



Nutrient Contents in a Cerrado Oxisol Fertilised with Swine Liquid Manure under an Environmental Conservation Perspective

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Authors' contributions

This work was carried out in collaboration between both authors. The author OLSW conceived the study, wrote the protocol and managed the analyses of the study. Author CCS wrote the first draft of the manuscript, performed the statistical analysis and managed the bibliographic research. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: The objective of this work was to evaluate the distribution of nutrients in the layers of a Cerrado oxisol, fertilised with liquid swine manure compared to the values of these nutrients established by the Conama (National Council of the Environment) for the conservation of quality from soil.

Study Design: The experiment was carried out in a randomized block design with four treatments, in five replications, 0, 10, 20 and 30 m³ swine net waste ha⁻¹, applied eight times, corresponding to the accumulated volumes of 0, 80, 160 and 240 m³ swine net waste ha⁻¹, respectively.

Place and Duration of Study: The study was conducted at the Rio Verde Foundation (13°03'01" S and 55°54'40" W), from February 2014 to January 2015.

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Methodology: The experiment was composed of 20 experimental units with dimensions of 11.0 m in length and 3.5 m in width. This swine liquid manure (DLS) waste was previously arranged in a stabilisation pond to conform to the microbiological standards of organic waste required by Conama. Soil samples were collected with depths in each plot to evaluate the nutrient contents.

Results: The net residue of swine manure influenced the total nitrogen contents in the layer of 0.10 to 0.20 and Fe in the layer of 0.20 to 0.40 m. From the environmental point of view, total nitrogen (NT), phosphorus (P), copper (Cu) and zinc (Zn) contents were below the values established by Brazilian environmental legislation for soil quality conservation.

Conclusion: In general, nutrient content in the profile of the Cerrado oxisol was not affected by the successive applications of swine net waste in the three soil layers, in the sense that there is an immediate concern that the content is above the critical environmental limit established by Conama.

Keywords: Organic fertilisation; wastewater; tropical soils; sustainability.

1. INTRODUCTION

In Brazil, swine manure up to the 1970s did not pose a problem to the environment, to the detriment of rudimentary swine breeding. Brazil's current scenario for this sector has changed due to its transformation to an industrial scale and, according to the Ministry of Agriculture, Livestock and Supply [2], the country is the fourth largest producer of swine in the world. Among the Brazilian pork-producing states, Mato Grosso, according to the Environment Secretariat [3], Mato Grosso is the fifth largest of swine producer in the country due to the new development cycle, which consists of increasing activities. Intensive livestock production in the confined model, such as poultry farming, swine farming, and cattle raising, because they are attracted by the availability of grain at a lower cost, and a commercial agricultural environment that allows large-scale operations.

Mato Grosso recorded a growth of 37.5% in the swine manure herd in relation to the previous year, that is, an increase from 1.900.903 to 2.613.925 heads, distributed in 415 farms [4]. With large-scale swine production, the final by-products of this chain, wastewater (water, urine and faeces) and manures are of concern as to their ultimate destination, which are usually the soils. The swine net waste is an alternative fertiliser because it is rich in nutrients, but the inadequate use of this residue can cause soil accumulation of elements present in its composition, such as, N, P, Cu and Zn and to be lost by surface runoff and by leaching, with the risk of contaminating surface and subsurface waters.

Many Brazilian researchers studied the influence of swine manure on agricultural crops [5,6,7]; in the soil nutrient dynamics [8], soil and / or water

management [9]. In the present study, the results obtained are similar to those reported in the literature. Thus, few or almost no studies were developed on soils under Cerrado, which is why this study was carried out in order to support producers and environmental agencies. The contribution and accumulation of nutrients in the soil of animal waste as fertilisers and / or biofertiliser, should be evaluated observing the environmental and sanitary bias, since in accordance with the national guidelines established by the National Environmental Council and the Ministry of the Environment Health, for soil and water quality conservation, soil as a filter tends to minimise the environmental impacts caused by the pollutant load present in these biofertilisers.

