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Uso de efluentes de piscicultura na fertirrigação de vegetais produzidos com base em práticas agroecológicas

Use of pisciculture effluents in the fertigation of vegetables produced based on agroecological practices

Aprovechamiento de efluentes de piscicultura en fertirrigación de hortalizas producidas con base en prácticas agroecológicas

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RESUMO
O aumento da demanda por alimentos, como resultado do crescimento populacional na última década, tem causado muitos problemas ambientais. Esse cenário tem exigido ações concretas e eficazes que possibilitem um aumento real da produtividade por meio do uso eficiente do solo e dos recursos naturais disponíveis. O objetivo deste trabalho foi avaliar o potencial de aproveitamento de efluente de piscicultura associado a compostos orgânicos, como substituto de fertilizantes químicos em lavouras de alface e pepino em sistema de cultivo sucessional. Foi realizado um delineamento estatístico de blocos casualizados com esquema fatorial 2 x 3, com 2 níveis para o fator efluente (com efluente, sem efluente) e 3 níveis para o fator fertilização (com composto, com fertilizante, sem fertilização). As variáveis avaliadas foram: Peso médio da planta, Peso fresco da parte aérea, Peso seco da parte aérea, Diâmetro médio da cabeça, Número médio de folhas e Produtividade para alface após 45 dias de cultivo e Número médio de frutos / planta, Comprimento médio do fruto, Diâmetro médio do fruto e Produtividade do pepino após 30 dias de colheita. Os maiores aumentos na produção de alface e pepino foram encontrados após o uso de efluente de piscicultura e fertilizante químico. Na parcela de solos fertirrigada com efluente da piscicultura, houve aumento no teor de nutrientes, com aumento no índice de saturação por bases e no pH do solo.

Palavras-chave: Fertilização, *Lactuca sativa* L., Eutrofização, *Cucumis sativus* L., Tambaqui.

ABSTRACT
The increase in food demand as a result of population growth in the last decade, has caused many environmental problems. This scenario has demanded concrete and effective actions that enable a real increase in productivity through the efficient use of soil and available natural resources. The objective of this study was to evaluate the potential use of fish farming effluent associated with organic compounds, as a substitute for chemical fertilizers in lettuce and cucumber crops in a successional cultivation system. A randomized block statistical design with 2 x 3 factorial arrangement was carried out, with 2 levels for the factor effluent (with effluent, without effluent) and 3 levels for the factor fertilization (with compound, with fertilizer, without fertilization). The evaluated variables were: Average weight of the plant, Fresh weight of the aerial part, Dry weight

of the aerial part, Average head diameter, Average number of leaves and Productivity for lettuce after 45 days of cultivation and Average number of fruits/ plant, Average fruit length, Average fruit diameter and Productivity for cucumber after 30 days of harvest duration. The greatest increases in lettuce and cucumber production were found after using fish farming effluent and chemical fertilizer. An increase in the nutrients content was found in the soils plot fertigated with fish farming effluent, with an increase in the base saturation index and in the soil pH.

Keywords: Fertilization, *Lactuca sativa* L., Eutrophication, *Cucumis sativus* L., Tambaqui.

RESUMEN
El aumento de la demanda de alimentos, como resultado del crecimiento demográfico en la última década, ha causado muchos problemas ambientales. Este escenario ha requerido acciones concretas y efectivas que permitan un aumento real de la productividad a través del uso eficiente del suelo y de los recursos naturales disponibles. El objetivo de este trabajo fue evaluar el potencial de utilización de efluentes de piscicultura asociados a compuestos orgánicos, como sustituto de fertilizantes químicos en cultivos de lechuga y pepino en un sistema de cultivo sucesional. Se realizó un diseño estadístico de bloques al azar con un esquema factorial 2 x 3, con 2 niveles para el factor efluente (con efluente, sin efluente) y 3 niveles para el factor fertilización (con compost, con fertilizante, sin fertilización). Las variables evaluadas fueron: Peso promedio de planta, Peso fresco del brote, Peso seco del brote, Diámetro promedio de cabeza, Número promedio de hojas y Productividad para lechuga a los 45 días de cultivo y Número promedio de frutos/planta, Longitud promedio de fruto., Diámetro promedio de fruto y productividad del pepino a los 30 días de cosecha. Los mayores aumentos en la producción de lechugas y pepinos se encontraron después del uso de efluentes de piscifactorías y fertilizantes químicos. En la porción de suelo fertirrigada con efluente de piscicultura hubo un aumento en el contenido de nutrientes, con un aumento en el índice de saturación de bases y en el pH del suelo.

Palabras clave: Fertilización, *Lactuca sativa* L., Eutrofización, *Cucumis sativus* L., Tambaqui.

1 INTRODUCTION

The scarcity of new agricultural areas linked to negative environmental impacts has caused the indiscriminate exploitation of natural resources, as well as a demand for concrete and effective actions aimed at increasing the efficiency and sustainability of agriculture (Sousa *et al.*, 2011; Soglio; Kubo, 2016).

To meet the increased food demand, it will be necessary to open new cultivation areas, increase the productivity and the efficiency in the use of agricultural inputs. With the use of current production techniques, the intensification of the supply of food will consist of an increase in mechanized soil management and the use of agrochemicals, energy and water (WWAP, 2018).

The use of agrochemicals plays an important role in agriculture, with numerous advantages. Utilizing these inputs can provide an increase in agricultural production, but can also increase its costs, threatening the sustainability of agroecosystems (Souza *et al.*, 2012).

According to the Brazilian National Fertilizer Association (ANDA), in 2018 (from January to November), fertilizer *consumption/demand* exceeded 33 million tons, where 72% of them were imported. Thus, organic fertilization presents an alternative to 16 mineral fertilizers extracted from deposits. These deposits are becoming scarce, in addition to their high costs of extraction and commercialization (Schumacher *et al.*, 2001).

According to WWAP (2018), agriculture is the main source of nitrogen and phosphorus for the environment. These cause eutrophication of the spring water, streams and rivers, which makes water an increasingly scarce resource to be used in agriculture.

Aquaculture, which includes fish farming, has been considered by some governmental and non-governmental entities as an activity that impacts the environment. The practice of fish farming produces organic and inorganic materials that are dumped in the water column, which compromises its quality and cause environmental impacts (Toledo *et al.*, 2003).

