite all the advantages that could be obtained with the use of foliar fertilization, the use of the main nutrients via foliar spraying has serious restrictions, as the high concentration of some nutrients can cause the plant's leaves to burn (ROSOLÉM, 1984). However, this fact was not verified in our work.

According to Borkert, Sfredo and Míssio (1987), the use of soluble salts containing nitrogen, phosphorus and potassium concentrations in the foliar fertilizer only allows the administration of low concentrations via the leaves, due to the possibility of burning the leaves. For this reason, several applications of this type of solution are necessary, so that there is a sufficient concentration of nutrients in the plants, capable of significantly increasing their production. In this sense, probably the application of only a single dose of foliar fertilizer performed in our study may have resulted in low nutrient availability for the evaluated forage grasses. In turn, this could explain the absence of effects of foliar fertilization on the evaluated characteristics (Tables 2, 3, 4 and 5).

Another hypothesis for the absence of effects of foliar fertilization on the physiological, productive and structural characteristics of forage grasses concerns the adequate soil fertility in the experimental area (pH in H_2O: 5,6; P: 1,4 (Mehlich-1); K: 250 mg/; : 3,3; : 0,9 e : 0,0 cmolc/; SB= 4,84; V=61%; m = 0%; MO = 2,9 %). Furthermore, fertilization with P_2O_5 via soil was also carried out during planting. It should also be considered that, during conventional soil preparation (plowing and harrowing), there is a stimulus for the rapid mineralization of organic matter, which also increases the availability of nutrients in the soil for the plant (ARGEL et al., 2007). These factors combined may have nullified the effect of the foliar fertilizer, due to the high content of nutrients in the soil (SOUZA et al., 1997), which probably met the productive requirements of these grasses of the genus *Urochloa*.

Another fact that may have caused the absence of foliar fertilization in the characteristics of grasses of the *Urochloa* genus was the more advanced stage of development of forage canopies at the time the foliar fertilizer was applied. On this occasion, most of the leaf blades were fully expanded and, therefore, in a more planophilic arrangement (smaller leaf angle). This leaf architecture allowed most of the fertilizer to be in contact with the ventral face of the leaf blades. This may have limited the absorption of some microminerals, as their greatest absorption occurs via the dorsal surface of the leaves (MALAVOLTA, 2006).

There are research studies in which foliar fertilization resulted in positive effects on forage production. However, most of these works were conducted in established pastures. For example, according to Pietroski et al. (2015), in their work with foliar nitrogen fertilization in Mombaça grass (*Panicum maximum* cv. Mombaça), the foliar application of nitrogen resulted in increased forage production, green color index and N accumulation, therefore, an important complementary practice to nitrogen fertilization of the soil. It is important to emphasize that the best soil fertility conditions in the experimental area of the work by Pietroski et al. (2015), together with the highest doses of nutrient applied via the foliar (0, 15, 30, 45 and 60 kg ha^{-1} of N) may have favored the occurrence of positive effects of the foliar fertilizer.

On the other hand, in the work by Trivelin et al. (1988), with foliar fertilization in sugarcane establishment, with urea solution (26% N) applied 30 days after planting on both sides of the leaf (abaxial and adaxial face), when the plants already presented beginning of tillering, there were no positive effects on plant growth. The result of Trivelin et al. (1988) is similar to the results obtained in our study.

The lack of consistency in the effects of foliar fertilization on forage plants is due, in part, to the high variability in the physicochemical characteristics of the soils, soil management and the concentration of nutrients in the applied foliar fertilizer. Therefore, there is a need to develop more research on the subject, to better understand the effects of foliar fertilization on forage plants.

Conclusion

Foliar fertilization with FH FOLIAR PASTURE fertilizer (14% N; 12% P; 12% K; 0.38% Mg; 10.2% S; 0.24% Cu; 0.18% of Mn and 0.63% of Zn) during plant establishment has no effect on physiological, productive and structural responses of marandu, mavuno, mulatto 2 and Ipyporã grasses.

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Keywords: Root Density, Leaf area index, Spad index, Forage production, *Urochloa*.

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