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AUTOMATED SYSTEM FOR THE PHYTOGENETIC LABORATORY PROPAGATION OF OLEA EUROPAEA REMOTELY CONTROLLED

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Abstract: In Argentina, since 1990, the area planted with olive trees has grown significantly, due not only to the increase in the profitability of olive oil production due to the price of olive oil and the information campaigns on the benefits for human health of its consumption, but also to the support measures adopted by the government, especially tax incentives. The current cultivated area (90,000 ha) has placed our country among the top ten producers worldwide. The asexual reproduction of plant species by direct implantation of cuttings (cuttings from an adult plant) has been known since ancient times. The olive tree multiplication technique improved from 1970 onwards, especially due to the process of rooting cuttings under nebulization. Hartman et al. of the University of California have pioneered the adaptation of this technique. Based on the above-mentioned background, the objective of this work is particularly oriented to define, design and build a laboratory prototype of an equipment to optimize the rooting phase, seeking to maximize the percentage of cuttings that form adventitious roots, implementing an environmental control system tuned for this purpose. The applied methodology corresponds to an experimental development, with emphasis on the selection of sensors: ambient relative humidity, leaf humidity, temperature of the implantation substrate and ambient temperature, as well as the selection of actuators to modify the substrate temperature, irrigation and heat extraction. Using Internet of Things (conceptsIoT), a telemetry system is integrated, which will allow alerting about any type of failure or anomaly, commanding the set points of the controlled variables and monitoring the internal and external environmental variables. The results achieved to date are presented in the paper.
Keywords: Propagation, cuttings, control, automation, IoT.

INTRODUCTION

Olive growing activity in Argentina originated in Arauco (La Rioja province) during the Spanish colonization [1]. The legislation of promotion initiated with the Law 11.643/1932 of Promotion of the Oliviculture, led to the implantation of about 50.000 Ha towards the end of the decade of 1950. Due to a strong subsequent retraction as a consequence of the competition with sunflower and corn oils, it was reduced to less than 30,000 Ha at the end of the 80s. Since the 1990s, the planted area has not stopped growing due not only to the increase in production profitability (improvement in prices and increase in consumption), but also due to governmental fiscal stimulus measures. At present, the total olive area is around 90,000 ha [2-4], distributed in Catamarca 27%, Mendoza 17%, San Juan 25% and La Rioja 26%, placing Argentina among the top ten producers worldwide. Individual plantations range from small orchards to farms of a thousand hectares. On the other hand, crop mechanization has raised planting densities to 1600 and 1900 olive trees/Ha, which multiplies the demand for seedlings to meet the expansion of the sector. Therefore, there is a need for devices and procedures to maintain the environmental conditions (soil, air, temperature, humidity, etc.) that are most suitable to ensure the rooting and development of olive tree cuttings, monitoring their growth and automatically storing the information for later analysis. The improvement of the rooting technique under nebulization developed in 1970 by Hartman [5], requires closed-loop control of environmental variables, especially soil temperature and air humidity and temperature, to keep the cuttings and favor net photosynthesis, which can be hydrated achieved by integrating a heated bed in an enclosure closed by a transparent plastic cover, i.e., creating a controlled environment. growth Irrigation control, in turn allows,experimenting with the influence of various nutrients incorporated through a dosage programmed by the phytotechnologist in charge, to obtain specimens resistant to various pathologies, along with an increase in the percentages of rooting and development of the seedlings.

This article is organized as follows: the next subsection presents a brief overview of asexual reproduction of the olive tree; Section 2 explains the design requirements to be satisfied; Section 3 advances in the discussion of the electromechanical and electronic aspects of the design options adopted. The conclusion of the presentation includes the state of progress achieved and future actions to be developed.

