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PERFORMANCE OF TIFTON 85 GRASS UNDER FERTIRRIGATION WITH SLAUGHTERHOUSE WASTEWATER

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ABSTRACT: The aim of this study was to evaluate the performance of Tifton 85 grass cultivated in soil columns and fertilized with different wastewater doses of swine slaughterhouse. The experiment was conducted in the Environmental Engineering Center and Sanitary of UFLA/MG in PVC columns filled with Dark Red Latosol (Oxisol) and randomly distributed. The treatments applied with nitrogen based load (300 kg ha de N years^{-1}) consisted of four doses of SW and A_QT_0 control at random. Three cuts were performed, at 60, 90 and 120 days after planting. The highest yields were 10.06, 16.82 and 20.39 t ha^{-1} in A_QT_0, A_AT_4 and A_AT_3 treatments, respectively. With the increase of nutrients by N rates and root development of Tifton 85 grass, we observed higher extractions of N, P and K in the second and third cut, with maximum extraction of 384 and 10.3 kg ha^{-1} of N and P in the higher dose treatments (A_AT_4), while the maximum extraction of the potassium was 117.7 kg ha^{-1} in the A_AT_3 treatment. There was productivity restriction in the third cut due to the reduction of availability of essential nutrients and losses by leaching.

KEYWORDS: productivity, forage, nutrients, disposal, agroindustrial wastewaters.

INTRODUCTION

Due to the scarcity of water resources and the growing demand for good quality water, several studies have been conducted over the years in order to search for viable alternatives to irrigation using lower quality water. Thus, Silva et al. (2011) argue that the reuse of wastewater for irrigation purposes contributes to the controlling of environmental pollution, saving water and fertilizers, recycling nutrients and increasing agricultural production.

High nutritional content and organic matter, coming from production process, characterize the wastewater from slaughterhouse; therefore, prior treatment is necessary before its final destination (Mees et al., 2009; Tocchi et al., 2013). According to Cabral et al. (2011), the disposal of wastewater in the soil, as an alternative of final destination, in addition to water source, promotes the nutritional increment for the development of cultivars, reducing production costs.

The fertirrigation with wastewater offers socioeconomic and environmental benefits, mainly the reduction of effluent release in the bodies of water and the recovery of nutrients (Rodríguez-Liébana et al., 2014), allowing to reduce the use of chemical fertilizers (Gil & Ulloa, 1997). However, depending on the origin and quality of the effluent, there are risks of soil and crops contamination by pathogens (Palese et al., 2009), as well as promoting salt accumulation, pH alteration and a decrease in soil infiltration rate (Bedbabis et al., 2014). On the other hand, in comparison to surface waters and/or groundwater, the use of wastewater in irrigation increases biomass production and improves crop productivity (Jang et al., 2012; Mojid et al., 2012). Therefore, finding a balance between the uses of these waters in conjunction with mineral fertilization is of great necessity, reducing fertilizer costs, in addition to providing a noble destination for these waters, increasing production, reducing fertilizer costs and increasing profitability of the producer.

Among the tropical pastures, Tifton 85 grass belonging to the *Cynodon* genus has been widely used in animal feed due to its higher production, nutritional content and good resistance to

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seasonality in relation to other genera, with a lower basal temperature of 12 ºC (Corrêa & Santos, 2006).

Some studies point to significant productivities of fertirrigated grasses with wastewater, such as Prior et al. (2015) studying the association of swine wastewater and mineral fertilization in maize crop; and Fia et al. (2010) evaluating forage performance in flooded water treatment systems for coffee processing.

The aim of this study was to evaluate the performance of Tifton 85 grass cultivated in soil columns and fertirrigated with different doses of wastewater from swine slaughterhouse.

MATERIAL AND METHODS

The experiment was carried out at the Federal University of Lavras, Lavras, Minas Gerais, latitude 21°13’45”S, longitude 44°58’31”W, average altitude of 918 m and Cwa climate, (mesothermal or tropical altitude), with dry winter and rainy summer, according to the Köppen classification (Sá Junior et al., 2012).

The soil used in the experiment was classified as Dark Red Latosol (EMBRAPA, 2013). The chemical and physical characteristics of the soil are presented in Table 1, before the application of the treatments.

TABLE 1. Physical and chemical characterization of the soil used in filling columns.

pH	N	P_{Dis}	K	Na	Ca+Mg	Al	H+Al	TB	CEC	OM
	--g kg^{-1}--	--mg kg^{-1}--	---g kg^{-1}---		--------------cmol dm^{-3}-----------					--g kg^{-1}--
5.60	0.2	3.21	0.02	-	0.92	0	2.32	0.98	3.3	16.4

Soil	Clay	Silt	Sand	Sand (Thick)	Sand (Thin)
	-------------------------dag kg^{-1}--------------------------				
Dark Red Latosol	60	24	-	8	8

The experimental system consisted of 15 soil columns constructed of PVC with a diameter of 0.30 m (area of 0.07 m^2) and 1.20 m of height. The columns were filled from the base with 0.05 m of nº zero gravel, 0.05 m of thick washed sand and 1.05 m of Dark Red Latosol. The soil columns were cultivated with Tifton 85 grass (*Cynodon* spp.) as shown in Figure 1. Soil liming was carried out to fill the 0.30 m surface of all 15 columns with the use of calcium carbonate PA ($CaCO_3$).

