

Growth of forest seedlings submitted to fertilization with swine wastewater**Crescimento de mudas florestais submetidas à diferentes dosagens de adubação com água residuária da suinocultura**

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ABSTRACT

From an economic point of view, swine stands out as an important exploitation of Brazilian livestock farming, promoting employment and income generation in rural areas. However, this activity becomes environmentally problematic because it produces large quantities of swine wastewater (ars), but has potential to be used as fertilizer. The present work had as objective to determine the dose of ars that would best provide increment of height and diameter in seedlings of *Luehea divaricata* Mart. & Zucc. (Malvaceae). The experimental design was randomized blocks with four replications and four seedlings per plot totaling 80 seedlings. Each plot received the following ars doses: 0, 12.5, 25, 37.5 and 50 m³ ha⁻¹. The results confirmed statistical differences between the average height of the seedlings in relation to the applied doses. The plants that received doses of 50 m³ ha⁻¹ presented higher average and maximum value of diametric growth and height. The application of ars showed positive results in the fertilization of tree seedlings, besides allowing a further route for the destination of this residue contributing to the reduction of environmental risks caused by its irregular destination.

Keywords: organic fertilization, wastewater, native species, forest recovery.

RESUMO

A suinocultura é uma importante exploração da pecuária brasileira promovendo a geração de emprego e renda no meio rural, mas por outro lado produzindo grandes quantidades de dejetos como a Água Residuária da Suinocultura (ARS). Este trabalho teve como objetivo determinar a dose de ARS que a melhor proporciona incremento de altura e diâmetro em mudas de *Luehea divaricata* Mart. & Zucc. (Malvaceae). O delineamento experimental utilizado foi blocos ao acaso, com quatro repetições e quatro mudas por parcela totalizando 80 mudas. Cada parcela recebeu as seguintes doses de ARS: 0, 12,5, 25, 37,5 e 50 m³ ha⁻¹. Os resultados confirmaram diferenças estatísticas entre as médias de altura das mudas em relação às doses aplicadas. As plantas que receberam doses de 50 m³ ha⁻¹ apresentaram maior média e valor máximo de crescimento diamétrico e de altura. A aplicação da ARS mostrou resultados positivos na adubação de mudas arbóreas além de possibilitar mais uma via para a destinação desse resíduo contribuindo para redução de riscos ambientais ocasionados pela sua destinação irregular.

Palavras-chave: Adubação orgânica, dejetos líquidos, espécies nativas, recuperação florestal.

1 INTRODUÇÃO

At the beginning of century XX, Paraná presented approximately 84.7% of its surface covered by forests (Ferretti et al., 2006), among them was the Semideciduous Seasonal Forest (FES). The advance of colonization and the expansion of the agricultural frontier led to the opening of areas for agriculture and livestock in several regions, which drastically reduced the areas occupied by native forests and contributed to the extinction of many species of plants (Maack, 1981). From the state phytogeographic units, FES was the one that had the greatest impact, since it occurred in areas with high agricultural potential, and was progressively replaced by coffee, corn, soybean, sugarcane, among others and by different cattle farms.

Amongst the cattle breeding business the swine is distinguished, whose flock exceeded the 38 million heads in 2012, becoming Brazil the fourth world-wide producer, being that the south region is about 50% of the national flock. Paraná is the third largest producer of pigs and the western and southwestern regions of the state are where the majority of farmers, mainly small producers (Gervásio, 2014) are concentrated.

Intensive and confined pig husbandry management is practiced in approximately 50% of the producing units, which for Nogueira e Silva (2006) entails the generation of waste that can reach up to 10 liters / animal / day. However, the increase in volume is directly related not only to the type of breeding system, but also to other factors such as: volume of water used, hygiene practices, equipment and speed of growth of the animals, which together lead to a larger quantity of wastewater produced (Gonçalves, 2002).

