ISSN 1808-8546 (ONLINE) 1808-3765 (CD-ROM)

EFFECTS OF DAIRY FARM WASTEWATER USE IN CULTIVATION ON FIG TREE (FICUS CARICA L.)

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1 ABSTRACT

The purpose of this study was to evaluate the effects of dairy farm wastewater (DFW) use on fig tree growth, production, on fig health standard and on nutrient concentration in fig tree leaves. The study was developed in the Integrated Agroecological System area, in Seropédica (RJ, Brazil) between June 2011 and May 2012. The applied fertilizer formulations were: Formulation 1, 100% of nitrogen dose recommended for fig tree supplied by fertilizing with castor bean cake (CB); Formulation 2, 50% of nitrogen dose supplied by DFW application and 50% of nitrogen dose supplied by CB; Formulation 3, 75% of nitrogen dose supplied by DFW application and 25% of nitrogen dose from CB; Formulation 4, 100% of nitrogen dose supplied by DFW application.Data were submitted to analysis of variance and the averages were compared by Tukey's test at 10% probability. The results demonstrated that branches length, number of leaves per branch, number of fruits, production and yield were lower in plants submitted to Formulation 4. Contamination of fruits by thermotolerant coliforms or Salmonellasp did not occur after DFW use as fertilizer. The results showed that the use of DFW in fig tree cultivation was sufficient to provide the nutritional needs of plants, as regards macronutrients and Fe.

Keywords: fertirrigation, environmental impact, final disposal of effluents and crop nutrition.

SILVA, J.B. G.; MARTINEZ, M. A.; SALOMÃO, L. C. C.; CECON,P. R.; MATOS, A. T.; SILVA, L. D. B.
EFEITOS DO USO DE ÁGUA RESIDUÁRIA DE BOVINOCULTURANO CULTIVO DA FIGUEIRA (F*ICUS CARICA* L.)

Recebido em 01/04/2020 e aprovado para publicação em 14/08/2020
DOI: http://dx.doi.org/10.15809/irriga.2020v25n3p590-602

2 RESUMO

Objetivou-se com este trabalho avaliar os efeitos do uso da água residuária de bovinocultura de leite (ARB) no crescimento, produção, padrão fitossanitário dos frutos e na concentração de nutrientes nas folhas da figueira. As formulações de adubação aplicadas foram: Adubação 1 - 100% da dose de nitrogênio fornecida pela adubação com torta de mamona (TM); Adubação 2 - 50% da dose de nitrogênio comaplicação de ARB e 50% com TM; Adubação 3 - 75% da dose de nitrogênio com aplicação de ARB e os outros 25% da dose com TM; Adubação 4 - 100% da dose de nitrogênio com aplicação da ARB. Os resultados foram submetidos à análise de variância e as médias comparadas utilizando-se o Teste de Tukey a 10% de probabilidade. Diante dos resultados verificou-se que comprimento dos ramos, o número de folhas por ramos, o número de frutos, a produção e a produtividade foram menores nas plantas submetidas à Adubação4. Não ocorreu contaminação dos frutos por coliformes termotolerantes e Salmonella sp. Diante dos resultados concluiu-se que o uso de ARB no cultivo da figueira não proporciona deficiência nutricional às plantas no que se refere aos macronutrientes (N, Ca, Mg, K e P).

Palavras-chave: fertirrigação, impacto ambiental, disposição final de efluentes, nutrição vegetal.

3 INTRODUCTION

The Brazilian fig production in 2018 was 23.674 tons. This production was reached in a 2.410hectare area and productivity of 9,82 tons per hectare (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2019). The reason for good productive and commercial results obtained in the country with fig tree is closely associated with its wide climatic adaptation and rusticity.

According to Dalastra et al. (2009), in order to increase the fig tree crop cultivation area, an alternative for fig producers would be the organic production of unripe figs for industrial processing, for better prices in face of added value. At present, there has been an increased interest of consumers in organic products, free of chemical contaminants or residues, resulting from conventional exploration of horticultural plants.

Previous studies demonstrated that agricultural productivity significantly increases in fertirrigated areas with wastewaters, if these cultures are properly managed. Souza et al. (2013) found an increase in the production of pine nuts by applying bovine biofertliser to the soil. The authors pointed out that the use of biofertilizer increased the photosynthetic rates of the crop. Pinto and Araújo (2019) applied the vine as a source of potable fertilization in soybean cultivation and concluded that this effluent can be used as a biofertilizer in partial or total replacement to mineral fertilization with potassium chloride.Silva Junior et al. (2012) verified yield increase in the banana tree after use of wastewater cassava in the cultivation.

