A biophysical model describing carbon and water fluxes in tomato fruit. A good candidate for the future virtual fruit

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Multi-criterial approaches for the inventory and the evaluation of traditional cultural landscapes

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The Mediterranean environment is characterized by an high variability in ecological features and by a rich biodiversity, whose interaction has generated complex agro-forestry systems. The resulting cultural landscapes can represent a remarkable trait of Italian landscape. Nonetheless, since several decades they are at risk mainly owing to the consequences of cultural intensification, that has turn out in new cultural models, i.e. specialized high density agronomic plantation, or in a progressive abandonment of agricultural land. In order to prevent the degradation or loos of these particular ecosystems, it becomes a priority to adopt measures for their preservation and promotion. Regardless of this necessity, up to now it lacks in Italy an exhaustive classification of the traditional landscapes that necessitate to be preserved. The inventory is the first step to be considered in order to elaborate a successive global evaluation of their function and conservation requirements.

The present study reports on an holistic multidisciplinary methodology formulated and proposed for the classification and the analysis of cultural landscapes. As far the inventory is concerned, it has been evaluated the concomitant presence of a plurality of characterizing descriptors, represented and implemented in a GIS system, such as geomorphological parameters, pedoclimatic features, land use typology and history of the territory. As far as the evaluation of cultural landscape significance is concerned, it has been proposed a global value obtained by integrating particular values, like the biological, historical, socio-economic, artistic, emotional ones.

A biophysical model describing carbon and water fluxes in tomato fruit – a good candidate for the future virtual fruit

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Introduction

In order to progress in our understanding of fruit quality build-up, we need to integrate the numerous processes involved and to describe the complex interactions and feedback mechanisms among these processes occurring at different scales. A virtual fruit model has been recently designed by Génard et al. (2007) which proposes a hierarchical organization of different fruit levels (from cells to organ) and intends to integrate process-based models describing the main processes involved in fruit growth and composition. Cell expansion, xylem and phloem fluxes, transpiration and respiration should be integrated in the virtual fruit. The Fishman and Génard (1998) model proposes an integrative approach of these processes involved in fruit growth and carbon and water accumulation in peach fruit. This model assumes that the fruit mesocarp behaves as a single large cell and relies on a biophysical description of water and carbohydrates transport coupled with the stimulation of cell wall extension driven by the turgor pressure (Lockart, 1965). In this study we showed that the peach model could describe growth of tomato fruit in relation to carbon and water fluxes with minor modifications.

Results

Main modifications of the model relied on the literature on tomato and mainly concerned: (i) the decrease in cell wall extensibility coefficient during fruit development. (ii) The increase in the membrane reflection coefficient to solute from 0 to 1, which accounted for the switch from symplasmic to apoplasmic phloem

unloading. (iii) The negative influence of the initial fruit weight on the maximum rate of active carbon uptake based on the assumption of higher competition for carbon among cells in large fruits containing more cells. The sensitivity analysis indicated that there were no strong interactions among parameters and that the model was mostly sensitive to the phloem sucrose concentration. This parameter was assumed to be constant and it was independently estimated on 17 experimental datasets (0.11 g g^{-1}). Finally the model was calibrated and evaluated with satisfaction on 17 experimental datasets obtained under contrasted environmental (temperature, air vapour pressure deficit) and plant (plant fruit load and fruit position) factors. The main source of errors might be the estimation of the initial fruit weight. Then the model was used to analyze the variations in the main fluxes and factors involved in the control of fruit growth (phloem and xylem fluxes, transpiration and respiration rates, carbon transport pathways, osmotic and turgor pressures) involved in tomato fruit growth and accumulation of carbon in response to virtual carbon and water stresses.

Discussion

The present adaptation to tomato fruit confirmed the genericness of the Fishman and Génard (1998) model and its suitability for fleshy berry fruit. This model integrating simple biophysical laws was able to mimic the fruit behaviour and to analyze the interactions and feedback regulations among the fruit system components, for instance between fruit osmotic and turgor regulation and water and phloem fluxes in response to environmental and plant factors. Thus it may be fruitfully integrated in the future virtual fruit.

Detached tomato fruit grown on various sucrose solutions and comparison with fruit grown on plant

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Introduction

In vitro fruit culture should be very interesting to study the influences of various external and endogenous factors in order to better understand the fruit growth mechanisms. For that, it seems that two conditions have to be met: the first is that the main growth processes which occur in the fruit grown on the plant exist also in the in vitro fruit; the second is to understand the possible differences if mechanisms are lacking or superadded in order to be able to extrapolate to the fruit growth on the plant. In this view, effects of sucrose concentration and osmotic pressure of the solution entering the fruit on parameters of several important fruit growth processes (cell division and expansion, dry matter, sugars and water accumulations, maturation) were studied in vitro and some comparisons with the in planta fruit were made.

Materials and methods

Fruits of Cherry tomatoes were sampled some days after anthesis from plants grown under greenhouse. These fruits were transferred in glass containers with nutrient solutions of different sucrose concentrations and osmotic pressures, in which fruit pedicel was immerged. Fruit diameter was measured through the glass container at various times over the growth period up to maturity. In addition, fruit samples were taken out at four times to measure a number of parameters: fruit weight, dry matter mass and water mass, Brix, pericarp cell number and volume. These parameters were also measured on fruits grown on the plant.

Results

In vitro, a fraction of the fruits did not grow, likely due to contaminations. In healthy fruits, cell number increased with sucrose concentration between 2 and 8%. In the in planta fruit, this number was in the middle of this range. The volume of one pericarp cell increased with sucrose concentration up to 4 - 8% and decreased when PEG was added. In the in planta fruit, this volume was much higher. Also fruit diameter increased with sucrose concentration up to 4 - 8% and decreased at higher concentration or when mannitol or PEG was added. Fruit expansion rate was null when osmotic potential of the solution was close to – 2.5 MPa, which coincides with the value predicted by a model of water import in fruit. In planta fruit was much