Rožnovský, J., Litschmann, T., (eds): Mendel a bioklimatologie. Brno, 3. – 5. 9. 2014,
ISBN 978-80-210-6983-1

Using portable Dynagage sap flow logging system to measure sap flow in the young plants on soil conditioner in nursery

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Abstract

The experiment was established in spring 2013 on experimental plots of the Faculty of Horticulture Lednice, Mendel University in Brno. The aim of this work was to evaluate the effect of hydro absorbent (Hydrogel) and growing technology on morphological and physiological parameters of the model plants (*Tilia platyphyllos* L.). For the individual treatments of the experiment a substrate was premixed with an addition of the hydro-absorbent Hydrogel at a rate of 2; 3.5 and 5 grams per cubic meter of the substrate and there was also a control variant. The hydro absorbent Hydrogel retains a lot of water in addition to the humidity of the substrate and it releases the water for the root system, when the moisture content decreases. The plants which were cultivated with a hydro absorbent in the substrate was measured sap flow at the value 14g.h^{-1}, while the sap flow at the value 12 g.h^{-1} for plants from the control variant was observed. Due to our investigation, we can conclude, that Hydrogel doesn't have significant affect to increase sap flow in plants.

Key words: sap flow, transpiration, water stress

Introduction

The water flow represents the biggest energy flow in vegetation which also causes its magnificent climatic effect. Plants can only survive when their exposed parts are effectively conditioned, i.e. cooled. From all the water taken up by plants, the majority is transpired, leading to leaf cooling and only minor amount of water is consumed to

all the other processes. The transpiration can be estimated through measurement of sap flow rates in a tree stem (Čermák and Kučera, 1981; Salaš et al. 2010).

In the last decades, the reaction of the scientific community to this problem has been to invest a substantial amount of research into new irrigation technologies and more efficient scheduling approaches. Plant-based methods are considered to have a greatest potential for irrigation control although, in some cases, there are issues in defining a reference or threshold value and other issues including plant variability within the orchard (Naor and Cohen, 2003). Improved scientific and practical knowledge on plant responses together with advances in electronic sensors and automated equipment for monitoring and data communication, are helping to overcome some of these limitations (Fereres et al. 2003; Naor et al. 2006). In addition, thermal remote sensing methods can be combined with plant-based methods for precise irrigation of heterogeneous commercial orchards using a manageable number of instrumented plants (Sepulcre-Cantó et al. 2006).

Materials and methods

The experiment was established at a multipurpose scientific experimental workplace on plots of the Faculty of Horticulture in Lednice in 2013. *Tilia platyphyllos* L. was selected as the object of the study, which is one of the species with relatively simple technology that is growing with the increasing demand for water and leaf area large enough to accurately measure the parameters. All used garden containers had the same volume – 5 L. In the experiment, each variant used 50 pieces of planting material and the planting technology was traditional. For the individual treatments of the experiment a substrate was premixed with an addition of the hydro-absorbent Hydrogel at a rate of 2; 3.5 and 5 grams per cubic meter of the substrate and control variant (Table1). The substrate used was peat mixture RKS II from manufacturer AGRO CS, a. s., Česká Skalice. Chemical and physical characteristics of the substrate: pH 5.5–7.0; N 250–350 mg.1L^{-1}.; P_2O_5 200–250 mg.1L^{-1}.; K_2O 300–400 mg. 1L^{-1}.

The irrigation system was automatic; containers had sensors for measuring the humidity and temperature of the substrate. Temperature for automatic irrigation was installed and set to 25 ^{0}C.

To study the sap flow, the plants were selected, and the micro sensors were installed. The sap flow was measured three times per month for each variant. Work principle of the micro-sensors in trunk gages is that they have four pairs of differential temperature sensors spaced around the circumference of the trunk. This design ensures that flow rates varying around the circumference are accurately monitored and averaged into one reading. Up to 18 radial heat flux sensing thermocouples are also spaced evenly around the circumference to ensure that radial heat is accurately monitored. Micro-sensors were connected to a datalogger AVRD to take readings every 10s, and to store the data to determine the means at intervals of every 10 min.

