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Effects of fertirrigation with compost tea of sewage sludge on growth and physiological quality in seedlings of *Sesbania virgata (Cav.) Pers.*

Efeito da fertirrigação com extrato de compostagem de lodo de esgoto sobre o crescimento e a qualidade fisiológica em plântulas de Sesbania virgata (Cav.) Pers.

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Abstract: In this study were evaluated effects of fertirrigation with different concentrations of compost tea of sewage sludge on cambaí-amarelo (*Sesbania virgata*) growing. Seedlings were grown in nurseries covered 50% shading and watered daily, composted sewage sludge was used in the concentrations 0 (Control), 0.15; 0.20; 0.25 and 0.30 $mg.ml^{-1}$. The plant height, root growth, steam diameter and plant height/stem diameter ratio, shoot dry matter, roots dry matter and the total dry matter of the plants were determined 150 days after planting. Dickson quality index were calculated. In general, moderate concentrations of composted sewage sludge improves growth and biomass distribution. Composted solid waste showed promise for the production of *Sesbania virgata* seedlings.

Keywords: Agroecosystem, biomass distribution, seedlings production

Resumo: Neste estudo foram avaliados os efeitos da fertirrigação com diferentes concentrações de lodo de esgoto compostado sobre o crescimento de plântulas de cambaí-amarelo (*Sesbania virgata*). As mudas foram produzidas em viveiro coberto 50% de sombreamento e regadas diariamente, lodo de esgoto compostado foi utilizado nas concentrações de 0 (controle), 0,15; 0,20; 0,25 e 0,30 $mg.ml^{-1}$. A altura da planta, o comprimento da raiz, o diâmetro do caule e a razão altura da planta/diâmetro do caule, a biomassa aérea seca, matéria seca das raízes e a matéria seca total das plantas foram determinados 150 dias após o plantio. O índice de qualidade de Dickson foi calculado. Em geral, as concentrações moderadas de lodo de esgoto compostado melhoram o crescimento e distribuição de biomassa das mudas. A compostagem de lodo de esgoto mostrou-se promissora para a produção de mudas de *Sesbania virgata*.

Palavras-chave: Agroecossistemas, distribuição de biomassa, produção de mudas

Introduction

The genus *Sesbania* (Fabaceae) are distributed mainly in the South, Southeast, and Central-Western regions of Brazil. Occur in primary and secondary forests and scrubs in the lowlands as well as at higher altitudes. Also has been described in literature as bio accumulative species, showing high ability to fix N_2 by *Rhizobium* interaction (CUMMINGS et al., 2009). Within *Sesbania*, *S. virgata* stands out due to their fast growth (pioneer species), easy propagation and high biomass production, they are used on a large scale in agroforestry systems and for reforestation in impacted areas (FLORENTINO et al., 2009; KWESIGA et al., 1999; STÅHL et al., 2005; ZANANDREA et al., 2009; SILVA et al., 2011). *S. virgata* is a shrub and grows up to 6 m in height and 25 cm trunk diameter (ARAÚJO et al., 2004).

Agroforestry systems, excludes the use of most chemical inputs used in conventional systems - among them, insecticides, herbicides and chemical fertilizers, may will cause greater negative impact on the system than others alternative methods. An agroforestry is a consortium among native and cultivated species planted primarily to manage and maintenance soil fertility and quality, water, weeds, pests, diseases, biodiversity and wildlife in an agroecosystem (ANDOW; HIDAKA 1989; MOITINHO et al., 2010).

Studying the plant responses to different environmental conditioners helps to understand both the establishment, as well the management of native species in projects of reforestation in impacted or degraded areas (PONTES et al., 2014; SILVA et al., 2011; CARNEVALI et al., 2016). Municipal wastewater treatment plants will continue to face the challenge of disposing of millions of tons of sewage sludge generated each year (ANTOLÍN; FISCONARO; SÁNCHEZ-DIAS, 2010; CAI et al., 2010). In order to reduce the final disposal of waste, an alternative could be their application in seedling production, in maintaining or restoring the quality of soils, reducing the need for inorganic fertilizers, municipal sewage sludge is a good source of plant nutrition such as N, P, K and organic matter (LOGAN; HARRISON, 1995; CARAVACA et al., 2002). However, the main factor of this practice is the availability and concentration of trace metals and organic pollutants (RAMÍREZ; DOMENE; ALCAÑIZ, 2008). If a successful composting procedure is conducted these risks could be reduced effectively (CAI et al., 2010). Understanding not only the level of changes in plant responses, but also the composition of the urban waste, allows more effective managements (BERTON et al., 1997).

