BIA
BOLETIM DE INDÚSTRIA ANIMAL

FORRAGICULTURA E PASTAGENS

MORPHOLOGICAL CHARACTERISTICS AND PRODUCTION OF XARAES AND ZURI GRASS FERTILIZED WITH COMBINATIONS OF SULFUR AND POTASSIUM

Lucas Gimenes Mota,
Universidade Federal de Mato Grosso, Cuiabá, MT, Brazil,
https://orcid.org/0000-0003-2820-8922
Corresponding author:
lucasgimenesmota@hotmail.com

Pedro Emanuel da Costa Lourenço,
Universidade Federal de Viçosa, Viçosa, MG, Brazil,
https://orcid.org/0000-0001-6948-7628

Luiz Jardel Müller Motta,
Universidade Federal de Mato Grosso, Cuiabá, MT, Brazil,
https://orcid.org/0000-0002-6753-8847

Aline Müller Motta,
Universidade Federal de Rondonópolis, Rondonópolis, MT, Brazil,
https://orcid.org/0000-0003-1856-822X

Jenifer Santos de Mattos,
Universidade Federal de Rondonópolis, Rondonópolis, MT, Brazil,
https://orcid.org/0000-0002-2065-2554

Carla Heloisa Avelino Cabral,
Universidade Federal de Rondonópolis, Rondonópolis, MT, Brazil,
https://orcid.org/0000-0002-5385-1947

Carlos Eduardo Avelino Cabral,
Universidade Federal de Rondonópolis, Rondonópolis, MT, Brazil,
https://orcid.org/0000-0002-8318-9552

Received: 23/10/2020
Approved: 19/11/2021

Abstract

Sulfur and potassium are essential elements for the development of forages as part of protein synthesis, nutrient transport, activation of photosynthesis enzymes and stomatal activity. Thus, this study aimed was to evaluate the production and morphology of Xaraes grass (*Urochloa brizantha* cv. Xaraes) and Zuri grass (*Megathyrsus maximus* cv. Zuri) fertilized with combinations of sulfur (S) and potassium (K) (only S, only K, with S and K, and without both), and identify which of these nutrients should be prioritized in maintenance fertilization. Two experiments were conducted in the greenhouse, in a completely randomized design. The first experiment was utilized the Xaraes grass and the second experiment the Zuri grass. Each experimental plot consisted of 5 dm^3 pots with five plants per pot. All treatments were fertilized 200 mg/dm3 per pot with nitrogen. On treatments fertilized with sulfur it were applied ammonium sulfate (21% N and 24% S) as nitrogen supply, thus, it was applied 228 mg/dm^3 of sulfur per plot. On treatments without sulfur, the nitrogen source was urea (46% N). The treatments with potassium were fertilized 100 mg/dm^3 with potassium, utilizing potassium chloride (58% K_2O). The harvest was performed when the plants reached the height of 35 and 75 cm, for xaraes and zuri respectively. For Xaraes grass, the fertilization with S and K in different combinations had a significant effect ($P<0.05$) on forage mass, leaves number and tillers per pot, individual tiller mass, leaf blade, stem + sheath, and dead material, as well as relative forage mass. For Zuri grass, the combinations of S and K showed statistical difference ($P<0.05$) just on leaf blade mass and dead material, and the number of leaves per pot, as well as on relative leaf blade mass. Based on the results obtained in the two experiments, the S and K combination in the maintenance fertilization of xaraes grass improves the forage development, however, S does not increase the productive indexes of zuri grass.

Keywords ammonium sulfate, *Megathyrsus maximus*, tillering, tropical grass, *Urochloa brizantha*

CARACTERÍSTICAS MORFOLÓGICAS E PRODUÇÃO DOS CAPINS-XARAÉS E ZURI ADUBADOS COM COMBINAÇÕES DE ENXOFRE E POTÁSSIO

Resumo

O enxofre e o potássio são elementos essenciais para o desenvolvimento das forrageiras, pois participam da síntese de proteínas, transporte de nutrientes, ativação de enzimas da fotossíntese e atividade estomática. Dessa forma, o objetivo com este estudo foi avaliar a produção e a morfologia dos capins *Urochloa brizantha* cv. Xaraés e *Megathyrsus maximus* cv. Zuri adubados com combinações de enxofre (S) e potássio (K) (somente com S, somente com K, com S e K e sem ambos) e identificar qual destes nutrientes deve ser priorizado na adubação de manutenção. Foram realizados dois experimentos em casa de vegetação, em delineamento inteiramente casualizado. No primeiro experimento foi utilizado o capim Xaraés e no segundo experimento o capim Zuri. Cada parcela experimental consistiu em vasos de 5 dm^3 com cinco plantas em cada vaso. Todos os tratamentos foram adubados com nitrogênio na dose de 200 mg/dm^3 por vaso. Nos tratamentos que houve aplicação de enxofre, utilizou-se sulfato de amônio (21%N e 24% S) como fonte de nitrogênio, dessa forma, aplicou-se de 228 mg/dm^3 de enxofre por vaso. Nos tratamentos com ausência de enxofre a fonte de nitrogênio utilizada foi a ureia (46% N). Os tratamentos com presença de potássio foram adubados com a dose de 100 mg/dm^3 por vaso de potássio, na forma de cloreto de potássio (58% K_2O). O corte foi realizado quando as plantas atingiram a altura de 35 e 75 cm, respectivamente, para o capim-xaraés e capim-zuri. No capim-xaraés, a adubação com S e K em combinações diferentes tiveram efeito significativo ($P<0,05$) na massa de forragem, número de folhas e de perfilhos por vaso, massa seca de cada perfilho, lâmina foliar, de colmo+bainha e de matéria morta; bem como na massa de forragem relativa. No capim-zuri, as combinações de S e K apresentaram diferença estatística ($P<0,05$) apenas para as variáveis massa seca de lâmina foliar, de matéria morta e número de folhas por vaso, bem como na massa relativa de lâminas foliares. Com base nos resultados obtidos nos dois experimentos a combinação de S e K na adubação de manutenção do capim-xaraés promove o desenvolvimento do capim, contudo, o S não incrementa os índices produtivos do capim-zuri.

