Transpiration and Calcium Accumulation in Apricot Fruit

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Abstract

The seasonal variation of transpiration rate and accumulation of calcium (Ca) in fruit of apricot (*Prunus armeniaca* L.) are presented. Midday transpiration rate (open system ADC-LCA4) was higher just after fruit-set peaking at about 0.5 mmol m^{-2} s^{-1}, thereafter it declined reaching the lowest value three weeks later. In parallel, Ca was linearly accumulated within the early four weeks of fruit development reaching 80% of the final content. Afterward it slowly increased reaching about 6 mg per fruit at harvest time. Results suggest that transpiration decline can be held to account for the early cessation of Ca import into the fruit. Opportunities for field manipulation to increase fruit Ca content are discussed.

INTRODUCTION

Calcium (Ca) content is known as a major factor in preventing physiological disorders in fruit. It is very important for successful storage and handling (Poovaiah et al., 1988; Bussi et al., 2003, Tzoutzoukou and Bouranis, 1997). Based on that evidence, researches have been devoted to the exogenous application of Ca in order to improve Ca-related fruit characteristics, however, effectiveness of Ca spray is often inconsistent (Tzoutzoukou and Bouranis, 1997; Manganaris et al., 2005). Probabily this is due to poor knowledge of Ca transport mechanisms at fruit scale. Efforts of elucidating the factors governing Ca movement have been done in a number of fleshy fruit (Saure, 2005; Montanaro et al., 2006; Dichio et al., 2006) but fewer studies were developed on apricot fruit.

Calcium movement in plants seems to be mostly related to transpiration rate which is the main driving force of the xylem stream (Saure, 2005) therefore this study was designed to investigate the relationship between Ca accumulation and transpiration in apricot fruit.

MATERIALS AND METHODS

The experiment was carried out during the 2007 season in Southern Italy on mature apricot plants cv. "Tyrinthos" (*Prunus armeniaca* L.) trained to Y-transverse with 1.111 plants ha^{-1}. The plants were managed to local commercial practice. Bloom occurred during the last week of March and fruit-set was recorded at March 31st.

Fruit transpiration was measured using a portable gas exchange analyser (ADC-LCA4, ADC BioScientific Ltd, Hoddesdon, England) operated at a flow rate of 200 µmol s^{-1} (chamber model PLC-3) under the prevailing environmental conditions. Measurements

were taken throughout the growth season every 8-10 days on detached fruit at midday (11:30 – 13:30 h). On each measurement day, transpiration was valuated on about 10 fruit randomly chosen from 3 plants, for each fruit at least three records were taken.

At the end of transpiration measurements, the fruit were grouped in three bulks (about 3 fruit each), promptly transferred in lab and dried (72 h, ventilated oven at 60°C). Calcium (flesh tissue) was determined using a spectrophotometer (model AA-40, Varian Inc., Palo Alto, USA) on acid digested samples (H_2SO_4 + HNO_3).

RESULTS AND DISCUSSION

Fruit transpiration had a maximum value of 0.55 ±0.03 (SE) mmol m^{-2} s^{-1} in the first measurement day (i.e. 6 days after fruit-set). During the following 3 weeks transpiration rapidly decreased by 43% compared to the early values, thereafter it remained steadily close to 0.3 mmol m^{-2} s^{-1} (Fig. 1). The transpiration profile detected is in agreement with previous observations in kiwifruit (Montanaro et al., 2006), although for kiwifruit transpiration decreased down to about 10% of the initial values due to profound anatomical and physiological modifications of fruit itself (Xiloyannis et al., 2008).

Calcium accumulation pattern (mass per fruit) exhibited a shorter, roughly linear phase up to 30 days after fruit-set, afterward fruit Ca content reached a plateau close to 6 mg $fruit^{-1}$(Fig. 2). That pattern agrees with what reported for other species (among others kiwifruit, apple, tomato) being in line with the idea that Ca contained by fruit at ⅓ or ½ of the whole growth season accounts approximately 80% of the total Ca content at harvest (Ferguson and Watkins, 1989; Ho and White, 2005; Montanaro et al., 2006). Our results highlight that fruit Ca content is gained within the early four weeks after fruit-set, suggesting that failure of good soil calcium availability at that time may easily lead to poor fruit Ca uptake. In addition, any attempt to increase Ca via exogenous applications, would probably be more effective during this stage.

