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SUPPLEMENTATION OF NUTRIENTS FOR TABLE BEETS BY IRRIGATION WITH TREATED DAIRY EFFLUENT

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ABSTRACT: This study was conducted to evaluate the nutritional status of table beet plants cultivated in a greenhouse irrigated with treated dairy effluent at different irrigation depths. The experimental design used was a randomized block in a 3 x 3 + 1 factorial arrangement with four replications and conducted in a greenhouse. The treatments consisted of three types of water sources and three irrigation depths applied by drip irrigation: anaerobic effluent; anaerobic/aerobic effluent; tap water, and irrigation for replenishment 50; 100 and 150% of the crop evapotranspiration (ETc). All these treatments were applied in combination with 50% of the recommended nitrogen fertilization for the table beet cultivation. A control treatment was irrigated with tap water with irrigation depth equal to 100% ETc and received the complete dose (100%) of mineral nitrogen fertilizer. Table beet seedlings were arranged in 40 fiberglass boxes with a base area of 1 m^2. Table beets were harvested 72 days after transplanting (DAT) when the leaves and roots were analyzed. Irrigation with wastewater promoted appropriate levels of macronutrients, distributed between the leaves and roots. The sodium was increased significantly in the leaves and roots of table beets in effluent treatments at increasing irrigation depths, which was antagonistic to the absorption of potassium.

KEYWORDS: water reuse, *Beta vulgaris*, anaerobic and aerobic system, drip, nutritional status.

INTRODUCTION

The increase in food consumption coupled with the stagnation of the area available for agricultural crops intensifies the use of more productive systems to optimize natural resource and land use.

The processing of animal and vegetable products from agroindustries, mainly food using fermentative processes, generates liquid residues rich in organic matter, nutrients, and salts, and even after treatment, they still present potential for pollution to the water bodies, mainly due to the presence of nitrogen and phosphorus (Karadag et al., 2015). It is important to note that most dairy plants are small and medium-sized with financial difficulties to keep specialized personnel and are thus unable to implement technological innovations that allow environmentally appropriate disposal of these waters (Saléh, et al., 2009). In cases where dairy plants do not remove whey from the effluent, they produce four times the volume of milk processed (Carvalho et al., 2013).

Irrigation with wastewater of organic origin is an alternative to replace quality water, allows the maintenance of soil moisture, acts as source of nutrients, and prevents the risk of contamination of water resources. Regarding the nutritional development of plants, the effluent presented agronomically desirable characteristics such as the presence of nitrogen (N), phosphorus (P), and potassium (K) macronutrients (Bame et al., 2014; Grundmann & Maab, 2017, Pereira et al., 2011; Singh et al., 2010; Bourazanis et al., 2016)

Regarding implications for agricultural reuse, several aspects have been widely evaluated and discussed. One of the relevant aspects, of a sanitary nature, is related to the recommended microbiological guidelines for the use of sewage in agriculture (Pedrero et al., 2012; US EPA,

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2012), where concerns are concentrated on the health of the farmer and consumers of agricultural products. Other environmental aspects refer to the possible accumulation of heavy metals and toxic elements in soils and plants, the contamination of groundwater by these substances and nitrate (Elgallal et al., 2016; Leal et al., 2009), increase in soil salinity and sodicity (Matsumoto et al., 2012; Ganjegunte et al., 2017; Assouline & Narkis, 2011; Muyen et al., 2011) changes in its physical properties (Abegunrin et al., 2016; Bonini et al., 2014; Levy et al., 2014), and unbalanced supply of nutrients to plants (Blum, 2011; Pereira et al., 2011).

Table beet consumption, as part of a healthy diet, is intensified in the summer, a time of low supply by producers due to high temperatures and precipitation. During the last ten years in Brazil, an increase in demand for consumption and processing of this fresh tuberous crop in the food industries has been observed. Currently, table beet is one of the 17 most important vegetables propagated in Brazil (Tivelli et al., 2011). According to AGRIANUAL (2016), the commercial volume of table beets for the Society of Warehouses and General Warehouses of São Paulo (CEAGESP) was 16,682.00 tons in 2016. The cultivation in a protected environment is an important alternative to guarantee both production in the off season and financial return. The guarantee of production when irrigated with water with a certain salt content, classified as moderately tolerant (Ayers & Westcot, 1999), makes table beet a favorable crop for cultivation with wastewater.

