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Morphogenesis of the giant missionary grass in response to pig slurry fertilization

Morfogênese da grama-missioneira-gigante em resposta à adubação com dejeto líquido de suínos

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ABSTRACT

*The morphogenesis of giant missionary grass (**Axonopus jesuticus** x **A. scoparius**) was evaluated in this study in response to the application of 0, 40, 80, 120, 160, and 200m³ ha^{-1}year^{-1} of pig slurry, calculated to provide 0, 100, 200, 300, 400, and 500kg N ha^{-1}year^{-1}, respectively. The experiment was carried out in the field, at Chapecó, Santa Catarina, Brazil, in 2010–2011. The doses were fractioned in four applications, performed after the pasture cuttings, during the growth season of the grass. Morphogenetic evaluations were performed weekly between 10/26/2010 and 12/07/2010 (spring), 12/14/2010 and 01/11/2011 (late spring/early summer), 01/18/2011 and 02/07/2011 (summer), and 02/15/2011 and 03/21/2011 (late summer). The leaf senescence, leaf elongation, and pseudoculm elongation rates, canopy and pseudoculm heights, leaf blade length, and tillering increased because of fertilization. The application of pig slurry as a source of nitrogen alters the tissue flow of giant missionary grass, which requires attention to pasture management in order to maximize the efficiency of forage use and to prevent losses of herbage by leaf senescence.*

Key words: *canopy structure, leaf elongation, organic manure, senescence, tiller.*

RESUMO

*A morfogênese da grama-missioneira-gigante (**Axonopus jesuticus** x **A. scoparius**) foi avaliada neste estudo em resposta à aplicação de doses de 0, 40, 80, 120, 160 e 200m³ ha^{-1}ano^{-1} de dejeto líquido de suínos, calculadas para suprir 0, 100, 200, 300, 400 e 500kg de N ha^{-1}ano^{-1}, respectivamente. O experimento foi realizado no campo, em Chapecó, Santa Catarina, Brasil, em 2010-2011. As doses foram fracionadas em quatro aplicações, após os cortes da pastagem, durante a estação de crescimento da gramínea. As avaliações morfogenéticas ocorreram semanalmente entre 26/10/2010 e 07/12/2010 (primavera), 14/12/2010 e 11/01/2011 (final da primavera/início do verão), 18/01/2011 e 07/02/2011 (verão), e 15/02/2011 e 21/03/2011 (final do verão). As taxas de senescência foliar, alongamento foliar e alongamento do pseudocolmo, a altura do dossel e do pseudocolmo, o comprimento de lâmina foliar e o afilhamento foram incrementados como resultado da fertilização. A aplicação de dejetos de suínos como fonte de nitrogênio altera o fluxo de tecido de grama-missioneira-gigante, o que requer atenção ao manejo da pastagem para maximizar a eficiência de uso da forragem e prevenir perdas por senescência.*

Palavras-chave: *estrutura do dossel, crescimento de folhas, adubação orgânica, senescência, perfilhos.*

INTRODUCTION

Giant missionary grass is a triploid hybrid resulting from the natural crossing between ***Axonopus jesuiticus*** (Araújo) Valls x ***A. scoparius*** (Flügge) Kuhlm. The dry matter (DM) production and nutritive value of this hybrid has been proven in several studies (TCACENCO & SOPRANO, 1997; DESCHAMPS & TCACENCO, 2000). MIRANDA et al. (2012) reported the positive response of this grass to pig slurry rates (PS), but the morphogenetic variables were not evaluated. Plant morphogenesis is defined as the dynamics of the appearance and expansion of plant form in space (CHAPMAN & LEMAIRE, 1993). Nitrogen (N) affects this process, and its effects vary according to species,

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rates of N, defoliation, and climate conditions. The effect of N on the morphogenesis of forage grasses have been widely studied (QUADROS & BANDINELLI, 2005; PEREIRA et al., 2011), but little information is known on the effects of this type of fertilizer on morphogenetic traits (EDVAN et al., 2010; MONDARDO et al., 2011). This study had the objective to investigate the effect of increasing doses of PS on the morphogenetic traits of giant missionary grass.

