Soil chemical attributes, technological quality and yields of sugar cane submitted to organic and mineral fertilizers

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Abstract
The experiment was carried out to evaluate the effects of organic and mineral fertilizers on soil chemical properties, technological quality and yield of sugar cane, performed in a field experiment in the city of Dracena, São Paulo, Brazil. The experimental design was a randomized block with four replications. For the treatments two compounds were produced. Compound 1: sugar cane bagasse (70%) + ashes (10%) + byproduct of tanning (20%) + decomposing microorganisms; Composite 2: sugar cane bagasse (70%) + ashes (10 %) + byproduct of frigorific (20%) + decomposing microorganisms. The evaluated treatments were the following: 1) 275 kg/ha (half dose) of mineral fertilizer 5 25 25; 2) 10 t/ha of compost 1 + treatment 1, 3) 15 t/ha of Compound 1 + 1 treatment; 4) 20 t/ha of compost 1 + treatment 1, 5) 10 t/ha of compost 2 + treatment 1, 6) 15 t/ha of compost 2 + treatment 1, 7) 20 t/ha of compost 2 + treatment 1. There was a change among the sources in calcium content in the soil only for the application of 15 t/ha of compost, however, all values are considered low. There was no difference in the phosphorus in the soil between the doses of compounds. The concentration of P in soil is directly proportional to the doses of organic compost. The pH, organic matter, K, Mg, S-SO_4^{-2}, Al, B, Cu, Mn, Fe and Zn in soil were not affected by the doses of organic compost. The dose of 15 t/ha of organic compound associated with 275 kg/ha of mineral fertilizer (5 25 25) gave the best response in the production of stems of sugar cane. The average doses of organic compost with the byproduct of frigorific showed higher cane yield. Technical quality was not affected by the treatments.

Key Words
Composting, Saccharum spp., plant nutrition.

Introduction
With the growth of agribusiness in Brazil, the volume of organic waste is increasing. Such waste can be recycled through composting and used sustainably since they are sources of raw material for production of organic fertilizers. If these residues do not have a suitable target, they can cause problems to sanitation, through contamination of water, soil, plants and animals. There is a range of organic waste that can be applied in agriculture, for example, cattle manure, chicken manure, swine manure, filter cake, castor bean, green manure, peat, among others. Composting is a viable treatment, allowing the co-processing of various waste products generating good agronomic characteristics (Fernandes *et al.* 1993). Composting can be defined as a biological process, aerobic and controlled by means of which it is possible humified organic material, resulting in the final product as organic compost. During the thermophilic phase of composting, pathogens are eliminated from the mass of the compound, and this is a fundamental process from the standpoint of health (Matos *et al.* 1998). The need of additional mineral fertilization with the application of organic waste may be compared with the nutritional requirement and level of crop productivity, soil properties, type and quality of the material (Abreu Junior *et al.* 2005). The necessity of agricultural sectors to meet domestic and external demand is always stimulating the need for increasing productivity through minimizing environmental impacts. For this goal to be achieved it is essential there is good management of soil and adequate fertilization, to provide conditions for the development of the best features of the plant. This study aimed to evaluate the effects of organic and mineral fertilizers on soil chemical properties, technological quality and yield of sugar cane.

Methods

The experiment was carried out on a plantation of sugar cane variety RB835486, located in Dracena, São Paulo, Brazil. The soil of the area was classified Ultisoil. Chemical analysis was performed on soil samples collected in the 0 - 20 cm deep, with the following chemical properties: pH ($CaCl_2$) 4.6, organic matter, 12.0 g/dm^3; P (resin), 3, 0 mg/dm^3; S-SO_4^{-2}, 1.0 mg/dm^3; K (resin), 1.4 mmol$_c$/dm^3; Ca (resin), 6.0 mmol$_c$/dm^3; Mg (resin), 4.0 mmol$_c$/dm^3; Al, 2.0 mmol$_c$/dm^3; H + Al, 18.0 mmol$_c$/dm^3; sum of bases, 11.4 mmol$_c$/dm^3; capacity cation exchange, 29.4 mmol$_c$/dm^3; aluminum saturation, 0.15%; base saturation, 34.0%; B, 0.11 mg/dm^3; Cu, 0.6 mg/dm^3; Fe, 29.0 mg/dm^3; Mn, and 7.4 mg/dm^3; Zn, 0.9 mg/dm^3. In turn, the results of size analysis were: Clay, 130 g/kg; silt, 20 g/kg sand, 850 g/kg.

The experimental design was a randomized block with four replications. Each plot was consisted of 6 rows of sugar cane with 15 meters long, spaced at 1.4 meters. For the treatments two compounds were produced. Compound 1: sugar cane bagasse (70%) + ash (10%) + byproduct of tanning (20%) + decomposing microorganisms; Composite 2: sugar cane bagasse (70%) + ashes (10 %) + product of frigorific (20%) + decomposing microorganisms. The treatments were: 1) 275 kg/ha (half dose) of mineral fertilizer 5 25 25; 2) 10 t/ha of compost 1 + treatment 1, 3) 15 t/ha of compost 1 + treatment 1, 4) 20 t/ha of compost 1 + treatment 1, 5) 10 t/ha compound 2 + treatment 1, 6) 15 t/ha of compost 2 + treatment 1, 7) 20 t/ha of compost 2 + treatment 1. The dose of the compound was calculated on dry basis.

