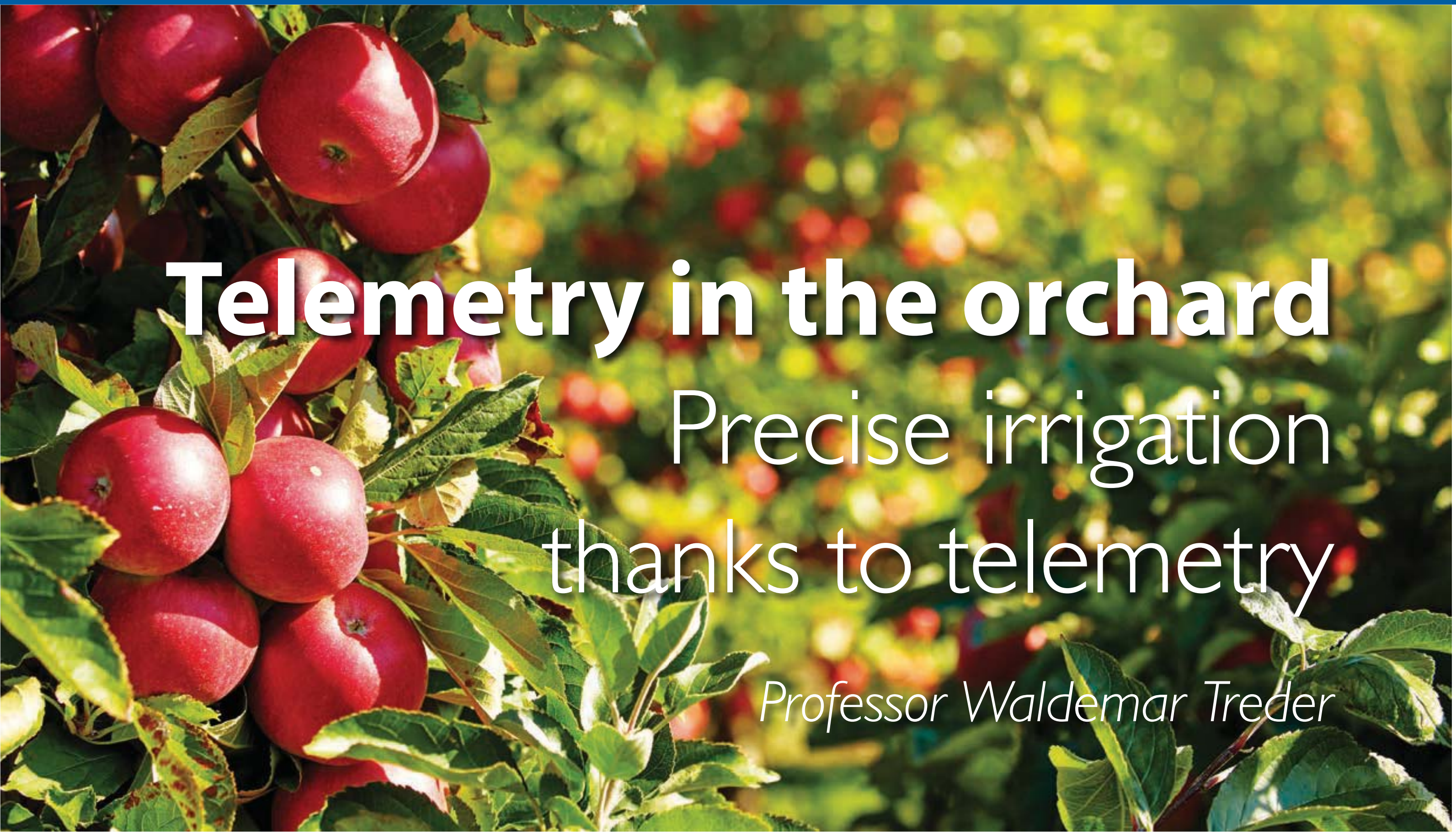

Telemetry in the orchard

Precise irrigation thanks to telemetry

Professor Waldemar Treder

„„Modern telemetry and automation are not just solutions for industrial applications, in the common sense of the term. They also begin to cover completely new fields in which only marginally they have been used so far. The following article describes the use of telemetry, or as it is currently defined, the Internet of Things, for applications in agricultural production, which has recently turned into a fully-fledged, more and more demanding and modern, agricultural industry.

