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Bioclimatic architecture with intelligent model of vertical crop protected high performance as an alternative to introduce the strawberry in the region

Arquitectura bioclimática con modelo inteligente de cultivo vertical protegido de alto rendimiento como alternativa para introducir la fresa en la región

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Abstract

In the present investigation it was shown that greenhouses are systems that help us to produce any kind of crop, if it´s in the right conditions and these are adequately controlled. Due to the inconveniences that arise to be able to grow strawberries in the region of the State of Hidalgo, due to the climatic conditions that occur, it has been necessary to implement new alternatives to have new sources of production in order to obtain new commercialization products. In this way it´s why the proposal and alternative to solve the internal climate control of a greenhouse, it has been given through the implementation of an "ON / OFF" automation control. The complete automation circuit was developed, each variable was automated, and its programming code was developed. The results showed that the system automatized the variables of interest to control for the microclimate of the greenhouse.

Greenhouse, Automation, Control

Resumen

En la presente investigación se mostró que los invernaderos son sistemas que nos ayudan a producir cualquier tipo de cultivo, siempre y cuando este se encuentre en las condiciones adecuadas y estas estén controladas adecuadamente. Debido a los inconvenientes que se presentan para poder cultivar la fresa en la region del Estado de Hidalgo, por las condiciones climáticas que se presentan, se ha tenido que implementar nuevas alternativas para tener nuevas fuentes de producción a fin de obtener nuevos productos de comercialización. Es por esto por lo que se ha dado la propuesta y alternativa para solucionar la climatización interna de un invernadero mediante la implementación de un control “ON/OFF” de automatización. Se desarrolló el circuito completo de automatización, cada variable se automatizo y se desarrolló su código de programación. Los resultados mostraron que el sistema automatiza las variables de interés para controlar el microclima del invernadero.

Invernadero, Automatizacion, Control

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1. Introduction

The production of food that takes place in the Mexican countryside, are high quality products that are mostly exported to other countries. For this reason opportunities are offered to all those who are involved or who are surrounded by this area, such as farmers and agricultural entrepreneurs, who are interested and are even more involved in controlled systems to achieve greater production in a shorter time. "Strawberry production", compared in traditional production.

In the greenhouses nowadays they count on a great amount of systems of control and supervision, these types of systems are used mainly in the manipulation of the climatic variables that are inside a greenhouse, with the purpose of producing cultures of quality, contributing the ideal conditions of temperature, humidity, luminosity and irrigation, this due to its importance to be able to obtain crops any time of the year and in better conditions.

That is why through the design of control and the constant measurements that will be carried out through the sensors that will be implemented inside a greenhouse, the pertinent actions to be carried out by the different actuators were established. With the sensors that will be implemented, they will be the means to obtain information inside the environment of the greenhouse, when detecting deviations in temperature and humidity, it will be possible to carry out the activation of the lighting, activation of the fans, or some other pertinent action. This will respond immediately, according to the schedule established for the drives.

2. Selection of greenhouse structure that is implemented.

Based on the alternatives of structures that are known, it is proposed that the construction of the greenhouse is based on the type "Tunnel", since this construction has several advantages in this regard and favor construction, which presents a high resistance to the winds, in relation to the construction, it can be said that it is easy at the time of construction, it presents a high transmutation of sunlight, it can be implemented flexible covering materials, it is optimal for large productions, the construction can be carried out small according to the needs, presents volume of air retained.

This type of structure helps us to have a good option to start crops under greenhouses.

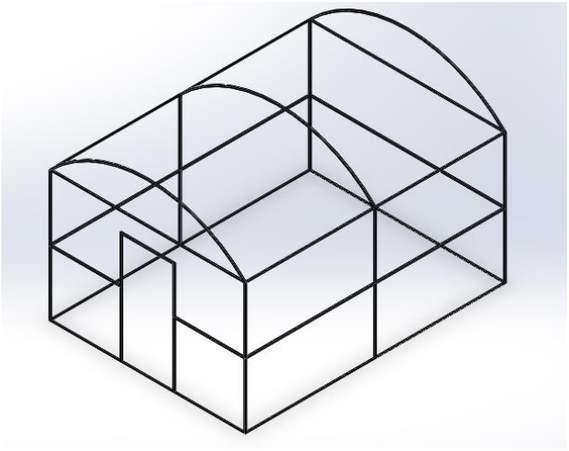

Figure 1 Structure of the tunnel type greenhouse

3. Edaphoclimatic requirements of the strawberry for production in the state of Hidalgo

Requirements	Description
Temperature	The temperature fluctuations that must be presented must be in a range of 15-20 ° C of annual average.
Humidity	The range of relative humidity that must be presented must range between 65 and 70%
Light	To be able to have optimal conditions in the production, it is necessary 12 hours of light daily to have good productivity.
Irrigation	Strawberry plants require approximately 450-600 ml of solution per day. [1]