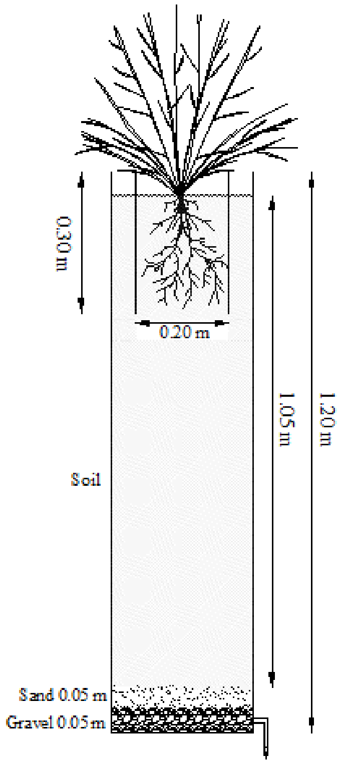

FIGURE 1. Schematic configuration of the soil column profile used in the experiment.

The different treatments included the application of the Swine Slaughterhouse Wastewater (SW) from an agro-industry of Lavras-MG, in four different loads, and another with conventional chemical fertilization (A_QT_0) characterized as standard treatment. The applications of the treatments occurred monthly, between August and December 2015, following the recommendation of 300 kg ha^{-1} $year^{-1}$ of nitrogen proposed by the Soil Fertility Commission of the State of Minas Gerais (Ribeiro et al., 1999) for pasture. Adopting the A_QT_0 standard as the recommended dosage of N, N dosages were tested via wastewater at the following dosages: 100, 200, 300 and 400% of the recommendation.

The SW characterizations were performed monthly in the Laboratory of Analysis of Wastewater of the Nucleus of Environmental and Sanitary Engineering of the Engineering Department of UFLA, following the methodology proposed by APHA; AWWA and WEF (2012). The results are shown in Table 2.

TABLE 2. Characterization of slaughterhouse wastewater (SW) applied during the experimental period.

Variables	SW			
	Avg + SD	Min	Max	CV (%)
pH	7,7 ± 0,3	7,7	0,30	3,4
CE (dS m^{-1})	1,2 ± 0,11	0,4	1,6	8,7
COD (mg L^{-1})	5.813 ± 3007	2.700	10.731	51,7
BOD (mg L^{-1})	2.360 ± 1139	1.245	3.766	48,3
P (mg L^{-1})	11,9± 9,61	1,2	22,08	80,7
N (mg L^{-1})	157,5 ± 27,00	115	188	17,2
O&G (mg L^{-1})	2.403 ± 1896	386	4.765	78,9
Ca (mg L^{-1})	65,0 ± 38,1	24,1	103,4	58,7
Mg (mg L^{-1})	89,0 ± 52,22	16,7	33	141
Na (mg L^{-1})	21,5 ± 3,60	16,7	25,7	16,7
K (mg L^{-1})	12,6 ± 5,00	8,1	19,8	39,7
SAR (mmol L)$^{-0,5}$	1,3 ± 0,4	1,0	1,8	28,5

pH - hydrogen potential; EC – electric conductivity; COD – chemical oxygen demand; BOD – biochemical oxygen demand; P – total phosphorus; TN – total kjeldahl nitrogen; O&G – oil and grease; Ca – calcium; Mg – magnesium; Na – sodium; K - potassium; SAR - sodium adsorption ratio; Med – arithmetic average; SD - standard deviation; Min – minimum value; Max – maximum value; CV – coefficient of variation.

During the growth cycles of Tifton 85 grass, some of the required water was supplied by SW application and another part came from irrigation management with water from the UFLA supply system. The climatic data, necessary for the estimation of the reference evapotranspiration (ETo) by the Penman-Monteith equation (Allen et al., 2006; Carvalho et al., 2011), were obtained at the Conventional Weather Station installed on the UFLA campus under monitoring of the National Institute of Meteorology. A kc of 0.8 proposed by Drumond et al. (2006) was adopted. The variations of temperature and relative humidity occurred during the experiment are shown in Figure 2. The water level applied to the soil columns was determined based on the water deficit obtained by the difference between ETc, precipitation and wastewater level applied (Figure 3).

