Combating waste

New equipment increases water use efficiency in the field by more than 30%

Concern about the high consumption of water for irrigation in Brazil has encouraged researchers to look for alternatives to reduce waste. Calculations done by the National Water Agency (ANA) point out that the type of irrigation widely used in agriculture accounts for 72% of total usage. Research groups from various institutions have developed technologies that can reduce current consumption by more than 30%. Some projects, at various stages of development, have resulted in patent filings and gone on to become different types of commercial products.

Two of these technologies were developed at Embrapa Instrumentation, a unit of the Brazilian Agricultural Research Corporation in São Carlos (São Paulo State). One is known as the dihedral sensor, which can be placed in the plant's root system to measure water tension in the ground, that is, the amount of moisture retained by soil particles. The instrument consists of two plates of either glass or ceramic whose dimensions are adjustable—measuring, for example, 5 centimeters long by 3 centimeters wide—installed so as to form a dihedron. With the sides and the opening sealed, the water present in the soil enters the equipment through a porous ceramic plate and fills a volume on the rectangular face, which is blackened inside. Based on the length of this rectangle, measured from the vertex, the water tension can be calculated, which in turn indicates whether or not to irrigate. Previous work has determined critical water tensions—indicating that it is time to irrigate—for a number of crops. And so, it is enough to compare the tension detected by the dihedral sensor with what is in the literature for this particular crop and the type of terrain to determine whether or not the crop needs to be irrigated. According to Adonai Gimenez Calbo, a researcher and leader of the research group that developed the equipment, the area of liquid inside the dihedral sensor is easily detected because it darkens. "The reading can be done by sight or by using an optical device," he says.

According to Calbo, in comparison with other conventional tensiometers and moisture sensors, the dihedral sensor stands out for its use of low cost material, such as glass and ceramic, for its simplicity and because it is not subject to interference from factors such as temperature, salinity, soil density and the presence of ferromagnetic substances. Other advantages it offers over competing products are direct reading and measurement of a wide range of tensions of the water in the ground. "Thus, the dihedral sensor can meet diverse demands, among them the determination of water tension in very

Agricultural irrigation system in Sud Mennucci, in rural São Paulo State

PHOTO ANA DRUZIAN / OLHAR IMAGEN

low or very high ground, which other equipment cannot do."

Another sensor created by Calbo and his collaborators and known as IG, which in the Tupi Indian language means water, is made up of a porous ceramic block with small particles resembling glass beads inside. The device, placed between the roots of plants, also measures water tension in the soil and can be used to automate irrigation. When the soil is dry, air passes over the sensor, which activates drip irrigation devices, for example. When the soil is wet, the water trapped between the beads restricts the flow of air, interrupting the flow of water. The two sensors developed at Embrapa do not require frequent maintenance for their operation and therefore are useful in automating irrigation. The applications of both technologies are similar, although the IG sensor is better suited to irrigation management.

Agriculture consumes 72% of total water usage and new technologies may help prevent excessive waste in the field

Sonia M. Zanetti, currently a researcher at the Chemistry Institute on the Araraquara campus of São Paulo State University (Unesp), has developed a type of sensor based on a mixture—which she declined to reveal—of semiconductor oxides. "With the synthesis method we use, these oxides produce a powder with nanometric particles, which is then pressed to form a porous nanostructured ceramic sensor," she says. Its electrical properties are altered by the presence of water and thus it is possible to measure the moisture by monitoring the electrical resistance of the sensor. The more water there is in the soil, the lower the resistance.

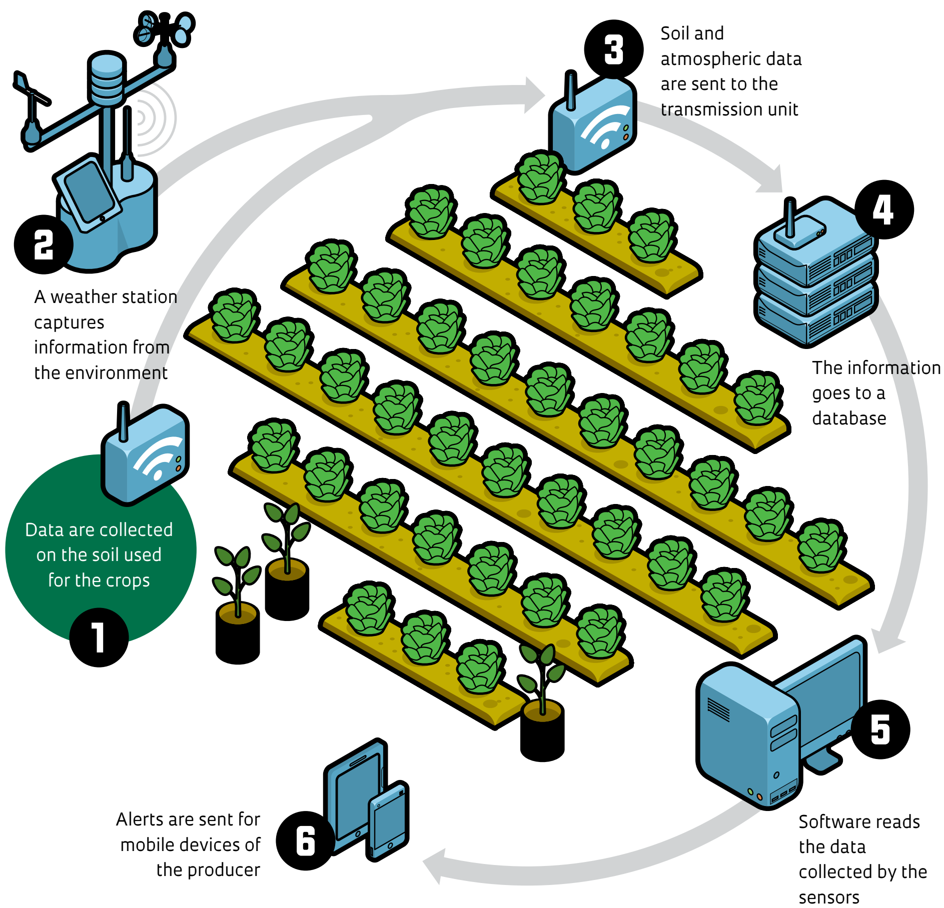
The work was done in partnership with the Center for Research and Development of Functional Materials (CDMF), one of the Research, Innovation and Dissemination Centers (RIDC) supported by FAPESP, and developed at the Sencer Company, based in São Carlos. Zanetti coordinated the project, which began in 2007 and was completed in 2014. "It resulted in not only development of the sensor, but also of a complete system," she says. "It consists of probes placed in the crops (rods with integrated sensors) connected to a wireless transmission unit, which sends data to a computer, as well as an online platform for viewing and processing the collected data."