The use of this nutrient-rich water in irrigated agriculture is a sustainable solution to combine the correct destination of effluents from fish farming, with the reduction of the use of chemical fertilizers in agricultural production. Thus, reducing the production cost of the crop and making it more sustainable. There are few or no studies evaluating the use of fish farming effluent combined with organic compound in planting fertilization without the use of industrialized chemical fertilizers in the field cultivation.

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Therefore, the objective of this study was to evaluate the potential use of fish farming effluent associated with organic compounds, as an alternative for chemical fertilizer in lettuce and cucumber crops under successional cultivation.

2 MATERIAL AND METHODS

The study was performed at the Federal Institute of Roraima - IFRR/Novo Paraíso Campus, located alongside the BR-174 road to Manaus-AM, at Km 514, in the municipality of Caracaraí, Vila Novo Paraíso, N 01º14'51.6" and W 60º28'20.4", with an altitude of 105 meters and an approximate area of 524 ha (Pereira, 2014).

The climate type is "Am" Tropical wet, with an average of 30 days of low rainfall per year (Barbosa, 1997). The climate of the experimental area is usually hot and humid, with rainfall between 1,700 and 2,000 mm per year (Barbosa, 1997). This *region's soil* is *classified* as Petroferric Plinthosol (Pereira, 2014).

A randomized block design (RBD) was adopted, arranged in a 2 x 3 factorial arrangement consisting of a factor 1 (fish farming effluent) with 2 levels (with effluent-CE, without effluent-SE) and a factor 2 (fertilization) with 3 levels (with compound-CC, with fertilizer-CF, without fertilization-SA). The experiment involved *4 blocks*, 6 *treatments, 4 replicates per treatment in a total of 24 experiments (plots).*

The water used for irrigation came from an artesian well. The limnological parameters of this water were measured throughout the experimental period (Table 1), to ensure it is within potability standards recommended by the Ministry of Health through Regulation nº 2914/11 and the Resolution nº 357/05 of CONAMA.

Table 1: Limnological parameters of the water from artesian well - School Allotment -IFRR/CNP

Nº	Limnological parameters	Everage	SD	Reference standard
1	Electrical conductivity (µS/cm)	0.12	0.03	10 a 100
2	DO (mg L^{-1})	6.11	0.72	4 a 10
3	pH	6.23	0.41	6 a 9
4	Temperature (°C)	28.10	1.17	25º a 32°
5	Water transparency (cm)	100.00	0.00	30 a 60
6	Ammonia (mg L^{-1})	0.07	0.11	0.02 - 2,00
7	Phosphate (mg L^{-1})	0.01	0.01	0.01 – 0.03
8	Nitrate (mg L^{-1})	0.03	0.07	0.25 – 10.00

Source: Standard Methods for the Examination of Water and Wastewater, 23RD EDITION. American Public Health Association, USA 2017.

The fish were cultivated in a ferrocement tank with 2 m of ratio, a depth of 70 cm, and a capacity of 8 thousand liters.

The tank contained 300 tambaqui fry (*Colossoma macropomum* Cuvier, 1818), with an initial average weight of 2 grams and a density of 4.83 fish m^{-2}. Among these, 60 juveniles tambaqui (20 %) were selected to be cultivated during the experimental period. The fish were fed a commercial diet containing 36% of crude protein-CP (min), 120 g/Kg of humidity (max), 35 g kg^{-1} of crude fiber (max), 150 g kg^{-1} of mineral matter (max) with 6 to 8 mm of thickness. They were fed twice a day (at 8 am and 4 pm), by throwing the commercial diet on the entire surface of the tank (Chagas, 2007).

After eutrophication, the tank water was then characterized (Table 2) as a fish farming effluent. This effluent was first used on the fertigation of the lettuce, followed by the cucumber. At this point a transparency value of 40 cm was observed in a column of water.

Table 2: Limnological parameters of the fish farming effluent - School Allotment -IFRR/CNP

Nº	Limnological parameters	Everage	SD	Reference standard
1	Electrical conductivity (µS/cm)	0.25	0.03	10 a 100
2	DO (mg L^{-1})	6.98	0.652	4 a 10
3	pH	7.85	0.66	6 a 9
4	Temperature (°C)	27.87	1.36	25º a 32°
5	Water transparency (cm)	35.56	5.27	30 a 60
6	Ammonia (mg L^{-1})	0.59	0.143	0.02 a 2,00
7	Phosphate (mg L^{-1})	6.64	1.724	0.01 a 0,03
8	Nitrate (mg L^{-1})	0.82	0.211	0.25 a 10,00

Source: Standard Methods for the Examination of Water and Wastewater, 23RD EDITION. American Public Health Association, USA 2017.

Daily replenishment of the tank water was performed to control and maintain the stability and reproduction of the planktonic community within the tank. It was promoted by the irrigation process not exceeding 30% of its total volume, according to Guilherme (2013).

The organic compound was produced according to the methodology described by SISTEMINHA EMBRAPA (Guilherme, 2013), in which 4 materials were used: grass/spontaneous vegetation, chicken bedding, bovine manure and wood sawdust.

After 90 days of the composting process, the stable compound was sieved using a 6 mm metal mesh sieve, and then applied to fertilize the cultivation rows.

Analyses of the soil from the experimental area and the organic compound were performed before beginning the experiment. The results were used to correct the soil acidity and to fertilize the planting using a commercial *04-14-08 NPK formulation and the* organic compound.

After 30 days of limestone incorporation, 6 windows of 12.60 meters in length and 1 meter in width were built, using 1-row cultivator and a rotoencanteirator. The chemical and organic compounds were then incorporated, according to the treatments and recommendations for a lettuce culture (Prado; Filho, 2016). NPK 04-14-08 fertilizer was used at a dose of 540 g/plot (chemical fertilizer) and the organic compound at a dose of 7.2 kg/plot (organic fertilizer).

After the lettuce cultivation, 50% of the recommended fertilization was incorporated for the cultivation of cucumber (Carvalho *et al.*, 2013; Trani *et al.*, 2015).

A pressurized drip irrigation system with a peripheral pump and PVC pipes was used to apply the effluent and for conventional irrigation. The drippers of the type “xique-xique” were used, with a maximum flow of 10 L h^{-1} in each dripper and a working pressure of 5 mca.