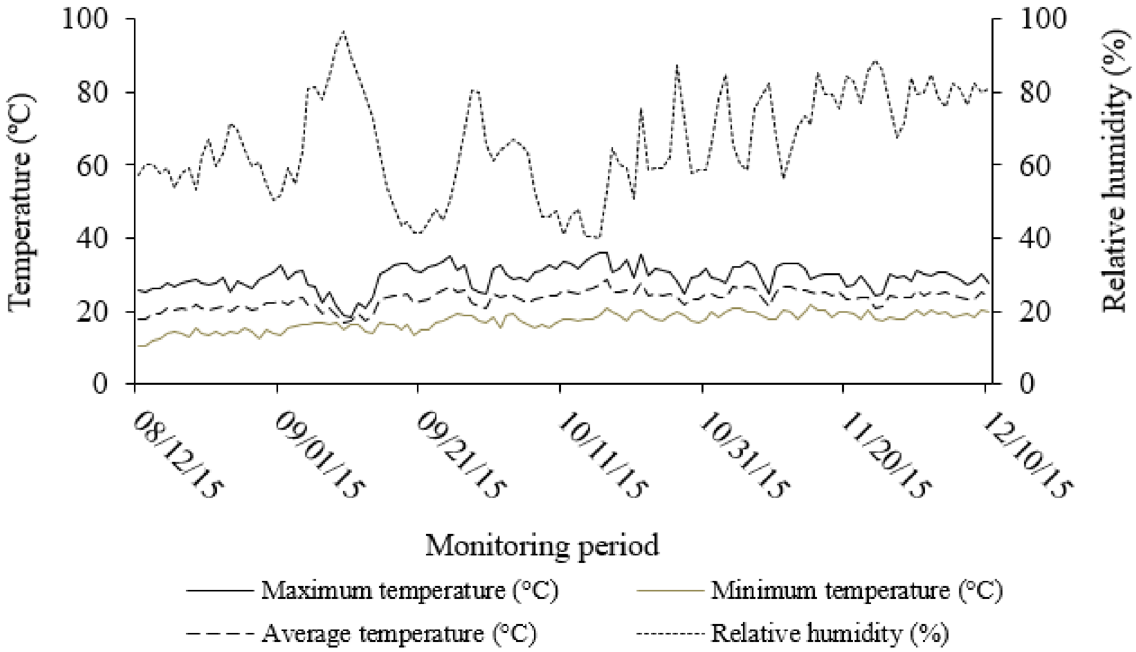

FIGURE 2. Temperature and humidity variation that occurred during the experiment.

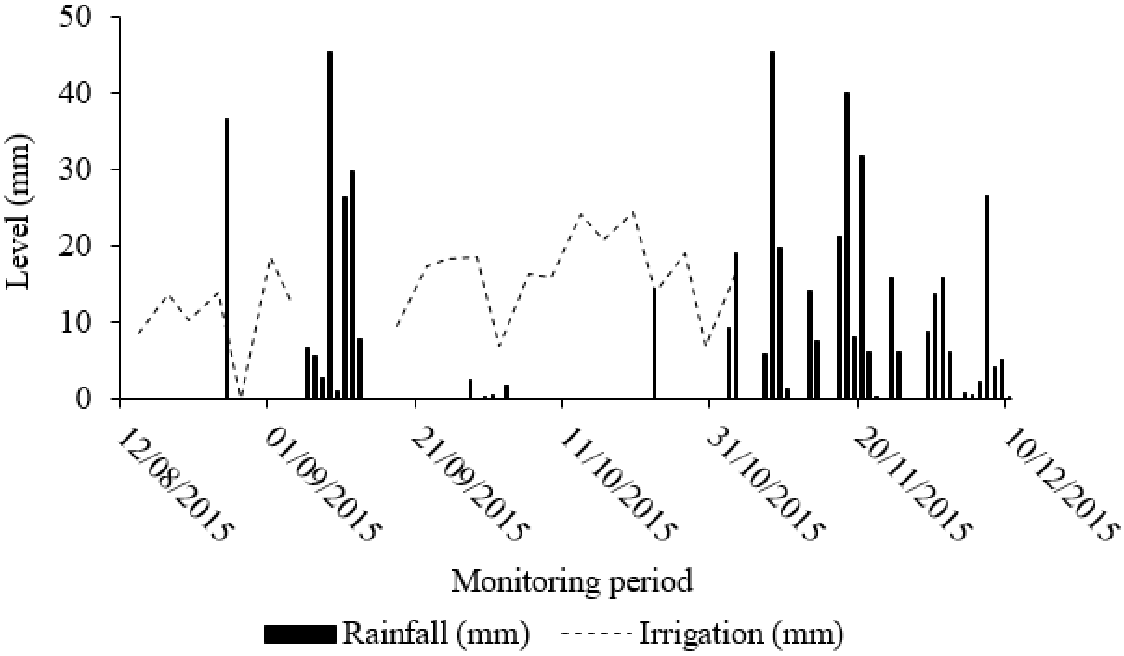

FIGURE 3. Distribution of rainfall and irrigation level that occurred during the experiment.

