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Pigeon pea (*Cajanus cajan* L.) and corn (*Zea mays* L.) biomass production for silage as a function of mechanized tillage systems

Produção de biomassa de guandu (*Cajanus cajan* L.) e milho (*Zea mays* L.) para silagem em função de sistemas mecanizados de preparo do solo

Producción de biomasa de guandu (*Cajanus cajan* L.) y maíz (*Zea mays* L.) para ensilado en función de los sistemas de preparación del suelo mecanizado

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Abstract

Mechanical soil management has a huge impact on early plant development and can promote effects at all stages of the silage forage production cycle. Thus, this work was conducted to verify if a mechanized system of soil preparation influences the accumulation of pigeon pea

and corn biomass. The experiment was conducted at the farm school of Federal University of Mato Grosso do Sul, Faculty of Veterinary Medicine and Animal Science. The experimental delimitation chosen was randomized blocks, the treatments were two systems of tillage (conventional and reduced), associated to two crops (*Cajanus cajan* L., cv. BRS Mandarim e *Zea mays* L. hybrid TG Status). The cv. BRS Mandarim in conventional tillage system impacted higher biomass values. In addition, the same soil preparation system promoted oscillations between the crops (P<0.05), where cv. BRS Mandarim showed biomass values 7% higher than cv. Status TG. In reduced handling system, the crops presented the same biomass productivity. Despite the increase of dry weight during the cycle of cv. BRS Mandarim biomass production, there was a reduction in the dry matter fraction, indicating that the specific weight per plant decreased at the end of the evaluation period. The tillage system that was fulfilled conventionally promoted higher estimates of pigeon pea biomass. Corn was not influenced by mechanized tillage system.

Keywords: Forage Production; Grass; Legumes.

Resumo

Os manejos mecânicos do solo impactam no desenvolvimento inicial das plantas podendo promover efeitos em todas as fases do ciclo de produção de forragem para silagem. Assim, este trabalho foi conduzido para verificar se o sistema mecanizado de preparo do solo influência no acúmulo de biomassa de guandu e milho. O experimento foi conduzido na fazenda escola da Universidade Federal do Mato Grosso do Sul, da Faculdade de Medicina Veterinária e Zootecnia. O delineamento experimental empregado foi de blocos ao acaso, os tratamentos são dois sistemas de preparo do solo (convencional e reduzido), associados a duas culturas (*Cajanus cajan* L., cv BRS Mandarim e *Zea mays* L. híbrido TG Status). A cv. BRS Mandarim no sistema de preparo do solo realizado de forma convencional impactou em maiores valores de biomassa. Além disso, o mesmo sistema de preparo do solo promoveu oscilações entre as culturas (P<0,05), em que a cv. BRS Mandarim apresentou valores de biomassa 7% superiores ao da cv. Status TG. No sistema de manejo reduzido, as culturas apresentaram a mesma produtividade de biomassa. Apesar do aumento do peso seco durante o ciclo de produção de biomassa da cv. BRS Mandarim ocorreu redução na fração de matéria seca, indicando que o peso especifico por planta reduziu ao final do ciclo de avaliação. O sistema de preparo do solo realizado de forma convencional promoveu maiores estimativas de biomassa de guandu. O milho não foi influenciado pelo sistema mecanizado de preparo de solo.

Palavras-chave: Leguminosa; Gramínea; Produção de forragem.

Resumen

La gestión mecánica del suelo afecta al desarrollo inicial de las plantas y puede promover efectos en todas las fases del ciclo de producción de forraje para ensilado. Por lo tanto, este trabajo se llevó a cabo para verificar si el sistema de preparación del suelo mecanizado influye en la acumulación de biomasa de guandu y maíz. El experimento se llevó a cabo en la granja escolar de la Universidad Federal de Mato Grosso do Sul, de la Facultad de Medicina Veterinaria y Ciencias Animales. El diseño experimental utilizado fue bloques aleatorizados, los tratamientos son dos sistemas de preparación del suelo (convencionales y reducidos), asociados con dos cultivos (*Cajanus cajan* L., cv BRS Mandarin y *Zea mays* L. hybrid TG Status). cv. BRS Mandarin en el sistema de preparación del suelo realizado convencionalmente impactó mayores valores de biomasa. Además, el mismo sistema de preparación del suelo promovió oscilaciones entre cultivos (P<0.05), en los que cv. BRS Mandarin presentó valores de biomasa 7% más altos que cv. Status TG. En el sistema de gestión reducido, los cultivos presentaron el mismo rendimiento de biomasa. A pesar del aumento del peso seco durante el ciclo de producción de biomasa de cv. BRS Mandarin hubo una reducción en la fracción de materia seca, lo que indica que el peso específico por planta se redujo al final del ciclo de evaluación. El sistema de preparación del suelo realizó convencionalmente mayores estimaciones de biomasa de guandu. El maíz no fue influenciado por el sistema mecanizado de preparación del suelo.

