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Sewage Sludge as Fertilizer in Soybean Cultivation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The objective of the present study was to evaluate the effects of the application of treated sewage sludge on the initial development of soybean plants (*Glycine max* L.). Seven treatments were used: (T1) only the soil (absolute control); (T2) soil + residue at the dose of 5.0 g/dm^3; (T3) soil + residue at a dose of 10.0 g/dm^3; (T4) soil + residue at the dose of 15.0 g/dm^3; (T5) soil + residue at the dose of 20.0 g/dm^3; (T6) soil + residue at the dose of 25.0 g/dm^3; and (T7) culture with PK. The variables of emergence, first count and emergence speed of seedlings, green mass, shoot length, root length, dry shoot mass and dry root mass of the plants were analyzed. The experimental design was in randomized blocks, with four replicates of 25 plants for each treatment. The use of the organic residue positively influenced the characteristics observed in relation to the control and the PK, and in the appropriate dose, it can be recommended as an input and soil conditioner. Sewage sludge presents high potential as a fertilizer for soybean cultivation.

Keywords: Glycine max L.; organic waste; soil conditioner.

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1. INTRODUCTION

The soybean (*Glycine max* L.), originating in China, is the most cultivated oleaginous in the world, being adaptable the most diverse regions, and standing out for its economic importance. The great potential of the external market of soybean and its excellent adaptation to the different edaphoclimatic conditions of Brazil boosted its cultivation in all regions of the country [1]. Among the different crops that were introduced after the opening of areas in the Cerrado, soybean was the one that grew the most in cultivation area, presenting in some Brazilian regions, average productivity above average obtained by the North American soybean [2].

Sewage sludge has been used as an agricultural fertilizer to increase crop productivity, since it has high agronomic potential, rich in organic matter and nutrients such as nitrogen and phosphorus. However, agricultural use of sludge has some potential risks associated with the presence of heavy metals, toxic organic compounds and pathogenic microorganisms, which should be taken into account for the safe use of this by-product as a soil conditioner [3].

Studies with wheat crop showed results with positive effects of the application of sewage sludge, in which the authors obtained greater amount of total organic carbon, improvement in the physical attributes such as soil density, reduced in about 20% in the superficial layer and increase of the weighted mean diameter of soil aggregates [4]. The application of alkaline sewage sludge to acid soils has proved to be an interesting alternative to recycle this type of waste, since it has improved soil fertility and may reduce costs with soil management and crop fertilization [5].

Verified the effect of nitrogen and composted sewage sludge on wheat production parameters. The treatment that provided a higher productivity of grain and dry matter was the treatment that received the highest dose of sludge. When applied in agronomic rates, sewage sludge can greatly reduce the cost of production, by the lower use of soluble mineral fertilizers.

Based on this scenario, the objective of this work was to evaluate the performance of the sludge from sewage treatment as an agricultural fertilizer in the soybean crop, seeking the recovery of this residue.

2. MATERIALS AND METHODS

The work was developed at the Garanhuns Academic Unit of the Federal Rural University of Pernambuco, Garanhuns, PE, Brazil, located at 08º 53´ 25´´ S, 36º 29´ 34´´ W and at 896 meters of altitude. According to the climate classification of Köppen, the climate is of the type Cwa, tropical of altitude.

2.1 Assays

The treatments used were:: (T1) only the soil (absolute control); (T2) soil + residue at the dose of 5.0 g/dm^3; (T3) soil + residue at a dose of 10.0 g/dm^3; (T4) soil + residue at the dose of 15.0 g/dm^3; (T5) soil + residue at the dose of 20.0 g/dm^3; (T6) soil + residue at the dose of 25.0 g/dm^3; and (T7) culture with PK.

First, the seeds were inoculated with Bradyrhizobium bacteria and then seeded in polyethylene bags (volume of 7.8 dm^3) on the substrate, three seeds per bag, and the experiment conducted inside the greenhouse.

Seedlings were considered to be emerged from the moment the epicotyl appeared above the soil line. The daily counts of the number of emerged seedlings were carried out at the same time, beginning on the fifth day and occurring until stabilization (45^{th} day), with cultural treatment when necessary. Subsequently, thinning was done, leaving only one plant per bag.

2.2 Variables Analyzed

First emergency count: It was performed together with the emergency test, computing the percentage of normal seedlings obtained on the fifth day after the test installation.