Table 1. Variants of the experiment and the application rate of Hydrogel

Variants	*Application rate* ($g.m^{-3}$)
1	0.0 – control variant
2	2.0
3	3.5
4	5.0

Results

Figure 1 shows differences in sap flow in the trunks of plants at four variants. Accordingly we can observe that in all cases the highest sap flow was in the afternoon, between about 13:00 and 14:00. This may be due to the fact that during this period there was a higher temperature than in the other daytimes (Fig.4) and the humidity was 68% in average (Fig.5). At the same time, there was observed a small stream of sap at the control variant (var.1), where there was not used any hydro absorbent Hydrogel. The results show that the response of the plants obtained by the stem heat balance method varied dynamically from 5 to 15 min (Trejo-Chandia, 1997).

As shown in Figure 2, in this time period as compared with Figure 1, the sap flow was high, and the percentage was about 80%. Unlike variants 1 and 2, in the variants 3 and 4, the increased sap flow can be observed, resulting in more intense release of vapor into the atmosphere. The atmosphere humidity was 68% in average, the temperature was 22 ^{0}C and the substrate humidity in the container was 25%. With global warming, it is likely, that both daytime and nighttime temperatures will be

increasing. If the diurnal temperature range remains constant, the global warming will lead to an increase in transpiration because the saturated vapor pressure curve is steeper at higher than at lower temperatures (Kirschbaum, 2004).

