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Using of Electronic Circuits and Programming to Control the Seedlings Germination Inside the Greenhouses

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ABSTRACT

Climate change has resulted in unpredictable weather conditions, resulting in a global food deficit. A feasible solution to this problem would be for households to grow a reasonable percentage of their veggies and crops in a greenhouse that does not require a lot of land. When compared to open field gardening, a greenhouse will often produce more crops per square metre because the microclimatic parameters that impact crop output are continuously monitored and controlled to guarantee that an optimal environment is maintained. The greenhouse system is made up of two greenhouses: Electronic circuits is installed in the first greenhouse(G1) and the second greenhouse is devoid of electronic Circuits (G2). Therefore, a program was designed to know and control the environmental conditions inside the greenhouse(G1). The system was created and tested on a smaller scale. For that, seedlings of cantaloupe (Cucumis melo) were grown in both greenhouses. Germination percentage, speed of germination, length of seedling, the seedling vigor index (G1), (G2), 98.8, 91.6 percent, 1.3, 1.7 days, 8.4, 6.6 cm, and 14,10 cm respectively.

Keywords: Greenhouse, Electronic circuits and speed of germination

INTRODUCTION

greenhouses are prefabricated structures that may be used for a long time and are covered with glass translucent polythene and shade net to grow seedlings of vegetables, spices, and flower crops. Protected cultivation is the process of altering the natural environment in order to promote crop growth and output. Artificially regulating temperature, humidity, and light to meet the needs of the crop in order to boost agricultural yield and extend the growth season. For the expansion of horticulture industry availability of quality planting material is the basic need (Singh, *et al*,. 2017). Greenhouses used in Egypt on an increasingly large scale for early production of warm season vegetable, fruit and flowers. In Egypt, numbers of greenhouses reached 62421 greenhouses with area reached 6344 feddans, according to (Agriculture Directorates of Governorates, Vegetable Affairs Sector, 2020). Greenhouses with appropriate mechanisms for controlling environmental conditions are required to produce agricultural plants throughout the year. People's lives are becoming increasingly intelligent. Agriculture is on its way to becoming more sophisticated. When the Android system is used to control the greenhouse climate, it can boost crop yield, lower greenhouse energy consumption, and lower labour costs (Zhao, *et al*., 2017). Sumit, *et al*., (2012) Use an embedded system that continuously analyses the microclimatic parameters of a greenhouse and activates actuators when safe thresholds are surpassed, restoring optimum conditions. Their design incorporates a Liquid Crystal Display (LCD) that is directly connected to a microcontroller, ensuring that the user is always informed on the state of the greenhouse. Obviously, a system like this can only offer information to the user about the conditions within the greenhouse while the user is physically present. Mahmoud and Ala'a (2013) It is discussed a Wireless Sensor Network (WSN) with smart watering capacity. When the moisture level lowers, this device monitors the microclimatic factors around each row of crops and activates the appropriate irrigation pumps. Using electronic circuitry and programming, this technology creates ambient conditions for seedling growth within greenhouses. For greenhouse environment control, an intelligent close loop control system based on model embedded deep reinforcement learning (MEDRL) has been developed. Computer vision algorithms are utilised to recognise crop growing periods and sex, which are then used to train crop growth models with different growing times and sex. These model outputs, together with the cost factor, generate real-time greenhouse setpoints that are fed back to the control system. When compared to traditional greenhouse management procedures, the entire MEDRL system has the power to undertake optimization control precisely and conveniently, and expenses will be considerably lowered. Zhang, *et al*.,(2019) they mentioned that the greenhouses for greenhouse environment control, an intelligent close loop control system based on model embedded deep reinforcement learning (MEDRL) has been developed. Computer vision algorithms are utilised to recognise crop growing periods and sex, which are then used to train crop growth models with different growing times and sex. These model outputs, together with the cost factor, generate real-time greenhouse setpoints that are fed back to the control system. When compared to traditional greenhouse management procedures, the entire MEDRL system has the power to undertake optimization control precisely and conveniently, and expenses will be

