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Growth of eucalyptus seedlings irrigated with different vinasse concentrations

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ABSTRACT

With the increase of ethanol production, the generation of residues, such as vinasse, has been treated as an environmental problem, demonstrating the need to seek alternatives for the sustainable use of this residue. Inadequate disposal of vinasse causes a series of environmental impacts on soil, water and air. The present study aimed to evaluate the growth of Eucalyptus urograndis 3281 (GG100) seedlings irrigated with different vinasse concentrations. For this it was used a completely randomized design (CRD) was used, with five treatments (0%, 15%, 30%, 45% and 60% of water-diluted vinasse) and 4 replicates, each experimental unit consisting of 25 seedlings, 90 days of age. The plants were placed in pots of 18 L containing Red Latosol, irrigated with the dilution of the vinasse, prepared in gallons of 50 liters separately, where it obtained the effluent mixtures in: 0%, 15%, 30%, 45%, 60%. After 120 days of the experiment, plant height, stem diameter, green matter weight, dry matter weight, root weight, leaf area and mortality were evaluated. There were significant differences for plant height, leaf area, stem diameter and green and dry matter weight. In our study the application of vinasse with 60% showed higher plant growth in relation to the control for plant height, stem diameter, leaf area, dry matter and green weight.There was no damage to the eucalyptus cultivars at the different doses used. Vinasse can be used for Urograndis GG100 eucalyptus irrigation, provided that it is applied in low concentrations with high potential for the sustainable use of this by-product of sugarcane. In this study, the concentration that presented the best performance among the tested was 60%, with high potential for fertigation.

INTRODUCTION

The production of ethanol in Brazil has increased over the years mainly due to the need to reduce fossil fuel consumption. The ethanol production forecast for the 2015/2016 crop is 28.52 billion liters (Conab, 2015). The increase in ethanol production leads to higher generation of waste from this process, among them vinasse.

Vinasse is liquid, a residue resulting from the fermentation of ethanol from sugarcane. Vinasse presents significant amounts of chemical elements essential to plants in its composition (0.46 kg m^{-3} of N, 0.24 kg m^{-3}

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P_2O_5, 3.06 K_2O, 2.67 kg m^{-3} SO_4 and 1.18 kg m^{-3} CaO) and a high organic matter content (0.53 kg m^{-3}) (Santos *et al*., 2006).

According to Freire and Cortez (2000), pure vinasse has a high pollutant load due to the presence of organic matter, low pH, biochemical indices (BOD) ranging from 20,000 to 35,000 mg L^{-1} and high corrosive power, which can all be detrimental to fauna and flora, when disposed of in an irregular manner.

In view of this problem which concerns the final disposal of this residue generated by the ethanol distilleries, studies on the correct use of vinasse in fertirrigation have been extensively developed for the final destination of this residue (Zolin *et al*., 2011; Barbosa *et al*., 2012; Barbosa *et al*., 2013), followed by the use of its elements as a soil nutrient incorporaion factor and the optimization of cost reduction processes via its management (Pires and Ferreira, 2008). For Pires and Ferreira (2013), one of the viable and economical alternatives to dispose of this waste is its use in biofertilization.

However, the effect of vinasse on eucalyptus forests is still poorly studied, according to Abreu Junior *et al*., (2005), eucalyptus is cultivated on a large scale because of its favorable characteristics such as rapid growth, management ease, species diversity and for industrial purposes.

In this context, it is expected that the vinasse doses studied will have a beneficial effect on the growth of eucalyptus plants. As such, the objective of this study was to evaluate the growth of *Eucalyptus urograndis* 3281 (GG100) seedlings irrigated with different concentrations of vinasse

MATERIAL AND METHODS

The work was carried out in the experimental area of the University of Rio Verde (UniRV), located in the municipality of Rio Verde-GO, (50° 57'23"- West, 17° 46' 08" South). The climate of the region is type Aw (Köppen-Geiger) - Tropical, with rains concentrated in summer (October to April) and a well defined dry period during the winter season (May to September).

The hybrid eucalyptus variety used was Urograndis GG100, with 90 days of age and, on average, 15 centimeters in height.

The experimental design was completely randomized (CRD), with five treatments (0%, 15%, 30%, 45% and 60% vinasse concentration diluted in water) and 4 replicates, each experimental unit consisting of 25 plants.

