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ESTABLISHMENT OF MOMBASA GRASS FERTILIZED WITH PHOSPHORUS AND ORGANIC COMPOST SOURCES

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ABSTRACT

The objective of this study was to evaluate the effect of phosphorus sources in the absence and presence of earthworm humus on tillering, forage production and P accumulation of *Panicum maximum* cv. grass Mombasa. The experiment was conducted in 5 dm^3 pots in a greenhouse located at the University of Mato Grosso, Alta Floresta - MT, Brazil. The treatments were arranged in a 4x2 + 1 with four replications, four P sources: simple superphosphate (SS) (18% soluble P_2O_5), Bayovar rock phosphate (BRP) (14% soluble P_2O_5), Top- Phos 280 HP (TP) (28% soluble P_2O_5) and bone meal (BM) (9.6% soluble P_2O_5), in the absence and presence of earthworm humus, and the control treatment (no P). At 46 days after emergence (DAE) the number of tillers were counted and at 46, 65 and 80 DAE cuts were made to evaluate the accumulation of dry matter and P accumulation. Application of the phosphorus sources, simple superphosphate and bone meal associated with earthworm humus resulted in higher dry matter accumulation of Mombasa grass and higher total phosphorus accumulation in the three cuts, in relation to isolated application of these phosphorus sources. The presence of humus did not influence tillering of the grass however more soluble sources promoted greater tillering.

Key words: Phosphate fertilizer; pasture fertilization; earthworm humus; *Panicum maximum*

ESTABLECIMIENTO DE PASTO MOMBASA FERTILIZADO CON FUENTES DE FÓSFORO Y COMPUESTO ORGÁNICO

RESUMEN

El objetivo de este trabajo fue evaluar el efecto de fuentes de P en la ausencia y presencia de lombricompuesto sobre el macollaje, la producción de forraje y la acumulación de P del pasto *Panicum maximum* cv. Mombasa. El experimento fue realizado en vasos de 5 dm^3 en invernadero localizada en la Universidad del Estado de Mato Grosso, Alta Floresta-MT, Brasil. Los tratamientos fueron ordenados en esquema factorial 4x2 + 1 con cuatro repeticiones, siendo cuatro fuentes de P: superfosfato simple (SS) (18% de P_2O_5 soluble), fosfato natural de Bayóvar (FNB) (14% de P_2O_5 soluble), Top- Phos 280 HP (TP) (28% de P_2O_5 soluble) y harina de huesos (FO) (9,6% de P_2O_5 soluble); en ausencia y en presencia de lombricompuesto, y un tratamiento control (sin P). A los 46 días después de la emergencia (DAE) se contó el número de macollos y a los 46, 65 y 80 DAE se realizaron tres cortes para la evaluación de la acumulación de materia seca y acumulación de P. La aplicación de las fuentes de fósforo el solapamiento simple y la harina de huesos asociados al humus de gusano proporcionaron una mayor acumulación de materia seca del pasto Mombasa y una mayor acumulación de fósforo en un total de tres cortes en relación con la aplicación aislada de estas fuentes de fósforo. La presencia de lombricompuesto no influenció el macollaje del pasto, sin embargo, las fuentes más solubles promovieron mayor cantidad de macollos.

Palabras clave: Fertilización fosfatada, fertilización de pasturas, lombricompuesto, *Panicum maximum*

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INTRODUCTION

In Brazil livestock production is predominantly based on using pasture for animal feed, however there are clear consequences caused by low soil fertility and incorrect pasture management with regards to forage productivity and its nutritional value (Duarte *et al.,* 2015).

Phosphorus (P) is among the most important elements for the vigor and development of plants (Cecato *et al.,* 2007), where appropriately balanced doses and sources may directly influence the production and quality of forage used for animal feed (Bonfim-Silva & Monteiro, 2006).

