Design and implementation of an intelligent thermal chamber to produce plantain hills

J López Hurtado¹ and H A Gallego Becerra²

¹Master in Physical Instrumentation, DICOPED research group, Faculty of Basic Sciences, Technological University of Pereira, Colombia.
²Master in Physics, Headline Professor, Director of the DICOPED research group, Senior Researcher, Faculty of Basic Sciences, Technological University of Pereira, Colombia.

jholopez@utp.edu.co

Abstract. The project is aimed on the design and construction of a prototype device which allows the measurement, visualization and control of the temperature and relative humidity, and soil moisture inside a thermal chamber. This prototype consist mainly of two sensors, one of them to measure the temperature and humidity in the air, and the other one to measure the humidity of the soil; In addition, an Arduino development card, which be used to process the data and control the different measured Physical variables. A liquid crystal display (LCD) to display the measured data and the process it takes; In addition to other electronic devices that complement the processing and control in real time, the backup or monitoring of the thermal chamber through the days, the automatic turning on and off of a misting irrigation system and the automatic opening or closing of two windows used to let circulate oxygen inside the place.

1. Introduction

Although it is not a secret to say that any country in the world moves economically for what it produces, in Colombia one of the most important economic sectors is the agricultural sector, where different types of vegetables, fruits, plants, among others are produced. It is perhaps, the countryside one of the most vulnerable areas of Colombia and, without technological and industrial investment to help technify the agricultural processes that moves this nation.

It is worth bringing to the discussion that raised by the former president “Juan Manuel Santos”, within the framework of the Fourth International Cocoa Seminar, based on the agreements made in the peace process with the guerrillas of the “FARC-EP”, where he mentioned "The central axis of this agreement is in the field and it is the one that will benefit most from peace" [1]. Where he explained that this is stipulated, which will mean more investment, more public goods, more productive projects and more financing. Then, he said "This is what we are going to take to the countryside, especially those regions affected by war, which are almost all" [1].

According to President Santos, almost all of Colombia rural areas has been affected by the armed conflict presented for many years in this country, which has left thousands of people dead, entire families displaced, families that have remained in these areas that live with very little sources and, above all, that do not have the possibility of generating a greater income.
The implementation of this intelligent thermal chamber to produce plantain hills seeks to generate a positive social impact on the population of the “Villanueva Village Center”, in El Águila - Valle del Cauca, Colombia; since this project encourages a new form of employment in this place, including and using electronic equipment as a work tool. It is also intended to improve the coexistence of the community, because it is expected that their economic income will improve by having greater quantity and quality in the production of plantain hills and the fruit of the plantain plant; and thus, having a better quality of life.

The project is implemented from the adaptation of a land and construction of a greenhouse with metal structure attached to the ground by concrete, where it is sought to control the temperature and humidity of this place, for accelerating the production of plantain hills, and with this achieve more uniform plants and fruits, and with a minimum probability of infection by fungi and pests. This is achieved by setting the temperature and humidity in a reference range within the greenhouse.

Also, it seeks to train a group of students of the Educational Institution Justiniano Echavarría, in different academic subjects concerning Mathematics, Physics, Electronics and Programming, in order to bring them closer to the project and make them understand the operation of the intelligent stage of the thermal chamber.

2. Methodology

For the execution of this project, different phases or stages were established to carry an orderly sequence and arrive at an accurate result. Initially, several activities were carried out in the first phase.

2.1. first phase

A bibliographic review was carried out in specialized journals of national and international order. On the other hand, we searched regional publications on the web and meetings with agronomists, in order to determine the progress of instrumentation in this area and the use of technology as a tool to technify this type of processes or other similar, in the Colombian rural area [2] [3] [4] [5].

It was also reviewed all the documentation requested from the Mayorality Office of El Águila town and on web pages of the state, everything concerning the demographic situation of the aimed Municipality; all this with the purpose of knowing more details and establishing a geographical framework with the main territorial, population, economic and social difficulties of the habitants where this project is developed [6] [7].

In this same stage, the current government regulations related to the creation and permanence of nurseries in Colombia were reviewed. This documentation was collected from the Colombian Agricultural Institute (ICA) [8] [9].

At the same time, it began with the training of a group of students of higher degrees, of the Educational Institution Justiniano Echavarría, in consolidating concepts related to the environment on physical variables which are very important in the germination of crops; variables such as: temperature and relative humidity and soil moisture. In addition, a course of Basic Electronics, Algorithmia and Programming in C language begins with them, all this with the aim of teaching them how to program on development cards such as Arduino and use different peripherals and sensors from the world of electronics. It should be noted that this stage of the project is executed throughout all its implementation.

2.2. second phase

Through the use of rectangular metal tubes, different work tools in the field and work techniques developed by the same people in the rural area of Colombia, the land was adapted and vertical supports fixed to the ground with cement, and other in horizontal way which were fixed to the vertical supports with welding, to give shape to the space of thermal chamber. This work was carried out in collaboration with students who were part of the work group and some habitants of the Villanueva district. Figure 1 shows the beginning and ending of the architectural construction work of the thermal chamber space.
2.3. third phase
Adaptation and implementation of the irrigation system. Figure 2 shows the pressure pipe system and installed nebulizers. In addition, a series of stopcocks and an electrovalve were installed to control the flow of water.

At this point it is important to emphasize that the irrigation system by fogging becomes important, since the plants need a minimum part of water in the form of mist for a correct growth [3].

2.4. fourth phase
Different ways of implementing with high-performance electronic techniques, an intelligent system that was minimally operated by the human being, all this for making more technic the production process of plantain hills in a thermal chamber and thus be able of designing a team which will execute this task with the least possible error.