Three cuts of the Tifton 85 grass were made at 60, 90 and 120 days after transplanting to the soil columns. The cuts were carried out after each beginning of flowering at 5 cm of height.

After the collections, the Tifton 85 grass was sent to a greenhouse with forced air circulation at 65 °C for 72 h, followed by grinding in a Wiley type mill to quantify the dry matter yield and analyses of nutrient content of nitrogen, phosphorus, potassium, calcium, magnesium and sodium, according to Silva (2009) methodology.

The experiment was set up in a completely randomized design (CRD) with three replicates. Soil data were submitted to analysis of variance using the F-Test at 0.05. In the statistical analysis, the computer program Sisvar 5.1 was used (Ferreira, 2011).

RESULTS AND DISCUSSION

Tifton 85 Grass Productivity

The dry matter yields of Tifton 85 grass are shown in Table 3. The control treatment A_QT_0, at the dosage of 30 kg ha^{-1} of N, 110 kg ha^{-1} of P_T and 40 kg ha^{-1} of K, provided a dry matter yield of 10.06 t ha^{-1}, being 277% higher than the yield of 3.62 t ha^{-1} obtained in the A_AT_1 treatment. This result may be related to the greater easiness of NPK assimilation by Tifton 85 grass in its initial stage. In the second cut, there was no statistical difference between the data, although maximum yields of 20.39 (A_AT_3) were observed, however after 116 days of monitoring, the highest SW dosage increased the yield of 19.26 06 t ha^{-1} (A_AT_4).

According to Fontaneli et al. (2012), the dry matter yield of Tifton 85 grass can range from 8 to 20 t ha^{-1} year^{-1}, depending on the level of fertility that is submitted. Matos et al. (2010) evaluated plant extractive capacity in constructed flooded systems and found an increase in dry matter productivity of Tifton 85 grass of 14.9 t ha^{-1} after receiving rates of 570 kg ha^{-1} d^{-1} of BOD from dairy wastewater.

The SW dosages applied, based on the nitrogen recommendation (Ribeiro et al., 1999), provided high concentrations of soluble salts in the soil solution, such as sodium, and the lower availability of essential nutrients such as phosphorus interfered in the productivities of the three cuts.

TABLE 3. Average productivity estimate, by cutting the Tifton 85 grass subjected to treatment with SW and A_QT_0.

Treatments	Average Productivity (t ha^{-1})				
	1st cut	2nd cut	3rd cut	Average ± SD	CV (%)
A_QT_0	10.06a	7.30b	5.56c	7.64±2.27	29.68
A_AT_1	3.62b	13.56ab	7.03bc	8.07±5.05	62.53
A_AT_2	1.61b	11.69ab	14.32ab	9.38±6.90	73.58
A_AT_3	2.29b	14.04ab	20.39a	12.24±9.18	75.01
A_AT_4	3.59b	16.82a	19.26a	13.22±8.43	63.77

*Averages followed by the same letter in the columns do not differ from each other by Tukey test at 5% probability.

Extraction of nutrients by Tifton 85 grass

Tables 4, 5 and 6 show the average values of nitrogen, total phosphorus, potassium, sodium, calcium and magnesium extraction, based on the productivity and concentration of the dry matter of Tifton 85 grass in the three cuts.

The extraction of macronutrients and sodium by Tifton 85 grass was influenced by the interaction between the different dosages of SW and the cuts. After the first cut, 60 days after planting, a statistical difference was observed between SW dosages and conventional chemical fertilization (A_QT_0), as seen in Table 4.The maximum extractions were obtained with the conventional chemical fertilization treatment (A_QT_0), being 169.16 kg ha^{-1} of TKN, 3.45 kg ha^{-1} of P_T, 17.65 kg ha^{-1} of K, 27, 79 kg ha^{-1} of Ca + Mg and 2.68 kg ha^{-1} of Na.

In a study with constructed wetland systems (CWs), Fia et al. (2011) concluded that Tifton 85 grass removed about 450 kg ha^{-1} of TKN and 100 kg ha^{-1} of P in two cuts after 120 days of cultivation. Fia et al. (2014) found that Tifton 85 grass was able to extract between 9.8 and 17.6 kg ha^{-1} d^{-1} of TKN and between 0.6 and 1.7 kg ha^{-1} d^{-1} of P_T, which represented 4.6 and 5.4% of the TKN and P_T, respectively, contributed to the system.

TABLE 4. Average removal of nitrogen (TKN), total phosphorus (P_T), potassium (K), sodium (Na) and calcium plus magnesium (Ca + Mg) by Tifton 85 in treatments with SW and A_QT_0 the first cut.