Increased production as a function of suitable phosphorus plant nutrition is due to the biological functions that the nutrient plays, acting in the processes of photosynthesis, metabolism of sugars, storage and transfer of genetic information, as well as promoting initial root formation and development and plant growth (Malavolta, 1996). These characteristics make phosphorus fertilization a key factor for the establishment and maintenance of pastures (Cecato *et al.,* 2007).

In general, the Mombasa grass presents a high response to fertilization (Ferreira *et al.,* 2008) and provides greater efficiency of P use in the soil than other cultivars of the same genus (Vilela, 2005).

However, due to the high cost of phosphate fertilizer it is of interest to investigate the agronomic efficiency of different alternative sources of associated P or organic compost, since the adoption of organic fertilization in Brazil is growing gradually each year. The use of organic compost may improve the soil chemical properties by increasing the availability of nutrients to plants, as noted in Piatã grass (Dias *et al.* 2015), Marandu grass (Dias *et al.* 2012) and others.

An organic material of choice is earthworm humus, which may have a higher population and activity of microorganisms (Fiuza *et al.* 2011), which favors the bioavailability of nutrients for plants due to the mineralization process. Furthermore, it presents high nutrient availability, soil acidity buffering, high cation exchange capacity and moisture retention, contributing to the growth and development of plants (Brown & James, 2007).

Given the above, the objective of this study was to evaluate the effect of P sources in the absence and presence of earthworm humus on tillering, forage production and P accumulation in the forage *Panicum maximum* cv. Mombasa.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse at the State University of Mato Grosso - UNEMAT, Alta Floresta campus. Pots were used with capacity for 5 dm^3 and cultivated with forage grass *Panicum Maximum* cv. Mombasa. The soil used to fill the pots classified as Typic Hapludox according to the classification criteria of USDA (2014). Chemical and granulometric attributes of the soil determined according to the methodology proposed by Embrapa (2009) were: pH (water)= 5.7, O.M.= 5.8 g dm^{-3}, $P_{(Mehlich)}$= 4.6 mg dm^{-3}, K= 0.059 $cmol_c$ dm^{-3}, Ca= 1.4 $cmol_c$ dm^{-3}, Mg= 0.35 $cmol_c$ dm^{-3}, (H+Al)= 4.60 $cmol_c$ dm^{-3}, SB= 1.8 $cmol_c$ dm^{-3}, V%= 28.2%, CTC= 6.41 $cmol_c$ dm^{-3}, total sand (%)= 54.03, silt (%)= 9.05, clay (%)= 36.92.

Correction of soil acidity was performed 30 days before planting in order to raise the V% to 50%, using limestone with 95% PRNT. During this period the soil was incubated and the moisture content maintained at approximately 60% of field capacity.

The treatments were arranged in a 4x2+1 factorial scheme with four repetitions, consisting of four phosphorus sources: simple superphosphate (SS) (18% soluble P_2O_5), Bayovar rock phosphate (BRP) (14% soluble P_2O_5), Top-Phos 280 HP (TP) (28% soluble P_2O_5) and bone meal (BM) (9.6% soluble P_2O_5), in the absence and presence of earthworm humus, and one control treatment (no P).

Basic fertilization consisting of 200 mg dm^{-3} N and 150 mg dm^{-3} K was applied to all treatments in the forms of urea and potassium chloride, respectively (Malavolta,1981). For phosphate fertilization 50 mg dm^{-3} P of each source were applied separately and incorporated with the full soil mass with humus in the treatments that received in the quantity of 2.22 g dm^{-3}.

After planting which occurred on April 11 2015, irrigation was performed daily to maintain soil moisture at 60% of the total pore volume. At four days after planting there was emergence of the grass, and eight days after emergence (DAE) thinning was conducted, leaving three plants per pot for evaluations.

At 46 DAE the number of tillers per pot was counted, and after this the first cut was made, cutting the plants to 30 cm above the soil. At 65 and 80 DAE the second and third cuts were made, repeating the procedures performed at the first. After the second cut coverage fertilization was performed with N, applying 200 mg dm^{-3} of N in the form of urea.