One irrigation shift was daily performed for lettuce and cucumber, between 8 and 10 am, with water depths of 11.67 mm and 6.67 mm for lettuce and cucumber, respectively.

The plots were assembled for the cultivation in succession, with the lettuce being the first culture, followed by the cucumber. The American lettuce (*Lactuca sativa* cv. *Lucy Brown*) was chosen for the lettuce cultivation, with an average cycle of 45 to 55 days after transplanting. Regarding the cucumber cultivation, the hybrid "*caipira guarani*” was *chosen, with a cycle of* 50-60 days after transplanting. The plots presented dimensions of 1 x 2.40 m, containing 4 rows of plants each. The spacing between rows was 25 cm and 30 cm between plants for lettuce culture. For cucumber culture, the spacing between rows and plants were 75 cm and 60 cm respectively.

The plot had 28 plants of lettuce and 8 plants of cucumber, resulting in a total population of 672 lettuce plants and 192 cucumber plants. The useful area of the plot presented the two central rows containing 10 lettuce plants after discarding the plants at the end of the rows. The useful area of the cucumber plantation contained 4 cucumber plants located in the two external rows.

Lettuce and cucumber seedlings were transplanted when the plants reached 2 to 3 leaves and 8 to 10 cm in height. It was carried out in the morning, in a milder temperature, to minimize the dehydration effect of the seedlings.

The limnological parameters (electrical conductivity, dissolved oxygen, potential of hydrogen, temperature, transparency, ammonia, phosphate and nitrate) of the water sources were measured every 15 days, to ensure the supply of drinking water and effluents is similar to what is found in the fish farms.

To evaluate the effect of the treatments, the following variables in the lettuce culture were measured: Average weight of the plant - **AWP**, Fresh weight of the aerial part - **FWAP**, Dry weight of the aerial part - **DWAP**, Average head diameter - **AHD**, Average number of leaves - **ANL** and Productivity – **P**. For the cucumber culture, Average number of fruits/plant - **ANFP**, Average fruit length - **AFL**, Average fruit diameter - **AFD** and Productivity – **P** were all measured. These variables were measured in the different sources of fertilization.

The lettuce harvest started 45 days after transplanting. The cucumber harvest of the 4 central plants of the plot started 41 days after transplanting, with the fruits reaching between 10 and 15 cm in length. The cucumber was harvested weekly and it lasted 30 days from the date of the first harvest.

120 days after the beginning of the experiment, the lettuce was already transplanted and the fish in the tank presented an initial average weight of 23.14 g. At this point, the fish were then collected from the tank using a trawl made of 25 mm silk mesh. They were counted and weighed using a *digital hanging scale, in order* to evaluate the productivity of the system.

The data collected from the experiment were first submitted to the Shapiro Wilk Test of Normality. After no abnormality was detected, the data was submitted to the analysis of variance (ANOVA). The averages were compared using the Tukey test at 5% probability (Mendes, 1999). The factors that showed insignificant interaction had their discussion based only on the main effect of each level. The statistical analyses were performed using the software SISVAR version 5.7 (Ferreira, 2014).

3 RESULTS AND DISCUSSION

3.1 LETTUCE CULTURE

An interaction between effluent and fertilization factors on the average weight of the plant (AWP) was observed. The use of the fish farming effluent and the chemical fertilizer showed the best AWP results for lettuce, followed by the interaction between the effluent with the most complex composition (Table 3).

Table 3: Average values of the weight of the plant-AWP (g/plant), for lettuce culture submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer -CF, Without fertilization-SA).

AWP	Fertilization		
	CC	**CF**	**SA**
Effluent	------------------ g/plant ------------------		
SE	11.83 bB *	95.57 aB	3.81 bA
CE	123.92 bA...	402.27 aA	30.41 cA
VC (%)	16.86		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different ($p > 0.05$) according to Tukey's test. Source: Authors

It can be seen that the interaction between the effluent and the mineral fertilizer obtained the highest AWP value (402.27g). Since the lettuce has a very short production cycle (average of 40 days), this crop requires fast demand for nutrients readily assimilated into the soil (NOBLE and LIGHFOOT, 2003). This nutritional demand was probably supplied by the effluent, which acts as a second nutritional source, providing readily assimilated nutrients by the crop (GURGEL *et al.*, 2008; OLIVEIRA *et al.*, 2009).

Lower values of AWP were found by Santos *et al.* (2015), on the evaluation of the productivity of lettuce (*Lactuca sativa L.*) in different water depths and types of fertilizers in the state of Alagoas, obtaining a maximum AWP of 235 g.

Regarding the FWAP, the highest average value was achieved by the treatment using effluent with chemical fertilizer, followed by the use of effluent with organic compound (Table 4).

Table 4: Average values of fresh weight of the aerial part-FWAP (g/plant), for lettuce culture submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer-CF, Without fertilization-SA).

FWAP	Fertilization		
	CC	**CF**	**SA**
Efluente	------------------ g/plant ------------------		
SE	10.00 bB*	88.46 aB	2.38 bA
CE	109.28 bA..	375.23 aA	25.58 cA
VC (%)	18.35		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different (p > 0.05) according to Tukey's test. Source: Authors

Based on table 4, it was clear the significant interaction between the factors effluent and fertilization for FWAP, since the use of the mineral fertilizer NPK in the proportion (04-14-08) with effluent resulted in higher FWAP values, when compared to other treatments. This shows, once again, that the effluent can provide a fast mineralization and is a good nutritional source (Nahas, 2002; Oliveira *et al.*, 2009).

Lopes *et al.* (2003) found better results when analysing the response of three lettuce cultivars submitted to different nitrogen sources. Two of the three cultivars presented higher values of FWAP than those found in this study: cultivars Verônica and Vera achieved FWAP values of 474.13 g and 461.68 g, respectively.

Regarding the DWAP variable, the best results were found from the interaction between the effluent and the chemical fertilizer (20.46 g), followed by the interaction between the effluent with the organic compound (6.48 g/plant) and using only chemical fertilizer (6.31 g/plant) (Table 5).

Table 5: Average values of dry weight of the aerial part - DWAP (g/plant), for lettuce culture submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer-CF, Without fertilization-SA).