The immediate reason for including these issues in Telemetron is the fact that three years ago we started the process of diversifying potential recipients of our telemetric solutions including agricultural producers. The eSAD system was created as a result of cooperation with the Institute of Horticulture and personally with Professor Treder. It is currently subject to the commercialization process under the name AGREUS and is being prepared for launch on the market. The sooner this happens, the sooner it will be possible to start our completely new branch of activity: support for modern, precise agriculture, i.e. Smart Farming.

I encourage you to read the article prepared by Professor Treder, the undisputed authority in the field of irrigation and fertigation of crops. The following text describes the complexity of the processes taking place in this field and indicates how useful the modern solutions derived from automation and telematics systems can be. Issues raised are not easy, the terminology is not encouraging, but it is worth to read. This is a new, dynamically developing area of industrial production, so important for the future of the inhabitants of our world."

Jerzy Białousz

Humanity faces the challenge of feeding a dynamically growing population. The only way to increase food production is a further intensification of agriculture. The availability of water is a factor that particularly affects the amount of crop yield and quality of animal husbandry. Unfortunately, most forecasting scenarios predict in the near future a further increase in average air temperature with decreasing rainfall. Limited water resources may in the future be a barrier to the economic development of many regions of the world and negatively affect the condition of the environment and the quality of life of societies. It is, therefore, necessary to take measures to increase water retention, improve water quality and increase the efficiency of irrigation. Agriculture is the main consumer of water in the world. In the European Union, an average of 24% of water consumption is used by agriculture, but in countries with high agricultural culture and hot climate, the proportion of water used for irrigation reaches even 80% of the total consumption. Due to the significant increase in irrigated land area, water consumption in the world increased twice in the 1960-2000 period. Therefore, everything must be done to manage the limited resources of water as economically as possible.

In the scale of the Polish economy, agriculture is a significant consumer of water as well. If we want to compete in global markets, we will be forced to significantly increase the area of irrigated crops, and thus the greater use of water. Unfortunately, Poland has one of the worst water balances in Europe. The reasons for this are low surface water resources, small annual precipitation, high evapotranspiration and the low share of river inflow from outside the country. Renewable water resources in Poland are about 1600 m3 per capita per year, which is three times less than the average in Europe. Another bad phenomenon is the continuous reduction of water quality caused by anthropogenic activities. Unfortunately, in the next dozen or so years it should be expected that the water balance of Poland will deteriorate further. Very worrying is the fact that after the very dry year 2015 severe droughts in 2018 again occurred. Such a frequency of occurrence of very dry years in Poland has not been recorded so far. Insufficient water during the growing season significantly reduces the yield, but above all, it lowers its quality. The only way to maintain a high level of horticultural production is to use irrigation.

In Polish conditions, to ensure high yields of good quality fruits, an average of 100 – 200 mm water (1000 – 2000 m^3 water per ha) should be provided by irrigation. In our climatic conditions, about 200 – 250 liters of water is needed to produce 1 kg of apples. In dry years, about 30% of this water comes from irrigation. These very large amounts of water affect production costs. The significant cost is not only the price of water but also the price of electricity, by means of which water will be collected and pressed into the irrigation system. In the case of water from deep-water deposits, the price of electricity required for pumping can be even higher than the water price. Taking into account the perspective of climate change and anticipated future increases in water and energy prices, irrigation becomes an important element affecting the costs of fruits production. With a certain amount of available water and growing demand (intensification of plant production and climate change), we are forced to use in practice the most effective methods of irrigation. Surveys conducted by us among producers of fruit plants indicate a positive direction for the development of irrigation in Poland, e.g. in predominating orchards (about 78%) irrigation systems in farms are water-saving drip installations. Unfortunately, none of the nearly 1000 respondents knew any method of estimating the water needs of plants. Over 80% of users of irrigation systems declared that the dose of irrigation sets „by eye". Only a dozen or so percent of fruit farms declared using soil moisture measurements. These studies have shown that the vast majority of manufacturers do not use any reliable criteria for estimating irrigation needs, which in practice is associated with very irrational use of water. In most cases, too high doses of water are used, often up to 50% higher than the water needs of plants. Pilot experiments carried out at the Institute of Horticulture indicate that with the proper application of reliable irrigation criteria, water consumption can be significantly reduced to significantly increase the effectiveness of irrigation (yield increase per unit of water used). In practice, we have two groups of criteria: climate and soil. The climatic criteria use calculation models for estimating water needs to determine the amount of evapotranspiration (evaporation from the soil surface – evaporation, plants – transpiration). In the case of soil criteria, irrigation is carried out based on measurements