Emergency speed index: According to the methodology of Nakagawa [6].

Green mass: The green mass of the plants of each experimental unit.

Aerial part length and root: At the end of the emergency test, the length of the aerial part (from the soil surface to the apex of the plant) and the root (from the base of the neck to the end of the root) of plants of the experimental unit was measured with the aid of a graduated ruler.

Dry mass of the aerial part and root: After the measurements, the aerial parts and roots of the plants of the experimental unit were packed in paper bags of Kraft type, and placed in oven with forced air circulation, regulated at 60ºC, until reaching constant weight (72 hours), after which the dry mass is determined on a digital scale.

2.3 Statistical Procedure

The experimental design was a randomized block design with four replicates of 25 plants for each treatment, using five doses of the residue (treated sewage sludge), the absolute control and the cultivation with PK. Data were submitted to analysis of variance (F test) and the means compared by the Dunnett test, at 5% probability. Statistical analyzes were carried out with the aid of the statistical software SAEG, Version 9.1 [7].

3. RESULTS AND DISCUSSION

The physical and chemical analyzes of the soil used as substrate and the chemical analysis of the residue (Table 1).

The emergency values and first emergency count as a function of the treated treatment method were shown in Table 2. It was found that the procedures soil + residue at a dose of 10.0 g/dm^3 and soil + residue at a dose of 15.0 g/dm^3 differed statistically in relation to the absolute control and PK cultivation. Regarding the nutrients, it is observed that there is no dry sludge in the ratio C/N has a value close to 13, demonstrating its higher potential as a nitrogen source, although this better performance may not occur in high percentages of the residue, which was observed in this work.

Sewage sludge is an attractive alternative to substrate composition because it contains theoretical content of various nutrients. Agricultural use of these wastes has been recommended as a source of organic matter and for benefits in the soil chemical industry such as increased pH, reduced exchangeable acidity and increased nutrient availability [8]. The use of the sewage method, when performed correctly, causes beneficial changes in the soil, since in addition to incorporating organic matter, nutrient release occurs slowly and continuously [9].

The effects of the application of the sewage examination method on the emergency speed index and green mass were shown in Table 3. It was found that a fertilization with a sewage method at a dose of 15.0 g/dm^{3}differed statistically when compared with an absolute witness and cultivated with PK. Also mention the development of soybeanplants in the sludge application plots, in contrast to plots devoid of application, even if subjected to mineral fertilization and incorporation.

The contents of components observed in the method analyzed reveal values well below the limits imposed by the main environmental inspection agencies, due to predominantly domestic sewage, therefore, it is suitable for agricultural use in relation to chemical uses. For the type and condition of the substrate used within a 45-day study period or the method of promoting an increase in recovering soil quality, this value is not respected by the significant increase in key technical characteristics such as phosphorus, or potassium, or magnesium, an organic matter and CTC [10].

Table 1. Physical and chemical analysis of soil used as substrate and chemical analysis of sewage sludge samples

Chemical analysis of residue	**N total**	**C**	**M.O.**	**P**	**K**	**Ca**	**Mg**	**Na**	**Cu**	**Zn**	**Mn**	**Pb**	**Fe**
	g/Kg								**mg/Kg**				
	22.5	285.9	4930	45.0	2.1	9.4	1.2	0.3	155.0	548.0	207.0	120.0	16.9
Soil physical analysis		**Argila + Silte**				**Argila**			**Silte**		**Areia**		
	Teor	35%				24%			11%		64%		
Chemical Soil Analysis	**Ph (H_2O)**	**P**		**K^+**		**Ca^{++}**			**Mg^+**	**Na^+**	**Al^{+++}**		
		mg/dm^3							**cmol$_c$/dm^3**				
	6.80	62.00		0.90		7.75			2.45	0.28	0.00		

Table 2. Emergence (E) and first emergence count (PC) of soybean seedlings, performed as a function of sewage sludge doses, compared with an absolute control and with PK cultivation

Treatments	Absolute witness		PK cultivation	
	E (%)	PC (%)	E (%)	PC (%)
5.0 g/dm^3	5^{NS}	5^{NS}	-10^{NS}	-5^{NS}
10.0 g/dm^3	35*	40*	25*	30*
15.0 g/dm^3	50*	35*	35*	25*
20.0 g/dm^3	10^{NS}	20^{NS}	-5^{NS}	10^{NS}
25.0 g/dm^3	-7^{NS}	-1^{NS}	-22^{NS}	-11^{NS}