DWAP	Fertilization		
	CC	**CF**	**SA**
Effluent	------------------ g/plant ------------------		
SE	0.88 bB*	6.31 aB	0.33 bB
CE	6.48 bA..	20.46 aA	2.37 cA
VC (%)	8.57		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different (p > 0.05) according to Tukey's test. Source: Authors

Among the interactions between the factors analysed, the one between fish farming effluent and mineral fertilizer presented the highest values of DWAP. This could be explained by the mineralization and fertilization promoted by the effluent, contributing to the fast availability of nutrients to the crop (Medeiros *et al.*, 2008: Almeida *et al.*, 2017).

Santos *et al.* (2015) evaluated the productivity of lettuce culture in different water depths, types of organic fertilizers and chemical fertilizers, in Arapiraca Alagoas-AL. They obtained 23.30 g/plant of DWAP, which is higher than what was found in this study.

The variable average head diameter – AHD was the only one that did not show any significant interaction between the factors evaluated.

The treatment 2 (fish farming effluent with fertilizer-CECF), resulted in the highest value of AHD (Table 6), which was 28.68 cm, followed by treatments 1 (effluent with organic compound- CECC), and 5 (only fertilizer -SECF), with 20.37 cm and 20.12 cm respectively. These later results showed no significant difference between them.

Table 6: Values of average head diameter - AHD (cm), for lettuce culture submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer-CF, Without fertilization-SA).

AHD	Fertilization		
	CC	**CF**	**SA**
Effluent	------------------ g/plant ------------------		
SE	12.37 bB*	20.12 aB	5.50 cB
CE	20.37 bA..	28.68 aA	14.25 cA
VC (%)	6.96		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different (p > 0.05) according to Tukey's test. Source: Authors

Based on the AHD values, the treatment using the effluent with chemical fertilizer, resulted in a fertilization with two different sources of nutrients, which explains the highest value of average head diameter when compared to the other treatments. However, the treatments T1-CECC and T5-SECF had similar AHD values, with no significant difference between them. This suggests that the treatments using the organic compound with irrigation using fish farming effluent presented a similar performance to the treatment using chemical fertilizer with irrigation using well water. These data were similar to the one reported by Guimarães *et al.* (2016), who evaluated the use of wastewater from fish farming in the cultivation of the lettuce cultivars; Vera, Isabela, Angelina and Amélia.

As shown in Table 7, the highest ANL values were achieved by the interaction between fish farming effluent and chemical fertilizer (28.75 leaves/head), followed by the use of effluent and organic compound (19.12 leaves/head). This last result was similar to the one found after using well water and chemical fertilizer (17.12 leaves/head).

Table 7: Values of average number of leaves-ANL (und/plant), for lettuce culture submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer -CF, Without fertilization-SA).

ANL	Fertilization		
	CC	**CF**	**SA**
Effluent	------------------ g/plant ------------------		
SE	7.87 bB*	17.12 aB	6.12 bB
CE	19.12 bA..	28.75 aA	12.00 cA
VC (%)	6.68		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different ($p > 0.05$) according to Tukey's test. Source: Authors

The use of chemical fertilizer with effluent increased the availability of sufficient amounts of nitrogen required in the soil, which provided better results of the variable studied. This nutrient is directly responsible for the vegetative growth of the crop (BENINNI *et al.*, 2005).

Rezende *et al.* (2017) found an average number of leaves lower than those found in this study through evaluating the effect of drip fertigation with nitrogen and potassium. This was combined with planting fertilization on the growth of Vera lettuce in a protected environment

The interactions between the levels of effluents and fertilization had a significant effect on the lettuce productivity (Table 8). The combination of effluent with the fertilizer and with the organic compound presented the best productivity values, which were 50,032 and 14,572 kg ha^{-1}, respectively.

Table 8: Average values of productivity-P (Kg ha^{-1}), for lettuce culture submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer-CF, Without fertilization-SA).

P	Fertilization		
	CC	**CF**	**SA**
Effluent	------------------ g/plant ------------------		
SE	1,333 bB*	11,795 aB	318 bA
CE	14,572 bA..	50,032 aA	3,412 cA
VC (%)	18.35		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different (p > 0.05) according to Tukey's test. Source: Authors

The interaction between fish farming effluent and chemical fertilizer (*04-14-08 NPK formulation*) showed a productivity of 50,031.66 kg ha^{-1}, for lettuce, whereas the combination of irrigation using well water and chemical fertilization (NPK) presented a productivity of 11,795.00 kg ha^{-1}. This highlighted the capacity of the fish farming effluent in enhancing the availability of nutrients in the soil for the crops (Pullin, 2003; Gurgel *et al.*, 2008; oliveira *et al.*, 2009).

This mineralization capacity, mainly of nitrogen and phosphorus, is due to the presence of microorganisms in the fish farming effluent. These heterotrophic microorganisms play a very important role in the cycling of nutrients in the fish farming tanks (Schoeder, 1978; Moriarty, 1997).

Guimarães *et al.* (2016), studied the use of saline water from fish farming for the irrigation of seven lettuce cultivars (Regiane, Vera, Isabela, Elisa, Amélia, Lavínia and Angelina). They evaluated the number of leaves, leaf area, head diameter, fresh and dry weight of the aerial part, and concluded that the diluted fish farm effluent can provide an increase in the productivity of the crop.

3.2 CUCUMBER CULTURE

No interaction between the factors (Table 9) was observed when the variable average number of fruits per plant – ANFP was evaluated.

The treatments that presented the highest ANFP values were those using the effluent and chemical fertilizer, followed by the treatment using well water and chemical fertilizer, showing values of 8,81 and 5,56 fruits/plant, respectively.

Table 9: Values of average number of fruits per plant-ANFP for cucumber culture submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer-CF, Without fertilization-SA).

ANFP	Fertilization		
	CC	**CF**	**SA**
Effluent	-------------- Fruits/plant --------------		
SE	2.62 bA *	5.56 aB	0.00 cB
CE	3.12 bA...	8.81 aA	2.37 bA
VC (%)	33.46		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different ($p > 0.05$) according to Tukey's test. Source: Authors

The combination of fish farming effluent and chemical fertilizer (*04-14-08 NPK formulation*) presented the highest ANFP value, as the result of the greater and faster availability of nutrients for the crop. The nutrients and microorganisms presented in the effluent act on the conditioning and availability of the chemical fertilizer, and then contribute to the development and production of the plant (Pullin, 2003; Gurgel *et al.*, 2008; Oliveira *et al.*, 2009).

