Residual Effect of the Chemical and Organic Fertilization on the Initial Growth of Cotton Plant Irrigated with Freshwater and Domestic Effluent

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ABSTRACT

In the last few decades, the environmental preservation has become factor of great social and economic importance. Continuous efforts have been carried through in order to develop alternatives of residues recycling to make possible the prevention and control of the pollution. Amongst the measures most promising can be detached the organic fertilization and wastewater reuse, that allow the soil fertilization by means of the application of residues characterized by the high organic content. However, more detailed studies in this direction should be done to minimize the possible sanitary risks of these practical. Therefore, the objective of this work was to evaluate the residual effect of chemical and organic fertilizers applied in sesame (*Sesamum indicum* L.) on initial growth of cotton (*Gossypium hirsutum* L.) cultivated in succession crop, when irrigated with treated domestic effluent and freshwater. For this, cotton plants was cultivated in 20 L pots previously cultivated with sesame plants, which was submitted to the treatments that resulted of factorial combination of five levels of castor meal (0, 2, 3, 4 and 5 ton ha^{-1}), two qualities of irrigation water (freshwater and domestic wastewater), and two additional treatments with chemical fertilization (NPK + freshwater and NPK + wastewater). The wastewater was treated in an anaerobic reactor and the irrigation was carried through daily in accordance with the water cotton demand. Plants height, leaf area and mean leaf number/plant were evaluated at thirtieth and fiftieth days after emergency. Results showed that the residual effect of organic fertilization with castor meal provided to greater initial growth of cotton plant. The irrigation with domestic wastewater propitiated greater initial growth of cotton plants in relation to freshwater irrigation.

Keywords: cotton, castor meal, wastewater, Brazil

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1. INTRODUCTION

The use of by-products as conditions of soil and natural fertilizer is a very promising alternative to grant allocation to waste in several human activities. This practice, and sustain the respect of environmental preservation, has been shown to be a viable option because it reduces the cost of production of several agricultural products. Among the activities that allow this practice, those with more prominent are the organic manure and reuse of water.

Organic manure is to fertilize the soil by using organic compounds. These natural fertilizers are added to the soil by incorporation and, after the mineralization of its organic matter, releasing nutrients that can be absorbed by crops, contributing to its nutrition and allowing its full growth and development (Kiehl, 1985).

In comparison to mineral fertilizers, biofertilizers the release of their nutrients more slowly, which is a great advantage, since the more gradual release of crops ensures greater stability in the supply of nutrients, reducing the need for reaplicações over the cycle or even between successive cycles. Santos et al. (2001), found that the fertilization with organic compound provides residual effect on the production of lettuce grown until 110 days after application of the compound. Furthermore, the organic fertilization caused an increase in content of bases, CEC and nutrient soil, effects not observed when the conventional fertilization.

Among the commonly used organic fertilizers, there is a cake of castor meal, which is the most traditional and important by-product of the productive chain of the castor bean (*Ricinus communis* L.), produced from the extraction of oil from oleaginous seeds. In India, the main producing country of the world's castor oil, about 85% of the castor meal is used as organic fertilizer (Severino, 2005).

When compared to other organic fertilizers, the cake of castor bean shows higher levels of nutrients in proportion of 16.2 kg ton^{-1} of phosphorus, 11.2 kg ton^{-1} for potassium and 64.1 kg^{-1} ton of calcium, in cattle as there are levels of 3.4 kg ton^{-1}, 1,3 kg^{-1} ton and 3.5 kg ton^{-1} of these nutrients (Beltrão, 2002).

For reuse of water means the use of water previously used one or more times in any human activity, to meet the needs of other beneficial uses, including the original. Can be direct or indirect, and course of actions planned or not (Lavrador Filho, 1987). According to van der Hoek et al. (2002) the biggest advantages of the use of wastewater is its wide availability, the conservation of water available and the possibility of recycling nutrients, contributing to the preservation of the environment. Hence, the reuse of water can be considered from two aspects: first as an instrument for the reduction of water consumption (demand control) and, as additional water resource to be used in some applications, enabling the provision of water of better quality, for the noblest purposes.