ASEXUAL REPRODUCTION BY CUTTINGS

Plant multiplication can be sexual or asexual, the latter also called vegetative because, with a few exceptions, it only occurs in plants. Vegetative propagation makes it possible to reproduce a plant so that its daughters are genetically equal to each other, which guarantees their climatic adaptation and productive yield. This type of propagation is based on the fact that each cell contains all the genetic information necessary to produce a new individual. In the olive tree, a variety is a group of individuals equal to each other, which present a visible genetic variation within the species. Except for a few obtained by genetic improvement, their origin was the vegetative multiplication or cloning of olive trees chosen for the size of their olives or the quantity and flavor of their oil [6-7]. Asexual reproduction of plant species by direct implantation of cuttings (cuttings or cuttings of segments of an adult plant) in the soil has been known since ancient times. In order to favor rooting, the next evolutionary step in this agricultural technique was the use of specially prepared plots of land, in which a layer of manure provides heating to the substrate where the cuttings are implanted, thus facilitating their development, this propagation procedure being called “hot bedding”. As can be seen in the specialized literature [8-9], propagation by cuttings is used for a large number of varieties in arboriculture, floriculture and horticulture, either for the development of species of economic interest, or for the multiplication of those that are in danger of extinction. Among the various existing propagation techniques, vegetative propagation by the method of “rooting of cuttings under nebulization” stands out[5], conceived with the aim. of improving the quality of seedlings to be used in modern olive growing, This method is recognized as one of the processes with the greatest phytotechnological impact, due to its efficiency in obtaining high rooting percentages, reduction of the size of the cutting, practicality of implementation and greater economic viability for the establishment of large-scale clonal plantations. As described by [10], the method consists of three phases:

- Rooting, to cause the growth of several adventitious roots at the bases of leafy cuttings, preferably supplied by trees grown for that purpose.
- Hardening, to promote the functioning of the radical systems obtained in the previous phase.
- Raising of seedlings, grown in pots, to a single trunk, an important basis for the success of the new olive growing, as it allows for more suitable planting densities.

The laboratory prototype, whose implementation this work describes, is oriented to optimize the first phase, that is, to increase the percentage of cuttings that form adventitious roots and to reduce the amount of labor required for this purpose. A control system is implemented, which includes sensors for ambient relative humidity (both indoor and outdoor), leaf humidity, substrate temperature and ambient temperature (also indoor and outdoor), as well as actuators to: modify substrate temperature, irrigation and heat extraction. In addition, a telemetry and data recording system is integrated, which allows alerting about any type of failure or anomalous operation, as well as remote reconfiguration of the operating parameters. The above is summarized in Figure 1.

DESIGN REQUIREMENTS

GENERAL REQUIREMENTS

- The total cost of development should be kept as low as possible, within the limits established by the funding agency.
- The prototype to be developed should be conceived for experimentation applicationsphytotechnical, to provide an environment for propagation by cuttings of various plant species, allowing the possibility of changing the substrate for implantation as needed.
- The design should be modular, that is, it should allow to enlarge the area where the cuttings are to be rooted in order to increase proportionally the amount of seedlings obtained.

SPECIFIC REQUIREMENTS

In the context established by the general requirements, the items that will specifically govern the development will be defined.

ENVIRONMENT OF USE

The prototype should be used indoors (inside a greenhouse) since in the main producing provinces mentioned in point 1, there are large amplitudes between the minimum winter temperatures and the maximum summer temperatures. Thus, for the period 1961-2019, according to official data [11], extremes of -9.2°C and +47.0°C have been recorded. The temperature in the environment confined by the hot bed cover should not exceed 30°C. Higher temperatures would increase the respiration and transpiration rates of the cuttings, which could eventually wilt due to the combined action of the heat and the excess misting induced by it. Temperatures below 20°C delay radicle sprouting in the cuttings. The propagation table should be installed in a greenhouse where temperatures between 10°C and 35°C are guaranteed so that the confined atmosphere can be adequately regulated.

Structural mechanical aspects

In addition to a light and resistant structure, the equipment must have pumped irrigation and forced ventilation with its corresponding supports.

Automation and Telemetry Aspects

The hot bed system should have the capacity to automatically control the following internal variables: substrate temperature, leaf humidity and ventilation. Since the external environment acts as a disturbance on the system, temperature and humidity sensors should be included. In order to maintain adequate leaf humidity values in the cuttings, it is necessary to have an irrigation and drainage subsystem.