MATERIAL AND METHODS

The study was conducted between October 2010 and March 2011, at Epagri, Chapecó (27°07' S, 52°37' W, 679m asl), in a pasture of giant missionary grass (accession code 14337, ***Axonopus*** BRA-002020). The climate is Cfa (humid subtropical), and during the experimental period the total rainfall was 1,311mm and the mean temperature was 22.1ºC. The soil is dystrophic oxisol with the following characteristics: clay= 54.6%, pH in water= 5.58, P= 11.3mg dm^{-3}, K= 136.67mg dm^{-3}, Organic matter= 3.69%, Al= 0.17$cmol_c$ dm^{-3}, Ca= 5.36$cmol_c$ dm^{-3}, Mg= 3.24$cmol_c$ dm^{-3}, Al saturation= 2.42%, Zn= 2.98mg dm^{-3}, Cu= 2.04mg dm^{-3}, Mn= 7.28mg dm^{-3}, and Fe= 1.17g dm^{-3}. The treatments consisted of the application of six doses of PS, 0, 40, 80, 120, 160, and 200m^3 PS $ha^{-1}year^{-1}$, which were calculated to provide 0, 100, 200, 300, 400, and 500kg N ha^{-1} $year^{-1}$, respectively. The experimental design was randomized blocks, with five replicates, and the plots measured 30m². The average values of the physicochemical properties of PS were: pH in water= 6.98, DM= 2.53%, P= 1.56kg m^{-3}, K= 0.64kg m^{-3}, Ca= 0.37kg m^{-3}, Mg= 0.30kg m^{-3}, Cu= 28.93g m^{-3}, Zn= 33.23g m^{-3}, Fe= 151.82g m^{-3}, Mn= 14.77g m^{-3}, total N= 2.74kg m^{-3}, and mineral N= 1.32%.

Since PS contained considerable amounts of P and K, and high doses were applied, a quantity of 300kg ha^{-1} $year^{-1}$ of triple superphosphate and potassium chloride was applied in the plots of control treatment. The PS doses were fractioned into four applications, which were superficially distributed after the pasture cutting in October of 2010, December of 2010, January of 2011, and February of 2011. The cuts were made when the pasture plots reached an average height of 20cm, leaving residues of approximately 8cm. The vegetal material was removed from the surface of the grassland with the aid of rakes. For the transport and removal of PS from the lagoon, a tractor and a tank with a capacity of 3,000L attached to a suction pump were used. The agitation of PS prior to removal from the lagoon was made through suction and the devolution to the lagoon was taken three times. In the experimental area, PS was deposited into four tanks with 1,000L each, and after the homogenization, by mechanical agitation, four samples (liquid fraction + viscous) were taken and analyzed for pH, N-NH_4^+, N-NO_3^-, N total, DM, and macro and micronutrients (TEDESCO et al., 1995). The evaluations were performed between the cuttings, so that it was possible to carry out four cycles of observations in the followings periods: 10/26/2010 and 12/07/2010 (spring), 12/14/2010 and 01/11/2011 (late spring/early summer), 01/18/2011 and 02/07/2011(summer), and 02/15/2011 and 03/21/2011 (late summer). The elapsed time between evaluations was quantified in degree-day (OMETTO, 1981), adopting 10ºC as the basal temperature. The canopy height (CH) and the number of basal tillers (considered the tillers originated in the stolon's nodes) were determined in a sample which are of 0.20mx0.25m, in the center of the plots. To evaluate the morphogenetic variables, eight basal tillers (presenting one full expanded leaf and until two expanding leaves) were selected and tagged with a colored plastic label. The tillers were visited weekly and evaluated for the following traits: a) leaf blade length/tiller (LBL), considered the total length of the green leaf area/tiller; b) number of green leaves/tiller (NGL); c) number of senescent leaves/tiller (NSL); d) leaf senescence length/tiller (LSL), considered the total length of the senescence leaf area/tiller and; e) pseudoculm height (PSH). These data were used to calculate the following morphogenetic variables: a1) leaf elongation rate (LER; mm/DD/tiller); b1) green leaf appearance rate (LAR; nº/DD/tiller); c1) leaf senescent rate (LSR; nº/DD/tiller); d1) leaf senescence elongation rate (LSER; mm/DD/tiller); e1) pseudoculm elongation rate (PSER; cm/DD/tiller). The phyllochron was calculated by the inverse of the leaf appearance rate (P=1/LAR; DD/leaf/tiller), and the leaf life span was obtained by the product of the phyllochron and the number of green leaves/tiller. The data were submitted to variance analysis and regression analysis as a function of PS doses using the statistical program SISVAR (*a computer statistical analysis system*, version 5.1).

