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PEACH RESPONSE TO WATER DEFICIT UNDER THE CLIMATIC CONDITIONS OF SOUTH-EASTERN ROMANIA

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Abstract

In arid and semi-arid regions, the research and application of new irrigation techniques that economize water without altering tree performance and fruit quality is a challenge. In the present work, the impact of water deficit irrigation applied to peach trees was evaluated. In the context of global warming, saving water is a major goal. The studied crop was peach, Catherine sel. 1 cultivar, fourteen years old, grafted on rootstock Tomis 1. The planting distance was 4 m between rows and 3 m between trees in the row. The split-plot experiment described here is monofactorial, with the irrigation strategy having three gradations. The irrigation regime consists of a fully irrigated treatment T1 (100% ETc), a deficit irrigation treatment (T2), irrigated with half the amount of water in T1 (50% ETc), and a control, non-irrigated treatment (T3). The paper describes the quality of fruits for three years of study, 2020, 2021 and 2022, and 2022, respectively, in the semi-arid region of Dobrogea, Romania. The study suggests that moderate water stress can be profitable for enhancing key fruit quality characteristics.

Key words*: Prunus persica (L.) Batsch, irrigation, soil water potential, quality fruit*

INTRODUCTION

Knowing exactly when and how much to irrigate is essential to attaining sustainable and environmentally sound water management since water is a valuable and expensive natural resource. Reduced total precipitation and altered seasonal distribution are predicted by climate change scenarios, which will make the problem of water scarcity for agricultural use worse (Ondrasek, 2014). An irrigation technique known as deficit irrigation (DI) involves irrigating a crop with less water than necessary for the best possible plant growth. It lowers the amount of water needed to irrigate crops, enhances how well plants respond to a certain water shortage, and either lowers irrigation requirements or boosts crop water use efficiency (Chai et al., 2016). The effects of DI on fruit quality depend on the intensity and duration of the water stress period and on the sequence in which the water deficits occur, as well as on the cultivar (Castel & Buj, 1990). Significant water savings with no impact on harvested yield quantity and quality, increased crop water productivity and farm profitability, and enhanced environmental protection are potential benefits of DI approaches (Geerts & Raes, 2009; Ruiz-Sánchez et al., 2010). Deficit irrigation will become more widely used as water resources become increasingly scarce, especially in regions with limited water supplies (Aragues et al., 2014). Although it originated in the Middle East (Persia or China), the peach (*Prunus persica* (L.) Batsch) tree is now grown in every region with a temperate climate (Chavez et al., 2014). Due to the fruits appreciated by the customers, peaches are among the most significant fruit species in the world. Peaches are a rich source of minerals and vitamins and contain a good amount of sugar (Pakbin et al., 2014). Although peaches are very popular in Romania, their climate-related favorability is rather limited. The Dobrogea zone of Romania is more appealing than other parts of Romania because of its favorable environment, with winter temperatures that are not too low. It also has suitable soils (chernozem mostly), and irrigation can solve water deficiency. The purpose of this work was to study and show the effects of moderate water deficit on fruit quality of mature, Catherine sel. 1 cultivar under drip irrigation.

MATERIALS AND METHODS

Climate and soil conditions

The orchard under study is situated in Agigea, Dobrogea, Romania, at latitude 44º05' North and longitude 28º37' East. The experimental plot is located around two kilometers from the Black Sea and has an average elevation of 30 meters. With an average yearly air temperature of 12.0°C, an average yearly precipitation of 498.7 mm, and a climatic water deficit of around -405 mm (Paltineanu et al., 2007), this region can be described as semi-arid (Paltineanu et al., 2016; Septar et al., 2022). An automatic weather station was used to record the climate data (iMetos, IMT 300, Pessl Instruments, Austria) with a 1-h time-step. With an alkaline pH in the topsoil and a loamy texture, the soil is a calcareous chernozem with good soil structure (0-60 cm depth, with 27-32% g/g clay content, 1.6-2.8% g/g humus content, 1.5-6.8% g/g carbonate content), while in the non-structured subsoil, the humus content is lower than 1% g/g and the carbonates from 9 to 14% g/g; land slope is between 2.0 and 2.5% (Paltineanu et al., 2011). According to Indreias (1997), the average tree rooting depth was 80 cm, and the soil's field capacity and wilting point values were 0.300 and 0.125 cm^3 cm^{-3}, respectively.