Palabras clave: Legumbres; Hierba; Producción de forraje.

1. Introduction

Corn is the main grass species used for silage productions in tropical climate regions, since it has good agronomic indexes due to the high photosynthetic power (Ben-Asher et al., 2013). On the other side, it presents varied nutritional levels of crude protein (Oliveira et al., 2011). Thus, it is pertinent to include forage materials with higher nutritional values to diversify forage production.

The inclusion of legumes is a promising alternative, e.g., pigeon pea (*Cajanus cajan* L.) apparently seems to be a good alternative for diversification of forage production, as it can be cultivated in tropical and subtropical environments; presenting high agronomic and nutritional potential, since in its composition it contains good levels of important amino acids

such as lysine, methionine, tryptophan (Alencar et al., 2014; Garg e Singh, 2017; Rachaputi et al., 2018).

In addition, pigeon pea, as a legume, presents symbiosis with atmospheric nitrogen fixing microorganisms, positively impacting soil ecology (Gupta et al., 2015). Therefore, this forage material can supply demands of primary, secondary and environmental productions (Phelan et al., 2015).

On the other hand, for pigeon pea to reach maximum productivity potential, it is necessary to identify which factors can maximize forage mass production; although the crop is implanted in a multifactorial environment, the soil preparation can be one of the decisive factors in plant development, as mechanical soil management impacts initial plant development (Lima et al., 2010; Hakamada et al., 2013), being able to promote effects at all stages of the silage forage production cycle.

The soil preparation system conventionally fulfilled can promote greater root system development due to lower penetration resistance (Theodoro et al., 2018), impacting positively the plant growing dynamic, may resulting in bigger productivity of forage mass.

Thus, this work was conducted to verify if a mechanized system of tillage influences the accumulation of pigeon pea and corn biomass

2. Material and methods

The experiment was conducted at the farm school of Federal University of Mato Grosso do Sul, Faculty of Veterinary Medicine and Animal Science (20°26'50.6"S 54°50'34.0"W), in the city of Terenos at 407 meters altitude. The soil was classified as Red Latosol, with very clayey texture (710 g kg^{-1} clay, 130 g kg^{-1} sand, 160 g kg^{-1} silt) with the following chemical attributes: pH (Water): 6,3; P (mg dm^{-3}): 7.4; MO (g dm^{-3}): 42.6; K (cmol dm^{-3}): 1.34; Ca (cm^{-1} dm^{-3}): 6.7; Mg (cm dm^{-3}): 7.1; Al (cmolc.dm^{-3}): 0; Al + H (cm dm^{-3}): 5.7. The climate of the region was identified as Aw - Tropical climate with dry winter (Kottek et al., 2006). The soil was occupied by intense spontaneous vegetation and brachiaria grass that were desiccated by glyphosate (3 L ha^{-1}) application in the first half of April 2017.

The experimental delimitation used was randomized blocks, with 10 replications per treatment in a 2 x 2 factorial scheme: two tillage systems (conventional and reduced), associated to two crops (*Cajanus cajan* L., cv BRS Mandarin and *Zea mays* L. hybrid TG Status). The experimental portion had 10 m^2.

A 90 horsepower and 3.580 kg tractor was used in the tillage, and an operation with a 14 chopped disk harrow was performed with 36 inches in total area to create favourable conditions. Subsequently, two systems were used, identified as reduced and conventional, considered as treatments. The reduced preparation consisted of two plowing types, one using a harrow and one using a levelling offset harrow, with 42 flat 28-inch discs. The conventional preparation consisted of a plow operation with four 42-inch flat discs followed by four with the levelling harrow. After the tillage, the mechanized sowing of corn (hybrid Status TG) was performed on October 27, 2017, to obtain the final population of 78 thousand plants per hectare, with a space of 0.5 meters between lines. Pigeon pea cv. BRS Mandarin was sown on the same date, obtaining the final population of 256 thousand plants per hectare. Fertilization and other crop managements were executed according to technical recommendations for the region (Godoy and Santos, 2013; Galvão et al., 2017). Evaluation consisted of cutting all plants from each portion, 15 cm above the ground for achieving biomass estimation. Pigeon pea cut occurred in five different moments (33, 48, 63, 78 and 93 days after emergence) and the corn cut was in the hard grain stage (R5), with 2/3 of the milk line. Subsequently, plant weight was estimated using a digital scale and biomass production was estimated per unit of area.