Feigin et al. (1991) consider the application of wastewater for irrigation of agricultural crops such as respect more reasonable and more feasible to reuse. This is based, mainly in the high water demand of the agricultural sector, which accounts for approximately 70% of the total water abstracted, which may reach up to 85% in areas of dry climate, appearing as the activity that consumes more water (Ayers & Westcot, 1991; Hespanhol, 2002; Christofidis, 2003; Capra & Scicolone, 2004). The reuse of water for irrigation is not a new concept and has been practiced for many years and in countries such as Australia, Saudi Arabia, Israel and Mexico.

WHO (1989) cites the benefits of reuse of wastewater: the recovery and saving of water, high-power fertilizer from the effluent, the formation of humus and the reduction or elimination of environmental pollution. Feigin et al. (1991) stated that the irrigation of crops with treated sewage effluent can be active part of the treatment system, where the soil and plants act as "living filter", absorbing and retaining pollutants and pathogens in waste and wastewater. The complete application through irrigation, thus the sequence of treatments aimed at reducing the level of microorganisms and various organic and inorganic compounds to acceptable levels. However, we emphasize that despite the potential benefits of organic fertilization practices and reuse, the implementation of by-products in agricultural soils can be harmful to the environment, human health, the aquifers and crops irrigated because both solid waste in liquid may contain organic and inorganic pollutants, which, in contact with the soil are leached to groundwater contaminated groundwater and surface water. Moreover, these compounds can serve as attractions for pathogenic microorganisms, resulting in transmission of disease to the population. Another issue to be considered is the persistence of organic compounds in soil, and the adaptability of crops for this type of management as some crops may have sensitivity or intolerance to the nutrients released after the decomposition of the waste.

2. MATERIALS AND METHODS

This work was conducted in an area belonging to the Water and Sewage Company of the State of Paraíba (CAGEPA), located in the city of Campina Grande - PB - Brazil, where are located the Biological Station of Treatment of Sewage (EXTRABES) and the group's search Research Program in Basic Sanitation (PROSAB).

The experiment was conducted in pots filled with soil of 20L Neosoil Regolithic (EMBRAPA, 1999) irrigated daily with the water demand for culture, determined by Equation 1 in accordance with its Kc. The chemical characterization of soil is used in Table 1. Treatments were arranged in 5 x 2 factorial in randomized blocks design, with three replications. The factors consisted of five doses of castor meal in the substrate (0, 2, 3, 4 and 5 ton ha^{-1}) and two qualities of irrigation water (freshwater and wastewater).

$$WD = ETc = ETo \times Kc \quad \text{(Equation 1)}$$

WD = Water demand of culture
ETc = Culture evapotranspiration, mm day^{-1};
ETo = Reference evapotranspiration, mm day^{-1};
Kc = Crop coefficient

Table 1. Chemical characterization of soil.

Chemical characterization	
pH (water)	6,03
Organic matter (%)	0,73
Phosphorus (mg/ 100g)	0,88
Potassium (meq/100g)	0,30
Aluminum (meq/100g)	0,06
Calcium (meq / 100g)	1,90
Magnesium (mg/ 100g)	0,64
Sodium (mg/ 100g)	0,07
Hydrogen (mg/ 100g)	0,52
Calcium carbonate	-
Organic carbon %	0,40
Nitrogen %	0,06
Eletric conductivity (mmhos/cm)	0,23

The domestic wastewater used in the experiment were from PROSAB of Campina Grande - PB, which receives every day about 1.50 m³ of raw sewage from the city. The sewage is treated by UASB reactor (Upflow Anaerobic Sludge Blanket), which removes organic matter and pathogens.

Were realized water analysis to determine the following parameters in the effluent: nitrogen, phosphorus, calcium, magnesium, sodium, potassium, calcium carbonate, electrical conductivity, pH, BOD and COD in the PROSAB's Laboratory of Chemical Analysis and Laboratory of Irrigation and Salinity of University of Campina Grande (in portuguese, Universidade Federal de Campina Grande), the chemical characterization of the treated wastewater can be seen in Table 2.