The forage collected in the three cuts and dried in an oven with forced air circulation at the temperature of 65 +/- 2°C until reaching constant mass followed by acquisition of the dry mass. Subsequently, samples were ground and subjected to chemical analysis of P, according to the methodology reported by Embrapa (2009). With the data of P content in dry matter of the shoots and accumulation of dry shoot matter per pot, the P accumulation was calculated.

The data obtained was submitted to analysis of variance by the F-test and mean comparison by the Tukey test (P<0.05), using the statistical program Assistat (Silva & Azevedo, 2002).

RESULTS AND DISCUSSION

The P sources had an effect on the number of Mombasa grass tillers (**Table 1**). The Top-Phos resulted in greater tillering than the other P sources, except simple superphosphate from which it did not differ. These results were also observed in Mombasa grass when using different P sources, where simple superphosphate and triple superphosphate did not differ from the control treatment (Cecato et al. 2008). This may have occurred because the initial P content of this soil is average according to interpretations of the Cerrado manual: Soil Correction and Fertilization (Sousa & Lobato, 2004), and therefore permits that the control treatment present similar production to the treatments that received P fertilization. These results differ from those obtained in this study wherein the average number of tillers of treatments that received P (factorial average) compared to the control was 500% greater (**Table 1**). This can be explained by the low P content in the soil of this study, which according to interpretations presented very low initial contents (Sousa & Lobato, 2004) which highlights the importance of P in the vital plant activities (Mesquita *et al.,* 2010), resulting in low tillering in the absence of its application.

Table 1. Number of tillers (NT), dry matter (DM) in the first, second and third cut and total accumulation of dry matter (TA) for Mombasa grass grown with P sources in the absence and presence of earthworm humus.
Tabla 1. Número de macollas (NT), materia seca (MS) en el primer, segundo y tercer corte y acumulación total de materia seca (TA) para pasto Mombasa cultivado con fuentes P en la ausencia y presencia de lombricompuesto.

P sources	NT	1st cut	2nd cut	3rd cut	TA
	No. per pot	- g per pot			
SS	19 ab	22.16 a	10.7	29.75 a	62.62 a
TP	20 a	22.60 a	10.13	30.46 a	63.20 a
BM	16 bc	18.46 b	8.56	25.68 b	52.70 b
BRP	15 c	18.90 b	9.58	24.05 b	52.54 b
LSD	4	3.12	2.30	3.71	5.91
Humus					
With	19	21.28	10.01	29.41a	60.70 a
Without	17	19.78	9.47	25.57 b	54.83 b
LSD	6	1.65	1.22	1.97	3.14
Mean (factorial)	18 a	20.53 a	9.74 a	27.52 a	57.76 a
Mean (control)	3b	3.96 b	1.68 b	4.86 b	10.51 b
			F-Test		
P	6.04**	7.10 **	2.34 ns	10.49 **	15.09 **
H	2.98 ns	3.41 ns	0.80 ns	15.98 **	14.68 **
P x H	1.35 ns	2.08 ns	1.46 ns	2.61 ns	3.61 *
Fat. x Cont.	92.58**	187.13 **	81.15 **	246.71**	423.56 **
CV (%)	17.64	12.22	19.06	10.88	8.24

Means followed by different letters in the columns differ by the Tukey test (P<0.05). **, * and ns: significant (P<0.01), (P<0.05) and non-significant, respectively. LSD= least significant difference. SS: Simple superphosphate, TP: Top-Phos, BM: Bone meal, BRP: Bayovar rock phosphate.

Similar effects also occurred for the accumulation of green matter in the three cuts, in which the means of the treatments that received P were higher than those of the control treatment which did not receive phosphorus fertilization.