The objective of the present study was to evaluate the nutritional status of table beet plants irrigated with different water sources (treated dairy effluents) and irrigation depths in protected cultivation.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse (210 m^2) of arc type at the University of São Paulo Animal Science and Food Engineering campus located in the city of Pirassununga / SP, Brazil, latitude 21°59'S, longitude 47°26'W, and altitude of 634 m. The climate is subtropical, type CWa, with dry winters and hot and rainy summers, according to the Köppen classification (Oliveira & Prado, 1984). The minimum and maximum values for temperature and relative humidity inside the greenhouse during the experiment interval are shown in Figure 1.

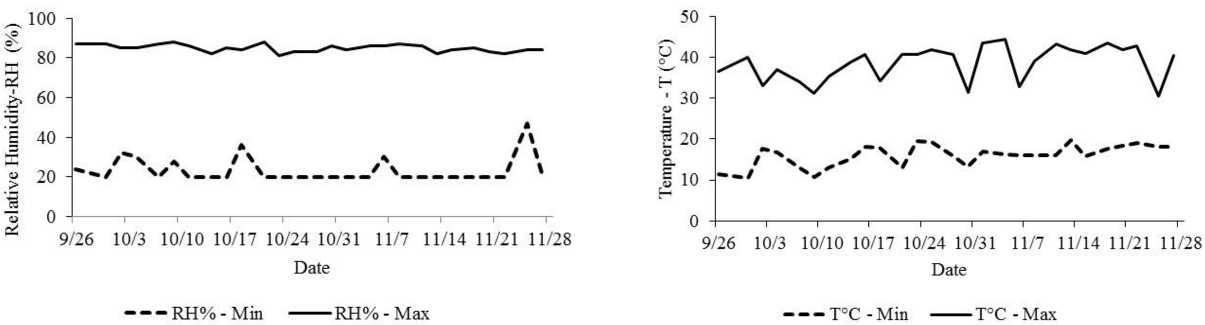

FIGURE 1. Minimum (Min) and maximum (Max) relative humidity (%) and temperature (°C) values between 9/26/2013 and 11/27/2013.

The experimental design used randomized blocks in a 3 x 3 + 1 factorial scheme with four replicates. The treatments were from three sources of water: (1) anaerobic effluent - ANE, treated by a sequential anaerobic batch reactor with a biofilm; (2) aerobic effluent - AE, fixed bed anaerobic / aerobic combined reactor; and (3) tap water - TW, treated by direct filtration followed by chlorination. Three irrigation depths, W1, W2, and W3, with 50%, 100%, and 150% replacement of crop evapotranspiration (ETc) estimation, respectively, were used. The treatments were applied in combination with 50% of the mineral nitrogen fertilization recommended for table beets, in addition to the control table beet with 100% of the need for mineral nitrogen fertilization and 100% of ETc-W2.

Table beet seedlings, ‘Cabernet’ hybrid, were transplanted on 09/16/2013 and arranged in fiberglass boxes with a base area of 1 m^2 and free depth of 40 cm, totaling 40 experimental plots. Each plot received 24 table beet seedlings in 4 rows spaced 0.2 m and 0.15 m between plants. Only the two central lines were considered for evaluation.