In light of this problem, this study aimed to evaluate the redistribution of nutrients in the profile of an oxisol of the Cerrado in the 0 to 0.10 layers; 0.10 to 0.20 and 0.20 to 0.40 m after successive applications of liquid swine manure compared to the values of these nutrients established by the National Council of the Environment for the conservation of quality from soil.

2. MATERIALS AND METHODS

The study was conducted at the Rio Verde Foundation in Lucas do Rio Verde – Mato Grosso (13°03 '01 "S and 55°54' 40" W), from February 2014 to January 2015. The soil in the region was classified as oxisol. The climate of the region is of the type Aw, according to the classification of Köppen and Geiger, characterised as tropical rainy, hot and humid, with a longer dry season and a rainy season of four months, between December and March, since in summer there is usually more rainfall than in winter (Table 1). The average

temperature is 25°C and the average annual rainfall is 1869 mm (Fig. 1).

For the characterisation of the physical and chemical attributes of the soil of the experimental area, four trenches were opened at four depths: 0 to 0.10; 0.010 to 0.20 and 0.20 to 0.40 m for sample collection, to determine the nutrient content in the soil profile, as well as the granulometry that followed the methodology recommended by Embrapa [10]. The design was in a randomized block with four treatments in five replicates of swine net waste, which corresponded to 0, 10, 20 and 30 m³ ha⁻¹, and in the accumulated of eight applications corresponded to 0, 80, 160 and 240 m³ ha⁻¹, volumes were defined to meet the nitrogen requirement of the Tifton 85 forage plant (test plant). It should also be noted that the total experimental area was occupied by the soybean crop in the previous crop, and the area was scrubbed by means of brush cutter coupled to a tractor, after which the leveling grid was passed to homogenise the area of the experiment.

The mass growth of the aerial part of the test plant was monitored during the last 4 applications net waste of swine.

The experiment was composed of 20 experimental units with dimensions of 11.0 m in length and 3.5 m in width. The spacing between the plots was five meters, and these plots were arranged in each block so that their position did not coincide with the position of the plots of the next block, to avoid potential contamination by

surface runoff. On the sides of each plot was installed PVC plaques forming a protective barrier. The swine net waste used in the experiment came from swine grange in the state of termination near the Rio Verde Foundation. This swine net waste was previously arranged in a stabilisation pond to conform to the microbiological standards of organic waste required by Conama Resolution 357.

For each application swine net waste was transported from this farm to the experimental area in 1000 L containers to then applied to the plots. After planting by molting of the test plant, swine net waste was manually applied with irrigators, in the volumes cited, however, before each application to the soil, swine net waste samples were collected for analysis of their chemical composition (Table 2), which were placed in plastic bottles of 200 mL and kept in a Styrofoam box with ice for shipment to the laboratory.

The accumulated nutrient amounts, in kilogram per hectare, with the eight swine net waste applications, corresponding to one year of experiment, are presented in Table 3. After this time soil samples were collected with the aid of dutch stainless steel in the depths 0 to 0.10 m, 0.10 to 0.20 to 0.20 to 0.40 m in each plot to evaluate changes in chemical attributes (pH, total nitrogen, available phosphorus, exchangeable ions potassium, calcium plus magnesium, copper, zinc, iron and manganese and soil organic matter, (CTC) according to Embrapa [10] and Tedesco et al. [11].