RESULTS AND DISCUSSION

The fertilization of the giant missionary grass changed the tissue flow and structural traits of the canopy. There was a significant linear effect for the leaf elongation rate (LER), pseudoculm elongation rate (PSR), leaf senescent rate (LSR), leaf senescence elongation rate (LSER), number of basal tillers, and green leaf blade length/tiller (LBL), showing that the plant can respond positively to higher amounts of PS or N to the highest dose tested in this study. These results are in accordance with those previously reported by MIRANDA et al. (2012) for the same pasture's PS treatments, which verified the linear effect of PS for dry matter production (DMP). The positive effect of N fertilization on LER (Figure 1) was expected, since the leaf elongation is a consequence of N's influence on cell division (GASTAL & NELSON, 1994). Positive results were also verified in ***Panicum maximum*** × ***P. infestum*** var. ***Massai*** in response to N application, with an almost 122% increase of LER at dose of 1,200kg N ha^{-1} (LOPES et al., 2013). However, the effect of N on grasses is variable, since the influence of genotype, environment, management, and experimental conditions. MONDARDO et al. (2011) verified the quadratic increase in the LER of pearl millet up to 115m³ PS ha^{-1} $year^{-1}$. In ***Brachiaria brizantha*** cv. 'Piatã', ORRICO JR. et al. (2012) found a 55.15% increase in LER in response to rates of biofertilizer produced from cattle and swine manure at doses up to 300kg N ha^{-1}. In ***P. maximum*** × ***P. infestum*** var. ***Massai***, an almost 122% increase in LER was verified at a dose of 1,200kg N ha^{-1} (LOPES et al., 2013). MACHADO et al. (2013) observed an increase in LER near 46% in ***Paspalum plicatulum*** after the application of 100kg N ha^{-1}, but no effect was verified on ***A. affinis***. The LER values obtained here (0.55 to 1.03mm $tiller^{-1}$ DD^{-1}) were higher than those that BANDINELLI et al. (2003) found for ***Andropogon lateralis*** in response to N application up to 400kg N ha^{-1} $year^{-1}$ (0.449 to 0.659mm $tiller^{-1}$ DD^{-1}). Already, in ***P. plicatulum***, MACHADO et al. (2013) registered an increase of 0.382 (control) to 0.558mm DD^{-1} on this attribute, in response to N fertilization. As the consequence of the LER increase, there was an increase in the leaf blade length/tiller (LBL) (Figure 1), which was also observed in ***B. brizantha*** (Hochst. ex

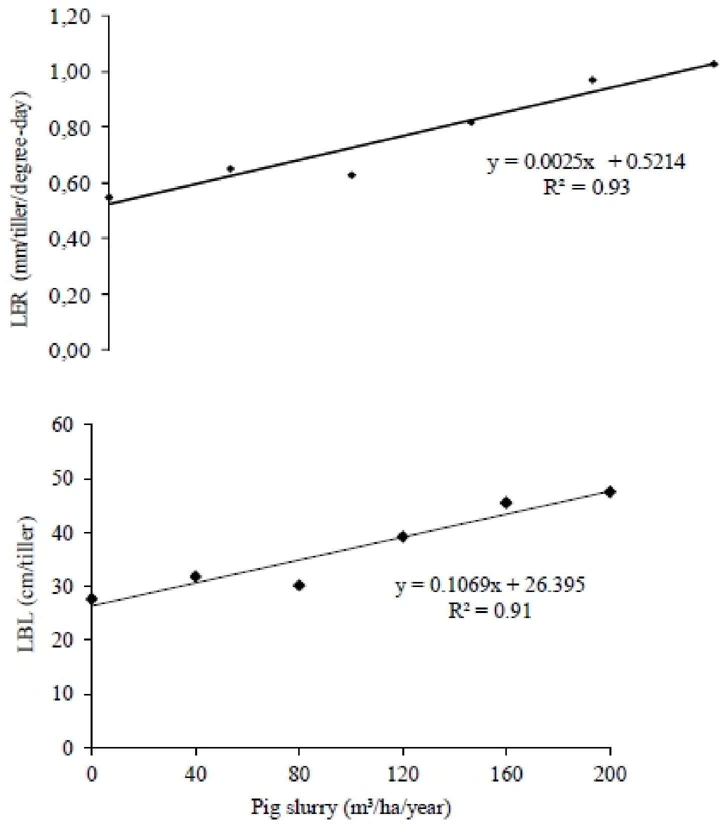

Figure 1 - Leaf elongation rate (LER) and leaf blade length (LBL) of giant missionary grass as function of pig slurry doses. (Basal temperature to calculate the thermal sum in degree-day = 10ºC).

A. Rich.) Stapf. cv. 'Marandu' (ALEXANDRINO et al., 2004), and ***P. maximum*** Jacq. (PATÊS et al., 2007) under N fertilization.