Biomass data from the crops were subjected to analysis of variance, considering a 5% significance level. In addition, the green weight, dry weight and dry matter data were subjected to a regressive analysis, adopting as the model choice criterion the highest determination coefficient (R^2) and its significant effect (5%)

Results and discussion

To cv. BRS Mandarin the conventional form of tillage system impacted higher biomass values. In addition, the same soil preparation system promoted oscillations between crops (P<0.05), in which cv. BRS Mandarin presented biomass values 7% higher than cv. Status TG (Table 1). As expected, tillage system fulfilled in a conventional form impacted positively in production of pigeon pea biomass (Table 1), possibly for being associated to smaller penetration resistance, because, in theory, this type of soil management allows an adequate root development (Trabaquini et al., 2013; Oliveira et al., 2015), which can promote a balance in plant leaf area dynamics, directly influencing the accumulation of aerial part biomass (Lima et al., 2010).

Table 1 – Corn biomass and pigeon pea cultivated for silage production in function of mechanized tillage system. Terenos, MS. Harvest 2017/18.

	Soil preparation system	
Crops	Conventional	Reduced
Pigeon pea ' BRS Mandarin' (kg ha^{-1})	32,944.9^{Aa}	30,027.2^{Ab}
Corn 'Status TG' (kg ha^{-1})	30,705.6^{Ba}	33,873.6^{Aa}
C.V. (%)	14.45	

Averages followed by equal lowercase letters in rows, and uppercase letters in columns do not differ from each other at 5% probability. C.V.: coefficient of variation.

The crops presented the same biomass productivity (Table 1) in the reduced management system, however, this system did not interfere corn biomass production. This data corroborates Silva et al. (2000) that, when cultivating a corn hybrid for silage production in different medium textures tillage systems, they did not find significant differences between treatments and the one represented by conventional tillage. Therefore, when aiming forage silage production in this scenario, it would be pertinent to choose pigeon pea as a supplementary roughage source, as it has a high nutritional value (Alencar et al., 2014; Rachaputi et al., 2018). In the same way, when implanting pigeon pea, there may be an improvement in the chemical and physical composition of the soil (Fernandes Júnior et al., 2010; Lima et al., 2012; Guimarães et al., In the Press).

For the variables related to productivity: green weight (kg ha^{-1}) and dry weight (kg ha^{-1}), the corn crops in tillage system as a function of days after emergence did not fit any model (P>0.05). Regardless the type of management, the production information of cv. BRS Mandarin in function of the days after emergence have adjusted in a first degree equation (Fig. 1A and 1B). In view of this, as the emergence days progress, there is biomass accumulation from the aerial part. On the other hand, the opposite occurred with the dry matter fraction (DM), where the equation presented better fit to the second degree model, generating minimum values of 1310 kg ha^{-1} of DM at the end of the production cycle (Fig. 1C).

