Development of Physiology-Based Methods for Sustainable Management of Pistachios under Changing Central Valley Climatic Conditions

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INTRODUCTION

The overarching goal of this research is to characterize the physiological responses of pistachio trees to abiotic stresses, with the aim of using this knowledge to improve production and guide pistachio plant improvement - phase one, carbohydrate management.

METHOD

Currently, evaluating the physiological status of trees for guiding orchard- management decisions are limited to analyses of tree water status, leaf nutrient levels, and visual observations. Until recently, these methods were adequate, and produced dramatic improvement in pistachio yields. However, as the climate becomes more erratic, and the abiotic stresses more severe, these proven approaches may become less effective. Research effort, described here, focuses on the development of new methodologies to measure trees' physiological status that complement the currently used methods. Specifically, we aim at mechanistic understanding of tree nonstructural carbohydrates (NSCs) management in the context of dormancy, chilling requirements and yield performance. We have employed a large-scale approach to gain knowledge on carbohydrate seasonal dynamics, across California, to determine pistachio carbohydrate management in relation to climate, tree age and geographic distribution. Specifically, we want to determine if the predormancy carbohydrate status of the orchards can be managed, and if it is correlated with following-year growth, health and yield of the orchard.

RESULTS

Analysis of the carbohydrate content revealed very strong dependence of NSCs dynamics on tree phenology and growth (Figure 1; points 1-6 and a-b). We have noticed that there is large change of carbohydrate content in twigs during dormancy and early spring (1). This dynamic is characterized by accumulation of NSCs near buds (a) and their release during flowering (2), followed by accumulation (3) and reduction during vegetative growth (4). Low levels of NSCs are maintained throughout the summer until near-end of stem radial growth (b). Carbohydrate accumulation (5) was completed in October - November (6). This pattern reflects yearly cycle of NSCs management by pistachio tree.

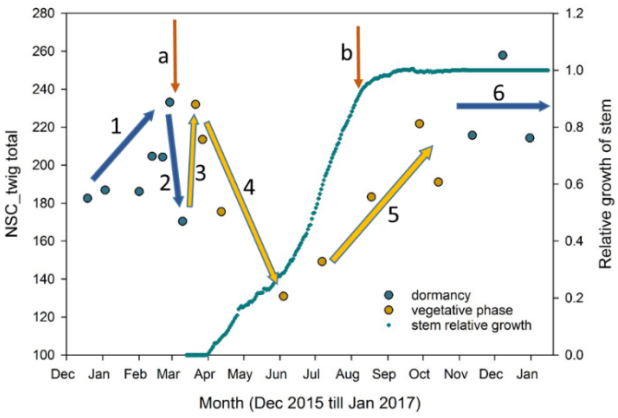

Figure 1. Change in carbohydrate content in pistachio twigs and relative radial growth of stem. For 1-6 and a-b denominators see text.

During fall of 2016, we initiated a large-scale “citizen research” project to gain needed knowledge on carbohydrate seasonal dynamics in twigs of pistachio trees across age groups, climate conditions and management practice to provide the proof of concept.

Already over 40 orchards are supplying us with twig samples from across California’s Central Valley. The initial results allow us to link the dynamics of nonstructural carbohydrates in twigs to phenology (Figure 2), and tree age. We are waiting for 2017 yield reports to address the issue if carbohydrate status and their season dynamics can be associate to orchards performance. We also expect to determine levels of carbohydrates for healthy trees in order to facilitate carbohydrate-based management for specific locations. The description of the citizen research project can be found at: http://www.plantsciences.ucdavis.edu/plantsciences_faculty/zwieniecki/CR/cr.html.

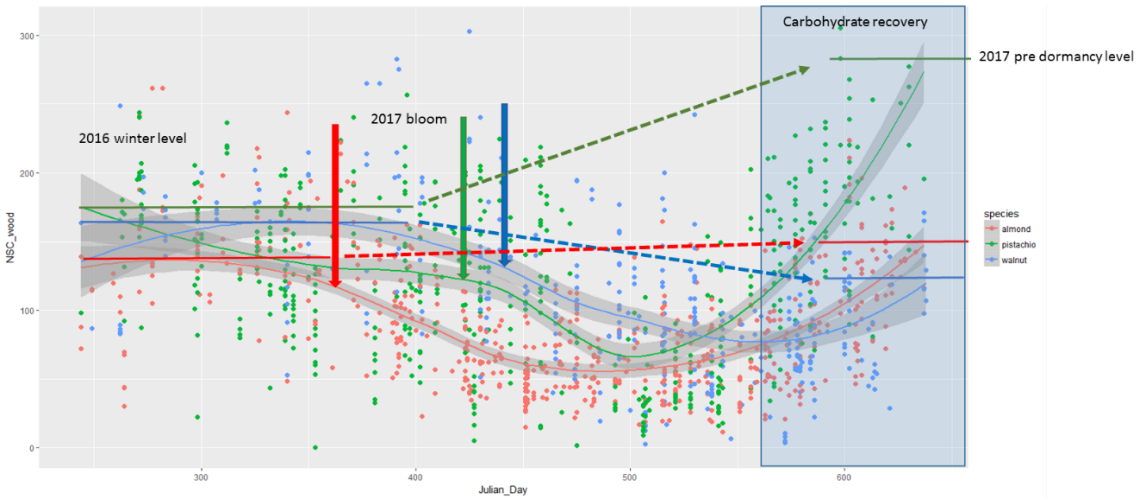

Figure 2. Seasonal pattern of soluble sugars and starch concentration (NSC) in three major tree crop species almond, walnut and pistachio during the 2016-2017 season. Each data point represents single orchard determined from averaging three twig samples. Gray lines are running average content of the total NSCs concentration in wood. Higher levels of NSCs in 2016/17 winter allow for the energy support of the bloom. During summer, all species reduced reserves to low levels, reflecting demand for NSCs to support yield and tree growth that exceeds photosynthetic supply. In the fall, NSCs level is expected to recover to accumulate reserves for the spring of 2018. Interestingly, pistachio (green) accumulated almost twice as much NSCs 2017 fall, potentially reflecting its strong alternating crop behavior – 2017 was considered an OFF year, next year is expected to be an ON year potentially supported by an increased accumulation of NSCs.

CONCLUSION AND APPLICATIONS

Seasonal dynamics and levels of nonstructural carbohydrates are closely linked to phenology of pistachio. NSCs level during dormancy and the pattern of their release to sustain spring growth might be a predictor of current-year yield as NSCs reserves are necessary for formation of healthy flowers and early growth rate. The observed large accumulation of NSCs after an OFF (2017) year might predict the presence of the ON year in 2018, although with disclaimer that high level of NSCs might be necessary but not sufficient to guarantee the high yield, as other factors might influence the outcome. In other words, low levels of winter NSCs might always result in low yield despite good orchard management during the summer, but high levels will not guarantee the outcome without proper management and climate. Analysis of carbohydrate in the fall can provide growers with information if postharvest-management reached the goal of orchard preparedness for dormancy, i.e., if NSCs level in woody tissue recover or exceed prior

year winter levels, and if it is consistent with local regional levels. This knowledge provides potential for precision postharvest-management leading to induction of dormancy, and may lead to saving water and fertilizer treatment in the fall.