The plants were placed in 18 L pots containing Red Latosol, by the Brazilian classification system, SBCS (2013), irrigated with the dilution of the vinasse, separately prepared in 50 liter containers. The following effluent mixtures were obtained: 0% only H_2O was used; 15% concentration, 7.5 liters of vinasse was diluted in 42.5 liters of H_2O; 30% concentration, 15 liters of vinasse was diluted in 35 liters of H_2O; 45% concentration, 22.5 liters of vinasse was diluted in 27.5 liters H_2O; 60% concentration, 30 liters of vinasse was diluted in 20 liters of H_2O.

The irrigation process was performed daily at 5:00 p.m., over a period of 120 days. At the beginning of the irrigation the seedlings received 250 ml of diluted effluent on each plant, increasing according to the water deficit, ending with an irrigation of 500 ml. The water used came from the well of the University of Rio Verde.

The macro and micronutrient contents are shown in Table 1. The chemical characteristics of the vinasse are presented in Table 2.

Table 1: Soil macro and micronutrient contents.

pH	Ca	Mg	Al	H+Al	K	K	PMel	S	O.M
$CaCl^2$	$cmol_c/dm^3$					mg/dm^3			g/dm^3
5,10	0,73	0,23	0,04	2,80	0,05	19,6	3,07	16,73	20,00
B	Fe		Mn		Zn	Co	Na		Cu
mg/dm^3									
0,23	62,85		14,83		0,57	1,44	2,0		4,60

Table 2: Chemical characteristics of the vinasse in the 4 concentrations.

Chemical Characteristics	Concentration Vinasse			
	15%	30%	45%	60%
pH	4,72	4,62	4,65	4,58
COD (mg $CaCO_3$/L)	1827	1936	2384	2911
BOD (mg O_2/L)	909	1140	1430	1646
Phosphorus (mg P/L)	11,2	14,2	21,5	29
Total Nitrogen (mg N/L)	5,5	10	17,1	19,6
Ammonia Nitrogen (mg NH_4/L)	0,95	0,59	0,77	0,71

The analysis of the water used in the vinasse dilution and irrigation of *E. urograndis* GG100 in the 0% treatment is presented in Table 3 according to the parameters indicated by Almeida (2010).

Table 3: Chemical characteristics of the well of the University of Rio Verde used for eucalyptus irrigation.

Chemical Characteristics	Concentration
pH	7,00
Electric conductivity (µs cm^{-1})	142,0
COD (Mg L^{-1} de $CaCO_3$)	39
BOD_5 (mg L^{-1} de O_2)	23,40
Total Nitrogen (mg L^{-1} de N)	0,18
Ammonia Nitrogen (mg L^{-1} de NH_4)	0,04
Phosphorus (mg L^{-1} de P)	0,83
Nitrate (mg L^{-1} de NO_3)	0,47

One hundred and twenty days after the implementation of the experiment, the data were collected. The following parameters were evaluated: plant height (PH), stem diameter (SD), leaf area (LA), green matter weight (GMW), dry matter weight (DMW), root weight (RW) and mortality (M).

To measure the height of the plant, a scale was used and the measurement was made from the ground level to the stem end.

The diameter of the stem was calculated with the aid of a digital caliper measured at 2 cm from the ground. The stem diameter and plant height ratio was calculated by dividing the diameter of the stem by the height of the corresponding plant, and then obtaining the mean values of the treatments.

The weight of the green mass was conducted with the random collection of two plants from each plot, weighed shortly after their removal from the soil. In order to calculate the of the dry mass weight, the plants were stored in Kraft paper bags and taken to an oven with induced circulation, at 65ºC for 3 days (72 hours) until reaching constant weight and then weighed.

The leaf area was calculated by scanning all leaves that were later processed in the Quantroot software.

The evaluation of plant mortality was obtained through the difference between the number of live seedlings and the number of seedlings used in each plot (5 seedlings).

The results were submitted to the regression study for the dilution factor (0%, 15%, 30%, 45% and 60%) in order to verify if there were differences between the treatments using the SISVAR statistical program (Ferreira, 2011)

RESULTS AND DISCUSSION

According to the regression test, there were no significant differences between the different vinasse concentrations for the characteristics of stem diameter/plant height, root weight and mortality.

With the application of 60% vinasse, the plant height was 4.93 cm higher than the control. These results may be related to the higher concentration of N and P in this treatment (Figure 1). Bouchardet *et al*. (2011), working with initial growth of seedlings *Eucalyptus grandis* noticed that when correct doses of nitrogen (N) are applied, the crop shows beneficial results as to plant height (Figure 1).

