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A new method for determining water uptake in elderberry plantation

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Abstract

A considerable quantity of elderberry (*Sambucus nigra* L.) fruit gets yearly on the market in Hungary. The decisive majority of this quantity is harvested from feral plants. The area of elderberry plantations is only 150–180 ha in spite of the fact that it would be possible to produce this valuable fruit on larger surface if suitable watering system were applied. The fruit of elderberry is important from the aspect of food industry. The goal of present study is promoting the effective irrigation of elder berry plantation. The experiments were carried out in the Experimental Farm of the University for Horticulture and Food Industry in Szigetcsép from 1989. The measuring of the water demand of elderberry using the heat pulse method was started in 1996. The measurement of the sap-flow in the trunk is a new element of phyto-climate researches. The development of the equipment was started in 1991 and improvement of the method is still going on. In this phase, first of all the connections between sap-flow velocity and meteorological data were investigated. Summarising the experiences of the trials it can be announced that: (1) The water circulation of elder plants principally depends on the conditions of atmosphere. It is barely sensitive to the water content of the soil. (2) The transpiration intensity reacts sensitively to the change of meteorological conditions. (3) The changing rate of the transpiration coefficient is particularly large in certain intervals of the meteorological elements.

Keywords: Sap-flow; Water uptake; Evapotranspiration; Study orchard; Field experiment

1. Introduction

The basic research goals were as follows:

- to develop a methodology to measure transpiration of trees with the heat pulse technique,
- to measure transpiration of at least one nut and one deciduous tree crop to establish diurnal, weekly, and, if it is possible, annual transpiration rates,
- to compare measurements from heat pulse techniques with predictions from meteorological based transpiration/evapotranspiration equations and from changes in soil water content measured in the vicinity of experimental site,
- to compare measurements from heat pulse technique with the results of transpiration simulation model using only standard meteorological parameters measured in the study orchard,
- to evaluate the potential for use of the heat pulse technique in irrigation scheduling.

The present paper would like to show the first results of the field experiments carried out in elderberry stand. The used heat pulse sound was its own development of the Soil Science and Water Management Department.

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The research plan consisted of measurements to be made on on-going experiment of elderberry stand because the fruit of elderberry is important from the aspect of food industry. The goal of present study is promoting the effective irrigation of elderberry plantation. A considerable quantity of elderberry (*Sambucus nigra* L.) fruit gets yearly on the market in Hungary. The decisive majority of this quantity is harvested from feral plants. The measurement of the sap-flow in the trunk is a new element of phyto-climate researches. The development of the equipment was started in 1991 and improvement of the method is still going on. In this phase, first of all the connections between sap-flow velocity and meteorological data were investigated.

2. Materials and method

Two measurement campaigns were organised. The field experiments were carried out between 10 and 13 July of 2000 and 8 and 15 July of 2001, in the Study Orchard of the University of Horticulture and Food Industry in Szigetcsép. The plantation was founded in 1989. Various micro-climate measurements have been carried out in the study orchard since 1990. The installation of the instrument in the examined plantation during the field experiment is shown in Fig. 1. The plantation is used as demonstration area of the students of the University in the frame of agrometeorology training. The type of soil is sandy loam. The average leaf area index was $4\,m^2m^{-2}$ during the field experiment period. The average relative coverage was 0.95. Meteorological data collection was carried out simultaneously with the experimental measurements. The parts of meteorological observation were global radiation, air and soil temperature, air humidity, wind speed measurements and cloudiness observation. The frequency of the data collection was 8 min. The height of air temperature measurements was 0.05, 1, and 2 m. The soil moisture was measured of the upper 1 meter layer by 20 cm using weighting method.

As a new tool of the in situ measurements of the water demand of elderberry, the heat pulse method, was started in 1996. The main element of the measurements was the use of determination of the sap-flow. The method is very simple in principle (Huber and Schmidt, 1937; Vieweg and Ziegler, 1960) but in practice it has many difficulties. The sap-flow was measured using the heat pulse method. The goal of the heat pulse method is to determine the sap-flow rate and using this information to calculate the real transpiration of the plant (Cohen et al., 1988; Herzog et al., 1997). The base of the method is the solution of the two dimensional heat transport equation in case of linear heat source.

The slap moves in the xylem and we would like to know the speed of the stream. The signal of the movement is a heat pulse. A short heat pulse is loaded into the sap which is flowing in the xylem and the time of heat wave movement is measured. The heat sound consists of three needles. The Fig. 2 shows the size of the sound. The rights position of the three needles highly determines the results of the field measurements. The needle is put in the middle of the sound heating element of the system. It issues the heat pulse. The two other needles are the heat sensors. The sound is introduced into the xylem tissue of the plant. The Fig. 3 shows a totally equipped sound on the stem of a control plant. It is a laboratory picture. It was taken during the calibration campaign of the instrument in the laboratory of the Department before the field experiments. The showed instrument is its own development of the Department. A heat pulse is emitted by the middle needle and the temperature equalisation time (t_0) of the heat sensors is measured. The heat stream and consecutively the

Fig. 1. The installation of the instrument in the field experiment.

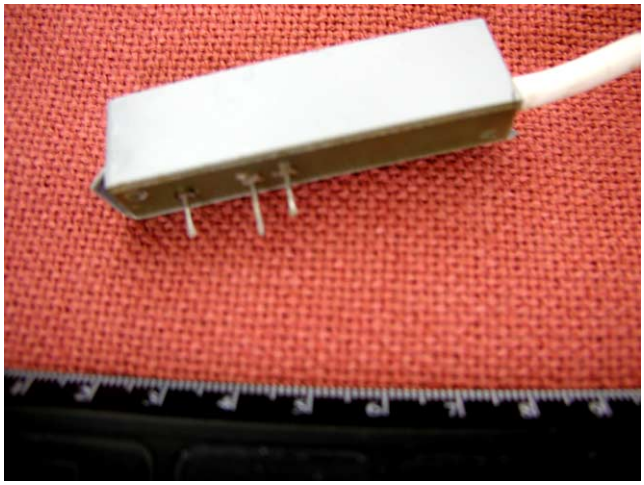

Fig. 2. The sensor head of the sap-flow instrument.