The LSR and LSER increased linearly with PS doses (Figure 2), which has been frequently verified in forage grasses under N fertilization (MARTUSCELLO et al., 2006; SILVA et al., 2009). In ***A. aureus***, COSTA et al. (2013) verified that this trait was affected positively and linearly by N fertilization, and in ***A. laterallis***, BANDINELLI et al. (2003) registered a proportional increase of senescence elongation in response to N doses. As the increase of leaf senescence is associated with the loss of forage and nutritional value reduction (PEREIRA et al., 2011), the management of this grass would have to be changed for PS or N application, and adjusted for stocking in continuous stocking or intervals between cuts in rotational stocking. The senescence increase of giant missionary grass across PS doses can be partially attributed to the tillering stimulus (Figure 2), since this process limits the light penetration in the canopy. In this study, the number of basal tillers increased by 46% when

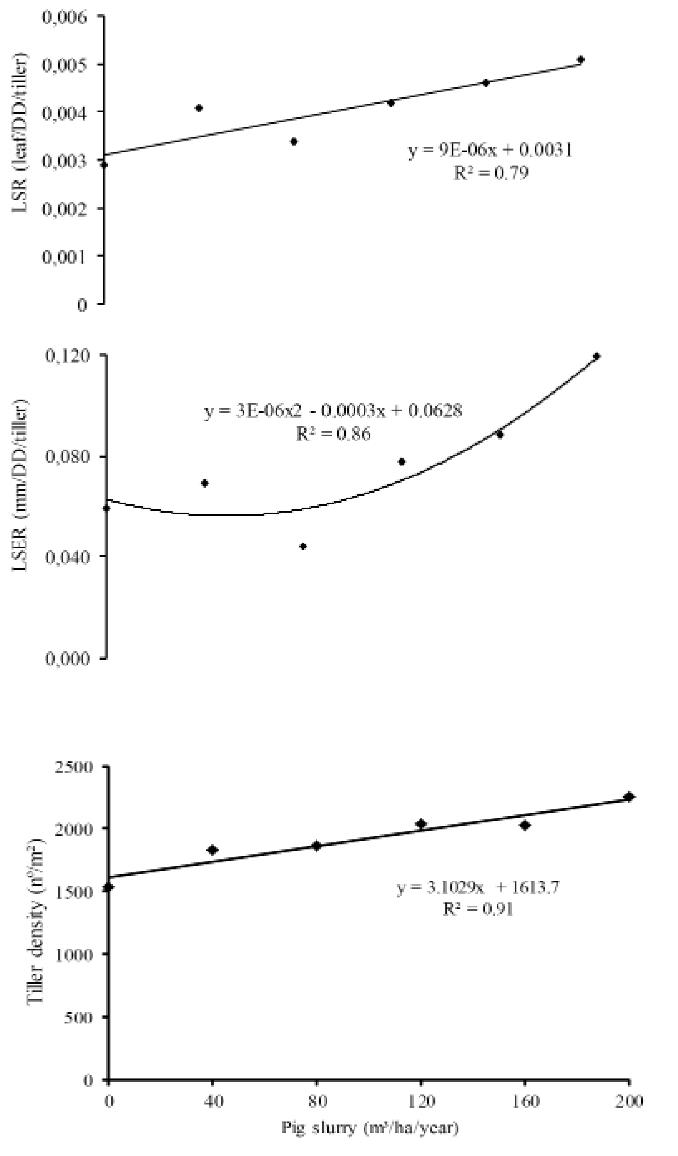

Figure 2 - Leaf senescent rate (LSR), leaf senescence elongation rate (LSER) and tiller density of giant missionary grass as function of the pig slurry doses. (Basal temperature to calculate the thermal sum in degree-day = 10ºC).

fertilizer-PS was increased from 0 to 200m³ PS ha^{-1}. The positive response of tillering to N application was also verified for other tropical grasses, such as ***A. aureus*** (COSTA et al., 2013), ***Brachiaria*** sp. (FAGUNDES et al., 2006) and ***P. maximum*** (MESQUITA & NERES, 2008).

The PSH and the PSER showed a linear increase in function of the PS, with maximum increases of 98% and 127%, respectively, in relation to the absence of fertilization (Figure 3). CASTAGNARA et al. (2011) observed a quadratic response in the PSH in ***Brachiaria*** sp. submitted to N fertilization up to 160kg N ha^{-1} $year^{-1}$. SANTOS et al. (2009) reported that the pseudoculm length of ***Brachiaria*** sp. was the morphogenetic trait most influenced by N. In pearl millet, MONDARDO et al. (2011) observed a quadratic increase in this variable up to 115m³ P Sha^{-1} $year^{-1}$. As a result of the effect of PS on the elongation of the pseudoculm, there was an increase of the canopy height (Figure 3), as reported in other studies about the effect of N fertilization on tropical grasses (CASTAGNARA et al., 2011). At the highest dose, this attribute was 85% higher than the control treatment. N intensifies the competition for

