

## MORPHOMETRIC INCREASE OF TREE SPECIES SUBMITTED TO FERTILIZATION WITH SWINE WASTEWATER

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**ABSTRACT** - Swine is an important exploration of Paraná's cattle raising, promoting the generation of employment and income in rural areas, however, it generates large amounts of solid and liquid residues. Based on these considerations, the objective of this work was to analyze the development of native tree species submitted to fertilization with swine wastewater. Four native tree species were selected: *Anadenanthera colubrina* (Vell.) Brenan (Fabaceae), *Astronium graveolens* Jacq. (Anacardiaceae), *Cordia trichotoma* (Vell.) Arráb. ex Steud (Boraginaceae) and *Heliocarpus popayanensis* Kunth (Malvaceae). The applied doses of wastewater had been of 0, 25 and 50 m<sup>3</sup> ha<sup>-1</sup>. They were applied every two months, adding up a total of 6 applications and the measured morphometric variables of the seedlings were height (cm) and stem diameter (mm); the experimental design selected was completely randomized design and samples of the witness plots were collected in order to assess the chemical conditions of the soil. For the height variable only the species *Astronium graveolens* was statistically different from the others. With respect to stem diameter, it was found that *Heliocarpus popayanensis* presented the highest average, but it was statistically similar to *Cordia trichotoma*, however, differing significantly from the others. The use of swine wastewater as a fertilizer is a good option to optimize the growth of native species in question, especially the 25 m<sup>3</sup> ha<sup>-1</sup> dose of swine wastewater, because it was the treatment that presented the best results of the increment values of both morphometric variables measured.

**Key words:** Dejection correct destination, native species, organic fertilization.

## INCREMENTO MORFOMÉTRICO DE ESPÉCIES ARBÓREAS SUBMETIDAS À ADUBAÇÃO COM ÁGUA RESIDUÁRIA DA SUINOCULTURA

**RESUMO** - A suinocultura é uma importante exploração da pecuária paranaense promovendo a geração de emprego e renda no meio rural, contudo, gera grandes quantidades de resíduos sólidos e líquidos. Diante do exposto, objetivou-se com o presente trabalho analisar o desenvolvimento de espécies arbóreas nativas submetidas a adubação com água residuária da suinocultura. Foram selecionadas quatro espécies arbóreas nativas - *Anadenanthera colubrina* (Vell.) Brenan (Fabaceae), *Astronium graveolens* Jacq. (Anacardiaceae), *Cordia trichotoma* (Vell.) Arráb. ex Steud (Boraginaceae) e *Heliocarpus popayanensis* Kunth (Malvaceae). As doses de água residuária aplicadas foram 0, 25 e 50 m<sup>3</sup> ha<sup>-1</sup>. Essas foram aplicadas a cada dois meses, somando um total de 6 aplicações e as variáveis morfométricas mensuradas das mudas foram altura (cm) e diâmetro do caule (mm). O delineamento experimental selecionado foi o delineamento inteiramente casualizado e, foram coletadas amostras de solo das parcelas testemunhas para avaliar as condições químicas do solo. Para a variável altura apenas a espécie *Astronium graveolens* foi estatisticamente diferente das demais. Com relação ao diâmetro do caule, verificou-se que *Heliocarpus popayanensis* apresentou a maior média, mas foi semelhante estatisticamente a *Cordia trichotoma*, contudo, diferindo significativamente das demais. O uso da água residuária da suinocultura como fertilizante é uma boa opção para otimizar o crescimento das espécies nativas em questão, especialmente a dose de água residuária de 25 m<sup>3</sup> ha<sup>-1</sup> pois foi o tratamento que apresentou os melhores resultados dos valores de incremento de ambas variáveis morfométricas mensuradas.

**Palavras-chave:** destino correto aos dejetos, espécies nativas, adubação orgânica.

### INTRODUCTION

The economic cycles that developed in Paraná were determinant factors for the elimination of native vegetation, for exploitation purposes, such as mining, timber extraction, cattle raising and the opening of areas for agriculture, so that only 8% of the original plant cover remains unchanged (CAMPOS, TOSSULINO, MULLER, 2006; FERRETTI et al., 2006; HAUER, 2010).