These characteristics of management make the environmental organs consider the swine an activity with virtual effects of environmental degradation and is listed as being of great polluting potential (PARIZOTTO et al., 2017). In accordance with Kunz et al. (2005), the risk of pollution is due to the fact that the swine wastewater has high levels of phosphorus and nitrogen, heavy metals, various chemical substances such as antibiotics and hormones, and may also contain different types of pathogenic microorganisms, among others. In addition, improper handling of such wastes caused by overflowing of mounds and the application of doses in the soil above the volume authorized by the legislation for the purpose of fertilizing crops causing the pollutants to reach rivers, contaminate the soil and reach the groundwater.

For Oliveira et al. (2004) the increase of the risk of environmental contamination refers to the levels of copper and zinc, because these elements are present in the composition of dietary supplement of feed and antibiotics. Even if ARS contains low levels of these elements, they are fundamental to most living creatures but its application at doses above the recommended limit by legislation (BRASIL, 2009) can take on its accumulation in the soil, which may promote phytotoxicity to plants and other biotic components of ecosystems.

In the understanding of Matos *et al.*, (1997) the storage and use of wastewater without technical criteria can promote soil degradation through pore obstruction, making it difficult to aerate and infiltrate / percolate water in the system, besides promote an increase in the amount of salts, consequently causing the salinization of the environment.

If on the one hand the swine wastewater presents risks of environmental contamination, on the other hand, it has been looking for ways for its adequate destination as well as the use of its potential for the nutrition of plants of different agricultural cultures. Through the application of ARS the following nutrient amounts can be supplied to soil up to the values of 3.18 kg / m³ of N,

5.40 kg/m³, P₂O₅, 1.38 kg/m³ K, 3.30 kg/m³ of Ca, 1.17 kg/m³ of Mg, 108.30 g/m³ of Fe, 78.80 g/m³ of Zn (KONZEN *et al.*, 1997).

Studies like Souza *et al.* (2010) performed fertigation with ARS for the culture of tomato plants and proved through foliar analyses that all the nutritional needs of the crop were supplied. Cabral *et al.* (2011) found an increase in Ca and Mg contents and, in contrast, the reduction of Al values in the soil profile after ARS application during elephant grass cultivation. The results obtained by Seidel *et al.* (2010) showed the efficiency of the application of swine manure as base fertilizer in the corn crop under no-tillage system, and grain yield was statistically the same when compared to chemical fertilization.

In relation to plant tree fertilization using alternative forms via organic fertilizer from animal waste has a reduced number of works such as Batista *et al.*, (2014) that found increase in diameter and height of *Eucalyptus urophylla* S.T. Blake seedlings when fertilized with swine wastewater and Moreira *et al.*, (2015) concluded that the application of ARS contributed to the *E. urophylla* seedlings obtained a better Dickson quality standard and greater gain in diameter and in the percentage of dry matter of the stem

To native tree species the amount of works is also limited, highlighting the results obtained by Araújo *et al.* (2016) where the use of ARS as base fertilizer contributed to the growth of native species *Anadenanthera colubrina* (Vell.) Brenan and *Heliocarpus popayanensis* Kunth. In the study of Meira *et al.* (2017) the authors found positive growth responses of *Anadenanthera colubrina* var. *Cebil* (Griseb.) Altschul seedlings with the use of different types of organic compounds.

Thus, for the potential to provide nutrients for the nutrition of different plant species and to enable another route of ARS destination in the rural properties the present work had the objective of evaluating the increase in height and diameter of *Luehea divaricata* Mart. & Zucc. (Malvaceae) seedlings submitted to different doses of swine wastewater.

2 MATERIALS AND METHODS

The experiment was carried out in the area of environmental restoration of the Federal University of Paraná - Setor Palotina - PR (Figure 1). The altimetric landing is around 330 m.s.n.m. and the geological framework belongs to the Paraná Sedimentary Basin, with lithology composed of basalts (basic-intermediate rocks) belonging to the JKSGB1 units of the Serra Geral Formation (MINEROPAR, 2006). The main pedological unit, according to EMBRAPA (2007) is the Eutropherric Red Latosol. The type of climate according to the Köppen is Cfa type, without dry season (IAPAR, 2017).

The experiment was implemented following a randomized block design, arranged in four planting lines with five sample units each. Each amostral unit was composed by four plants of *Luehea divaricata* that had been distributed randomly between blocks.

