Accumulation of K^+ and Cs^+ in Tropical Plant Species

H. Velasco[a], R. M. Anjos[b], C. B. Zamboni[c], K. D. Macario[b], M. Rizzotto[a], A. S. Cid[b], I. M. A. Medeiros[c], J. Fernández[d], L. Rubio[d], P. Audicio[e] and T. Lacerda[a]

[a]*Grupo de Estudios Ambientales, Instituto de Matemática Aplicada San Luis (GEA- IMASL), Universidad Nacional de San Luís, CONICET, San Luís, Argentina*
[b]*Instituto de Física, Universidade Federal Fluminense, Niterói, RJ, Brazil.*
[c]*Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN), São Paulo, SP, Brazil*
[d]*Departamento de Biología Vegetal, Universidad de Málaga, Málaga, España*
[e]*Centro de Investigaciones Nucleares, Facultad de Ciencias, UDELAR, Montevideo, Uruguay*

Abstract. Concentrations of K^+ and $^{137}Cs^+$ in tissues of the *Citrus aurantifolia* were measured both by gamma spectrometry and neutron activation analysis, aiming to understand the behavior of monovalent inorganic cations in plants as well as its capability to store these elements. In contrast to K^+, Cs^+ ions are not an essential element to plants, what might explain the difference in bioavailability. However, our results have shown that $^{137}Cs^+$ is positively correlated to $^{40}K^+$ concentration within tropical plant species, suggesting that these elements might be assimilated in a similar way, and that they pass through the biological cycle together. A simple mathematical model was also proposed to describe the temporal evolution of ^{40}K activity concentration in such tropical woody fruit species. This model exhibited close agreement with the ^{40}K experimental results in the fruit ripening processes of lemon trees.

Keywords: tropical fruits, ^{40}K, ^{137}Cs , neutron activation, gamma spectrometry.
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INTRODUCTION

The activity concentrations of ^{137}Cs and ^{40}K from root to shoot for a tropical woody fruit specie (C*itrus aurantifolia*) were assessed in order to improve the understanding on the behavior of monovalent inorganic cations in plants as well as its capability to store these elements. In this study, a theoretical model was developed with the purpose of describe the temporal evolution of their activity concentrations in fruits.

The model assumes that fruit dry mass grows according to a logistic model. The input of potassium by fruit is non linear and it presents three main temporal phases. In the phase 1 (0-60 days) the incorporation of K follows approximately the fruit growth dynamics: this input proceeds predominantly from the branches. In the phase 2 (60-90 days) the input is approximately linear with time; the fruit grows continuously but the flow remains roughly uniform. In the phase 3 (>90 days) the potassium uptake by fruits decreases (maturation period).

THEORETICAL APPROACH AND RESULTS

The fruit dry matter growth follows the differential equation (logistic):

$$\frac{dM(t)}{dt} = \alpha M(t)\left[M_m - M(t)\right] \qquad (1)$$

where M is the dry matter (g), t the time in days, α the maximum growth rate (d^{-1}), and M_m the maximum value of $M(t)$.

The K concentration decreases exponentially following the differential equation:

$$\frac{dC_K(t)}{dt} = -\beta\left[C_K(t) - C_{K\min}\right] \qquad (2)$$

where C_K is the fruit potassium concentration (g kg^{-1}), β is the exponential decreasing parameter (d^{-1}), and $C_{K\,min}$ the minimum value of $C_K(t)$ (g kg^{-1}).

The capability of plants to store ^{137}Cs and ^{40}K can be estimated through their respective accumulation rates in different compartments of the plant [1,2]. The stem-to-fruit concentration ratios is:

$$CR_F = \frac{C_F}{C_{stem}} \tag{3}$$

where C_F is the fruit activity concentration and C_{stem} represents the activity concentration of the radionuclide in the main stem. The ^{40}K/^{137}Cs discrimination ratio results of the division of the ^{40}K and ^{137}Cs concentration ratios. Table 1 and Figure 1 show our results for lemon trees.

TABLE 1. ^{137}Cs and ^{40}K concentration for fruit in lemon trees (C*itrus aurantifolia*).

	^{137}Cs (Bq kg^{-1})	^{40}K (Bq kg^{-1})	$CR_F[^{137}Cs]$	$CR_F\,[^{40}K]$	$CR_F\,[^{137}Cs]/\,CR_F\,[^{40}K]$
Mature Fruit	301(24)	759(76)	3.1(0.4)	3.2(0.4)	1.0(0.2)
Green Fruit	395(22)	1049(55)	4.1(0.4)	4.4(0.6)	1.1(0.2)
Old Leaf	420(26)	1216(91)	4.3(0.5)	5.2(0.6)	1.2(0.2)
New Leaf	581(47)	1249(106)	6.0(0.8)	5.3(0.6)	0.9(0.2)

(Values in parentheses represent one standard deviation from the mean from 10 measurements)

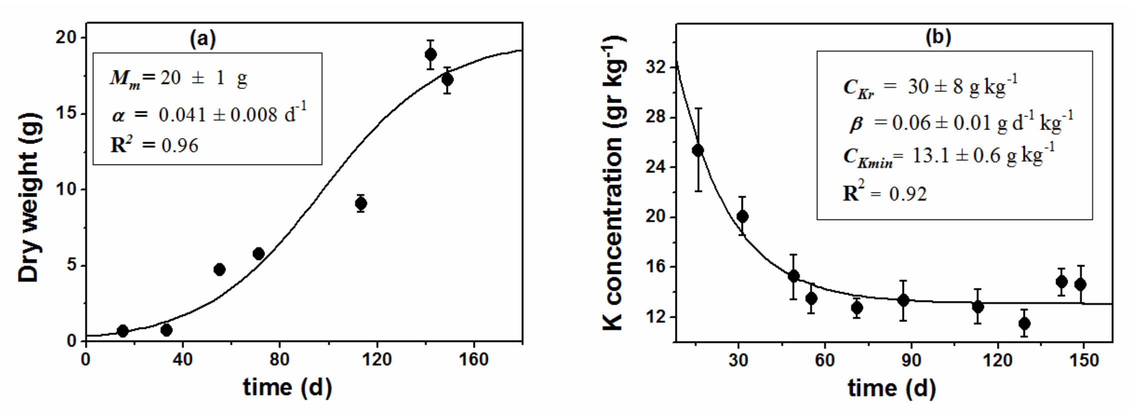

FIGURE 1. The fruit dry matter growth (a) and the K^+ distribution (b) during ripening process of lemon fruits. The solid curves represent the theoretical approaches.

CONCLUSIONS

$^{137}Cs^+$ and K^+ showed very similar distributions, exhibiting, therefore, similar behavior. Their activity concentrations were age-dependent and decreased with increasing age of leaves and fruits. A very simple three compartment model was proposed, which was calibrated with K experimental data. The agreement between the model and experiment is reasonable.

The availability of a theoretical approach to simulate the input of radionuclides into the edible parts of plants is important, given that the assessment of population dose rates is a vital food chain model issue.

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