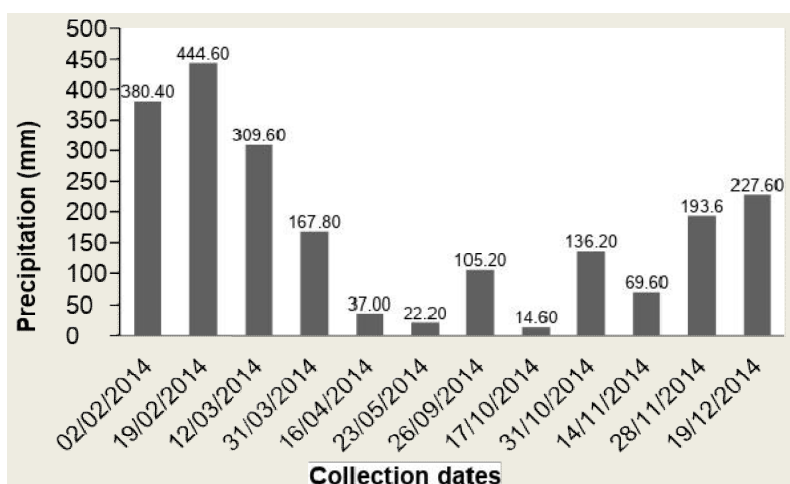


Fig. 1. Precipitation during the experiment at the Rio Verde Foundation in Lucas do Rio Verde – Mato Grosso

Table 1. Chemical soil attributes, experimental area of the Rio Verde foundation (Lucas do Rio Verde, Mato Grosso)

Depth (m)	pH CaCl ₂	Al	H+Al	Ca (Cmol _c dm ⁻³)		Mg	SB	TpH ₇	V -----(%)-	m (g kg ⁻¹)	Matter organic
0- 0.10	4.70	0.38		15.5	2.38	2.10	4.19	19.69	21.14	9.23	53.80
0.10 - 0.20	4.35	0.37		14.8	2.17	0.10	2.56	17.36	14.75	12.88	54.80
0.20 - 0.40	4.68	0.47		11.25	1.80	1.30	2.35	13.6	17.79	16.71	54.20
Depth (m)	Na	K	P	Cu Zn Fe (mg dm ⁻³)			Mn	Clay cmol _c kg ⁻¹			
0- 0.10	1.18	101.61	20.36	0.11	0.29	4.47	0.22	32.7			
0.10 - 0.20	1.01	110.95	8.07	0.09	0.28	4.72	0.16	27.73			
0.20 - 0.40	2.03	43.42	1.83	0.09	0.25	3.06	0.13	20.42			

pH: hydrogen potential; Al: aluminum; H: hydrogen; Ca: calcium; Mg: magnesium; SB: sum of bases; TpH₇: cation exchange capacity at pH 7.0; V% : base saturation; m%: saturation by aluminum; MO: organic matter; Na: sodium, K: potassium; P: phosphor; Cu: copper; Zn: zinc; Fe: iron; Mn: manganese

Table 2. Chemical composition of the swine net waste samples applied in the experimental plots

NP	Collect	RES	pH	N P K Ca Mg S -----kg m ⁻³ -----					Fe Zn Cu Mn Na B -----g m ⁻³ -----						
1	Feb/2014	May	6.8	5.60	0.11	0.70	7.52	3.07	0.99	104	23	29	110		
2	May	Jun	7.2	2.80	0.10	0.60	0.20	0.10	0.20	91.00	0.61	0.41	1.22		
3	Jul	Aug		5.00	0.70	0.50	5.14	1.61	3.33	10.00		0.01	0.01		
4	Aug	Sep		2.80	16.07	0.21	12.0		8.20					1100	0.10
5	Sep	Oct		5.60	0.33	0.43	3.06		0.01		40	20.00	150	300	175
6	Oct	Nov		2.80	8.24	0.33	6.00	3.00	3.00	11.00	10	40.00	30.2		161
7	Nov	Dec		1.40	0.22	0.46	4.50	1.50	10.00		10	10.00	10.00	200	160
8	Dec	Jan/2015		1.40	0.20	0.45	4.50	1.50	5.00	10.30	10	10.00	10.20	200	161

NP: number of plots; RES: Results; pH: hydrogen potential; N: nitrogen; P: phosphor; K: potassium; Ca: calcium; Mg: magnesium; Fe: Iron; Zn: zinc; Cu: copper; Na: sodium; B: boron