Treatments	1st cut				
	TKN	P_T	K	Na	Ca + Mg
	-------------------------------kg ha^{-1}---------------------------------				
A_QT_0	169.16a	3.45a	17.65a	2.68b	27.79b
A_AT_1	55.20b	0.24b	8.62b	0.60a	9.07a
A_AT_2	26.10b	0.30b	2.73b	0.37a	3.45a
A_AT_3	40.61b	0.26b	4.51b	0.40a	4.40a
A_AT_4	62.42b	0.55b	11.12ab	0.79a	7.35a
Average	70.69	0.96	8.93	0.97	10.41
CV (%)	37.27	90.03	35.84	34.43	35.05

Averages followed by the same letter in the columns do not differ from each other by Tukey test at 5% probability.

The effect of the treatment with higher dose of SW (A_AT_4) provided in the second cut better performance of Tifton 85 grass in nutrient extraction, showing significant differences in relation to the effects of A_QT_0 treatment and maximum removals of 383.64 kg ha^{-1} of TKN and 10.35 kg ha^{-1} of total phosphorus (Table 5).

Serafim & Galbiatti (2012) when evaluated the production and chemical composition of *Brachiaria brizantha* cv Marandu fertilized with wastewater from pig farming, observed that the doses of 300 and 600 m^3 ha^{-1} showed higher values of dry matter mass production. According to Abou-Elela et al. (2010), the capacity of sodium extraction by Tifton 85 grass can be considered high, since this chemical element is difficult to remove in wastewater treatment systems.

TABLE 5. Average removal of nitrogen (TKN), total phosphorus (P_T), potassium (K), sodium (Na) and calcium plus magnesium (Ca + Mg) by Tifton 85 in treatments with SW and A_QT_0 the second cut.

2nd cut					
Treatments	TKN	P_T	K	Na	Ca + Mg
	kg ha^{-1}				
A_QT_0	146.16b	2.49b	66.07a	2.73a	29.67a
A_AT_1	141.26b	5.78ab	51.50a	2.10a	24.97a
A_AT_2	250.19b	5.33ab	43.93a	2.20a	21.15a
A_AT_3	356.84a	10.05a	52.19a	4.67a	32.54a
A_AT_4	383.64a	10.35a	59.07a	1.62a	39.75a
Average	255.62	6.80	54.55	2.67	29.62
CV (%)	24.84	30.68	23.17	74.84	32.63

Averages followed by the same letter in the columns do not differ from each other by Tukey test at 5% probability.

At 120 days after sowing, the reduction of nutritional extraction of Tifton 85 grass (Table 6) was observed in the third cut, with the maximum extractions being 234 kg ha^{-1} of TKN (A_AT_4), 7.9 kg ha^{-1} of P_T (A_AT_3), 4.5 kg ha^{-1} of Na (A_AT_4) and 16.7 kg ha^{-1} of Ca + Mg (A_AT_4). These results represent a reduction in nutrient assimilation of 39% of TKN, 63% of P_T and 58% of Ca + Mg when compared to the higher extractions in the second cut, although still higher in more than 200% in relation to the columns received A_QT_0.

TABLE 6. Average removal of nitrogen (TKN), total phosphorus (P_T), potassium (K), sodium (Na) and calcium plus magnesium (Ca + Mg) by Tifton 85 in treatments with SW and A_QT_0 the third cut.

3rd cut					
Treatments	TKN	P_T	K	Na	Ca + Mg
	kg ha^{-1}				
A_QT_0	71.30b	1.60ab	29.20c	1.50c	6.90b
A_AT_1	69.50b	1.00b	41.30bc	1.60c	6.60b
A_AT_2	171.80a	2.16ab	50.30bc	2.50bc	12.70ab
A_AT_3	217.30a	7.91a	117.70a	4.10ab	14.90ab
A_AT_4	234.00a	3.84ab	83.50ab	4.50a	16.70a
Average	152.80	3.30	64.40	2.90	11.60
CV (%)	21.20	72.70	27.30	23.80	30.80

Averages followed by the same letter in the columns do not differ from each other by Tukey test at 5% probability.

The total extractions of the nitrogen (N), phosphorus (P) and potassium (K) macronutrients showed a quadratic behavior as a function of the nitrogen rates recommended for pasture (Ribeiro et al., 1999) applied by slaughterhouse wastewater (SW). Due to the adaptability of the Tifton 85 grass, the conditions of the soil columns, the extractions at 60 days after planting were 65.4 kg ha^{-1} of N, 0.6 kg ha^{-1} of P and 11.1 kg ha^{-1} of K (Figures 4A, 4B and 4C).

With the increase of nutrients by N rates and root development of Tifton 85 grass, higher extractions of N, P and K were observed in the second and third cuts, with maximum values of 384 and 10.3 kg ha^{-1} of N and P (A_AT_4), while the maximum potassium extraction was 117.7 kg ha^{-1} in the A_AT_3 treatment. According to Matos et al. (2009), the results of phosphorus and potassium extracted in this study are considered low, since the wastewater supply in the treatments was carried out based on the nitrogen nutritional need. Therefore, essential nutrients, such as phosphorus, may have been applied in doses lower than the necessary for the crop. Table 7 shows the equations of adjustment of the N, P and K extractions for each cut as a function of the doses.