Already having cleared the electronic techniques necessary for the design of the prototype, software was created in which the studied techniques could be implemented. After having created the necessary software, the appropriate hardware was established for implementing the realized program. With the hardware modules developed, the software operation of the entire set of devices was interconnected and simulated. Figure 3a and 3b shows the designed equipment, in which it was also necessary to power it by solar energy, because in the Villanueva area there are constant interruptions of the electricity supply.
2.5. fifth phase
Having already designed and implemented this hardware, it began with the functional tests of the equipment in the field to verify its proper functioning and make adjustments. Then we adapted a box or cabinet which was fitted outside the thermal chamber to keep the prototype.

With the verification of the proper functioning of the prototype of the designed equipment, the sowing and accelerated reproduction of the plantain hills proceeded. Figure 4 shows the process of sowing the mother seed of plantain inside the thermal chamber.

3. Results and discussion
Practical comparative analyzes in the field showed a delay of 4 months in the outbreak of plantain hills in plants exposed to the environment (figure 5) and 2 more months, to be extracted and transplanted to another place.
Figure 5. Plantain hills after 4 months in plants free exposure in the environment.

Otherwise, it occurred inside the thermal chamber, as shoots of baby seedlings of the mother seedlings were observed, at approximately 18 days and 10 more days, they took time to be extracted from the thermal chamber (figure 6a) and transplanted into bags outside this place. Then, for 1 to 2 more months, plantain hills were ready to transplant to the field (figure 6b).

Figure 6. a) Plantain hills of 18 day inside the thermal chamber, b) Plantain hills of 45 day outside the thermal chamber.

This is how it is possible to obtain plantain hills ready to transplant to the field with a reduction in time greater than 40%, through the use of the Technique of Accelerated Reproduction of Seed or Planting Material (TRAS) [2], than with the Traditional method to free exposure.

The best seed reproduction results within the thermal chamber were obtained at temperatures between 30 and 60 °C and relative humidity levels between 30 and 100%; which was possible to control by means of the misting irrigation system and the automatic opening and closing of 2 windows (figure 7a) and, using the digital temperature and humidity sensor SHT10 “SEN0148” shown in figure 7b. In addition, to maintain a soil moisture level (rice husk) between 30 and 80% (figure 7c). Emphasizing that all site control is performed with the "Arduino Uno" Microcontroller (figure 7d).
Figure 7. a) Automatic opening and closing mechanism of windows, b) Temperature and relative humidity sensor, c) soil moisture sensor, d) “Arduino Uno” microcontroller.

Figure 8 shows, after 5 months, plantain plants transplanted to the field, extracted from the thermal chamber; Here you can see healthy plants with an average height of 3.5m. Evidence that this method of seed reproduction is ideal for the production of plantain hills in a shorter time and of good quality.

Figure 8. Plantain plants extracted from thermal chamber and planted 5 months ago.

4. Conclusions
With the implementation of this project and especially using a device built to control various physical variables, it has been obtained a product of very good quality in less time than traditional techniques. This is important for generating a changes in the traditional way of producing plantain hills in the countryside and also motivating both the national government and farmers to promote and invest in technification for agricultural processes in rural areas of Colombia. In addition, it can be impacted a population whose has suffered with the armed conflict in Colombia and with limited economic sources, since new form of work was generated for improving their budget income.

References
[1] Ministerio de Agricultura y desarrollo Rural de Colombia 2016 El eje central del acuerdo de paz está en el campo [online]. Available in: https://www.minagricultura.gov.co/noticias/Paginas/El-eje-central-del-acuerdo-de-paz-esta-en-el-campo.aspx
[2] Aguilar M, Reyes G and Acuña M 2004 Guía técnica No 1 Métodos alternativos de propagación de semilla agámica de plátano (Musa spp.) Universidad Nacional Agraria (Managua, Nicaragua) p 18.
[3] Stanley M 2014 Los sistemas de nebulización se utilizan cada vez más en cualquier clima – Control de la temperatura y la humedad con un sistema de nebulización Freshplaza [online].
Available in: http://www.freshplaza.es/article/85147/Control-de-la-temperatura-y-la-humedad-con-un-sistema-de-nebulización

[4] Álvarez E, Ceballos G, Gañán L, Rodríguez D, González S and Pantoja P 2013 Producción de material de siembra limpia en el manejo de las enfermedades limitantes del plátano Centro Internacional de Agricultura Tropical (Cali, Colombia).

[5] Ardiles Hurtado J, Cañarachín Paredes E T and Clavijo Turpo J C 2013 Folletos de cámaras térmicas para plantaciones de plátano Ministerio de Educación (Oxapampa, Perú) [online]. Available in: https://issuu.com/prea-pasco/docs/folleto_platanos_finalizado

[6] Cadavid Palacio L, Cadavid Palacio M, Aguado L E and Mejía F J 2000 Esquema De Ordenamiento Territorial Municipio de El Águila Valle del Cauca Alcaldía Municipal de El Águila Valle del Cauca p 416.

[7] Departamento Nacional de Planeación Gobierno de Colombia 2018 El Águila Valle del Cauca TerriData Ficha 76243 p 23 [online]. Available in: https://terridata.dnp.gov.co/index-app.html#/perfiles/76243

[8] Instituto Colombiano Agropecuario (ICA) 2009 Resolución 003180 de 26 de Agosto de 2009 Requisitos y procedimientos para la producción y distribución de material de propagación de frutales en el territorio nacional y se dictan otras disposiciones p 11.

[9] Instituto Colombiano Agropecuario (ICA) Manual técnico para viveristas en musáceas (plátanos y bananos) [online]. Available in: https://sioc.minagricultura.gov.co/Platano/Documentos/005%20-%20Documentos%20T%20%28%20Agosto%20-%20Manual%20%20%20Tecnico%20Viveristas.pdf

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