Table 3. Accumulated nutrients during the eight applications

Treatments/ nutrients	80	160	240	Treatments/ nutrients	80	160	240
	Doses of applied swine net waste				Doses of applied swine net waste		
	(kg ha ⁻¹)				(kg ha ⁻¹)		
N	374.85	749.70	1124.55	S	246.85	493.71	740.57
P	253.67	556.85	835.27	Zn	1.12	2.25	3.38
K	135.21	187.43	239.65	Cu	1.41	2.76	4.11
Ca	517.17	1034.34	1551.51	Mn	4.89	9.78	14.68
Mg	166.67	303.34	440.02	Fe	4.33	8.66	12.99

N: Nitrogen; P: phosphor; K: potassium; Ca: calcium; Mg: magnesium; S: sulfur; Zn: zinc; Co: copper; Mn: manganese

The data set was analysed, in principle, by the tests of normality and homogeneity of the variances to verify the normality and homogeneity of data variance, and then the analysis of variance applying the F test to 5% of probability and, where significant, means were compared by the Tukey test. The data of each variable were analysed within the same soil layer in the different treatments. The analyses were performed by the statistical program Sisvar 5.6 [12].

3. RESULTS AND DISCUSSION

The swine net waste did not change the soil pHCaCl₂, with a mean of 5.03 in the 0 to 0.10 m layer for the doses tested (Table 4). At the 160 m³ ha⁻¹ dose, the pH in the 0 to 0.10 m layer is in the appropriate range, in the other layers and for all doses this attribute is in the low to medium range, according to the fertility classification of Sousa and Lobato [13].

At the beginning of the experiment the pH of the soil in the 0 to 0.10 m layer was at 4.70 and with the successive applications of swine net waste to the soil did not correct the pH in the arable layer, however, so that the plants explore the nutrients available the range considered ideal is 5.5 to 6.0. Thus, similar results to the present study in which soil pH is not altered by the addition of manure were observed by Cassol et al. [14], Scherer et al. [15] and Ceretta et al. [16]. Scherer et al. [17] consider the influence of organic fertilisers on the pH to be minimal. It is possible to infer that the swine net waste applied in volumes of up to 240 m³ ha⁻¹ in the oxisol of the Cerrado did not alter the pH of the soil. Ceretta et al. [16], mention that the possibility of altering the pH of the soil with the application of liquid swine manure is minimal, especially in the case of highly buffered soils, although aluminum contents can be reduced, especially by the increase of organic compounds of low molecular weight.

When applied at high, repeated doses, organic wastes in general can increase soil pH over time. However, this effect is usually temporary and of small magnitude, compared to limestone [18]. However, the pH in the 0 to 0.10 m layer of this study is corroborated by Scherer et al. [17] who did not observe effects on the components of soil acidity, cation saturation, exchange capacity of cations with the addition of swine residue in soil.

The calcium content decreased as the soil depth increased, but in the first two layers of (0.0 to 0.10 and 0.10 to 0.20 m) a real increase of this nutrient of 3.98 was observed 4.53 cmol_c dm⁻³ provided by the dose of 240 m³ ha⁻¹, when compared to the control. However, this higher dose promoted a change in the Mg content in the first two layers of soil from 3.66 to 4.33 cmol_c dm⁻³ (Table 3). In the soil, calcium is the strongly adsorbed element of NH₄⁺, K⁺ and Mg⁺², so it is not lost by leaching. Couto et al. [19] evaluated soils of six properties under pasture fertilised with swine liquid manure, and observed that the calcium content was between 2.3 and 5.0 cmol_c dm⁻³ and for Mg 1.1 and 2.2 cmol_c dm⁻³. Calcium concentrations relatively close to those of this study were verified by Lourenzi et al. [20], after 19 applications of DLS for 100 months, the authors observed in the highest dose (80 m³ ha⁻¹) accumulation of exchangeable calcium and magnesium contents in the 0 to 0.02 m layer of 4.3 and 2.06 cmol_c dm⁻³ in the 0.18 to 0.20 m layer, these authors attribute the accumulations of calcium and magnesium contained in the 19 applications of the residue. Cassol et al. [14] when studying a oxisol fertilised for six years with swine manure, observed that the DLS altered the exchangeable calcium and magnesium content of the soil in the layers from 0 to 0.2 and 0.4 a (200 m³ ha⁻¹), but from the soil layer of 0.19 to 0.21 m the small changes occurred in the contents of these elements in part were attributed to the levels of the nutrient in soil And not from the application of DLS.

