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SUNFLOWER GROWTH IRRIGATED WITH SEWAGE EFFLUENT UNDER ORGANIC FERTILIZATION

CRESCIMENTO DE GIRASSOL IRRIGADO COM EFLUENTE DE ESGOTO SOB ADUBAÇÃO ORGÂNICA

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ABSTRACT: In the semi-arid region of Brazil due to water scarcity, the use of alternative water sources is of vital importance, such as the use of saline waters and treated sewage effluents. Therefore, in the present work, the growth of sunflower plants irrigated with tap water and treated domestic sewage effluent, associated with organic fertilization was evaluated. The research was carried out in a protected environment at the Federal University of Campina Grande, Campus I, Campina Grande, PB. A completely randomized experimental design with factorial arrangement was used (4 x 2) + 2, with 5 repetitions. the treatments consisted of organic manure dosages (7.5, 10, 12.5 and 15% of manure on a weight basis) and two water sources (supply water and treated domestic sewage effluent). According to the results obtained, it can be indicated that the use of domestic sewage effluent for sunflower irrigation increased sunflower growth in relation to the use of water supply. The application of manure doses of 12.5 and 15% improved the early growth of the sunflower, with significant increases in the growth variables.

KEYWORDS: *Helianthus annuus* L. Water reuse. Protected environment.

INTRODUCTION

Sunflower is a fairly widespread crop because it is a rich source of oil extracted from its grains, as well as being used as a source of bran and silage for animal feed (ANDRADE et al., 2012). This crop is adapted to different edaphoclimatic conditions, even to the semiarid zone of Northeast Brazilian, where it has great economic viability.

This crop is not very demanding to the water, but its development is altered by hydric deficit of the soil, being necessary the practice of the [illegible] yield, especially in areas with water deficiency. In this way, water is a limiting factor for agricultural production, especially for semi-arid regions, which can significantly reduce agricultural production (SANTOS et al., 2009).

In semiarid regions, due to low surface water availability, it is necessary to reuse water in the planning of water resources, as an alternative for agricultural development, with the additional advantage of recycling the nutrients present in the sewage effluent in nutrition of plants.

The use of domestic effluent in agriculture is a strategic point in the integrated management of water resources, as it increases the volume of supply to meet the demand of the sector, also means a nutritional contribution (REBOUÇAS et al., 2010; ALVES et al., 2009), thus reducing the consumption of surface water and the need to import fertilizers through the producing regions.

However, when domestic sewage water is used in agriculture, despite the available nutrient load, it is not always enough to meet the nutritional demand of the crop, and there is generally a need for [illegible] to ensure good productivity of the crop (ANDRADE et al., 2015). In this case, the use of organic fertilizers as a mineral supplement presents some advantages in relation to the application of chemical fertilizers, mainly the gradual release of nutrients as they are required for the growth of the plant. If the nutrients are ready to available in the soil, as with chemical fertilizers, they can be lost through volatilization (nitrogen), fixation (phosphorus) or leaching (mainly potassium) (SEVERINO et al., 2004).

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Currently, the main organic fertilizers used are derived from industrial, urban or rural raw materials, vegetable or animal, where livestock manure stands out (VERAS et al., 2015).

The organic fertilization of the soil can supply the nutrients needs of the plants, in addition, the bovine manure promotes improvements in the physical structure of the soil and increases the capacity of water retention, generating many benefits for the plants (SEDIYAMA et al., 2012).

Therefore, the objective of this work was to evaluate the development of the sunflower crop irrigated with effluent from treated domestic sewage (domestic effluent), associated with organic fertilization.

MATERIAL AND METHODS

The experiment was carried out in a protected environment belonging to the Academic Unit of Agricultural Engineering of the Center of Technology and Natural Resources, of the Federal University of Campina Grande, Campus I, Campina Grande, PB.

The average maximum and minimum temper-atures during the growing season durring carried out of experiement were 28.2 and 16◦C, respectively. There was no rainfall during the period over which the experiment was conducted.

The treatments consisted of four doses of organic fertilization (E_1 - 7.5, E_2 - 10, E_3 - 12.5 and E_4 - 15% of manure on a weight basis) and two sources of water for irrigation (A_1 - Supply water and A_2 treated sewage effluent (domestic effluent), arranged in factorial arrangement (4 x 2) + 2, with the last two being Control, which consisted of nitrogen fertilization according to the dose recommended by Novais et al. (1991) using water from supply for irrigation (Control 1) and treated domestic effluent (Control 2), with 5 repetitions, totaling 50 experimental units.