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considerably lowered. Progressive farmers are now cultivating high-value crops and flowers under commercially protected conditions (Maitra, *et al.*, 2020). Nursery management is a vital aspect of ensuring a steady supply of disease-free early seedlings, especially for high-value vegetables and flowers, which require special attention. For a nursery with a convey size of 1000 m^2 in a greenhouse. Commercial nursery business is becoming a highly successful industry for experienced farmers that cultivate vegetable seedlings and sell them to various areas. Vegetable and flower seeds are transplanted types of crop that require a single location to grow with better care and are then transplanted to the main field after a few days (Mohanta, *et al.*, 2020).

The following were the study's key goals:

- Electronic circuits are used to control the environmental parameters inside the greenhouse.
- Design a program to regulate the greenhouse's environmental conditions.
- The effect of environmental factors on the germination of cantaloupe seedlings was investigated.

MATERIALS AND METHODS

The major goal of this project is to design a model that employs electronic circuits and programming to offer climatic conditions for seedling growth within greenhouses. The structures of two greenhouses (the First greenhouse does have sensors (G1) and the second greenhouse does not have sensors (G2)) were used to achieve this goal. The studies was place on an open roof (third floor) of the Faculty of Agriculture Engineering, Al- Azhar University, Nasr City, Cairo Egypt (latitude 30° 02' 30" N, longitude 31° 14' 07" E, and mean altitude above sea level 18 m). The studies was place across two seasons in 2020/2021.

1.Greenhouses

During this research, two comparable gable-span greenhouses were planned, built, and operated. Because expanding the whole size of the model will require increasing the capacity of the devices and increasing their number to cover the entire area with good efficiency, the model is designed with relatively small dimensions to lower the expenses of cooling, ventilation, and heating. It is 100 x 50 x 80 cm^3 in size is shown in Fig. (1). The greenhouse (G1) is covered with polycarbonate and greenhouse (G2) with shading net 63%.

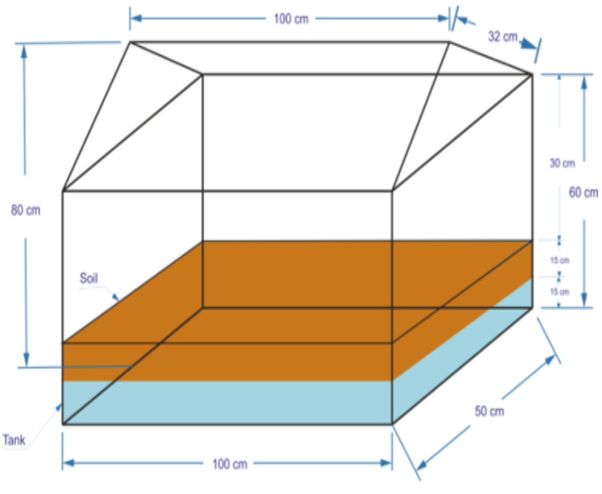

Fig. 1. Greenhouse (Dimension cm).