Regarding the applied waters, the effluents were filtered by geotextile fabric and disinfected by ultraviolet lamps. During the experiment, the effluent and TW samples were collected for analysis at the points before the irrigation system with biweekly frequency, totaling five samplings. Conditioning and sampling were performed according to the National Guide for Collection and Preservation of Water Samples (CETESB/ANA, 2011) and analyzed according to APHA, AWWA, WEF (2012). The parameters analyzed were: electrical conductivity (EC), pH, total Kjeldahl nitrogen (N-TKN), N-NH_4^+, N-NO_3^-, N-NO_2^-, P-PO_4^-, Na^+, Ca^{+2}, Mg^{+2}, K^+, alkalinity, and total volatile acids. The sodium adsorption ratio (SAR) was determined according the method by to Ayers & Westcot (1999) (Table 1). Before and after the reactors (ANE and AE), the chemical oxygen demand (COD) was determined. The raw and filtered COD at the entrance of the dairy effluent treatment plant prior to treatment was 1894.03 ± 633.48 mg L^{-1} and 1429.46 ± 583.60 mg L^{-1}, respectively, and they were reduced by 90.81% in the anaerobic system and 96.77% in the aerobic system after treatment.

TABLE 1. Mean and standard deviation of chemical parameters for treated dairy effluents and tap water.

Parameter	TW	AE	ANE
N-TKN (mg L^{-1})	ND	1.39±2.77	42.24±1.77
N-NH_4^+ (mg L^{-1})	ND	0.31±0.62	16.29±9.05
N-NO_3^- (mg L^{-1})	0.20±0.04	10.60±4.51	0.37±0.44
N-NO_2^- (mg L^{-1})	0.20±0.40	4.50±1.73	0.09±0.05
P-PO_4^- (mg L^{-1})	ND	0.80±0.16	1.30±0.23
Ca^{+2} (mg L^{-1})	3.27±0.97	42.84±22.34	45.43±14.24
Mg^{+2} (mg L^{-1})	1.68±1.02	51.44±35.79	52.79±53.09
Na^+ (mg L^{-1})	ND	50.25±13.05	69.80±18.43
K^+ (mg L^{-1})	0.50±0.14	112.50±79.23	56.77±70.36
Fe (mg L^{-1})	0.20±0.14	0.06±003	0.17±0.22
Mn (mg L^{-1})	0.002±0.000	0.006±0.006	0.014±0.008
SAR ($mmol_c$ $L^{-1})^{0.5}$	-	1.32±0.32	1.86±0.49
EC (dS m^{-1})	0.03±0.00	1.15±0.53	2.05±0.69
Ph	6.97±0.32	8.27±0.20	7.92±0.16
Alkalinity (mg L^{-1})	19.75±7.80	682.12±225.65	1.256.53±306.27
TVA (mg L^{-1})	10.22±1.45	25.61±5.29	66.82±42.82

TW=Tap water; AE=Aerobic effluent; ANE= Anaerobic effluent; TKN= Total Kjeldahl Nitrogen, SAR= Sodium Adsorption Ratio; EC= Electrical Conductivity; TVA= Total Volatile Acids; ND= Not Detected.

Irrigation was performed using a 2.4 L h^{-1} flow drip system, spaced at 0.20 m with one irrigation line for every two crop lines.

Irrigation management was based on the restoration of the crop evapotranspiration estimation (ETc) by the evaporation of the reduced class A tank, installed in the central part of the greenhouse. The culture coefficients (Kc) used was proposed by Marouelli et al. (2008) for the different stages of development. The reduced tank correction coefficient (Kp) proposed for the environment was 1, as recommended by Prados (1986) and cited by Farias et al. (1994). The irrigation frequency was every two days beginning on 09/25/2013 with the application of the different depths (W1 = 50%, W2 = 100%, and W3 = 150%). Soil moisture was monitored weekly in each experimental plot by the gravimetric method. The total irrigation depths applied to the three water types (ANE, AE, and TW) were TW - 187.25; 356.75; 573.5 mm for W1, W2, and W3, respectively; ANE - 148.00; 238.50; 354.75 mm for W1, W2, and W3, respectively; and AE = 162.00; 260.00; 362.25 mm for W1, W2, and W3, respectively.

The soil used to fill the experimental plots, being predominant in the region, was classified as Red Latosol, according to EMBRAPA (1999). A composite sample was taken and sent for analysis in the Laboratory of Agricultural Sciences/FZEA Soils/USP (Table 2).