Calcium accumulation linearly correlates with fruit transpiration (R^2 = 0.81) (not shown) confirming the relationship between them (Saure, 2005). It is therefore reasonable to infer that the decrease in fruit transpiration caused Ca accumulation to proceeded more slowly during the final stages of fruit development. In view of the fact that during the last three weeks of fruit growth Ca was very weakly increased nevertheless transpiration was at 55% of the initial values (Fig. 1, 2) an increase of skin conductance concomitantly to a decline of functionality of conduits could be hypothesised.

Considering the effect of some characteristics of the micro-environment close to the fruit (e.g. light, air humidity and movement) on the transpiration rate (Dichio et al., 2003; Montanaro et al., 2006; Tromp and Vuure, 1993), it may be suggested that higher Ca content is obtainable with appropriate canopy architecture and management during the early fruit growth.

CONCLUSIONS

Results indicate that the early four weeks of growth had a great significance in terms of Ca accumulation and that higher transpiration rate can conceivably enhance the accumulation of Ca. It may be concluded that adopting techniques able to promote fruit exposure to light and air movement (e.g. summer pruning) could offer useful tools for improving fruit Ca content.

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ACKNOWLEDGEMENTS

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Figures

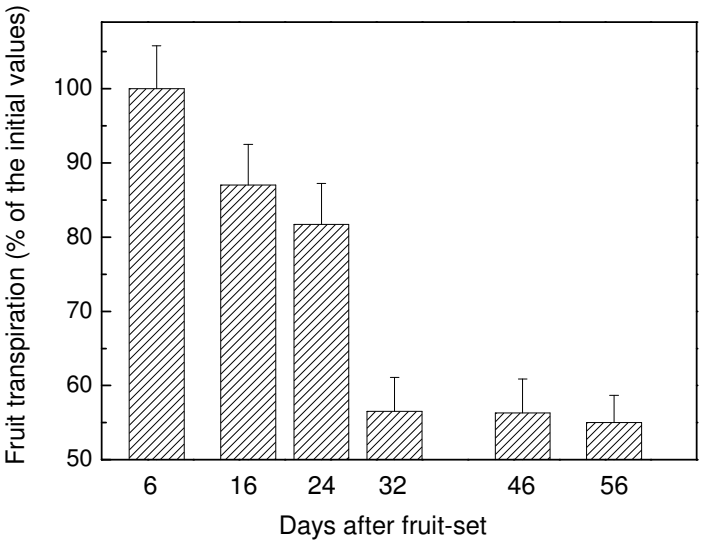

Fig. 1. Fruit transpiration rate as percentage of the initial values taken at day 6 after fruit-set. The histograms represent the mean (± SE) of about 30 measures taken at midday (11:30 -12:30 h) on three plants. Fruit-set = March 31st.

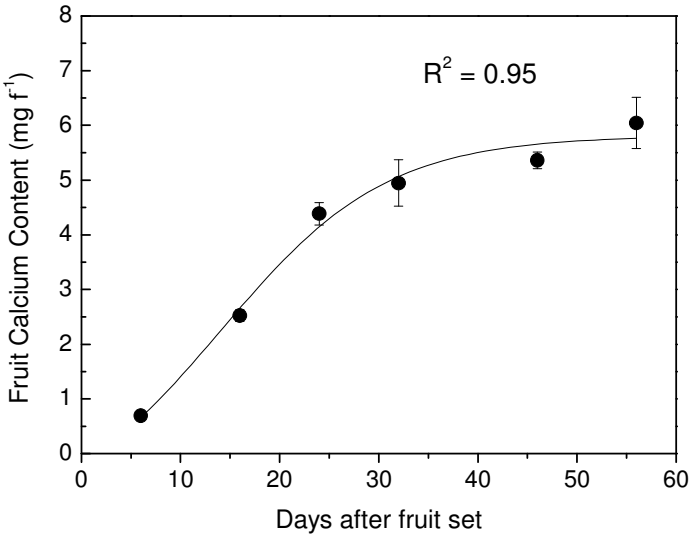

Fig. 2. Seasonal accumulation patterns of calcium (mg per fruit). Each point is the mean (± SE) of three analyses.