2. Greenhouse (G1) control unit

A 12 x 12 x 4 cm^3 fan with a voltage of 220 volts and a speed of 2600 rpm provides airflow inside the greenhouse. The fan was placed in the middle of the gable triangle on the model's front side, with 1 cm diameter holes on the opposite side, where the fan suctions air from the ventilation holes to switch between outside and greenhouse air. A simple and straightforward technique was used for the heating procedure. This system contains a small fan (9.9 cm), 220 volts, and a tungsten bulb that is 200 watts. In a plastic container, the lamp is kept. The top and sides of the box were perforated. The fan is mounted on one side of the box, with the package facing out and the intake facing in. Fix the tungsten lamp within the box, which should be lined with heat-resistant aluminium foil on all sides. When the fan rotates, the pressure inside the box drops, and outside air infiltrates via holes in the box, passing over the incandescent bulb to gain heat, before being discharged into the greenhouse. Outside the greenhouse, place the heating box. A Peltier electrical component was used in the cooling system (TEC1-12710). There are two sides to this sculpture. When linked to a 12 volt continuous source, one side's temperature rises to 50 ^{0}C, while the other side's temperature lowers to -10 ^{0}C. The piece was put on a heat sink with a fan to spread heat and evacuate heat. The little fan circulates cold air within the greenhouse, while the large fan exhausts hot air outside. Two cooling units have been put in the greenhouse. A humidifier with an ultrasonic mist producer was used. It is conveyed to the water by transforming high-frequency sound waves into mechanical energy. When submerged in water, the device emits a high frequency of up to 1.7 mHz. The frequency is transferred through the water's surface. Because of the high frequency, water molecules crack on the surface as a result. Water that has been frosted to a micron size. Place the device outside the greenhouse in a plastic box. The box was fitted with a blower that sucked the air out, allowing it to become saturated with moisture and then travel into the greenhouse. The white LED was chosen as the illumination source because it contains the majority of the visible light spectrum that the plant requires. It also uses less energy than other agricultural lamps.

3.Agriculture process:

Agriculture environment ingredients seeds 30 Kg of Bait Moss, 30Kg vermiculite sacks, 0.350 Kg of ammonia nitrate, 0.250 Kg of superphosphate, 0.200 Kg of potassium sulfate, 0.150 Kg of magnesium sulfate and 0.50 K g of Mon Ket. This amount is enough to plant 50 trays according to Agriculture Directorates of Governorates, Vegetable Affairs Sector, (2020). In each greenhouse, one tray with 84 seeds was sown.

4.The electrical circuit design diagram:

The electrical circuit design diagram is shown in Fig. (2). The power source is electrical energy. The effort of all devices was unified to reduce cost, all components were connected to the source in parallel so that each component could be controlled individually. All circuit elements operate on a voltage of 220 volts, except for the refrigeration device. Electronic components (Arduino board, timer, Bluetooth, temperature and humidity sensor, relay and 2 Power Supply (Current Adapter)). The first power supply to convert the source voltage, 220 volts, to 12 volts, 10 amps DC, because one refrigeration device needs (12 volts, 10 amps DC), and when the two devices are connected together in parallel, the equivalent load is 12 volts, 10 amps. The second power supply to convert the voltage of the source 220 volts to 5 volts, 3.8 amps, which supplies energy to the electronic components. All components were connected to the source parallel to the possibility of controlling each component individually (lighting, pump, humidifier, fans, heating lamp) where all the previous components operate on a voltage of 220 volts. Diagram showing how to connect the Arduino board to the electronic components is shown in Fig. (3).

The control strategy for the system in this experience is developed to be controlled as follows:

1. The temperature control need the definition of two limits threshold: maximum limit and minimum limit. When the upper limit is exceeded refrigeration device is activated the greenhouse environment and when the temperature drops below the lower limit, the refrigeration processes deactivated while a heater is activated and vice-versa.
2. Humidity control is need the definition of two limits threshold: maximum limit and minimum limit. When the humidity of the greenhouse enclosure minimum this threshold, a fogging system is activated and then deactivated when maximum condition is restored.
3. The lighting condition is controlled by: Choose three lighting periods.
4. The ventilation condition is controlled by: Fan turn on and off fixed time.

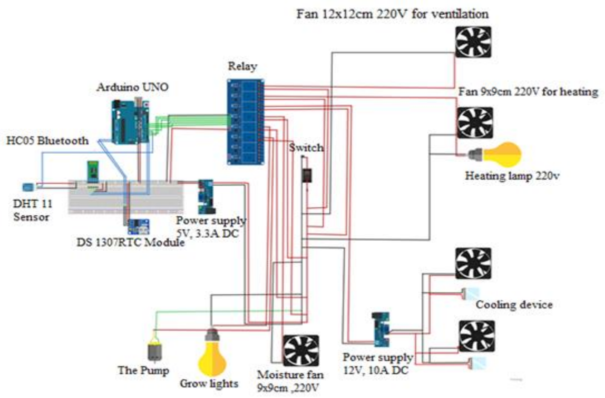

Fig. 2. The electrical circuit design diagram.