TABLE 2. Soil analysis for experimental plots.

pH ($CaCl_2$)	P (res) (mg dm^{-3})	S	K (res) (mmolc dm^{-3})	Ca	Mg	H+Al	O.M. (g kg^{-1})	T.C.
6.0	6	31	1,7	30	10	20	22	12,9
Continued								
BS (mmolc . dm^{-3})	CEC	V (%)	B (mg .dm^{-3})	Cu	Fe	Mn	Zn	
42	62	67	0.18	1.5	7	5.1	1.6	
Continued								
Total Sand Texture (g dm^{-3})	Clay	Silt	Texture Classification					
640	341	19	Mean Clay					

BS=Base Sum; O.M.=Organic Material; T.C.=Total Carbon; CEC=Cation Exchange Capacity; V=Saturation per base.

The initial result of the soil analysis (Table 2) defined the fertilization doses for table beet cultivation, as suggested by Raij et al. (1996), with 360 kg ha^{-1} of P_2O_5, 180 kg ha^{-1} of K_2O, 2 kg ha^{-1} H_3BO_3, and 20 kg ha^{-1} of organic matter (commercial preparation provided by Vida Verde, state of São Paulo, Brazil). It was decided to perform differentiated fertilization by depth, concentrating the fertilization of macro and micronutrients in the top 0.2 m. In the total volume of the plot, 351 L, the proportion of two parts of soil was mixed for one part of fine sand, in addition to limestone with RTNP[1] = 71%, in order to raise V% to 72%. Three nitrogen fertilizations were carried out on days 07, 17, and 31 of October 2013 in the form of ammonium nitrate with 50% of the dose of 120 kg of nitrogen per hectare, as recommended by Raij et al. (1996) for table beets, in all treatments except for the control, which received 100% of the dose (120 kg of N ha^{-1}).

Harvesting occurred on the 11/27/2013, seventy-one days after planting the seedlings, for leaf and root samples to be washed at that time with water and hydrochloric acid solution at a dilution of 0.1% to remove impurities, and then, they were dried in an oven with forced circulation at 65°C. Subsequently, the samples were processed in a mill and sent for nutritional diagnosis analysis, in accordance with Malavolta et al. (1997), by the Laboratory of Agricultural Sciences/FZEA Soils/USP. After sampling, soil samples were taken in each experimental plot at depths of 0-10 cm and 10-20 cm, and the samples were submitted for chemical fertility analysis, according to the methodology described in Raij et al. (2001), to determine sodium for calculation of the percentage of exchangeable sodium in the soil (Laboratory of Agricultural Sciences/FZEA Soils/USP).

The data were submitted to analysis of variance. For the situations in which there were significant differences, the averages were compared by the Tukey test with a significance level of 5%. For the comparisons between the control and the treatments, the Dunnett test was applied with a significance level of 5%. The software used was SISVAR 5.3 (Ferreira, 2011).

RESULTS AND DISCUSSION

The production of table beet roots was influenced by the use of treated dairy effluents and the applied irrigation depths. The development of plants was favored when irrigated with ANE and AE. Irrigation with effluent treated with anaerobic system resulted in better yields in all irrigation depths compared to other treatments (AE and TW) (Gomes et al., 2015).

The results of soil chemical analysis after table beet cultivation are presented in Table 3. By statistical analysis, no difference was observed between the studied soil layers, 0-10 cm and 10-20 cm.

[1] RELATIVE TOTAL NEUTRALIZATION POWER

TABLE 3. Soil chemical analysis after table beet cultivation.

Water Source	pH $CaCl_2$	P	S	K	Ca	Mg	Na	H+Al
		---- mg dm^{-3} ----		------------------------ mmolc dm^{-3} ------------------------				
T	5.9 b	41.75 b	57.12 a	2.37 b	30.12 b	4.75 b	0.00 b	13.08 a
TW	6.0 b	41.50 b	44.87 a	2.71 b	31.75 b	4.92 b	0.15 b	11.92 ab
AE	6.4 a	54.79 a	63.33 a	3.40 a	37.62 a	9.25 a	3.54 a	9.55 bc
ANE	6.4 a	55.96 a	65.33 a	3.65 a	37.92 a	10.50 a	4.33 a	9.25 c
C.V. (%)	3.65	22.09	58.11	16.68	18.79	30.13	51.48	25.04