The experimental units were arranged in triangular form in double row, spaced at 0.60 m between single row, 0.50 m between plants of each row and 1.00 m between double row. The cv. Catissol 01 provided by the Coordination of Integral Technical Assistance-CATI, through the Seed Production Nucleus "Ataliba Leonel", of the Department of Department of Seeds, Seedlings and Matrices, São Paulo.

The domestic effluent used in the experiment was collected from the Monte Santo stream, in the city of Campina Grande. Initially, the effluent received a primary treatment in a tank of cement, gravel and sand, later the effluent was pumped for the Anaerobic Reactor (UASB – Upflow Anaerobic Sludge Blanket) and then it was treated in a stabilization lagoon (wetland). Finally, the effluent was pumped to a deposit of 5000 L located inside the protected environment to irrigate the plots.

The water supply came from the supply system of Campina Grande-PB (CAGEPA), from the Epitácio Pessoa dam.

The chemical characteristics of the soil used (Table 1) were determined according to the method recommended by Embrapa (1997).

Table 1. Chemical analysis of the soil used in the experiment.

Chemical Characteristics	Layer –(0 – 40 cm)
Calcium ($cmol_c$ kg^{-1} of soil)	1,55
Magnesium ($cmol_c$ kg^{-1} of soil)	1,00
Sodium ($cmol_c$ kg^{-1} of soil)	0,14
Potassium ($cmol_c$ kg^{-1} of soil)	0,25
Sulfur ($cmol_c$ kg^{-1} of soil)	2,94
Hydrogen ($cmol_c$ kg^{-1} of soil)	1,86
Aluminium ($cmol_c$ kg^{-1} of soil)	0,00
Cation Exchange Capacity - T ($cmol_c$ kg^{-1} of soil)	4,80
Qualitative Calcium Carbonate	Absent
Organic Carbon - %	0,37
Organic matter - %	0,64
Nitrogen - %	0,03
Assimilable phosphorus (mg kg^{-1})	0,80
pH H_20 (1:2,5)	5,45
$EC_{1:2}$dS m^{-1}	0,15
Saturation Extract – pH	5,13
Chloride ($mmol_c$ L^{-1})	0,12
Carbonate ($mmol_c$ L^{-1})	6,50

Bicarbonate (mmol$_c$ L^{-1})	1,80
Sulfate (mmol$_c$ L^{-1})	Absent
Calcium (mmol$_c$ L^{-1})	4,87
Magnesium (mmol$_c$ L^{-1})	6,38
Potassium (mmol$_c$ L^{-1})	0,60
Sodium (mmol$_c$ L^{-1})	2,56
Sodium Adsorption Ratio (mmol L^{-1})$^{1/2}$	1,08
Exchangeable Sodium Percentage (%)	2,92

Before sowing, the volume of water necessary for the soil to reach the field capacity was determined by the capillarity saturation method followed by free drainage.

The sunflower plants were grown in 20 L plastic pots filled with Neosolo Regolítico Dystrophic soil, sandy-loam, non-saline and non-sodium. The pots were drilled in the bottom and covered with geotextile layer + 1.0 kg of gravel (n° zero) to help drainage. The volume of the pot was divided into three parts, with the lower two thirds occupied by the soil used in the study and the upper third homogenized with bovine manure according to the dosages corresponding to each treatment.

Ten sunflower seeds were planted per pot at 0.03 m depth and distributed equidistantly. At 10 DAP, the first thinning was done, leaving three plants per pot. The second thinning was done at 30 DAP leaving one plant per pot. In addition, manual weeding and tutoring of plants in vertical trellis system were carried out.

Irrigation was carried out daily from sowing, using a enough volume of water to maintain soil moisture at field capacity. Water management of rrigation was for each treatment using irrigation frequency of 48 h on germination phase, 48 h on slow growth phase and, 24 h on intense growth phase, flowering and achenes formation. The applied water volume was calculated for the soil to reach the field capacity, according to Equation 1:

$$VI = (VIP - VD) / (1 - FL) \qquad \text{Eq. 01}$$

wherein
VI = Water volume applied for irrigation (mL)
VIP = Water volume applied to previous irrigation (mL)
VD = Water volume drained from previous irrigation (mL)
FL = Leach Fraction (0.1)

Water from drainage of pot was taken every 15 days after leaching. The drained volume was collected individually to determine the electrical conductivity (ECw).

The following variables of crop development were determined: germination percentage (GP%), emergence speed index (ESI), number of leaves (NL), stem diameter (SD), plant height (PHe) and leaf area (LA).