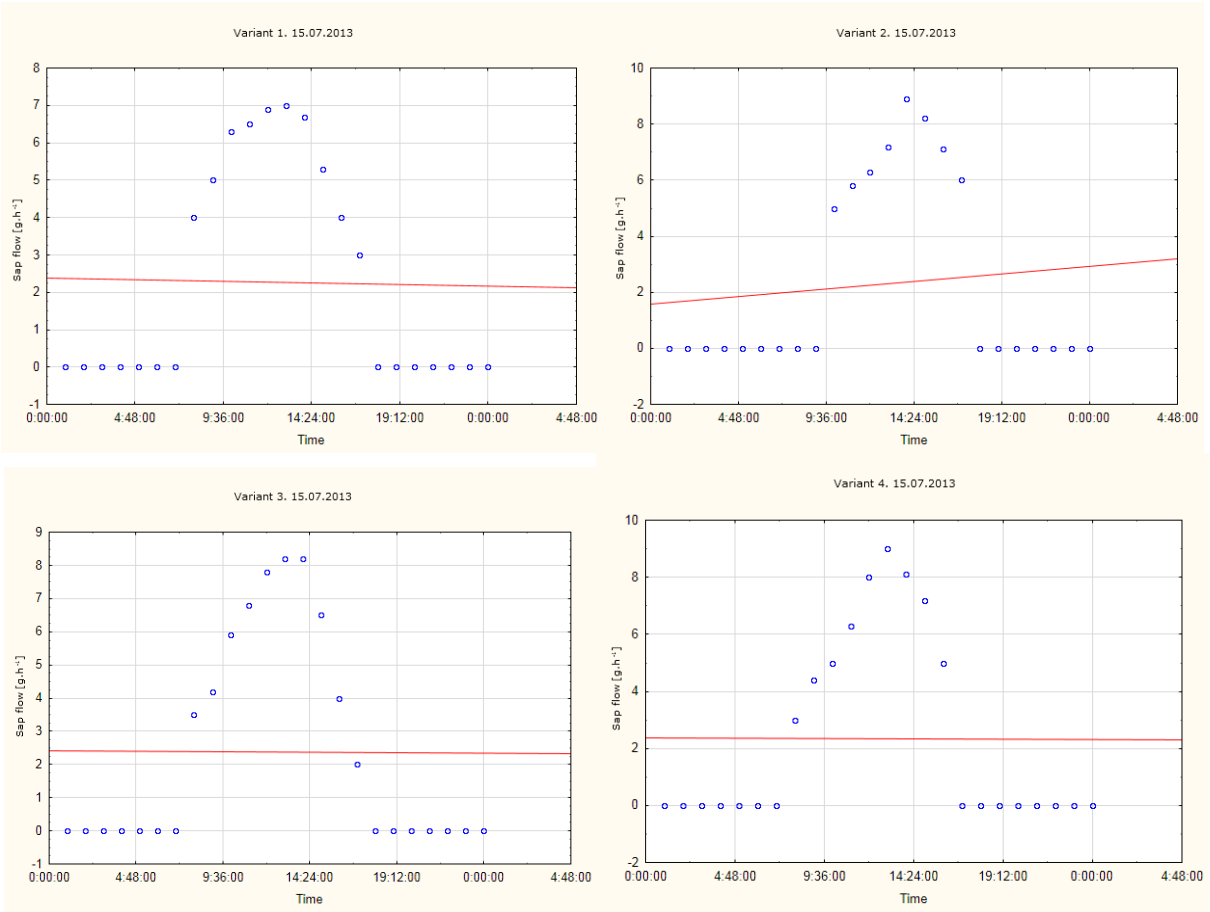

Fig.1. Time series of the daily average sap flow density averaged for four variants, 15.07.2013

Figure 3 shows that at all variants (var.2-4) except the control variant (var.1), the sap flow was substantially the same. Even the definition of the coefficients was identical. This means that for 73% of the cases, the sap flow transpiration rate per hour was about 0.11-0.13. The difference of radial temperature slightly varied during the day due to the cooling of the heater taking place by sap circulation; meaning that when the sap flow increases the difference of radial temperature diminishes (Fig.4). The high stomatal resistance accompanied by low evaporative demands of the wet air caused a strong decrease in transpiration. However, the surface resistance of the moist soil remained low (Fig.5), which created suitable condition for

evapotranspiration from soil. In this situation, evapotranspiration from the soil exceeded transpiration. Evapotranspiration and transpiration of different vegetation types are at present well represented in many different SVAT models of different levels of complexity (Čermák and Kučera, 1981).