The fig tree has great adaptation capacity to the most varied soil types and is one of the fruitful species that mostly responds to nitrogenated fertilizing. The fig tree also responds very favorably to organic matter applications in the soil. According to CaetanoandCarvalho (2006), of the benefits of the use of organic fertilizer in the fig tree crop, the improvement of soil physical properties, supply of nutrients and increase of nematophagous organism population in the soil can be considered the most important ones. The same authors obtained an increase of approximately 14%, 7% and 12%, in yield, fruit mean weight and number of green figs per plant, respectively, in plots fertilized with manure in relation to that without manure.

Studies addressing the agronomic behavior of the fig tree associated to the final disposal of effluents are necessary, owing to the lack of data on the use of dairy farm wastewater in organic fig tree culture, concerning physiologic, sanitary and production aspects, and the necessity of offering to cattle-raisers low-cost alternatives for wastewater treatment, reducing thus environmental impacts. Thus, the present study aimed at evaluating the effects of the use of dairy farm wastewater on growth, production, plant health standard of fig tree fruits and on fig tree leaves nutrient concentrations.

4 MATERIAL AND METHODS

The study was performed in the Integrated Agroecological System (SIPA) area, in Seropédica (RJ, Brazil) between June of 2011 and May of 2012. The total fig tree (*Ficuscarica* L.) cultivation area, of variety "Roxo de Valinhos", was 1.014 m^2 and the culture was introduced in the year of 2008, in 3 x 2m spacing. The soil of the experimental area was classified as Yellow-Red Argisol by Loss et al. (2010) and the climate of the region was classified as Aw according to Köppen, with elevated temperatures and rain in the summer and dry winter with pleasant temperatures (CARVALHO et al., 2010). The rain concentrates in the period of November to March, with mean annual precipitation of 1213mm and annual mean temperature of 24.5°C.

The adopted delineation was completely randomized, with four treatments (different fertilizing formulations) and five replications; each experimental plot was formed by two plants, totalizing 40 useful plants and 20 experimental plots.

Dairy farm wastewater (DFW), collected from the farmyard of 'FazendinhaAgroecológica', was used for fig tree crop fertirrigation. Characterization of the DFW was performed in the Laboratory of Water Quality of the Department of Agricultural Engineering at the Federal University of Viçosa (UFV, MG, Brazil), according to methodologies recommended by American Public Health Association(2005). The following characteristics were analysed: total solids, DBO, DQO, C-Total, N-Total, N-NH4 $^+$, N-NO3-, P-Total, Ca, Mg, K, In, Zn, Cu, pH, electric conductivity (EC) and sodium adsorption ratio (SAR). Table 1 presents characterization of DFW used in the experiment.

Table 1. Characterization of dairy farm wastewater used in experiment, from Integrated Agroecological System farmyard

Characteristics	**Mean values**	**Standard deviation**	**Characteristics**	**Mean values**	**Standard deviation**
Ph	6.48	0.34	K (mg L^{-1})	123.13	48.10
CE (mS cm^{-1})	2.91	0.61	Na (mg L^{-1})	75.00	64.95
ST (mg L^{-1})	24.179	3.012	Ca (mg L^{-1})	210.10	192.33
DQO (mg L^{-1})	26.875	12.590	Mg (mg L^{-1})	137.55	110.23
DBO (mg L^{-1})	3.522	1.914	RAS ($mmol_c$ $L^{-1})^{1/2}$	1.39	-
N-total (mg L^{-1})	696.20	400.49	Fe (mg L^{-1})	9.65	-
N-NH_4^+(mg L^{-1})	588.79	467.86	Cu (mg L^{-1})	6.25	-
N-NO_x(mg L^{-1})	1.07	-	Mn (mg L^{-1})	17.08	-
N-Org (mg L^{-1})	15.27	-	Zn (mg L^{-1})	1.00	-
P (mg L^{-1})	81.15	40.65			

Nitrogen was considered the reference nutrient for fig tree fertilizing. The necessary water sheets for application of different nitrogen concentrations were calculated by Equation 1 (MATOS, 2006).

