DESIGN AND FABRICATION OF AUTOMATIC SPROUTING MACHINE

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Abstract. Through newspapers, television and the Internet information, self-cultivation of sprouting in the household as well as the trading model are very popular in the country. Particularly, when a plant-based stimulants information is widespread, self-cultivation of household sprouting becomes increasingly urgent. Current seed nursery machine in the market are not attractive to the user, which is mainly due to lack of user convenience. Thus, the fully automatic machine with a good price will create a special appeal to everyone. For this reason, this paper designs and fabricates sprouting machine automatically. Users do not need to operate the device during the sprouting development, but still ensure 100% success rate of high quality produce. In addition, the device can optimize important parameters affecting of sprouting development such as humidity, temperature, air and water. Sprouting are always in the best growth state, shorten the time to harvest products as a result.
Keywords. Sprouting, auto machine, environment stability.

1. INTRODUCTION

Nowadays, in Vietnam market, there are many types of seed nursery machine with variable categories and diverse origins. Products from abroad are derived mainly from China, Korea, … with compact size, about 3kg bean sprouts per times operation. Products of Vietnam mostly are handmade, small size, about 5kg of bean sprouts per times operation, which are suitable used for household. Recently, on the market also introduced bean sprouts machine automatically with sell price 50 million VND per machine. However, the operation mode is primarily user-set watering duration, and using one kind of seed for an assortment of sprouting at the same time. There doesn't have a machine to monitor and control the temperature, humidity and biological characteristics of each type of seed. Especially, there is no commercial system to create the artificial environment according to the characteristics of growth and development of seeds.

Aware of the essential needs of household about fresh sprouts, and through the process of understanding, research and development, we propose this paper dulled by "Design and fabrication of automatic sprouting machine". Our machine aims to automate the process of nurturing environment in order to shorten harvest time, increasing the rate of seeds germination, decreasing the rate of spoiled seeds, saving water irrigation, and environmentally friendly.

This paper describes the method of application theoretical characteristics about growth environmental types of seed, then construct and design nursery multi-function system for fresh sprouts. The design system is controlled fully automatic by microcontroller to create an environment of growth, artificial ideal for sprouting. The control system operates in two modes: automatically according to pre-established parameters for bean sprouts and setup parameters by user.

2. RELATED WORKS

First of all, we do research about the different characteristics type of sprouting related to some important parameters of the environment such as temperature, humidity, light, watering. Then, we design pattern incubator and control system to be able to create artificial environmental growth near optimal condition.

For this reason, sprouting grows well and yield the high quality product.
From documents regarding the cultivation and safe technical production for bean sprouts, fresh sprouting cultivation techniques and seed production technology [1], we have conducted some important parameters environment which need for the development of sprouting as follows.

2.1. Ideal environment growth for bean sprouts

Bean sprouts is made from the seeds of green bean, about 3 to 7cm length, high value in nutrition. In order to make bean sprouts effective growth, many attentions should be paid to the environmental conditions [2][3].
Water is the important condition to control and regulate the germination of seeds. Some of the predominant use of the water as follows.

- In water absorption stage, bean pods dilate to absorb CO_2, increase the effects respiratory tract.
- The second stage is the organic structure in bean to transfer from the condensate state to the reconciled state, increase the activity of yeast, and conduct normal germinate operation.
- The third stage is the organic complex resolution of the switched compound under the form of water. The water helps to bring nutrients to the growth, and to provide requirements for the process of the cells growth. Ingredients water need to be full provided throughput the beans germination. At the same time, fresh water must be sufficient to beans growth, which is used to excrete waste to bring away CO_2 and regulating temperature. It is worth noting that after the beans germinated, either too much water or too long the soaking time water will lack of oxygen which affect to the growth of bean sprouts. This can spoil bean sprouts as a bad result.

Temperature for bean sprouts growth need warm and hot. In which, the lowest temperature to bean sprouts germination is 10^oC, the highest value is $28 – 30^oC$, and do not exceed 32^oC. If the temperature is too low, the harvest time will be long, product quality decrement. Otherwise, when the temperature is too high, bean sprouts are fast growth, high fiber, and poor quality. Therefore, the best range of temperature is $26 – 28^oC$. When the temperature is high, the bean sprouts grow faster, but they will be thin.
Oxygen and hydrogen have the effect of promoting the respiration process of sprouting. Air flow helps to release heat energy, provide for active growth of the sprouting. At the same time, oxygen can promote the activity of yeast, starch and other nutrients. Composition air in the nursery environment compared with the normal environment is more hydrogen and less oxygen, to control the effects of respiration and metabolism of bean sprouts, which are beneficial for the growth and create bean sprouts white, soft and fresh.
Light and the change of color of the bean sprouts have intimate contact with each other. Bean sprouts product require vertical, white, and yellow or pale green leave. So, they should be placed in low humidity conditions and sunlight avoidance during bean sprouts growth process. Especially, when the bean sprouts germinate, approximately 1.5cm height is the critical stage of sunlight avoidance. Moreover, in order to keep the best quality in the market consumption, bean sprouts should be careful to avoid the sun which cause them to be changed color.