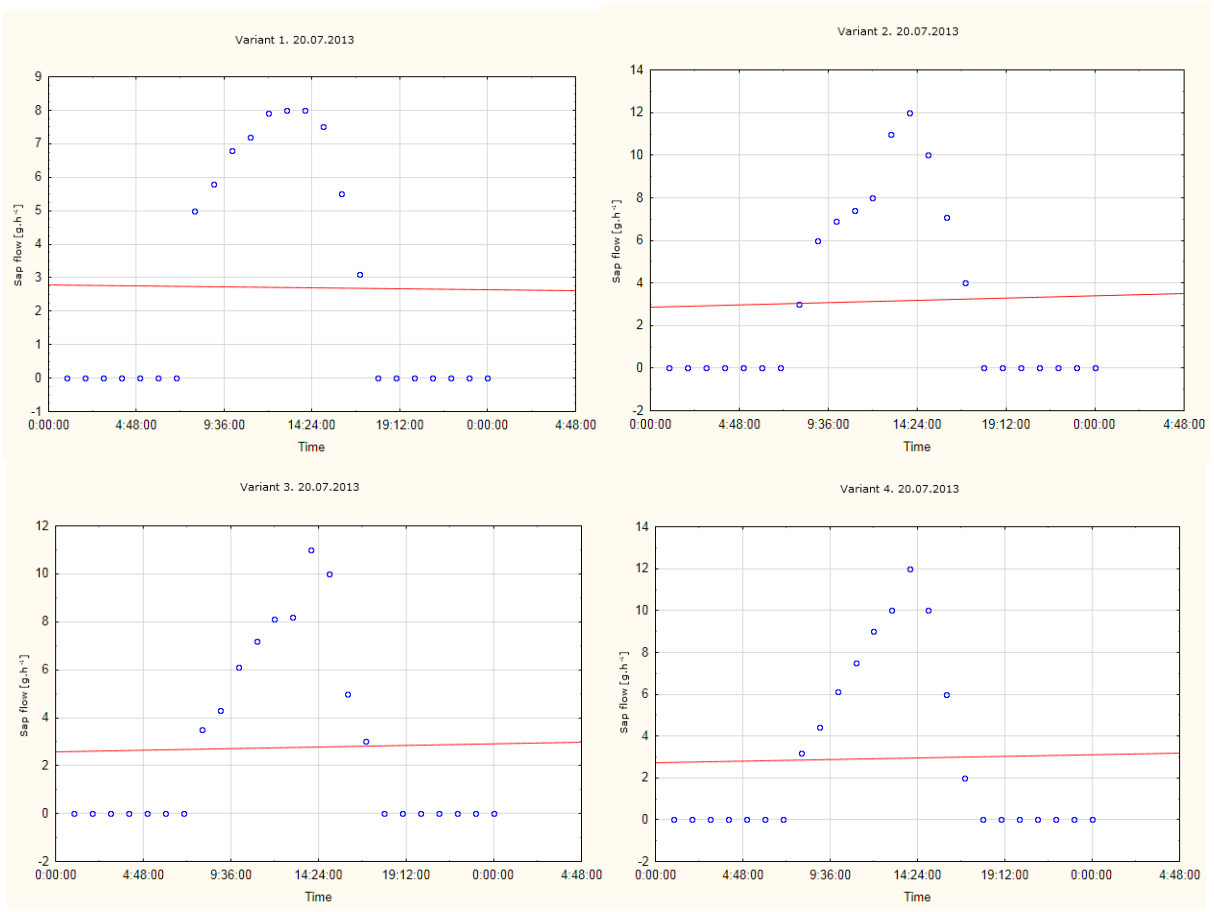

Fig.2. Time series of the daily average sap flow density averaged for four variants, 20.07.2013

Discussion

The experiments show that there is a small difference in sap flow among the variants planted with hydro absorbent and a control variant. As indicated above, the plants planted with Hydrogel performed predominantly high sap flow, which means high transpiration of vapor into the atmosphere. Anyway, other important factors, such as wind, humidity of the substrate, leaf area and plant height, might influence the transpiration besides the hydro absorbent. However, the surface resistance of the moist soil remained low and created suitable conditions for evapotranspiration from

the soil. The stem heat balance method appeared to underestimate the values (4.3%) of daily transpiration in plants.