$$TA_{AR} = \frac{\left[N_{abs} - \left(T_{m1}\ MO\ \rho_s\ p\ 10^7\ 0.05\ \frac{n}{12}\right)\right]}{\left[T_{m2} N_{org} + (N_{ammoniacal} + N_{nitrate})\ TR\right]} \quad (1)$$

Where,

TA_{AR}- application rate/blade (m^3 ha^{-1});

N_{abs}- nitrogen uptake by culture to obtain desired yield (kg ha^{-1});

T_{m1}- annual rate of organic matter mineralization previously existing in soil (kg kg^{-1}), considering 0.01 kg kg^{-1} $year^{-1}$ (MATOS, 2006);

MO - soil organic matter content (kg kg^{-1});

ρ_s- specific weight (t m^{-3});

p – considered soil depth (m), considering 0.40 m;

n - number of months of cultivation of culture, considering 12 months;

T_{m2}- annual rate of organic nitrogen mineralization (kg kg^{-1} $year^{-1}$), considering 0.5m kg kg^{-1} $year^{-1}$ (MATOS, 2006);

N_{org}- organic nitrogen supplied by applied residue (mg L^{-1});

$N_{ammonical}$- ammoniacal nitrogen released by applied residue (mg L^{-1});

$N_{nitrate}$- nitric nitrogen supplied by applied residue (mg L^{-1}), and;

TR – recovery rate of mineral nitrogen by culture (kg kg^{-1} $year^{-1}$), considering 0.70 kg kg^{-1} $year^{-1}$ (MATOS, 2006).

The applied fertirrigation formulations were: Formulation 1, 100% of nitrogen dose recommended for fig tree supplied by castor bean cake; Formulation 2, 50% of nitrogen dose recommended for fig tree supplied by DFW application and 50% of nitrogen dose supplied by castor bean cake; Formulation 3, 75% of nitrogen dose recommended for fig tree supplied by DFW application and 25% of nitrogen dose supplied by castor bean cake; Formulation 4, 100% of nitrogen dose recommended for fig tree supplied by DFW application.

The applied nitrogen dose was 433 kg ha^{-1}, according to recommendation of AlmeidaandSilveira (1997). Supplementary organic fertilizing was calculated by subtracting nitrogen values recommended by AlmeidaandSilveira (1997), from the quantity of the nutrient present in the different water sheets of applied DFW, using castor bean cake as supplementary fertilizer. Samples of castor bean cake were sent to the Laboratory of Organic Matter and Residues of the Department of Soils at the UFV, for chemical and physical classification, according to methods proposed by American Public Health Association (2007). Table 2 presents chemical and physical characterization of castor bean cake. Fertirrigationwas carried out in August, September, November of 2011 and February of 2012. Table 3 presents total amount of nutrients supplied to experimental plots after incorporation of different fertilizing treatments, considering the sum of the four applications.

Table 2. Chemical and physical characterization of castor bean cake used as supplementary fig tree fertilizer

Characteristics	Value	Characteristics	Value
TOC (dag kg^{-1})	37.55	pH	5.75
Ca (dag kg^{-1})	0.48	Cu (mg kg^{-1})	4.00
Mg (dag kg^{-1})	0.18	Zn (mg kg^{-1})	53.30
K (dag kg^{-1})	0.52	Mn (mg kg^{-1})	43.80
P (dag kg^{-1})	0.35	Fe(mg kg^{-1})	1.249.30
TKN (dag kg^{-1})	5.00	Cd (mg kg^{-1})	0.60
N-NH_4^+ (dag kg^{-1})	3.55	Ni (mg kg^{-1})	Notdetected
N-NO_x (dag kg^{-1})	0.003	Pb (mg kg^{-1})	Notdetected
N-Org(dag kg^{-1})	0	Cr (mg kg^{-1})	23.10
Density (mg cm^{-3})	0.49		

TOC, total organic carbon; TKN , total Kjeldahl nitrogen

Table 3. Total nutrient amount supplied to experimental plots after incorporation of fertilizer, considering sum of four applications

Nutrients	Supply (kg ha^{-1})			
	Formulation 1	Formulation 2	Formulation 3	Formulation 4
N	433.00	433.00	433.00	433.00
P	40.82	26.42	19.23	12.03
K	60.64	39.45	28.86	18.26
Ca	55.98	43.57	37.35	31.15
Mg	20.99	20.69	20.54	20.39
Fe	14.58	8.00	4.71	1.43
Cu	0.05	0.48	0.70	0.93
Mn	0.51	1.52	2.03	2.53
Zn	0.62	0.38	0.27	0.15

Drip irrigation was used in the experimental area using nominal flow emitters of 8 Lh^{-1}and 3 drippers for plant. Irrigation management was carried out based on the water balance in the soil; soil moisture was monitored during the whole crop cycle. For that, sensors connected to a TDR (Time Domain Reflectometry) were used, at 0.20 and 0.60 m depths, considering the first one for definition of necessary water sheet for total irrigation. A two-day irrigation shift was adopted, as recommended byAndradeet al. (2014).