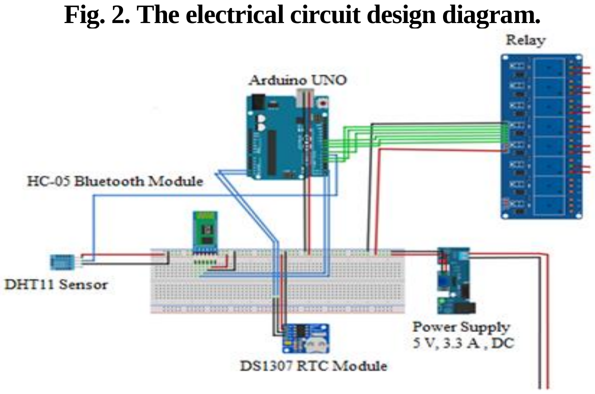

Fig. 3. Diagram showing how to connect the Arduino board to the electronic components.

5. Program Flowcharts:

The flowcharts for various are shown in Fig. (4, 5, and 6). The program for the system was written in Arduino language. Fig. (4) the current temperatures inside the greenhouse are read. The heater is turned on if the temperature inside the greenhouse is less than required. The cooler is turned on if the temperature inside the greenhouse is greater than required. Fig. (5) the current relative humidity reading inside the greenhouse. The humidifier is operated if the relative humidity inside the greenhouse is less than required. The humidifier is stopped if the relative humidity inside the greenhouse is greater than the required. Fig. (6) the ventilation fan runs for 3 minutes and then turns off for 120 minutes.

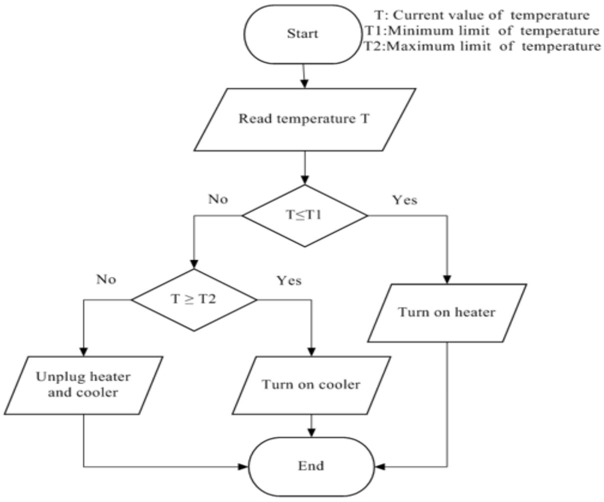

Fig. 4. Flow chart for the temperature control subroutine.

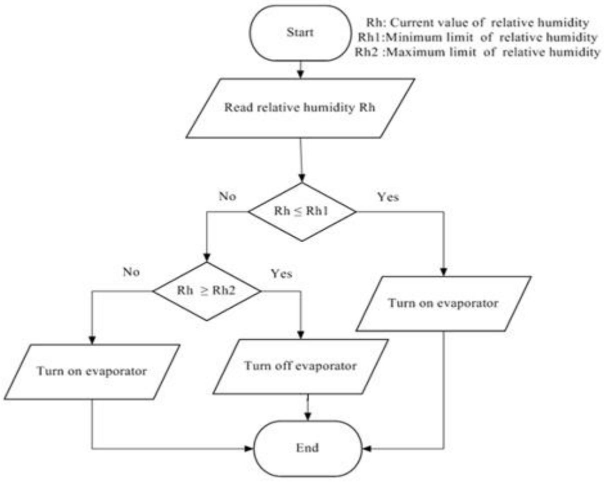

Fig. 5. Flow chart for the relative humidity control subroutine.

