Original Article

DOSES OF PHOSPHORUS ON INITIAL DEVELOPMENT AND FORAGE PRODUCTION OF CULTIVARS OF *Panicum maximum*

DOSES DE FÓSFORO NO DESENVOLVIMENTO INICIAL E PRODUÇÃO DE FORRAGEM DE CULTIVARES DE Panicum maximum

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ABSTRACT: Phosphorus shortage in the Savanna is one of the main limiting factors for forage production and directly responsible for the degradation of pastures in this Brazilian region. Thus, the aim of this study was to evaluate the effect of increasing doses of P on the initial development and forage production of four cultivars of *P. maximum*. The experiment was conducted during the months of December 2010 to May 2011 at Universidade Estadual de Mato Grosso do Sul, Unit of Aquidauana-MS. It was used the completely randomized design in a factorial scheme 4x5, with four replications. The experimental unit consists of polyethylene pots with 5 L capacity arranged in countertop in greenhouse. The first factor consisted of four *P. maximum* cultivars (Massai, Mombaça, Áries and Atlas), while the second factor consists of five doses of phosphorus (0, 5, 10, 30 and 45 mg dm^{-3}). It was evaluated the following morphometric traits: plant height, length and width of the leaf blade, number of tillers, dry mass of shoot and of roots at 60 DAS. The approximate dose of 25 mg dm^{-3} of phosphorus provided better initial development and forage production in all cultivars evaluated of *Panicum maximum*. Mombaça cultivar has better initial development and forage production about to the others.

KEYWORDS: Phosphate fertilizer. Morphometric characters. Degraded pastures.

INTRODUCTION

In Brazil, areas with pastures, native or cultivated, occupy around 180 million hectares, and of this total, it is estimated that 40 million hectares are in different stages of degradation (OLIVEIRA et al., 2014). Pastures are the basis of Brazilian livestock, serving as a powerful cost-saving tool, making it essential to rational use and the professional management of pastures, through forage supply of better quality, with balanced protein content, digestibility and fertilization (LIMA et al, 2007).

The region of the Brazilian Savanna contains soils conducive to the establishment of pastures containing favorable physical characteristics, suitable topography and few climate limitations, however, in most cases, has limitations in relation to fertility, standing out among them the low pH and levels of nutrients, especially phosphorus (P) (BENÍCIO et al., 2011).

Guedes et al. (2009), claim that a major problem in establishing and maintaining pastures, on these soils, lies in extremely low levels of P available and P total. These authors add, beyond this natural poverty in P of our soils, the high adsorption capacity of this element, because of its acidity and high levels of iron and aluminum oxides. It is natural that in such circumstances, the phosphorus fertilization is required. Thus arises the need to identify which species and / or cultivars are more responsive to phosphorus fertilization and which have better agronomic performance in low availability conditions of P.

Panicum pastures are from African origin, belonging to the Poaceae family, which constitutes about 81 genera and more than 1460 species. In Brazil, the species *Panicum maximum* is considered one of the most widespread grass, being in area one of the main grasses grown for its high production capacity of dry matter, forage quality, ease of establishment and acceptability by the animals (TORRES et al., 2013).

Research on *P. maximum* response to the application of P in Brazilian soils are incipient and inconclusive (GUEDES et al., 2009). Thus, the aim of this study was to evaluate the effect of increasing

Received: 11/05/16
Accepted: 05/10/16

doses of P on the initial development and forage production of four cultivars of *P. maximum*.

MATERIAL AND METHODS

The experiment was conducted during the months of December 2010 to May 2011 at Universidade Estadual de Mato Grosso do Sul, Unit of Aquidauana-MS, located in the Savanna biome, comprising the coordinates 20º27'S and 55º40'W, and with an average elevation of 170 m. The soil of the area was classified as Ultisol Dystrophic of the sandy texture classified bay Schiavo et al. (2010), and the climate of the region, according to the classification described by Köppen-Geiger, is Aw (Savanna Tropical) with average annual rainfall of 1,200 mm and maximum and minimum temperatures of 33 and 19ºC, respectively.

It was used the completely randomized design in a factorial scheme 4x5, with four replications. The first factor consisted of four *P. maximum* cultivars (Massai, Mombaça, Áries and Atlas), while the second factor consists of five doses of phosphorus (0, 5, 10, 30 and 45 mg dm^{-3}), having as source the single superphosphate (18% P_2O_5, 16% CA and 8% S).