The fertilizers (organic and mineral) were applied in the furrow before the placing of stems. For evaluation of treatments, the soil was sampled at the time of harvest the stalks at 0 - 20 cm depth. For technology assessment were collected 10 stems at harvest, which was performed without straw removal by burning. Soil analysis followed the methodology described by Raij *et al.* (2001) and technological analyzes followed Fernandes (2003). The results were statistically evaluated by analysis of variance, interactions with comparison of means at 5% probability by Tukey test, correlation and regression study.

Results

The organic compounds produced from the waste and by-products for a composting period of 35 days showed the following characteristics on a dry basis: The byproduct of tanning: 0.70% total N; 0.08% P_2O_5; 0.11% K_2O; 2.07% Ca; 0.11% Mg; 0.50% S; and 24/1 C/N ratio. Byproduct of frigorific: 2.14% total N; 4.43% P_2O_5; 0.20% K_2O; 6.74% Ca; 0.24% Mg; 0.12% S; and 11/1 C/N ratio. Examining the interaction between doses and sources of compost, it was found that for the 0 – 20cm soil only Ca showed a significant effect. For the use of the compost residue frigorific the calcium content in the soil was higher at 20 t/ha, different from the treatment with application of 0 and 15 t/ha (Figure 1). Results can possibly be attributed to variations in sampling, since only t/ha caused a reduction in calcium content in the soil, a value lower than for the treatment without application of organic fertilizer.

Phosphorus had an effect for the average doses of compost in the 0 - 20 cm, with the highest values with application of compost and no statistical difference between the two organic fertilizers applied. As can be seen from the results of the analysis of compounds, phosphorus levels are higher in the compost with the addition of frigorific residues from the value found in the inclusion of tannery waste. However, even with the use of compounds with different phosphorus levels the levels in the soil after one year of application were similar. Possibly, the action of organic acids, humic acids and alcohols, which provide substances such as phenols, contribute to increased nutrient availability. There was a positive linear response to both nutrients a dose of 20 t/ha of organic compost (Figure 1).

The other chemical characteristics showed no significant effects. pH was 4.5 to 4.7; organic matter, 11.6 to 12.1 g/dm^3; K, 1.4 to 1.2 mmol$_c$/dm^3; Mg, 2.2 to 2.3 mmol$_c$/dm^3; S-SO_4^{-2}, 7.5 to 8.2 mg/dm^3; Al, 4.6 to 4.8 mmol$_c$/dm^3; B, 0.12 to 0.14 mg/dm^3, Cu, 0.45 to 0.52 mg/dm^3; Mn, 1.93 to 2.04 mg/dm^3, Fe, 4.15 to 4.74 mg/dm^3 and Zn, 1.09 to 1.13 mg/dm^3. The highest yield of cane was for the use of 15 t/ha compound, which did not differ between the treatments with application of organic fertilizer, but differed from the treatment with zero dose of compost, which is an increase in production of 10%. This increase in production of stalks of sugar cane due to fertilization with organic compost can be attributed to several factors, such as nutrient supply, improvement in the physical structure of the soil, increasing microbial activity, water availability, soil aeration and larger roots, reflecting the increased vigor of plants (Magalhães *et al.* 2006). Tthe interaction of all factors in different ways depends on soil and climate conditions and the variety of sugar cane.

The analysis of interaction between doses and sources of compounds indicated no significant difference, even though the preliminary analysis of the compound formed from frigorific had a higher concentration of nutrients. This result can be sustained by the introduction of organic material to soil, which provides a favorable environment for growth and production. The only difference was for the average of the sources of compost, with the highest straw yield for the treatments with compost generated by the inclusion of by-product of a frigorific (103.7 t/ha) compared to treatments with tannery compost (98.7 t/ha). The variables from technological analysis showed no difference between the treatments. Reducing sugars (glucose and fructose) 0.36 to 0.38%; total reducing sugars (sucrose, glucose and fructose) 17.65 to 18.54%; total recoverable sugar (TRS): 161.96 to 167.84 kg/t; reading sucrose: 85.00 to 88.25%; Purity: 84.20 to 93.21%; Fiber: 13.80 to 14.31%; Brix: 21, 97 to 22.65; Pol of sugar cane (sucrose apparent percentage): 16.41 to 17.27%.

Although there was statistical variation in the production of stems, TRS production per area was not significant in the analysis of interaction between doses and sources of compounds. In percentage terms, the treatment with high production of TRS was 15 t/ha of compost by-product of frigorific (17.59 t/ha) compared to treatment without compost (16.28 t/ha) was 8 %, which can become financially viable depending on the cost of mineral fertilizers. Evaluating the results of technological analysis, it was found that the increase in sugar yield due to higher straw yield in response to fertilization, treatments did not improve the technological quality of raw material ATR/ha and straw yield had a correlation of 0.90 with significance of $P < 0.0001$, while the correlation with for the concentration of ATR correlation was found.