Several variables are used to evaluate seedling quality, including germination and emergence indexes, shoot height, root configuration, stem base diameter, ratio of stem base diameter to shoot height, dry and fresh matter weight of shoot and root, shoot stiffness, stomatal conductance, chlorophyll fluorescence and nutritional aspects (JOSÉ; DAVIDE; OLIVEIRA, 2014; BARBOSA; NOBREGA; SANTIAGO, 2014; PONTES et al., 2014; SANTIAGO et al., 2015). The Dickson quality index (DQI) is a tool to evaluate seedling physiological quality; DQI is considered a promising, robustness indicator of biomass distribution integrated measure of morphological traits (DICKSON; LEAF; HOSNER, 1960; JOHNSON; CLINE 1991).

In this work, the growth patterns were used to evaluate the effects of fertirrigation with composted sewage sludge (CSS) solution in *Sesbania virgata* plants.

Materials and methods

The untreated dewatered municipal sewage sludge was collected from municipal wastewater treatment plant ETE Guaxinim, Dourados, MS (SANESUL). Sewage sludge was mixed with sugarcane bagasse in a 1:1 ratio by volume in wet base. The resulting mixture was then fermented in a static forced-aeration composting device. After 35 days, the finished compost was placed in a storehouse and allowed to age for 4 months. The mature compost was air dried and passed through a 10 mm sieve. The compost was soaked with deionized water (water/compost equal to 1.000/500 mg.ml in volume) for 1 weak and leached on nylon gauze with a mesh screen of 50 mm to remove gravitational water. The soaking and leaching process was repeated three times. This solution was used in the irrigation in 0 (Control), 0.15; 0.20; 0.25 and 0.30 mg.ml^{-1}. For irrigation, was used a frequency of 20–30 ml per cell every 5 days.

Seedlings grown in nurseries covered with 50% shading and watered daily, from direct seeding in polyethylene tubes containing agricultural substrate Plantimax ®. After thinning, a seedling with greater vigor apparent in each cartridge was kept suspended in tray (SANTIAGO; PAOLI 2003), making batches of 30 individuals per replicate, for three replicates per treatment. Figure 1 shows the seedlings obtained.

Figure 1. Seedlings of *Sesbania virgata* under irrigation with composted sewage sludge solution.

The maximum, average and minimum temperature, average global solar radiation and relative humidity of the air were collected, Figure 2 shows the values. The meteorological data were used to determine the reference evapotranspiration (ETo) according to the Penman-Monteith model (ALLEN et al., 1998).