For the planting of the seedlings were opened pits 30 cm deep by 15 cm wide, spaced 1x2,5 m between seedlings and between blocks, respectively. The treatments had been defined in function of the different doses of ARS, being: T1 = 0 m³ ha⁻¹, T2 = 12.5 m³ ha⁻¹, T3 = 25 m³ ha⁻¹, T4 = 37.5 m³ ha⁻¹ and T5 = 50 m³ ha⁻¹. The swine wastewater was obtained from Mr. Miotto's estate, which produces pigs in the confinement system at the nursery and maternity stages, and all the wastewater produced is stored in a biodigester on the property until the time of its use.

The ARS applications had been carried out each 70 days, totalizing five applications between the period from october/16 to september/17. All the seedlings had been measured before the plantation and remeasured 270 days after that, to verify the mortality tax and the increment occurred in diameter (mm) and height (cm). The morphometric data of the seedlings versus the different doses of ARS received were statistically tested using the SISVAR[®] program (FERREIRA, 2008) and the calculations performed were variance analysis, Tukey test and regression for the variables height and diameter.

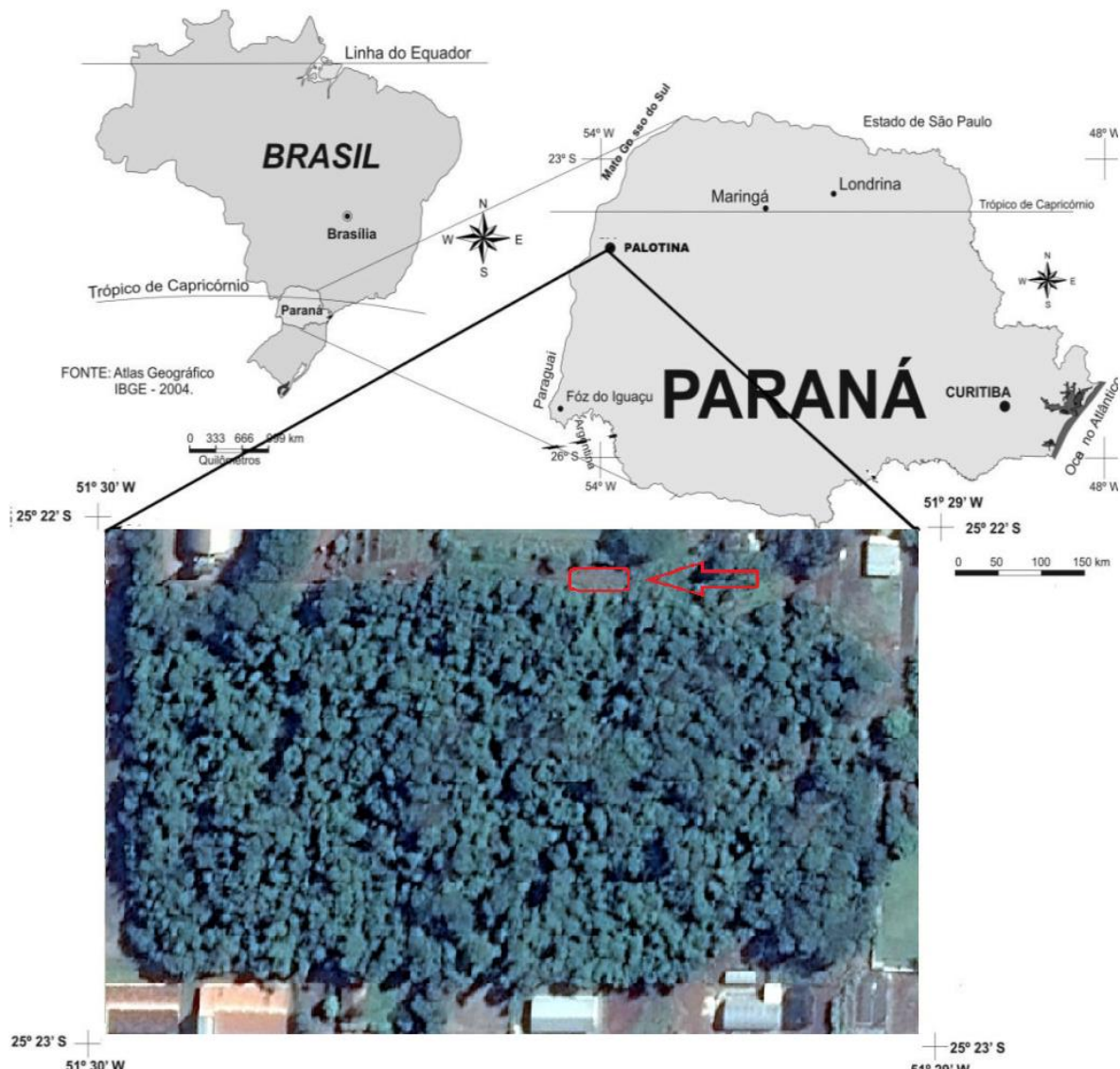


Figure 1. Location of the environmental restoration area and indication of the experiment site in the UFPR/Palotina Sector.

Source: Authors (2017).

3 RESULTS AND DISCUSSION

Data of the plants heights and diameter had been submitted to the variance analysis with the aim to verify existence of significant difference between the means of the treatments since that in each experimental unit more than one observation was made. In tables 1 and 2 are the results of the ANOVA for variables height and diameter, respectively.

Table 1. Analysis of variance regarding the height data of the *Luehea divaricata* seedlings under effect of different doses of Swine Wastewater in the forest restoration area of the UFPR/Palotina Sector.

	D. F.	Sum of Squares	Medium Square	Fc	Pr>Fc
Block	3	3001,077505	1000,359168	0,846	0,4747
Dose	4	24426,175254	6106,543813	5,167	0,0014
Sample error	53	62642,517733	1181,934297		
Total	61	90069,770492			
CV (%)	29,47				
Average overall	116,66				

Source: Authors (2018).

For height variable, the results had pointed the existence of significant differences at ARS doses effects on the averages of the height variable, to the level of 1% of probability for test F ($Pr>F = 0,0014$). Evidence of significant differences in the effects of ARS doses on the means of the diameter variable was found (Table 2), at the 1% probability level by the F test ($Pr>F = 0.0071$).

