Scientia Horticulturae 238 (2018) 177–186

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Irrigation positively affects the chestnut's quality: The chemical composition, fruit size and sensory attributes

Margarida Mota[a,*], Teresa Pinto[a], Alice Vilela[b], Tiago Marques[a], António Borges[c], João Caço[d], Jorge Ferreira-Cardoso[a], Fernando Raimundo[a], José Gomes-Laranjo[a]

[a] University of Trás-os-Montes and Alto Douro, Department of Biology and Environment, Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), 5001 801 Vila Real, Portugal

[b] University of Trás-os-Montes and Alto Douro, Department of Biology and Environment, CQ-VR, Chemistry Research Centre, 5001 801 Vila Real, Portugal

[c] Geosil – Empreendimentos Agro-silvícolas, Sortes, Bragança, Portugal

[d] Hubel Verde, SA.- Engenharia Agronómica, Pechão, 8700-179 Olhão, Portugal

ARTICLE INFO

Keywords:
Castanea sativa
Soil moisture
Nutrition
Chestnut calibre
Market value

ABSTRACT

In the northeast of Portugal there is a tendency to introduce irrigation system on the chestnut orchards but the effect of irrigation on the chestnut's quality has not been studied yet. This study aims to evaluate the effect of irrigation on the 'Judia' cultivar chestnuts quality concerning its chemical composition, fruit size and tastiness. Three treatments were applied during 2015 and 2016: the drip system, the micro-sprinkler system and a non-irrigated treatment. In both years the bigger chestnuts and production were always present in irrigated treatments. Significant differences among treatments were found in ashes, starch, soluble sugars, and crude protein contents in 2015, but in 2016 no significant differences were found. Moreover, the non-irrigated chestnuts were the sweetest but with smaller calibre. The chestnuts from micro-sprinkler were the firmest and they were as sweet as the drip's chestnuts. Results suggest that irrigation, namely with sprinkler system, valorise the chestnuts by increasing its size and keeping its nutritional value and its sensory quality.

1. Introduction

The nutritional value of the chestnut, which is a consequence of its chemical composition, reflects the interaction between the binomial genotype and climate conditions and its related to the mineral composition of the soil where the chestnut trees are cultivated (Ferreira-Cardoso et al., 2007; Pereira-Lorenzo et al., 2006). The 'Judia' cultivar mostly grows in the northeast region of Portugal, where are produced more than 22.000 tons of chestnuts (INE, 2017). The use of irrigation on the Portuguese chestnut trees is still incipient but, according to the Autoridade de Gestão do PRODER (2013), from the new 835 ha planted within 2007–2013, about 23% included an irrigation system. According to Breisch (1995) and Mota et al. (2017, 2014) the irrigation increases chestnut yield as it happens in other dry fruits (Garrot and Kilby, 1993; Goldhamer and Beede, 2004). Also Dengiz et al. (2011) reports the need of irrigation for good vigour of the chestnut orchard. Currently, we are witnessing the evidence that the lack of rain in the end of the summer or in the autumn (IPMA, 2017) in not-irrigated orchards constraints the chestnut development and consequently their productivity and brings losses to the income in the chestnut sector (Vida Rural, 2017).

Some studies have focused on the effect of irrigation on the chestnut's size index, fruit weight or production per tree (Martins et al., 2011; Martins et al., 2010) but, as far as our knowledge goes, the effect of watering on the chestnut's chemical composition has not yet been studied. However, it is known from the other fresh crops the interest of irrigation into the final fruit composition. For instance, in grapes, different water regimes influence the fruit weight, phenols and anthocyanins' levels but not the total soluble sugars (Intrigliolo and Castel, 2011; Santos et al., 2005). For apples (Mills et al., 1996) and citrus (Ballester et al., 2013) the sugars level was higher in deficit irrigated trees with better shelf life. Carbonell-Barrachina et al. (2014) found that in pistachio the regulated deficit irrigation had no significant influence on production yield, weight, size, colour and on the mineral composition but it had influence in the lipids composition. From these studies, become clear the existence of a benefit due to irrigation on fruit quality but is highlighted the importance of a good water management to meet the desired final product. According to Mota et al. (2017, 2014) a minimal irrigation, based on tree water potential, was enough to increase the chestnut production per tree but chestnut composition was not evaluated. The irrigation system also brings the possibility for

Abbreviations: TI, drip irrigated; SI, sprinkler irrigated; NI, non irrigated; DM, dry matter; OM, organic matter; CF, crude fat; CP, crude protein; SS, soluble sugars

* Corresponding author.
E-mail address: mmota@hubel.pt (M. Mota).

https://doi.org/10.1016/j.scienta.2018.04.047
Received 22 December 2017; Received in revised form 22 April 2018; Accepted 23 April 2018

developing fertigation programmes which naturally will enhance plant nutritional status and the chestnut quality as well.

The chestnut is a great source of starch, with low fat and cholesterol free, low in sodium, rich in dietary fibre, and rich in potassium and in proteins with high biological value and thus, its integration in the human diet is highly recommended (Ferreira-Cardoso et al., 2007; De Vasconcelos et al., 2010; Ferreira-Cardoso and De Vasconcelos, 2011). Additionally, it can be a healthy alternative to specific human groups as the diabetics (chestnuts have low glycaemia index) or celiac patients since the chestnut is gluten free (Mujić et al., 2010). Besides the chestnut's health benefits, the consumer appreciates it mostly due to its sweetness (Pereira-Lorenzo et al., 2006) and the chestnut market tends to valorize its size (Breisch, 1993; Martins et al., 2011).