Fructification pruning of the fig tree was performed on July 06 of 2011 and analysis of fig tree growth was evaluated by branches growth and number of leaves; length of branches was measured using a tape measure. For computation of the number of leaves, the number of knots was also considered. Regarding production, the number of figs per plant, accrued production and accrued estimated yield were evaluated. The figs were harvested still unripe, considering a production destined to industry. Harvest was carried out weekly. Fruits presenting 35 mm diameter, approximately 20 grams and partially filled interior were harvested.

The analysis of fig tree leaves nutrients occurred for determination of macro and micronutrient concentrations. The sampling of culture leaves consisted in the collection of recently ripe and totally expanded leaves, from medium-sized branches, three months after sprouting and from the different plant sides (North, South, East and West) (FERNANDES and BUZETTI, 1999). Four leaves were collected from each plant, totalizing eight leaves per experimental plot and subsequently, samples were sent to the Laboratory of Plant Mineral Nutrition, in the Department of Soils at the UFV (MG, Brazil), for quantification of Ca, Mg, K, P, N, Zn, Fe and Mn levels, according to methodology proposed by Silva (1999).

The analysis of the health quality of figswas performed in March of 2012, analysing concentrations of thermotolerant coliforms and *Salmonella sp*in the Laboratory of Foods, Waters and Drinks, of the Food Engineering Department at the UFRRJ, according to methodproposed by American Public Health Association(2007). The interpretation of results was carried out according to resolution RDC number12 (2001)of the Brazilian Health Surveillance Agency (ANVISA), which regularizes the microbiological standards for foods (BRASIL, 2001).

Data were submitted to analysis of variance. Averages were compared by Tukey's test at 10% probability. Statistical analyses were performed employing the SISVAR software (FERREIRA, 2011).

5RESULTS AND DISCUSSION

The results obtained for branch length, number of leaves, production, plant health quality of fruits and concentration of macro and micronutrients in fig tree will be presented below.

5.1 Length of branches and number of leaves

Table 4 presents means for branches length and number of leaves per branch in each treatment, followed by Tukey's test results at 10% significance level.

Table 4. Mean values for branches length and number of leaves per branch of fig trees in each treatment and Tukey's test results at 10% significance level

Formulation	Lengthofbranches	Number of leaves per branch
	Cm	leaves branch^{-1}
Formulation 1	115,44 a	51 a
Formulation 2	113,99 a	52 a
Formulation 3	109,23 a	50 a
Formulation 4	69,34 b	38 b

Means followed by same letter do not differ by Tukey's test at 10% significance level

It was noticed that Formulation 4 presented the lowest mean value for branches length in relation to the other treatments. It is believed that such behavior is associated with application of high ammonia concentrations to plants submitted the Formulation 4. It is verified in Table 1 that the nitrogen present in DFW is mostly ammoniacal; consequently, plants submitted to Formulation 4 may have suffered toxicity to ammonia. According to Marschner (2006), one of the main symptoms of toxicity to ammonia is plant growth restriction. Holzschuh et al. (2009) and Holzschuh et al. (2011) observed lower growth of the rice culture after applying nourishing solutions with ammonia concentrations of 67.5 and 135 mg L^{-1}, respectively.

Branches lengths of plants submitted to Formulations 1, 2 and 3 are coherent with those found in the literature. Leonel and Tecchio(2010) verified mean lengths of branches varying between 96 and 144 cm.

The low development of plants submitted to formulation 4 may be associated with the ammonium content in the DFW. Most plants develop toxicity when cultivated only with ammonia. According to some authors the foliar area, the stem diameter and the height of the plants can be affected by the excess of ammonium (MENDOZA-VILLARREAL et al., 2015;GUIMARÃES; CAIRO; NEVES, 2014).

5.2 Production

Table 5 presents mean values for number of fruits, production per plant, yield of fig trees in each treatment and Tukey's test results at 10% significance level.