The experimental unit consists of polyethylene pots with 5 L capacity arranged in countertop in greenhouse, which were filled with soil of the region (Table 1) and placed on a wooden bench at 1 m above the ground. In each pot were placed ten seeds at 1 cm depth, being the thinning carried out 15 days after sowing, leaving five plants per pot. The plants were irrigated every day of conducting the experiment in the morning.

Table 1. Soil chemical analysis of the experimental field in the layer 0 to 20 cm.

pH (CaCl)	Ca	Mg	K	Al	H+Al	S	CEC	OM	P	V
---	----------			$cmol_c\ dm^{-3}$	----------			-- $mg\ dm^{-3}$ --		-- % --
4.35	1.01	0.50	0.19	0.29	1.50	1.69	4.47	4.50	9.41	37.81

S: sum of bases; CEC: cation exchange capacity; OM: organic matter; P: Melich.

It was evaluated the following morphometric traits: plant height (PH), length and width of the leaf blade (LLB and WLB, respectively), number of tillers (NT), dry mass of shoot and of roots (DMS and DMR, respectively) at 60 days after sowing. PH, LLB and WLB were determined using a ruler graduated in centimeters, being measured five plants of the plot. The leaves of each plant used for the measurements were marked with a red tape, to ensure the sampling the same sheet. We consider for PH the height measured from ground level to the insertion of the first leaf fully developed of the plant. To measure the LLB, it was considered the length from the ligule to its apex. WLB was measured in the center of the leaf. Subsequently, root and shoot of each plant were collected for the assessment of DMS and DMR, which were dried in an oven at 65ºC by 72 hours.

Data were subjected to analysis of variance and the averages compared by Tukey's test at 5% probability, using the statistical software SAS (SAS INSTITUTE, 1999).

RESULTS AND DISCUSSION

The factors cultivars (C) and doses of P (P) influenced significantly ($p>0.05$) all traits evaluated (Table 2). There was a significant interaction ($p>0.05$) among C x D for the traits PH, WLB and NT, which indicates that the different doses of P assessed differently influence the growth of each cultivar.

Table 2. Summary of the analysis of variance (ANOVA) for the traits plant height (PH), length and width of the leaf blade (LLB and WLB, respectively), number of tillers (NT), dry mass of shoot and of roots (DMS and DMR, respectively) according to different doses of phosphorus (P) and cultivars (C) of *P. maximum*.

SV	DF	PH	LLB	WLB	NT	DMR	DMS
Cultivars (C)	3	782.09*	985.89*	16.33*	917.53*	35.84*	80.50*
Doses of P (P)	4	4460.14*	897.69*	2.37*	366.07*	241.44*	958.03*
C x P	12	40.71*	51.52^{ns}	0.14*	78.45**	12.62^{ns}	22.90^{ns}
Residue	168	5.71	37.98	0.06	3.90	8.34	11.88
Average	---	18.01	13.97	1.66	7.34	8.65	15.59
CV (%)	---	13.27	44.12	15.15	26.91	33.41	22.11

SV: sources of variation; DF: degrees of freedom; CV: coefficient of variation * e ^{ns}: significant at the 5% probability and not significant by F-test, respectively.

It was verified that regardless of the dose of P, cultivars Aries, Mombaça and Massai had the highest values for the traits PH, WLL and NT, respectively (Table 3). This was possibly due to the growth characteristics of each cultivar. According to Oliveira et al. (2014), such differences are depending on morphological characteristics of each cultivar, some have a larger size, as Aries, others have wider leaves, as Mombasa, while others have narrower leaves, lower size and high tillering, as Massai.

Table 3. Average values to the unfolding of significant interaction among cultivars of *Panicum maximum* (C) x doses of P (P) to traits plant height (PH), leaf blade (WLB), number of tillers (NT).