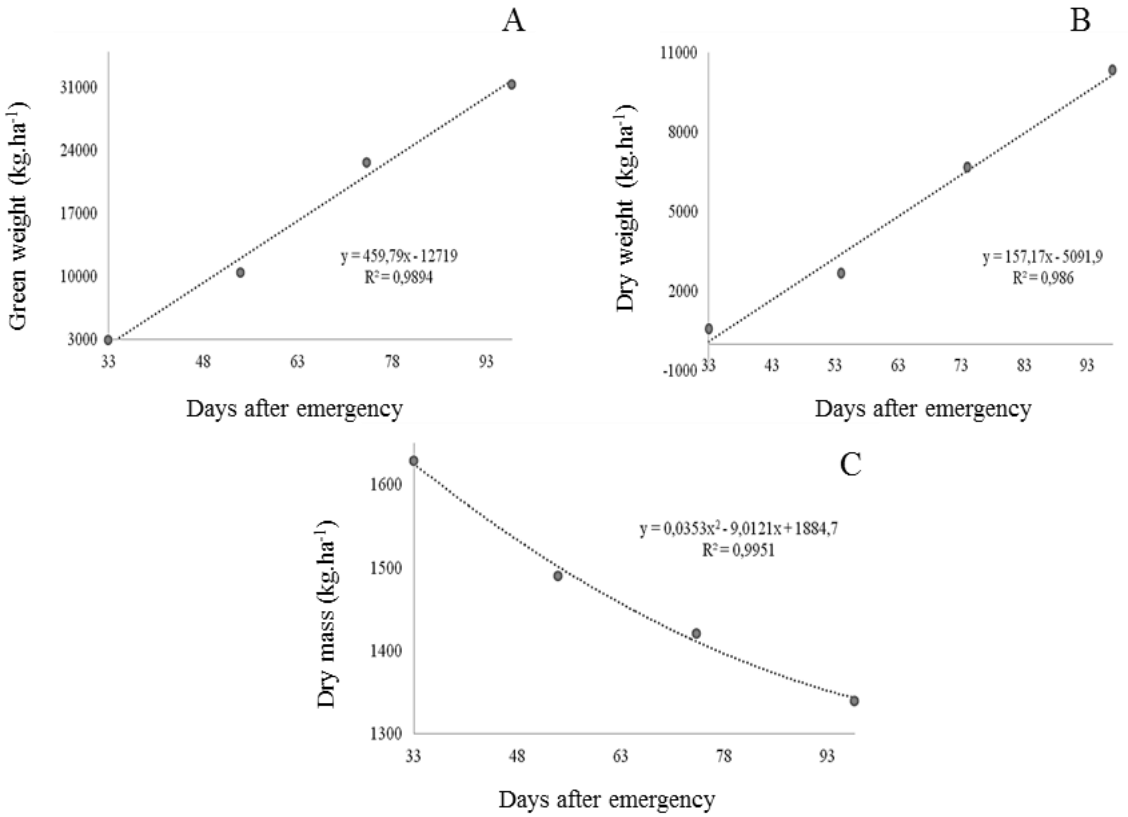

Figure 1 – Pigeon pea biomass production 'Mandarin BRS' in function of the cutting season. Terenos, MS. Harvest 2017/2018. A: green weight (kg ha^{-1}); B: dry weight (kg ha^{-1}); C: dry matter (kg ha^{-1}).

Despite the increase of dry weight during the cv. BRS Mandarin biomass production cycle, there was a reduction in the fraction of DM (Fig. 1C), indicating that the specific weight per plant decreased at the end of the evaluation cycle. This event is not associated to tillage methods, however, it can be related to plant densification, that may have induced the light competition, resulting in plant stalk etiolation, reducing its diameter, being able to stop the plant to express its maximum production potential. In addition to the possible botanical modifications mentioned, there may be a reduction in the number of pods per plant (Bezerra et al., 2009; Bezerra et al., 2012), which may compromise pigeon pea nutritional value.

Therefore, regardless of the tillage system, it is necessary to make studies with thickening of pigeon pea plants to verify the impact on the chemical composition of the forage material destined for silage.

Final considerations

Through the results obtained in this study, we conclude that conventional tillage system promoted higher estimates of pigeon pea biomass and corn was not influenced by

mechanized tillage system.

To adopt a soil tillage system, the root system of crops and the soil compaction intensity should be evaluated. Considering that there is a lack of knowledge on this subject, we suggest studies with plants used in animal production systems and its relationship with mineral nutrition, sanity and yield to implement the sustainability of farms.

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References

Alencar, D. P., Maciel, M. P., Botelho, L. F. R., & Albuquerque, L. (2014). Feijão guandu cru na alimentação de frangos caipiras criados em sistema semi-intensivo. *Pesquisa Agropecuária Brasileira*, *49*(9), 737-744. doi: 10.1590/S0100-204X2014000900010

Ben-Asher, J., y Garcia, A. G., Flitcroft, I., & Hoogenboom, G. (2013). Effect of atmospheric water vapor on photosynthesis, transpiration and canopy conductance: A case study in corn. *Plant, Soil and Environment*, *59*(12), 549-555. doi: 10.17221/346/2013-PSE

Bezerra, A. A. C., Távora, F. J. A. F., Freire Filho, F. R., & Ribeiro, V. Q. (2010). Características de dossel e de rendimento em feijão‑caupi ereto em diferentes densidades populacionais. *Pesquisa Agropecuária Brasileira*, *44*(10), 1239-1245. doi: 10.1590/S0100-204X2009001000005

Bezerra, A. A. C., Neves, A. C., Neto, F. A., & Da Silva Júnior, J. V. (2009). Morfofisiologia e produção de feijão-caupi, cultivar BRS Novaera, em função da densidade de plantas. *Revista Caatinga*, *27*(4), 135-141. Retrieved from https://periodicos.ufersa.edu.br/index.php/caatinga/article/view/3287

Lima, C. L. R., Reinert, D. J., Reichert, J. M., & Suzuki,L. E. A. S. (2010). Produtividade de culturas e resistência à penetração de Argissolo Vermelho sob diferentes manejos. *Pesquisa Agropecuária Brasileira*, *45*(1), 89-98. doi: 10.1590/S0100-204X2010000100012

