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BIOTECHNICAL POTENTIAL OF PASPALUM SUBMITTED TO SIMPLE SUPERPHOSPHATE DOSES AND MOISTURE CONTENT

Potencial biotécnico do paspalum submetido à doses de superfosfato simples e teores de umidade

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Abstract – The objective of this study was to evaluate the development of grass *Paspalum millegrana* Schrad propagated through seeds and tillers, subjected to different levels of water and phosphorus to be used in erosion control on slopes. The experimental trial was conducted in greenhouse with propagation of tillers and seeds of Paspalum grass, at the Federal University of Sergipe, São Cristóvão, Brazil. The design was the completely randomized design with sixteen treatments and four replications, arranged in a factorial scheme corresponding to (0, 100, 200, 300 and 400 mg kg^{-1}), two water contents in the soil (60% and 100% of total pore volume) filled with water and two types of propagation (tillers and seeds). Plants were harvested at the end of four months of conducting the experiment and evaluated the following variables: number of tillers (NT), number of inflorescences (NI), Shoot Length (SL), Root Length (RL), Shoot Dry Weight (SDW) and Root Dry Weight (RDW). The phosphorus and water levels interacted positively with the variables studied and showed that this grass, presented biotech important features like good tillering, and the consequent formation of dense aerial biomass and root required for slope protection against erosion. The specie Paspalum millegrana showed a better development among the variables analyzed under conditions of less water availability with 60% VTP and the best responses of the simple superphosphate dosages were between 200 and 300 mg kg^{-1}.

Keywords – Erosion, Phosphorus, Vegetative propagation, Soil bioengineering

Resumo – O objetivo desse trabalho foi avaliar o desenvolvimento do capim *Paspalum millegrana* Schrad propagado por meio de sementes e perfilhos, submetidos a diferentes níveis de água e fósforo a ser utilizado no controle da erosão em taludes. O ensaio experimental foi conduzido em casa-de-vegetação com propagação de perfilhos e sementes do capim Paspalum, na Universidade Federal de Sergipe, São Cristóvão, Brasil. O delineamento utilizado foi o inteiramente casualizado com dezesseis tratamentos e quatro repetições, arranjados em um esquema fatorial correspondente a quatro doses de superfosfato simples (0, 100, 200, 300 e 400 mg kg^{-1}), dois teores de água no solo (60 e 100% do Volume Total de Poros) preenchidos com água e dois tipos de propagação (perfilhos e sementes). As plantas foram colhidas ao final de quatro meses de condução do experimento e avaliadas as seguintes variáveis: Número de Perfilhos (NT), Número de Inflorescências (NI), Comprimento Parte Aérea (SL), Comprimento de Raízes (RL), Massa Seca da Parte Aérea (SDW) e Massa Seca de Raiz (RDW). As doses de fósforo e os níveis de água interagiram de forma positiva com os parâmetros estudados e evidenciaram que esta gramínea, apresentou características biotécnicas importantes como bons perfilhamentos, e consequente densa formação de biomassa aérea e radicular necessários para proteção do talude contra a erosão. A espécie *Paspalum millegrana* apresentou melhor desenvolvimento entre as variáveis analisadas em condições de menor disponibilidade de água com 60% de VTP e as melhores respostas das dosagens de superfosfato simples ficaram entre 200 e 300 mg kg^{-1} de solo.

Palavras-Chave – Erosão, Fósforo, Propagação vegetativa, Bioengenharia de solos

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INTRODUCTION

The erosion of fluvial slopes, strongly resulting from anthropic actions, has directly interfered in the survival of species of fauna and flora; the biological communities in aquatic environments; reduction of agricultural areas; as well as to intensify the silting of watercourses, making it difficult to navigate, fish and public water supply (TANG et al., 2010; RIBEIRO et al., 2011).

In the case of the São Francisco river, the disordered historical occupation of its banks, from where the riparian vegetation was removed for various purposes, promoted significant increases in the erosion levels of these places, especially by the overlapping of the base of the river slopes, because of the low cohesion of the soil. The reinforcement promoted by the root system of the plants promotes the aggregation of alluvial soils, which are generally less cohesive, reducing the particle drag, resulting in a lower rate of erosion and reducing the sedimentation of watercourses (HOLANDA et al., 2008).