Regarding to the coefficient of data variation for the height variable, this value was of 29.47% and 32.08% for the diameter. For Zimmermann (2014) among the reasons for the variation in growth of the seedlings part can be attributed to the experimental error, which according to the author represents the random variation between the experimental units with the same treatment, plus the variations of technique error committed during the conduction of the experiment. However, several other conditions may be related to environmental resistance, whether biotic or abiotic, individual local site properties, interspecific competition with invasive plants and herbivory predation caused by the attack of leaf-cutting ants, which, although not evaluated, were identified during the experiment. Carvalho (2008) postulated another conditioning factor related to the intrinsic characteristics of the seedlings themselves, which, although they originate from seeds from the same matrix tree, have different genetic patrimony resulting from the cross-fertilization carried out by this species.

Table 2. Analysis of variance regarding the diameter data at the soil level of the *Luehea divaricata* seedlings under effect of different doses of Swine wastewater in the forest restoration area of the UFPR/Palotina Sector.

	D. F.	Sum of Squares	Medium Square	Fc	Pr>Fc
Block	3	158,439990	52,813330	11,112	0,3524
Dose	4	748,834554	187,208638	3,942	0,0071
Sample error	53	2516,757997	47,486000		
Total corrected	61	3424,032541			
CV (%)	32,08				
Average overall	21,48				

Source: Authors (2018).

Analysis of variable height proved the existence of statistical differences between the averages of the vertical development of the seedlings in relation to different doses of ARS with a dose of $50 \text{ m}^3 \text{ ha}^{-1}$. This ARS dose allowed to the plants a highest average growth and was significantly different from the other doses. For the variable diameter, the behavior between the doses did not present statistical difference, but nevertheless all the treatments that used ARS had an average growth superior to the control treatment. The Tukey test results for the height and diameter variables are condensed in table 3.