Table 4. pH and nutrient contents in the layers 0 to 0.10; 0.10 to 0.20 and 0.20 to 0.40 m of an oxisol of the Cerrado fertilised with different volumes of swine net waste from February 2014 to January 2015

Doses (m ³ ha ⁻¹)	pH CaCl ₂	pH H ₂ O ^{ns}	N* (%)	P -----mg dm ⁻³ -----	K -----cmol _c dm ⁻³ -----	Ca+Mg -----cmol _c dm ⁻³ -----	Cu -----mg dm ⁻³ -----	Zn -----mg dm ⁻³ -----	Fe* -----mg dm ⁻³ -----	Mn -----mg dm ⁻³ -----	organic matter (g kg ⁻¹)	Na mg dm ⁻³	CTC cmol _c dm ⁻³
-----0 a 0.10 m-----													
0.0	4.93	5.63	0.04	19.32	127.99	3.98	0.03	0.28	3.88	0.31	49.0	2.54	4.64
80.0	4.84	5.54	0.04	18.10	136.58	3.73	0.04	0.43	4.74	0.73	50.6	4.82	4.50
160.0	5.43	6.13	0.04	21.78	148.79	3.88	0.06	0.23	5.12	0.32	78.6	2.79	4.54
240.0	4.92	5.62	0.05	17.47	157.84	4.53	0.03	0.33	4.30	0.46	71.9	3.04	5.29
-----0.10 a 0.20 m-----													
0	4.85	5.55	0.018 b	15.94	79.14	3.68	0.03	0.30	4.68	0.39	56.8	2.71	4.22
80	4.53	5.13	0.039 a	20.09	98.14	3.40	0.03	0.38	3.89	0.40	48.8	3.80	4.14
160	4.46	5.16	0.024 ab	20.65	99.50	3.58	0.06	0.32	5.05	0.45	60.2	2.03	4.05
240	4.79	5.49	0.026 ab	14.51	108.09	4.33	0.04	0.30	5.09	0.52	60.1	3.04	5.02
-----0.20 a 0.40 m-----													
0	4.59	5.29	0.016	5.07	53.99	2.53	0.05	0.25	4.45 b	0.28	54.5	3.80	3.10
80	4.57	5.27	0.017	5.47	68.43	3.33	0.03	0.32	4.39 b	0.44	47.0	5.07	3.96
160	4.36	5.06	0.025	5.83	66.99	2.55	0.04	0.31	5.10 b	1.98	50.0	3.04	3.04
240	4.56	5.26	0.024	7.82	47.53	2.40	0.05	0.28	5.53 a	0.52	56.9	3.80	2.94

The averages followed by the same column letter do not differ statistically from each other. The Tukey test was applied at a 5% probability level. * * P < 0.05.
 pH CaCl₂: pH in calcium chloride; pH H₂O: pH in water. N: nitrogen; P: phosphor; K: potassium; Ca: calcium + Mg: magnesium; Cu: copper; Zn: zinc; Fe: Iron; MN: manganese; MO: organic matter; Na: sodium; CTC: exchange capacity of cations

Potassium had the same behavior as calcium and magnesium, that is, their contents decreased along the profile for all doses. The levels of K in the layers (0.10 to 0.20 and 0.20 to 0.40 m) were 96.21 and 60.49 mg dm⁻³, respectively. Considering only the highest dose (Table 3) the content of this element of 157.44 (first layer) to 108.09 (intermediate layer) and from this to 47.54 mg dm⁻³ (last layer), (Table 2), Evidencing its low mobility in the soil, mainly in clayey soils. It is observed that the increase in K contents with the doses agrees with Scherer et al. [21] who also observed an accumulation of this element at the soil surface by the addition of DLS.

