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Treated sewage effluent as a source of water and nitrogen for Tifton 85 bermudagrass

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ABSTRACT

The use of treated sewage effluent in agriculture has been a current practice in several countries. However, in Brazil, there are few studies about this subject. This research work aimed at evaluating the potential utilization of secondary-treated sewage effluent (STSE) as an alternative source of water and nitrogen (N) for Tifton 85 bermudagrass pasture. A field experiment was carried out at Lins, State of São Paulo, Brazil, for 2 years, using a randomized complete block design, with four replications and five treatments, as follows: (i) T1 (control) – irrigation with potable water and addition of mineral-N fertilizer (MNF) – 520 kg N ha^{-1} $year^{-1}$; (ii) T2–T5 – irrigation with STSE (31.9 mg total-N L^{-1}) and addition of MNF – 0, 171.6, 343.2 and 520 kg N ha^{-1} $year^{-1}$, respectively. Potable water and STSE characteristics were monitored monthly; above ground grass dry matter yield (DM) and crude protein content (CP) were determined bimonthly. Increases in DM and CP were observed for the high MNF rates associated with irrigation with STSE. STSE irrigation can efficiently substitute potable water for irrigation of Tifton 85 bermudagrass pasture and, simultaneously, save 32.2–81.0% of the recommended N rate without loss of grass DM and CP yield.

1. Introduction

The application of treated sewage effluent (TSE) in the soil–plant system through irrigation is a recent practice in Brazil (Fonseca et al., 2005). TSE irrigation is a source of water recycling and it provides a source of N that can provide the needs for plant nutrition and increase crop yields (Smith and Peterson, 1982). Also, it is a low cost (Bouwer and Chaney, 1974) and ecologically correct alternative for the wastewater destination in the environment (Toze, 2006).

Crops chosen to receive TSE irrigation should present the following characteristics: (i) high water and N demands; (ii) good potential use; (iii) marketable and economically viable (Segarra et al., 1996). Considering the large Brazilian pasture coverage area, they might constitute a great potential for TSE irrigation. ‘Tifton 85’ hybrid bermudagrass (*Cynodon dactylon* Pers. X *C. niemfuensis* Vanderyst) pasture stands out among the pasture cultivars, because of its characteristics: (i) high quality yielding potential and good hay quality potential (Hill et al., 1993); (ii) highly responsive to N fertilization (Alvim et al., 1999) and the response is closely related to the soil water potential (Marcelino et al., 2003); (iii) high water and nutrient uptake rates (Fageria et al., 1997); (iv) high tolerance to salinity (Grattan et al., 2004) and sodicity (Grieve et al., 2004); (v) a

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pasture crop that adequately fits the main criteria established by Segarra et al. (1996).

This research work aimed at evaluating the potential utilization of secondary-treated sewage effluent (STSE), as a source of water and nitrogen for Tifton 85 bermudagrass pasture during a 2-year period.

2. Materials and methods

The experiment was carried out at the municipal district of Lins, State of São Paulo, Brazil (longitude: 49°50′W; latitude: 22°21′S; average altitude: 440 m; average slope 10%), close to the sewage treatment plant (STP), which is operated by Sabesp (Company for basic sanitation of the State of São Paulo). The soil of the experimental area is a Typic Haplustult (Soil Survey Staff, 1999), sandy clay loam, cropped with Tifton 85 bermudagrass. Prior to the experiment, the area was a fallow land. Four months before grass planting it was limed with 2.0 Mg ha^{-1} of dolomitic limestone (30.8% of CaO and 19.8% of MgO). This rate was used to raise base saturation to 60% in the 0–20 cm layer, to correct soil acidity and to provide adequate conditions for pasture establishment, according to Werner et al. (1996). The grass cultivar was seeded in January 2002 and 12 months later the experiment started. At this time, composite soil samples were collected and used for chemical (Van Raij et al., 2001), mineralogical (Embrapa, 1997) and physical (Camargo et al., 1986) analyses. Intact soil samples were taken to determine the water retention curve, according to Camargo et al. (1986).

The experiment was arranged in a randomized complete block design with five treatments and four replications. The treatments consisted of: (i) T1 (control), irrigation with potable water and addition of mineral-N fertilizer (MNF), 520 kg N ha^{-1} year^{-1}; (ii) T2–T5, irrigation with STSE and addition of MNF, 0, 171.6, 343.2 and 520 kg N ha^{-1} year^{-1}, respectively. Plot size was 100 m^2 (10 m × 10 m) and plots were 10 m apart. The crop area in each plot that was sampled to determine yield was 48 m^2, because the border areas (1 m each side) and the central area (16 m^2) were not used. This was necessary, because the conventional sprinklers were located in the middle of each plot, at a height of 90 cm, and the irrigation was unequally distributed to these areas.