The improvement of the positive nutritional effects of swine wastewater and concomitant development of tree plants was also confirmed by studies such as Batista et al. (2013) that concluded that the use of ARS in the proportion of 50% resulted in better morphological characteristics of eucalyptus seedlings cultivated with the compound of urban solid waste. To Pelissari et al. (2009) the ARS provided better results in height/diameter ratio of eucalyptus seedlings being possible to anticipate in up to one-third the time of production of seedlings. Other similar results were the one reached by Souza et al. (2006) that, using different types of organic fertilizers found differentials with higher rates of growth in height and diameter for seedlings of native species of *Cedrela odorata* L. and *Schinus terebinthifolius* Raddi. For the authors, the use of native species in commercial plantations is compromised by the lack of knowledge about the silvicultural behavior of these species, especially in relation to their nutritional requirements, which can also be considered for the plants destined to the recovery of areas, such as legal reserve and permanent preservation areas.

Table 3. Results of the Tukey test for the data of the height and diameter variables of the *Luehea divaricata* seedlings under effect of different doses of swine wastewater in the forest restoration area of the UFPR / Palotina Sector.

Variable	Hight	Diameter
Dose		
$0 \text{ m}^3 \text{ ha}^{-1}$	88,75 a	16,49 a
$12,5 \text{ m}^3 \text{ ha}^{-1}$	93,33 ab	17,28 a
$25 \text{ m}^3 \text{ ha}^{-1}$	125,67 abc	23,49 a
$37,5 \text{ m}^3 \text{ ha}^{-1}$	129,57 bc	24,43 a
$50 \text{ m}^3 \text{ ha}^{-1}$	140,33 c	24,56 a

Lowercase letters compare averages of variables only in the columns. Averages followed by equal letters do not differ significantly by Tukey test at 5%.

According to Pereira and Rodrigues (2013) the physical and chemical attributes of soil, the moisture content variation that change due to the topography and the competition with weeds can be considered the most influential factors in the development of native tree species. This is because

these plants have rates of growth and different ecological/nutritional needs, a fact also evidenced by Scheer et al. (2017) in that tested *L. divaricata* seedlings did not respond positively to the addition of chemical fertilizers, and the best result was observed in the treatment without the addition of NPK and with limestone dose of 250g/grave.

Regression analysis was performed to verify the existence of relationship between the doses applied and the vertical and horizontal growth of seedlings of *Luehea divaricata*. The model that best expressed the relationship between variables analyzed was linear regression (Figure 1 A and B) with R^2 calculated values in 0.7788 for height and 0.8405, both significant at 1% level of probability. The trend of increasing the height growth of the seedlings with increasing doses of ARS up to the dose of $37.5 \text{ m}^3 \text{ ha}^{-1}$ was verified, which in this case presented higher values than the others. This same behavior of seedlings when submitted to larger doses of the ARS also repeated with the variable diameter.

For Miyazawa and Barbosa (2015) swine wastewater has many nutrients needed for the development of plants as boron (B), calcium (Ca), phosphorus (P), magnesium (Mg), nitrogen (N), potassium (K), among others, which qualifies this wastewater for use agriculture, because, these can be absorbed by plants resulting in the increase of its growth.

However, the use of ARS must be done in a way that respects the current legislation regarding the availability to the soil of doses of heavy metals such as Cu and Zn that should be below the established reference values (PARANÁ, 2004). These procedures should be performed to prevent surface waters contamination (rivers and lakes) and underground (groundwater and aquifers), and not to promote negative effects on soil characteristics (MATOS et al., 1997).