Because of this local vegetal covering gradual elimination, the formation of degraded areas had happened, which can be defined as an environment that was modified by the action of the man and that, due to a lot of factors, it reduces the limit of natural recovery of the soil, becoming necessary the human intervention to recoup these places (NOFFS et al., 2000). In this direction, the degraded areas present some problems as the reduction of the potential resources renewed, desertification, drying of

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the atmospheric climate and erosion (ARAÚJO et al., 2007).

Amongst the implanted economic activities in the Paraná, the pig farming has been gaining prominence, and in 2016 this state had a flock of approximately 7.131.132 animals, which conferred the status of state with the largest flock of these animals. Due to this factor, the large volume of wastewater generated by this activity has become a serious problem (PRIOR et al., 2015), since in general it is estimated that each animal produces on average 8,6 L of waste per day (OLIVEIRA, 1993).

It is known that this wastewater has a high potential for subsurface water pollution, due to the high concentration of nutrients. Therefore, prior to its use as a fertilizer, swine wastewater, hereinafter referred to as SW, must undergo processes capable of reducing health risks. One of these processes is fermentation, which can be promoted in biodigestors or composting processes (TOKHUN et al., 2010; CADIS and HENKES, 2014).

However, when used correctly, studies have shown that one of the alternatives for recycling swine wastewater is using it as fertilizer, since it is rich in nutrients, which can be mineralized and then made available to plants. Rosa et al. (2017) quantified through chemical analyzes how much nutrients can be added to the soil by SW obtaining values up to 707 mg L<sup>-1</sup> of N; 33,01 mg L<sup>-1</sup> of P; 265 mg L<sup>-1</sup> of K<sup>+</sup>; 236 mg L<sup>-1</sup> of Ca; 67 mg L<sup>-1</sup> of Mg<sup>2+</sup>; 27,4 mg L<sup>-1</sup> of Fe<sup>2+</sup>, 39 mg L<sup>-1</sup> of Zn<sup>2+</sup>, among others.

It is known that the nutrients are of great importance for the numerous organic molecules (proteins, nucleic acids, etc.), that is, they are indispensable for the development of the plants (SILVA et al., 2004; KERBAUY, 2008), proving that very high doses of this effluent can hinder development, while lower doses can optimize plant development.

Finally, the low amount of information about silvicultural behavior and, above all, about the nutrition of native species, also compromises their use when searching for better quality wood for the most varied possible uses, as described by Souza et al. (2006).

Faced with this panorama, where it becomes necessary to recompose degraded areas or even to restore the legal areas of permanent preservation and reserves, it's extremely important to create techniques that optimize the

development of native species after its plantation, therefore, according to Barbosa (2006), its necessary to perform research that can speed up and/or improve the natural regeneration of the degraded areas. This factor, ally to the necessity of a correct form for SW discarding, becomes essential the search for alternatives that guarantee the good development of native species from the use of the dejection, solving both the environment problems, the recovery of degraded areas and discarding of the wastewater.

In this direction, the objective of this work was to evaluate the effect of using swine wastewater different doses on the development of morphometric characteristics (height and stem diameter) of native tree species at Semideciduous Seasonal Forest of western Paraná, Brazil.

## MATERIAL AND METHODS

The site of the experiment was located in the area of environmental recuperation of the Palotina (Paraná State, Brazil), with coordinates 24°17'31,25"S and 53°50'31,64"W. The altimetric plateau is around 330 m and the regional climate is of the Cfa type, according to the classification of Köppen, with no predominance of dry season (IAPAR, 2017). The soil of the area is the eutropherric RED LATOSOL (BHERING et al., 2007).