Palavras-chave capim tropical, *Megathyrsus maximus*, perfilhamento, sulfato de amônio, *Urochloa brizantha*

INTRODUCTION

In tropical region, grasses with C4 photosynthetic metabolism shows a great forage mass production, which favors the development of pasture livestock in Brazil, given that pasture is the cheapest basal food used in beef cattle systems and contributes significantly to the animal's nutrition, as long as it is well managed. Among a large variety of grasses available are the cultivars *Megathyrsus maximus* BRS Zuri (COSTA et al., 2020) and *Urochloa brizantha* cv. Xaraes (SILVA et al. 2016), which are grasses with a high capacity for forage mass production. However, in Brazilian Cerrado soils, the productivity of these grasses can be reduced due to the low availability of phosphorus and high acidity levels (REZENDE et al., 2016), which contribute to pasture degradation.

Nitrogen, phosphorus and potassium supply and other nutrients are essential for the proper plant development. In established pastures, nitrogen is the most used nutrient in fertilization, as it increases the forage mass, changes the growth rate and is one of the most extracted by grasses (MARTUSCELLO et al., 2016; GALINDO, et al., 2018). However, when the fertilization planning is carried out exclusively with nitrogen, it becomes important to verify which is the next limiting nutrient for grass development, to optimize production and improve forage quality.

Then, the nutrient most extracted by the plant is potassium, thus, replacement in the system becomes important (BACKES, et al., 2018; GALINDO et al., 2018). Potassium has a fundamental role in plant nutrient transport, activation of photosynthesis enzymes and stomatal activity (HAFSI et al., 2014). Because of this, in the *Urochloa hybrid* cv. Mulate II grass, potassium promotes more tillers and leaves production by the plant, which causes the occurance of forage accumulation (CABRAL et al., 2017). Bonfim-Silva et al. (2018) observed an increase in leaves number and mass produced by *Urochloa brizantha* cv. BRS Piata submitted to potassium doses associated with nitrogen. Furthermore, fertilization with potassium associated with nitrogen increases the potassium concentration in the leaf of *Urochloa brizantha* cv. BRS Piata (MORAIS et al., 2016) and crude protein in *Urochloa brizantha* cv. Xaraes (OLIVEIRA et al., 2017).

In addition to potassium, it is important to evaluate sulfur levels found in the soil, as this nutrient is important for the synthesis of some amino acids. Sulfur is

one of the essential elements for plant, participating in amino acids synthesis and proteins (MAZID et al., 2011). Soil sulfur deficiency can lead to reduced production and affect nitrogen use efficiency (SANTOS et al., 2019). Among the effects observed in response to sulfur fertilization in poor soils, there is an increase in production, tillering, root growth, which allows the plant to explore a large soil volume and, consequently, absorb more nutrients (SCHMIDT & MONTEIRO, 2015). Santos et al. (2019) observed an increase in the leaf: stem ratio of *Urochloa brizantha* cv. BRS Piata, in increasing sulfur levels and reported that this effect is associated with protein synthesis and leaf expansion provided by sulfur. Thus, for grasses to respond to their productive potential, these nutrients must be available in adequate amounts.

Thus, this study aimed to evaluate productive response and morphological characteristics of *Urochloa brizantha* cv. Xaraes and *Megathyrsus maximus* cv. BRS Zuri fertilized with potassium and sulfur in different combinations and verify which of these nutrients should be prioritized in maintenance fertilization. As potassium is extracted more than sulfur, it was expected that potassium fertilization absence compromises grass development more than sulfur absence.

MATERIAL AND METHODS

Experimental area, experimental design and treatments

Two experiments were carried out in a greenhouse, at the Federal University of Rondonópolis, Mato Grosso State, Brazil, in a completely randomized design consisting with 4 treatments. Treatments consisted of four maintenance fertilization strategies: only with sulfur (S), only with potassium (K), with sulfur and potassium (SK), and without sulfur and potassium (without SK, control).

Experiment 1 was carried out with xaraes grass (*Urochloa brizantha* [*Hochst. ex A. Rich.*] *Stapf* cv. Xaraes) with five replications and experiment 2 with zuri grass (*Megathyrsus maximus* [(*Jacq.*) *B.K. Simon & S. W. L. Jacobs] Jacobs* (*syn. P. maximum Jacq.*) cv. BRS Zuri) and three replicates. In both experiments, each experimental plot consisted of a 5.0 dm^3 pot with Oxisol. Before being transferred to pots, the soil was sieved in a 4 mm mesh (Table 1). For daily irrigation, the gravimetric method was used (CABRAL et al., 2018) to keep the soil at maximum field capacity.