[2]

Table 1 Optimal conditions for the cultivation of the strawberry

4. Present variables that are kept inside a greenhouse

In order to generate any type of crop, it must have an ideal environment, of which, the climatic variables are an important factor to be able to make an optimal crop.

For any production of any product, it is necessary to control one or more variables the objective of being able to carry out the production. The correct control of these variables is an important factor to be able to obtain a good quality and a correct efficiency within the production of crops. Within the greenhouses, it is necessary to control the relative humidity, luminosity and temperature, this because they are variables that directly affect any development of the plant. [3]

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5. Parameters to control

5.1 Relative humidity

The present air consists of several components, one of which is water, which is present in a gaseous state. In such a way the relative humidity is defined as the ratio between the partial pressure of the water and the saturated vapor pressure at a given temperature.

- In order to avoid excessive humidity, it must have a relationship with the irrigation system, which must establish a programmed irrigation system.

- In case the humidity system is too low. Based on the humidity sensors, the irrigation system must be activated in order to increase humidity.

- According to the cloudy days and cold short irrigation schedule, although in relation to this, in relation to humidity, the programming is established to be activated the irrigation system or not. [4]

5.2 Brightness

For a greenhouse, light is an essential sample, in order to obtain an adequate growth of the plants, this is due to the photosynthesis that is carried out by means of radiation, which is a variable that influences greenhouse climate control, since affects significantly the temperature. In some cases the luminosity depending on the region in which you are taking a certain crop, it is necessary that the crop is supported with artificial lighting, due to the behavior that you have in the plants, if you do not light lighting plants enter a state of numbness, which would result in a delay in the harvests.

5.3 Temperature

For a greenhouse the temperature is an individual parameter, of great importance, since it is one of the agents that influence the growth and the development of the plants, for this it is necessary to know that within the crops it is necessary to take into account the three possible temperature ranges.

- Minimum temperature range: it is the lowest temperature, which will affect the growth of the.
- Maximum temperature range: it is the highest temperature that can be found, which affects the evaporation of nutrients from the crop, which causes that there is not a correct growth in the crop, and pests such as fungi and animal species occur.
- Optimum temperature range: it is the appropriate temperature at which you will work to be able to develop the crop properly.[3]

5.4 Cultivation irrigation

It will be determined that this drip system is based on the drip system, this due to the data collected, and the advantages that are presented in relation to this type of irrigation, it should be mentioned that this system has certain disadvantages, in relation to installation, but the most important thing is that this system is as efficient as possible.

The returns are reflected, until the second season, which reflected an increase of 8% using partial spray, while drip irrigation increased by 13%. These two systems not only showed the increase in relation to the performance, but it was also reflected in the use of water, which was reduced by 10% in relation to the drip system. [5]

6. Control system

Within the processes in which a control is required, the ON / OFF positioning control can be adequate and good option, this is because it is the simplest way to control by feedback, it is a control of two positions in the that the final element of control only occupies two possible positions.

This method only accepts two positions for the actuator: ON (100%) and OFF (0%). The operating logic is to have a reference point, if the variable is greater the actuator adds up in one position, and if it is smaller the actuator assumes another position [6].

6.1 ON / OFF control characteristics

- Continuous cyclic variation of the controlled variable.
- The controller does not have the ability to produce an exact value in the controlled variable for a reference value.
- Optimum operation in processes with minimum delay time and slow ratio speed.
- It has a simple construction mechanism, that's why this type of controllers is widely used, and they are mostly used in temperature regulation systems.

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7. Selection of actuators and drives

7.1 Selection of the solenoid valve

The solenoid valve that is selected is a 3/4 "Pulse and 2-way plastic solenoid valve.

- They are used for systems with pipes at great distances.
- It is used in regions without electric power or in areas of difficult access.
- They occupy a small amount of energy (pulse) to open or close.
- To have a good functionality of this it is suggested its use with an irrigation controller.
- Ideal for irrigation with filtered water.

7.2 Fan selection

This type of axial extractor HXB-400 / L, is designed and direct applications, of which stand out its high performance and low power consumption.

