Sugar Cane Nutrient Distribution Analysis

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Abstract. Neutron Activation Analysis (NAA), Molecular Absorption Spectrometry (UV-Vis), and Flame Photometry techniques were applied to measure plant nutrient concentrations of Br, Ca, Cl, K, Mn, N, Na and P in sugar-cane root, stalk and leaves. These data will be used to explore the behavior of element concentration in different parts of the sugar–cane to better understand the plant nutrient distribution during its development.

Keywords: micro and macro nutrients, Instrumental Neutron Activation Analysis, Molecular Absorption Spectrometry and Flame Photometry.
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INTRODUCTION

Macronutrients are basic elements required to give volume to the plants. Examples of macronutrients in plants are carbon, oxygen and hydrogen extracted from the air and water, and nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur extracted from the soil under natural conditions [1]. On the other hand, micronutrients are needed in small quantities in plant development. Examples of such micronutrients are boron, chlorine, copper, iron, manganese, molybdenum, nickel and zinc [1]. In this work we have quantified macro and micronutrients in different parts of the sugar-cane root, stalk and leaves, using three techniques: Neutron Activation Analysis (NAA) [2], Molecular Absorption Spectrophotometry (UV-Vis) [3] and Flame Photometry (FP) [4]. This study is important for understanding the transfer of nutrients from the soil to the plant.

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EXPERIMENTAL PROCEDURE

To study the distribution of macro and micro nutrients in the plant we collected one sugar-cane plant from the Centro Universitário da FEI, São Bernardo do Campo (SP, Brazil). The harvest was performed nine months after planting the sugar cane. The plant was separated into root, stalk and leaves. These parts were crushed, dried at about 100 ^{o}C for 24 hours and shredded to reach good homogeneity.

To determine the elements concentration using NAA, a sample of each part (root, stalk and leaves) was sealed into individual polyethylene bag, together with a standard (NIST 1573a certified reference material and synthetic element standards), and irradiated in a pneumatic station in the nuclear reactor (IEA-R1, 3.5 MW, pool type) at IPEN, allowing the simultaneous activation of these materials. After the irradiation, the activated materials (samples of sugar-cane and standard) are gamma-counted using an HPGe detector of high energy resolution and the peak areas, corresponding to gamma transitions, related to the nuclides of interest, are evaluated using in-house software [5].

To perform the molecular absorption spectrometry analysis (UV-Vis) it is necessary to react the analyte with an analyte-sensitive reagent [3] so the samples were digested using a microwave-assisted digestion [6]. This digestion was performed using nitric acid, following strategies suggested by Parkinson and Allen [7]. In order to perform the UV-Vis analysis an analyte sensitive reagent was used for calcium determination. Murexide was used as a complex-formation reagent according to the Murexide method [3]. The UV-Vis measurements were done with a CARY 500 (Varian) spectrometer. The flame photometry analysis does not need an analyte sensitive reagent; it needs only the sample in the liquid form. In this case the samples were prepared using the same strategies used for the UV-Vis analysis.

For both analytical methodologies, UV-Vis and FP, the analytical calibration is performed using diluted primary standards prepared at the same time, following the same procedures applied to the samples. The efficiency of each analytical curve is checked with the recovery of the diluted primary standard, and the detection limit is obtained with a blank sample (same sample matrix, but without the analyte concentration). All measurements are done in duplicate, in order to estimate the uncertainty measurement.

RESULTS AND DISCUSSION

The concentration of macro and micro nutrients Br, Ca, Cl, K, Mg, Mn, Na, N and P in specific parts of sugar-cane was measured using NAA, Flame Photometry and UV-Vis techniques. The results for root, stalk and leaves are presented in Table 1.

Using NAA, the elements Br, Ca, Cl, K, Mg, Mn, Na and P concentration can be determined simultaneously, which allows a fast analysis, mainly when quantitative analysis in a large number of samples for several elements must be done. Moreover, this technique is not destructive permitting the storage of the sample for future reexamination. Using FP and UV-Vis techniques the concentration of several macro and micro nutrient can be measured, but the detection limit depends on the analyzed element.

TABLE 1. Micro and macro nutrient (Br, Ca, Cl, K, Mg, Mn, Na, N and P) concentration present in the sugar-cane root, stalk and leaves using NAA, Flame Photometry and UV-Vis techniques.

Element	Root(g/kg)	Stalk(g/kg)	Leaves(g/kg)
Br	0.0096(4)[a]	0.0127(3)[a]	0.0105(4)[a]
Ca	1.10(3)[a]	1.89(4)[a]	1.20(4)[a]
	1.41(15)[b]	1.17(16)[b]	1.22(24)[b]
	<1.0[c]	1.07(2)[c]	1.08(2)[c]
Cl	0.84(2)[a]	3.44(3)[a]	3.69(4)[a]
K	7.5(3)[a]	21.7(6)[a]	18.9(5)[a]
	7.01(81)[c]	17.2(25)[c]	16.9 (23)[c]
Mg	1.77(5)[a]	1.66(5)[a]	1.90(5)[a]
Mn	0.104(4)[a]	0.053(2)[a]	0.074(3)[a]
Na	0.133(7)[a]	0.068(4)[a]	0.070(4)[a]
P	25.80(21)[a]	11.23(20)[a]	3.72(3)[a]

[a] NAA
[b] UV-Vis
[c] Flame Photometry

The deviations presented in Table 1 refer to the standard deviation obtained after four analysis of each sample by NAA. The element concentration was expressed by the mean value and the relative uncertainty expressed as a function of the error associated with the certified reference material used (NIST 1573a). Since the other elements values are not certified, synthetic standards were used (Br, Cl, Mg and P, with an uncertainty of the order of 0.5%). In the case of FP and UV-Vis analysis the deviation shown in the Table 1 are relative to the standard deviation of three analysis of each sample, i.e., three complete procedure of analysis (including sample digestion and complex formation). According to the statistics definition the uncertainty level in this situation is within 95% confidence level [7]. The uncertainties values are higher for these techniques due to the sample digestion which implies on the use of volumetric accessories.

The observed values for calcium concentration using the three techniques are compatible. Nevertheless, the lower concentration observed for calcium in the root (<1.0 g/kg) using the flame photometry technique is due probably to its higher detection limit. The concentration values for potassium using FP and NAA techniques are in agreement considering the uncertainties. According to NAA, the results for Br and Mg present no significant variation in different parts of the sugar-cane (root, stalk and leaves). Phosphorus presents a high concentration in the root decreasing for the aerial parts of the plant (stalk and leaves). The transfer process of this element during the plant development may be studied in detail. In the case of Mn and Na the results show also a higher concentration of these elements in the root with a lower constant value in the other parts of the plant. The results for chlorine indicate a higher concentration in the stalk and leaves.

CONCLUSION

In this work it was examined the viability of measuring macro and micro nutrients in sugar-cane using three different techniques: Neutron Activation Analysis (NAA), Flame Photometry (FP) and Molecular Absorption Spectrophotometry (UV-Vis).

These techniques are complementary and they can be extended to quantify other elements, which are also relevant in vegetable nutrition. These data will be used to explore the behavior of element concentration in different parts of the sugar–cane to better understand nutrient distribution during its development. These analytic techniques can also be applied to quantify other elements in vegetable nutrition.

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