The germination percentage of (GP%) was determined by the relation between the number of germinated seeds and the number of seeds planted, the count being carried out 10 days after sowing. The index of emergency speed (ESI) was measured through daily counts of the number of plants emerged in relation to the number of days elapsed since the installation of the experiment (MAGUIRE, 1962).

At 60 days after planting (DAP), the growth analysis was carried out, where the following variables were measured: number of leaves (NL) per plant, considering only those that had a minimum length of 3.0 cm; plant height (PHe), measure from the neck of the plant to the apical bud using a tape measure; the diameter of the stem (SD), measured with the help of a digital pachymeter five centimeters above the neck of the plant; the leaf area (LA), measured with a millimeter ruler, measuring the central nerve of all the leaves. The calculation of the leaf area was carried out according to the method proposed by Maldaner et al. (2009).

The data obtained were subjected to the analysis of variance, the waters of the different treatments being compared with the Tukey test ($p < 0.05$) and the manure doses. When significant, they were subjected to a regression analysis. The statistical program SISVAR-ESAL (FERREIRA, 2011) was used.

RESULT AND DISCUSSION

According to the analysis of variance, a significant effect was verified for the water source factor for sunflower irrigation ($p < 0.05$) for the variable germination percentage (Table 2). In the factor organic fertilizer and water source interaction with organic fertilization no significant effect was recorded. The parcels irrigated with treated domestic effluent provided a higher percentage of germination in relation to those irrigated with water supply, having registered values of 70 and 61%, respectively. For the emergency speed index (ESI), no significant effect was observed for any of the sources of variation.

The results recorded on the percentage of germination refute those found by Andrade et al. (2007), which observed no effect of the use of water sources for irrigation of sunflower: domestic effluent and water supply. The results found in this study show that the domestic effluent can be used as a source for the irrigation of the sunflower crop, without causing damage to the germination of the seeds or the emergence of the plants.

Table 2. Anova and mean values for germination percentage (GP%) and emergence speed index (ESI) of sunflower plants (cv. Catissol 01) at 10 days after planting, as a function of irrigation water sources and organic fertilization dose.

Source of Variation	Average Squares		
	DF	%GP	ESI
Water Source (WS)	1	$2{,}954^{*}$	$0{,}159^{ns}$
Organic Fertilizer (OF)	3	$0{,}143^{ns}$	$0{,}030^{ns}$
Interaction WS x OF	3	$1{,}677^{ns}$	$0{,}021^{ns}$
Cont. 1 vc Cont. 2	1	$640{,}000^{ns}$	$0{,}010^{ns}$
Cont. 1 vc Factorial	1	$111{,}111^{ns}$	$1{,}808^{ns}$
Cont. 2 vc Factorial	1	$537{,}778^{ns}$	$1{,}463^{ns}$
Residue	28	0,736	0,118
CV %	-	10,61	18,58
Water Source		**%**	**Germination day^{-1}**
Water Supply		61,00b	1,78a
Domestic effluent		70,00a	1,91a

^{ns}, *= not significant and significant at 0.05 probability, respectively; Cont. 1 - Plants irrigated with water supply with 100% N; Cont. 2 - Plants irrigated with domestic effluent treated with 100% of the recommended dose of N.

Based on the analysis of variance, it can be indicated that no significant differences were found in the water source for irrigation for the variable number of leaves (NL) (Table 3). Andrade et al. (2012), when working with the sunflower crop, they verified that the plants irrigated with waste water presented a greater number of leaves, compared with plants irrigated with water supply, contrary to those obtained in the present study.

Table 3. Anova and mean data for number of leaves (NL) and stem diameter (SD) of sunflower plants (cv. Catissol 01) at 60 days after planting, as a function of water source for irrigation and dose of organic fertilization.

Source of Variation	Average Squares		
	DF	NL	SD (mm)
Water Source (WS)	1	11,495 ns	0,041 ns
Organic Fertilizer (OF)	3	35,250**	12,609*
Interaction WS x OF	3	0,159 ns	3,368 ns
Cont. 1 vc Cont. 2	1	11,980 ns	1,513 ns
Cont. 1 vc Factorial	1	3,131 ns	8,575 ns
Cont. 2 vc Factorial	1	8,000 ns	1,659 ns
Residue	28	6,239	2,687
CV %	-	11,51	12,49
Water Source		**Mean**	
Supply		19,57a	13,15a
Domestic efluente		20,66a	13,09a

^{ns}, *, **= not significant and significant at 0.05 probability, respectively; Cont. 1 - Plants irrigated with water supply with 100% N; Cont. 2 - Plants irrigated with domestic effluent treated with 100% of the recommended dose of N.