- Frame type mouthpiece manufactured by rejected.
- High resistance to the corrosion.
- Propeller with feeding and balancing.
- They can drive depending on the model, three-phase or single-phase motor.
- Presents a series of accessories for your protection.

7.3 Luminosity Lamps

With the implementation of this BLOOMSPECT 300W LED greenhouse lamp, it allows us to maintain healthy and strong indoor gardening and hydroponic plants. The lighting is suitable for all types of stages that can occur in plants. Thanks to this type of lamp, it provides plants with an optimum amount of blue, red, and white. Which presents the characteristics and specifications:

- Spectrum: 630nm-660nm, 440nm, 460nm-470nm, 3500K, 7500K
- Input voltage: AC 100-240V
- Frequency: 50-60 Hz
- Model number: BS300
- Power LED: 300W
- LED Quantities: 60pcs 5W Epiled / BridgeLux LED
- Avg. Power consumption: 132W
- HPS replacement: 250W HPS / MH
- Dimensions: 29.5 cms x 20.7 cms x 6 cms to cover an area 0.90 for 0.90 mts for the vegetation stage, or 0.60 for 0.60 mts area for flowering.

7.4 Selection of heating (fogging systems)

This type of FOGDA24-250BRB nebulizers, meet the requirements to reduce the temperatures inside the greenhouse, likewise increases the humidity levels and depending on the correct connection helps to stimulate the propagation. The nebulizer has the following characteristics.

- Drops of 65 microns in size from average to 4.1 bar (60 psi)
- Uniform layer of fine drops for the propagation and application of chemical products.
- The incorporation of an anti-drip valve allows an instantaneous start of the system and prevents drainage of the pipeline.
- The disassembly and assembly for cleaning and maintenance is simple and without the need for tools.
- Engineering grade thermoplastic construction resistant to UV radiation for protection against corrosion.

7.5 DHT11 humidity sensor selection

This type of sensor is capable of measuring both relative humidity and temperature, this type of sensor is only able to provide whole measures, since it has a resolution of 1% for relative humidity and 1 ° C for temperature.

This sensor has a built-in humidity and temperature sensor, which has its corresponding calibrated output signal. Thanks to this device, it gives us great long-term stability. Working in an operating range of (0 ° C - 50 ° C) due to the interface that this device presents, when it is incorporated it becomes extremely easy, since integration makes any project quick and easy. Bearing in mind that this sensor can transmit its signal up to 20 meters. [7]

7.6 DHT11 humidity sensor selection

The LM35 sensor is a precision integrated temperature sensor, whose output voltage is linearly provides the temperature ° C this type of sensor does not require any external calibration or it is necessary to adjust it from which this component throws a typical pressure of + - 1.4 ° C at an ambient temperature and during its operating range it establishes a precision of + - 3.4 ° C, which has established an operating range of (-55 to 150 ° C).

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8. Selection of the microcontroller

For the selection of programmable logic control, it is necessary to take into account basic factors, in order to avoid connection problems, compatibility, oversizing, software, among other factors.

Selection criteria		
Application	Basic	ON / OFF control
Type of connection.	UBS	Connection to establish with the computer.
Cost	Economic and functional	
Number of entries	6	Sensors
Number of departures	5/6	Drive of the actuators.

Table 2 Selection criteria for the controller

To be able to perform the monitoring and control of temperature and humidity variables, Arduino has been selected, since this is an open source hardware platform, which is based on a simple board of inputs and outputs, analog and digital. Because of the ease and simplicity of using and manipulating, we have opted for the use of this microcontroller. In addition, that the software with which it is handled is completely free and like all the functions that are handled in this. This type of microcontroller would perform the function of receiving the corresponding signals of temperature and humidity of the corresponding sensors, to subsequently perform the corresponding control action [8].

Controller	Advantages	Disadvantages	Programming
Arduino	Cheap Open source A lot of information about Arduino Accessible for anyone	Not very robust Work with 5V signals	Programming in C / C ++

Table 3 Arduino controller table

9. Control loop design

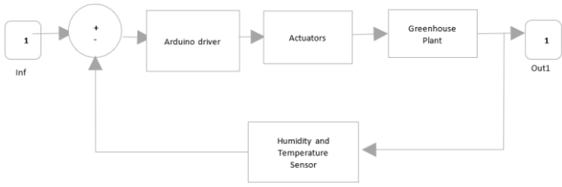

Figure 2 Block diagram of the control loop

- Arduino controller: Inside the Arduino controller, the reference or setpoint of the input will be taken, and which will be making the corresponding comparisons of the values that the sensors are sending, correspondingly, if there is a certain difference or rather a comparison error of the readings, the controller will perform the corresponding activation actions, in order to counteract the error found.

