Title
UPTAKE AND REDISTRIBUTION OF PHOSPHORUS (32P) IN CITRUS IS AFFECTED BY
ROOTSTOCK VARIETIES

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INTRODUCTION

The production of citrus in Brazil accounted for 20.8 million tons of fruits in 2007 what represented 19.1% of the world crop harvested (FAO, 2009). Such statistic is supported by oranges grown in approximately 670 thousand ha in the State of São Paulo, and which fruits have been mostly destined for the frozen concentrated orange juice (FCOJ) industrial plants. Maintenance of such economical significance is possible with establishment of nutrient management of groves for high yield and superior crop quality.

Limited phosphorus (P) availability of inherently low fertility tropical soils predominant in Brazil impairs citrus production (Quaggio et al., 1998, 2002). Adequate P supply of citrus trees is important for nonbearing and young bearing trees, since i) growth rate of these is greater than that of adult ones, and ii) root system of the same explores smaller volume of soil in the field (Quaggio et al., 2004).

Research work has demonstrated that tree growth and fruit yield in response to P fertilization are greater for sweet oranges on Cleopatra mandarin rootstock compared to those either on Rangpur lime or Swingle citrumelo (Mattos et al., 2006). Furthermore, Soil and leaf chemical analyses have been used as criteria for nutrient management of citrus and even tough soil-P critical leaves were established for orange groves (Quaggio et al., 1998), total leaf nutrient concentration has not discriminated P nutritional status of trees as well. Mature leaves of citrus are sampled for nutrient analysis, and since redistribution of P from old to new tissues occur, deficiency symptoms are most observed from the base to the apex of stems (Mengel and Kikby, 2001) hindering a correct diagnostic. The extent to which P phloem translocation occurs in citrus trees is not clearly known.

Based on the previous, a comprehensive understand of processes defining the overall response of citrus to added P shall to be investigated. Therefore, the objectives of this study were to evaluate $^{32}$P uptake and redistribution by a sweet orange variety grafted on two rootstocks as a function of nutrient availability in nutrient solution.

MATERIALS AND METHODS

Young plants of Pêra sweet orange on Rangpur lime [Citrus limonia (L.) Osb.] = RL or Cleopatra mandarin (C. reshni hort. ex Tanaka) = CL were acclimated and grown under a greenhouse in pots with 9.0 L nutrient solution modified from Sarruge (1975) to contain either deficient (0.005 mmol L$^{-1}$ = D) or sufficient (1.0 mmol L$^{-1}$ = S) levels of P.

Total volume of individual pots was maintained with addition of deionized water and nutrient solutions were continuously aerated and renewed each 7- to 10-day interval for 3 months. After this period, half of each group of plants (S or D) was maintained in sufficient P whereas the other half was changed to deficient P solutions both labeled with $^{32}$P (14.8 MBq per pot). Plants were thereafter grown for 50 days without renewing solutions. The treatments based on P availability in the media were DD, DS, SS and SD, which combined with rootstocks were arranged in a randomized block design with three replicates.

At the end of the labeling period, plants were destructively harvested and separated into vegetative and reproductive parts for evaluation of dry mass production. Tissue samples were dried, ground to a fine powder and digested for nutrient analysis and measurement of $^{32}$P activity in a liquid scintillation counter. Concentrations of P in plant parts derived from the nutrient solution and P remobilized in the plant were calculated.

Data were tested for significant differences among treatments using the GLM procedure of the SAS$^®$ system (1996). Means and standard deviations were used to describe studied variables.
RESULTS AND DISCUSSION

Phosphorus content of citrus plants derived from the nutrient solution (P_{pdns}) varied according to $^{32}$P availability and was negligible on P = 0.005 mmol L$^{-1}$ (DD and SD treatments; Figure 1a). On the other hand, greater values were observed for plants previously grown on deficient and subsequently on sufficient P treatments (36.8-85.9 mg per plant), compared to plants under the SS treatments, since P_{pdns} varied from 21.4-53.1 mg per plant. Those arise on the fact that phosphate uptake is a highly regulated process in plants and acquisition mechanisms are dependent on nutrient availability in the growing media (Raghothama and Karthikeyan, 2005). Up to 35% of the $^{32}$P in nutrient solutions with P = 1.0 mmol L$^{-1}$ were taken up by plants (data not shown).

Our data also demonstrated that, despite variations on plant growth on different rootstocks, P uptake of those on RL per unit of total dry matter was greater than those on CL confirming the superior efficiency of the former under a non mycorrhized condition (Figure 1b).

Young tissues were a major sink for $^{32}$P from the nutrient solution compared to older ones in the DS treatments (Figure 2a). Approximately, a 3-fold increase on P distribution occurred in plants under the DS compared to SS treatments within the same rootstock. Such differential distribution also demonstrated the superior efficiency of the RL rootstock on P absorption.

Our estimates of P remobilized from plant reserve to young leaves in new growth flushes suggested that the process was more marked for plants on CL irrespective to P treatments (Figure 2b). At the whole-plant level, P deficiency causes reallocation and translocation of P from older plant tissues to growing organs (Kochian et al., 2004). These probably explains the fact that visual symptoms of P deficiency are more frequent on citrus trees on CL in the field and presents the need to fine tune P fertilization recommendations with basis on the use of scion/rootstock combinations by citrus growers.
Figure 2. Labeled-P distribution in young and old tissues (A) and P remobilized in young leaves (B) of Pêra sweet orange on Rangpur lime (RL) or Cleopatra mandarin (CL) rootstocks grown in nutrient solution. Legend: D = deficient (P = 0.005 mmol L⁻¹), and S = sufficient (P = 1.0 mmol L⁻¹) - first letter indicates pre-condition of plant growth and the second letter indicates condition of plant labeling.

REFERENCES