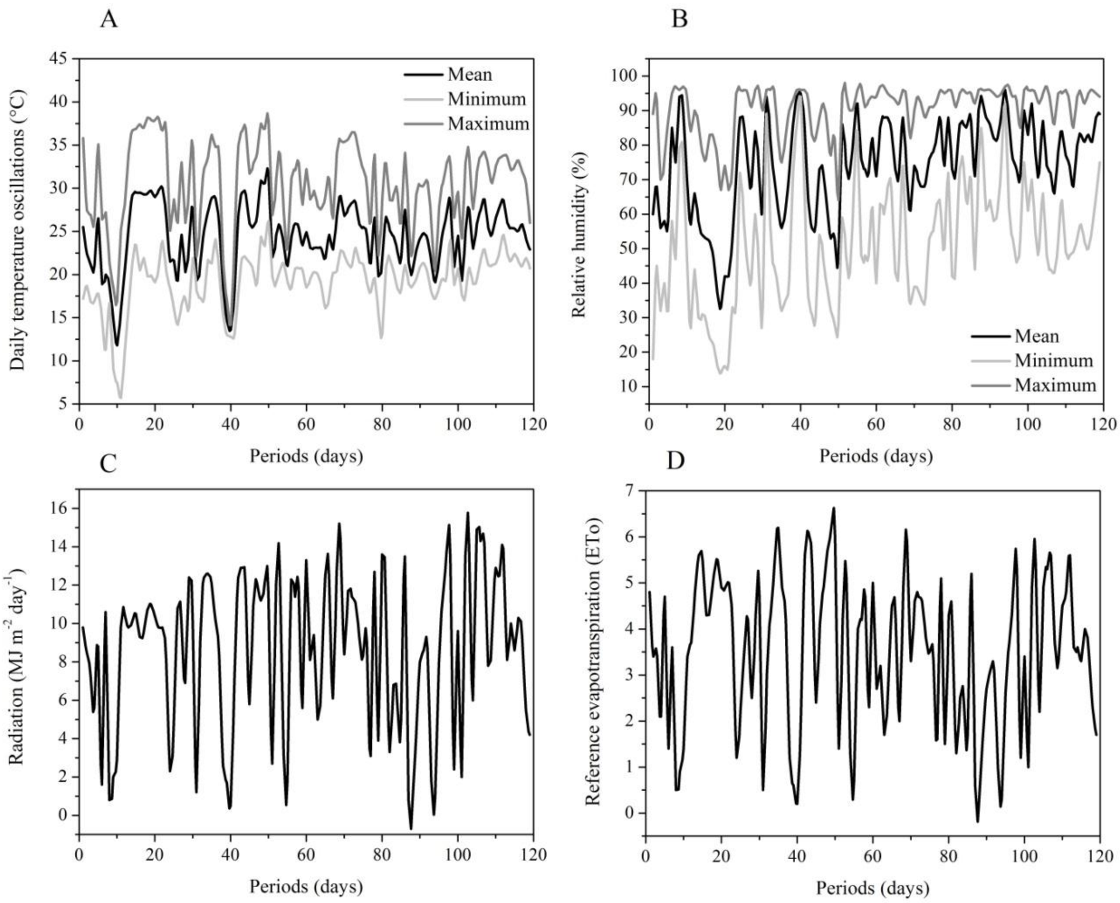

Figure 2. Maximum, mean and minimum air temperatures (A); relative humidity (B); Global solar radiation (C); total reference evapotranspiration (ETo) (D); determined during the experimental period between September 2015 and January 2016.

The variables of growth analyzed were: shoot growth, root growth, steam diameter and plant height/stem diameter ratio. After that, the material sampled was dried in a greenhouse at 70 ºC for 72 hours so that, after drying, the shoot dry matter, roots dry matter and the total dry matter of the plants were determined. Dickson quality index (DQI) was determined using the methodology described by DICKSON; LEAF; HOSNER (1960).

The statistical procedure used was a completely randomized experiment. The results were submitted to analyses of variance and the Tukey test, and the averages of the evaluation periods of ratio plant height/stem diameter and Dickson index were adjusted using regression equations and analyzed utilizing R software. Differences with P values of less than 0.05 were considered significant.

Results and discussion

In general, increasing concentrations of CSS, promote alterations in growth variables. It is observed in Tables 2 seedlings produced in formulated treatments with CSS showed statistically superior results of the growth characteristics evaluated compared to control. Differences between treatments were significant ($p < 0.05$). Shoot heights 32.42 and 23.79 cm were found in seedlings with the treatment concentrations 0.20 and 0.30 $mg.ml^{-1}$, respectively. Root length and stem diameter, also had higher values in treatments 0.20 and 0.30 $mg.ml^{-1}$. Similar results were also observed by Maia (1999) using soil, sewage sludge and pine bark as substrate.

Table 1. Mean values of stem diameter (SD), shoot (SG) and root (RG) growth. Measurements were taken 150 days after planting. Dourados, MS, 2016.

CSS mg.ml	Stem diameter	Shoot	Root
	mm	cm	cm
0	2.46 ± 0.16 b	14.92 ± 0.97 cd	22.98 ± 0.67 c
CV (%)	20.25%	19.59%	8.78%
0.15	3.03 ± 0.13 b	20.82 ± 0.61 bc	27.01 ± 1.02 a
CV (%)	12.46%	8.41%	10.75%
0.20	3.59 ± 0.15 a	32.42 ± 1.44 a	31.97 ± 2.29 a
CV (%)	12.41%	12.56%	20.33%
0.25	3.26 ± 0.18 a	19.36 ± 0.18 c	26.52 ± 1.21 a
CV (%)	15.94%	15.89%	13.00%
0.30	3.29 ± 0,12 a	23.78 ± 1.44 b	25.78 ± 1.70 b
CV (%)	10.74%	17.16%	18.68%

Different letters indicate significant differences between treatments by the Tukey test ($p<0.05$).

For the variables, dry shoot weight dry, root weight and total dry weight, highest values were observed in treatments 0.20 and 0.30 $mg.ml^{-1}$ (Table 2). However, only treatment 0.20 $mg.ml^{-1}$ showed significant differences ($p < 0.01$) among the treatments.

Table 2. Mean values of dry shoot weight dry, root weight and total dry weight. Measurements were taken 150 days after planting. Dourados, MS, 2016.

