Use of fish farming water in the irrigation of plants with economic interest: a case study in the Brazilian Backwoods

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Abstract

Most Brazilian soils are known to present a low natural fertility. This problem is most evident in the Brazilian Backwoods, mainly due to their edaphoclimatic conditions. In opposition to the agriculture challenges, on the other hand, activities of fish farming have been growing in Brazil. However, aquaculture is an activity that generates effluents with a high amount of organic matter (OM) and nutrients. In a dual perspective, to solve the problem of the low soil fertility and the toxic potential of the effluents generated in the fish farming, the implementation of integrated farming systems could be an interesting alternative, proposing to reuse the water from fishponds by enhancing OM and recycling nutrients via irrigation. Thus, the present work aims to carry out a chemical study of water from fishponds for use in irrigation of plants of economic interest. The soil collected and characterized in this study was a dystrophic Red-Yellow Argisol (dRYA). Samples of FFW and the dRYA was characterized and its physical/chemical attributes determined. According to the results, chemical characteristics allow the FFW the in the irrigation of plants with economic interest. Since dRYA is low in OM (2.12%), TOC (0.43%) and %V (47%), soil samples showed a non-natural fertility at a level of considerable profitability. Thus, according to our findings (about FFW and dRYA chemical characterization), it is possible to consider the use of water from fish farming in the soil/plant irrigation. At future, agronomic assays will be carried out in order to evaluate the real effects of the FFW irrigation in an organic-agroecological farm, in a family nucleus system of production, in the Brazilian Backwoods.

Key-words: Fish Farming Water, Brazilian Backwoods, Organic Matter, Organic Agriculture

In recent decades, Brazil has passed from a major food importer to one of the most important exporters. In this sense, agriculture is extremely important for the overall performance of the country economy (Embrapa, 2018). Actually, one of the challenges in agriculture is the quality of the Brazilian soils, which are mostly low in natural fertility; since they are high weathered, acidic and poor in organic matter (OM) and nutrients, resulting in a low agricultural productivity (Manzatto et al., 2002). This problem is aggravated in the Northeast Region, which has a semi-arid climate, characterized by a water deficit and an irregular rainfall pattern, resulting in a poor environment for agricultural production (Buainain and Garcia, 2013).

On the other hand, fish farming activity has been growing in Brazil. In 2018, the country became the 4th largest fish producer in the world. Thus, Brazilian fish farming is a growing activity with a great potential due to the country water resources and favorable climate (Medeiros, 2019). In the Northeast Region, fish farming has been prominent, since the low rainfalls and the periods of prolonged drought make it difficult for ruminant creation and commercial-proteins production. While 17 ML of water are needed to produce 1 kg of cattle protein,
only 800 L is required for the same amount of fish. (Baiardi and Alencar, 2015).

According to Queiroz et al. (2004), aquaculture is considered an activity that generates liquid effluents that present a high amount of OM and nutrients. Considering the challenges concerning poor soil fertility and the toxic potential of fish farming effluent, the implementation of an integrated farming systems, such as agriculture-aquaculture, could be an interesting alternative. In this system, water from fishponds could be applied for soil/plant irrigation, thus incorporating OM and nutrients to the substrates, increasing the production and the generation of farm profit (Oliveira and Santos, 2015).

This work aims to conduct a chemical study of water from fishponds and samples of dystrophic Red-Yellow Argisol (dRYA) for possible use in irrigation of plants of economic interest in an integrated system.

Farms, municipality of Itacuruba, Pernambuco State, Brazil (08°43'48'' S; 38°40'48'' W). To characterize the water from the fishponds (FFW sample), the following parameters were analyzed: pH (using an Even PHS-3E pH meter; Araucária, Brazil), electroconductivity (EC) (using a Tecnopon MCA 150; Piracicaba, Brazil), turbidity (using a TU430 digital probe; São Leopoldo, Brazil), total organic carbon (TOC) (using a Shimadzu TOC-V CPH spectrophotometer equipped with a spectrophotometric detector operating in the infrared region, model Shimadzu SSM- 500 Kyoto, Japan), and the contents of macro- and micronutrients (Nogueira and Souza, 2005).

The collections were carried out in May 2018 according to the National Guide for Water and Soil Collection (CETESB, 2011).

Dystrophic Red-Yellow Argisol (dRYA) samples were collected at the Federal Rural University of Pernambuco (UFRPE) in the municipality of Serra Talhada, Pernambuco, Brazil (07°57'11.4" S; 38°17'41.0" W).

For sample preparation, soil was air-dried and sieved to 10 mesh (2 mm) for future analysis and measurements. To characterize the dRYA, the following analyses were performed: total solids (TS) (ISO, 1993), TOC and OM (NEN, 1994), pH (ISO, 1994), EC (PIPER, 1942), cation exchange capacity (CEC) — comprehending by the sum of ‘exchangeable acidity’ (A) and ‘sum of bases’ (SB) — and base saturation (%V) (ISO, 1994).

Statistical tests and analyses were performed using the software SPSS Statistics v. 25, developed by IBM®.

Fish farming water had a pH of 6.71, an electroconductivity of 81.21 µS m⁻¹, a turbidity of 5.14 NTU, and TOC of 111.47 mg L⁻¹ (Table 1). According to the Brazilian environmental legislation (Brasil, 2011), the pH and turbidity of the sample are within the ideal range for its use in irrigation.