Experimental design and Irrigation Application

This split-plot study was mono-factorial and employed three distinct watering treatments. Peach trees (*Prunus persica* (L.) Batsch) were used for this study since they are characteristic of the region. The biological material was Catherine sel.1, a peach cultivar registered in Romania in 2001 at RSFG Constanţa (Figure 1).

Figure 1. Catherine sel. 1 cultivar

The tree is standard, medium vigor, and consistently productive, it is a clingstone cultivar. Its fruit is big, orange with attractive red coloring, with orange, firm, flavourful, and very sweet flesh (Dumitru et al., 2013).

Three seasons in a row (2020, 2021, and 2022) were used for the study. In the spring of 2006, the 4 m × 3 m scheme was used to plant the fruit trees. The plots under study consisted of three consecutive rows of fruit trees, with three trees in the center row designated for measurements and observations. The canopy of the trees was designed like a conventional vase, and clean cultivation was the method of soil management applied both within and between tree rows. As previously reported by Paltineanu et al. (2007) for the area, the irrigation regime consisted of a fully irrigated treatment (T1) watered in accordance with the irrigation needs (100% of ETc = ETo x Kc, Penman-Monteith method, Allen et al., 1998), a deficit irrigation treatment (T2) irrigated with half the amount of water of T1 (50% of ETc), and a control, non-irrigated treatment (T3). Irrigation was provided in T1 when the soil water content (SWC) approached the mid-interval between field capacity (FC) and wilting point (WP). Drip irrigation was employed as the watering technique. There was a 0.6 m dripper spacing and a 2.0 l/h dripper discharge.

The irrigation season ran from May to August in 2020 and from June to August in 2021. Six treatments (20 mm in T1 and 10 mm in T2) were used during the dry period of 2020, with 120 mm in T1 and 60 mm in T2. With 20 mm in T1 and 10 mm in T2, we only used four irrigations in 2021, with a total of 80 mm in T1 and 40 mm in T2. In T3, no water was used. T1 irrigation schedule took the weather forecast into account in addition to ETc and SWC dynamics.

Because only one-fourth of the orchard area received irrigation water, the fruit tree rows displayed a wetted bulb about 1 m wide at the soil surface after irrigation application. The water depth was estimated to be equivalent to 80 mm for the tree rows.

Soil water content measurements

Every week, the soil water potential (SWP) of each fruit tree was measured using Watermark resistance blocks (6450 Watermark Soil Moisture Sensor) positioned at four different depths of 20, 40, 60, and 80 cm, and 150 cm from the tree trunks. The sensors were

positioned at 45° angles below the horizontal on the same vertical line, following the Paltineanu and Howse (1999) methodology.
WatchDog dataloggers (DataLogger, WatchDog Model 1650, Spectrum Technologies, USA) were used to record the data. Previous field data research has established correlations between gravimetrically measured SWC and SWP detected by Watermark sensors (Paltineanu et al., 2011). During the experiment, these relationships were then employed to convert soil water matric potential data into SWC values.

Assessed parameters

An average of fifteen fruits per treatment were evaluated annually. After harvest, fruit height and longitudinal and transversal diameter were measured to track fruit growth. A metric digital caliper (Insize Co., Ltd. China) was used to make the measurements. The average weight of the fruit resulted from weighing ten fruits per treatment and dividing the total weight by the number of weighed fruits. The fruit was weighed by using a precision balance (Kern & Sohn GmbH, Germany). The fruits from the experimental plot were harvested from the 11th to the 12th of August in 2020, the 2nd to the 3rd of August in 2021, and the 3rd to the 4th of August in 2022.