On the other hand, it can be observed that there was a significant effect of organic fertilization on the number of leaves, obtaining the best results for a 15% dose of manure (Figure 1A). Probably due to the availability of nitrogen for sunflower plants, which stimulated vegetative development and emission of more leaves per plant.

Continuing with the analysis of Table 3, it can be indicated that there was a significant effect for the SD of the sunflower plants corresponding to the dose factor of organic fertilization. The effect of SD as a function of the doses of organic fertilization was adjusted to a quadratic model, with higher values of SD reached for the application of 12.5% of manure, with increases of 23, 10 and 11% in relation to the doses E_1, E_2, and E_3, respectively (Figure 1B). Pereira et al. (2013) also observed an increase of 12.44% for stem diameter in *Vigna unguiculata* plants when they were fertilized with manure when sowing.

According to Santana et al. (2012), the increase in the diameter of the stem of the plants occurs due to the addition of organic matter in the soil, which results in many beneficial effects, such as improvement in the biological, physical and chemical properties of the soil, increasing the supply of nutrients for plants. Borchartt et al. (2011), indicates that the increase of the organic matter content by the addition of manure, can increase the availability of nutrients to meet the nutritional requirements of the plants and also contributes to the improvement of the storage capacity of water in the soil and the cation exchange capacity, causing a greater nutrients use initially present in the soil, enabling an adequate nutrition of the plants.

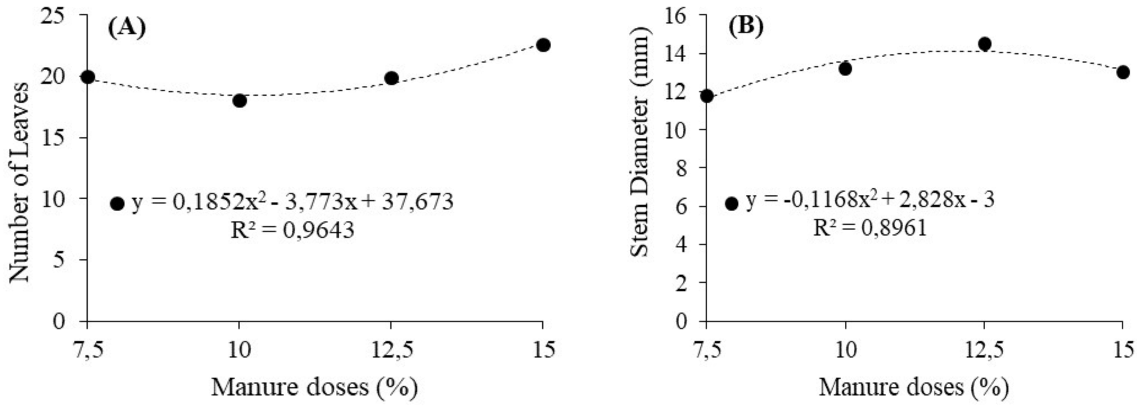

Figure 1. Number of leaves (A) and stem diameter (B) of sunflower plants (cv. Catissol 01) grown under organic fertilization.

According to the analysis of variance, no significant differences were observed for the plant height variable (PHe) of sunflower for any of the variation sources studied (Table 4).

Table 4. Anova and mean data for the height of plants (HPe) and leaf area (LA) of sunflower plants (cv Catissol 01) 60 days after planting, depending on the source of water for irrigation and organic fertilization.

Source of Variation	Average Squares		
	DF	PHe	LA (cm^2)
Water Source (WS)	1	532,900^{ns}	9,894^{ns}
Organic Fertilizer (OF)	3	252,333^{ns}	181,856^{ns}
Interaction WS x OF	3	295,367^{ns}	78,251^{ns}
Cont. 1 vc Cont. 2	1	48,400^{ns}	3764,376^{ns}
Cont. 1 vc Factorial	1	413,878^{ns}	249949,776^{ns}
Cont. 2 vc Factorial	1	122,500^{ns}	17844,203^{ns}
Residue	28	127,956	64,196
CV %	-	9,23	20,13
Water Source		**Mean**	
Supply		123,05a	1620,27a
Domestic effluent		123,10a	1690,72a

^{ns} = not significant; Cont. 1 - Plants irrigated with water supply with 100% N; Cont. 2 - Plants irrigated with domestic effluent treated with 100% of the recommended dose of N.

Several authors such as Brito et al. (2012) and Andrade et al. (2014), when evaluating the behavior of the ornamental sunflower under different doses of manure and irrigation with treated domestic effluent, did not see significant effects for the source factor of water for irrigation on the variable height of plants.