Regarding telemetry, since the variations of the magnitudes to be monitored are very slow, with time constants in the range of minutes/hours, the sampling frequency to be used will be accordingly low, so it will be possible to have time to implement routines to improve the quality of the measurements in each sampling cycle. It should be noted that the signals telemetered correspond to three types of variables: a) controlled variables (temperatures, humidity, etc.); b) actuator variables (signals associated with the operation of the various effectors present); c) auxiliary variables, to monitor the availability of the subsystems (AC power supply, DC power supply, water level, etc.) that make up the equipment in order to trigger the relevant alarms in case of failure.

Figure 1: System components.

BASIC ENGINEERING

In line with the general and specific requirements outlined in the preceding section, the design options adopted are discussed below.

MECHANICS AND STRUCTURE

The mechanical structure to be implemented is shown in Figure 2. In it, two tables containing the heated substrate for rooting the cuttings can be seen. Each table has a total surface of 1 m^2 and the cuttings are protected by using a cover. Two beds will be implemented in order to evaluate their performance in rooting different varieties of olive trees.

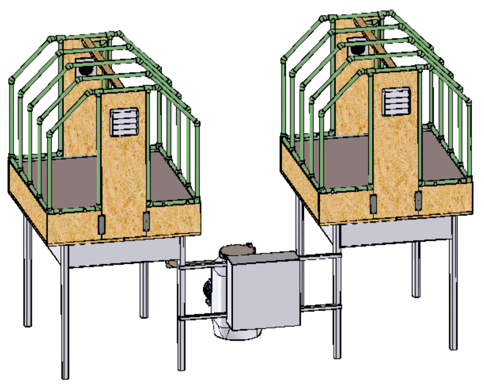

Figure 2: Structural distribution.

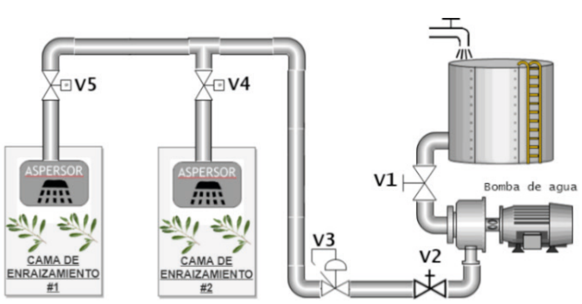

Figure 3: Irrigation subsystem.

IRRIGATION SUBSYSTEM

Micro-sprinklers are used for this subsystem, which will irrigate the cuttings on the surface of the cultivation tables until they reach a sufficient root development to be transplanted. For the calculations and pipe sizing, the main and secondary losses will be taken into account in order to obtain the necessary power in the pump and achieve the required pressure in the sprinkler according to the necessary flow. The irrigation circuit is composed of a tank, a shut-off valve V1, a pump, a valve non-return V2, an overpressure valve V3 and two solenoid valves, V4 and V5, which allow directing the water to the rooting bed 1 or 2, respectively (see Figure 3). Each micro-sprinkler operates at a nominal pressure of 3 bar, has an outlet orifice diameter of 0.82 mm, nominal flow rate of 7 l/h. The choice of the micro-sprinklers has been made with the maximum irrigation uniformity on the surface of the tables, so 2 units per table will be used. The supporting piping and the micro-sprinklers will be located on top of the hot bed, with the necessary connections to the main piping. The maximum flow rate required by the pumping unit will be 28 l/h, in the case of irrigation as indicated for the requested process. The tank-tank will be located at ground level, as will the pump, and the piping will be 25.4 mm diameter PVC. Based on calculations pre-dimensioning of the flow to be supplied, it has been decided to have two plastic tanks to store 40 liters of water, feeding an electric pump. The friction head loss in a pipe with multiple outlets turns out to be lower than in a simple pipe, this is due to the fact that the

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flow will be decreasing in the direction of flow, therefore, the velocity decreases and the head loss decreases as well. To correct this value, a Christiansen loss reduction coefficient is introduced, depending on the number of sprinklers connected downstream. Preliminary calculations yield a pump power of about 0.5 HP.