Cultivars	PH (cm)	WLL (cm)	NT
		0 mg dm^{-3}	
Áries	15.58 ab	1.51 b	4.08 b
Atlas	16.05 a	1.40 b	3.14 c
Massai	10.56 c	0.76 c	7.03 a
Mombaça	14.07 b	1.79 a	3.75 c
		5 mg dm^{-3}	
Áries	20.19 a	1.63 b	4.21 b
Atlas	18.86 b	1.70 b	3.03 c
Massai	11.51 c	0.80 c	6.17 a
Mombaça	17.41 b	2.18 a	4.13 b
		15 mg dm^{-3}	
Áries	26.34 a	2.00 b	5.33 c
Atlas	23.40 b	2.09 b	5.44 c
Massai	15.23 c	1.07 c	14.47 a
Mombaça	19.98 b	2.59 a	6.58 b
		30 mg dm^{-3}	
Áries	28.72 a	1.91 b	6.31 b
Atlas	23.69 b	2.07 b	6.06 b
Massai	15.18 d	1.09 c	16.61 a
Mombaça	18.55 c	2.35 a	5.56 c
		45 mg dm^{-3}	
Áries	20.06 a	1.85 a	10.28 b
Atlas	16.03 b	1.64 b	5.50 d
Massai	13.37 c	0.94 c	21.61 a
Mombaça	17.87 b	1.96 a	7.68 c

Averages followed by the same letters on the lines, within each P, do not differ by Tukey's test at 5% probability.

There was a quadratic fit ($p>0.05$) to PH in response to doses of P for all cultivars, being the highest values obtained with the dose approximately 25 mg dm^{-3} of P, with maximum points from 23 to 28 cm (Figure 1). Similar results have been achieved by Rossi and Monteiro (1999), Cecato et al. (2007), Ferreira et al. (2008) and Cecato et al. (2008), who verified that the P provides a linear increase on PH in different cultivars of *P. maximum*.

Just like PH, WLB adjusted to quadratic equations ($p>0.05$) in response to the P, being the highest values obtained with the approximate dose of 25 mg dm^{-3}, with maximum points from 23 to 28 cm (Figure 2). Patês et al. (2007) have found that cell elongation rate has quadratic behavior in *P. maximum* in response to different doses of P, corroborating the results obtained from this study for LLB. According to Oliveira et al. (2014), PH is mainly influenced by cell elongation, while WLB foliar is determined by the number of cell divisions that occur perpendicular to the leaf central leaf. Given these considerations, we can infer that doses of P above 25 mg dm^{-3} decreases leaf elongation (LLB) and, concurrently, the traits PH and WLB.

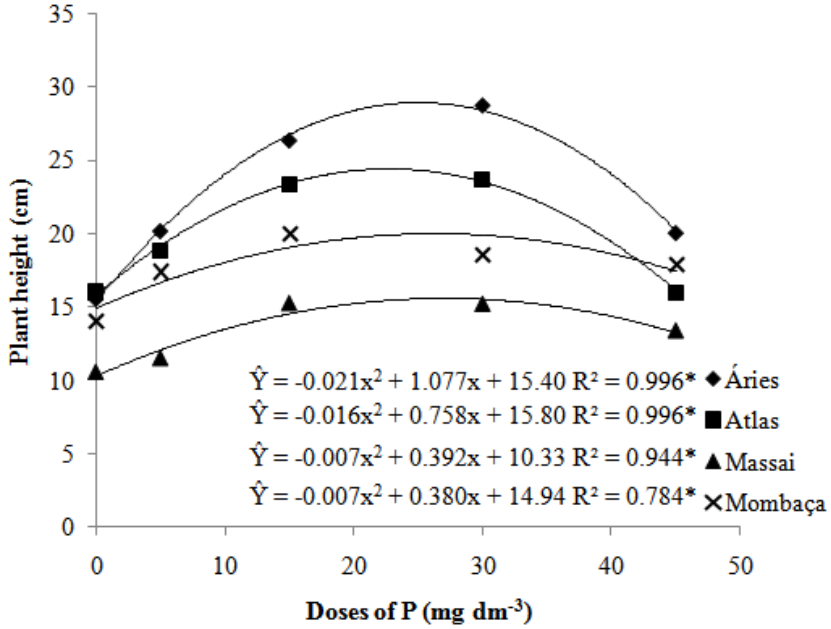

Figure 1. Unfolding of significant interaction among cultivars of *Panicum maximum* (C) x doses of P (P) to plant height (PH).