2.2. Environmental growth for the sprouting

Sprouting are vegetables that are cultivated in a short time, just harvested after 5 to 7 days sowing. Sprouting are easily digestible, multi-vitamins, minerals, organic acids, amino acids, protein, other benefic enzymes. These nutrients are very important for human health. Currently, there are many varieties of sprouting such as: mustard sprouts, beet greens, microgreens, sunflower sprouts, spinach sprouts, peanuts sprout, green peas sprout, etc.
Temperature, humidity and light: the suitable temperature for the growth and development of sprouting is from $25 – 30^oC$, humidity required is 60 – 70%, strong light avoidance, and breathable [4][5]. We should close tightly the tray grown sprouts to limit exposure to light in about 1-3 days after sowing because of the lack of light help seeds focuses on developing germ, at the same time limiting the wind blew and the

light carries heat loss, moisture content of seeds. From the day 4 to the harvest plants, they need light to photosynthesis help rigid stem cable and leaves more green. If we add light sunshine to sprouting about two hours per day, vegetables will be green and limit number of diseases related to germ.
A lot of fresh water is used for sprouting. According to research material, the roots of sprouting seize at the surface, drought and waterlog tolerance weakly, and easy to be disease. Therefore, proper irrigation is necessary.

3. SYSTEM DESIGN

From the background theory about the environment growing of sprouting, we do research and build a pattern model. We also design the hardware control system to be able to create artificial environment for the chamber nursery.

3.1. Overview of the system

Process of control chamber nursery to create the artificial growth environment automatically illustrates through hardware control system as shown in Figure 1. All activities of the system are controlled by microcontroller ATmega328 [6]. The microcontroller receives the parameters of temperature and humidity environment through the sensors. After receiving data from the sensor, the microcontroller will synthetic handle and control the output suitable actions such as: turn on the water pump to reduce the temperature and humidity of the environment, turn on heat resister if the temperature of the irrigation water is low, ... to create the best growth environment for sprouting.

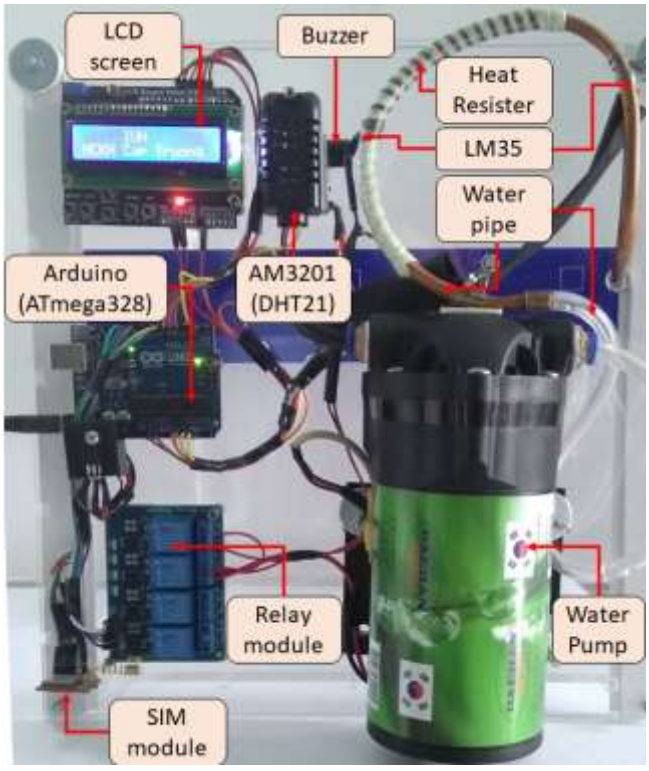

Figure 1: Hardware control system.

The key design solution is to use a closed-loop automatic control algorithm to stabilize important parameters affecting the bean sprout development such as humidity, temperature, air and water. Figure 2 describes the process of stabilizing the environmental parameters by measuring the parameters from the sensor: temperature, humidity, water content. Through the central microcontroller, measured values from

the sensor are compared with the desired stability parameter. Thus the error value will be corrected gradually through the loop until there is no error (or less than the allowed minimum).