In Cerrado soils concentration >80 mg dm⁻³ potassium and a CTCpH7 ≥4 cmol_c dm⁻³, are considered high, and values in the range of 51 to 80 mg dm⁻³, adequate [13]. In very clay soils, K is retained in the soil by means of CTC, [22]. In this study, although the soil was highly clayey and with CTC low to adequate (2.94 and 5.29 cmol_c dm⁻³) according to the classification of Ribeiro et al. [23]. The same trend of Ca, Mg and K had the P, with higher content in the superficial layer and decrease in its contents with depth. The presence of P in the surface layer does not ignite an alert signal, since the soil is protected with organic matter, although Brazilian legislation does not recognise phosphorus as a soil contaminant [24].

However, according to Basso [25] there is great concern regarding fertilisation with swine residue manure and a consequent increase in the concentrations of this element due to the several negative impacts on the environment, especially with regard to water quality. However, the excess of phosphorus on the surface alerts to its transfer via surface runoff which represents a risk to water quality [26]. In the soil layer 0.20 to 0.40 m the P content was low (6.05 mg dm⁻³) in comparison to the two upper layers, however, this occurrence is also justified by its dynamics, since it is not very mobile, being firmly retained in the solid phase of the soil [27]. The P content available in the soil after the eight DLS applications, in the 0.10 to 0.20 m layers falls within the high availability class (> 12mg dm⁻³) considering the clay content between 60 and 100% [13].

Ceretta et al. [28] observed that the fractions of P (inorganic + residual) decreased with increasing soil depth, regardless of the dose of liquid swine manure (DLS) used. The levels of P unchanged in the soil profile of this study are corroborated by

Silva et al. [29] when studying swine manure addition in dystrophic oxisol of the Cerrado at doses up to 180 m³ ha⁻¹, these authors verified phosphorus levels after 60 days of fertilisation with the residue, of 1.30 and 1.26 g kg⁻¹ in the layers From 0 to 0.20 and 0.20 to 0.40 m, respectively, and in the study of these authors, this nutrient also did not vary along the soil profile in the treatments that received swine waste application.

In the studied soil layers (0 to 0.10; 0.10 to 0.20 and 0.20 to 0.40 m) the levels of P are below the environmental critical limit of 100 mg dm⁻³ according to Sousa and Lobato [30]. Micronutrient contents in the soil layers were not significant, except in the 0.20 to 0.40 m layer in which the Fe content was 5.53 mg dm⁻³ provided by the dose of 240 m³ ha⁻¹. Based on the values referenced by Ribeiro et al. [23], the Fe levels in all soil layers in this study are considered to be very low (<8 mg dm⁻³). In the 0 to 0.10 m layer, the Cu and Zn contents were respectively 0.04; 0.31 mg dm⁻³, however, these contents remained practically unchanged when compared to the contents of these micronutrients in the 0.10 to 0.20 m layer which are 0.04 and 0.32 mg dm⁻³.

In the layer of 0.20 to 0.40 m the contents were 0.04 and 0.30 mg dm⁻³ for Cu and Zn respectively (corresponding to 0.08 kg Cu ha⁻¹, 0.62 kg Zn ha⁻¹). The Cu and Zn contents in the three soil layers were interpreted as very low <0.3 and <0.4 mg dm⁻³, respectively. In a study of the available levels of Cu and Zn in soils with swine manure, Hadlich and Ucha [31] found similar levels of 0.18 and 2.4 kg ha⁻¹ for these micronutrients in the superficial layer. Larger magnitudes were found by Giroto et al. [32], when they observed significant accumulations of these micronutrients in the soil surface layer, of 64.0 kg Cu ha⁻¹ and 79.6 kg of Zn ha⁻¹, in the highest dose of manure (80 m³ ha⁻¹), however. These authors explain that this increase occurred as a function of the application time, for seven years, and amounts of Cu and Zn present in the waste.