Fernandes Júnior, P. I., Da Silva, A., J. P.; Passos, S. R., De Oliveira, P. J., Rumjanek, N. G., & Xavier G. R. (2011). Produção e comportamento reológico de exopolissacarídeos sintetizados por rizóbios isolados de guandu. *Pesquisa Agropecuária Brasileira*, *45*(12), 1465-1471. doi: 10.1590/S0100-204X2010001200018

Garg, N., & Singh S. (2017). Arbuscular mycorrhiza Rhizophagus irregularis and silicon modulate growth, proline biosynthesis and yield in Cajanus cajan L. Millsp.(pigeonpea) genotypes under cadmium and zinc stress. *Journal of plant growth regulation*, *37*(1), 46-63. doi: 10.1007/s00344-017-9708-4

Guimarães, I. C. N., Theodoro, G.F., Yamashita, N.Y.B., Golin, H. O., & Rezende, R. P. (2019). Influência do cultivo de milho e guandu para produção de silagem na resistência do solo à penetração. *Archivos de Zootecnia* (In the Press).

Gupta, G., Parihar, S. S., Ahirwar, N. K., Snehi, S. K., & Singh, V. (2015). Plant growth promoting rhizobacteria (PGPR): current and future prospects for development of sustainable agriculture. *J Microb Biochem Technol*, *7*(2), 096-102. doi: 10.4172/1948-5948.1000188

Lima, J. D., Sakai, R. K., & Aldrighi, M. (2012). Produção de biomassa e composição química de adubos verdes cultivados no Vale do Ribeira. *Bioscience Journal*, 709-717. Retrieved from http://www.seer.ufu.br/index.php/biosciencejournal/article/view/13484

Oliveira, F. C. L., Jobim, C. C., Silva, M. S., Junior, M. C., Junior, V. H. B., & Roman, J. (2011). Produtividade e valor nutricional da silagem de híbridos de milho em diferentes alturas de colheita. *Revista Brasileira de Zootecnia*, *40*(4), 720-727. doi: 10.1590/S1516-35982011000400004

Oliveira, P. D. D., Sato, M. K., Lima, H. V. D., Rodrigues, S., & Silva, A. P. D. (2016). Critical limits of the degree of compactness and soil penetration resistance for the soybean

crop in N Brazil. *Journal of Plant Nutrition and Soil Science*, *179*(1), 78-87. doi: 10.1002/jpln.201400315

Phelan, P., Moloney, A. P., McGeough, E. J., Humphreys, J., Bertilsson, J., O'Riordan, E. G., & O'Kiely, P. (2015). Forage legumes for grazing and conserving in ruminant production systems. *Critical Reviews in Plant Sciences*, *34*(1-3), 281-326. doi: 10.1080/07352689.2014.898455

Rachaputi, R. C., Bedane, G. M., Broad, I. J., & Deifel, K. S. (2018). Genotype, Row Spacing and Environment Interaction for Productivity and Grain Quality of Pigeonpea (*Cajanus Cajan*) in Sub-Tropical Australia. *Biosciences Biotechnology Research* Asia, *15*(1), 27-38. doi: 10.13005/bbra/2605

Silva, V. D., Reinert, D. J., & Reichert, J. M. (2000). Densidade do solo, atributos químicos e sistema radicular do milho afetados pelo pastejo e manejo do solo. *Revista Brasileira de Ciência do Solo*, 24(1), 191-199. doi: 10.1590/S0100-06832000000100021

Theodoro, G. F., Golin, H. O., Rezende, R. P., & Abreu, V. L. S. (2018). Influência de sistemas de preparo na manutenção da palhada e resistência do solo à penetração. *Journal of Neotropical Agriculture*, *5*(2), 25-30. doi: 10.32404/rean.v5i2.2220

Trabaquini, K., Formaggio, A. R., & Galvão, L. S. (2015). Changes in physical properties of soils with land use time in the Brazilian savanna environment. *Land Degradation & Development*, *26*(4), 397-408. doi: 10.1002/ldr.2222

Galvão, J.C.C.; Borém, A., & Pimentel, L. (2017). *Milho: do plantio à colheita*. 2. ed., Viçosa: UFV. 382p.

Godoy, R., & Santos, P. M. (2013). *Cajanus cajan.* In: FONSECA, D.M.; J.A.M. (Ed.) *Plantas forrageiras*. Viçosa: UFV: 294-309.

Kottek, M., Grieser, J., Beck, C., Rudolf, B.; Rubel, F. 2006. World map of the Köppen-Geiger climate classification updated. Meteorolog. Zeitsch, *15*(3): 259-263. doi: 10.1127/0941-2948/2006/0130

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