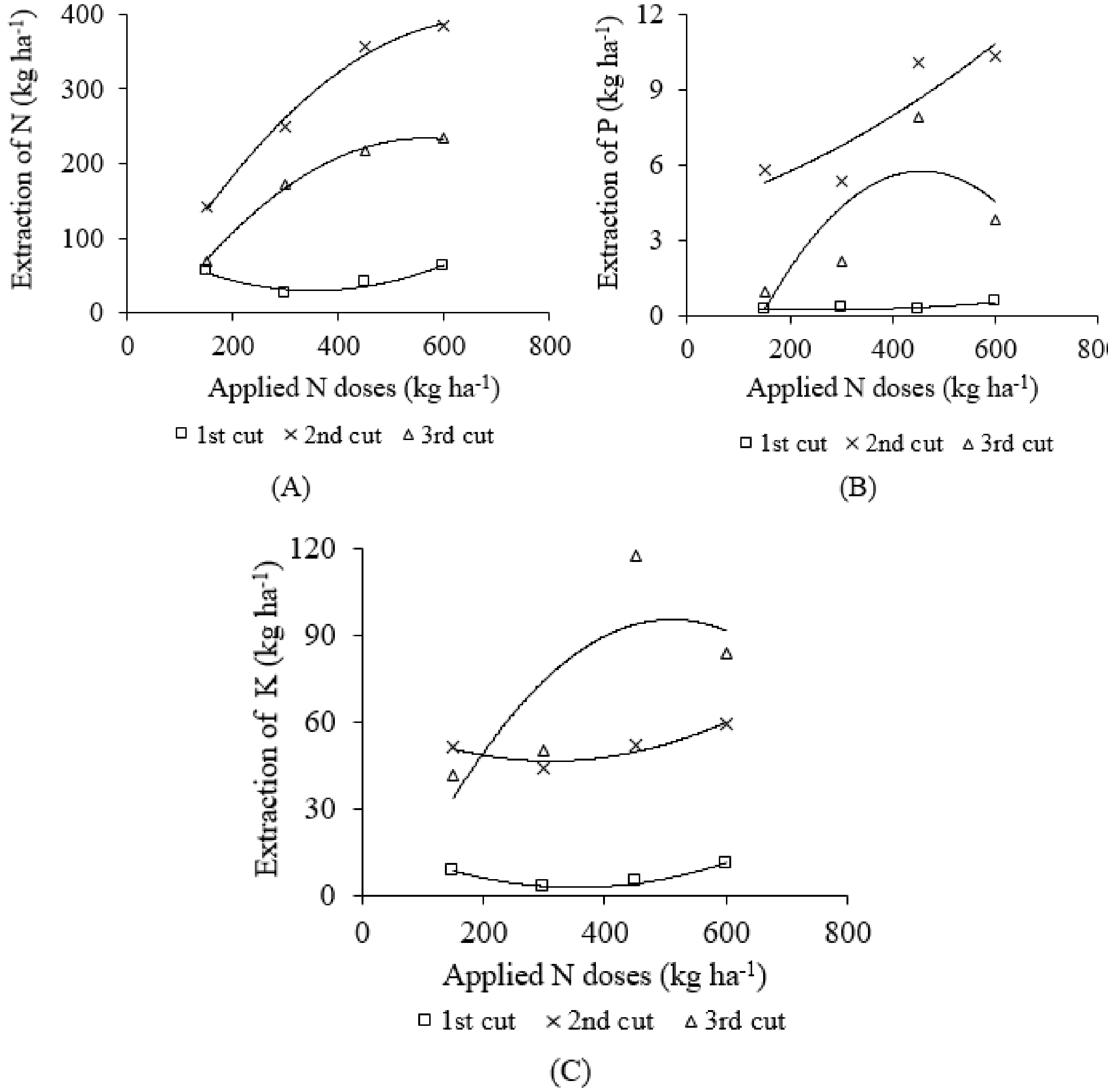

FIGURE 4. The total content of nitrogen (A), phosphorus (B) and potassium (C) in Tifton 85 grass taken from the three cycles of production in relation to the applied nitrogen doses by slaughterhouse wastewater (SW).

TABLE 7. Adjustment equations of total extraction of nitrogen (N), phosphorus (P) and potassium (K) according to the doses of nitrogen applied via slaughterhouse wastewater (SW) for the three cuts made.