HEAT TRANSFER

The energy balance within the proposed olive propagation system includes all modes of heat transfer, i.e., radiation, conduction and convection. The first component of the energy balance is the solar radiation incident on the hotbed canopy, which can be transmitted, reflected or absorbed. The proportion of radiation passing through the roof is known as transitivity and depends on the characteristics of the roof and the type of radiation (direct or diffuse). Another component of the energy balance is ventilation (natural or forced), which prevents excessive heating during the day and affects humidity. On the other hand, plant transpiration produces heat loss within the canopy, which depends on the water vapor concentration, transpiration conductance, leaf area index, net radiation of the crop and. stomatal resistance that limits transpiration The condensation of water vapor inside the canopy, although reduced, constitutes another heat loss to be considered in the energy balance; as well as the soil, which constitutes about 10% of the total losses [6-7].

CONTROL AND ELECTRONICS - BLOCK DIAGRAMS

Figure 4 shows a block diagram of the proposed equipment. The automation and telemetry system consists of:

- USCE: Rooting Bed Sensor Unit, in charge of sensing substrate temperature, leaf humidity and ambient temperature and humidity of the rooting bed.
- USPA: Environmental Parameters Sensor Unit, in charge of sensing light and ambient temperature and humidity outside the rooting bed.
- UCA: Actuator Control Unit. It is in charge of controlling the sprinklers, the substrate heating element and the fan installed on each rooting hot bed. As all electrical power passes through this unit, a single-phase energy meter is included.
- URT: Recording and Telemetry Unit or, whose purpose is to record and transmit, through a data server, the information provided by the other aforementioned subsystems.

All units will be interconnected through a Modbus network, using the RS485 standard as the physical layer. Modbus is selected because many control equipment (PLC, sensors, microcontrollers, among others) have been using it for more than 40 years. The structure of this protocol revolves around the messages and not the physical equipment or the communication medium. This means that the same type of message, which was used via RS232, is currently used via TCP/IP, except that it is embedded in the application layer of the OSI standard.

ROOTING BED SENSOR UNIT (USCE)

The USCE is an embedded system consisting of a microcontroller, its respective power supply and different sensors in charge of measuring the environmental parameters of the controlled system. It will have an RS485 interface on which the MODBUS RTU protocol will be implemented, being the USCE a slave device within this network. Figure 5 shows a block diagram with all the components of the USCE.

- The DS18B20 is a digital temperature sensor that uses the 1-Wire protocol to send and receive data, requiring only one data port to communicate with the microcontroller. It is mounted inside a waterproof stainless steel tube.

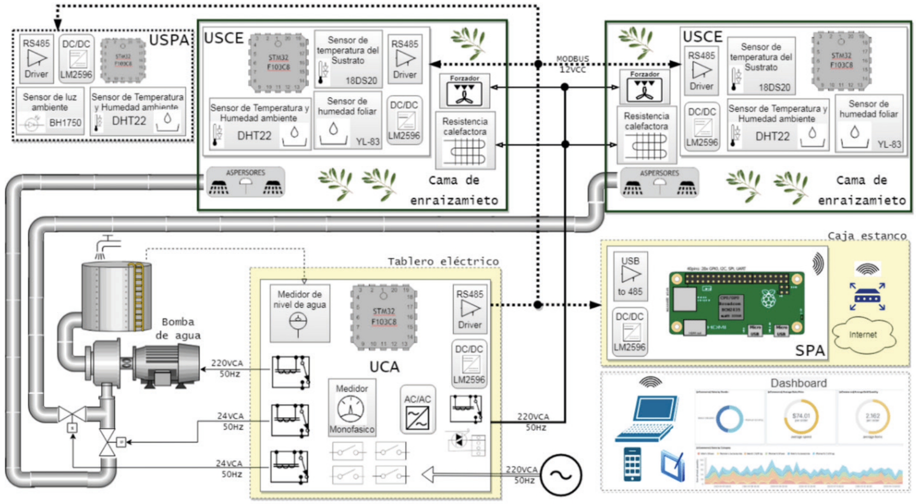

Figure 4: Proposed control and telemetry system.