At seeding, it was fertilized with phosphorus at a dose of 300 mg/dm^3 per pot,

Table 1 - Chemical characterization of Oxisol used in the experiments

pH	P	K	S	Ca	Mg	Al	H+Al	O.M	SB	CTC	V	m
$CaCl_2$	mg/dm³			$cmol_c/dm^3$				g/kg	$cmol_c/dm^3$		%	
6.0	3.4	119.0	1.0	2.3	2.0	0.0	1.7	23.0	4.6	6.3	73.0	0.0

using triple superphosphate (41% P_2O_5). Twenty seeds per pot were implanted and after emergence, thinning was carried out, leaving five plants per pot. After thinning, it was fertilized with nitrogen at a dose of 100 mg/dm³ per pot, using urea. Thirty days after sowing, the uniformity cut and implantation of treatments were carried out. All treatments were fertilized with nitrogen at a dose of 200 mg/dm³ per pot. For the treatments that received sulfur, ammonium sulfate (21%N and 24%S) was used as a nitrogen source, thus, the fertilization of 200 mg/dm³ of nitrogen in the sulfur treatments resulted in the application of 228 mg/dm³ of sulfur per pot. In treatments without sulfur, the nitrogen source used was urea (46% N), applying 200 mg/dm³ per pot. The treatments with the presence of potassium were fertilized with a dose of 100 mg/dm³ per pot of potassium, in the form of potassium chloride (58% K_2O).

The harvest was performed when the plants reached the height of 35 and 75 cm (COSTA and QUEIROZ, 2017), respectively, for xaraes and zuri grass. At each harvest, nitrogen fertilizers (ammonium sulfate and urea) and potassium were reapplied, so that three evaluations were carried out, with an average interval of 20 days.

Measurements and statistical analysis

After the plants reached the harvesting height, the number of tillers (n°/pot) was counted and forage mass was collected, respecting the residue height. In order not to compromise regrowth, the residue height of 15 and 30 cm was determined for *Urochloa brizantha* and *Megathyrsus maximus*, respectively (EUCLIDES et al., 2014).

After harvesting the plants, the morphological components were separated into leaf blade, stem+sheath, and dead material. Leaves total number (n°/pot) were counted and the material was sent to drying in an air circulation oven at 55±5°C for 72 hours. After drying, all plant material were weighed. Forage mass (g/pot) was obtained by adding the leaf blade mass, stem + sheath, and dead material. Individual tiller mass (g/tiller) was obtained by dividing forage mass and tillers number.

Individual leaf mass (g/leaf) was estimated by the ratio between the leaf blade mass and leaves number. Leaf appearance rate (leaf/day) was estimated by dividing the leaves number per tiller and the interval between evaluations. Phyllochron (days/leaf) was obtained by the inverse of the leaf appearance rate. Relative forage mass was calculated by the forage mass ratio of each treatment compared to the treatment with the highest production and relative leaf blade mass was calculated by the leaf blade mass ratio of each treatment compared to the treatment with the highest leaf blade mass.

For statistical analysis, the cuts were admitted as a random effect in the variance analysis, and to compare the averages, the Tukey test was used, at 5% probability of error, for this, the SISVAR software was used (FERREIRA, 2019).

RESULTS AND DISCUSSION

Experiment 1 – *Urochloa brizantha* cv. Xaraes

Fertilization with sulfur and potassium in different combinations had no significant effect (P>0.05) on each leaf dry mass, number of leaves per tiller, leaf appearance rate and phyllochron of xaraes grass (Table 2). However, there was a difference between treatments in grass forage mass (P<0.05).

Treatment that received only potassium had a similar forage mass (P>0.05) to the treatment that received only sulfur and to the treatment with sulfur and potassium, which obtained greater mass (P<0.05). Even though grasses submitted to

Table 2 - Forage mass (g/pot), individual leaf mass (g/leaf), individual tiller mass (g/tiller), leaves number (n°/pot) and tillers (n°/pot), number of leaves leaves per tiller, leaf appearance rate (leaf/day) and phyllochron (days/leaf) of xaraes grass fertilized with combinations of sulfur and potassium

Variables	Treatments				SEM
	S	K	SK	Without SK	
Forage mass	22.28b	24.14ab	27.09a	17.48c	1.1068
Individual leaf mass	0.22a	0.20a	0.22a	0.20a	0.0119
Individual tiller mass	0.37b	0.46a	0.49a	0.38b	0.0189
Leaves number	102.4ab	109.8a	118.4a	81.26b	6.0857
Tillers number	66.7a	61.8ab	66.5a	53.5b	2.5182
Number of leaves per tiller	2.02a	2.23a	2.35a	1.91a	0.1343
Leaf appearance rate	0.13a	0.14a	0.15a	0.12a	0.0089
Phyllochron	7.84a	6.80a	6.62a	8.02a	0.4475

Means followed by the same letter, in the line, do not differ by Tukey's test (P>0.05)
*SEM= standard error of the average

fertilization only with potassium and only sulfur obtained similar forage mass (P>0.05), the forage mass of xaraes grass fertilized only with sulfur was lower when compared to the treatment fertilized with sulfur and potassium (P<0.05), which demonstrates that the sulfur absence promoted greater limitation than the potassium absence.

This effect is explained by the synergism that occurs between potassium and other nutrients since it is a nutrient involved in several reactions in plant physiology, which includes enzymatic activation. In the assimilation of sulfur, potassium activates an enzyme that participates as an enzyme activator in cysteine synthesis (Yang et al., 2007) and therefore, the synergism when these two nutrients were used. Similarly, potassium is also able to increase the efficiency of nitrogen functions in the plant, thus, when potassium is associated with nitrogen fertilization, there is an increase in the production of forage mass (MORAIS et al., 2016).