Nutrient	Cuts	Extraction x Nitrogen Dosage Adjusted Equations	R^2
Nitrogen	1st	$\hat{y} = 0.0006xDose^2 - 0.4001xDose + 100.67$	0.92
	2nd	$\hat{y} = - 0.0009xDose^2 + 1.2402xDose – 28.12$	0.99
	3rd	$\hat{y} = - 0.001xDose^2 + 1.0724xDose – 68.58$	0.99
Phosphorus	1st	$\hat{y} = 3x10^{-6}xDose^2 - 0.0014xDose + 0.41$	0.85
	2nd	$\hat{y} = 8x10^{-6}xDose^2 + 0.006xDose + 4.215$	0.79
	3rd	$\hat{y} = - 6x10^{-5}xDose^2 + 0.0535xDose – 0.638$	0.63
Potassium	1st	$\hat{y} = 0.0001xDose^2 - 0.0979xDose + 20.05$	0.99
	2nd	$\hat{y} = 0.0002xDose^2 - 0.0998xDose + 62.00$	0.87
	3rd	$\hat{y} = - 0.0005xDose^2 + 0.4891xDose – 29.29$	0.65

CONCLUSIONS

The use of slaughterhouse wastewater in the Tifton 85 grass can be considered as an alternative source of fertilizers for production and nutritional supply for animals.

The dosages of slaughterhouse wastewater provided higher increases in the productivity of the second and third cuts of Tifton 85 grass, with an average over 8 t ha^{-1}.

The extractive capacity of Tifton 85 grass was intensified with the application of higher nutrient dosages, reaching 383.6, 10.35, 59.07, 1.62 and 39.75 kg ha^{-1} of N, P, K , Na and Ca + Mg, respectively.

There was a restriction of productivity in the third cut due to the reduction of the availability of essential nutrients and losses of nutrients by leaching.

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REFERENCES

Abou-Elela SI, Kamel MM, Fawzy ME (2010) Biological treatment of saline wastewater using a salt-tolerant microorganism. Desalination 250(1):1-5.

Allen RG, Pereira LS, Raes D, Smith M (2006) Evapotranspiration del cultivo: guias para la determinación de los requerimientos de agua de los cultivos. FAO, 298p. (Paper, 56).

APHA - American Public Health Association, AWWA - American Water Works Association, WEF - Water Environment Federation. (2012)Standard methods for the examination of water and wastewater. 22 ed. Washington, 1496p.

Bedbabis S, Rouina BB, Boukhris M, Ferrara G (2014) Effect of irrigation with treated wastewater on soil chemical properties and infiltration rate. Journal of Environmental Management 133:45-50. DOI: http://dx.doi.org/10.1016/j.jenvman.2013.11.007

Cabral JR, Freitas PSL, Rezende R, Muniz AS, Bertonha A (2011) Impacto da água residuária de suinocultura no solo e na produção de capim-elefante. Revista Brasileira de Engenharia Agrícola e Ambiental 15(8):823-831. DOI: http://dx.doi.org/10.1590/S1415-43662011000800009

Carvalho LG, Rios GFA, Miranda WL, Neto PC (2011) Evapotranspiração de referência: uma abordagem atual de diferentes métodos de estimativa. Pesquisa Agropecuária Tropical 41(3):456-465. Available: http://www.scielo.br/pdf/pat/v41n3/a20v41n3.pdf. Accessed: Aug 1, 2016.

Corrêa LA, Santos PM (2006) Irrigação de pastagens formadas por gramíneas forrageiras tropicais. São Carlos, Embrapa Pecuária Sudeste, 6p. (Comunicado Técnico, 48).

Drumond LCD, Zanini JR, Aguiar APA, Rodrigues GP, Fernandes ALT (2006) Produção de matéria seca em pastagem de Tifton 85 irrigada, com diferentes doses de dejeto líquido de suíno. Engenharia Agrícola 26(2):426-433. DOI: http://dx.doi.org/10.1590/S0100-69162006000200010

EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária (2013) Sistema brasileiro de classificação de solos. 3 ed. Rio de Janeiro, Centro Nacional de Pesquisa de Solos. 353p.

Ferreira DF (2011) Sisvar: a computer statistical analysis system. Ciência e Agrotecnologia 35(6):1039-1042. DOI: http://dx.doi.org/10.1590/S1413-70542011000600001

Fia FRL, Matos AT, Fia R, Lambert TF, Matos MP (2011) Remoção de nutrientes por *Typha latifolia* e *Cynodon* spp. cultivadas em sistemas alagados construídos. Ambi-Agua 6(1):77-89. DOI: http://dx.doi.org/10.4136/ambi-agua.175

Fia R, Boas RBV, Campos AT, Fia FRL, Souza EG (2014) Removal of nitrogen, phosphorus, copper and zinc from swine breeding wastewater by bermudagrass and cattail in constructed wetland systems. Engenharia Agrícola 34(1):112-113. DOI: http://dx.doi.org/10.1590/S0100-69162014000100013

Fia R, Matos AT, Fia FRL, Matos MP, Lamber TF, Nascimento FS (2010) Desempenho de forrageiras em sistemas alagados de tratamento de águas residuárias do processamento do café. Revista Brasileira de Engenharia Agrícola e Ambiental 14(8):842-847. DOI: http://dx.doi.org/10.1590/S1415-43662010000800008

Fontaneli RS, Santos HP, Fontaneli RS (eds) (2012) Forrageiras para integração lavoura–pecuária–floresta na região sul-brasileira. Brasília, Embrapa.