Regarding the manure doses, Nobre et al. (2010) and Andrade et al. (2014), observed a significant effect of this fertilizer on the height of sunflower plants, registering the best results for the 15% dose of manure, an aspect that was not verified in the present study.

For the leaf area variable (LA), no significant effects were observed for any of the sources of variation tested (Table 4). Costa et al. (2010) corroborated the results found in this study, since they verified that the leaf area (LA) was not affected by the type of irrigation water in the sunflower crop. The leaf area is an important index in studies of nutrition and plant growth, since it determines the accumulation of dry matter, the vegetal metabolism, the potential photosynthetic capacity, the yield and the quality of the harvest (OLIVEIRA et al., 2013), being widely used in studies that seek to evaluate the growth of plants.

Water consumption

According to the variance analysis, a non-significant effect on plant water uptake was observed for the water source, organic fertilization and interaction factors (Table 5). In the contrasts there was no significant effect for both water sources, witnesses with the other doses and types of organic fertilization. These results suggest that, despite the higher salinity of the domestic sewage effluent, the soil osmotic potential due high electrical conductivity of this water source did not reduce the plants water uptake, probably due to the culture tolerance of sunflower to saline stress. In addition, organic fertilization in the soil may have influenced the attenuation of salinity deleterious effects, mainly due to the increase of soil matrix potential in the pot, which may have reduced soil water tension, facilitating absorption.

The salinity of sewage effluent did not cause deleterious effects in the growth phase, but reduced the germination percentage of sunflower seeds because it is the most sensitive phase to salinity (SANTOS JÚNIOR, 2014).

Table 5. Anova and mean data for the water consunption of sunflower plants (cv Catissol 01) depending on the source of water for irrigation and organic fertilization.

Fonte de Variação	**Average Squares**	
	DF	Water consunption
Water Source (WS)	1	45001,735 ^{ns}
Organic Fertilizer (OF)	3	886237,294 ^{ns}
Interaction WS x OF	3	172577,848 ^{ns}
Cont. 1 vc Cont. 2	1	56250,000 ^{ns}
Cont. 1 vc Factorial	1	38474,453 ^{ns}
Cont. 2 vc Factorial	1	262530,009 ^{ns}
Residue	1	547560,000 ^{ns}
CV %	1	513777,779 ^{ns}
	28	239072,466
	-	14,51
Water source		Average (mL)
Supply water		3336,75
Domestic sewage efluente		3403,83
Doses of organic fertilization (%)		
7,5		3068,49
10,0		3077,67
12,5		3524,50
15,0		3710,50
Tes. 1		3463,33
Tes. 2		3613,33

^{ns}, *, **= not significant and, significant at 0.05 probability, respectively. Cont. 1 = Plants irrigated with supply water containing 100% N. Cont. 2 = Plants irrigated with domestic sewage effluent containing 100% of the recommended dose to N.

CONCLUSIONS

The use of sewage effluent treated as a water source for sunflower irrigation did not limit the growth of the crop.

The application of manure to the soil is beneficial for the early growth of sunflower in both water sources, with significant increases in the growth variables, mainly when using doses of 12.5 and 15% of manure.

The high salinity of domestic sewage effluent did not interfere with water absorption by sunflower plants as it is a salt tolerant species.

RESUMO: Na região semiárida do Brasil, devido à escassez de água, o uso de fontes alternativas de água é de vital importância, como o uso de águas salinas e efluentes de esgoto tratado. Portanto, no presente trabalho, avaliou-se o crescimento de plantas de girassol irrigadas com água da torneira e efluente de esgoto doméstico tratado, associado à adubação orgânica. A pesquisa foi realizada em ambiente protegido da Universidade Federal de Campina Grande, Campus I, Campina Grande, PB. Utilizou-se delineamento experimental inteiramente casualizado, com arranjo fatorial (4 x 2) + 2, com 5 repetições. Os tratamentos consistiram de dosagens de adubo orgânico (7,5; 10; 12,5 e 15% de esterco por peso) e duas fontes de água (água de abastecimento e efluente de esgoto doméstico tratado). De acordo com os resultados obtidos, pode-se indicar que o uso de efluente de esgoto doméstico na irrigação com girassol aumentou o crescimento do girassol em relação ao uso de água. A aplicação de doses de estrume de 12,5 e 15% melhorou o crescimento inicial do girassol, com aumentos significativos nas variáveis de crescimento.

PALAVRAS-CHAVE: *Helianthus annuus* L. Reuso de água. Ambiente protegido.

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