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SOIL-PLANT RELATION IN CUBAN SUGAR CANE BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

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ABSTRACT:
This paper shows the result of soil-plant relation in samples from Cuban sugar canes of different soil types and cane varieties, using the INAA from thermal reactor. The behavior of minor and trace elements in sugar cane leaves is uniform and independent of sugar cane variety or type of soil. The soil-plant relation shows four principal groups of micro elements, according to their absorption by the plant.

Key words: multi-element analysis, neutron activation analysis, sugar cane, leaves, soil-plant relation, toxicity.

INTRODUCTION

The study of the soil-plant relation in sugar cane in Cuba is devoted almost entirely to the major elements and especially to the principal nutrients (N,P,K), using chemical and agrochemical methods. Normally, nuclear analytical techniques are not used. Also INAA with 14 MeV neutrons was used only in the NPK relation study [1].

Cuba is one of the largest cane sugar producers in the world, and as in other developing countries, the sugar cane plantations are 40-50 years old. In this long period, the degradation of the soil composition, especially from micro nutrients, is considerable, because usually their fertilization is only by NPK products.

Of the numerous inorganic analytical methods available, INAA with thermal neutrons from reactor is particularly well-suited for obtaining substantial information on the elemental composition of various environmental and biological samples [2], then this technique is considered as a competitive to study the soil-plant relation for micro nutrients.

sugar cane can be considered as a powerful micro element extractor plant, according to the Cu, Zn, Co, Ni and Mn concentrations in their leaves [15].

The presence of the determinated elements in sugar cane leaves is very important, because some of which are considered to be essential macro or micro nutrients. For example: *Ca* and *Mg* play significant roles in photosynthesis, carbohydrate metabolism, nucleic acid synthesis and chlorophyll [16]. Ca plays an important role in nitrogen metabolism and Mg in respiration. *Na* is useful for glycolysis for halophyte plants [17,18]. Its deficiency results in root stunt formation, reducing fruiting an inhibition of photosynthesis [12]. *Fe* and *Co* are essential activators for enzyme catalyzed reactions involved in chlorophyll, vitamin B_{12} synthesis and nitrogen fixation [19,20].

Al, Si and *As* are essential elements for the rigidity of plant tissues [17,21], *Mn* is a cofactor and activator for several enzymes involved in respiration and nitrogen metabolism. Its defiency causes a yellow green color of chlorophyll [19,22,23]. *Br* and *Zn* may enhance growth of the plant [24] and *Rb* in plant morphology. *Cu* and *Ti* are imprescindible in the chlorophyll synthesis [25]. *Cr* is essential for increasing glucose tolerance and has a vital function for lipid metabolism.

On the other hand, the soil-plant relation for Cuban sugar cane (Figure 2) shows four principal groups of micro elements, according to their absorption by the plant. Br, Cu, Hg, Rb and Sr can be considered as "very strong absorbed", so the relation is bigger 2 (e.g. 200% absorption). Au, Ba, Eu and Zn as "strong absorbed", As, Ce, Cs, Hf, Th and U as "regular absorbed" and the rest as "low absorbed".

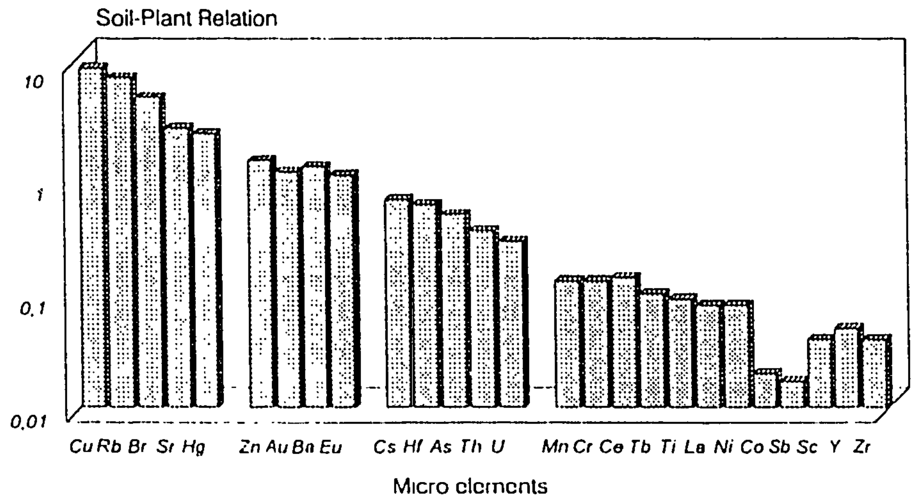

Figure 2.- Soil-Plant relation for micro elements in sugar cane.

This paper shows the result of soil-plant relation in samples from four sugar cane zones, different in soil types and cane variety, which are representative of the largest volumes of sugar cane planted in Cuba.

MATERIAL AND METHODS.

More than 100 sugar cane leaves and soil samples were taken from four important zones. All were burn at 400 °C, mechanically powdered in an Agate mill, homogenized and put in polyethylene or aluminum paper in portions of 50-80 mg. For the 5-100 hours irradiation in the thermal column aluminum containers were used. For the irradiation in the reactor reflector (2-3 minutes) polyethylene containers were used.