Gil I, Ulloa JJ (1997) Positive aspects of the use of water: the reuse of urban wastewater and its effect on areas of tourism. Mediterraneennes, 31:218-229. Available: http://agris.fao.org/aos/records/QC1997001469. Accessed: Aug 8, 2016.

Jang TI, Kim HK, Seong CH, Lee EJ, Park SW (2012) Assessing nutrient losses of reclaimed wastewater irrigation in paddy fields for sustainable agriculture. Agricultural Water Management 104:235-243. DOI: http://dx.doi.org/10.1016/j.agwat.2011.12.022

Matos AT, Abrahão SS, Lo Monacol PAV, Sarmento AP, Matos MP (2010) Capacidade extratora de plantas em sistemas alagados utilizados no tratamento de águas residuárias de laticínios. Revista Brasileira de Engenharia Agrícola e Ambiental 14:1311-1317. DOI: http://dx.doi.org/10.1590/S1415-43662010001200009

Matos AT, Freitas WS, Lo Monaco PAV (2009) Capacidade extratora de diferentes espécies vegetais cultivadas em sistemas alagados utilizados no tratamento de águas residuárias da suinocultura. Ambiente & Água 4(2):31-45. DOI: http://dx.doi.org/10.4136/ambi-agua.84

Mees JBR, Gomes SD, Vilas Boas MA, Fazolo A, Sampaio SC (2009) Removal of organic matter and nutrients from slaughterhouse wastewater by using Eichhornia crassipes and evaluation of the generated biomass composting. Engenharia Agrícola 29(3):466-473. DOI: http://dx.doi.org/10.1590/S0100-69162009000300013

Mojid MA, Biswas SK, Wyseure GCL (2012) Interaction effects of irrigation by municipal wastewater and inorganic fertilisers on wheat cultivation in Bangladesh. Field Crops Research 134:45-50. DOI: http://dx.doi.org/10.1016/j.fcr.2012.06.010

Palese AM, Pasquale V, Celano G, Figliuolo G, Masi S, Xiloyannis C (2009) Irrigation of olive groves in Southern Italy with treated municipal wastewa-ter: effects on microbiological quality of soil and fruits. Agriculture, Ecosystems & Environment 129:43-51. DOI: http://dx.doi.org/10.1016/j.agee.2008.07.003

Prior M, Sampaio SC, Nóbrega HP, Dieter J, Costa MSSdeM (2015) Estudo da associação de água residuária de suinocultura e adubação mineral na cultura do milho e no solo. Engenharia Agrícola 35(4):744-755. DOI: http://dx.doi.org/10.1590/1809-4430-Eng.Agric.v35n4p744-755/2015

Ribeiro AC, Guimarães PTG, Alvarez VH, (eds) (1999) Recomendações para o uso de corretivos e fertilizantes em Minas Gerais: 5. Aproximação. Viçosa, Comissão de Fertilidade do Solo do Estado de Minas Gerais. 359 p.

Rodríguez-Liébana JA, Elgouzia S, Mingorancea MD, Castilloa A, Peña A (2014) Irrigation of a Mediterranean soil under field conditions with urbanwastewater: effect on pesticide behaviour. Agriculture, Ecosystems & Environment 185:176-185. DOI: http://dx.doi.org/10.1016/j.agee.2013.12.026

Sá Junior A, Carvalho LG, Silva FF, Alves MC (2012) Application of the Köppen Classification for climatic zoning in the state of Minas Gerais, Brasil. Theoretical and Applied Climatology 108:1-7. DOI: http://dx.doi.org/10.1007/s00704-011-0507-8

Serafim RS, Galbiatti JA (2012) Efecto de la aplicación de la agua residual porcina en el pasto *Brachiaria brizantha* cv Marandu. Colombiana de Ciência Animal 4(1):185-203. Available: http://vufind.uniovi.es/Record/ir-ART0000486559/Details. Accessed: Aug 9, 2016.

Silva FC (ed) (2009) Manual de análises químicas de solos, plantas e fertilizantes. Brasília, Embrapa Comunicação para Transferência de Tecnologia. 627p.

Silva DF, Matos AT, Pereira OG, Cecon PR, Barista RO, Moreira DA (2011) Alteração química de solo cultivado com capim Tifton 85 (*Cynodon* spp.) e fertirrigado com percolado de resíduo sólido urbano. Acta Scientiarum Technology 33(3):243-251. DOI: http://dx.doi.org/10.4025/actascitechnol.v33i3.6124

Tocchi C, Federici E, Scargetta S, D’annibale A, Patruccioli M (2013) Dairy wastewater polluting load and treatment performances of an industrial three-cascade-reactor plant. Process Biochemistry 48:941–944. DOI: http://dx.doi.org/10.1016/j.procbio.2013.04.009