In sulfur and potassium absence, there was a lower forage mass (P<0.05), which can be explained by the smaller leaves and tillers number (Table 2). Promising effect of sulfur on tillering was observed by Schmidt & Monteiro (2015) researching with *Megathyrsus maximus Jacq*. cv. Tanzania and by Cabral et al. (2020), who fertilized several types of grass with ammonium sulfate, the same source used in this study, observed positive responses in the number of tillers in relation to fertilization performed with urea. Potassium also changes the leaves emission and tillers, as Cruz et al. (2021) observed an increase in leaves number of *Urochloa brizantha* cv. Paiaguás performing fertilization with increasing levels of potassium and Cabral et al. (2017) verified an increase in tillers number of Mulato II cultivar, a hybrid of *Urochloa* spp.

Omission of these two nutrients can result in significant losses in forage mass, as observed in this study and reported by Prado et al., (2011). Sulfur is essential for the synthesis of some proteins (PAIVA & NICODEMO, 1994) and, therefore, an increase in forage mass production (P<0.05) can be observed in the treatment with sulfur alone when compared to the control treatment (Table 2). Rosado et al. (2016), evaluating nitrogen fertilization with three different sources (urea, ammonium sulfate and calcium nitrate), observed that *Megathyrsus maximus* cv. "Mombaça" obtained a response of 13.6% more in production when they used ammonium sulfate compared to the treatment that received urea. As for potassium, the importance was highlighted by Bonfim-Silva et al. (2018), who observed increasing production responses of

Urochloa brizantha cv. Piata at different doses of potassium associated with nitrogen.

Tillers number per pot were similar (P>0.05) among the treatments that received fertilization (Table 2), however, the fertilization only with potassium was similar to the treatment without fertilization. This demonstrates that only sulfur is capable of maintaining tillering in fertilization with only one of these nutrients. Thus, although the use of sulfur alone does not maximize the forage mass (Table 2), the promoted tillering is capable of to delay the degradation process, as the tillering is fundamental for the establishment of the plant, for the permanence of the pasture and for that there is a greater proportion of the area of covered soil, which avoids erosion and weed appearance.

Nutrients omission limited the production of leaves by plants, with the treatment without fertilization being the most limiting for the development of leaves (Figure 1). This result is similar to that of Miranda et al. (2017) who observed a smaller leaves number in the omission of these two nutrients. Leaf blade amount present in the plant is highly correlated with the photosynthetic rate, thus, with the increase in leaves number, there is a respective increase in the photosynthetic rate, which positively results in forage mass (MARTUSCELLO et al., 2016; SOUZA et al., 2019).

The leaf blade dry mass (Figure 1) presented the same result as the forage mass, in which the treatment with sulfur and potassium obtained the highest (P<0.05)

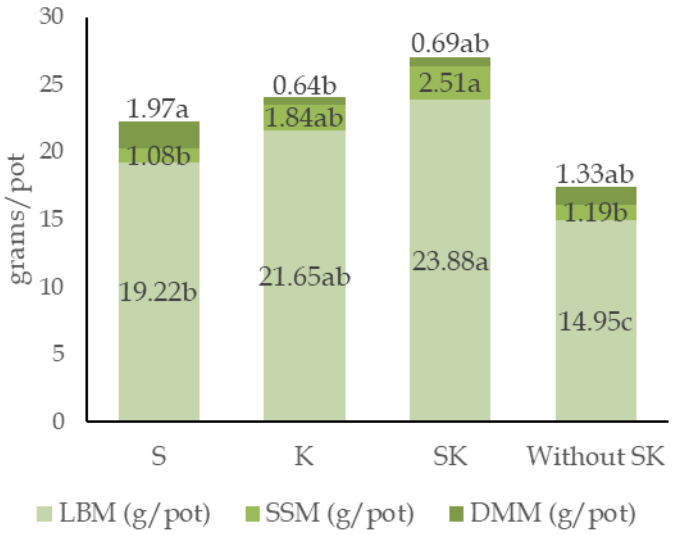

Figure 1 - Leaf blade mass (LBM), stem + sheath (SSM) and dead material (DDM) of xaraes grass fertilized with combinations of sulfur and potassium.
Means followed by the same letter, in the same characteristic, do not differ by Tukey's test (P<0.05)

dry mass and was similar (P>0.05) to treatment with potassium only, which in turn did not differ (P>0.05) from the treatment with sulfur alone. The lowest (P<0.05) leaf blade dry mass was observed in the control treatment, that is, without any fertilization. Sulfur presence in fertilization (S) increased (P<0.05) the leaf blade dry mass in relation to the treatment without fertilization. This result shows the importance of applying sulfur in maintenance fertilization of xaraes grass. Bortoluzzi et al. (2017), performing fertilization with two sources of nitrogen, urea and ammonium sulfate, observed an effect of sulfur supply via ammonium sulfate on the production of leaf blade and shoot dry mass.

Stem + sheath dry mass was higher (P<0.05) in the combined fertilization with sulfur and potassium in relation to the treatments with only sulfur and control, while the treatment with only potassium was equal (P>0.05) to the others treatments (Figure 1). Fertilization with nitrogen and sulfur stimulates the protein synthesis of plant causing it to produce more leaves and anticipate the plant's senescence process causing a greater (P<0.05) presence of dead material (Figure 1) as observed in the treatment with only sulfur compared to that which received only potassium (MARTUSCELLO et al., 2015; ARTUR & MONTEIRO, 2014).