Clemente *et al.* (2006), reported an ANFP similar to what was found in this study, on the evaluation of cucumber fruits of "caipira" and salad types using organic cultivation under cerrado conditions in Embrapa - DF.

According to Table 10, the highest AFL values were achieved on the treatments using effluent with chemical fertilizer, effluent with organic compound and without effluent, which were 16.82, 16.49 cm and 16.46 cm respectively.

Table 10: Values of average fruit length - AFL (cm), for cucumber submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer-CF, Without fertilization-SA).

AFL	Fertilization		
	CC	**CF**	**SA**
Effluent	-------------------- cm --------------------		
SE	13.76 aB *	16.46 aA	0.00 bB
CE	16.49 aA...	16.82 aA	13.61 bA
VC (%)	12.05		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different (p > 0.05) according to Tukey's test. Source: Authors

The AFL values were significantly higher using fish farming effluent, demonstrating the nutritional efficiency of this effluent when acting as a source of water and nutrients, as well as promoting the cycling and availability of the nutrients from other sources of fertilization such as the organic compound and the chemical fertilizer (Oliveira *et al.*, 2009; Sousa Junior *et al.*, 2013).

A significant interaction was observed when the variable average fruit diameter-AFD (Table 11) was analysed, showing the correlation between levels of the factors evaluated. It was significant due to the AFD value of treatment 6, which was 0 (zero). This means that the other interactions did not show any significant difference. The average value of AFD was 6.62 cm, after discarding the sample with a value of 0 (zero).

Table 11: Values of average fruit diameter - AFD (cm), for cucumber submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (With compound-CC, With fertilizer-CF, Without fertilization-SA).

AFD	Fertilization		
	CC	**CF**	**SA**
Effluent	-------------------- cm --------------------		
SE	6.42 aA *	6.84 aA	0.00 bB
CE	6.77 aA...	6.48 aA	6.60 aA
VC (%)	7.34		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different (p > 0.05) according to Tukey's test. Source: Authors

The cucumber fruits of the "caipira" type are harvested with an average diameter of around 6 cm, depending on the requirements of each market (Carvalho, 2013). The diameter of the fruits from this study were within the demands of the consumer market for commercialization for this type (average diameter of 6 cm). Martins *et al.* (2018) found the same average diameter of this study.

The variable productivity - P showed a significant interaction between the levels of the factors evaluated (Table 12). The treatments using fertilizer and effluent, and only fertilizer, followed by the ones using only effluent and without effluent and fertilizer showed significant differences for productivity. Among the interactions between SE and CE, only the treatments that used the fertilizer showed significant interaction. The highest productivity was achieved by using effluent and fertilizer (CE-CF), with an average of 85,92 kg ha^{-1} of productivity.

Table 12: Average values of productivity-P (kg ha^{-1}), for cucumber culture submitted to the following factors: effluent (Without effluent-SE, With effluent-CE) and fertilization (with compound-CC, with fertilizer-CF, Without fertilization-SA).

P	Fertilization		
	CC	**CF**	**SA**
Effluent	------------------------- kg ha^{-1} -------------------------		
SE	21,70 abA *****	44,64 aB	0.00 bB
CE	27,24 bA.....	85,92 aA	21,64 bA
VC (%)	38.36		

* Average values followed by the same lowercase letter in the lines and uppercase in the columns are not significantly different ($p > 0.05$) according to Tukey's test. Source: Authors

The cucumber cultivation is highly demanding in soil fertility, especially during the fruiting season. Changes in the availability of soil nutrients compromise the production and health of the fruits (Papadopoulos, 1994). When the cultivation is carried out with an adequate supply of nutrients in the soil, the productivity of the cucumber type "caipira" is around 40 to 70 t ha^{-1} (Trani *et al*. 2015).

Silva *et al*. (2011) produced organic cucumber in the cerrado, and obtained yields of 33.5 t ha^{-1} for the Exocet hybrid and up to 37.5 t ha^{-1} for Aladdin. Higher productivity was found by this study (85.92 kg ha^{-1}). It is noted that the use of the effluent increased the productivity of the cucumber "caipira" type.

The greatest increases in the productivity of the two cultures evaluated in this study, resulted from the significant interaction between the fish farming effluent and the recommended chemical fertilization. This combination of effluent and fertilizer showed greater productivity rates than using only irrigation with fertilizer.

The interaction between fish farming effluent and chemical fertilizer showed higher productivity rates, which is evidenced by the capacity this effluent to enhance the mineralization of nutrients in the soil, as well as making them readily available for plants (Gurgel *et al.*, 2008; Oliveira *et al.*, 2009).

The microorganisms from the effluent increase the availability of nitrogenous and phosphate compounds, and also act on the decomposition of solids and the cycling of nutrients in the fish farming tanks. Once they are brought to the soil by irrigation, they add minerals to the organic matter such as nitrogen and phosphate compounds, making them readily available in the soil to be absorbed by the crops (Moriarty, 1997: Sousa Junior *et al.*, 2013).

Therefore, when the crops are irrigated with effluent, we will be adding these microorganisms to the soil biota. This improves the soil microbiology, contributing to the nutrient cycling and therefore improving the solubilization of natural phosphate, making it readily available for crops (Oliveira *et al.*, 2009).

Ammonia and organic matter present in the effluent also contributes to the mineralization of the soil's natural phosphorus. The activity of microorganisms is related to the organic matter (carbon source) and nitrogen available, since the ammoniacal nitrogen (NH_4^+), which is an essential nitrogen source for microorganisms, increases the solubilization of phosphorus. On the other hand, the ammonium nitrate (NH_4NO_3) in its nitric form reduces the solubilization of phosphorus and leads to an increase in the nutrient leaching to deeper layers of soil (Nahas, 2002; Oliveira *et al.*, 2009).

The effluent also plays an important role in this process as it acts as a second source of fertilization. Its nutrient composition from the fish excrement and the remains of the feed not consumed by them are rich in important nutrients such as nitrate (NO_3-) and phosphate (PO_4^{-3}), that can be readily assimilated by the plants (Queiroz; Boeira, 2007; Von Sperling, 1996; Menegaz *et al.*, 2011; Sousa Junior *et al.*, 2013).

The substitution of chemical fertilizers to organic compounds allow the producers to reuse a range of products and by-products in their properties, significantly reducing the costs of the crops production (Lima *et al*., 2014).

