Deficit irrigation:

Is it impacting yield and nutritional quality of fruits?

Drought-related crop losses combined with reductions in the amount of cultivated land will ultimately threaten the economic sustainability of perennial crops in farming communities that cannot adapt to an inconsistent water supply. Hence, farmers' responses to water shortage and recurrent droughts will ultimately result in the reduced application of water, designated as deficit irrigation (DI). It is well known that DI may result in various advantages such as: maximizes water productivity, reduce the risk of diseases and pest attacks, nutrient losses through leaching, and may cause a positive effect on fruit nutritional quality.

The net effect of DI strategies on plant responses to water stress and their consequences on fruit nutritional quality had not yet been studied for pomegranate, an increasingly important crop, especially in India. Previous to the New Ag International conference in New Delhi, we met with Tiziana Centofanti, a researcher at the Center for Irrigation Technology in Fresno (California) after she and a team of scientists from USDA-ARS have just completed a 3-year study on the topic. This study is in particular the first to analyze the effect of deficit irrigation strategies on concentration of antioxidants in pomegranate fruit.

"Our study is the first one showing that deficit irrigation strategies, as low as 35% of Etc, does not affect yield within a given year and fruit nutritional quality of pomegranate. Long-term studies are needed to better predict physiological responses to water deficit in crops and trees relative to nutritional quality and productivity".

Pomegranate (Punica granatum L.) is a fruit cultivated since ancient times throughout the Mediterranean region and considered to have originated in Persia. It is grown extensively in arid and semi-arid regions of the world for its requirement of hot and dry climate and high alkaline soils. There is an increasing demand for pomegranate fruit and juice due to its reported large quantities of healthy bioactive compounds, mineral nutrients and antioxidants. Very little is known about effects of drought and reduced irrigation on pomegranate fruit nutritional characteristics and especially levels of antioxidants, which are compounds that may provide health benefits in addition to basic nutritional value. Over a hundred different types of potential antioxidants called phenolics have been identified in pomegranate fruits and seeds. Phenolics are secondary plant metabolites that are often produced by plants in response to various stresses and seem to have human health benefits for the prevention of chronic diseases. The goal of the study was to evaluate the physiological response of pomegranate trees to deficit irrigation strategies relative to fruit yield and quality (as measured by the phenolics contents).

NO SIGNIFICANT CHANGE IN YIELD

One year old pomegranate (Punica granatum L.) trees variety 'Wonderful' were planted on February 25, 2010 in California. The experiment to determine the water requirement of developing pomegranates was carried out on a USDA field site on a sandy loam soil.

Four treatments were applied: 35%, 50%, 75% and 100% of evapotranspiration (ETlys) based on pomegranates grown in a lysimeter located adjacent to the field plot. When a 4 mm of equivalent weight loss occurred in the lysimeter, replacement irrigation was triggered. Deficit irrigation treatments began in 2012. Trees were drip irrigated with surface drip tubing containing 0.002 m3 h−1 snap on turbulent flow emitters spaced 0.45 m apart. A total of four replications per treatment were used in this study. The trees were not fully matured in 2012 and additional pruning was done

during the growing season to shape the trees as well.

As appears in Fig 1, the research team did not observe any significant differences in fruit yield among DI treatments within the 2012 and 2013; however, yield in 2013 was significantly (P=0.004) higher than in 2012 independently of treatment (Fig.1). This difference yield is attributable to the age of the tree and pruning that was done during 2012 to shape the tree. Pruning was done during dormancy in between 2012 and 2013 so the yield was not impacted in 2013 (and in 2014).

AND NO SIGNIFICANT DIFFERENCE IN QUALITY

It is known that the increased synthesis of total phenolics is a response of plants to protect themselves from ion-induced oxidative stress in case of pathogen attack, high salinity, high temperature, and water stress. In the study, as appears in Fig 2, no significant differences were observed (P≥0.1) among DI