Association of the two nutrients in the fertilization promoted higher (P<0.05) relative forage mass (Figure 2), not differing (P>0.05) from the treatment with

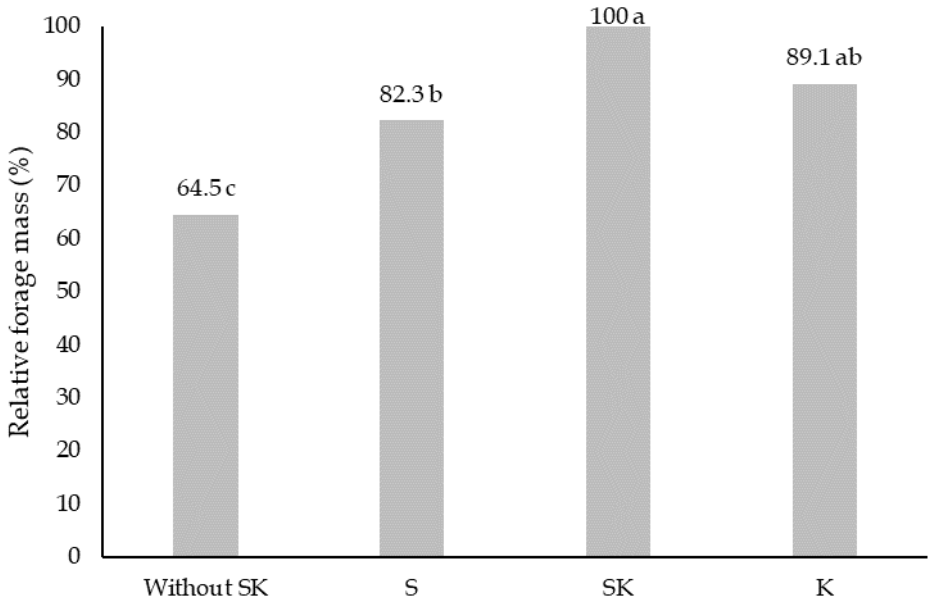

Figure 2 - Relative forage mass of xaraes grass fertilized with combinations of sulfur and potassium

Means followed by the same letter do not differ by Tukey test (P>0.05)

potassium alone. This, in turn, was similar (P>0.05) also to the treatment with only sulfur, which presented intermediate relative forage mass. Finally, the control treatment showed the lowest (P<0.05) relative forage mass, showing that sulfur and potassium are two important nutrients for maintenance fertilization of Xaraes grass.

Thus, it is essential to carry out the fertilization of potassium associated with nitrogen with a sulfur source. However, it is necessary to performe the economic analysis of fertilizer with sulfur, as ammonium sulfate is a more expensive product. In addition, the omission of these two nutrients (control treatment) can result in low productivity of xaraes grass, which can result in limited forage production, since a 35% reduction (Figure 2) was observed in relation to grass fertilized with the two nutrients (SK).

Experiment 2 – *Megathyrsus maximus* cv. Zuri

Sulfur and potassium combinations in fertilization of zuri grass showed statistical difference (P<0.05) only for the variables leaf blade mass, dead matter dry mass and number of leaves per pot. The treatments did not influence (P>0.05) forage mass, stem + sheath, individual leaf mass and tiller, tillers number, number of leaves per tiller, leaf appearance rate and phyllochron (Table 3).

Leaf blade mass in the treatment receiving only sulfur fertilization was similar (P>0.05) to the treatment with the omission of the two nutrients. However, greater leaf

Tabela 3 - Forage mass (g/pot), leaf blade mass (g/pot), stem + sheath (g/pot), dead matter (g/ pot), individual leaf mass (g/leaf), individual tiller mass (g/tiller), leaves number (n°/pot) and tillers (n°/pot), number of leaves per number of tillers, leaf appearance rate (leaf/day) and phyllochron (days/leaf) of xaraes grass fertilized with combinations of sulfur and potassium

Variable	Treatments				SEM
	S	K	SK	Withou SK	
Forage mass	11.27a	12.65a	12.58a	9.97a	0.7169
Leaf blade mass	9.45b	12.65a	12.58a	8.62b	0.7374
Stem + sheath mass	0.12a	0.00a	0.00a	0.40a	0.1055
Dead matter mass	1.69a	0.00b	0.00b	0.95ab	0.3034
Individual leaf mass	0.158a	0.174a	0.162a	0.153a	0.0120
Individual tiller massa	0.217a	0.245a	0.248a	0.187a	0.0317
Number of leaves	59b	75ab	82a	56b	5.4826
Tillers number	49a	46a	50a	47a	3.3842
Number of leaves per tiller	1.31a	1.60a	1.88a	1.16a	0.2251
Leaf appearance rate	0.087a	0.107a	0.125a	0.077a	0.0150
Phyllochron	14.38a	9.43a	8.81a	14.85a	1.7893

Means followed by the same letter, in the line, do not differ by Tukey's test (P>0.05)
*SEM= standard error of the mean

blade mass was observed for treatments fertilized only with potassium (K) and with sulfur and potassium (SK) (Table 3). Thus, the importance of potassium for the development and production of leaf blade by the plant is evidenced. Hojo et al. (2011) obtained lower shoot mass production by subtracting potassium in the fertilization of *Megathyrsus maximus* Jacq. cv. Tanzania in relation to fertilization with all nutrients supply.

