SHORT COMMUNICATION

Heavy Metals Accumulation in Banana (*Musa spp.*) Leaves from Industrial Area in Rio de Janeiro

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Abstract:

Banana plants (*Musa spp.*) are a common fruit crop in tropical and subtropical region, being adapted to extensive area in Brazil. Besides their fruits, the banana leaves also offer nutritional, medicinal benefits, and may absorb and retain different heavy metals, acting as biomonitors for the assessment of heavy metal pollution in the environment. In this work, the concentrations of Aluminum (Al), Cadmium (Cd), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Nickel (Ni), and Zinc (Zn) were analyzed from banana plants cultivated near the Industrial District of Santa Cruz in the West Zone of Rio de Janeiro, Brazil. The leaves samples were dried, chopped, and submitted to acid digestion with nitric acid for metal quantification by optical emission spectrometers with inductively coupled plasma (ICP-OES) according to standard methods. When compared to chemical fingerprinting of different plant species, the banana leaves contain higher concentration of Al (1,190.57 ± 120.83 mg.kg^{-1}) and Mn (811.82 ± 422.01 mg.kg^{-1}) than the plant reference values. The concentration measurements for heavy metal contents of Cd (0.09 ± 0.05 mg.kg^{-1}), Co (0.15 ± 0.09 mg.kg^{-1}), Cu (5.86 ± 2.34 mg.kg^{-1}), Fe (89.22 ± 16.47 mg.kg^{-1}), Pb (1.54 ± 0.90 mg.kg^{-1}), Ni (3.10 ± 0.30 mg.kg^{-1}), and Zn (50.80 ± 13.90 mg.kg^{-1}) were also determined and are similar to reference values. Although it is complex to distinguish the origin of the heavy metals, bananas leaves can be used for environmental pollution detection and monitoring.

Keywords: biomonitoring; contaminants; heavy metals; industrial pollution

1. Introduction

Banana plants (*Musa* spp.) are one of the most important crops in several countries as a source of enriched food, being responsible for up 15% of total fresh fruit production and the fourth most relevant crop worldwide after rice, wheat, and maize [1]. This large percentage of production is suitable as the plants grow well in various conditions, recover rapidly after climatic alteration and have a large adaptation to intercropping and mixed farming [2]. In addition, various parts of the Musa plants such as the leaves, roots and flowers have been used in the treatment of insect bites and fresh wounds [3]. Plant leaves can absorb and retain different elements, acting as biomonitors for the assessment of heavy metal pollution in the environment [4]. In fact, many key plant species have been confirmed as an indication for environmental pollution [5].

Evaluation of heavy metals pollution in woody species have demonstrated that the species *Populus tremula* and *Salix caprea* have a significantly tolerance to high levels of heavy metals in soil and can be used in phytoremediation [6]. Aquatic macrophytes have recently been used as biological indicator in monitoring the heavy metals in water by analysing the metals contents in the roots, stem and leaves of *Myriophyllum spicatum* [7].

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On the other hand, the heavy metals content in leaves of the forest fruits (*Hippophae rhamnoides* and *Rubus fruticosus*) from the tailings dumps mining have revealed potentially toxic metals bioaccumulated in much larger quantities in the leaves of blackberry, highlighting the recommendation that these leaves may not used for medical purposes [8]. Futhermore, it was shown that greenhouse cultivation may increased metals' contents in vegetables such as cucumber (*Cucumis sativus* L.) and tomato (*Lycopersicon esculentum*) and may cause serious threat to human health [9].

In the present study, leaf samples of banana plants from an industrial area in Rio de Janeiro, Brazil were collected and determined the metal chemical elements. Air pollution in the study site is very high and comes from local and neighbor industries, representing a potential hazard to human health and environment [10]. Therefore, the aim of this study was to evaluate the usage of banana leaves as a baseline for future studies in environmental monitoring in tropical and subtropical regions where banana crops are grown by using a rapid method for heavy metal determination.

2. Results and Discussion

In this paper, the heavy metals were analyzed in banana leaves which are large, flexible, and waterproof. The concentration measurements (Figure 1) for heavy metal contents of Cd (0.09 ± 0.05 mg.kg^{-1}), Co (0.15 ± 0.09 mg.kg^{-1}), Cu (5.86 ± 2.34 mg.kg^{-1}), Fe (89.22 ± 16.47 mg.kg^{-1}), Pb (1.54 ± 0.90 mg.kg^{-1}), Ni (3.10 ± 0.30 mg.kg^{-1}), and Zn (50.81 ± 13.90 mg.kg^{-1}) were determined and were similar to reference values [11] and to different banana genotypes [12].