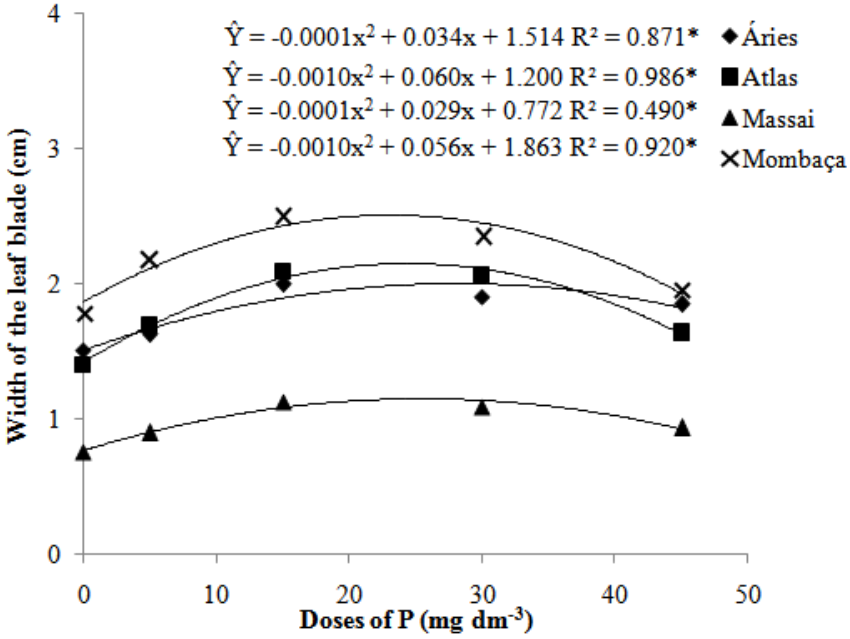

Figure 2. Unfolding of significant interaction among cultivars of *Panicum maximum* (C) x doses of P (P) to the width of the leaf blade (WLB).

The linear increase ($p>0.05$) of NT with the addition of P (Figures 3 and 4) is consistent with the results observed by Patês et al. (2007), Ferreira et al. (2008) and Guedes et al. (2009). These authors emphasize the importance of P for the initial establishment of forage, due to the higher development of roots and, consequently, higher tillering.

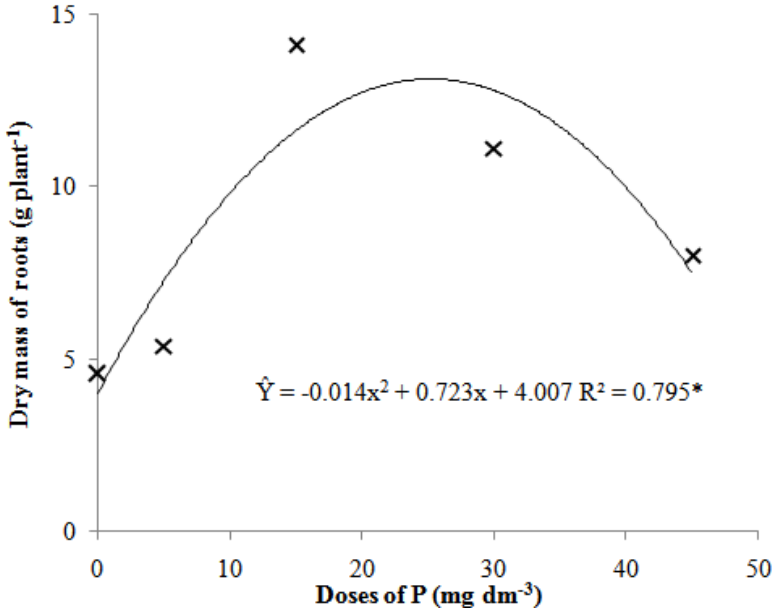

Figure 3. Average values of length of the leaf blade (LLB) in function of doses of P (P) in different cultivars of *Panicum maximum*.