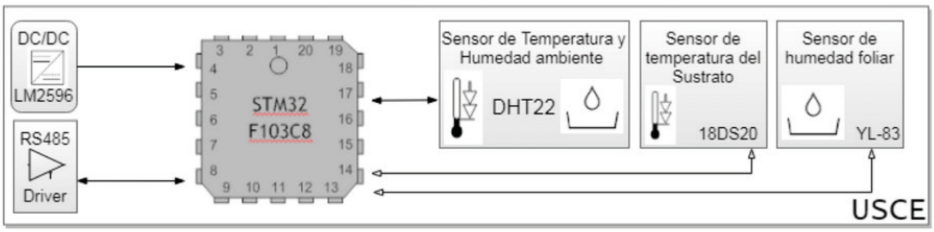

Figure 5: Block diagram of the USCE

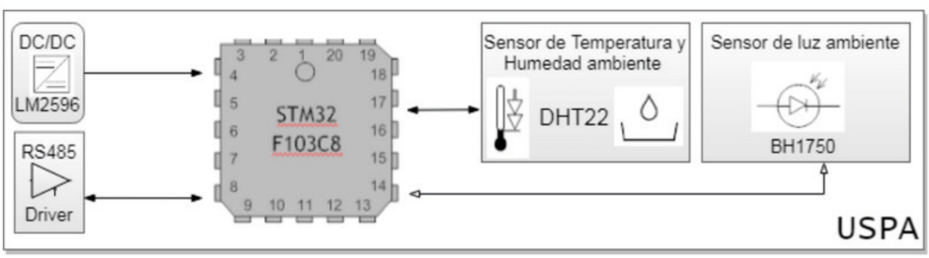

Figure 6: Block diagram of the SPA unit.

- The DHT22 (AM2302) is a digital temperature and relative humidity sensor with good performance and low cost. It integrates a capacitive humidity sensor and a thermistor to measure the surrounding air. The data output is via a digital signal, using a proprietary protocol, and requires only one microcontroller data pin. interface

- The YL-83 module is a board composed of bare conductive tracks, where one of them has the VCC signal and the other is GND. When water falls on the surface connecting the tracks (without short-circuit because on the other side of the board, both tracks have resistors), there is a decrease in the resistance between tracks, so the circulating current is sensitive to the amount of water falling on the tracks. This makes it possible to measure the amount of water falling on the leaves of the cuttings.

ENVIRONMENTAL PARAMETERS SENSORS UNIT (USPA)

The USPA is an embedded subsystem made up of a microcontroller, its respective power supply and different sensors in charge of measuring the environmental parameters external to the olive cuttings rooting bed. It will have an RS485 interface with MODBUS RTU protocol, being the USPA a slave device of this network (see Figure 6).

- The BH1750 is an illumination sensor with 16-bit resolution. It responds to visible light in a way comparable to the human eye and is not affected by infrared radiation and does not depend on the color temperature of the type of illumination: it works well in natural light and with different types of artificial illumination. It communicates digitally with the microcontroller via I2C bus.
- The previously mentioned DHT22 sensor will be used humidity and ambient temperature.for

ACTUATOR CONTROL UNIT (ACU)

The UCA, whose block diagram is shown in Figure 7, is an embedded system consisting of a microcontroller, its respective power supply and different power drivers responsible for controlling the operation of the actuators of the olive propagation system. It has an RS485 interface with MODBUS RTU protocol, being also the UCA a slave device within this network.

- To control the substrate temperature, a heating resistor is used, which dissipates 20 Watts per linear meter and its maximum operating temperature is 60° Celsius. With a length of 8.70 meters, the surface it can heat is equivalent to 1 square meter. As the electrical energy source is alternating current, (220V 50Hz), the power regulation is done by means of a firing phase control circuit using a TRIAC. In this way, the amount of heat supplied by the heating resistance can be regulated with an acceptable resolution.
- The irrigation system is implemented by combining a single-phase ½ HP electric pump and two solenoid valves. The electric pump is activated by a contactor, while the solenoid valves are controlled by relays. It is important to mention that this subsystem will periodically verify the amount of water remaining in the tanks by means of an electronic level measuring circuit.
- The ventilation system is implemented by means of an air extractor. It has the capacity to evacuate 30 cubic meters per hour and operates with alternating current (220V 50Hz). The extractor is activated periodically by means of a relay.