The probes monitor soil temperature and moisture simultaneously at depths of up to three levels. The grower can access this data through a smartphone or tablet, which facilitates management decisions related to irrigation of the crop. The system can be integrated with public data, such as the weather forecast, rainfall, temperature and humidity, wind speed and direction. This makes it possible to perform advanced analyses of the soil and planting based on historical data, trends and statistics, resulting in the optimal use of water. The savings on this resource can reach 30%.

In Santa Rita do Sapucaí, in southern Minas Gerais State, four young engineers have developed an algorithm (computer program) that automates crop irrigation. Called SMPIn (Smart Crop Monitoring System), it can generate savings of up to 40% of the water used in agriculture and 28% in energy consumption.

Monitored crops

A system created at Inatel, in Minas Gerais State, evaluates the soil and air to determine the need for irrigation



SOURCE: INATEL

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1 Moisture sensor among coffee plants developed jointly by Unesp, CDMF and Sencer

2 Drip system with IG sensor created by Embrapa

In addition to the computer program, the system consists of a data collection station, located among the crops, which is equipped with temperature and humidity sensors for the air and soil, wind speed and direction sensors, rain gauges and GPS. "This station collects the data and sends it by Wi-Fi or mobile telephone network to our database," says Pedro Lúcio Leone, one of the four SMPIn company partners responsible for the project. "With our algorithm, we can calculate when irrigation is needed. It all depends on the crop, the weather, evapotranspiration of the plants and the ground. Thus, it picks up changes in the weather, calculates the amount of evaporation, and tells the grower when irrigation is needed." The system, which adapts to different types of crops, works with any controlled irrigation method, such as sprinkler or drip. Data can be accessed by mobile devices such as a smartphone or tablet.

The SMPIn project began in 2013, after strawberry growers in the southern part of Minas Gerais lost 80% of their production due to the weather. At that time, Luiz Cláudio Andrade Junior, Vitor Ivan D'Angelo, Wellington Faria and Leone were students at the National Telecommunications Institute (Inatel); they decided to focus on a project for agribusiness and founded the company, which was incubated at Inatel. The system is still in the testing and validation phase. According to D'Angelo, the added advantage of their system over others on the market is that most only offer to control irrigation. "Our system also provides a micro-regional assessment of the weather, with more accurate information for the grower," he says. Another advantage, according to him, is that the system does not require a rural grower to have a computer, which reduces the costs of implementation.

PATENTS AND LICENSES

According to Everardo Chartuni Mantovani, an agricultural engineer and professor at the Federal University of Viçosa (UFV) and partner at the Irriger consulting firm, these four technologies—from Embrapa, Unesp and Inatel—will join others already on the market. "But this does not preclude the need to develop new methodologies or improve those already available," he says. Mantovani believes that of the four, the one developed by the partnership of Unesp, CDMF and Sencer of São Carlos is the most promising. "It is a new kind of system that does not yet exist," he says.

As far as sensors developed by Calbo and his collaborators are concerned, Embrapa has filed patent applications for the two types of technology, which have been licensed to Brazilian companies and to the United States to turn them into commercial products. In Brazil, the dihedral sensor has been licensed to Tecnicer Ceramic Technology, based in São Carlos, and in the U.S. market to Irrometer, based in California. The right to commercial exploitation of the IG has also been granted to these two companies and to Hidrosense, in Jundiaí, to Acqua Vitta Floral, in Bauru, and R4F, in Campinas, all located in São Paulo State. Different types of equipment can be manufactured using these two technologies, both in stationary and portable versions. It is estimated that once they reach the market, they will be priced between R\$10 and R\$150. Sencer has filed a patent application for a utility model of the rod with integrated sensors. Meanwhile the sensor developed by Zanetti is in the final testing phase. "The product is being demonstrated and evaluated in several locations, and we are in the process of negotiating initial sales," she says. ■

Project

Improvement of the sensor device for measuring soil moisture: application in precision agriculture (No. 2012/50132-8); **Grant Mechanism:** Innovative Research in Small Businesses Program (PIPE); **Principal Investigator:** Sonia Maria Zanetti (Sencer); **Investment:** R\$181,302.71 (FAPESP).

PHOTOS EDUARDO CESAR