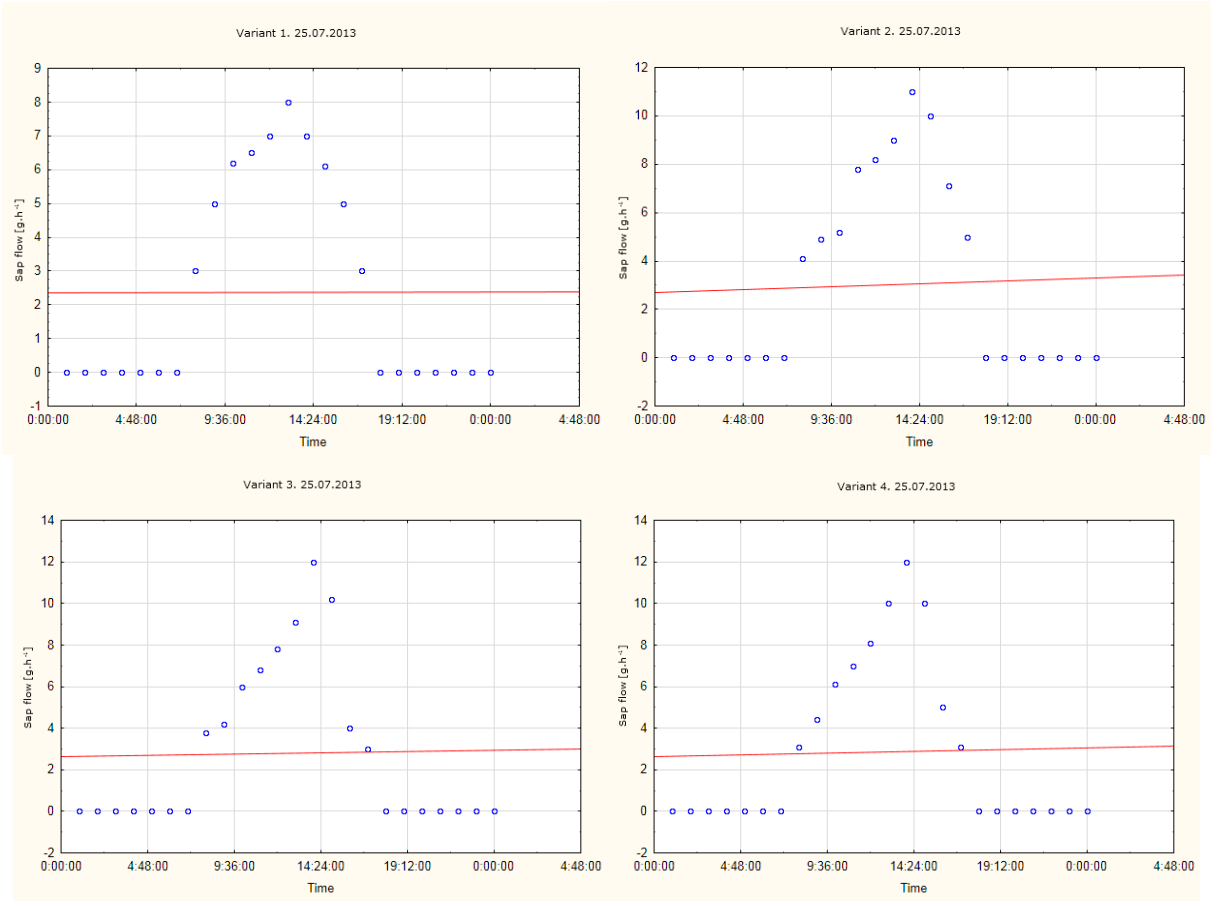

Fig.3. Time series of the daily average sap flow density averaged for four variants, 25.07.2013

Conclusions

The hydro absorbent Hydrogel retains a lot of water in addition to the humidity of the substrate and it releases the water for the root system, when the moisture content decreases. This results in constantly high moisture content, which affects the sap flow in the plant. In variants containing high percentage of Hydrogel there was observed a high transpiration rate. It should be noted that in addition to high sap flow and transpiration rate, the morphological parameters of the plants planted with hydro absorbent were much higher than at control variants.