REGISTRATION AND TELEMETRY UNIT (URT)

The URT, Figure 8, is an embedded system consisting of an SBC (single board computer) and its respective power supply. The selected SBC is a *Raspberry pi Zero W* that will be connected, through a USB-RS485 converter, to the MODBUS network constituted by the single phase energy meter, the UISs and the UCA. For the MODBUS network the URT is the master. In addition, the SBC integrates an 802.11 b/g/n interfacewireless LAN, which allows it to be connected to the Internet via a Wi-Fi. In order to visualize the environmental variables and the operating parameters of the system, a will be includedrouterMQTT (MOSQUITTOBroker), which will allow interacting with different mobile devices such as cell phones or tablets.

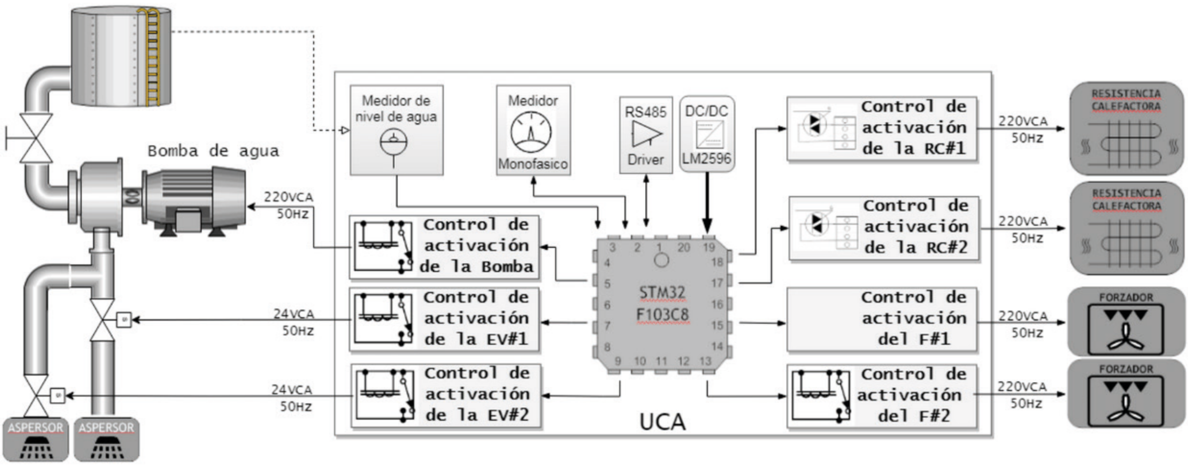

Figure 7: Block diagram of the UCA.

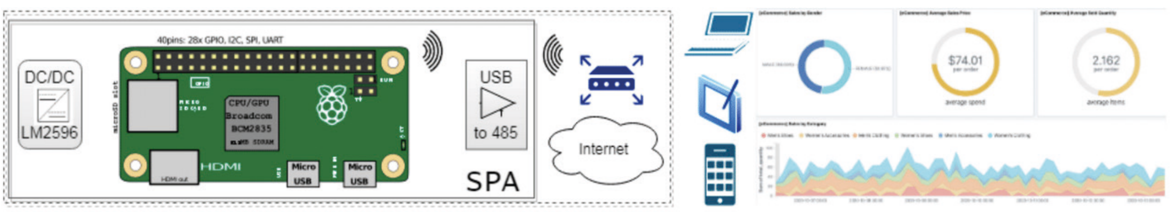

Figure 8: Block diagram of the RTU.

Figure 9: System. progress status

CONCLUSIONS

The intention of this work is to contribute to a technological improvement supporting the development of olive production in the northwestern provinces of Argentina. Adding not only a more complete automation system to a semi-automatic procedure, but also including real-time telemetry and internet of things. As shown in Figure 9, the phase corresponding to the construction of the mechanical structure and the implementation of the actuators has been completed. The tuning and tuning of the control system is currently underway. If the publicly known health situation allows it, it is planned to start the first olive tree implantation and propagation trials in the middle of 2021. As future developments, it is intended to apply this same system in the propagation of other plant species, both those of agricultural interest, but also for those endangered species of the native flora that have suffered so much punishment as a result of fires and clearings.

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