Irrigation management was based on the critical volumetric water content in the 0–60 cm layer. Tensiometers were installed at 0–20, 20–40 and 40–60 cm soil layers in all plots in the harvested area and the matrix potential (ψ_m) was monitored every 2 days, in the morning. The ψ_m values obtained and the water retention curve data (Table 1) were fit to the van Genuchten equation (Van Genuchten, 1980) to calculate the volumetric water content, using a computer program—Soil Water Retention Curve (Dourado-Neto et al., 2000).

The available water capacity (AWC) for the Tifton 85 bermudagrass, at the 0–60 cm layer, was estimated by the difference between the volumetric water content at $\psi_m = -19.6$ and -1470.1 kPa. Irrigation started when soil volumetric water content was 50% of AWC. Corresponding amount of potable water or STSE was applied to the soil–plant system, according to the respective treatment. Due to the high sodium adsorption ratio (SAR) of the potable water and the STSE (Table 2), 16% extra irrigation water (potable water and STSE) was applied (Ayers and Westcot, 1985).

The fertilization of the experiment plots was based on recommendations of Werner et al. (1996) for a forage/hay production system. All plots received the same annual rates of potassium (potassium chloride) and phosphate (simple superphosphate). Potassium was applied at a rate of 416 kg K_2O ha^{-1} year^{-1}. Phosphorus was applied in the beginning of the experiment at a rate of 100 kg ha^{-1} (P_2O_5), plus 50 kg ha^{-1} every 6 months. MNF (ammonium nitrate) was applied at increasing rates (0–520 kg N ha^{-1} year^{-1}), according to the respective treatment. Nitrogen and potassium fertilizers were manually distributed, just after every grass cut, according to Premazzi et al. (2003). Phosphate was always applied after three cuts.

The grass was harvested bimonthly, cut 5 cm above ground (12 cuts between 15 January 2003 and 14 January 2005), using a portable motorized grass trimmer. Total dry matter (DM) and crude protein (CP) yield were estimated by harvesting a 1.0 m^2 area randomly located within the harvested area of each plot. After taking grass sub-samples for CP determination, the remaining sample was dried at 60 °C until the mass was constant for DM determination. The grass sub-samples were rinsed in distilled water, separated into leaves and culms + - sheaths, oven dried at 60 °C for complement the DM calculation, grinded in a Wiley type mill, passed through a sieve with 0.85 mm mesh and stored in capped vials. For N-determination the samples were submitted to sulphuric acid digestion and determined by the semi-micro-Kjeldahl procedure, proposed by Malavolta et al. (1997). CP was estimated by multiplying N-concentrations by a factor of 6.25, according to ISO 5983 (ISO, 1997).

Rainfall and the amount of applied water (potable water and STSE) were measured and are presented in Fig. 1. The potable water used in treatment T1 was the current tap water treated by Sabesp. The STSE used for irrigation was generated in the STP located close to the experimental area. This plant is constituted by stabilization ponds, three anaerobic and three facultative ponds. The effluents have stayed in the anaerobic ponds for 5 and 15 days in the facultative ponds.

Samples of potable water and STSE were monthly collected before the waters entered the irrigation pump system. The samples were then refrigerated at 4 °C. Each sample was separated in three sub-samples: (A) unfiltered; (B) filtered through a 0.45 μm pore diameter glass microfiber; (C) filtered through a 0.22 μm pore diameter ester-cellulose membrane. Sub-samples (A) were submitted to analyses for the pH, electrical conductivity (EC), total solids (TS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD), according to APHA (1994). Mercuric chloride was added to the filtrates of sub-samples (B) to achieve a solution concentration of 30 mmol L^{-1} in order to preserve the samples. The samples (B) were then refrigerated until analyzed for dissolved organic carbon concentration (DOC) using a Shimadzu TOC-5000A equipment. The solid particle fraction, retained in the glass microfiber after sub-samples (B) filtering was submitted for analyses of total carbon (TC) and total nitrogen (TN) by dry combustion (Nelson and Sommers, 1996). The filtrates of sub-samples (C) were also preserved with mercuric chloride and then refrigerated until analysis. The samples (C) were used to determine the following parameters: (i) K and Na by flame