In the first and third cut the sources simple superphosphate and Top-Phos presented higher dry matter accumulation values in relation to the sources bone meal and Bayovar rock phosphate (**Table 1**). This is probably because they are soluble phosphate fertilizers in the form of granules and on contact with the ground the rapidly absorb moisture, leading to the dissolution of P (Benedito, 2007); furthermore there is less contact of the phosphate anion with soil particles, resulting in lower adsorption in relation to sources of fine particle size such as Bayovar rock phosphate and bone meal. In the cultivar Tanzânia simple superphosphate also showed higher efficiency compared with other sources of P (Yoorin thermophosphate and Arad hyperphosphate) for the production of dry matter (Nascimento *et al.,* 2002). However, in Marandu grass when using P sources consisting of simple superphosphate, natural phosphate reactive Algeria, and application of 50% natural phosphate reactive Algeria and 50% of simple phosphate mixture, there was no significant difference in dry matter production between the sources (Dias *et al.,* 2012).

Evaluating the means of the factorial, it can be observed that in the first, second, third cuts and the total dry matter accumulation there was significant difference in the means of the control, indicated by increases of 418%, 479%, 466% and 449%, respectively, with P application (Table 1). Confirming results were also obtained in Piatã grass (*Brachiaria brizantha* cv. BRS Piatã), where all treatments that received P presented greater dry matter accumulation of the shoots in relation to the control (Dias *et al.,* 2015). This result confirms the important role that P represents in the plant, being a key element in photosynthesis, respiration, energy storage and transfer, acting thereby in cell division and growth in addition to other processes of plant development (Novais *et al.*, 2007), which results in increased production of dry mass by the plants.

There was increased DM production in the third treatments with the presence of humus, presenting an increase of 15.01% in comparison to its absence (**Table 1**). This is because the presence of humus can result in increased soil microflora, and these microorganisms can promote the breakdown of organic matter into its simple form, with the release of inorganic phosphate ions (Prado, 2008), and thereby cause higher productivity.

In total dry matter accumulation there was the effect of interaction between P sources and humus (**Table 1**), where in the absence of humus the Top-Phos yielded 31.55% and 17.85% more dry matter in relation to bone meal and Bayovar rock phosphate, respectively (**Figure 1**). In the presence of humus simple superphosphate resulted in 29.8% higher productivity compared to Bayóvar rock phosphate which showed less accumulation of DM. Analyzing the presence of humus in each source, it is perceived that by associating superphosphate and bone meal with humus, there was greater total DM accumulation in relation to its absence, which was not observed in the other P sources evaluated.

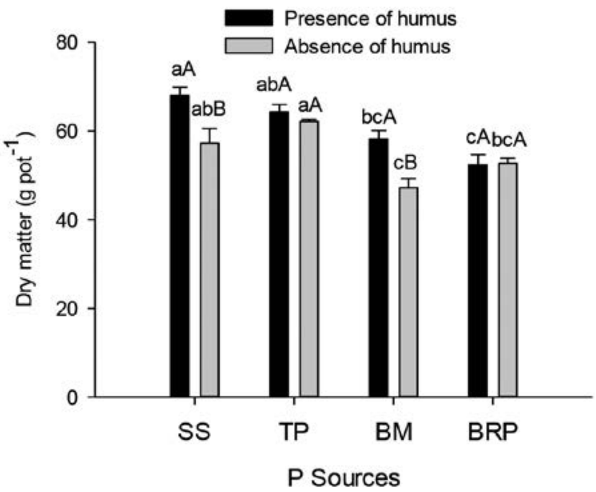

Figure 1. Effect of phosphorus sources in the presence and absence of earthworm humus on green matter accumulation of the third cut of Mombasa grass. Means followed by the same letter, lowercase in the sources and uppercase in the absence and presence of earthworm humus on the line, do not differ by the Tukey test at 5% probability. SS:Simple superphosphate, TP: Top-Phos, BM: Bone meal, BRP: Bayovar rock phosphate.

Figura 1. Efecto de las fuentes de fósforo en presencia y ausencia de lombricompuesto sobre la acumulación de materia verde del tercer corte de pasto Mombasa. Los medios seguidos de la misma letra, minúscula en las fuentes y mayúscula en ausencia y presencia de lombricompuesto en la línea, no difieren según la prueba de Tukey al 5% de probabilidad. SS: Superfosfato simple, TP: Top- Phos, BM: Harina de huesos, BRP: Fosfato natural de Bayóvar..

