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Monitoring of the Dendrometric Changes Influenced by Soil Water Content

Vladimír Kišš[1*], Viliam Bárek[1], Beáta Novotná[1], Lucia Tátošová[2]

[1] Department of Water Resources and Environmental Engineering, Slovak University of Agriculture in Nitra, Hospodárska 7, 949 76, Nitra, Slovak Republic

[2] Department of Landscape Planning and Land Consolidation, Slovak University of Agriculture in Nitra, Hospodárska 7, 949 76, Nitra, Slovak Republic

* Corresponding author's e-mail: vlado.kiss@gmail.com

ABSTRACT

Drought is generally associated with the persistence of low precipitation amount, decreased soil moisture and water availability relative to the normal levels in a designated area. The effects of drought, range from the morphological to molecular levels, and are evident at all phenological stages of the plant growth, at whatever stage the water deficit occurs. Determination of the surface water demands for irrigation purposes comes out from the assumption of hydrologic processes stationarity. This paper shows our research prerequisite that water stress participates in an important part on the volume changes of over ground parts, which is predictive for the irrigation demand. Malus domestica var. Yellow Transparent was chosen for the measurement of volume changes of the surface plant parts. Our measurements were realised by the Diameter dendrometer small (DD-S) from 24.08. to 13.09.2017. One tree was irrigated by the dose of 50 mm. We compared the dendrometric changes to soil moisture and rainfall on both irrigated and non-irrigated trees. The experiment showed the differences between the irrigated apple tree (the diameters of the branches fluctuated between 11.9 and 12.1 mm) and the non-irrigated apple tree (the diameter of the branches increased after three-day rain from 8.35 to 8.61 mm), in order to determine the water stress of plants based on dendrometric changes and optimize irrigation during the drought period.

Keywords: drought, dendrometer, irrigation, soil moisture

INTRODUCTION

Drought is generally associated with the persistence of low precipitation amount, decreased soil moisture and water availability relative to the normal levels in a designated area. However, there is no single universally accepted definition for drought. Tallaksen and Van Lanen [2004] define it as "a sustained and regionally extensive occurrence of below average of the natural water availability. The difference between droughts and other extreme events, like floods and earthquakes, is that the former in a less visible natural risk, the impacts of which are not systematically recorded. Droughts range among the most complex and the least understood natural hazards, affecting more people than any other one. They are also recurrent hazards, particularly in the areas with pronounced natural hydrological temporal variability [Portela et al., 2015]. Faced with the scarcity of water resources, drought is the single most critical threat of the world food security. The effects of drought, range from the morphological to molecular levels, and are evident at all phenological stages of the plant growth, at whatever stage the water deficit takes place [Farooq et al., 2009].

During the plant growth, water consumption by plants depends not only on the water content in the soil but also on the water content in the plants. Sometimes, during the vegetation period, rainwater or irrigation water is sufficient to cover the water demands for plants. When the water consumption is increasing, and there is not enough rain and irrigation, the plants draw water from the water supplies in soil. With decreasing soil water content, the physiological water scarcity in the plant body is observed, which can be visible even microscopically. At this point, the plant growth is slowed down, which is accompanied by a significant withering. In the next phase, the plant growth is completely stunted, ending by drying and dying [Švihra and Kleňová, 2011].

Determination of the surface water demands for irrigation purposes arise from the assumption of hydrologic processes stationarity. During the last 20 years, a reduction of runoff volume in water streams occurred and according to climate changes scenarios, the trend will continue. Therefore, their values need to be reassessed. This will lead to increasing number of the river basins with water deficit [Bárek et al., 2007, Fuska, Bárek, 2015]. Drip irrigation is therefore an economical way to apply water drop by drop directly to the crop. It is one of the newest ways of irrigation that has achieved the widest and fastest expansion in the irrigation of flowers, the subsurface lawn method, but it also has its application in the irrigation of maize and potatoes. Its advantage is an operational service, water optimization into the root plant system, water and energy savings, elimination of the soil degradation, integrated fertilization, etc. The main factor in the application of this irrigation method is the water consumption, or saving the amount of water compared to cthe onventional irrigation methods, such as basin and spray irrigation. Drip irrigation gives more moisture directly to the plant; thereby, it confers a positive effect on the quantity, uniformity and quality of the crop [Jobbágy et al., 2017, Igaz et al., 2008, Takáč et al., 2008].