Table 5. Mean values for number of fruits, production per plant, yield of fig trees in each treatment and Tukey's test result at 10% significance level

Formulation	Numberoffruits	Production	Yield
	fruits plant^{-1}	g plant^{-1}	kg ha^{-1}
Formulation 1	303 a	6.951 a	11.580 a
Formulation 2	304 a	6.976 a	11.622 a
Formulation 3	323 a	7.409 a	12.344 a
Formulation 4	207 b	4.757 b	7.952 b

Means followed by same letter do not differ by Tukey's test at 10% significance level

It was observed that the number of fruits of plants submitted to Formulation 4 diferred statistically from the other treatments, presenting lower value. Consequently, the production per plant and yield of this treatment also differed from the rest.

The low production of plants submitted to Formulation 4 can be explained by lower growth of branches, as the fig tree produces fruits in branches of the year and normally one fruit per knot. Therefore, with lower branch length, the number of fruits per plant was reduced. Silva; Couto; Santos (2010) verified lower root growth and volume in sunflower crop, in addition to lower dry mass values of leaves, stem and roots, when applying a nourishing solution with ammonia concentration of 210 mg L^{-1}. The same authors associated lower growth of plants cultivated exclusively with ammonia with factors related to lower photosynthetic activity of these plants, owing to the negative action of this ion on stomatal conductance in the plant (GUIMARÃES; CAIRO; NEVES, 2014).

The mean value for number of unripe fruits, production per plant and yield obtained in this study is superior to those found by some authors. Campagnolo et al. (2010) evaluated the use of system of shoot prunning for unripe fig production and observed mean values of 190 fruits per plant, production of 2.209 g plant^{-1} and yield of 3.681 kg ha^{-1}. Dalastraet al. (2009) studied the effect of pruning time on unripe fig production in organic system and observed values of 184 fruits per plant, production of 2.002 g plant^{-1} productivity of

3.335 kg ha^{-1}, when pruning was carried out in August, in western Paraná state.

In view of the aforementioned results, it can be noted that the castor bean cake can be partially substituted by DFW, without compromising fig tree production. Several studies reported wastewater use in agricultural production, showing the benefits brought by the effluent in the cultivation of some crops, if correctly managed (SOUZA et al., 2010).

5.3 Plant health quality of fruits

There was no fruit contamination by thermotolerant coliforms or *Salmonella sp.*, reducing the contamination risks by workers who harvest the fig tree.

Souza et al. (2010) performed wastewater application from pig farming on tomato plant cultivation and verified that, in all treatments, the fruits presented satisfactory consumption conditions, with absence of thermotolerant coliforms or *Salmonella sp.*, required by RDC number12of 2001. According to the same authors, the obtained results can be explained by the unfavorable conditions to these microorganisms, after interruption of application of the effluent in the soil, showing that the dehydration and germicidal action of solar beams are important factors in the elimination of pathogens. These results also can be explained because wastewater was applied directly to the soil, having no contact with the fruits.

5.4 Concentration of macro and micronutrients in fig tree

Tables6 and 7 presents mean values for N, K, Ca, Mg, P, Fe, Zn and Mn levels quantified in fig trees leaves in each treatment, followed by Tukey's test results at 10% significance level.

Table 6. Levels of Ca, Mg, K, P, Nquantified in fig tree leaves samples fertigated with DFW and Tukey's test result at 10% significance level

Fertirrigation	N	K	Ca	Mg	P
			g kg^{-1}		
Formulation1	29.97 a	21.51 a	31.28 a	6.58 a	1.70 a
Formulation 2	27.12 a	19.23 a	30.80 a	7.02 a	1.66 a
Formulation 3	27.25 a	19.14 a	32.24 a	7.01 a	1.65 a
Formulation 4	26.71 a	17.61 a	31.09 a	6.09 a	1.75 a
IAC (1997)*	20 – 25	10 - 30	30 – 50	7.5 – 10	1 – 3

Means followed by same letter do not differ by Tukey's test at 10% probability
* **Source:** Technical report 100, IAC, 1997

Table 7. Levels of Zn, Fe and Mn quantified in fig tree leaves samples fertigated with DFW and Tukey's test result at 10% significance level

Fertirrigation	Fe	Mn	Zn
		mg kg^{-1}	
Formulation1	247.60 a	59.14 a	24.36 a
Formulation 2	293.67 ab	58.58 a	23.59 a
Formulation 3	320.28 ab	69.32 a	23.77 a
Formulation 4	361.25 b	58.64 a	26.22 a
IAC (1997)*	100 – 300	100 – 350	50 - 90

Means followed by same letter do not differ by Tukey's test at 10% probability
* **Source:** Technical report 100, IAC, 1997

It was verified that the different DFW formulations provided equal results on macronutrient concentrations in the plant leaves.