Conclusion

Among the sources there was a change in calcium content in the soil only for the application of 15 t/ha of compost, however, all values are considered low; There was no difference between the doses of compounds in phosphorus in the soil; The concentration of P in soil is directly proportional to the doses of organic compost; The pH, organic matter, K, Mg, S-SO4-2, Al, B, Cu, Mn, Fe and Zn in soil were not affected by the doses of organic compost; Averaged across treatments, the organic compound containing the byproduct of frigorific had a higher yield of cane; The productivity of sugar is mainly increased by a larger straw yield production rather than by improving technological quality

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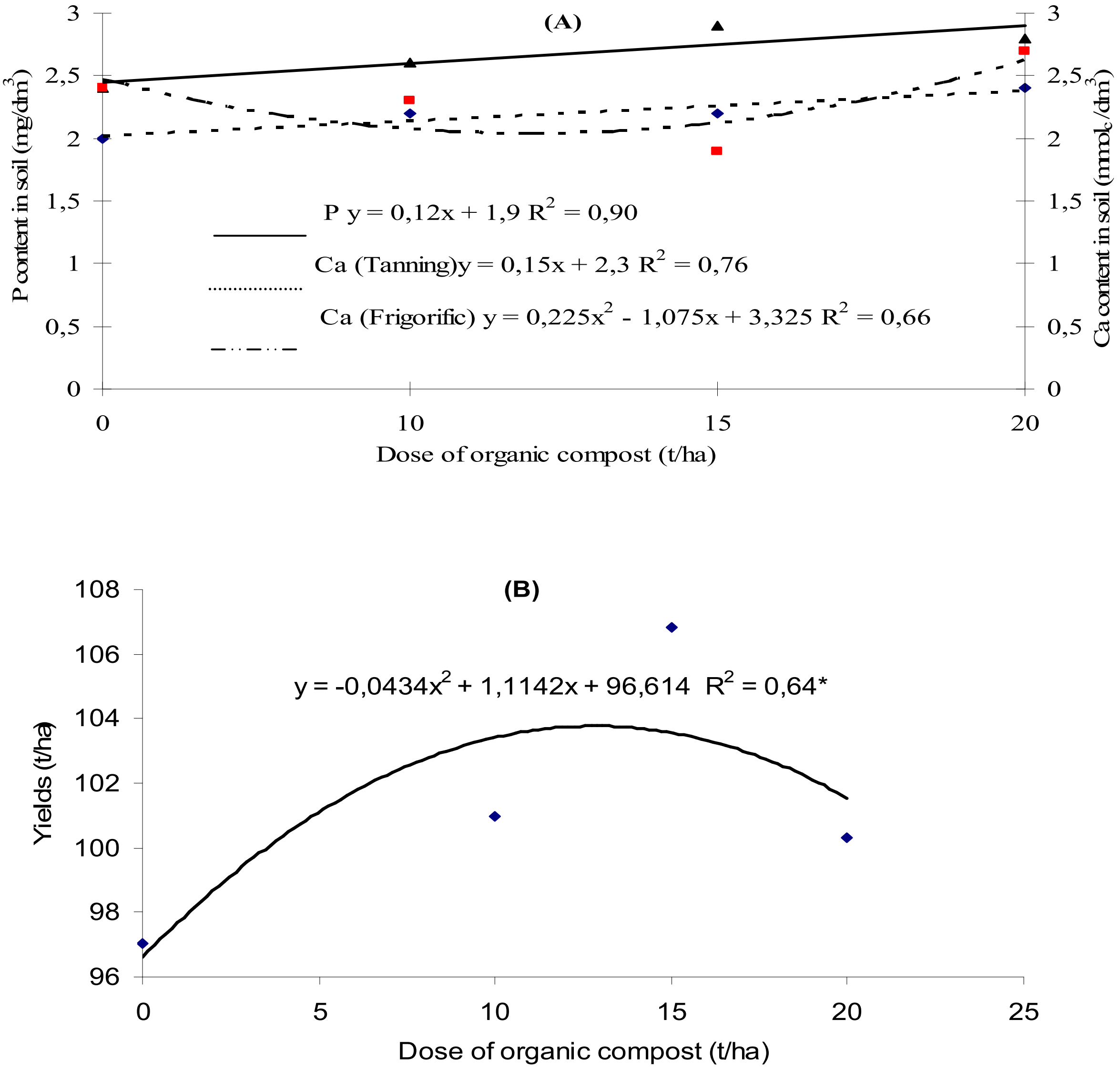

Figure 1. Average contents of phosphorus and calcium in the soil (A) and sugar cane yields (B) for doses of organic and mineral fertilizers. Agricultural year 2007/2008. Mineral fertilization with 275 kg/ha of 5:25:25.