There is a dimensional change in plants due to the growth and water content depending on the daily and seasonal plant dynamics. The daily changes reflect the water content variations in the texture. Seasonal dynamics reflect the long-term changes due to the growth. In our research, we focused on the plant water stress in the drought periods and optimization of the irrigation dose in real–time, based on the dendrometric changes.

MATERIAL AND METHODS

The surface plant parts of Malus domestica var. Yellow Transparent were chosen for measurement of volume changes. It is an undemanding variety originating from the Baltic area, characterized by frost resistance. It belongs to the earliest summer apple variety; it matures from the half of July to the beginning of August. The age of monitored apple trees is about 20 years.

Two trees were chosen to measure water demands, under the same conditions, to minimalize the mistakes caused by areal conditions. The trees were connected with to a dendrometer on the opposite places of the tree to monitor the potential changes caused by adumbration during the day. Our measurements were realised by means of Diameter dendrometer small (DD-S). Dendrometers are ideal equipment to fulfil the requirement for mean for exact and continual monitoring of radial and vertical changes into the plant texture, for example stalk, fruit, leaves. It is suitable especially for the measurement of young plant parts.

Figure 1. Dendrometer DD-S (Kišš, 2017)

The precision of measurement is up to 2 μm, in datalogger using DL18 is ± 0.1 %, the output signal is in the range of 0 – 11000 ohm. Any connection from the external source and equipment calibration is not necessary. The equipment does not cause plant disruption, it is not susceptible tp weather changes, and it enables to use it in the range of the external temperatures from -30 to 40°C and for the relative air moisture in the range from 0 to 100%. It is made from stainless steel and aluminium. The temperature coefficient is lower than 0.04% to one K of the temperature. The equipment weighs only 13 g; hence, it does not cause a considerable load for the plants. The standard length of the cable is 5 m, with the possibility of prolongation up to 100 m. The data are collected by a datalogger from time to time, according to the settings. There is only one restriction, i.e. the capacity of the internal memory card [Bárek et al., 2016]. We measured the data every 15 minutes. The soil moisture and rainfalls were taken from the meteorological station about 50 m from our experiment.

The research was carried out from 24.08. to 13.09.2017. One apple tree was irrigated by drip irrigation with the dose of 50 mm. The irrigation took place every day, except for the rainy days. On the basis of the measured and obtained data, we compared the dendrometric changes to soil moisture and rainfall on both irrigated and non-irrigated trees.

RESULTS AND DISCUSSION

For the non-irrigated apple trees, as it is seen in the first half of the experiment (Figure 2), the diameters varied around 8.4 mm, despite precipitations above 5 mm on 27.8.2017. After three days of rain dose, an increase in the diameter of the studs from 8.35 mm to 8.61 mm was observed. Subsequently, these averages declined, due to the minimum or zero precipitations dose in the current period. An increase in the growth was observed at the end of the experiment, when two-day precipitations of more than 2 mm were sufficient to increase the plant mass and thereby raised to 2 mm.

Figure 3 shows that soil moisture in 50 cm increased after the first rain dose in 27.08.2017 and gradually declined, which did not affect the dendrometric changes at this depth significantly, as it was in the case of three-day precipitation in the middle of the experiment.