- Actuators: Once the Arduino controller finds a deviation in relation to the value of the setpoint and with the value that the sensor is sending, the controller will send a pulse to activate the corresponding actuators, which are the ventilation system, refrigeration, irrigation etc. Depending on the readings that are available, any of these actuators will be activated to counteract the present error.

- Greenhouse: Inside the greenhouse there is the presence of different variables to control, which are the internal temperature of the greenhouse, relative humidity, lighting, irrigation, etc. From these variables present in the greenhouse, they will be read to be able to control them through the action of the corresponding actuators.

- Temperature Humidity Sensor: Thanks to the sensors that exist to take readings of the variables that are present in any process, in this case inside the greenhouse, they help us to establish a feedback to establish our closed loop control and with these signals that will receive the controller, treat them to be able to control, the humidity or internal temperature of the greenhouse.

10. Flow diagram of General operation

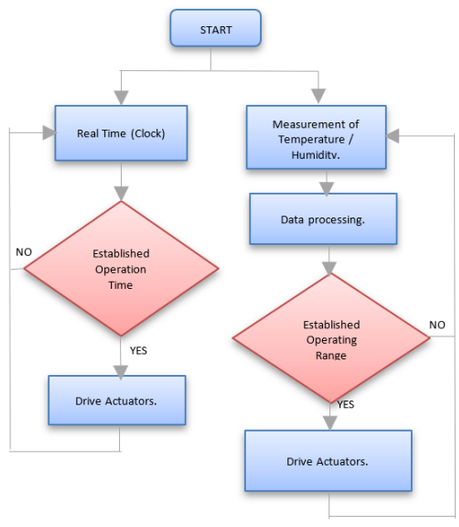

Figure 3 General operation diagram

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The process of operation that has the whole process proceeds as follows:

- Start: Once the program is started, along with all the relevant connections, the system will start working declaring that it will stay on.
- Temperature / Humidity Measurement: The sensor will begin to perform the temperature and humidity measurements periodically.
- Data Processing: The signals sent by the sensor will be processed to later make comparisons "some will be discretized".
- Established operating range: If any operating range has not exceeded the established limits, no component will be activated and the periodic measurements will follow. If the setpoint exceeds the established limits, it goes on to the next stage.
- Drive Actuators: Actuators will be activated to regulate the internal content of the temperature and humidity, and the measurement will be constant to continue making decisions of activation or deactivation.

Results

To characterize the different types of signals that give us values in relation to mV, it is performing an analog to digital conversion (ADC). This means that the input voltage 0-5V must be converted into integer values between 0-1023 values. To be able to convert these signals it is necessary to know that the analogue inputs of Arduino are 10 bits. This is why it is known that a bit can be 1 or 0. In the case of Arduino analog inputs: 210 = 1024 values (from 0 to 1023).

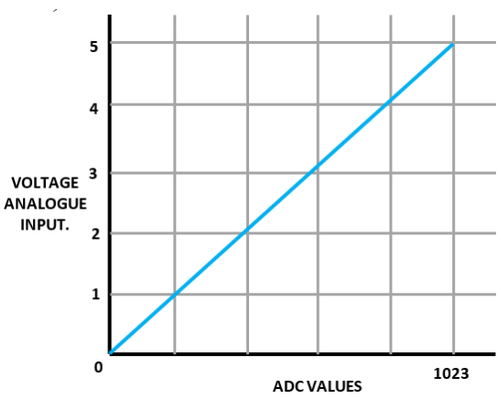

Figure 4 Ratio of ADC and Voltage

To obtain the value of the sensor voltage, it is necessary to convert the values back to voltage in the Arduino code.

For this you have to read the value read from the pin to which it is declared by 5 (this is because they are 5V maximum given by the sensor) and divide it by 1023.

$$voltage = \frac{(value\_ADC)(5)}{1023} \quad (1)$$

Based on this relationship we have the relation of the sensor output voltage with the digital values of Arduino. Subsequently, the sensor value is obtained, this is determined based on the relationship that exists between the voltage / variable of the sensor. Which is 10mV per 1 °.