In addition to higher costs, the chemical fertilizers can also contaminate the environment due to improper disposal. The use of organic compounds contributes to reductions in the impact on the environmental and degradation of agricultural soils, since many residues can be recycled by using composting techniques (Sediyama *et al*., 2016).

It is clear the chemical fertilizers present a quick result in improving crop production. However, it is also important to evaluate the higher costs of these fertilizers for the producer. In addition, the indiscriminate use of chemical fertilizers puts the health of producers at risk and gives rise to serious *environmental* pollution. Furthermore, it significantly reduces the microbial life present in soil, causing eutrophication of rivers and lakes. This eutrophication is due to the easy leaching of these chemicals, that is caused by irrigation and rain runoff, leading to large amounts of chemical nutrients to the water table (Bispo, 2017).

The fertilization technique using cheaper, accessible, and environmentally friendly organic compounds has been widely applied in lettuce cultivation (Santos *et al.*, 2001; Salles *et al.*, 2017). Once present in the soil, the organic matter (OM) improves the cation exchange capacity of soil (soil CEC), increasing porosity, infiltration and retention of water and aeration, favoring the development and maintenance of regular microbiological activity, and therefore the mineralization and cycling of nutrients (Leite; Galvão, 2008). Regarding the biological benefits, the OM promotes an increase in the number of beneficial microorganisms in the soil, improves the plant rooting and soil resistance to drought, diseases, and pests. It also improves the flavor of vegetables and leads to longer *Post-Harvest Conservation periods* (Prado; Filho, 2016).

The cultivation in succession is an essential practice in the cultivation of vegetables, presenting benefits such as control of pests and diseases, reduction of soil degradation. It has also been applied for the use of fertilizer residues and for the optimization of the crop area (Sediyama *et al.*, 2012).

The effects of residual fertilization from successive crops favors the cost –benefit ratio, in addition to promoting a range of benefits for the soil microbiome, environment and the farmer (Costa *et al.*, 2012; Silva, 2016).

The integrated and planned use of the fish farming effluent in the cultivation of vegetables reduces the costs of chemical and organic fertilization, especially the phosphate fertilization. It improves the physical and chemical conditions of the soil, in addition to recovering the costs of the irrigation system and reducing the pollution in aquatic ecosystems by recycling the nutrients present in the effluent (Oliveira *et al.*, 2009; Santos, 2009).

3.3 SOIL INCREMENTS

By comparing the results of the soil analysis after the experiment an increase in the nutrient supplies after being treated with fish farming effluent was observed. The soil plot that was not submitted to treatment with effluent did not show significant changes in their nutritional content after the experiment (Table 13). The changes observed in this untreated soil were only due to liming with dolomitic limestone.

Table 13: Soil analysis of the area after the experimental period - School Allotment -IFRR/CNP

Plots with effluent + liming and without fertilization												
pH	K	P	Zn	Fe	Mn	Cu	B	S	Ca	Mg	Al	H+Al
	-------------------------------- mg/dm³ --------------------------------								-------- cmolc/dm³ --------			
7.00	17.03	10.34	3.04	251.45	16.04	0.37	0.11	0.70	2.26	0.56	0.05	1.01
SB	t	T	V	m	SOM	P-Rem						
---- cmolc/dm³ ----			%		g kg^{-1}	mg/L						
2.86	2.91	3.87	74	2	13	56.40						
Plots with liming, without effluent without fertilization												
pH	K	P	Zn	Fe	Mn	Cu	B	S	Ca	Mg	Al	H+Al
	------------------------------- mg dm^{-3} --------------------------------								-------- $cmol_c$ dm^{-3} --------			
6.50	20.44	5.50	4.38	463.28	18.81	0.75	0.08	3.96	1.68	0.45	0.04	1.41
BS	t	T	V	m	SOM	P-Rem						
----- cmolc/dm³ -----			%		g kg^{-1}	mg/L						
2.18	2.22	3.59	60.79	1.80	11.2	51.14						

Source: water pH, KCl and $CaCl_2$ - 1: 2.5 ratio, Ca - Mg- Al- Extractor: KCl - 1 mol/L, S - Extractor - Monocalcium phosphate in acetic acid, P- Na - K- Fe - Zn- Mn- Cu- Mehlich Extractor 1, H + Al- Extractor: SMP, Org. Mat (OM) - Oxidation: $Na_2Cr_2O_7$ 4N + H_2SO_4 10N, B- Hot Water Extractor.

Earlier studies have shown that the use of fish farming effluents in vegetable cultivation can reduce fertilizer costs, especially phosphate fertilization, since the effluent contains a high concentration of phosphorus in its composition (Castro, 2003). During fertigation, the microorganisms from the effluent are transferred to the soil. They have the capacity to solubilize the phosphate in the soil, thus rapidly increasing their availability to be absorbed by the crop (Gurgel *et al.*, 2008).

The application of crop fertigation using the fish farming effluent reduces the cost of water, as well as decreases the amount of chemical fertilizers (Brune, 1994; Gurgel *et al.*, 2008). it presents great environmental benefits with a significant reduction of water usage, avoiding unnecessary costs associated with wastewater treatment systems (Billard & Servrin-Reyssac, 1992; Gurgel *et al.*, 2008).

4 CONCLUSIONS

The use of fish farming effluent with chemical fertilization increased the productivity of lettuce and cucumber crops.

The use of fish farming effluent in the irrigation of lettuce and cucumber favored the availability of nutrients in the soil solution.

The use of organic compound with the fertigation of fish farming effluent was a viable substitute for chemical fertilization in lettuce culture.

REFERENCES

ALMEIDA, J. P. N. de *et al*. Production of Piptadenia stipulacea (Benth.) Ducke seedlings irrigated with fish farming wastewater. **Revista Brasileira de Engenharia Agrícola e Ambiental**, June 2017, vol. 21, no. 6, p. 386-391. ISSN: 1415-4366.

ANDA - Associação Nacional para Difusão de Adubos. 2019. Disponível em < http://anda.org.br/estatisticas/ > Acesso em 20 de abril de 2019.

BENINNI E. R. Y.; TAKAHASHI H. W. e NEVES C. S. V. (2005) Concentração e acúmulo de macronutrientes em alface cultivada em sistemas hidropônico e convencional. Semina: Ciências Agrárias, 26:273-282.