Dechen *et al*. (2007), emphasize that each has a specific role in the plants metabolism and the imbalance among the nutrient proportions can cause deficiency or toxicity, limiting plant growth.

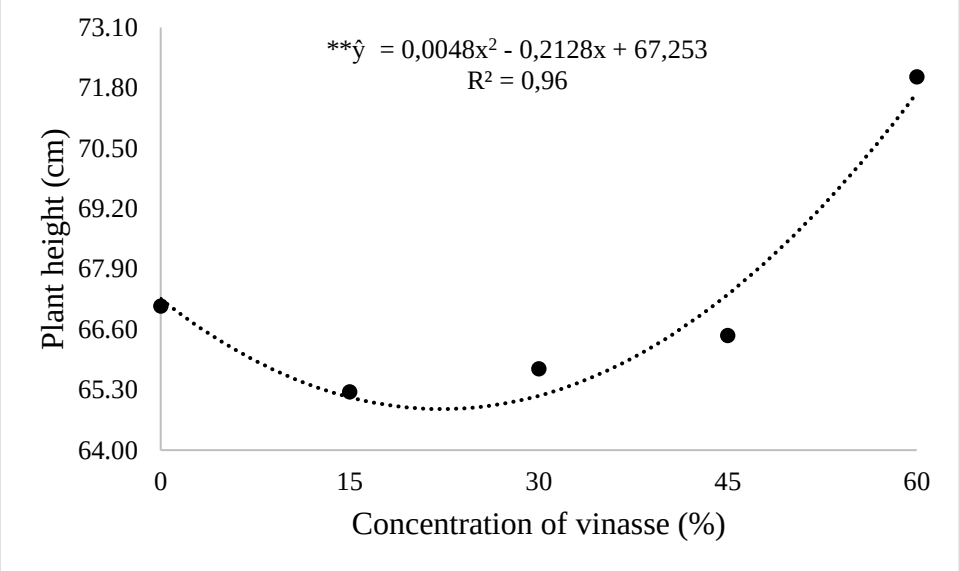

Fig. 1: Plant height (cm) of the eucalyptus clone irrigated with vinasse. ** Significant at 1% probability level. CV (%) = 1,41.

Among the elements essential for plants are phosphorus, which may be the main nutrient limitinh plant growth (Azziz *et al*., 2012). The concentration of 29 mg P/L and 19.6 mg N/L in the treatment with 60% vinasse (Table 2), may be associated with higher plant growth in this treatment when compared to the others.

The diameter and leaf area characteristics (Figure 2 and 3) presented a significant difference in relation to the concentration factor. At 60% vinasse, the plants responded with a higher result due to the high concentration of N and P. This relationship was confirmed by observing that as the vinasse doses were reduced, the plants responded with smaller stem diameter and leaf area.

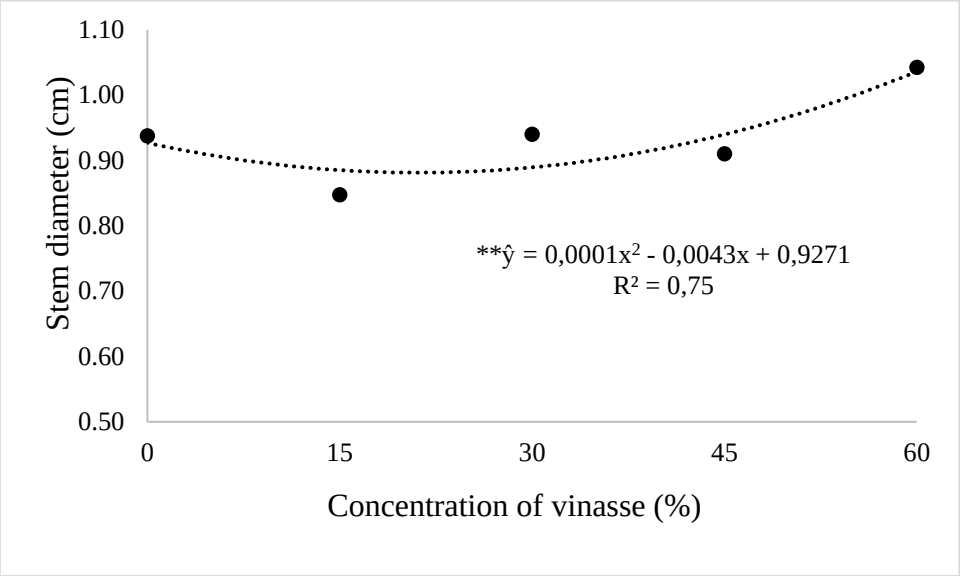

Fig. 2: Diameter of the stem (cm) of the eucalyptus clone irrigated different concentrations of vinasse. ** Significant at 1% probability level. CV (%) = 2.79