The planting of seedlings was held in May/13 and after one year, four native species have been selected, that possessed enough individuals to perform the experiment, which were *Anadenanthera colubrina* (Vell.) Brenan (Fabaceae), *Astronium graveolens* Jacq. (Anacardiaceae), *Cordia trichotoma* (Vell.) Arráb. ex Steud (Boraginaceae) and *Heliocarpus popayanensis* Kunth (Malvaceae).

The experiment was carried out from May 2014 to April 2015, and the design was a completely randomized design, arranged in the factorial scheme 4 x 3 (four species and three doses of SW), with five replicates for each treatment. The doses of SW were: 0 m<sup>3</sup> ha<sup>-1</sup> (treatment 1 - control), 25 m<sup>3</sup> ha<sup>-1</sup> (treatment 2) and 50 m<sup>3</sup> ha<sup>-1</sup> (treatment 3). The evaluated variables were diameter of the stem at ground level (mm) and plant height (cm).

In order to verify soil chemical conditions, a soil sample was collected from the place where the control plots were located to perform soil chemical analyzes (Table 1), in order to determine the content of nutrients available at the site of the experiment.

**TABLE 1** - Soils analysis of the place of the experiment.

pH (CaCl <sub>2</sub> )	4,7	SB (cmol <sub>c</sub> dm <sup>-3</sup> )	4,69
pH SMP	5,7	CTC (cmol <sub>c</sub> dm <sup>-3</sup> )	10,89
Al <sup>3+</sup> (cmol <sub>c</sub> dm <sup>-3</sup> )	0,1	P (mg dm <sup>-3</sup> )	5,1
H <sup>+</sup> + Al <sup>3+</sup> (cmol <sub>c</sub> dm <sup>-3</sup> )	6,2	C (g dm <sup>-3</sup> )	16,7
Ca <sup>2+</sup> (cmol <sub>c</sub> dm <sup>-3</sup> )	3,2	V(%)	43
Mg <sup>2+</sup> (cmol <sub>c</sub> dm <sup>-3</sup> )	1,1	M(%)	2
K <sup>+</sup> (cmol <sub>c</sub> dm <sup>-3</sup> )	0,39	Ca/Mg	2,91

It is important to note that it was not possible to perform the regression analysis to determine the best dose, since only 3 doses of SW were used, which in turn were not sufficient to validate such an analysis. No more doses

were tested because it was a forest restoration area with a limited number of individuals.

The increments in height and diameter were quantified by subtracting the final measure of the initial

measurement. All the statistical analyzes were performed with the aid of the Sisvar<sup>®</sup> program (FERREIRA, 2011).

The SW was obtained from an agricultural property in the municipality of Palotina, with intensive confinement system, which includes the stages of day care and maternity. All wastewater produced was stored in a biodigester and, after fermentation, was used to fertilize the crops on the property.

The fertilizer applications were held every 60 days, in a total of 6 applications. To minimize errors, the same equipment was used in all measurements of the experiment. After each measurement of the diameter, the

region of the stem where the reading was done was marked with white paint, so all measurements were done in the same place.

## RESULTS AND DISCUSSION

Monitoring the growth of individuals from the measurements made it possible to quantify the increase, and by the variance analysis, significant differences were found for the variables analyzed (Table 2), as well as the existence of interaction between the species and the doses of SW.

**TABLE 2** - Average height squared and diameter at ground level of native tree species.

Variance factor	Average square	
	Height	Diameter
Native tree species	17200,99*	1020,09*
Dose of swine wastewater	13676,87*	659,52*
Native tree species x dose of swine wastewater	5927,71*	285,05*
Error	2407,52	73,14

\*Significant at 5% minimum level of error probability for the Tukey test.

As there were significant differences between the data, the results were submitted to the Tukey test (5%) in order to verify differences between the averages. For the height variable, the Tukey test showed that *Astronium*

*graveolens* presented the lowest average, and the others did not differ statistically among themselves. It was noted that the dose of 25 m<sup>3</sup> ha<sup>-1</sup> presented the highest average differing from the other doses (Table 3).