Table 2. Chemical characterization of treated domestic wastewater used in the experiment.

pH	CE µS/m	Ca^{2+} meq/L	Mg^{2+} meq/L	Na^{2+} meq/L	K^{2+} meq/L	CO_3^{-2} meq/L	DBO mgO_2/L	DQO mgO_2/L	$N\text{-}NH_3$ mg/L
7,24	2009	2,23	2,77	8,81	0,88	0,0	99,7	347,8	77,4

The castor meal used for fertilization was provided by the National Center for Research on Cotton of Empresa Brasileira de Pesquisa Agropecuária (Embrapa Algodão) and was subjected to laboratory tests to determine its oil content, crude protein, ash and nutrients, which are in Table 3.

Table 3. Content (%) of nitrogen, phosphorus, potassium, calcium and magnesium present in castor meal.

Content (%) of nutrients in the castor meal				
Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
7,54	3,11	0,66	0,75	0,51

Between January and May of 2008, each pot was sown with a crop of sesame cultivar G4 until the end of the cycle and collection of plants, then when the soil was fallow for three months.
In order to evaluate the residual effect of mineral and organic fertilizer with castor meal, was conducted a second crop in the same pots, this time with cotton plants. The planting was conducted in August 2008, with seeds of herbaceous cotton, cultivar BRS Camaçari (one plant per pot), which was grown without supplementation of fertilization and maintaining the irrigation scheme of the first cycle of cultivation (treatment with wastewater and water supply). The Kc used for calculating the need for irrigation was determined by Azevedo et al. (1993) according to the table below (Table 4).

Table 4. Crop coefficient (Kc) for cotton estimated by the method of Class A Pan evaporation

	WEEKS																		
	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	16ª	17ª	18ª	19ª
Kc	0,36	0,47	0,57	0,67	0,75	0,82	0,88	0,93	0,97	1,00	1,02	1,02	1,02	1,01	0,99	0,96	0,92	0,86	0,80

It was made evaluations at 30 and 50 days after cotton plant emergence, when determined the plant height, leaf area and leaf number per plant. The individual leaf area was estimated by linear measurements according to Equation 2 below, proposed GRIMES & CARTER, (1969):

$$Y = 0{,}4322\, X^{2{,}3002} \qquad \text{(Equation 2)}$$

Y = Leaf area^{-1}, shown in cm^2;
X = Length of the main vein of the leaf of the cotton in cm.

Data were submitted to analysis of variance and polynomial regression analysis.

3. RESULTS AND DISCUSSION

The average values of plant height, leaf area and number of leaves measured at 30 days after emergence of cotton plants are in Table 5.
According to the results of analysis of variance, the water quality did not cause significant effect on any of the variables studied. For doses of castor meal, there was a quadratic effect for the variables plant height and leaf area, as seen in Figures 1A and 1B. The estimated maximum height was 26.73 cm and was achieved when the dose of castor meal used in the first cycle would be 3.06 ton ha^{-1}. Already a maximum leaf area (822.15 cm^2) was achieved when the dose was applied biocomposte of 3.29 ton ha^{-1}. It is important to emphasize that, until 30 DAE, all plots were irrigated with water, and therefore the effects observed are due only to the treatments in the first cycle of cultivation.

Table 5. Plant height, leaf area and number of leaves measured at 30 days after emergence of cotton plants

Factors	Plant height (cm)	Leaf area (cm^2)	Number of leaves
Castor meal doses			
0 ton ha^{-1}	22.08	546.95	10.67
2 ton ha^{-1}	26.55	750.27	12.50
3 ton ha^{-1}	25.50	760.29	12.00
4 ton ha^{-1}	27.58	939.08	13.00
5 ton ha^{-1}	24.42	686.91	11.50
Water source			
Wastewater (WW)	24.50 a	653.19 b	11.87 a
Freshwater (FW)	25.95 a	820.21 a	12.00 a
Factorial vs Add. treatments			
Factorial	25.23 a	736.70 a	11.93 a
Additional treatments	26.63 a	590.71 a	11.50 a
Additional treatments			
NPK + WW	27.00 a	524.87 a	11.33 a
NPK + FW	26.27 a	656.55 a	11.67 a

In each column, values followed by the same letter do not distinguish among themselves by Tukey test at a 5% probability level.