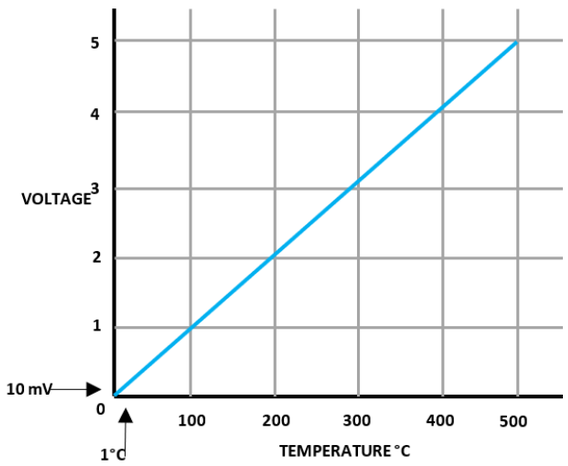

Figure 5 Ratio of mV vs Temperature

With the established relation, the voltage obtained in the previous step is now established by the value of the voltage-variable relation (in this case 100) and we will obtain the measurement variable of the sensor.

$$variable = \frac{(voltage)(relation\_voltage)}{variable} \quad (2)$$

The relationships that have been created, not only serve for the LM35 sensor, this relationship applies to any analog sensor that we connect to the Arduino. Simply change the Voltage / Variable relationships.

Based on those developed, the tests will be announced, based on the programs used by Arduino and Proteus, through the corresponding simulations. Of general operation.

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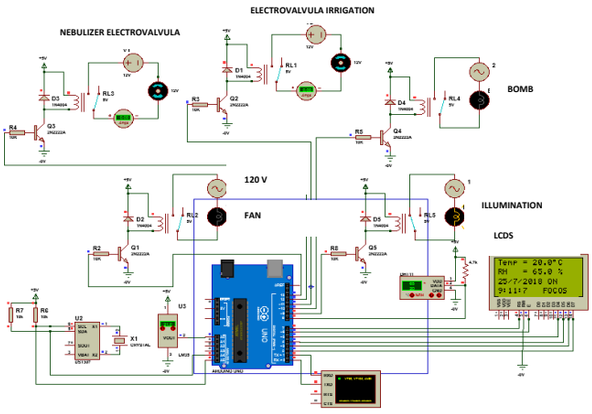

Figure 6 Complete circuit for the corresponding simulations

Within the tests that were carried out in relation to the activation of the lighting, it is possible to observe the proper functioning of the lighting based on time in real form, as can be seen in the display the time and date is observed, according to the programmed the lighting of the lamps was established a span of 12 hours, from 7am to 7pm, as shown in the display are 9am which indicates that the lamps should be lit, you can see that the analog output is active to perform the change of the relay and this can be observed that it is closed and the lamps or lighting is on, if it was not in the set time these would be deactivated.

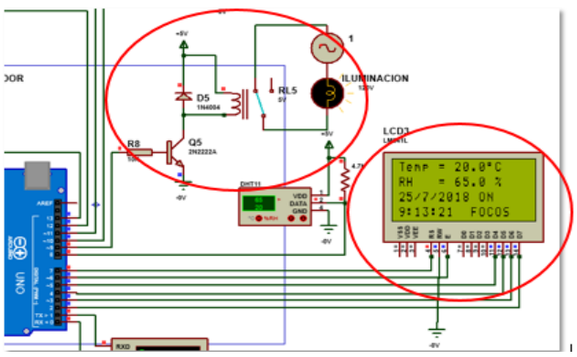

Figure 7 Circuit lighting performance

The tests of the drive to control humidity, were the following, this case is related to the DHT11 sensor, which can simulate the humidity and temperature, if the case where moisture increased its level, as can see in the image where the humidity is simulating in a value outside the setpoint (simulation of 70% humidity), therefore the fan is activated, in the simulation you can see the activation of this lighting and the relay appearing as closed to be able to energize the fan, as well as the analog output signal.

If the humidity is simulated in a value equal to or lower than that of the setpoint, the fan will tend to deactivate, since it is in ideal conditions.