Continued

Water Source	MO	SB	CTC	V	PST	B	Cu	Fe	Mn	Zn
	g kg^{-1}	--- mmolc dm^{-3} ----		-- % --	%	--------------------- mg dm^{-3} --------------------				
T	14.42 a	37.25 b	50.37 b	70.96 b	0.00 a	1.51 a	0.71 b	10.00 a	1.91 a	0.37 a
TW	14.79 a	39.46 b	51.42 b	72.90 b	0.29 a	1.05 a	0.75 ab	10.25 ab	2.25 a	0.47 a
AE	14.09 a	54.07 a	63.70 a	82.35 a	5.56 b	1.24 a	0.81 a	9.42 ab	2.26 a	0.44 a
ANE	14.39 a	56.15 a	65.42 a	84.31 a	6.62 b	1.19 a	0.75 ab	9.17 b	1.86 a	0.50 a
C.V. (%)	7.67	18.19	13.94	8.85	57.16	74.69	13.82	10.98	27.15	43.59

T = control: 100% replacement of crop evapotranspiration (ETc) with tap water and 100% nitrogen fertilization recommended for the crop; TW = tap water, 50% of the nitrogen fertilization recommended for the crop; AE = dairy effluent treated by aerobic system, 50% of nitrogen fertilization recommended for the crop; ANE = dairy effluent treated by anaerobic system, 50% of nitrogen fertilization recommended for the crop. Means followed by different letters differed by the Tukey test ($p < 0.05$).

In the soil, there was no interaction between irrigation depths and water sources; however, the latter factor altered the chemical properties of the soil. Effluent treatments (AE and ANE) significantly increased pH, phosphorus, potassium, calcium, and magnesium values, which resulted in higher values of base sum, cation exchange capacity, and V%. The micronutrients were not altered by the applied treatments (Table 3). Several authors (Prazeres et al., 2014; Herpin et al. (2007); Gomes et al., 2009; Becerra-Castro et al., 2015; Azevedo & Oliveira, 2005; Pereira et al., 2011) that have been working with crops irrigated with treated effluents of organic origin, mainly domestic sewage, also obtained similar results for the presence of macronutrients in the soil and a decrease in soil acidity, satisfactory in tropical soils. The sodium values and the percentage of exchangeable sodium in the soil (Table 3) were also higher in treated dairy effluents. The values observed indicate soil sodification potential and are at the limit (6%) recommended by the environmental agency of the State of São Paulo, CETESB (2006), as a premise for the application of effluents in agriculture. Research on wastewater of animal origin showed an increase in the percentage of dispersed clay by high salt application (Condé et al., 2013; Erthal et al., 2010). Prazeres et al. (2014) evaluated the soil chemical properties in the production of tomatoes irrigated with pretreated and diluted effluent from the cheese industry at different levels of salinity and verified a linear increase in soil conductivity but also achieved increases in productivity.