BILLARD, R.; SERVRIN-REYSSAC, J. **Les impacts negatoifs et positifs de la pisciculture détang sur lénvironnement.** In: BARNABÉ, G.; KESTEMONT, P. (eds.) Production, Environment and Quality. [s.l]: European Aquaculture Society special publication # 18, 1992.

BISPO, A. N. **Produção de alface em vasos submetida a diferentes proporções de composto orgânico**; Trabalho de conclusão de curso submetido ao Colegiado de Graduação de Tecnologia em Agroecologia do Centro de Ciências Agrárias, Ambientais e Biológicas da Universidade Federal do Recôncavo da Bahia; Cruz das Almas – BA, 2017.

BRUNE, D. E. **Sustainable aquaculture systems**. Washington: D.C., 1994. (Report prepared for the Offi ce of Technology Assessment, U.S. Congress, Food and Renewable Resources Program).

CARVALHO, A. D. F.; AMARO, G. B.; LOPES, J. F.; VILELA, N. J.; MICHEREFF FILHO, M.; ANDRADE, R. **A cultura do pepino**, Embrapa Hortaliças, Brasília-DF, 18p., 2013, Circular Técnica 113, ISSN 1415-3033.

CASTRO, R. S. **Cultivo de tomate cereja em sistema orgânico irrigado com efluentes de piscicultura**. Mossoró, 2003. 68p. Dissertação (Mestrado em Fitotecnia) – Departamento de Fitotecnia, Escola Superior de Agricultura de Mossoró.

CHAGAS, E. C. *et al.* Produtividade de Tambaqui Criado em Tanque-Rede com Diferentes Taxas de Alimentação. **Ciência Rural**, Santa Maria, v 37, nº. 4, p. 1109-1115, julho-agosto, 2007.

CLEMENTE, F. M. V. T.; LIMA, J. L.; LOPES, J. F.; RESENDE, F. V. **Avaliação do desempenho de pepino do tipo caipira e salada sob o cultivo orgânico nas condições de Cerrado**. EMBRAPA. Brasília, 2006.

COSTA, N. L.; SILVA, A. R. C.; GRANGEIRO, L. C. Efeito residual da adubação da cebola no rendimento de cenoura. **Agropecuária Científica no Semiárido**. Campina Grande-PB, v. 8, n. 1, p. 07-11, 2012.

FERREIRA, D. F. Sisvar: a guide for its bootstrap procedures in multiple comparisons. **Ciência e Agrotecnologia**, Lavras, v. 38, n. 2, p. 109-112, 2014.

GUILHERME, L. C. **Sistema Embrapa: SISTEMA integrado alternativo para produção de alimentos: agricultura familiar**, Circular Técnica, Parnaíba/PI, Março, 2013, acesso em: 26 outubro 2017. Disponível em: <https://ainfo.cnptia.embrapa.br/digital/bitstream/item/127573/1/Fol-Agricultura-Familiar.pdf>.

GUIMARÃES, I. P. *et al*. Use of fish-farming wastewater in lettuce cultivation. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Aug 2016, vol.20, no.8, p.728-733. ISSN 1415-4366.

GURGEL, G. C. de S. *et al*. Resposta biológica de plantas de pimentão cultivadas com efluente de piscicultura, fosfato natural e esterco bovino. **Revista Agro@mbiente On-line**, Boa Vista, RR, v. 2, n. 2, p.25-32, dez. 2008. Semestral.

LEITE, L. F. C; GALVÃO, S. R. S. Matéria orgânica do solo: funções interações e manejo em solo tropical. IN: ARAÚJO, A.S.F; LEITE, L. F. C; NUNES. L. A. P.L; CARNEIRO. R. F. V. (Ed) **Matéria orgânica e organismos do solo**. Teresina: EDUFIP, 2008. 19p.

LIMA, J. M. E.; SMIDERLE, O. J.; Alves, J. M. A.; CHAGAS, E. A.; SOUZA, A. G. Tipos de adubação e épocas de avaliação na sanidade e viabilidade de sementes de soja-hortaliças. **Revista Agro@mbiente**, v.8, p.244-252, 2014.

LOPES, M. C. *et al*. Resposta de três Cultivares de alface a diferentes fontes nitrogenadas em cobertura. **Horticultura Brasileira**, v. 21, p. 4, 2003.

MARTINS, J. K. D.; LUZ, S. R. O. T.; ENCK, B. F.; KEFFER, G. F.; DAMACENO, J B. D. (2018). Avaliação da produtividade do pepino conduzido em sistemas de tutoramento horizontal e vertical com e sem consórcio com amendoim em Rondônia. **Enciclopédia Biosfera**. 15. 150-156. 10.18677/EnciBio_2018A14.

MEDEIROS, S. S. *et al*. Utilização de águas residuárias de origem doméstica na agricultura: Estudo do estado nutricional do cafeeiro. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Campina Grande, v. 12, n. 2, p. 109-115, 2008.

MENDES, P. P. (1999). Estatística Aplicada a Aquicultura. Recife: Bargaço.

MENEGAZ, R. C., *et al*.; Remoção físico-química de fósforo por floco-sedimentação aplicada ao pós-tratamento de efluente de abatedouro avícola; **Revista Ciências Exatas e Naturais,** Vol.13, nº.2, 25 p; 2011.

MORIARTY, DJW., 1997. **The role of micro-organisms in aquaculture ponds**. Aquaculture, vol. 151, p. 333-349.

NAHAS, E. **Factors affecting the solubilization of insoluble phosphates**. Disponível em: <http://webcd.usal.es/web/psm/ abstracts/Kaempfer.htm> Acesso em: 18 ago 2002.

NOBLE, R.; LIGHTFOOT, C. **Trabajando con nuevos participantes en agro-acuicultura integrada.** In: FAO/ICLARM/IIRR. Agro-acuicultura integrada: manual básico. Roma: FAO, 2003. p.13-16. (FAO Documento Técnico de Pesca Nº 407).

OLIVEIRA, H. do V., *et al*. Alterações nas características químicas de um Argissolo Vermelho- Amarelo irrigado com efluente de piscicultura, em ambiente protegido. **Revista Agro@mbiente On-line**, Boa Vista, RR, v. 3, n. 1, p. 9-14, jul. 2009.

PAPADOPOULOS, A.P. Growing greenhouse seedless cucumbers in soil and in soilless media. 1994. 126p. (**Agriculture and Agri-Food Canada Publication**, 1902/E).