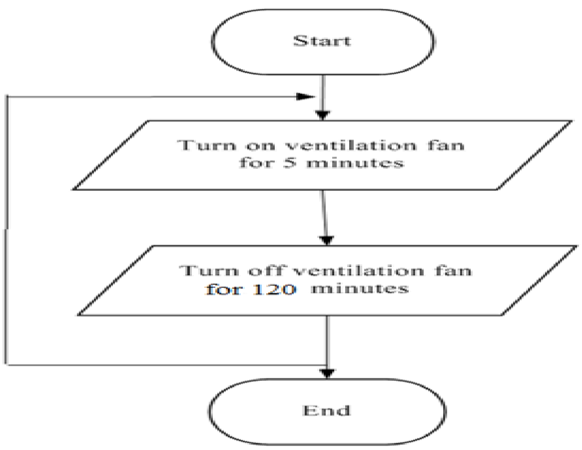

Fig. 6. Flow chart for the ventilation control subroutine.

6. Germination parameters:

1.Final germination percentage (GP):

It was calculated according to the germination count taken after 14 days and expressed as percentage according to the following equation which described by International Seed Testing Association (ISTA, 1993) and Ruan *et al.* (2002):

$$Germination\ percentage = \frac{Number\ of\ Germinated\ Seeds\ After\ 14\ Days}{Number\ of\ Cultured\ Seeds} x\ 100\ \dots\dots (1)$$

2.Mean germination time (MGT):

It was performed according to the following equation which described by Alvarado *et al.* (1987):

$$MGT = \frac{\sum d\ x\ n}{\sum n} \quad \dots\dots\dots\dots\dots\dots \quad (2)$$

Where: **(n) is the number of seeds which germinated on day (d), and (d) is the number of days counted from the beginning of germination.**

3.Seedling vigor index (SVI):

It calculated according to the following equation which described by Abdul-Baki and Anderson (1973):

$$SVI = (Average\ Shoot\ Length + Average\ Root\ Length) \times Germination\ Percentage \dots (3)$$

4.Seedling characters at laboratory.

1- Shoot length:

The shoot length of ten seedlings was registered and expressed in centimeters (cm).

2.Root length:

The root length of ten seedlings was recorded and expressed in centimeters (cm).

RESULTS AND DISCUSSION

1. Program destination:

Program opening screen is shown in Fig. (7). When you click on the open plotter, three graphs appear. It shows the change in temperature inside the greenhouse, temperature outside the greenhouse and relative humidity inside the greenhouse. When running the program, temperature inside the greenhouse 28 ^{0}C, temperature outside the greenhouse28.5 ^{0}C and relative humidity inside the greenhouse52 % is shown in Fig. (8). When you press the open plotter again, the data stops displaying when pressing manual operation, the manual control feature is activated of heater, coolant, ventilation fan, lighting, humidifier and pump. When you press Manual operation, the manual control feature is disabled again. In this part of the program, environmental factors can be automatically controlled without user intervention is shown in Fig. (9). Temperature control through which we can write the temperature that we want to maintain inside the greenhouse. If the internal temperature is greater than the desired temperature, the electronic cooler is automatically opened until the temperature drops to the required limit. But in the event that the internal temperature of the greenhouse is less than the given temperature, the heater starts automatically until the temperature reaches the required limit. But if the internal temperature is equal to the given temperature, no reaction will occur until the internal temperature is less or more than the given temperature. Grow light can control number of lighting hours. Three options are provided lighting for 6,7 and 8 hours. Ventilation control number of ventilation times can be controlled. Three options are provided ventilation for 5 minutes every 2 hours, ventilation for 5 minutes every 3 hours and ventilation for 5 minutes every 4 hours. Relative humidity With this feature, the relative humidity can be controlled. Three options are provided 40:55, 55:75 and 75:95%. In the event that the relative humidity inside the greenhouse is less than the required relative humidity, both the humidifier fan and the humidifier are operated at the same time until the relative humidity rises to the required limit. In the event that the relative humidity inside the greenhouse is higher than the required relative humidity, the ventilation fan is operated automatically until the relative humidity drops to the required limit. If the relative humidity is equal to the required relative humidity, the control devices will not operate until there is a decrease or increase in the internal relative humidity. Irrigation control number of irrigation times per day can be controlled. Three options are provided Once a day for 1 hour, twice a day for 1 hour And three times a day for 1 hour. The temperature inside the greenhouse was set at 28 ^{0}C, the relative humidity was55: 70%, and the ventilation was for 5 minutes every 2 hours. It was observed that the ventilation fan operated for 5 minutes every 2 hours. Also, operate the humidifier if the humidity inside the greenhouse drops below 55%. The operation of the cooler was seen if the temperature rose above 28 ^{0}C and turn on the heater if the temperature drops below 24 ^{0}C.