**TABLE 3** - Comparison of averages for the variable height of native tree species.

Native tree species	Dose of swine wastewater			Average
	0 m <sup>3</sup> ha <sup>-1</sup>	25 m <sup>3</sup> ha <sup>-1</sup>	50 m <sup>3</sup> ha <sup>-1</sup>	
<i>Anadenanthera colubrina</i>	36,8 Aa*	159,2 Bb	93,6 ABa	96,53 a
<i>Astronium graveolens</i>	14,2 Aa	27,8 Aa	23 Aa	21,67 b
<i>Cordia trichotoma</i>	80,2 Aa	82,4 Aa	76 Aa	79,53 a
<i>Heliocarpus popayanensis</i>	89,4 Aa	136,8 Bb	37,2 Aa	87,8 a
Average	55,15 A	101,55 B	57,45 A	

\*Lowercase letters compare averages in columns and uppercase in rows. Averages followed by equal letters do not differ significantly by Tukey test at 5%.

The outcomes showed that there was interaction between the dose 25 m<sup>3</sup> ha<sup>-1</sup> and the species *Anadenanthera colubrina* and *Heliocarpus popayanensis* proving that intermediate doses of this dejection tend to optimize the development of the plants, since that both had presented greater growth in height with the dose of 25 m<sup>3</sup> ha<sup>-1</sup>, even that statistically, the dose 25 m<sup>3</sup> ha<sup>-1</sup> did

not differ from dose 50 m<sup>3</sup> ha<sup>-1</sup> for *Anadenanthera colubrina*.

For the stem diameter variable, different results were obtained among the averages of the species, however, again, it was verified that the dose 25 m<sup>3</sup> ha<sup>-1</sup> presented the highest average, differing statistically from the others, according to Table 4.

**TABLE 4** - Comparison of averages for the diameter of the stem at ground level native tree species.

Native tree species	Dose of swine wastewater			Average
	0 m <sup>3</sup> ha <sup>-1</sup>	25 m <sup>3</sup> ha <sup>-1</sup>	50 m <sup>3</sup> ha <sup>-1</sup>	
<i>Anadenanthera colubrina</i>	5,58 Aab*	19,24 Bb	9,38 ABa	11,40 ab
<i>Astronium graveolens</i>	4,88 Ab	3,69 Aa	5,08 Aa	4,55 a
<i>Cordia trichotoma</i>	15,59 Aab	18,13 Aab	15,05 Aa	16,27 bc
<i>Heliocarpus popayanensis</i>	20,00 Aa	41,62 Bc	10,82 Aa	24,14 c
Average	11,51 A	20,67 B	10,09 A	

\*Lowercase letters compare averages in columns and uppercase in rows. Averages followed by equal letters do not differ significantly by Tukey test at 5%.

In the unfolding, to the diameter of stem variable, a similar behavior to that found to height variable has occurred, once that *Anadenanthera colubrina* and *Heliocarpus popayanensis* presented the highest average at the intermediate dose of SW, it means  $25 \text{ m}^3 \text{ ha}^{-1}$  and for *Anadenanthera colubrina*, although the dose  $25 \text{ m}^3$  has been greatest, did not differ statistically from dose  $50 \text{ m}^3 \text{ ha}^{-1}$ .

Normally, the plants show a correlation between the growth in height and in diameter, when growing on normal conditions of nutrition and competition, so that small height trees, presents small diameter, and vice versa (CUNHA, 2004). This fact can explain the behavior described previously, i.e. species that answered positively to fertilization in the variable height, answered also in the diameter of the stem.

*Anadenanthera colubrina* and *Heliocarpus popayanensis* are pioneers in ecological succession and pioneer species tend to respond appropriately to the situation found on the site of the experiment, which was characterized for being an area with sun exposure during the most of the day, an important abiotic factor for the development of pioneering species (MACIEL et al., 2003).