In order to minimize the problem of soil erosion, researchers (CHONG and CHU, 2007; STOKES et al., 2014) have been engaged in studying techniques that contribute to the stabilization of slopes and consequently help both the restoration of riparian forests and the favoring ecological succession processes, such as bioengineering soil. According to Durlo and Sutili (2005), soil bioengineering or natural engineering uses a set of techniques that combine the use of inert materials such as rocks, pieces of wood and geotextiles, with biological materials such as seedlings of woody plants and grasses in slope stabilization works.

In the case of the grasses vetiver grass (*Chrysopogon zizanioides* (L.) Nash) has been the most studied specie, the erosion control slope (SULEIMAN et al., 2013; MACHADO et al., 2015). In this sense, the knowledge of the biotechnical potential of species in Brazil, both for the control of erosive processes of marginal slopes and for the restructuring of the biological communities residing in these places, demand investigation of their ecological and agronomic characteristics.

The grass Paspalum millegrana Schrad, which occurs widely in the Americas from the USA to Brazil (SOUZA-CHIES et al., 2006; OLIVEIRA et al., 2013), fits perfectly in the characteristics demanded to improve soil resistance, as it is a specie of perennial cespitos development, with long, deep rhizomes and stems with heights of 80-120 cm (MACIEL et al., 2009). In addition to having morphological characteristics that express a lot of potential to be used in the stabilization of the slopes, because when combined with other techniques of bioengineering of soils, it can contribute potentially to the reduction of erosive processes, especially as it occurs in the right bank of the São Francisco river.

The objective of this study was to evaluate the development of Paspalum grass millegrana Schrad propagated through seeds and tillers, subjected to different levels of water and phosphorus to be used in erosion control on slopes.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse at the Campus of the Federal University of Sergipe in São Cristóvão - SE (37°06'20"W and 10°55'51"S). The specie used was the Paspalum millegrana Schrad from which vegetative (tiller) and seedlings of naturally occurring tussock were collected in Neossolo Flúvico (EMBRAPA, 2013) on the right bank of the São Francisco River, in the municipality of Amparo de São Francisco - SE, where according to Köppen´s tropical climate with dry summer, with an average annual rainfall of 1,400 mm and average annual temperature of 26ºC (CODEVASF, 2012).

The plants were grown in substrate composed of sandy soil and vermiculite, in a proportion of 2:1, in pots with a volume of 1.3 L with 8 kg of each mixture. The experimental units were uniformly fertilized with 54 mg of N Kg^{-1} of soil ($CO(NH_2)_2$), 165 mg of K Kg^{-1} of soil (KCl). Phosphate fertilization was carried out obeying the treatments with the doses 0, 100, 200, 300 and 400 mg Kg^{-1} of soil and having as source simple superphosphate. Nitrogen fertilization was divided in two stages (applied at the time of planting and when tillering was very expressive), according to Lopes and Abreu (1988).

The volumes corresponding to the water contents were determined from soil bulk density (BD), particle density (PD) (BLAKE, 1965) and total pore volume (VTP) (VOMOCIL, 1965), calculated by means of the expression:

$$VTP = 100\%, 60\%[1-[BD/PD]] \qquad \text{Eq. 1}$$

Water levels were monitored daily by weighing the vessel to provide the quantity of water that represents treatment (60% and 100% VTP). Over time, due to the differentiation of the stages of development as a function of the treatments of phosphate fertilization and water content, the vessels were weighed, with a frequency of up to three times a day, in order to compensate for the variations in terms of needs Different stages of development of the specie. Thus, uniformizing the water availability, the desired humidity was maintained according to the treatments tested.

The size of the seedlings was standardized at 0.2 m height, with bevel cut, and with presence of root, also uniform in length of 0.2 m. Vessels were initially kept with 60% moisture content of the VTP occupied by water during the first 15 days to ensure good leaf emission, tillering and uniform development of the plants. After the first two weeks, the treatments were applied with doses of phosphorus and water contents.

They were planted 100 seeds per pot of grass, with daily monitoring of their emergence and development, so that they could apply the amount of water needed to ensure early development. From the first weeks the pots were

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maintained with 60% moisture content of the VTP for uniform seedling development. As they reached 10 cm in height, with approximately one month of emergency, all vessels were submitted to the moisture contents of 60% and 100% of the VTP, according to the respective treatment, associated with P_2O_5 doses.