Data analyses

For the analysis of variance and other calculations of fruit quality attributes, SPSS 14.0 software and Microsoft Office Excel were used. The graphs' difference letters indicate significant variations with a probability (P) ≤ 0.05, based on Duncan's multiple comparison test.

RESULTS AND DISCUSSIONS

Climate conditions

During the growing season of the studied period, the average maximum and minimum air temperatures were 26.1 and 12.4°C, respectively, in contrast to the long-term average maximum and minimum air temperatures of 23.1 and 13.8°C. The long-term average air temperature was 18.7°C, while the study period average was 19.0°C (Figure 2). The growing season had a mean annual precipitation of 252.1 mm, slightly lower than the long-term total of 277.5 mm, and a mean annual reference evapotranspiration of 733.2 mm, slightly higher than the long-term total of 722.7 mm. These data indicate a relatively normal period for precipitation and evapotranspiration (Figure 3).

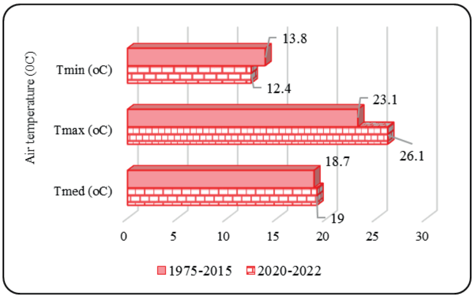

Figure 2. The mean air temperature, maximum and minimum air temperature for the growing season 2020-2022 compared to long-term data, 1975-2015, Agigea, Romania

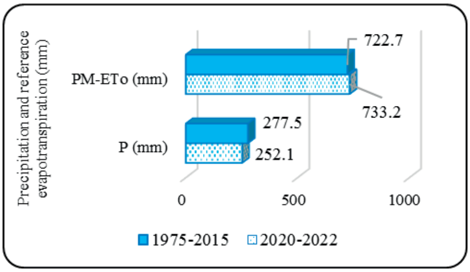

Figure 3. Precipitation and references evapotranspiration for the growing season 2020-2022 compared to long-term data, 1975-2015, Agigea, Romania

Soil water content (SWC)

Following the implementation of the six irrigations, Figure 4 illustrates the dynamics of the soil water content in 2020. Consequently, the values of SWC oscillated between FC and MAD (management permitted deficit, mid-interval between FC and WP), in the irrigated treatments. In the end of vegetation period, in the control treatment (T3) the SWC values approached to WP.
Following the application of the four waterings in 2021, the dynamics of the water content in the soil is illustrated in Figure 5. Without the values from the last watering in the T2 treatment, which were situated in the interval between MAD and WP, with values near to MAD, it was shown that the SWC values in T1 and T2 were between the interval of FC and MAD. In the control treatment (T3), the SWC values are situated in

the interval between MAD and WP due to the dry year.

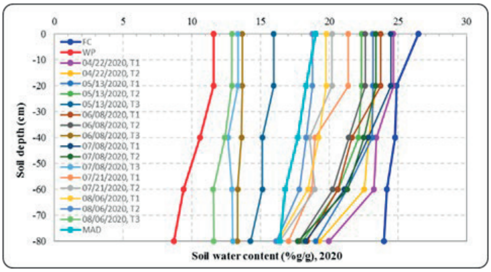

Figure 4. Soil water content in the treatments studied, Agigea village, Romania - 2020

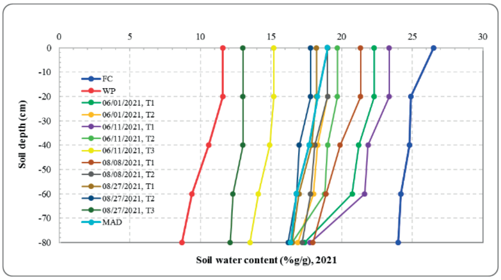

Figure 5. Soil water content in the treatments studied, Agigea village, Romania - 2021

Evaluations of peach fruit quality

Following harvesting, the experiment's fruits underwent laboratory analysis to determine their weight and biometric measures, respectively. The values that are displayed are the three years' worth of study's mean values. Fruit weight measured on the fruits of the under study showed that in the fully irrigated treatment (T1) had the highest value (182.9 g) and the non-irrigated treatment (T3) had the lowest value (112.0 g). Figure 6 illustrates significant differences in fruit weight on the treatments under studied.