Tables 4, 5, 6, and 7 present the macronutrient and micronutrient contents in the leaves and roots of table beet plants. There was an interaction between the treatments (water source and irrigation depths) only for N and P in the leaves and Na in the roots (Table 4 and 6). In the case of sodium, the values increased with greater irrigation depths in the treatments with effluent. Nitrogen leaf contents were inadequate in all treatments, as values were below those suggested by the literature (Trani et al., 1997), except for the AE treatment in W2 that was superior to the control. The form of nitrogen species may influence results of plant absorption. In the present study, the effluent treated by anaerobic system (ANE) presented values of 0.46 mg L^{-1} and 16.29 mg L^{-1} for the nitrate and ammoniacal forms, respectively, and for the anaerobic treatment followed by aerobic treatment (AE), the order of magnitude was inverse, being 15.10 mg L^{-1} and 0.31 mg L^{-1} for the nitrate and ammoniacal forms, respectively (Table 1). The high concentration of $N\text{-}NH4^{+}$ in the soil solution under certain conditions can be toxic to the plant, competing with the absorption of other cations while the plant needs to maintain the electroneutrality (Britto & Kronzucker, 2002; Burgarín et al., 1998). In the roots, however, the nitrogen content for anaerobic effluent was similar to the control. For the leaves, phosphorus content was reduced in the treatments with effluent when applied to the smallest irrigation depth, but the contents maintained normal in the root. Herpin et al. (2007), after three years of coffee cultivation with treated domestic sewage, found a reduction in the levels of phosphorus and nitrogen to deficient levels. Pereira et al. (2011) evaluated the impact of anaerobic treated effluent treatment on the soil-plant system in citrus plants under tropical conditions, and they found a reduction in P levels in the plant, associated with nutritional imbalance due to excess sodium and sulfur. For the other nutrients, all the appropriate values were reached, except for the micronutrient Zn (Table 3). The effects of the different water sources applied by irrigation were present for K and Ca in the leaf and N, P, K, Ca, and Mg in the root. Sodium was significantly increased throughout the plant in effluent treatments. Several authors performing research on crops that received irrigation with increasing doses of salts obtained linear reductions in production because of the absorption of the sodium (Oliveira et al., 2011; Nobre et al., 2013; Andrade et al., 2016). Potassium, both in the leaves and roots, had antagonistic behavior on sodium contents that were decreased in AE and ANE, which was also observed by Pereira et al. (2011) for citrus leaves. According to Epstein & Bloom (2005), the reduction in potassium content in plants irrigated with organic wastewater may be related to: (i) decreased availability of potassium in the soil due to higher leaching by addition of sodium, which partially replaced potassium in colloids from the soil; (ii) antagonistic effect of high levels of $N\text{-}NH4^{+}$ in the effluent; and (iii) high sodium concentration in the soil solution, which inhibits the passive absorption of potassium through the protein pathways. Calcium was significantly higher, both in the leaf and root for treatments irrigated with tap water supply. Magnesium was higher in the root for treated effluents. The micronutrients, in general for the plant, were not altered by the treatments with the exception of B and Mn in the leaf and Mn in the root, which were reduced in the treatments with dairy effluents.

Regarding the nutrients extracted by table beet plants, considering tons per hectare of roots and leaves, the quantities were in the range presented by Tivelli et al. (2011) (N=78 kg ha^{-1}, K=83 kg ha^{-1}, Ca=20 kg ha^{-1}, and Mg=27 kg ha^{-1}) for all treatments except P (18 kg ha^{-1}), which was only achieved in the greater irrigation depths with ANE.

TABLE 4. Irrigation depth and water source for nitrogen and phosphorus contents in table beet leaf.

Water Source	Irrigation Depth W1	W2	W3	Trani et al. (1997)
	Nitrogen (g kg^{-1})			
TW	23.05Aa	21.72Ab	24.62Aa	
AE	22.62Ba	30.73Aa#	2177Ba	30-50
ANE	26.22Aa	26.82Aab	23.72Aa	
T		24.12		
C.V.	13.29			
	Phosphorous (g kg^{-1})			
TW	2.97Aa	2.20ABab	2.05Ba	
AE	1.82Ab	2.20Aab	1.50Aa#	2-4
ANE	1.62Ab#	1.60Ab#	2.10Aa	
T		3.05		
C.V.	22.46			

Equivalent upper or lower case letters in rows and columns, respectively, do not differ statistically by the Tukey test ($p < 0.05$). TW = tap water; AE = aerobic effluent; ANE = anaerobic effluent; W1 = 50% of crop evapotranspiration (ETc); W2 = 100% of ETc; W3 = 150% of ETc; C.V. = coefficient of variation. # Differs from the control by the Dunnett test ($p < 0.05$).

TABLE 5. Macro and micronutrient contents in table beet leaf.