Leaves number were reduced ($P<0.05$) when there was omission of potassium in the fertilization, as observed in the treatments that received only sulfur (S) and without the two nutrients (without SK), compared to the treatment fertilized with both (SK). Avalhaes et al. (2009) observed that when potassium fertilization was not carried out, leaves number of elephant grass (*Pennisetum purpureum* cv. Mott) reduced in relation to the treatment with all nutrients supply.

There were no difference ($P>0.05$) between treatments in tillers number. Souza et al. (2007) did not observe the influence of potassium doses on the tanzania grass tiller population (*Megathyrsus maximus* Jacq. cv. Tanzania), in addition, they also did not observe any effect on the leaf/stem ratio.

Similar to Experiment 1, leaf appearance rate and phyllochron in zuri grass were also not influenced ($P>0.05$) by treatments (Table 3). In general, the leaf appearance rate and the phyllochron are more associated with the availability of nitrogen for plant, as in the present research only the nitrogen source was varied (ammonium sulfate in the treatments with sulfur and urea in the treatments without sulfur) and not the dose (200 mg/dm^3), there was no effect on these two variables (PEREIRA et al., 2011; CABRAL et al., 2020).

Treatments with both nutrients and only with potassium had higher ($P>0.05$) relative leaf blade mass (Figure 3) and the control and sulfur treatments had lower ($P>0.05$) relative mass. In general, it is observed that the potassium removal from maintenance fertilization of zuri grass results in less development of plant structure, having a significant effect in reducing leaves number. In addition, it can be seen that the zurigrass pots that received only sulfur produced 25% less leaf blade mass compared to treatments that received potassium (Figure 3).

Thus, it is noteworthy that fertilization with potassium is essential to increase the productive efficiency of the grasses studied, represented by two distinct species (*Urochloa brizantha* and *Megathyrsus maximus*). Therefore, the inclusion of potassium

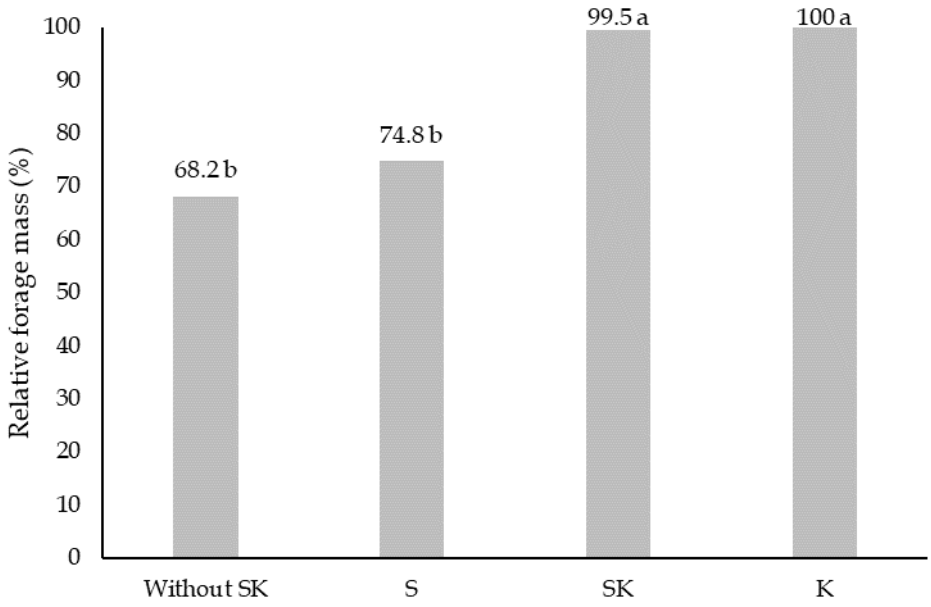

Figure 3 - Relative forage mass of zuri grass fertilized with combinations of sulfur and potassium

Means followed by the same letter do not differ by Tukey test (P>0.05)

should be prioritized in relation to sulfur in the fertilization of forage grasses and the sulfur absence compromised the development of xaraes grass more than that of zuri grass.

CONCLUSION

Potassium and sulfur combination in maintenance fertilization of xaraes grass promotes grass development. Sulfur does not increase the productive indexes of zuri grass. Potassium suppression in fertilization is a more limiting factor for grass development than sulfur.

REFERENCE

ARTUR, A.G.; MONTEIRO, F.A. Marandu palisadegrass growth and nutrient accumulation as affected by nitrogen and sulfur fertilizations. **Australian Journal of Crop Science,** v.8, p.422–429, 2014.