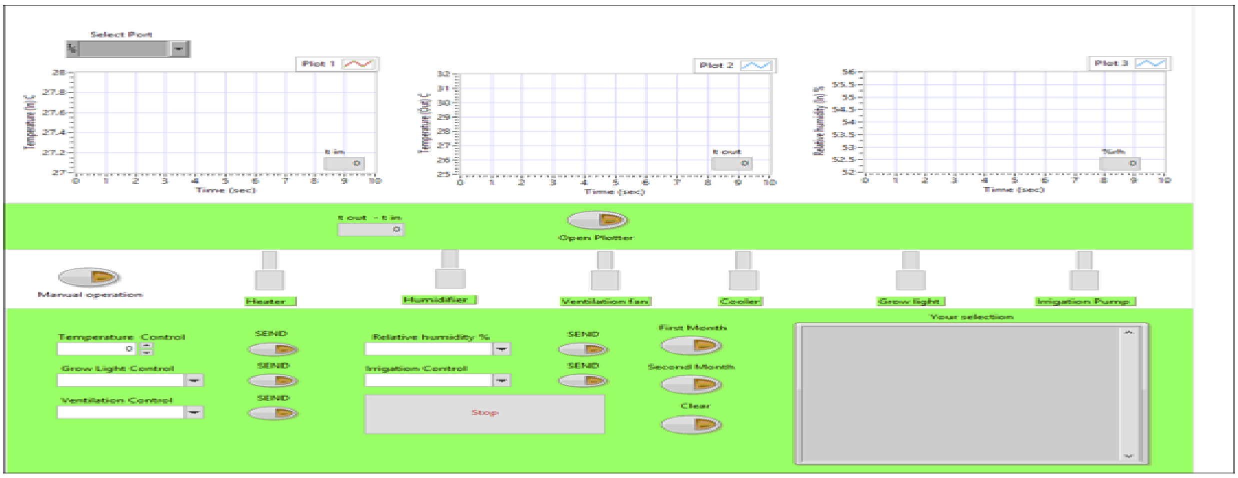

Fig. 7. Program opening screen.