For irrigated plants, the changes were not as significant as in the case of the non-irrigated crops. The precipitations on 27.08.2017 did not change the average values. They varied between 11.9 and 12.1 mm; however, the fluctuations were more observable than after the precipitation from 01.- 03.09.2017, when this difference was only 0.1 mm (Figure 4). This could be caused by a lack of soil moisture (Figure 5), despite the irrigation dose of 50 mm. The irrigation dose could infiltrate through the pores into the soil further from the root zone. After three days of rain, the soil was partially saturated with water and the irrigation dose was directly delivered to the root zone.

CONCLUSION

The experiment showed the differences between the irrigated and the non-irrigated apple

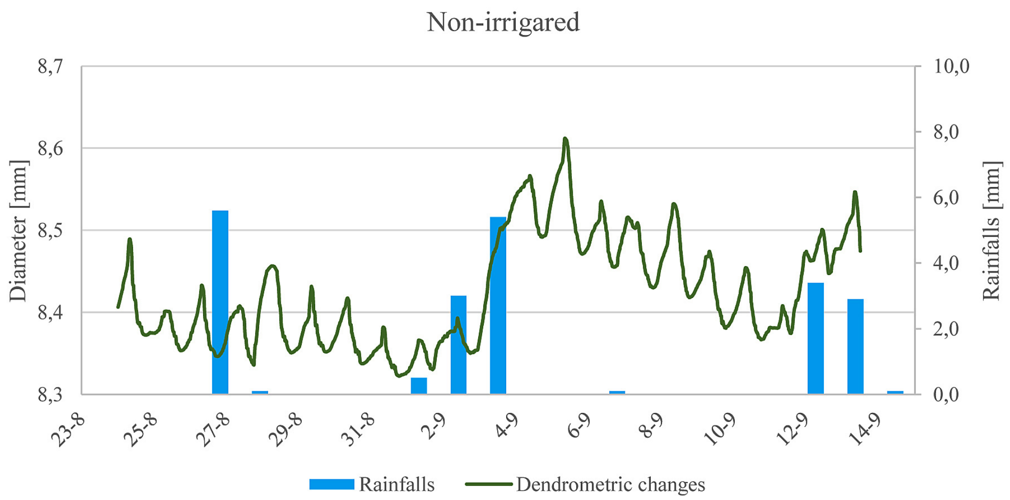

Figure 2. Dendrometric changes in comparison with rainfalls (non-irrigated tree) (Kišš, 2017)

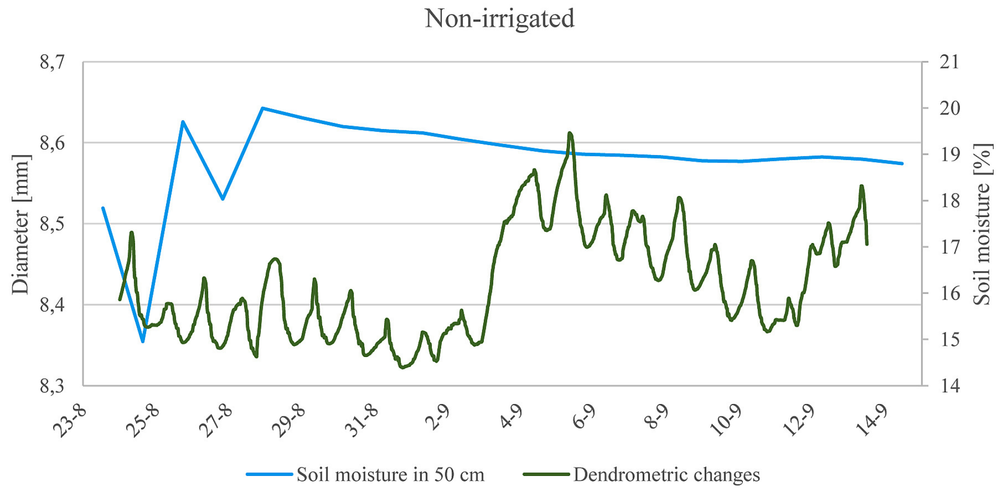

Figure 3. Course of the dendrometric changes in comparison with soil moisture (non-irrigated tree) (Kišš, 2017)