This study aims to understand the effect of watering through different irrigation systems on the chestnut's quality namely fruit size, chemical composition and sensory attributes. Additionally, the plant nutritional status is addressed in a general way because it is related to the soil fertility and moisture and affects the fruit quality.

2. Material and methods

2.1. Chestnuts orchard location and treatments

The experiment was performed in a commercial chestnut orchard during 2015 and 2016, located in the northeast of Portugal at 862 m of altitude. Trees were planted in 1993, spaced 10 by 5 m, and were traditionally rain-fed. The rootstocks are seedlings from *C. sativa* and they are grafted at 2 m height with 'Judia' cultivar. Two types of irrigation system were installed, each one in about forty trees, as follow: TI – drip irrigation – two pipes per tree row, emitters spaced 1 m, 3.6 L h^{-1}; SI – sprinkler irrigation – one handing pipe, emitters spaced 5 m, 50 L h^{-1}. Border trees were kept around the study area and between each tree sample (ten trees per treatment). Non-irrigated trees (NI) were kept for control (Fig. 1).

Irrigation on TI and SI systems was triggered every time the midday stem water potential (Ψw_{md}) was lower than −1.2 MPa. The decision to start the irrigation at this midday stem water potential was based on preliminary data taken in 2013 on the same orchard which indicated that the highest photosynthetic rate was achieved when the midday stem water potential (Ψw_{md}) was around −1 MPa (see more details in Mota et al., 2014). Plus we decided to define a value below it in an attempt to create a deficit irrigation condition that on one hand saves water and on the other did not harm too much the photosynthetic rate. The Ψw_{md} was measured weekly from July to October with a

Table 1
Irrigation period, number of irrigation events and total water volume applied in to the drip system (TI) and micro-sprinkler system (SI) in 2015 and 2016.

Year	Treatment	Irrigation Period	Nº of irrigation events	Total Water Volume m^3ha^{-1}
2015	TI	Jul 23rd–Sep 11th	9	461
	SI	Jul 26th–Sep 11th	9	479
2016	TI	Jul 20th–Sep 30rd	19	871
	SI	Jul 20th–Sep 30rd	19	979

Schoelander-type pressure chamber (model "pump-up", PMS Instrument® Corvallis, Oregon, USA). The leaves used to measure the Ψw_{md} were from the north fruit branch of the sample trees and were covered by a plastic and aluminium foil at least 40 min before readings, according to Fulton et al. (2014). Table 1 resumes the irrigation events. The mean water volume of the both treatments given in July, August and September was, respectively, 8.8 mm, 32.3 mm and 5.9 mm in 2015; and 6.7 mm, 49.1 mm and 36.8 mm in 2016.

2.2. Edapho-climatic conditions

General meteorological data (total monthly precipitation, PP; mean monthly air temperature, T_{med}; total monthly evapotranspiration of reference, ET_0 and air relative humidity, HR) were gathered from the agro-meteorological bulletins given by the Portuguese Institute of the Sea and Atmosphere (IPMA, 2015, 2016) which by its turn retrieved the data from a meteorological station located at 20 km away from the study site. The growing degree-days (GDD, ºD) was calculated according to Cesaraccio et al. (2001) using the following Eq. (1):

$$°D = (Tx - t0)\, n \quad (1)$$

Where "x" is the average temperature of each month, "t0" the base temperature, which was considered 6 °C (Gomes-Laranjo et al., 2008) and "n" the total of days of each month. Three soil profiles were opened, in the inter row of the trees, according to the slope of the study area in order to do a soil profile classification (according to IUSS Working Group WRB, 2014).

The soil water content was estimated with a capacitance probe (Diviner 2000, Sentek Technologies) and six access tubes were installed per treatment, one single tube per tree. The access tubes were located

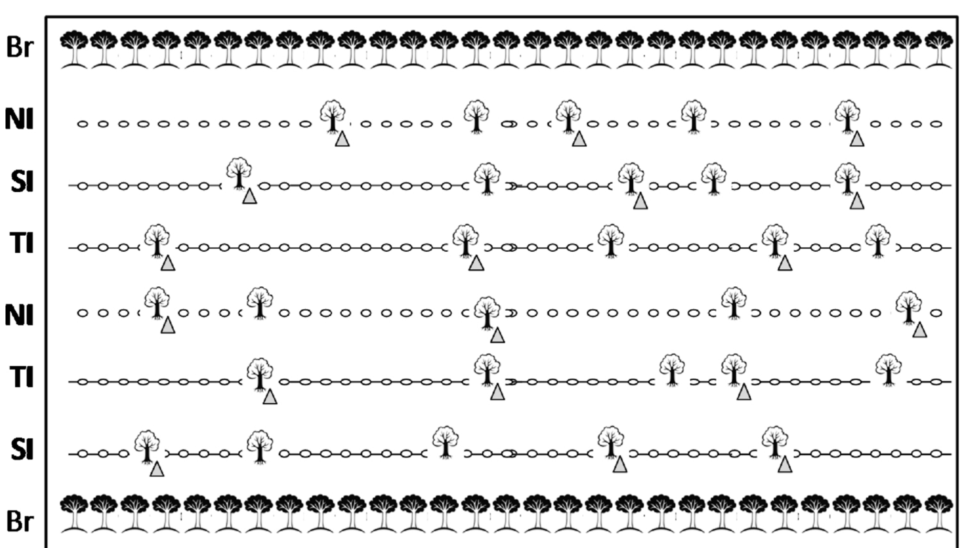

Fig. 1. Experimental plot in 2015 and 2016 with micro-sprinkler system (SI), drip system (TI), non-irrigated trees (NI) and border trees (Br). The triangles (Δ) represent the location of the access tubes of Diviner 2000. Sample trees are represented by trees (🌳).