PRADO, R. de M.; FILHO, A. B. C. **Nutrição e adubação de hortaliças**. UNESP, Campus de Jaboticabal, Jaboticabal-SP, v. 1, n. 1, p. 554-577, 2016.

PULLIN, R. **Agro-acuicultura integrada y medio ambiente**. In: FAO/ICLARM/IIRR. Agroacuicultura integrada: manual básico. Roma: FAO, 2003. p.17-18. (FAO Documento Técnico de Pesca Nº 407).

QUEIROZ, J. F.; BOEIRA, R. C. **Boas práticas de manejo (BPMs) para reduzir o acúmulo de amônia em viveiros de aquicultura**. Jaguariúna, SP: Embrapa Comunicado Técnico, n. 44, 2007.

REZENDE, R. *et al*. Produção e qualidade comercial de alface fertirrigada com nitrogênio e potássio em ambiente protegido. **Revista Ceres**, abr. 2017, vol.64, no.2, p.205-211. ISSN 0034-737X.

SALLES, J. S.; STEINER, F.; ABAKER, J. E. P.; FERREIRA, T. S.; MARTINS, G. L. M. Resposta da rúcula à adubação orgânica com diferentes compostos orgânicos. **Revista de Agricultura Neotropical**, Cassilândia-MS, v. 4, n. 2, p. 35-40, abr./jun. 2017.

SANTOS, F. J. S. **Cultivo de tilápia e uso de seu efluente na fertirrigação de feijão-vigna**. 2009. 162 f. Tese (Doutorado) - Curso de Engenharia Agrícola, Universidade Federal de Campina Grande, Campina Grande, 2009. Disponível em:

<http://www.alice.cnptia.embrapa.br/alice/bitstream/doc/937671/1/TeseSeixas.pdf>, acesso em: 21 agosto de 2017.

SANTOS, M. A. L. *et al*. Produção da cultura da alface (*Lactuta sativa* L) em função das lâminas de irrigação e tipos de adubos. **Revista Ciência Agrícola**, v. 13, n. 1, p. 33-39, 2015.

SANTOS, R. H. S.; SILVA, F. D.; CASALI, V. W. D.; CONDE, A. R. **Efeito residual da adubação com composto orgânico sobre o crescimento e produção de alface**. Pesquisa Agropecuária Brasileira, Brasília-DF, v. 36, n. 11, p. 1395-1398, 2001.

SCHOEDER, G. L. Autotrophic and heterotrophic production of microorganisms in intensely – manured fish ponds, and related fish yields. **Aquaculture**, v. 14, p. 303-325, 1978.

SCHUMACHER, M. V. *et al.* Influência do vermicomposto na produção de mudas de Eucalyptus grandis Hill ex Maiden. **Ciência Florestal**, Santa Maria, v. 11, n. 2, p. 121-130, 2001.

SEDIYAMA, M. A. N.; ALMEIDA, C. H. S.; VIDIGAL, S. M.; LOPES, I. P. C.; NASCIMENTO J. L. M. **Efeito residual da adubação orgânico do pepineiro sobre a nutrição e produção de feijão-vagem em cultivo subsequente**. 2012. Horticultura Brasileira 30. V:2. S5549-S5556.

SEDIYAMA, M.A.N.; MAGALHÃES, I.P.B.; VIDIGAL, S.M.; PINTO, C.L.O.; CARDOSO, D.S.C.P.; FONSECA, M.C.M.; CARVALHO, I.P.L. Uso de fertilizantes orgânicos no cultivo de alface americana (*lactuca sativa* l.) 'kaiser'. **Revista Brasileira de Agropecuária Sustentável**, v.6, n.2, p.66-74, 2016.

SILVA, C. K. *et al*. (2016). Efeito residual da adubação com composto orgânico no crescimento e desenvolvimento da alface. **Revista Univap**. 22. 84.

SILVA G. P. P.; RESENDE FV; SOUZA RB; ALBUQUERQUE JO; VIDAL MC; SOUSA JMM. 2011. **Desempenho agronômico de cultivares e de níveis de adubação para o cultivo orgânico do pepino no período chuvoso do cerrado**. Horticultura Brasileira 29: S4601-S4608.

SOGLIO, F. D; KUBO, R. R. **Desenvolvimento, agricultura e sustentabilidade**. Coordenado pela SEAD/UFRGS. Porto Alegre: Editora da UFRGS, 2016.

SOUSA JUNIOR, G. S. *et al*. Aproveitamento de água residuária da piscicultura na fertirrigação do tomate, **Congresso de iniciação científica**, 21ª edição, São Carlos, SP, Anais de Eventos da UFSCar, v. 9, p., 2013.

SOUSA, V. F. de; MAROUELLI, W. A.; COELHO, E. F.; PINTO, J. M.; COELHO FILHO, M. A. (Ed.). **Irrigação e fertirrigação em fruteiras e hortaliças**. Brasília, DF: Embrapa Informação Tecnológica, 2011. 769 p. il.; 18,5 cm x 25,5 cm.

SOUZA, R. T. M.; VERONA, L. A. F.; FACHINELLO, M.; MARTINS, S. R. Insumos em agroecossistemas familiares com produção de base ecológica na região oeste de Santa Catarina, **Workshop Insumos Agricultura Sustentável**, Santa Catarina - SC, p. 1-6, 2012.

TOLEDO, J. J. de *et al.* Avaliação do impacto ambiental causado por efluentes de viveiros da estação de piscicultura de Alta Floresta – Mato Grosso. **Revista do Programa de Ciências Agro-ambientais**, Alta Floresta, v. 2, n. 1, p.13-31, 2003.

TRANI, P. E; PASSOS, F. A.; ARAÚJO H. F. **Calagem e adubação do pepino**, Instituto Agronômico, Centro de Horticultura, Campinas (SP), fevereiro de 2015.

VON SPERLING, M. **Princípios de tratamento biológico de águas residuárias**: lagoas de estabilização, Belo Horizonte: UFMG – Departamento de Engenharia Sanitária e Ambiental, 1996. v. 3.

WWAP (United Nations World Water Assessment Programme). **Relatório mundial das Nações Unidas sobre desenvolvimento dos recursos hídricos 2018**: soluções baseadas na natureza para a gestão da água. Paris, UNESCO, 2018.