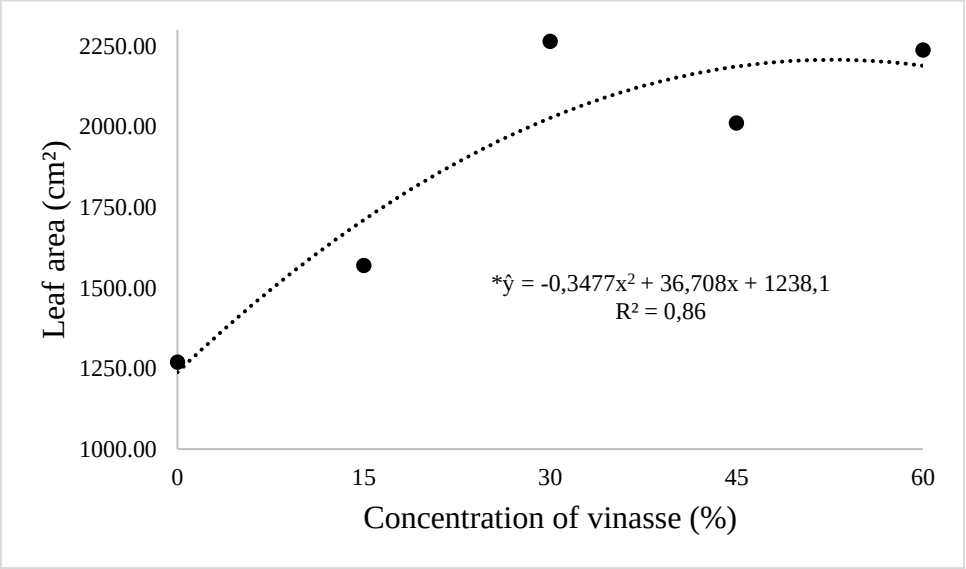

Fig. 3: Leaf area of the plant (cm²) of the eucalyptus clone irrigated with vinasse. * Significant at the 5% probability level. CV (%) = 12.63.

Gomes *et al*. (1991) reported that stem diameter, at collection time, and plant height, are the most indicated parameters to evaluate the quality of eucalyptus seedlings.

Garcez Neto *et al*. (2002), working with N dose applications in sunflower, concluded that increasing the dose influences the development of the leaf area and consequently the greater diameter of the plant, since the nitrogen changes the rate of elongation and/or cell division, thus contributing to the final size of the leaves.

Rossetto and Santiago (2012) point out that when vinasse is applied in correct quantities it provides numerous benefits to crops. Among them, the authors cite improvements in soil properties, both physical, chemical and biological. There were increases in soil organic matter content and microflora, making nitrogen

mineralization easier due to the presence of macro and micronutrients, generally improving soil fertility, increases in the water retention capacity in the soil and aid to grass productivity and that of other trees.

In the analysis of the green and dry matter weight, an increase of 42.62 and 7.33 g was observed for the treatment with 60% of vinasse in relation to the control, indicating the beneficial effect of vinasse on plant growth (Figures 4 and 5).