For pH, the allowable value may vary from 6 to 9 and, for turbidity, values up to 100 NTU are allowed (Brasil, 2011). Furthermore, turbidity value is related to the concentration of particulate organic matter in fish ponds, mainly OM from fish manure and residues of fish food (Fay and Silva, 2006). According to Silva et al. (2011), EC is within to ideal range, which may range from 0 to 25,000 µS m⁻¹. Due its low salinity, FFW sample can be applied for the soil/plant irrigation of most crops, with small perspective of developing future soil salinity problems. In addition, The CONAMA Resolution no. 430/2011 does not establish an normative or guiding value for TOC (Brasil, 2011). The evaluation of the nutritional values of FFW was made by analyzing the contents of its macro- and micronutrients (Table 2).
Table 1. Fish farming water (FFW) physical/chemical characteristics.

| Parameter       | FFW             |
|-----------------|-----------------|
| pH              | 6.71 ± 0.02     |
| EC (µS m⁻¹)     | 81.21 ± 2.45    |
| Turbidity (NTU) | 7.68 ± 5.55     |
| TOC (mg L⁻¹)    | 111.47 ± 2.40   |

ACRONYMS: FFW Fish farming water; EC Electroconductivity; TOC Total organic carbon.

Table 2. Macro- and micronutrients determined on samples of fish farming water (FFW).

| Nutrient | FFW (mg L⁻¹) |
|----------|--------------|
| P        | 0.02 ± 0.01  |
| K        | 6.84 ± 0.15  |
| Mg       | 4.20 ± 0.25  |
| Ca       | 9.60 ± 0.04  |
| Na       | 0.10 ± 0.01  |
| Fe       | 0.51 ± 0.04  |
| B        | n.d.         |
| Cl       | n.d.         |
| Cu       | 0.22 ± 0.01  |
| Zn       | n.d.         |
| Mn       | 0.02 ± 0.00  |
| Mo       | n.d.         |

ACRONYMS: FFW Fish farming water; n.d. Not detected or detected below the detectable level.
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**Fig. 1.** Test of moisture retention using a Dystrophic Red-Yellow Argisol (dRYA) percolated by samples of fish farming water (FFW) and conventional water of irrigation (TW; tap water) at predetermined times.

**Table 3.** Chemical and physical characteristics of a Dystrophic Red-Yellow Argisol (dRYA) for use in agronomic assays, in an integrated system of agriculture.

|                      | dRYA          |
|----------------------|---------------|
| TS (%)               | 99.12 ± 0.03  |
| pH                   | 5.08 ± 0.04   |
| EC (µS m⁻¹)          | 89.83 ± 4.23  |
| OM (%)               | 2.12 ± 0.17   |
| TOC (%)              | 0.43 ± 0.02   |
| A (cmolc kg⁻¹)       | 32.07 ± 0.13  |
| SB (cmolc kg⁻¹)      | 29.11 ± 0.26  |
| CEC (cmolc kg⁻¹)     | 61.18 ± 0.33  |
| %V (cmolc kg⁻¹)      | 47.58 ± 0.22  |

**ACRONYMS:** dRYA Dystrophic Red-Yellow Argisol; TS Total solids; EC Electroconductivity; OM Organic matter; TOC Total organic carbon; A Exchangeable acidity; SB Sum of bases; CEC Cation exchange capacity; %V Base saturation.
The analyzed soil presented typical characteristics suitable for a dRYA, i.e., an Argisol with low content of OM (2.12%) and TOC (0.43%), besides low %V (47.58 cmolc kg$^{-1}$) (EMBRAPA, 2018) (Table 3). Regarding to the electroconductivity, EC was 89.83 µS m$^{-1}$. In addition, the dRYA had an acidity of 32.07 cmolc kg$^{-1}$ (Al$^{3+}$ and H$^{+}$) and a pH of 5.08, typical of Brazilian Backwoods soils; a value outside to the ideal soil pH, which should range from 6.0 to 6.5, for most crops grown in Brazil (EMBRAPA, 2018).

Since the value of pH was below 6.0, aluminum can be toxic for most plants and directly interfere in the nutrient absorption (Ronquim, 2010). On other hand, the pH of FFW sample was 6.71 (Table 1); therefore, it is expected that FFW application may raise the soil pH, avoiding losses by nutrient lixiviation and supporting the nutrient absorption. Thus, the suggested integrated system of agriculture may lead a decreasing in the usual practices of conventional agriculture, e.g., liming and the excessive use of pesticide; and this way, collaborate with the development and application of organic/agroecological models of modern farming practices.

Based in our findings, the dRYA is low in OM and nutrients, making necessary to adapt it for an agriculture of high production. In this perspective, FFW application can improve soil fertility by incorporating OM and nutrients.

Tests of moisture retention was carried out in order to know the potential of FFW to enhance the retention of moisture in a dRYA when compared to the use of a conventional irrigation water (TW) (Figure 1).

After 21 days, the TW sample presented a moisture equal to the initial one, near 0.8% (TS = 99.12% ; Table 3). On the other hand, FFW sample kept moisture near 16% moisture. After 42 days, FFW sample reached the dRYA initial moisture.

The mean differences in the moistures when compared results of TW and FFW can be understood in terms of the role of the OM and nutrients presents in the soil. An important function of the OM is the capacity in to retain water molecules and nutrients in the soil particles, keeping it wetter for a longer time, improving soil quality and potential for an agricultural use (Cunha, Mendes and Giongo, 2015).

The studied soil — typical from Brazilian Backwoods — has a low content of OM and nutrients. Therefore, it is necessary to adapt it for an agricultural use. Through irrigation using fish farming water, the recycling and reuse of the OM and the nutrients can improve the soil quality and fertility, with a focus on the crop production and income generation in the countryside. Thus, agricultural productivity is expected to increase and make the Brazilian Backwoods an environment more favorable for agricultural practices, with emphasis on organic and agroecological systems of agriculture.

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