For accumulation of P there was no significant difference between the sources for the three cuts of Mombasa grass (**Table 2**). Similar data was obtained in work performed with different P sources (bone meal, simple superphosphate and Arad phosphate), in which bone meal showed no significant difference from simple superphosphate with regards to P accumulation (Oliveira *et al.*, 2012).

In the treatments which received phosphorus there were increases of 897.1%, 687.68%, 688.5% and 744.6% in the accumulation of P for the first, second and third cut and total P accumulation, respectively, in relation to treatments without phosphorus fertilization.

For the first and second cut the P accumulation was influenced by the presence of humus (**Table 2**), promoting an increase of 18.3% and 18.5%, respectively, compared to its absence. This effect may be due to the presence of fresh excreta of earthworms, which presents greater concentration and activity of microorganisms (Fiuza *et al.*, 2011). With the presence of these microorganisms it is possible to improve the supply of phosphorus to the plants (Silva Filho & Vidor, 2000) due to the capacity which various microorganisms have to solubilize phosphorus, making it assimilable for plants by means of production of organic acids and CO_2 through mineralization of organic C, production of enzymes and chelating compounds, and complexation by the microbiota (Meurer, 2006).

In P accumulation of the third cut there was no effect of interaction between P sources and

Table 2. P accumulation in the shoots of the first, second and third cut and the total P accumulation (TA) in Mombasa grass under P sources in the absence and presence of earthworm humus.
Tabla 2. Acumulación de P en los brotes del primer, segundo y tercer corte y la acumulación total de P (TA) en el césped de Mombasa bajo fuentes de P en la ausencia y presencia de lombricompuesto.

P sources	Phosphorus accumulation			
	1st cut	2nd cut	3rd cut	TA
	mg per pot			
SS	28.81	21.12	17.49	67.44 ab
TP	24.25	16.75	19.42	60.43 b
BM	30.56	20.96	23.04	74.57 a
BRP	26.42	21.19	19.53	67.15 ab
LSD	8.15	4.91	9.29	12.77
Humus				
With	29.82 a	21.54 a	21.43	72.81 a
Without	25.20 b	18.17 b	18.31	61.99 b
LSD	4.32	4.74	4.93	
Mean (factorial)	27.52 a	21.11 a	19.87 a	67.40 a
Mean (control)	2.76 b	2.68 b	2.52 b	7.98 b
	F-Test			
P	1.70 ns	2.92 ns	0.92 ns	3.05 *
H	4.80 *	5.84 *	1.69 ns	10.73**
P x H	1.10 ns	2.355 ns	4.26 *	3.15 *
Fat. x Cont.	61.21 **	82.59 **	23.18 **	143.79 **
CV (%)	24.08	19.87	37.87	15.37

Means followed by different letters in the columns differ by the Tukey test ($P<0.05$). **, * and ns: significant ($P<0.01$), ($P<0.05$) and non-significant, respectively. LSD= least significant difference. SS: Simple superphosphate, TP: Top- Phos, BM: Bone meal, BRP: Bayovar rock phosphate.

humus (**Table 2**), where in the absence of humus there was no difference between sources (**Figure 2**). However, in sugarcane there was significant difference among sources, where the bone meal showed higher exportation of P in relation to the triple superphosphate (Caione *et al.,* 2013), different from the results obtained in this work. However, in the presence of humus the bone meal presented significant difference amounting to a 96.6% increase in accumulation of P compared to Bayovar rock phosphate, but this did not differ from the simple superphosphate and Top-Phos. Given this fact, attention should be paid to bone meal because this source is available in large quantiles in the region resulting from high cattle production, in addition to its use being economically viable. Evaluating the presence of humus individually in each source, it was found that when associating bone meal with humus there was a 112.4% increase in phosphorus accumulation, which was not observed in the other sources.