The samples were irradiated in three reactors: Triga Mark II (5 MW, 1.10^{12} $n.cm^{-2}s^{-1}$) at the Dalat Nuclear Research Institute in Viet Nam [3], IBR-2 (16 MW, 1.10^{12} $n.cm^{-2}s^{-1}$) in the Joint Institute for Nuclear Research, Dubna, Russia [4] and VVRS-M (10 MW, 5.10^{13} $n.cm^{-2}s^{-1}$) at the Nuclear Physics Institute of Uzbequistan [5]. X-Ray Fluorescence Analysis was used as complimentary technique.

The spectra were collected using semiconductor detectors (HPGe and Ge(Li) with 60-70 cm^3 sensible zone), with energy resolution between 2.8 and 3.2 keV for the 1332 keV line of ^{60}Co. Both detectors were connected to 4096 channel ADC linked to IBM-PC. The spectra were processed using the TPA version of the SPAN system [6].

The elemental concentrations were determinated by the relative method using certified materials NBS-SRM-1573 "Tomato leaves" [7] and SOIL-7 [8], according to the methodology described in [9]. The principal nuclear data were taken from [10].

RESULTS AND DISCUSSION

The quantitative analysis confirmed the presence of Ca, Fe, Mg, Na, Si and Al as major components. This is characteristic of plant composition [11]. All they (except Si) were determinated in Egyptian sugar cane stalks and refuse [12,13] but in lower concentration then reported values in this work. Variations of the results may be due to different botanical structures, change in chemical composition and different environmental conditions, geochemical and biogeochemical fractionation of the soils, etc.

The rest of the elements (Figure 1) were determinated as minor and trace elements concentrations. The symbols present the average concentration of the elements. Concentration loss from the burn at 400

°C [14] is considered. The statistical deviation takes values less than (2-3)σ for all elements. From the fixed elements, only Br, Au, As, Mn, Cr, U, La, Co and Sc were reported in [12,13] before. Its possible due the difference in sample preparation (dried to 100 °C in stalks and refuse, incinerated in leaves) and to the concentration power of leaves, respect to stalks in sugar cane. The incineration helped to the preconcentration of trace elements in biological samples [11].

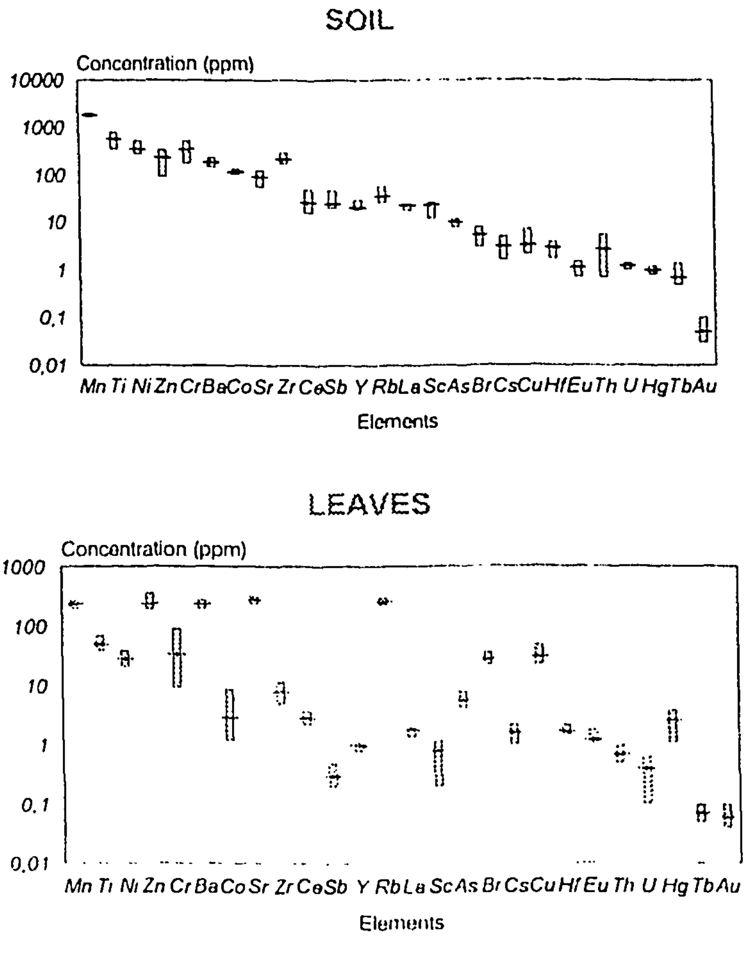

Figure 1.- Range of concentration values of minor and trace elements determinated by INAA.

One of the results of this research is: the behavior of minor and trace element's concentrations obtained by INAA in sugar cane leaves is uniform and independent of sugar cane variety or type of soil. Also the

All elements present in the first two groups play a specific role in the nutrition process of sugar cane. The role of Cu, Rb, Br, Zn has been studied in other works, but the roles of the rest of the elements have not been studied yet, and this is important, because the plant can absorb these elements only from the soil, usually they are not present in fertilizer composition. The poor absorption of essential elements as Mn, Cr and Ti is very interesting.

In 20-30 years of sugar plantation, the degradation of the soil may be considerable, because mechanization during the cutting prevents the micro elements returning to the soil. Manual work may be also an impediment, only in the case, when the cane plantation is cleared of the sugar cane leaves.

In at developing countries, the sugar cane leaves can be used as organic fuel and after that, the ash used as micro nutritional compliment to the fertilizer of the cane plantations. In Cuba this possibility begins studied at the present time, with the aim of regenerate the original chemical conditions of the sugar cane plantation soils.

The concentration levels of all elements studied by INAA is not an impediment to use the sugar cane leaves as animal food.

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