The results of macronutrient levels indicated that the nitrogen level was superior to adequate values for the culture, according to Fernandes andBuzetti (1999). Potassium, calcium and phosphorous concentrations were within the appropriate values, while magnesium values were below the expected values. The low magnesium concentration in leaves can be associated to the presence of competitor ions (Ca, K and NH^{4+}), which were supplied in higher quantity in the soil. According to LeonelandDamatto Junior (2008), nitrogen addition can reduce magnesium uptake by leaves.

As regards potassium, according to BRIZOLA et al. (2005) levels below 16g kg^{-1} in leaves indicate deficiency of this nutrient, however, it was noticed that in all formulations, potassium concentration was above 17g kg^{-1}.

Haag et al. (1979) quoted by LEONEL andDamatto Junior (2008), analysing fig tree plants under complete nourishing solution, reported the following nutritional concentrations: N = 33; K = 28; Ca = 19; Mg = 6.6 and P = 1.7; g 1. According to the same authors, concentrations associated with deficiencies of the above-mentioned elements were: N = 24.5; K = 1.8; Ca = 8; Mg = 1.1 and P = 0.9 g kg-1. Therefore, it is possible to infer that nutritional limitations did not exist in the fig tree growth stage, evaluated in the present study. The macronutrient values obtained in the leaf analysis are similar to those found by LeonelandDamatto Junior (2008) and Brizola et al. (2005), who evalued nutrient concentrations in the leaves, when plants were submitted to different doses of manure and potassic fertilizers, respectively.

In face of the obtained results, it is possible to infer that the use of DFW associated with castor bean cakein fig tree cultivation was sufficient to provide the plants nutritional needs, concerning macronutrients.However, it is noteworthy that nitrogen fertilization carried out with excess ammonia (formulation 4) can cause toxicity to the cultures, causing deleterious effects, such as nutritional deficiency, reduction of N-total in the cultures, reduction of growth, development and photosynthetic rate (CRUZ et al., 2011; GUIMARÃES; CAIRO; NEVES, 2014; MENDOZA-VILLARREAL et al., 2015).

As regards micronutrients, Mn and Zn concentrations were below the adequate values for the culture and no significant difference of these nutrients was observed between treatments.

In agreement with EPSTEIN (1975), manganese plays an important role in most Krebs cycle reactions and, due to its central position in respiration; lack of manganese has effects in other metabolic sequences. According toDechenandNachtigall (2006), manganese deficiency in plants is responsible for root growth reduction.

Zinc concentrations in fig tree leaves were the same for the different formulations, even with higher zinc quantity being supplied to the soil in Formulation 1. Zinc deficiency can be associated with the phosphorous concentration supplied in the soil, as according to Malavolta (1980), one of the causes for zinc deficiency in plants is associated with high phosphorous levels in the environment, causing zinc absorption reduction and, consequently deficiency symptoms. In agreement with the same author, the reasons for zinc deficiency induced by phosphorous are the following: phosphorous insolubilizes zinc in the roots surface, reducing its absorption; phosphorous inhibits zinc absorption and reduces zinc transport from the root to the aerial part of the plant.

The iron concentration was within the values established for fig trees in formulations 1 and 2 and above appropriate values in formulations 3 and 4. It was also noticed that values quantified for this element diferred only between formulations 1 and 4.

6CONCLUSIONS

After the use of DFW in the fertirrigation of the fig tree culture, it can be concluded that:

- The length of branches, number of leaves per branches, number of fruits, production and productivity were lower in plants submitted to the fertirrigation that received only DFW.

- Contamination of fruits did not occur by thermotolerant coliforms or Salmonella sp after the use of DFW for fig tree fertirrigation.

- The castor bean cake can be partially substituted by DFW, without compromising growth or production of the fig tree.

- The use of DFW in fig tree cultivation was sufficient to meet the plants nutritional needs, as regards macronutrients.

- Mn and Zn concentrations were below the adequate values for the culture, while using DFW and/or castor bean cake as fertizer.

- Fe concentration was higher in leaves collected from plants fertilized with DFW only.

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