In this case, in addition to the influence of light, the fertilization provided via SW enabled the rapid growth of *Anadenanthera colubrina* and *Heliocarpus popayanensis* which are pioneering species. In a work conducted by Duboc and Guerrini (2007), with native species fertilization it has been found that pioneering species exhibit high nutritional needs and therefore, respond positively to nitrogen fertilization and nitrogen is a nutrient present in high amount in the SW as verified by Konzen et al. (1997).

The results found in this experiment are similar to those of Batista et al. (2013), who showed that half-dose treatment of SW resulted in better nutritional and morphological conditions of *Eucalyptus* seedlings, promoting higher growth rates of seedlings.

Pelissari et al. (2009), cites the positive effect of the use of the SW for the production of *Eucalyptus* seedlings. To the authors, the result was obtained by the high content of nitrogen and phosphorus present in the solution, noting that its use decreased the production time of these seedlings from 90 to 60 days, that hence the replacement of chemical fertilizers for the wastewater.

On the other hand, one of the problems of the use of SW high doses is the phytotoxicity caused by the excess of nutrients, damaging the development of the plants, as stated by Couto et al. (2010), that the application of very high doses of SW raised the nutrient content to levels considered high, which is responsible for the lower growth of the plants at the dose  $50 \text{ m}^3 \text{ ha}^{-1}$ .

In this experiment, it was found that *Cordia trichotoma* did not respond positively to the application of SW, a result divergent from that found by Araújo et al. (2015), which proved that the foliar fertilizer and SW association favored the development of some native species as *Cordia americana* (L.) Gottschling & J.S. Mill. and *Cordia trichotoma*. According to Epstein and Bloom

(2006), some nutrients are assimilated in conjunction, as in the case of nitrogen and sulphur, and so, if the vegetable suffers a deficiency of any of these elements it will have difficulty absorbing the other. Thus, the non-consortium of swine wastewater (rich in nitrogen) with a sulphur source may have reduced the absorption of nitrogen available to plants.

Another important factor to be highlighted is that the place where it was conducted the experiment was a forest, which was replaced by a grassy field and currently is in the process of restoration of the arboreal vegetation, that is, for a long time, this place was a closed system with balance between imports and exports close to zero (VOGEL et al., 2006).

Thus, the nutritional capacity of the soil was sufficient for the plants there cultivated to grow without nutritional problems, at least in relation to the macronutrients. Fact evidenced by soil analysis, which showed that the levels of phosphorus (P) and potassium (K) were high and very high, respectively (Table 1), based on the manual of fertilizing and liming (SBCS, 2004).

Because SW has many nutrients in its chemical composition, with emphasis on macronutrients, and the soil already having a good reserve, the application of higher doses of nutrients could have the inverse effect to the desired one, as observed in the dose of  $50 \text{ m}^3 \text{ ha}^{-1}$  and also, according to Prior et al. (2015), that the continuous use of swine wastewater resulted in an increase in the content of phosphorus (P) and nitrogen (N) with an increase in the sodicity content of the soil.

Although the species have been conducted in the same location, i.e. received the same conditions, they had presented different behaviors, once *Heliocarpus popayanensis* and *Anadenanthera colubrina* showed best average growth with the dose  $25 \text{ m}^3 \text{ ha}^{-1}$  while *Cordia trichotoma* and *Astronium graveolens* did not show significant response in front of fertilization. Thus, it is important to highlight that besides the physical and chemical characteristics of the soil and climate, there is the genotype versus environment interaction, which implies that *Cordia trichotoma* and *Astronium graveolens* may not have responded to the fertilization by factors intrinsic to its genotype (SQUILASSI, 2003).

## CONCLUSIONS

The results allowed to conclude that the use of SW as fertilizer for native species is a viable alternative for the reuse of nutrients present in this effluent, especially for nutrient poor soils.

It is concluded that the intermediate dose ( $25 \text{ m}^3 \text{ ha}^{-1}$ ) presented the best performance in practically all cases, especially for the species *Heliocarpus popayanensis* and *Anadenanthera colubrina*.

This determines that this dosage value may be a starting point for the use of SW for fertilization purposes for native tree species.

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Morphometric increase...

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