Assessing the total accumulation of P there was the effect of interaction between P sources and humus (**Table 2**), where in the absence of humus there was no difference between sources (**Figure 2**). In the presence of humus the bone meal yielded 28.5% and 32.8% greater P accumulation in relation to the Top-Phos and Bayovar rock phosphate, where the simple superphosphate did not differ from the other sources. Analyzing the presence of humus in each source, it is perceived that by associating the simple superphosphate and bone meal with humus there were increases of 26% and 33.7% in total P accumulation, respectively, in relation to its absence, which was not observed in the other sources.

CONCLUSIONS

Application of the phosphorus sources simple superphosphate and bone meal associated with earthworm humus resulted in higher dry matter accumulation of Mombasa grass and greater phosphorus accumulation in the total of the three cuts in relation to isolated application of these phosphorus sources.

The presence of humus did not influence tillering of the grass, however the more soluble sources promoted greater tillering.

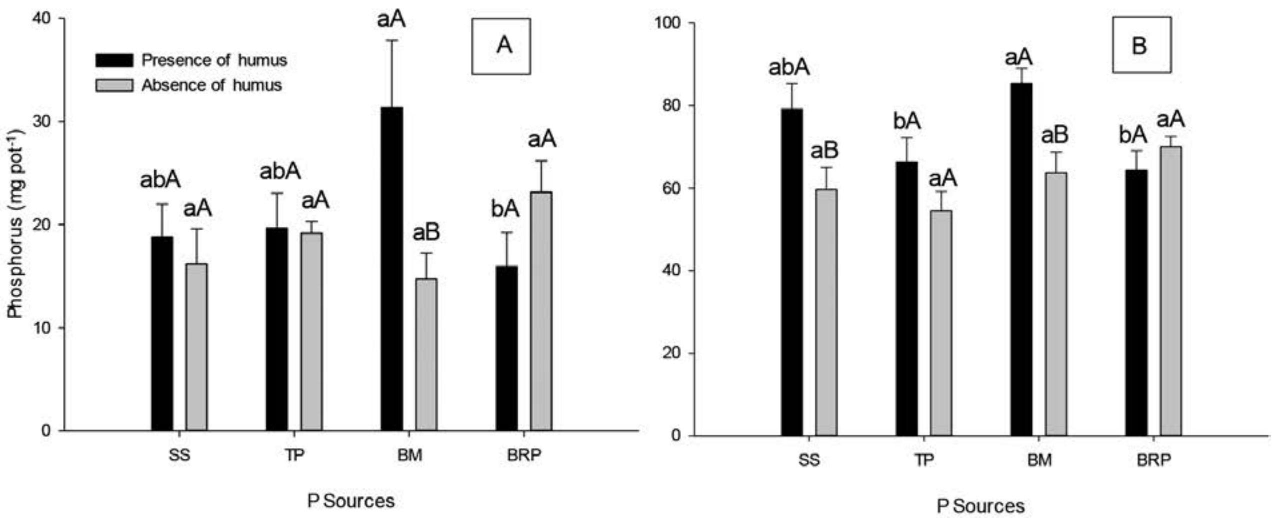

Figure 2. Effect of phosphorus sources with the presence and absence of earthworm humus on of the third cut (a), and total P accumulation in the shoots of Mombasa grass (b). Means followed by the same letter, lowercase in the sources and uppercase in the absence and presence of earthworm humus on the line, do not differ by the Tukey test at 5% probability. SS:Simple superphosphate, TP: Top-Phos, BM: Bone meal, BRP: Bayovar rock phosphate.
Figura 2. Efecto de las fuentes de fósforo con la presencia y ausencia de lombricompuesto en el tercer corte (a), y acumulación total de P en los brotes de pasto Mombasa (b). Los medios seguidos de la misma letra, minúscula en las fuentes y mayúscula en ausencia y presencia de lombricompuesto en la línea, no difieren según la prueba de Tukey al 5% de probabilidad. SS: Superfosfato simple, TP: Top- Phos, BM: Harina de huesos, BRP: Fosfato natural de Bayóvar

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