Organic Acids and Biosolid Trace Elements Phytoavailability

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INTRODUCTION

Trace metals phytoavailability is a major concern related to land application of biosolids. Formation of soluble complexes between metals and organic acids exudates in the rhizosphere by plants or produced by microbial activity seems to play an important role on trace metals phytoavailability (Mench & Martin, 1991; Marschner, 1995). The present study was carried out: i) to determine organic acids present at the rhizosphere of different plant species cultivated in the presence or absence of biosolids; and ii) to assess the correlation between production of organic acids and the shoot content of trace elements.

METHODS

Marandu grass, eucalyptus, sugar cane, and corn were grown in control (sand) or biosolid-treated pots (sand+biosolid at a rate of 80 Mg ha^{-1}) in a greenhouse experiment with a hydroponics system. Organic acids were collected after 45 days of seedling growth using a collection method adapted from Koo (2001), as follows: pots were removed from the greenhouse, the grown media was flushed with deionized water, and the plants were exposed to the sun for 6 hours to maximize photosynthesis. Afterwards, organic acids were eluted from the plant growing media with 200 mL of deionized water (the water was retained in the pot for 10 minutes), collected in plastic bottles, filtered through a 0.2 μm membrane and lyophilized for further determination by chromatographic analysis (HPLC/C_{18} column). After collection, plants were harvested to determine trace element concentrations (EPA 3051, using ICP-OES). Trace element and organic acid concentrations were compared within treatments using Tukey (5%) and were also correlated to evaluate if organic acid concentration was related to trace element phytoavailability.

RESULTS AND DISCUSSION

The organic acid compositions slightly differed between species. Average percentages of the total determined organic acid concentrations were acetic 43.2, citric 31.1, lactic 20.4, and oxalic 5.3. Little variation in organic acid composition in rhizosphere was also observed by Koo (2001) in a greenhouse experiment evaluating six different species. Biosolid treatment resulted in the highest trace element concentrations in plant tissue for most species (Table 1) and also in the highest concentration of organic acids in the growing media (Table 2). For lactic and acetic acids, the interaction between presence of biosolid and plant specie factors was not significant, but acid concentrations (mmol kg^{-1} of soil) in sand+biosolid (SB) treatments was higher than in sand (S) treatments: lactic acid, 0.47 (S+B) and 0.38 (S) and oxalic, 0.12 (S+B) and 0.08 (S). Generally, sugar cane was the specie that presented the lowest organic acid concentration in the rhizosphere and also the lowest trace element concentration in plant tissue. In the same way, eucalyptus presented the highest organic acid and trace element concentrations, which supports the hypothesis that organic acid influenced trace element availability. Citric acid concentration did not correlate with any of the studied metals and lactic and oxalic acids did not correlate with Cr. Total acid concentration correlated significantly (5%) with Cd, Cr, Cu, Ni and Zn concentration in the shoots.

Table 1. Trace element concentrations within Marandu grass (M), sugar cane (SG), eucalyptus (E) and corn (C) grown under sand or sand treated with biosolid.

Species	Cd		Cr		Cu	
	Sand	Sand+Biosolid	Sand	Sand+Biosolid	Sand	Sand+Biosolid
M	0.12Aab (0.04)	0.46Aab (0.09)	0.10Aa (0.02)	0.22Bb(0.08)	7.60 Aa(2.20)	11.00Bb (0.88)
SC	0.07 Ab(0.02)	0.15Ac (0.02)	0.00Aa (0.00)	0.08Ac (0.03)	1.63 Ab(0.31)	2.85Bc (0.26)
E	0.26Aa (0.08)	0.59Ba (0.19)	0.11Aa (0.01)	0.28Bab (0.03)	10.97Aa (0.71)	23.88Ba(5.98)
C	0.11Aab (0.02)	0.35Bb (0.12)	0.01Aa(0.00)	0.41Ba (0.17)	7. 43 Aa(1.57)	11.18Bb (2.99)

Species	Ni		Zn	
	Sand	Sand+Biosolid	Sand	Sand+Biosolid
M	0.29Aa (0.04)	3.68Bc (0.44)	23.72 Ab (2.15)	130.46 Bb (6.14)
SC	0.10Aa (0.05)	0.52Ad (0.07)	11.75 Ab (1.81)	22.17 Bd (2.37)
E	0.97Aa (0.37)	6.59Ba (0.93)	45.07 Aa (3.58)	153.95 Ba (12.42)
C	0.01Aa (0.01)	5.34Bb (0.87)	16.83 Ab (1.79)	97.94 Bc (9.11)

Values followed by the same lower case letter within each column are not different (Tukey, 5%). Values for sand and sand+biosolid within each trace element followed by the same upper case letter within each line are not different (Tukey, 5%).

Table 2. Organic acid concentrations within Marandu grass, sugar cane, eucalyptus and corn grown under sand or sand treated with biosolid.

Species	Acetic		Citric		Lactic(1)	Oxalic(1)	Total	
	mmol kg^{-1}							
	Sand	Sand + Biosolid	Sand	Sand + Biosolid			Sand	Sand + Biosolid
No plant	0.02Ab (0.00)	0.08Ad (0.01)	0.02Ab (0.00)	0,09Ad (0,01)	0.22c (0.10)	0.02d (0.02)	0.18Ab (0.03)	0.52Ac (0.06)
Marandu	0.22Aab (0.05)	1.06Bb (0.27)	0.09Ab (0.02)	0,76Bb (0,19)	0.48b (0.11)	0.07bc (0.04)	0.81Ab (0.18)	2.42Bb (0.62)
Sugar cane	0.15Aab (0.0 3)	0.54Bc (0.08)	0.05Ab (0.01)	0,45Bc (0,06)	0.24c (0.06)	0.05cd (0.01)	0.45Ab (0.07)	1.29Bc (0.20)
Eucalyptus	0.40Aa (0.03)	1.39Bab (0.27)	0.56Aa (0.04)	1,05Ba (0,22)	0.73a (0.10)	0.26a 0.05)	1.93Aa (0.13)	3.44Ba (0.70)
Corn	0.37Aa (0.04)	1.40Ba (0.15)	0.13Ab (0.01)	0,92Bb (0,10)	0.48b (0.21)	0.10b (0.02)	0.98Ab (0.09)	3.01Bab (0.33)

(1) Interaction between presence of biosolids and specie factors is not significant (5%). Values followed by the same lower case letter within each column are not different (Tukey, 5%). Values for sand and sand+biosolid within each acid followed by the same upper case letter within each line are not different (Tukey, 5%).

CONCLUSIONS

The results indicated that the organic acid contents of the rhizosphere have a straight relationship with the phytoavailability of biosolids derived trace elements.

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REFERENCES

Koo, B.J. (2001) *Assessing bioavailability of metals in biosolid treated soils: root exudates and their effects on solubility of metals*. Riverside, Thesis (Ph.D.) – University of California. 261p.

Marschner, H. (1995) *Mineral nutrition of higher plants*. London, Academic Press. 889p.

Mench, M. and Martin M. (1991) Mobilization of cadmium and other metals from two soils by root exudates of *Zea mays* L., *Nicotiana tobaccum* L., and *Nicotiana rustica* L. *Plant and Soil*, 132:187-196.