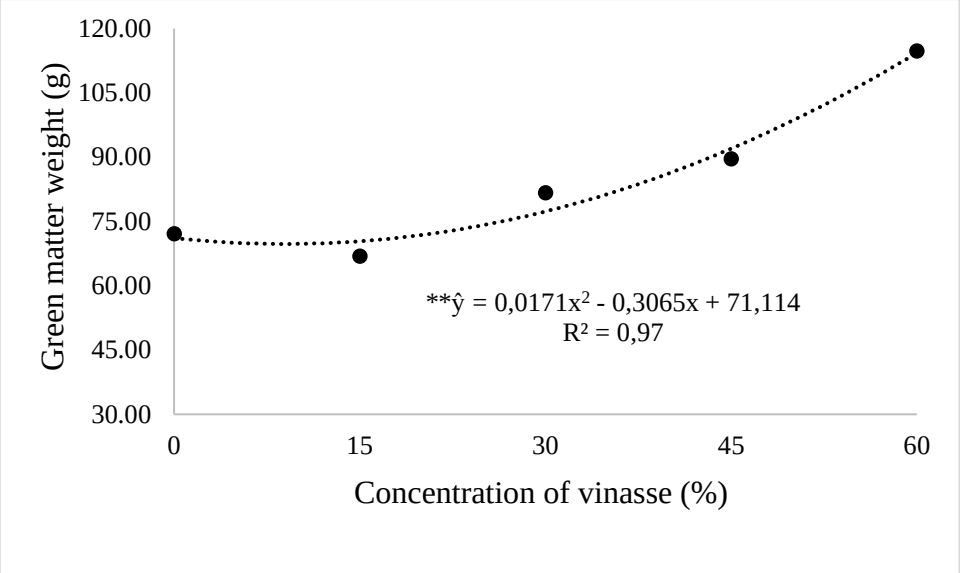

Fig. 4: Weight of green matter (plant-1 grams) of the eucalyptus clone irrigated with vinasse. ** Significant at 1% probability level. CV (%) = 5.54.

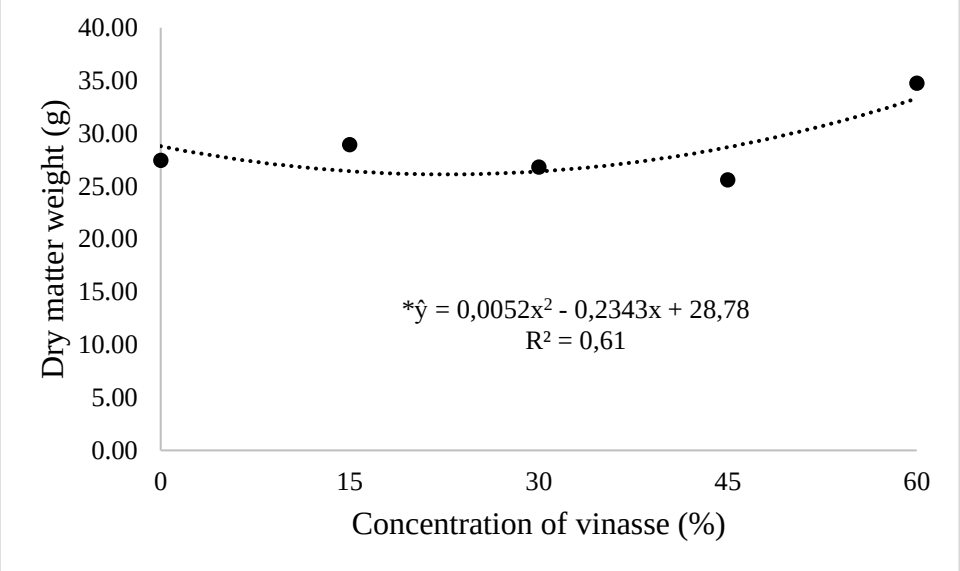

Fig. 5: Weight of dry matter (plant-1 grams) of the eucalyptus clone irrigated with vinasse. * Significant at the 5% probability level. CV (%) = 10.45.

The nutrients N and P are more required in the early stages of the seedlings; thus, the plant growth is related to the presence of such nutrients in the effluents used (Novais, *et al*., 1982).

The application of waste for the growth of *E. urograndis* has been reported as a viable alternative for sustainable production. According to Ribeiro (2015), the use of swine sludge on *E. urograndis* promoted the highest plant growth. In our study the application of 60% vinasse presented higher plant growth, in relation to the control, for plant height, stem diameter, leaf area and, dry and green weight.

In an experiment with vinasse doses and mineral fertilizer use, Toro (1996) concluded that the use of vinasse as fertilizer, increasing returns were obtained for sugarcane without mineral fertilization, although mineral supplementation is necessary to achieve higher productivity.

Pereira *et al*. (1992), carried out an experiment with increasing doses of vinasse on the germination of corn seeds. They verified that at high concentrations there were changes in its green matter weight growth, corroborating the results of this present study.

Conclusion:

Vinasse can be used for Urograndis GG100 eucalyptus irrigation, provided that it is applied in low concentrations with high potential for the sustainable use of this by-product of sugarcane. In this study, the concentration that presented the best performance among the tested was 60%, with high potential for fertigation.

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