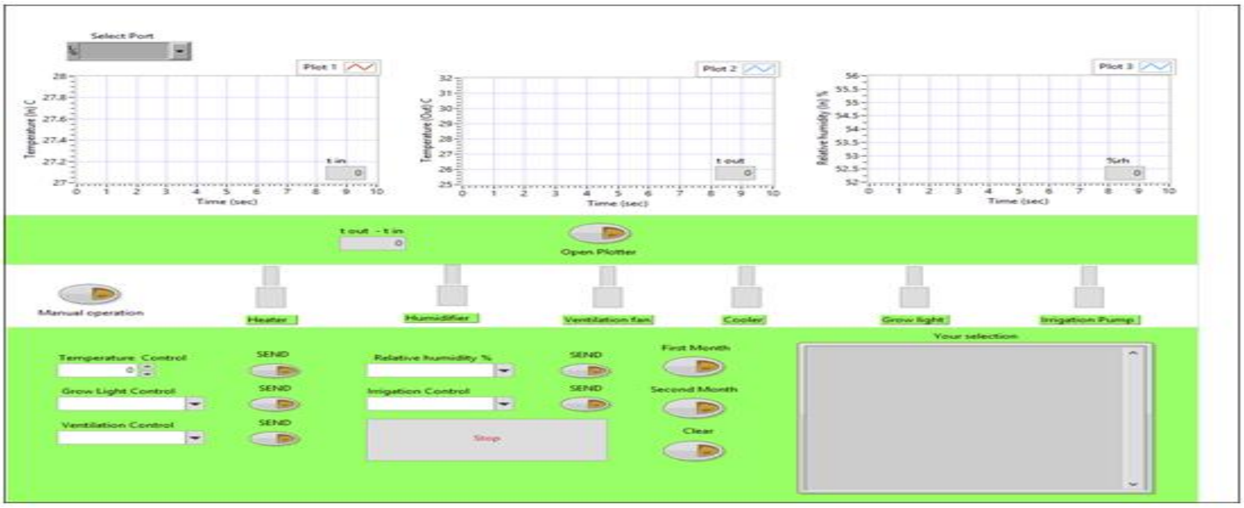

Fig. 8. Change in temperature inside the greenhouse, temperature outside the greenhouse and relative humidity inside the greenhouse.

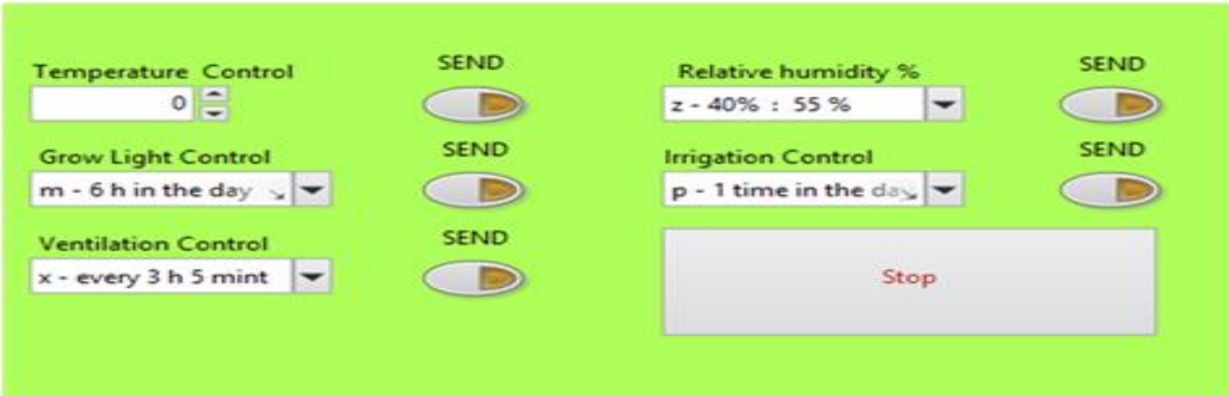

Fig. 9. Environmental factors can be automatically controlled without user intervention.

2. Germination parameters:

At the end of the observation period (11days) the percentage of seeds that did germinate ware 98.8% (G1) and 91.6% (G2), respectively. Actually, germination start within 6 days, as shown in Fig. (10) along with the percentage of seeds germinating per day, starting from the beginning of germination test. A large difference between the two groups appeared in their respective germination rate, showing a mean germination time (MGT) of 1.3 days in the case of (G1) and 1.7 days in the case of (G2). More significantly, 85.7% of (G1) seeds germinated within 2 days, while this percentage dropped to 54.8% of (G2) seeds. This result could have an important relevance, from the agricultural industry point of view, Seedling production in less time. At an agro-industrial scale, growers of watermelons, may find it useful that seeds germinate within 2 days, rejecting seeds of other lots that show retarded germination times. AS Well, at the end of the experience (25 days) the seedling vigor index that did at 14 cm of (G1) and 10.2 cm of (G2), respectively. As well, average length of the seedlings ware 8.4 cm of (G1) and 6. 6 cm of (G2), respectively. Also, average length of the root ware 5.4 cm of (G1) and 4.6 cm of (G2), respectively. From previous results, The seedlings of (G1) are better than of (G2), as a result of providing the appropriate environmental conditions in (G2).