BACKES, C.C.; SANTOS, A.J.M.; BESSA, S.V.; RIBON, A.A.; TEODORO, A.G.; RODRIGUES, L.M.; TOMAZELO, L.L.; LEITE, L.L.F. Taxa de cobertura verde e exportação de macronutrientes pelo capim Marandu em função da aplicação de gesso. **Archivos de Zootecnia,** v.67, p.234-242, 2018. https://doi.org/10.21071/az.v67i258.3659

BONFIM-SILVA, E.M.; MORAIS, L.P.V.C.; PACHECO, A.B.; SILVA, T.J.A.; SOUSA, H.H.F.; SANTOS, E.S.E.; BÄR, C.S.L.L. Interaction between nitrogen and potassium in fertilization of the piatã grass (*Urochloa brizantha*): productive and phytometric

characteristics. **Australian Journal of Crop Science,** v.12, p.1122-1128, 2018. https://doi.org/10.21475/ajcs.18.12.07.PNE1048

BORTOLUZZI, F.M.; CABRAL, C.E.A.; MACHADO, R.A.F.; ABREU, J.G.; CABRAL, C.H.A.; BARROS, L.V. Fosfato natural reativo aplicado em épocas distintas e associado a fertilizantes nitrogenados afetam a produção de capim-marandu. **Boletim de Indústria Animal,** v.74, p.9-16, 2017. https://doi.org/10.17523/bia.v74n1p9

CABRAL, C. E. A.; CABRAL, L. S.; BONFIM-SILVA, E. M.; CARVALHO, K. S.; ABREU, J. G.; CABRAL, C. H. A. Reactive natural phosphate and nitrogen fertilizers in Marandu grass fertilization. **Comunicata Scientiae,** v. 9, p. 729–736, 2018. https://doi.org/10.14295/CS.v9i4.1170

CABRAL, C. E. A.; PESQUEIRA-SILVA, L. C. R.; BARROS, L. V.; BEHLING NETO, A.; ABREU, J. G.; CABRAL, C. H. A.; SILVA, F. G.; GALATI, R. L.; FIORI, A. M. R.; SILVA JUNIOR, C. A. Defoliation height and potassium fertilization of Mulato II grass. **Semina: Ciências Agrárias,** v.38, p.2719-2726, 2017. https://doi.org/10.5433/1679-0359.2017v38n4Supl1p2719

CABRAL, C.E.A.; CABRAL, C.H.A.; SANTOS, A.R.M.; CARVALHO, K.S.; BONFIM-SILVA, E.M.; MOTTA, L.J.M.; MATTOS, J.S.; ALVES, L.B.; BAYS, A.P. Ammonium sulfate enhances the effectiveness of reactive natural phosphate for fertilizing tropical grasses. **Tropical Grasslands-Forrajes Tropicales,** v.8, p.86-92, 2020. https://doi.org/10.17138/TGFT(8)86-92

COSTA, J.A.A.; QUEIROZ, H.P. **Régua de manejo de pastagens – edição revisada.** Campo Grande, MS: Embrapa, 2017, 7p.

COSTA, N.L.; JANK, L.; MAGALHÃES, J.A.; BENDAHAN, A.B.; RODRIGUES, B.H.N.; SANTOS, F.J.S. Forage yield and morphogenesis of Megathyrsus maximus cultivars in Roraimas's savannas. **Research, Society and Development**, v. 9, 2020. https://doi.org./10.33448/rsd-v9i8.6054

CRUZ, C.A.C.; ORIOLI JUNIOR, V.; BERNARDES, J.V.S.; SARGENTIM, M.M.; SILVA, G.A.; KOCHENBORGER, A.C.D. Efficiency of phonolite as a potassium source for Paiaguás palisadegrass. **Pesquisa Agropecuaria Tropical**, v. 51, 2021. https://doi.org./10.1590/1983-40632021v5167857

EUCLIDES, V. P. B.; MONTAGNER, D. B.; BARBOSA, R. A.; NANTES, N. N. Manejo do pastejo de cultivares de *Brachiaria brizantha* (Hochst) e *Megathyrsus maximus* Jacq. **Revista Ceres,** v. 61, p. 808-818, 2014. http://dx.doi.org/10.1590/0034-737x201461000006

FERREIRA, D.F. SISVAR: A computer analysis system to fixed effects split plot type designs. **Revista Brasileira de Biometria**, v.37, p.529-535, 2019. https://doi.org/10.28951/rbb.v37i4.450

GALINDO, F.S.; BUZETTI, S.; TEIXEIRA, M.C.F.; DUPAS, E.; LUDKIEWICZ, M.G.Z. Acúmulo de matéria seca e nutrientes no capim-mombaça em função do manejo da adubação nitrogenada. **Revista de Agricultura Neotropical,** v.5, p.1-9, 2018. https://doi.org/10.32404/rean.v5i3.2132

HAFSI, C.; DEBEZ, A.; ABDELLY, C. Potassium deficiency in plants: effects and

signaling cascades. **Acta Physiologiae Plantarum**, n.36, p.1055-1070, 2014. https://doi.org/10.1007/s11738-014-1491-2

HOJO, R.H.; AVALHÃES, C.C.; VALE, D.W.; PRADO, R.M.; PIMENTEL, U.V. Desempenho do capim-tanzânia cultivado em solução nutritiva com a omissão de macronutrientes. **Scientia Agraria Paranaensis,** v.10, p.63-73, 2011. DOI: https://doi.org/10.18188/sap.v10i2.5538

MARTUSCELLO, J.A.; MAJEROWICZ, N.; CUNHA, D.N.F.V.; AMORIM, P.L.; BRAZ, T.G.S. Características produtivas e fisiológicas de capim-elefante submetido à adubação nitrogenada. **Archivos de Zootecnia,** v.65, p.565-570, 2016. https://doi.org/10.21071/az.v65i252.1927

MARTUSCELLO, J.A.; SILVA, L.P.; CUNHA, D.N.F.V.; BATISTA, A.C.S.; BRAZ, T.G.S.; FERREIRA, P.S. Adubação nitrogenada em capim-Massai: Morfogênese e produção. **Ciência Animal Brasileira,** v.16, p.1-13, 2015. https://doi.org/10.1590/1089-68916i118730

MAZID, M.; KHAN, T.A.; MOHAMMAD, F. Response of crop plants under sulphur stress tolerance: A holistic approach. **Journal of Stress Physiology & Biochemistry**, v.7, p.23-57, 2011.