CSS mg.ml	Dry shoot weight	Dry root weight	Total dry weight
	mg	mg	mg
0	0,14 ± 0,02 b	0,20 ± 0,03 b	0,35 ± 0,04 b
CV (%)	43,98	39,19	40,63
0,150	0,30 ± 0,02 b	0,41 ± 0,04 b	0,72 ± 0,06 b
CV (%)	24.45	31,01	27,47
0.200	0,86 ± 0,13 a	0,78 ± 0,12 a	1,66 ± 0,25 a
CV (%)	43,48	44,18%	43,35
0.250	0,30 ± 0,03 b	0,36 ± 0,03 b	0,67 ± 0,05 b
CV (%)	29.93	23,14	24,65
0.300	0,43 ± 0,06 b	0,39 ± 0,05 b	0,83 ± 0,12 b
CV (%)	45,08	41,05	43,12

Different letters indicate significant differences between treatments by the Tukey test ($p<0.05$).

Regression analysis for the average plant weight/stem diameter and DQI in response to CSS (Figure 3) indicated a polynomial behavior, with R^2 = 0,119 for weight/stem diameter ratio and, for DQI with R^2 = 0,677. This behavior suggests that moderate CSS concentrations may contribute to increase biomass allocation in *S. virgata* seedlings. The ratio plant height/stem diameter and Dickson index are best standard indicators of seedlings physiological quality. In general, plant height/stem diameter ratio is one of the most appropriate parameter to determine the seedling survival potential in the field acclimation, reflects reserves accumulation, and ensures better resistance and fixation in the soil soil (MOREIRA; MOREIRA, 1996; ARTUR et al. 2007). According to Birchler et al., (1998) in considering seedlings with appropriate quality patterns, this index must be <10. In both cases, CSS dose 0.200 mg.ml-1 showed the highest value.

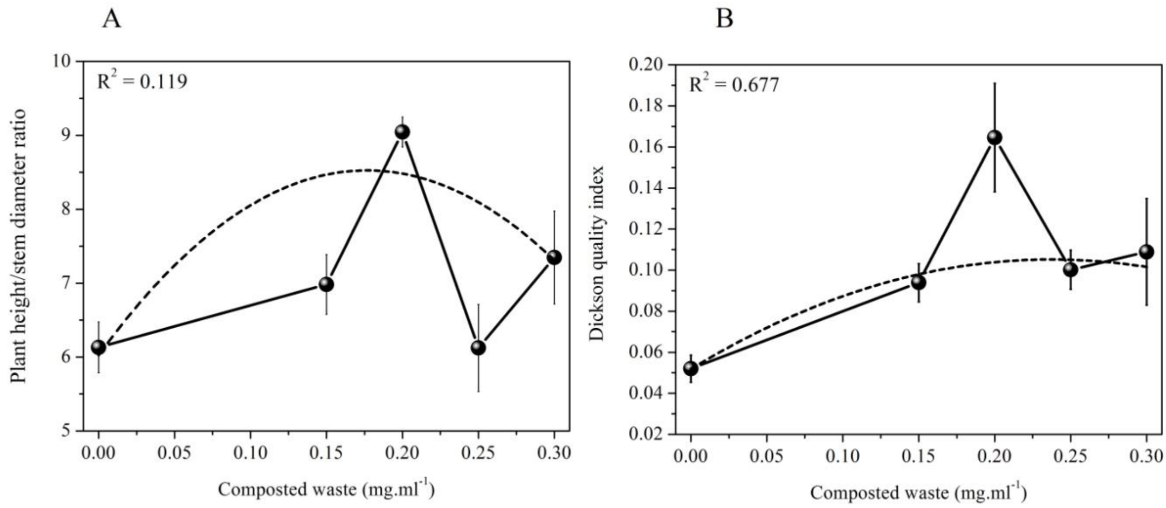

Figure 3. (a) Plant weight/stem diameter ratio and (b) Dickson Quality Index (DQI) of seedlings of *Sesbania virgata* under different concentrations of CSS irrigation.

Conclusions

In general, the species has a good tolerance to moderate concentrations of this biosolid, corroborating the literature about its potential use in substrate composition for the production of seedlings of this native species, supporting data for its application in degraded areas and restoration programs.

The *Sesbania virgata* seedlings have good growth in substrates irrigated with composted sewage sludge.

Our data indicates that CSS can be a suitable substrate component, depending on the amount of sewage sludge and decomposed litter used, and the specific nutritional characteristics desired in the substrate.

These results suggest the possible potential of this waste for the *Sesbania virgata* seedlings production.

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