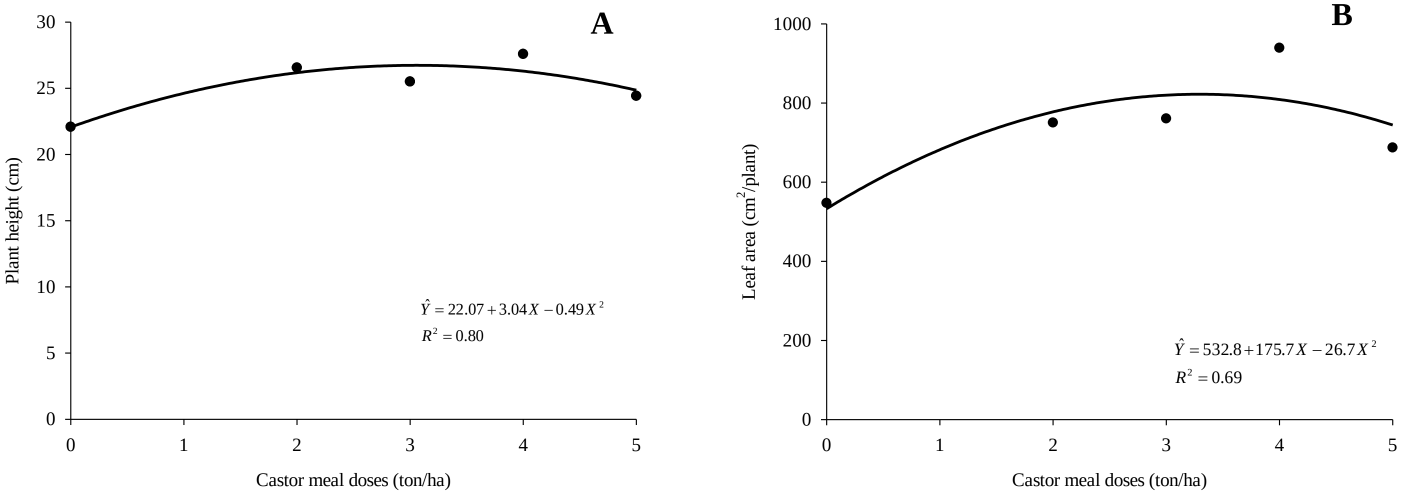

Figure 1. Plant height (A) and leaf area per plant (B) of cotton in relation of castor meal doses

In table 6 can be found that at 50 days after emergence, there were significant effects for dose of castor meal and the type of water used in irrigation. No significant interaction was found between the two factors.

Table 6. Plant height, leaf area and number of leaves measured at 50 days after emergence of cotton plants

Factors	Plant height (cm)	Leaf area (cm^2)	Leaf number per plant
Castor meal doses			
0 ton ha^{-1}	42.25	1048.34	13.83
2 ton ha^{-1}	45.75	1306.41	15.17
3 ton ha^{-1}	45.25	1351.10	14.67
4 ton ha^{-1}	46.58	1305.23	15.17
5 ton ha^{-1}	47.92	1304.87	16.17
Water source			
Wastewater (WW)	49.27 a	1382.94 a	15.87 a
Freshwater (FW)	41.83 b	1143.43 b	14.13 b
Factorial vs Add. treatments			
Factorial	45.55 a	1263.19 a	15.00 a
Additional treatments	48.75 a	900.52 b	13.00 b
Additional treatments			
NPK + WW	53.83 a	1036.18 a	14.33 a
NPK + FW	43.67 b	764.85 a	11.67 b

In each column, values followed by the same letter do not distinguish among themselves by Tukey test at a 5% probability level.

The irrigation of cotton with wastewater has increased leaf plant height, area and number of leaves in relation to irrigation with water supply, regardless of the dose and source of fertilizer applied in the first cycle of cultivation. Probably the greatest contribution of nitrogen and phosphorus present in wastewater in relation to water supply has encouraged the growth of plants. Similar results were obtained by Bezerra et al. (2005) and Fideles Filho et al. (2005), which found that application of wastewater promoted greater growth of cotton plants when compared with conventional irrigation with drinking water.

The castor meal used in the first cycle showed residual effect, providing greater growth of plants. As can be seen in Figures 2A and 2B, the plant height and leaf number per plant increased linearly with the increase of organic fertilizer applied in the previous crop, and this increase of 1.04 cm in height and 0.4 leaves per plant for each increase of one tonne per hectare at a dose of castor meal. Leaf area increased up to a dose of 3.46 tonnes per hectare of castor meal when the leaf area was estimated in 1346 cm^2 per plant (Figure 3).