MIRANDA, R.P.; PIETROSKI, M.; MATOS, F.B.; JUNIOR, G.F.S.; CAIONE, G. Nitrogen, potassium, calcium and súlfur omission in grass Convert. **Comunicata Scientiae,** v.8, p.452-458, 2017. https://doi.org/10.14295/cs.v8i3.2257

MORAIS, L.P.V.X.C.; BONFIM-SILVA, E.M.; PACHECO, A.B.; ABREU, J.G.; SILVA, T.J.A.; POLIZEL, A.C. Nitrogen and potassium in the cultivation of Piatã grass in Brazilian Cerrado soil. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.20, p.984-989, 2016. https://doi.org/10.1590/1807-1929/agriambi.v20n11p984-989

OLIVEIRA, E.M.; OLIVEIRA FILHO, J.C.; OLIVEIRA, R.A.; OLIVEIRA, R.M.; CECON, P.R. Determination of xaraes grass quality submitted to irrigation water levels and nitrogen and potassium doses. **Engrenharia Agrícola**, v.37, p.64-74, 2017. http://dx.doi.org/10.1590/1809-4430-Eng.Agric.v37n1p64-74/2017

PAIVA, P. J. R.; NICODEMO, M. L. F. **Enxofre no sistema solo-planta-animal.** Campo Grande-MS: Embrapa-CNPGC, 1994. 45p.

PEREIRA, V.V.; FONSECA, D.M.D.; MARTUSCELLO, J.A.; BRAZ, T.G.D.S.; SANTOS, M.V.; CECON, P.R. Características morfogênicas e estruturais de capim-mombaça em três densidades de cultivo adubado com nitrogênio. **Revista Brasileira de Zootecnia,** v.40, p.2681-2689, 2011. https://doi.org/10.1590/S1516-35982011001200010

PRADO, R.M.; HOJO, R.H.; AVALHÃES, C.C.; VALE, D.W.; PIMENTEL, U.V. Desempenho do capim tanzânia cultivado em solução nutritiva com à omissão de macronutrientes. **Scientia Agraria Paranaenis,** v.10, p.58-68, 2011. https://doi.org/10.18188/sap.v10i1.5270

REZENDE, C.G.B.; BONFIM-SILVA, E.M.; SILVA, T.J.A.; CABRAL, C.E.A.; SCHLICHTING. Fosfato natural reativo na adubação do capim piatã em Latossolo Vermelho do Cerrado. **Revista Agrarian**, v.9, p.55-62, 2016.

ROSADO, T.L.; GONTIJO, I.; ALMEIDA, M.S.; CHAMBELA NETO, A.; SIMON, C.P. Production and tillering of mombaça grass with different sources and levels of applied nitrogen. **Revista Engenharia na Agricultura**, v.24, p.139-146, 2016. https://doi.org/10.13083/reveng.v24i2.664

SANTOS, L.F.M.; LAPAZ, A.M.; TOMAZ, R.S.; LIRA, M.V.S.; MOREIRA, A.; REIS, A.R.; HEINRICHS, R. Evaluation of sulfur source and dose on the nutritional state and production of piatã forage. **Semina: Ciências Agrárias,** v.40, p.1237-1248, 2019. 10.5433/1679-0359.2019v40n3p1237

SCHMIDT, F.; MONTEIRO, F.A. Sulphur supply affects morphology, growth and nutritional status of Tanzania Guinea grass and Mineirão stylo. **Grass and Forage Science,** v.70, n.3, p.439-450, 2015. DOI: https://doi.org/10.1111/gfs.12122

SILVA, J.L.; RIBEIRA, K.G.; HERCULANO, B.N.; PEREIRA, O.G.; PEREIRA, R.C.; SOARES, L.F.P. Massa de forragem e características estruturais e bromatológicas de cultivares de B*rachiaria* e *Panicum*. **Ciência Animal Brasileira,** v.17, p.342-348, 2016. https://doi.org/10.1590/1089-6891v17i332914

SOUZA, J.T.A.; RAMOS, J.P.F.; COSTA, R.F.; ARAÚJO, D.L.; GUEDES, P.L.C.; FREITAS, R.P.; RIBEIRO, J.E.S.; CAVALCANTE, V.R. Ecofisiologia e rendimento forrageiro do capim elefante roxo em função de adubação nitrogenada. **Archivos de Zootecnia,** v.68, p.464-470, 2019. https://doi.org/10.21071/az.v68i264.4984

SOUZA, M.R.F.; PINTO, J.C.; OLIVEIRA, I.P.; MUNIZ, J.A.; ROCHA, G.P.; EVANGELISTA, A.R. Produção de forragem do capim-tanzânia sob intervalos de corte e doses de potássio. **Ciência e Agrotecnologia,** v.31, p.1532-1536, 2007. http://dx.doi.org/10.1590/S1413-70542007000500039

YANG, Q.; WANG, Y.; ZHANG, J.; SHI, W.; QIAN, C.; PENG, X. Identification of aluminum-responsive proteins in rice roots by a proteomic approach: Cysteine synthase as a key player in Al response. **PROTEOMICS**, v.7, p.737–749 2007. https://dx.doi.org/10.1002/pmic.200600703