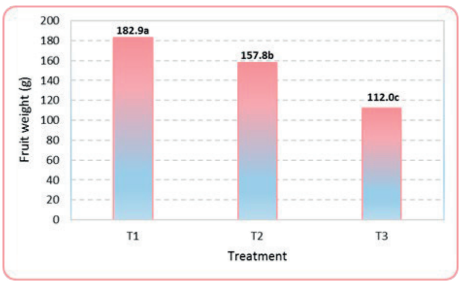

Figure 6. Fruit weight of the fruits to Catherine sel. 1 cultivar, 2020-2022

The longitudinal diameter of the peach fruits to Catherine Sel. I cultivar varied from 59.25 mm to 72.74 mm. The shortest longitudinal diameter can be observed in the control treatment (T3). Figure 7 illustrates significant variations between the researched treatments regarding the longitudinal diameter of the fruit, with probability (P) ≤ 0.05 using Duncan's multiple comparison test. In the case of the transverse diameter of the fruits, applying the watering treatments resulted in a trajectory similar to the longitudinal diameter of the fruits. The highest value regarding the transverse diameter of the fruits was obtained in the fully irrigated treatment (T1) and was 67.9 mm, while in the control treatment (T3), the lowest value of the transverse diameter was 56.1 mm, respectively. The significant differences in terms of transversal diameter of the fruits between the treatments under study are indicated by different letters in Figure 8.

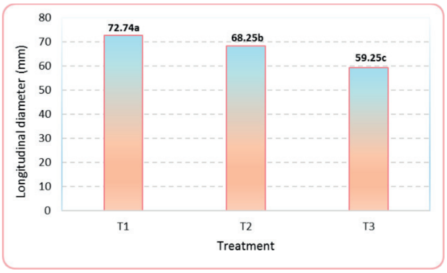

Figure 7. Longitudinal diameter of the fruits to Catherine sel. 1 cultivar, 2020-2022

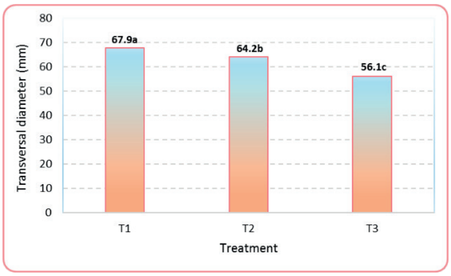

Figure 8. Transversal diameter of the fruits to Catherine sel. 1 cultivar, 2020-2022

The height of the fruits as indicated by the researched treatments showed a similar pattern. The height of the peach fruits oscillated from 52.6 mm to 63.8 mm. The significant variations in fruit height, following the researched treatments, are shown in figure 9.

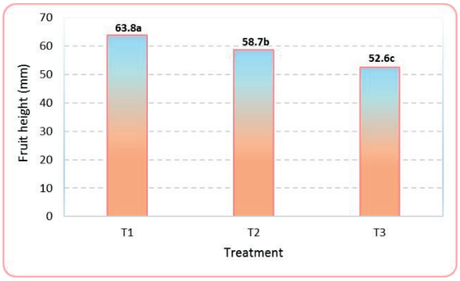

Figure 9. Fruit height of the fruits to Catherine sel. 1 cultivar, 2020-2022

CONCLUSIONS

The fully irrigated treatment (T1) increases fruit quality. However, the use of full irrigation treatment is not a unique option as water use becomes increasingly constrained due to global warming. As a result, deficit irrigation is recommended, taking into account that the soil water content (SWC) does not reach the wilting point (WP) in all horizons, at the same time.

Because drip irrigation delivers water directly to the target, producers may be able to conserve more water.

Effective water management, fruit production protection, and reduced water stress can all be achieved with sustainable practices and the appropriate strategy.

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