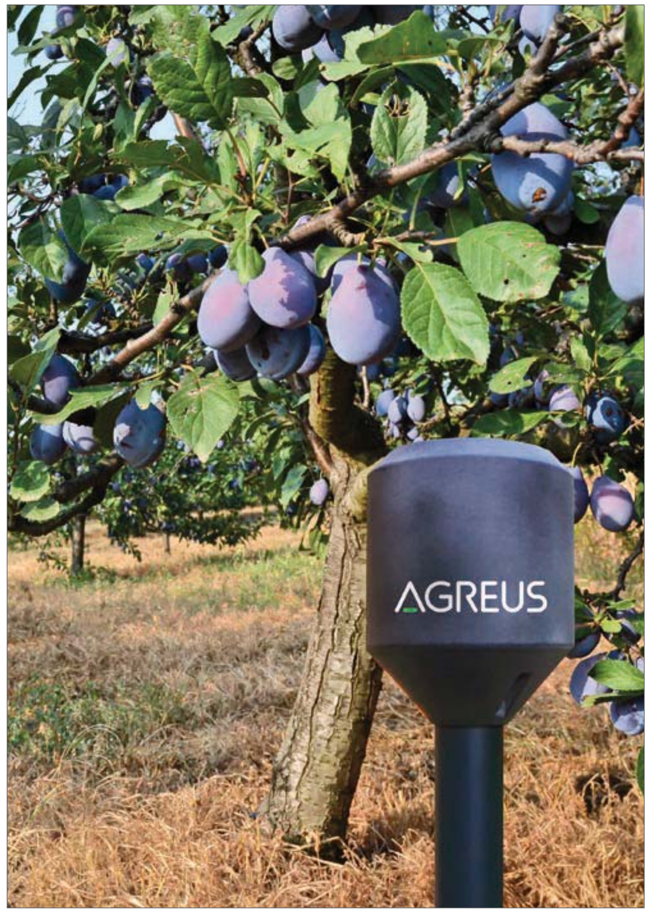

Fig. 1 Base Station of Agreus system

of soil moisture (or potential) in the active root zone of plants. Initially, despite the theoretical usefulness, the practical application of this method to control irrigation of plants was very limited. The main reasons are the relatively high price of sensors and soil moisture meters, the need for „manual" measurements and the limited use of soil moisture measurements to automate the entire irrigation control process. Most of these limitations can be eliminated by using wireless telemetry solutions.

Inventia together with the Institute of Horticulture in Skierniewice, Poland, undertook such activities. As part of the program „Measure RPO WM 1.2. Research and development of enterprises", the e-Sad project was initiated. The aim of the project was to develop a system consisting of devices for remote measurement of air parameters and soil in agricultural areas (temperature and humidity of air and soil moisture), as well as modules controlling irrigation valves. The result of these works is the „Agreus" system, whose first prototype elements were presented on June 14, 2018, in the Experimental Garden in Dąbrowice, Poland, on the 21st Open Doors of the Institute of Horticulture.

The heart of the system is a base station that transmits data from/to dispersed terminals, which create a network of sensors and measuring and executive modules. The transmission takes place using a long-range wireless radio network – LoRa. This technology, depending on the terrain conditions, allows covering with its operation a large area of crops with low energy consumption, which is a critical parameter for battery-powered devices. We installed the first base station on the building of the Institute of Horticulture in Skierniewice at Pomologiczny Street 18 (photo 1), obtaining an effective transmission within the Pomological and Greenhouse Complex as well as the Experimental Field of SGGW. The base station of the system can connect to the Internet using the Wi-Fi of the existing local network, independently via GSM (3G, LTE) or, optionally, via Ethernet cable connection. The Internet connection allows you to send the collected data to the cloud-operated portal. Data collected on an individual user account can be used to analyze and generate reports. Very important elements of the whole system are humidity, temperature and salinity sensors AM-100 (photo 2), air temperature and humidity sensors AM-200 (photo 3) and a radio-controlled valve station AM-421, developed by Inventia and tested by the Institute. The AM-421 is an executive module that allows independent control of four irrigation system valves activated by 9 VDC. This solution allows for the introduction of irrigation control automation everywhere where for some reason (technical or economic) the control cables have been impossible to install.