It was found that the residual effect of the castor meal was more pronounced than the residual effect of mineral fertilizer, since the plants had greater leaf area and number of leaf for additional treatments. According to Smith & Hadley (1989), when compared to mineral fertilizers, biofertilizers have the slower mineralization, which ensures that part of their nutrients become available only in the subsequent crops.

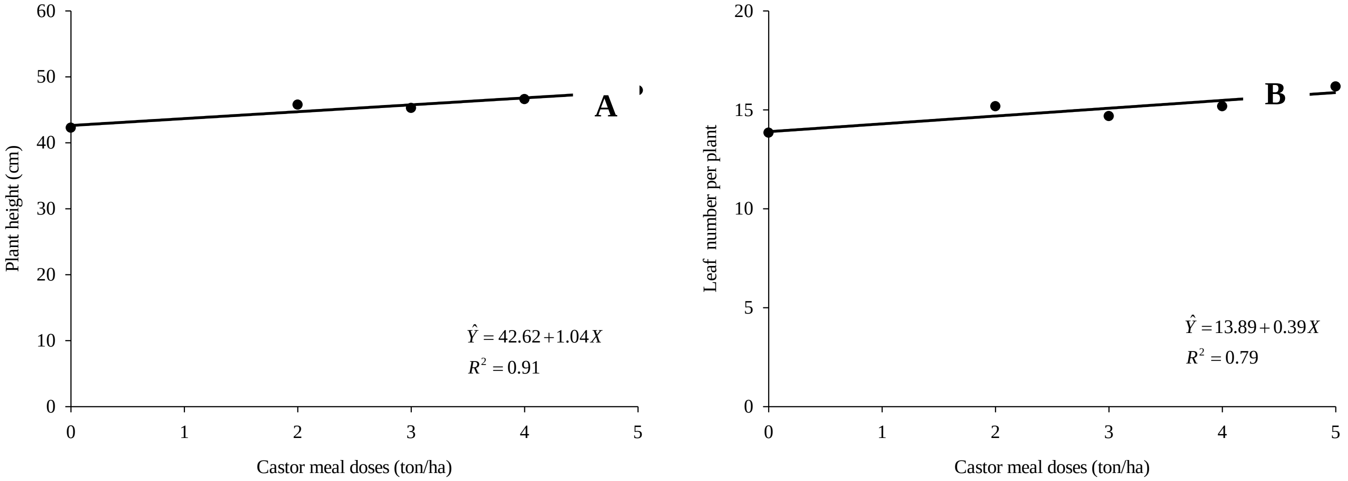

Figure 2. Plant height (A) and leaf number per plant (A) of cotton in relation of castor meal doses

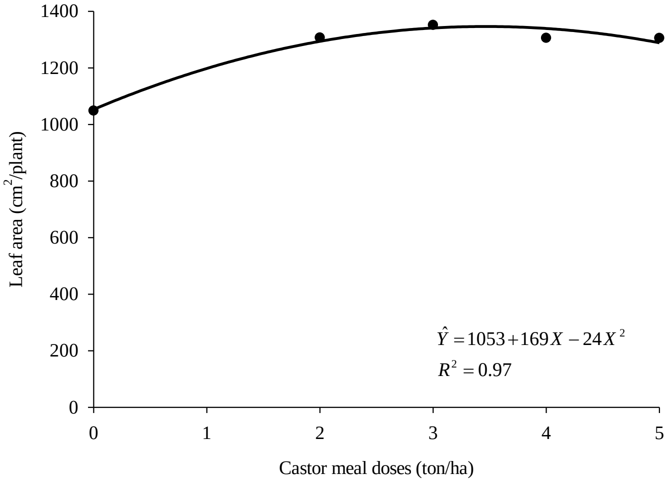

Figure 3. Leaf area of cotton plants in relation of castor meal doses applied in soil

4. CONCLUSIONS

Are observed residual effect of the dose of castor meal applied in the first crop on the leaf area and plant height of cotton in the two seasons tested.

The leaf number per plant was affected by dose of castor meal only at 50 days after plant emergence.

All parameters were affected by the water source used for irrigation at 50 days after plant emergence.

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