The experimental design was completely randomized with sixteen treatments and four replications, arranged in a factorial scheme (4 x 2) + 2 corresponding to four doses of simple superphosphate, two soil water contents and two types of propagation. The treatments were: T1 - Control without simple superphosphate application on tiller, T2 - control without simple superphosphate application on seeds, T3 -Application of 100 mg kg^{-1} simple superphosphate on tillers, T4 – Application of 100 mg kg^{-1} simple superphosphate on seeds, T5- Application of 200 mg kg^{-1} simple superphosphate on tillers, T6 - Application of 200 mg kg^{-1} simple superphosphate on seeds, T7 - Application of 300 mg kg^{-1} simple superphosphate on tiller, T8 - Application of 300 mg kg^{-1} simple superphosphate on seeds, T9 - Application of 400 mg kg^{-1} simple superphosphate on tillers, T10 - Application of 400 mg kg^{-1} simple superphosphate on seeds.

Plants were harvested at the end of four months of conducting the experiment, when the panicles had been launched in all tillers, assuming completion of the biological cycle of the species being held tiller number count by vase. A shoot was cut near the soil surface, composed of panicle, leaves and stems, separated from the rest of the plant or root. Height measurements were made of shoot and root system long after the harvest.

Root length was determined using a ruler, in centimeters, from the cervix to the apex of the root. After this measurement, the root was washed in running water on a 0.5 mm sieve to separate it from the soil. Then the material was packed in paper bags and forced to the kiln with forced circulation, at a constant temperature of 60°C, for 72 hours until reaching the constant weight, to obtain the aerial and root dry matter values.

The variables were evaluated: number of tillers (NT), number of inflorescences (NI), Shoot Length (SL), Root Length (RL), Shoot Dry Weight (SDW) and Root Dry Weight (RDW).

The evaluated parameters were submitted to analysis of variance using the Tukey's test ($P<0.50$), and there was an adjusted regression between them and the doses of simple superphosphate by tiller and seed. All analyzes were performed using STATISTICA software (STATSOFT INC, 2008).

RESULTS AND DISCUSSION

Number of tillers

Tiller and seed variables with 60 and 100% moisture contents increased quadratically ($P<0.05$), with simple superphosphate doses, but with notable differences between tiller and seed evaluated (Figure 1). This parameter allows to evaluate the size of the clump and the vegetation cover to protect the soil surface from erosive processes, especially those caused by the impact of rainfall and the consequent drag of the soil particles (ARAUJO-FILHO et al., 2015).

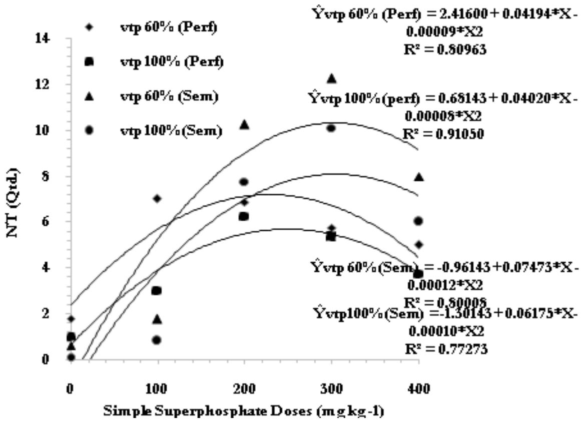

Figure 1 - Number of tillers in function of simple superphosphate doses. Significant at * P <0.05.

In relation to the number of tillers, it is possible that there is an inverse relation between the increase in VTP and the P_2O_5 doses related to the SDW, since the higher values of biomass are associated with the lower availability of water in the soil. This behavior seems to indicate an adaptive strategy for survival of this species to the longer periods of water scarcity, which could be associated to the low flow periods of the São Francisco River (HOLANDA et al., 2011), when the soil moisture in the higher parts of the slope is greatly reduced. Thus, it is believed that during the rainy season the plant develops well, increasing the SDW, which associated with its type of root system, makes it well tolerate the water restrictions, occurring in the period.