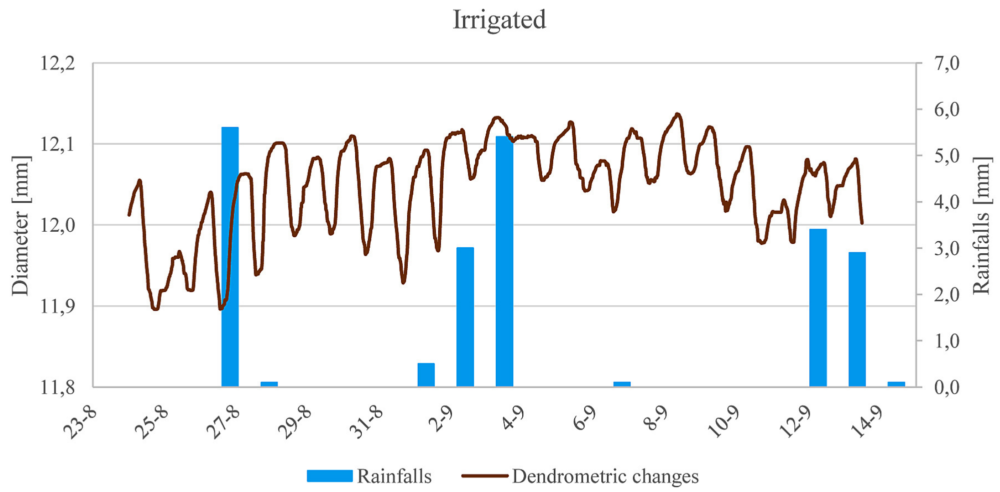

Figure 4. Course of the dendrometric changes in comparison with rainfalls doses (irrigated tree) (Kišš, 2017)

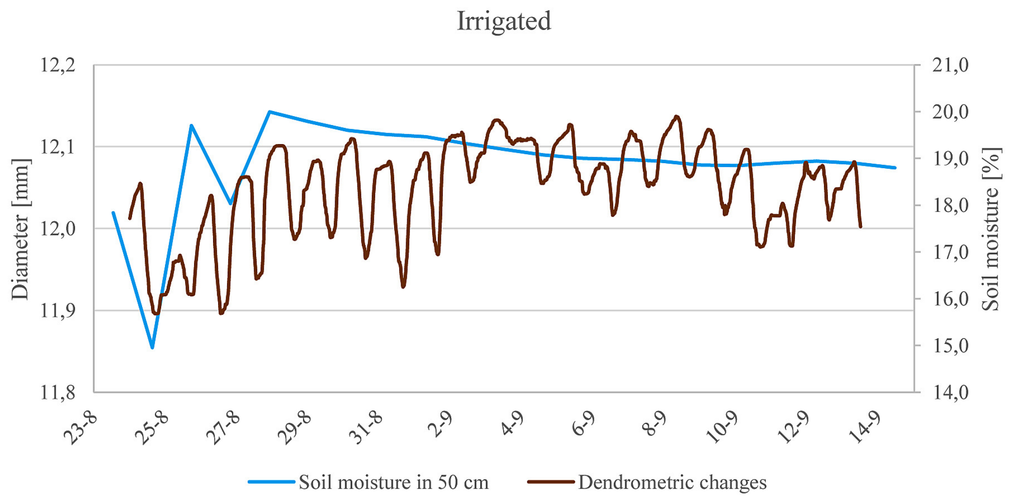

Figure 5. Course of the dendrometric changes in comparison with soil moisture (irrigated tree) (Kišš, 2017)

trees. The diameter of the branches at the non-irrigated tree was minor during the dry period and increased after a three-day rain dose up to 0.26 mm. On the other hand, the diameter of the branches at the irrigated tree varied from 11.9 to 12.1 mm. On the basis of the results, we conclude that dendrometers are one of the ways that enable determining the water stress of plants and optimizing irrigation, although further, longer measurements are needed.

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