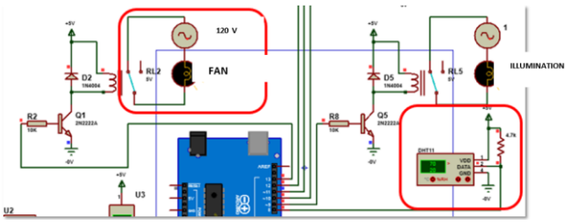

Figure 8 Operation of the fan, with a humidity greater than the setpoint

The operation to be able to lower the temperature levels, works from the established setpoint, which, if the temperature exceeds the declared level, will operate the pump, as well as the solenoid valve of the nebulizers, in an interval of 3 minutes with 20 drives in one hour, with intervals for every three minutes of 3 seconds to be lowering the temperature level. This type of drive is based on time. If the temperature is higher and it is not in the operating time it will not activate, until it is in the operating time, since, if it is not done in the established periods, it would cause problems in the humidity, making very abrupt changes with these two variables.

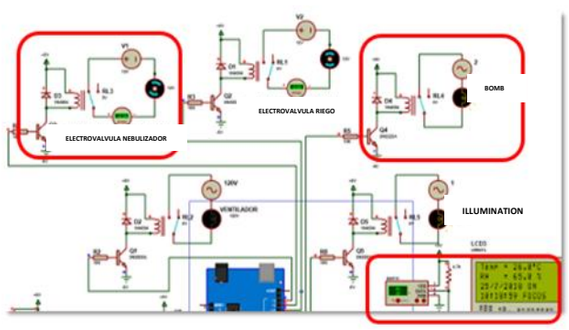

Figure 9 Moisture levels below the operating range

To be able to establish the correct functioning of the processes that are related to time, the DS1307 device has to be implemented, which is a clock, once programmed it takes the time in real time and from this it will be possible to take the drives that depend weather.

In this way it is also possible to observe the LM35 sensor and also to simulate the temperature conditions, to make the corresponding simulations and make the corresponding analyzes.

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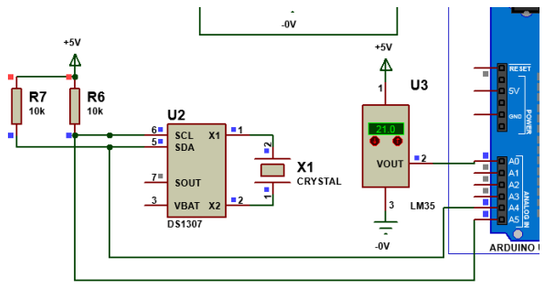

Figure 10 Analog section, DS1307 and LM35

Conclusions

The research carried out in this work allows to know the necessary requirements to take the necessary actions to have a correct automation, to provide the best climatic conditions inside the greenhouse.

Because it was possible to implement a closed control loop based on an ON / OFF control, which was applied to the selection of the possible final control elements (Actuators) to be able to control the internal climate of the greenhouse.

All the development of the project had the purpose of being able to mention, that it is possible to introduce the cultivation of the strawberry within these regions, provided that you have the appropriate climatic conditions, to be able to produce them by means of an adequate control.

References

[1] hydroenv. (2018). Obtenido de https://www.hydroenv.com.mx/catalogo/index.php?main_page=page&id=290

[2] elproductor. (21 de mayo de 2018). Obtenido de infoagro.com/: https://elproductor.com/articulos-tecnicos/articulos-tecnicos-agricolas/el-cultivo-de-la-fresa/

[3] Romero, L. (octubre de 2016). Desarrollo e Implementación de un Sistema Mecatrónico de Control de Temperatura a Traves del Flujo de Aire en un Modelo de Invernadero. Bogora, Colombia.

[4] casasdecultivo1. (30 de septiembre de 2010). Obtenido de http://casasdecultivo1.blogspot.com: http://casasdecultivo1.blogspot.com/2010/09/invernadero-inteligente-para-clima.html

[5] Eddy, D. (28 de Julio de 2010). hortalizas. Obtenido de http://www.hortalizas.com: http://www.hortalizas.com/irrigacion/riego-adecuado-para-tus-fresas/

[6] Rabañal Dopico, J. R., & Serrantes Villadoniga, J. A. (noviembre de 2006). Tecnicas Experimentales en Hidraulica. La Coruña, España: Universidad de la Coruña.

[7] Barrera Martin, E., Herrero Niño, R., & Meraz Garcia, A. (mayo de 2014). Invernadero Inteligente. Ciudad de Mexico, Mexico: Tesis.

[8] Baltazar Aguilar, J., Enciso Hernandez, D., & Vargas Dominguez, M. A. (mayo de 2014). Diseño e Implementacion de un Dispositivo Digital para el Control de Temperatura en un Invernadero de Tomate. Ciudad de Mexico, Mexico: IPN.

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