Number of inflorescences

Regarding this variable, the values varied directly influenced by the dosages of simple superphosphate, when related to the water availability at the level of 60 % of VTP (Figure 2), which presented the best results, especially seedlings, which presented the highest Number of inflorescence at both levels of water availability (60 and 100 % of VTP).

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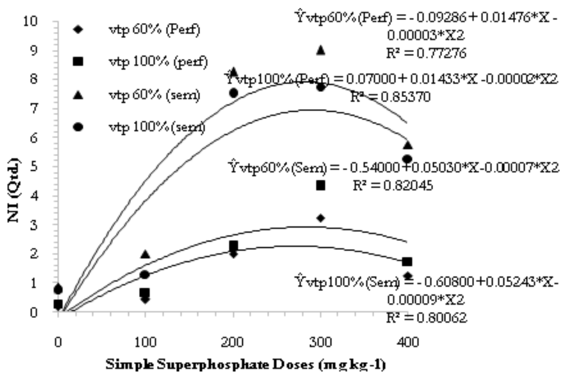

Figure 2 - Number of inflorescence in function of simple superphosphate doses. Significant at * P <0.05.

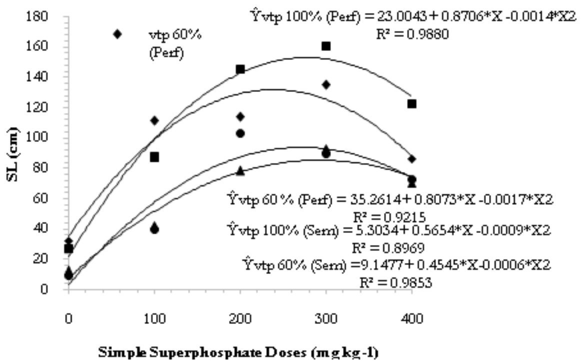

Figure 3 - Plant height in function of simple superphosphate doses. Significant at * P <0.05.

The poaceae in study has the characteristic of producing large quantities of seeds, being an adaptive characteristic of the species dissemination, since in natural conditions, it has low germination rates (LOPES and FRANKE, 2011).

In flooded areas, as is commonly observed at the base of the river slopes (HOLANDA et al., 2012a), it is possible that the lower development of the plants observed in the field is associated with excess water, as opposed to the furrows furthest from the water depth which have a better development. Therefore, the use of high doses of phosphorus for Paspalum millegrana can lead to deficiency of other nutrients as important as this under the mentioned conditions. According to Novais et al. (2016) phosphorus in high concentrations in the soil, decreases the availability of some micronutrients such as iron, copper and zinc to the plant, because these micronutrients are complexed.

Shoot Length

Comparing the results of this variable in relation to the means of propagation (tiller and seed) at different levels of P_2O_5 clearly observed to influence the phosphorus availability in soil on plant growth (Figure 3). The best dosage for better tillering was above 200 mg kg-1, and in the higher dosage there was inhibition of growth, since the excess of nutrients in the soil does not have positive effects on the growth of the plant by the toxic level that presents itself to the grass.

When associated with the water level in the soil, it is seen that better utilization of the plant to yield a moisture content of 100 % VTP. Several species of the genus Paspalum are identified as aquatic macrophytes, and thus have adaptive characteristics for flooded environments, enhancing photosynthetic utilization (PENTEADO and MACEDO, 2000).

The grasses have different behaviors under different levels of phosphorus, where there is a direct correlation between the phosphorous availability and growth of the aerial part of the plant (COSTA et al, 2006; BONFIM - SILVA et al., 2011). Several morphophysiological mechanisms are involved in the conversion of this chemical element into biomass, however, for poaceae. According to Alves et al. (2002), it seems that they are more tolerant to low phosphorus levels than legumes, because their fine roots are able to divide the chemical element between the root and the shoot in the same proportion, regardless of their concentration in the soil, in addition to its fasciculated root system being more efficient in the absorption of nutrients.

Root Length

In the evaluation of root length in propagation by tillers, significant differences (P<0.05) were observed in quadratic regressions for tillers and seeds at different moisture contents. The best results were observed for doses between 200 and 300 mg kg^{-1} in soil water saturation 60 % VTP (Figure 4).