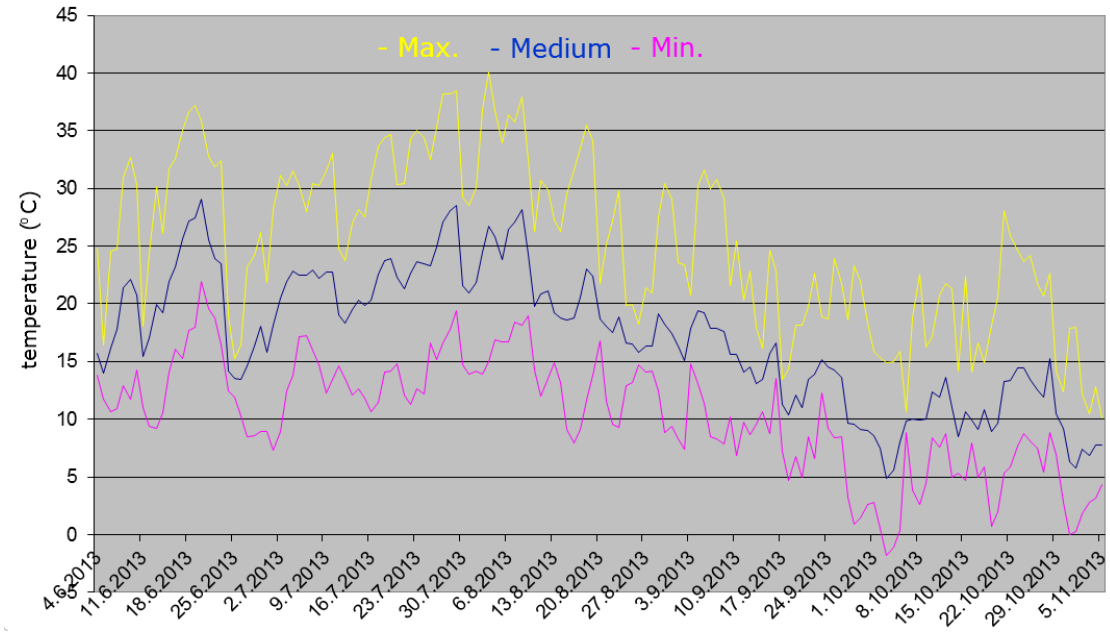

Fig.4. The average temperature in Lednice, 2013

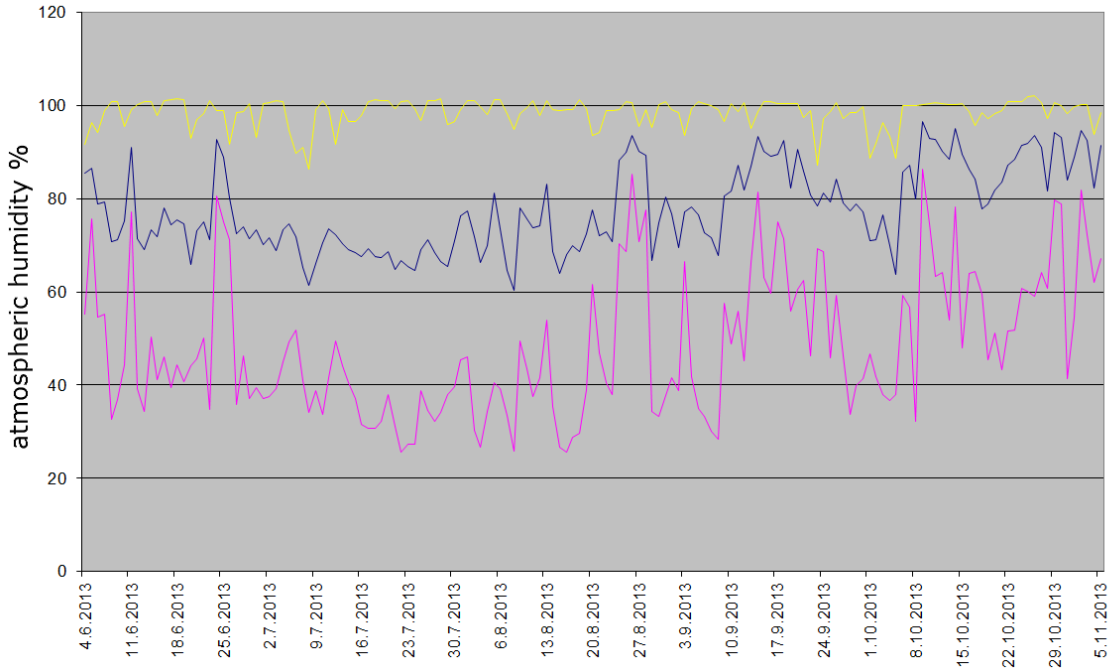

Fig.5. The atmospheric humidity in Lednice, 2013

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Summary

Pokus byl založen v Lednici na jaře v roce 2013 na pokusných plochách Zahradnické fakulty Mendelovy univerzity v Brně. Cílem práce bylo zhodnotit vliv aplikace hydroabsorbentu (Hydrogel) a zvolené pěstitelské technologie na morfologické a fyziologické parametry modelových rostlin (*Tilia platyphyllos* L.). Hydrogel byl aplikován ve třech koncentracích: 2 $kg.m^{-3}$, 3.5 $kg.m^{-3}$, 5 $kg.m^{-3}$ pěstebního substrátu, kontrolní varianta byla bez aplikace Hydrogelu. Hydroabsorbent Hydrogel má schopnost absorbovat a uvolňovat vodu a živiny rostlinám a zajišťuje maximální dostupnost vody pro kořeny rostlin v období sucha. U rostlin, které byly pěstovány v substrátu s hydroabsorbentem, byl zjištěn průtok mízy v hodnotě 14 $g.h^{-1}$, zatímco u kontrolní varianty byl zjištěn průtok mízy v hodnotě 12 $g.h^{-1}$. Výsledky ukazují, že Hydrogel neměl vliv na výrazné zvýšení průtoku mízy v rostlinách.

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