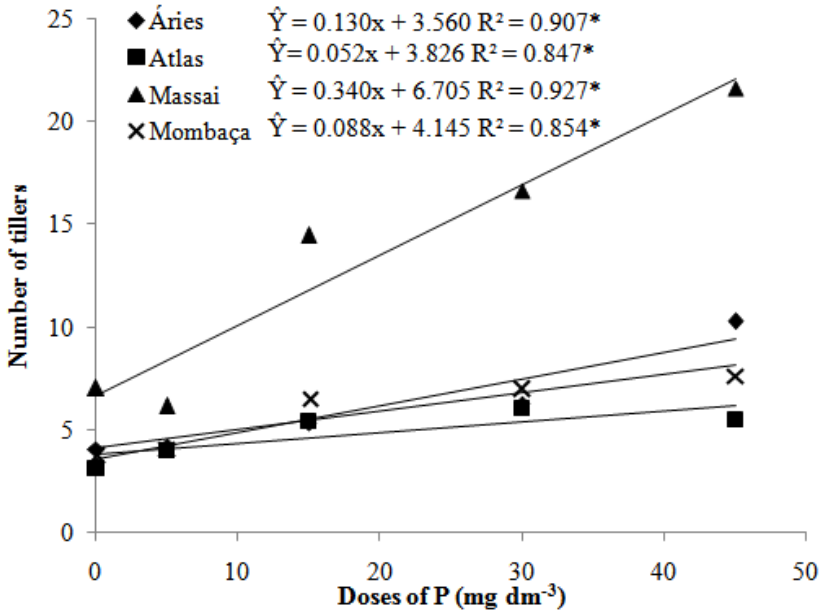

Figure 4. Unfolding of significant interaction among cultivars of *Panicum maximum* (C) x doses of P (P) to number of tillers (NT).

Mombaça obtained the highest values for the traits LLB, DMS and DMR (Table 4), which indicates the better initial development of this cultivar in addition to increasing in forage production compared with other cultivars. Similar results were obtained by Oliveira et al. (2014), who recommend the growing of this cultivar in the Savanna-Pantanal ecotone region.

There were quadratic fits ($p>0.05$) for DMR and DMS in response to doses of P (Figures 5 and 6), corroborating the results obtained by Ferreira et al. (2008) and Guedes et al. (2009). P provides a greater root development; therefore, under optimal conditions of P in the plant, there is a change in root morphology, increasing the lateral roots in number and size, generating increase in the root system of the plant. Moreover, there is increased production of photoassimilates that are redistributed throughout the plant, increasing shoot growth (PATÊS et al., 2007).

Table 4. Average values of length of the leaf blade (LLB), dry mass of roots and shoot (DMR and DMS, respectively) to different cultivars of *Panicum maximum* (C).

Cultivars	LLB (cm)	DMR (g planta^{-1})	DMS (g planta^{-1})
Massai	43.93 b	9.49 a	16.03 ab
Mombaça	48.63 a	9.78 a	17.97 a
Atlas	43.64 b	6.81 b	14.46 b
Áries	43.98 b	8.50 a	13.02 b

Averages followed by the same letters on the lines do not differ by Tukey's test at 5% probability.

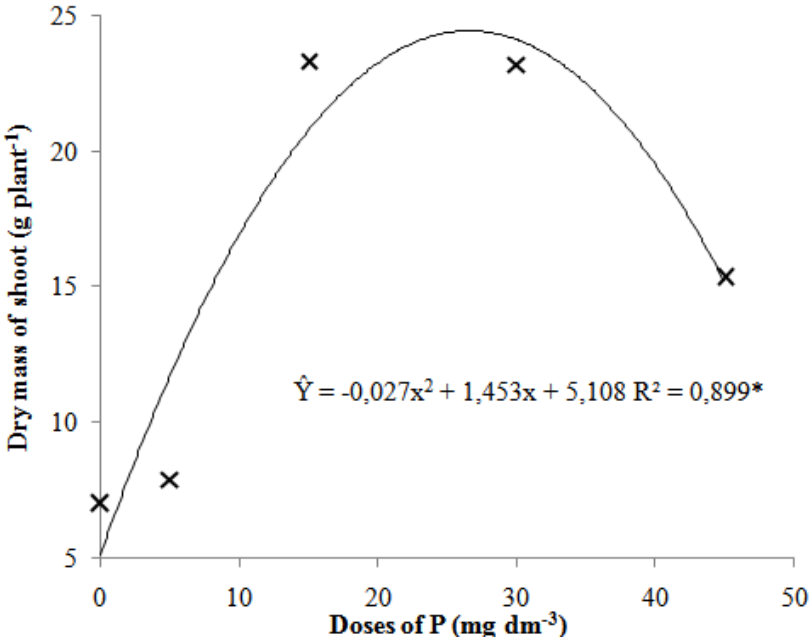

Figure 5. Average values of dry mass of shoot (DMS) in function of doses of P (P) in different cultivars of *Panicum maximum*.