Any displacement and remote reading of the measurement sensors allows the integration of both criteria for irrigation of plants (climatic and soil). Irrigation can be carried out based on the estimated indicator evapotranspiration (ETo), and the sensors can monitor the soil moisture in order to „manual" or automated introduction of necessary adjustments of the doses used and the irrigation frequency. A much better solution, however, is the automatic control of the operation of individual valves based on constant monitoring of the soil moisture measured in the area of the active plant root zone. In this case, the valve will open according to a defined schedule, if the soil moisture falls below a predetermined threshold. Thanks to the telemetric solution, the humidity, temperature and salinity of the soil can be measured anywhere in the entire area covered by the data transmission system. The information obtained here allows you to make decisions not only about the need for irrigation, but also fertilization or fertigation (fertilization with irrigation). The AM-100 probe directly measures the soil's electrical conductivity σb (so-called bulk EC), but with the calibration models on the Agreus platform, we can also determine the electrical conductivity of soil with full saturation of the water σe (saturation extract EC) and electrical conductivity of water contained in soil pores σw (pore water EC). The direct transfer of the results of electrical conductivity measurement (σb) to making decisions related to fertilization is practically impossible, as mechanical parts of soil and soil pores filled with air significantly modify the measurements. The measured values are very low, and their level depends not only on the actual salinity of the soil but also on the current humidity and primary air-water properties of the soil. With appropriate conversion models, the user also receives information on the potential content of mineral compounds in the soil (σe). The ranges of the σe parameter for many plant species were determined experimentally in the USA and for many years, they serve as information for making decisions about fertilization of specific plants. The quality of mineral nutrition of plants is affected not only by the soil's richness but also by the concentration of mineral compounds in the soil solution. Due to the drying of the soil, the water content in the soil pores decreases with the simultaneous increase in the concentration of mineral compounds dissolved in it. Excessive concentration of fertilizers initially only limits their uptake, but in extreme cases can lead to a physiological drought. The soil moisture measured by the AM-100 probe and the estimated electrical conductivity of the water contained in the soil pore (σw) allows optimal control of irrigation, taking into account the soil's abundance.

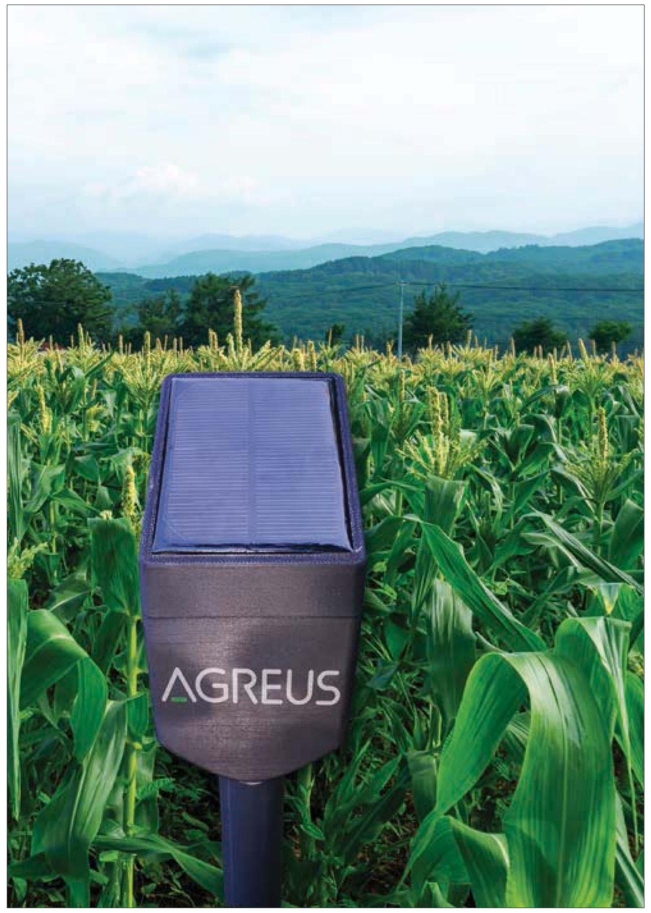

Fig. 2 Humidity, temperature, and salinity sensor

Agreus is obviously not only irrigation and fertigation. The temperature and humidity sensor we tested can be very useful for monitoring these parameters in the spring in the period of frost. Reliable information about the current temperature in various places of the orchard is necessary for active protection of orchards against frost. Based on our first research and observation, it can be stated that the possibilities of using modern telemetric systems in orcharding are very wide and the direction of their development will depend on the needs of users.

Fig. 3 Air temperature and humidity sensor AM-200

When developing the project, we use EU funding under the Action RPO WM program 1.2 Research and development activities of enterprises, project number RPMA.01.02.00-14-5663 / 16-00: *„The development of an innovative system for measuring distributed climate and soil parameters as a tool for optimization of irrigation, plant protection, and agrotechnical works."*

Fundusze Europejskie
Program Regionalny

Mazowsze. serce Polski

Unia Europejska
Europejski Fundusz Rozwoju Regionalnego