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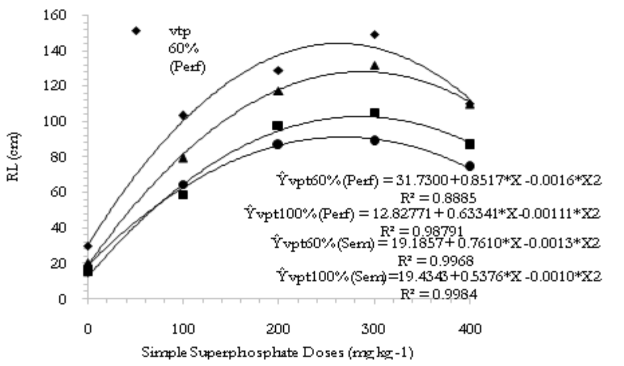

Figure 4 - Root length in function of simple superphosphate doses. Significant at * P <0.05.

The root growth is directly related to the availability of phosphorus in the soil (HOLANDA et al., 2012b). The high concentration of roots in a given soil layer tends to produce larger amounts of organic carbon, which may influence the physical, chemical and biological characteristics of the soil (BAQUERO et al., 2012). The higher root lengths and density may show greater initial resistance to soil erosion, allowing greater soil structuring due to increased carbon contribution and higher concentration of fulvic and humin acids in soils cultivated with grasses (GUIMARÃES et al., 2013) . In addition, the roots can also promote a higher water uptake in the deeper layers of the soil (STOKES et al., 2009), directly influencing the stability of these layers and, consequently, the resistance of the roots to the soil mass movement of the slope in study.

Shoot Dry Weight (SDW) and Root Dry Weight (RDW)

The results showed that the dry matter production of both shoots and roots paspalum grass presented significant differences with the doses of simple superphosphate in the soil. It was observed that the plants coming from seeds present a greater vigor translated by more dry matter of both shoot and root (Figure 5).

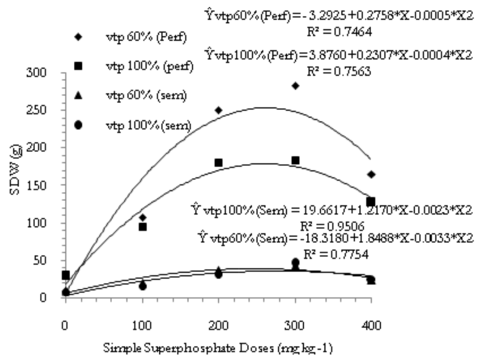

Figure 6 - SDW in function of simple superphosphate doses. Significant at * P <0.05.

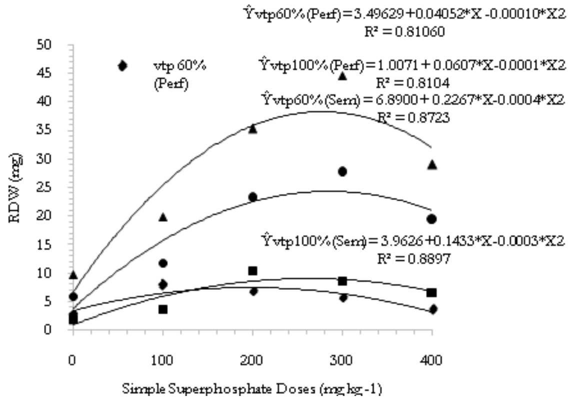

Figure 5 - RDW in function of simple superphosphate doses. Significant at * P <0.05.

It is worth mentioning that a vigorous seed presents adequate potential for good germination, resulting in normal seedlings under a wide variety of growing conditions. The tillers, although they promote a faster development of the plant, undergo strong stress, when separating the clumps for the formation of the seedlings, probably impacting on the dry matter production at the end of the cycle. According to Correia et al. (2009), a plant in ideal conditions of nutrition, mainly related to the level of phosphorus, tends to present a greater development of the roots and, as a consequence, will have a greater production of photoassimilates.

CONCLUSIONS

The specie Paspalum millegrana presented better development among the analyzed variables in conditions of lower availability of water with 60% of VTP.

The highest responses of simple superphosphate dosages were between 200 and 300 mg kg^{-1} of soil for paspalum grass.

The grass showed important biotechnical characteristics such as good tillering, and consequent dense formation of aerial and root biomass necessary to protect the slope against soil erosion.

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