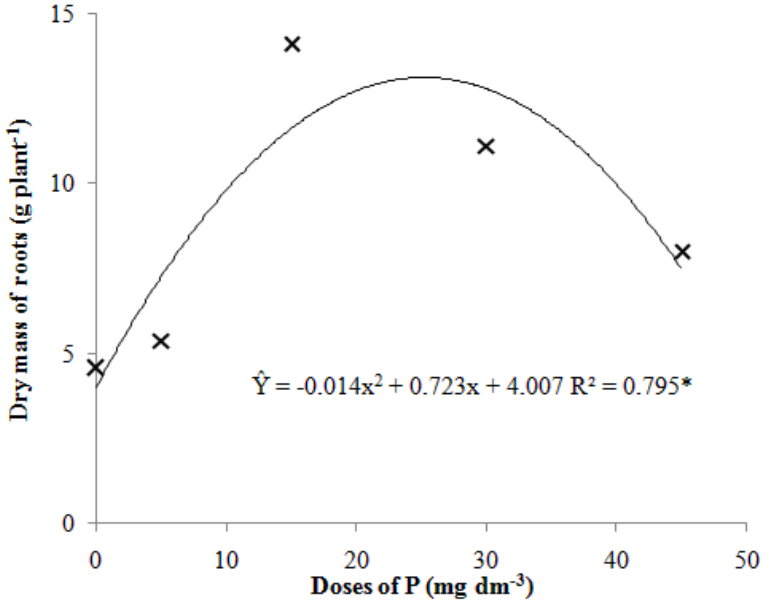

Figure 6. Average values of dry mass of roots (DMR) in function of doses of P (P) in different cultivars of *Panicum maximum*.

Furthermore, is possible to observe in Figures 5 and 6, that from 25 mg dm^{-3} of P there was a decrease in DMS and DMR. This was possibly the high availability of P in small volume of soil, which meant that there was no need for root development of the plant in deeper points for P uptake (LOBATO et al., 1994; BENÍCIO et al., 2011).

CONCLUSIONS

The approximate dose of 25 mg dm^{-3} of phosphorus provided better initial development and forage production in all cultivars evaluated of *Panicum maximum*.

Mombaça cultivar has better initial development and forage production about to the others.

RESUMO: A escassez de fósforo no Cerrado é um dos principais fatores limitantes para a produção de forragem e responsável diretamente pela degradação das pastagens nesta região brasileira. Assim, o objetivo deste trabalho foi avaliar o efeito de doses crescentes de P sobre o desenvolvimento inicial e produção de forragem de quatro cultivares de *Panicum maximum*. O experimento foi conduzido durante os meses de dezembro de 2010 a maio de 2011 na Universidade Estadual de Mato Grosso do Sul, Unidade Universitária de Aquidauana, MS. O delineamento experimental utilizado foi inteiramente casualizado, no esquema fatorial 4x5, com quatro repetições. A unidade experimental consistiu de potes de polietileno com capacidade de 5 L dispostos em bancadas na estufa. O primeiro fator foi composto por quatro cultivares de *P. maximum* (Massai, Mombaça, Áries e Atlas), enquanto o segundo fator consistiu de cinco doses de fósforo (0, 5, 10, 30 e 45 mg dm^{-3}). Foram avaliados os seguintes caracteres morfométricos: altura de plantas, comprimento e largura da lâmina foliar, número de perfilhos, massa seca da parte aérea e das raízes aos 60 dias após a semeadura. A dose aproximada de 25 mg dm^{-3} de fósforo proporcionou melhor desenvolvimento inicial e produção de forragem em todas as cultivares de *Panicum maximum* avaliadas. A cultivar Mombaça apresentou melhor desenvolvimento inicial e produção de forragem em relação às demais.

PALAVRAS-CHAVE: Adubação fosfatada. Caracteres morfométricos. Pastagens degradadas.

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