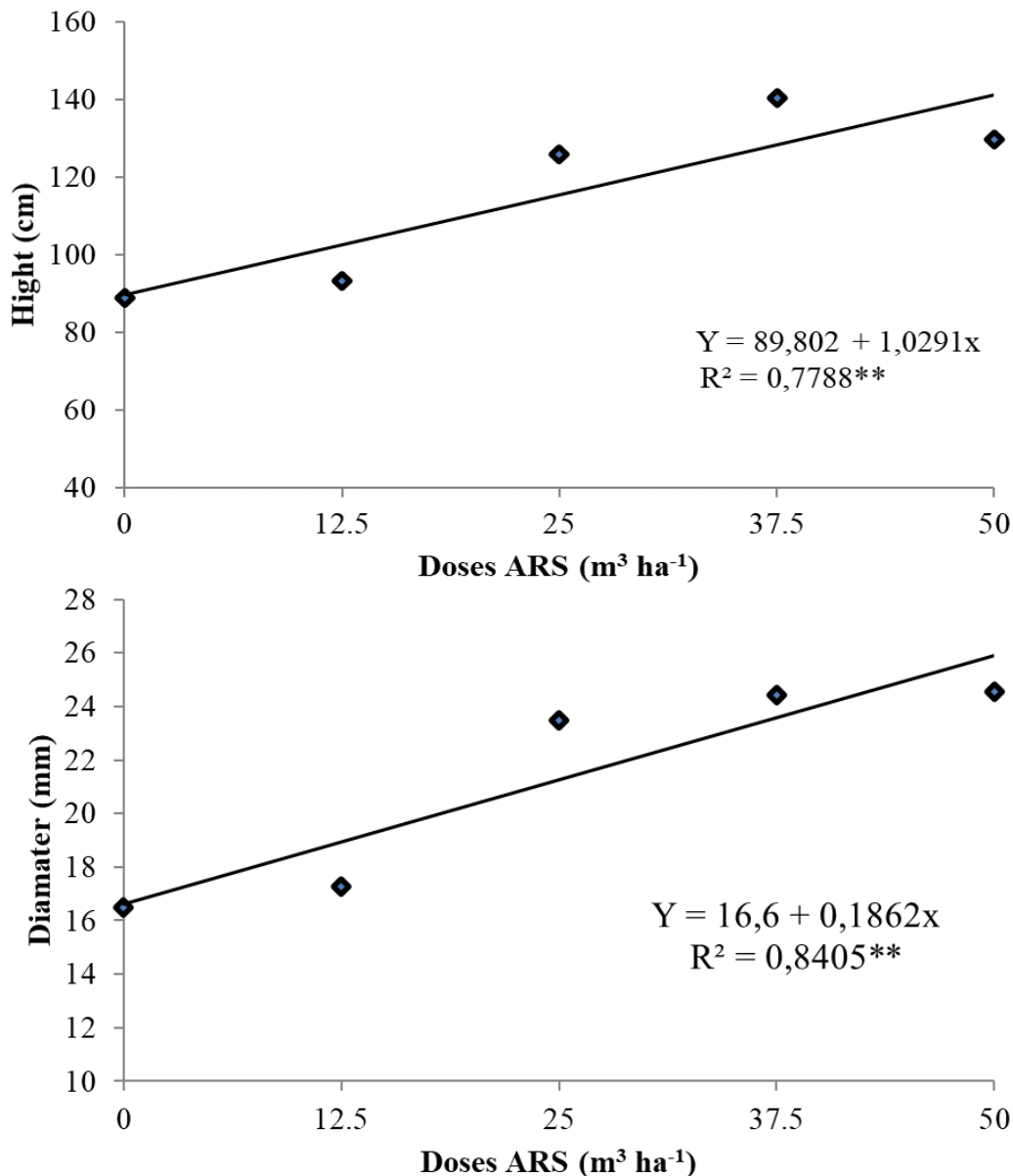


Figure 2. Variation of vertical and horizontal growth of *Luehea divaricata* seedlings submitted to different doses of Swine Residual Water in the forest restoration area of the UFPR/Palotina Sector.. A) Height and B) Diameter. ** - Significant to the minimum level of 1% of probability by the test F. Source: Author (2018).

4 FINAL CONSIDERATIONS

The application of ARS in a fertilizer form proved viable since it contributed to the growth of tree seedlings that can be used in crop-livestock, silvicultural integration systems and in environmental recovery areas. It also makes possible another way for destination of this residue contributing in such a way to reduce the ambient risks caused by its irregular discarding in the country properties.

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