** Significant to the witness by Dunnett test at the 5% probability level;*
^{NS}Not significant by Dunnett test at 5% probability level

Table 3. Seedling emergence rate (IVE) of green plants and green mass (MV) of soybean plants, as a function of the application of sewage sludge doses, compared with an absolute control and with PK cultivation

Treatments	Absolute witness		PK cultivation	
	IVE	MV (g)	IVE	MV (g)
5.0 g/dm^3	0.431^{NS}	25^{NS}	-0.458^{NS}	-7^{NS}
10.0 g/dm^3	0.680^{NS}	50^{NS}	-0.209^{NS}	18^{NS}
15.0 g/dm^3	4.001*	80*	3.111*	61*
20.0 g/dm^3	0.693^{NS}	26^{NS}	-0.196^{NS}	-6^{NS}
25.0 g/dm^3	-1.296^{NS}	-25^{NS}	-2.185^{NS}	-57^{NS}

** Significant to the witness by Dunnett test at the 5% probability level; ^{NS}Not significant by Dunnett test at 5% probability level*

Table 4. Shoot length (CPA) and root length (CR) of captured soybean plants as a function of sewage sludge application, compared with an absolute control and with PK cultivation

Treatments	Absolute witness		PK cultivation	
	CPA (cm)	CR (cm)	CPA (cm)	CR (cm)
5.0 g/dm^3	2^{NS}	1^{NS}	-3^{NS}	-4^{NS}
10.0 g/dm^3	5^{NS}	4^{NS}	0^{NS}	-1^{NS}
15.0 g/dm^3	14*	10*	9*	5*
20.0 g/dm^3	3^{NS}	2^{NS}	-2^{NS}	-3^{NS}
25.0 g/dm^3	1^{NS}	0^{NS}	-4^{NS}	-4^{NS}

** Significant to the witness by Dunnett test at the 5% probability level; ^{NS}Not significant by Dunnett test at 5% probability level*

Table 5. Shoot dry matter (MSP) and root dry mass (MSR) of soybean plants, as a function of the application of sewage sludge doses, compared with an absolute control and with PK cultivation

Treatments	Absolute witness		PK cultivation	
	MSP (g)	MSR (g)	MSP (g)	MSR (g)
5.0 g/dm^3	-1^{NS}	1^{NS}	-4^{NS}	-1^{NS}
10.0 g/dm^3	4^{NS}	2^{NS}	1^{NS}	0^{NS}
15.0 g/dm^3	11*	6*	8*	5*
20.0 g/dm^3	7^{NS}	4^{NS}	4^{NS}	2^{NS}
25.0 g/dm^3	-2^{NS}	0^{NS}	-5^{NS}	-2^{NS}

** Significant to the witness by Dunnett test at the 5% probability level; ^{NS}Not significant by Dunnett test at 5% probability level*

Soil + residue treatment at 15.0 g/dm^3 is the longest shoot and root length, being significant for the absolute control and for PK cultivation (Table 4). Nutrient contents contained in sewage sludge were used for plant growth due to the amount of nitrogen, as N is one of the elements that directly participates in protein reproduction and consequently in cell expansion and formation of indispensable new tissues. For plant growth [11] also state that there is an increase in the nitrogen content of the substrates they received or sewage sludge.

In general, sewage sludge can provide N to plants in satisfactory tests, as well as other elements such as P, Ca, Mg, Zn and Cu. It is noteworthy that N, without biodegradable content, may restrict application taxes more than heavy metals, due to mineralization of its organic load and subsequent nitrate leaching. Most of the nutrients in the sludge are in organic form, although only about 30 to 50% of the total is available in readily acceptable form to plants. P is 70% in organic form and can be used in the first year of cultivation, with most K available immediately to vegetables [12].

The treatment that provided the highest shoot and root dry mass was the treatment that received a sludge dose of 15.0 g/dm^3, differing statistically from the absolute control and PK cultivation (Table 5). This shows that the biosolid was able to provide how much mineral, confirming that the residue can be used to supply this nutrient in soybean plantations.

4. CONCLUSIONS

Being considered an excellent supplier of organic materials, or the waste removal method is able to improve the chemical and chemical properties of the substrate. According to studies, the use of the filming method as a substrate component represents a viable alternative for its final disposal, reflected in the economics of fertilizers and environmental benefits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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