The leaf contents of micronutrients from twenty-four banana genotypes have been already determined in rural areas [12]. The manganese contents were 43 to 574 mg.kg^{-1} and iron 56 to 212 mg.kg^{-1}, been the micronutrients with the highest contents in leaves. Interesting, at all stages of growth, the highest concentration of manganese in the banana plants have been found in the leaves. Total content of Al is however very small, suggesting that the plant does not take up much Al from soil [13].

In the Industrial District of Santa Cruz, the concentrations of airborne particulate trace metals are very high in comparison with other urban and industrial areas around the world [10], suggesting an industrial atmospheric pollution input onto banana leaves. When compared to chemical fingerprinting of different plant species, the banana leaves contain higher concentration of Al ($1,190.57 \pm 120.83$ mg.kg^{-1}) and Mn (811.82 ± 422.01 mg.kg^{-1}) than the plant reference values (Figure 1).
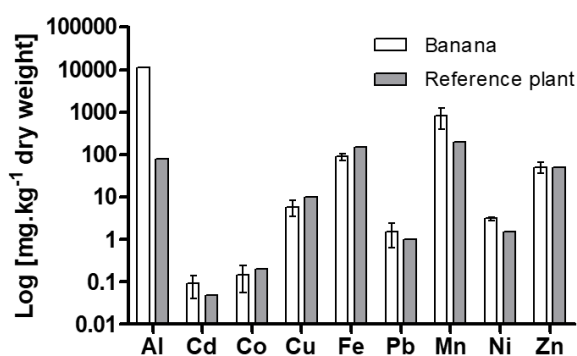

Figure 1. Heavy metal concentrations (mg.kg^{-1} dry weight) in banana leaves compared to reference plants [11].

Although it is complex to distinguish the origin of the heavy metals, bananas leaves can be used for environmental pollution detection and monitoring, as an enrichment of concentrations of the elements Al and Mn were observed, like previously shown using total suspended particles (TSP) and airbone particulate matter analysis [10].

3. Material and Methods

Fresh banana leaves were collected in Rio de Janeiro, Brazil at BASC (22°56'20"S; 43°43'1"W) in October 2016. The leaves were cut into smaller pieces for easy drying into paper bags at room temperature. The dried leaves (0.2 g) were extracted by adding 10 mL of nitric acid (Merck 65%) for 30 minutes at ultrasound and 1 hour at 60 °C [14]. The extracted solution was filtered (12 μM) and the metals were determined by optical emission spectrometers with inductively coupled plasma (ICP-OES) in quintuplicate following standards methods. The acquired results were in the range of the multielemental standard (Spex CertiPrep). Correlation

coefficient values of calibration curves were 0.998 or better. This technique has the follow detection limits for each elements: Al: 0.015 mg.L^{-1}; Cd: 0.002 mg.L^{-1}; Co: 0,005 mg.L^{-1}; Cu: 0.005 mg.L^{-1}; Fe: 0.01 mg.L^{-1}; Pb 0.002 mg.L^{-1}; Mn: 0.01 mg.L^{-1}; Ni: 0.005 mg.L^{-1}, Zn: 0.005 mg.L^{-1}. The statistical package GraphPad Prism 5 was used to analyze all data. The relationship between the groups was determined with Tukey test. A level of 0.05 and 0.01 alpha were used to determine the significance and correlation, respectively. The significance was reported as $p < 0.05$. Results are presented as means ± standard deviation.

4. Conclusions

Significant differences in foliar metal levels were observed and compared to published results, revealing that banana leaves can be used as a filter for metal determination. The measurements of heavy metal concentration in banana leaves obtained in this study have showed the accumulation of Al and Mn, reflecting the very high atmospheric pollution and soil contamination in this industrial area. The data described here can be used as a baseline for future studies in environmental monitoring in tropical and subtropical regions where banana crops are grown. The banana leaves may be used as biomonitors for the assessment of heavy metal pollution in the environment as they are easy to obtain and can retain different heavy metals, such as Aluminum, Cadmium, Cobalt, Copper, Iron, Lead, Manganese, Nickel, and Zinc.

Acknowledgments

References and Notes

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