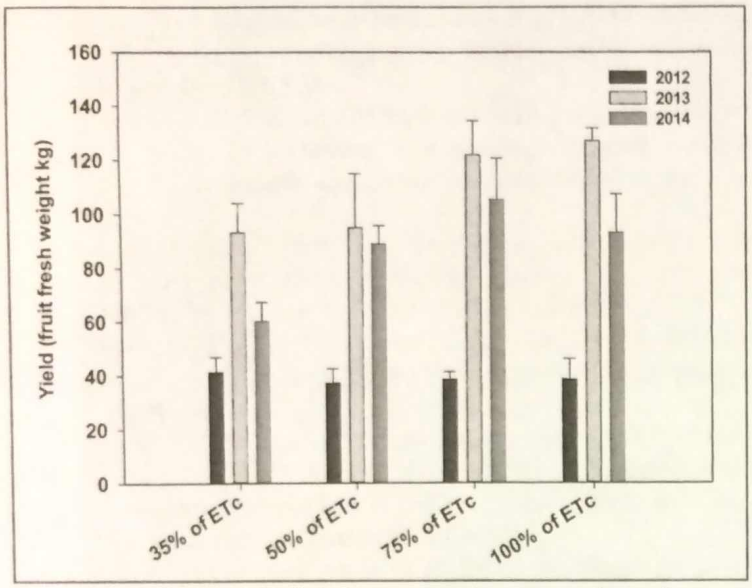

Figure 1. Fruit fresh weight (kg) of pomegranate grown under various deficit irrigation treatments (calculated as % of Etc). Bars and error bars represent average and standard errors of 4 replicates, respectively.

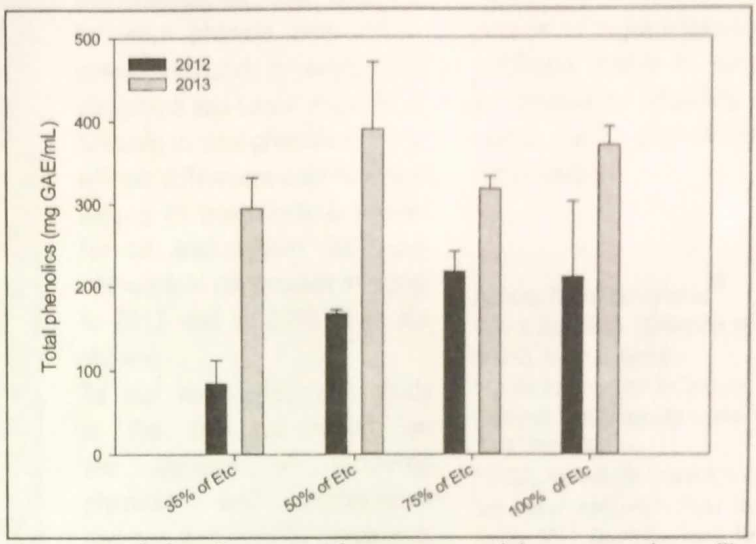

Figure 2. Total phenolics content in pomegranate juice, expressed as gallic acid equivalent (GAE) per ml of pomegranate juice. Bars and error bars represent average and standard errors of 4 replicates, respectively.

treatments in total phenolics in both, 2012 and 2013 (Fig. 2). Total phenolics were significantly higher ($P \geq 0.009$) in 2013 (possibly due to high temperatures recorded in 2013). Values of total phenolics are comparable to values reported in the literature for pomegranate.

Other authors have shown that deficit irrigation affected wine grape quality by increasing anthocyanin and phenolic concentrations (Chaves et al. 2010; Santesteban et al. 2011). In addition, the effect of salts, i.e. sodium and chloride, has been shown to influence phenols and antioxidants compounds in pomegranate (Bhantana and Lazarovitch 2010). Similarly to total phenolics, no significant differences were observed among DI treatments and years for all anthocyanin and non-anthocyanin compounds analyzed in 2012 and in 2013 (data not shown).

To our knowledge, this study is the first to report on the absence of increased phenolic and anthocyanin and non-anthocyanin compounds content in fruit with application of deficit irrigation strategies. The application of deficit irrigation may be a strategy to reduce water usage and increase agricultural sustainability of arid and drought-stricken regions.

The 2-year study conducted by Tiziana Centofanti and USDA scientists has shown that application of deficit irrigation strategies, as low as 35% of Etc, does not affect yield within a given year and fruit nutritional quality of pomegranate (relative to phenolics, anthocyanin and non-anthocyanin compounds).

Authors: Tiziana Centofantia, Gary S. Bañuelosb, Christopher M. Wallisb, James E. Ayarsb.
[a] Center for Irrigation Technology, California State University Fresno, Fresno, CA 93740 USA.
[b] USDA, Agricultural Research Service, San Joaquin Valley Agricultural Science Center, 9611 South Riverbend Avenue, Parlier, CA 93648-9757 USA.

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