The dynamics of soil micronutrients are complex [33], because the dynamic balance of these elements in the soil solution is linked to the organic matter content, plant absorption, crystalline and precipitated minerals, exchange and adsorption. In the environmental aspect according to resolution National council of the environment Conama 420/2009 [1], the prevention values for Cu and Zn are 60 and 300

Table 5. Dry shoot mass of Tifton 85 grass (kg ha⁻¹) in the last 4 applications of liquid swine

Treatments m ³ ha ⁻¹	Applications de DLS (fractional doses)			
	1	2	3	4
0	1435.33	1356.10	1773.43	1185.63
30	1292.27	1342.73	1782.70	1050.60
60	1349.10	1311.73	1649.03	1487.37
90	1244.90	1291.83	1616.73	1759.83

Data not analysed.

mg kg of soil, respectively, in the same aspect, it can be considered that The levels of nutrients in the soil fertilised with DLS by eight consecutive applications in the oxisol of the Cerrado according to Conama [1], are not within the framework of concern regarding the contaminant aspects by Cu and Zn elements, however these results Are not indicative that the quality and concentration of certain elements in the form of nitrate, sulfate, zinc and copper have not leached to water resources by compromising environmental quality.

For the highest N content found in the soil, only the highest DLS volume applied (240 m³ ha⁻¹) was 1,000 kg ha⁻¹, in the 0 to 0.10 m layer (Table 3). The P content following this same reasoning is 34.94 kg ha⁻¹ and K 315.68 kg ha⁻¹. The application of DLS increased soil organic matter content (OM) with the respective doses, mainly in the superficial layer, with decreasing as it deepens in the profile. Lourenzi et al. [34] associate the accumulation of organic matter in the soil fertilised with DLS to the addition of large amount of dry matter that contributes to a greater contribution of surface organic residue. The observations of Homem et al. [35] reinforce the organic matter data obtained in this work, according to the author, the decrease in organic matter in the profile is attributed to the increase of the soil microbial population and, consequently, greater decomposition of organic matter from the priming effect.

The nutrient contents found in the soil after the successive applications of DLS considering each volume of the manure throughout the soil profile followed the order: K> P> N> Ca + Mg> Fe> Mn> Zn> Cu. The eight DLS applications in the 0 to 0.10 m layer did not promote changes in NT contents (0.04 g dm⁻³); P (19.16 mg kg⁻¹); Cu (0.04 mg dm⁻³); Zn (0.31 mg dm⁻³); (4.51mg dm⁻³), Mn (0.45 mg dm⁻³), in the values of the bases, CTC and soil organic matter (Tables 4). The eight DLS applications do not alter the nutrient content distributed in the oxisol of the Cerrado

layers, except for N, in the 0.10 to 0.20 m layer. In the oxisol of the Cerrado very clayey texture the distribution of the nutrients along the profile occurs in order K> P> N> Ca + Mg> Fe> Mn> Zn> Cu.

In relation to the test plant there was no significant effect on Tifton 85 biomass production as a function of DLS fertilisation by four consecutive DLS applications (Table 5).

In general, it can be inferred that by the mass data of the aerial part of the test plant, the nutrient stock in the oxisol under DLS applications for four consecutive applications in the soil profile, in the treatment with the highest volume of liquid waste (90 m³ ha⁻¹) was observed linear growth of the biomass, evidencing the biofertiliser besides being stored in the soil contributed to the growth of Tifton 85 grass.

4. CONCLUSION

In general, the nutrient content in the profile of the oxisol of the Cerrado was not affected by the successive DLS applications in the three soil layers, so that there is an immediate concern of the contents being above the critical environmental limit established by Conama [1]. However, it is necessary to evaluate the distribution of these elements in depth and in the systems water and atmosphere with respect to time.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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