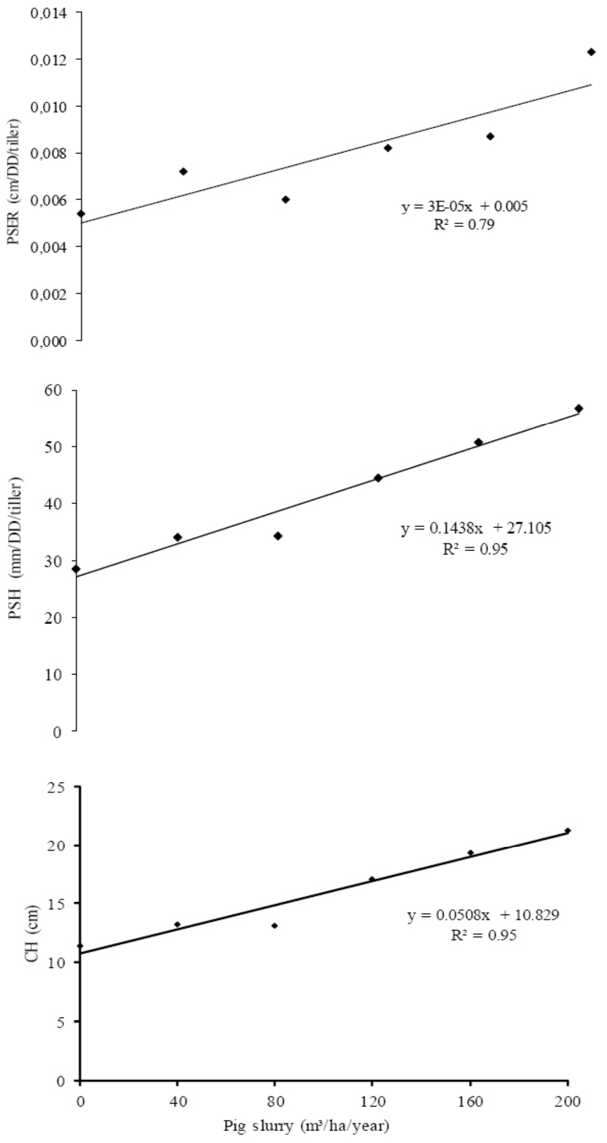

Figure 3 - Pseudoculm elongation rate (PSER), pseudoculm height (PSH) and canopy height (CH) of giant missionary grass as function of the pig slurry doses. (Basal temperature to calculate the thermal sum in degree-day = 10ºC).

light, and as one of the responses to this is an increase in the PER, the tillers become larger, and the plants become higher (SANTOS et al., 2009).

The LAR and phyllochron were not affected by the fertilization, with an average of 0.0057 leaf/tiller/DD and 215.7 DD, respectively. The effect of N fertilization on leaf appearance is variable, and the species and fertilizer doses can be considered. HIRATA (2000) observed a small effect of N on the LAR of bahia grass, which was more influenced by the month of the year and cutting height. In ***A. lateralis*** fertilized with up to 400kg N ha^{-1}, BANDINELLI et al. (2003) did not verify the effect of N on phyllochron, which was similar (203.6 DD) to our results for giant missionary grass. In ***P. maximum*** fertilized with up 200kg N ha^{-1}, MESQUITA & NERES (2008) verified an increase in the LAR and a reduction in the phyllochron.

In addition to the experimental differences in the climate, type, and dose of nitrogen fertilizer, the form of growth of the grasses studied should be considered. In tufted grasses, the N nutrition affects the expression of basic morphogenetic variables at the tiller level in a number of ways, increasing the LER and tillering rate and having a slight effect on the LAR; the effect of N nutrition on leaf tissue production on strictly stoloniferous species appears to be very dependent on the response of stolon internode elongation (CRUZ & BOVAL, 2000). Since giant missionary grass is a morphological intermediate (caespitose-stoloniferous), the effect of N nutrition on leaf production can be more dependent on the response of stolon internode elongation, which was not evaluated in this study. A detailed analysis of the tiller demography, stolon ramification, and growing point density of this hybrid is needed for a full understanding of its response to N fertilization.

CONCLUSION

The application of liquid swine manure in giant missionary grass alters the tissue flow, which requires attention to management in order to maximize the efficiency of forage use and to prevent losses of forage by leaf senescence. There appears to be a possibility for further positive responses to N applied via PS beyond 500kg N ha^{-1} $year^{-1}$ in respect to the LER and tiller density.

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