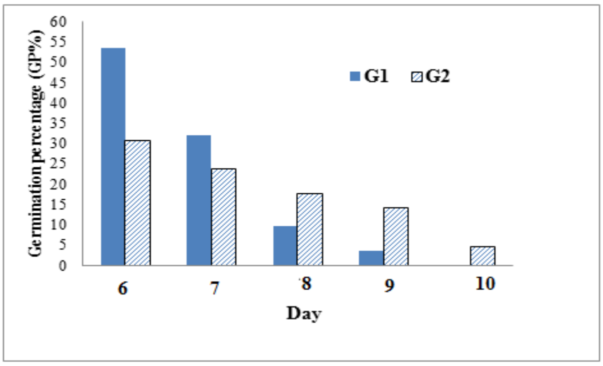

Fig. 10. Percentage of germinated seeds as a function of the day after sowing.

CONCLUSION

The automated greenhouse control system that has been successfully designed and built in this study is intended to protect seedlings in nurseries from intruders while also growing them to maturity if necessary using a very small area of land, as opposed to open field cultivation, which may require more square metres of land to produce the same amount of crops. Because pests are normally kept out of the greenhouse enclosure, this approach produces healthier crops. The system is totally automated because it does not require the user to make any adjustments. The microclimatic characteristics are also available for the user to read and monitor the greenhouse's performance via a remote terminal to achieve the most suitable condition for seedlings growth.

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التحكم فى الصوب الزراعية باستخدام الدوائر الالكترونية والبرمجة لإنبات الشتلات

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نتيجة لتغير المناخ أدى الى ظروف مناخية غير مستقرة لا يمكن التنبؤ بها, مما أدي ذلك الى نقص في الغذاء العالمي. وقد يكون الحل العلمي لهذه المشكلة هو زراعة الخضروات والمحاصيل وكذلك الشتلات في الصوب الزراعية بنسبة معقولة لسد هذا النقص التي لا تطلب الكثير من الأراضي عند مقارنتها بزراعة في الأراضي المكشوفة بدون صوب زراعية, وغالباً ما يكون انتاج المتر المربع داخل الصوبة اكبر بكثير من الحقل المكشوف, نظرا لمراقبة الظروف البيئة داخل الصوبة والتحكم فيها باستمرار لضمان الحفاظ على البيئة المثلى داخل الصوبة. يتكون النظام من صوبتين متماثلتين في الأبعاد, الصوبة الأولى تم تجهيزها بالدوائر الالكترونية والأجهزة الازمة للتحكم في الظروف البيئية داخلها (G1), الصوبة الثانية لا تحتوي على أي دوائر الكترونية ولا أجهزة (G2), لذلك تم تصميم برنامج لمعرفة الظروف البيئية داخل الصوبة (G1) والتحكم في هذه الظروف, حيث تم انشاء الصوبتين على مساحة صغيرة وذلك تقليل التكلفة وسهولة عملية التحكم, وتم زراعة شتلات الكنتالوب في صنيه 84 عين, حيث وضع صنيه واحده داخل كل صوبة فكانت نسبة الإنبات, سرعة الإنبات, طول الشتلة و مؤشر قوة الشتلة لكلا من (G1) , (G2)، 98.8 ، 91.6٪ ، 1.3 ، 1.7 يوم ، 8.4 ، 6.6 سم ، 14.10 سم على التوالي .

الكلمات المفتاحية: الصوب الزراعية ، الدوائر الالكترونية، نسبة انبات الشتلات