Water Source	K	Na	Ca	Mg	S
	g kg^{-1}				
	20-40*	-	25-35*	3-8*	2-4*
TW	47.82a	135.00b	86.48a	35.67a	3.36a
AE	31.60bc	400.28a	44.88b	24.71a	3.12a
ANE	25.30c	413.33a	40.59b	35.77a	2.95a
T	38.72b	107.50b	66.60ab	27.93a	3.50a
C.V.	15.74	11.16	33.86	32.31	19.22

Continued

Water Source	B	Cu	Fe	Mn	Z
	mg kg^{-1}				
	40-80*	5-15*	70-200*	70-200*	20-100*
TW	303.17a	6.84a	345.43a	404.09a	15.02a
AE	177.17b	6.87a	302.39a	226.90b	14.39a
ANE	185.25b	8.19a	282.14a	195.56b	14.00a
T	351.02a	8.57a	391.55a	474.75a	16.80a
C.V.	15.74	26.03	34.07	24.40	19.50

* Adequate contents, Trani et. al., 2007. Equal lowercase letters in the columns do not differ statistically by the Tukey test ($p < 0.05$). TW = tap water; AE = aerobic effluent; ANE = anaerobic effluent; W1 = 50% of crop evapotranspiration (ETc); W2 = 100% of ETc; W3 = 150% of ETc; C.V. = coefficient of variation.

TABLE 6. Irrigation depth and water source for sodium content in table beet root.

Water Source	Irrigation Depth W1	W2	W3
	Sodium (g kg^{-1})		
TW	2.00Ab	1.50Ac	1.68Ac
AE	6.00Ba	8.00ABb#	10.75Ab
ANE	9.33Ba	14.68Aa#	16.33Aa
T		2.50	
C.V. (%)	29.16		

Equivalent upper or lower case letters in rows and columns, respectively, do not differ statistically by the Tukey test ($p < 0.05$). TW = tap water; AE = aerobic effluent; ANE = anaerobic effluent; W1 = 50% of crop evapotranspiration (ETc); W2 = 100% of ETc; W3 = 150% of ETc; C.V. = coefficient of variation. # Differs from the control by the Dunnett test ($p < 0.05$).

TABLE 7**.** Macro and micronutrient contents in table beet root.

Water Source	N	P	K	Ca	Mg	S
	g kg^{-1}					
TW	13.72b	1.52b	26.98b	5.02a	1.63bc	0.94[a]
AE	13.82b	1.69ab	25.71b	3.81c	2.01ab	0.79[a]
ANE	17.57a	2.02a	28.14b	3.91bc	2.26a	0.89[a]
T	16.00ab	1.50b	32.62a	4.57ab	1.35c	1.02[a]
C.V.	15.29	21.16	11.38	12.04	20.69	35.71

Continued

Water Source	B	Cu	Fe	Mn	Z
	mg kg^{-1}				
TW	19.42a	13.07a	345.43a	69.95a	27.68a
AE	17.91a	13.83a	242.27a	32.79b	17.62a
ANE	19.79a	16.02a	239.34a	23.37b	22.24a
T	23.78a	13.17a	381.47a	79.50a	27.86a
C.V.	23.07	38.02	63.47	41.15	49.23

Matching lower case letters in the columns do not differ statistically by the Tukey test ($p < 0.05$). TW = tap water; AE = aerobic effluent; ANE = anaerobic effluent; W1 = 50% of crop evapotranspiration (ETc); W2 = 100% of ETc; W3 = 150% of ETc; C.V. = coefficient of variation.

CONCLUSIONS

In the soil irrigation with treated dairy effluents, the values of pH, P, K, Ca, Mg, and Na increased. The micronutrients were not altered, and the high sodium contents resulted in a percentage of exchangeable sodium (PES) limit values, as recommended by the environmental agency for potential sodification.

Sodium was increased throughout the plant for effluent treatments and with increasing irrigation depths.

Leaf contents were adequate for most of the macronutrients and micronutrients in a generalized sense, including nitrogen and zinc but not phosphorus, which was reduced in effluent treatments at the smallest irrigation depth.

The different water sources influenced the contribution of K and Ca in the leaves and N, P, K, Ca, and Mg in the roots. Potassium, in both the leaf and root, had a behavior that was antagonistic to sodium contents, which were decreased in treatments with effluent.

The extraction of nutrients by table beet plants was adequate with the exception of phosphorus, which was only reached in the greatest irrigation depths of the anaerobic effluent treatment.

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