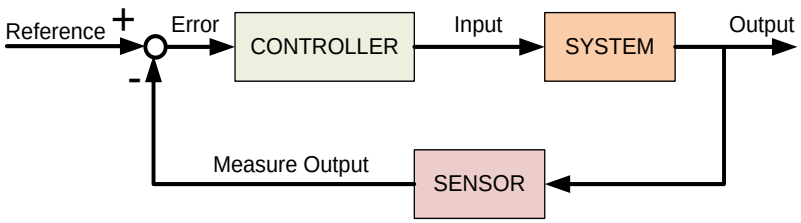

Figure 2. Loop control system.

The control system uses DHT21 sensor to measure humidity and temperature of environment [7]. We use two LM35 temperature sensors to measure the temperature of the water [8]. The important parameters to monitor and control the system are temperature, watering, temperature and humidity environment.
For the sprouting, optimal water temperature is from 26^0C to 28^0C, humidity of environment in the nursery is from 65% to 70%, fresh air and light for the chamber nursery. Different with bean sprouts, amount of irrigation water is a little in the form of spray. Moreover, the sunlight intensity is related to sprouting to stimulate growth. Under these conditions, sprouting has beautiful green color.

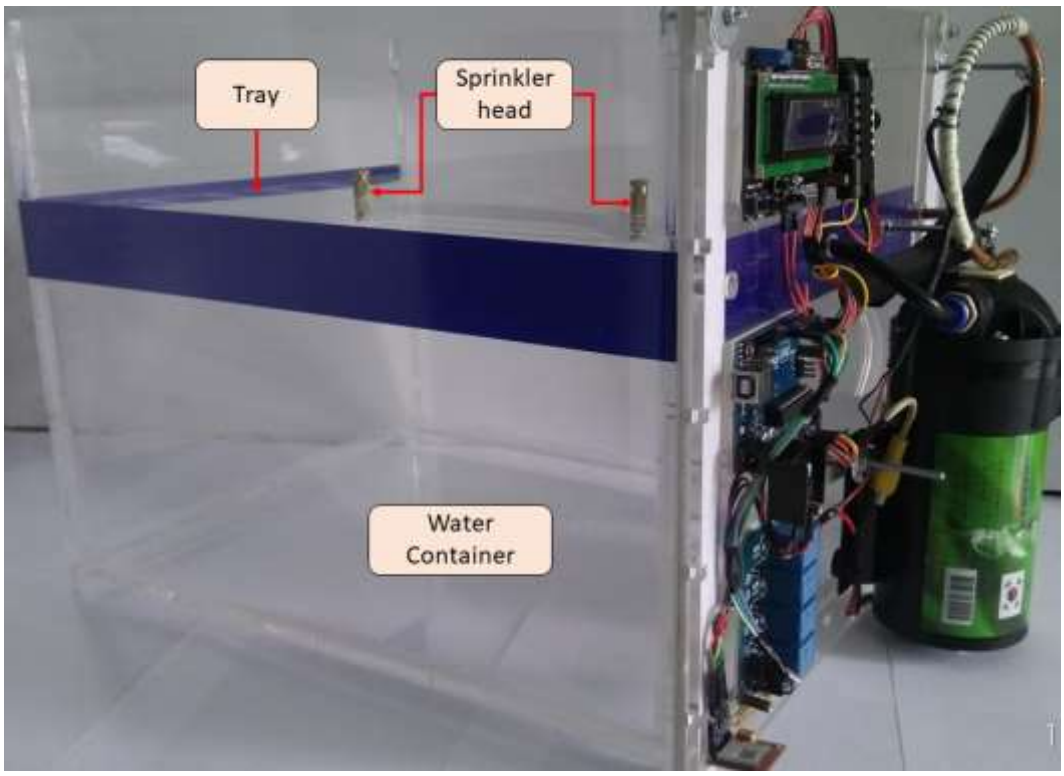

Figure 3. The chamber nursery model.

The chamber nursery model is small scale in size (Length x Wight x Height = 40x30x30cm), as shown in Figure 3. However, we can fully develop models with large scale to produce fresh sprouting for trading. Special highlights of the model are the automatic watering system and enable reused water by adding the sponge to filter the water. With designed chamber nursery in conjunction with smart control system, it works automatically according to pre-installed environmental parameters. Moreover, users can setup different watering durations during the day in real-time.

3.2. Hardware design

a. Control and LCD display module:

Principle diagram of control circuit and LCD display are shown as Figure 4. The circuit consists ATmega328 microcontroller to read and adjust sensors data in real-time about temperature, ambient humidity and ambient temperature water sprouting. The control circuits include multiple modules such as watering systems, thermal environment to form the artificial environment. Moreover, five buttons are used to choose operation mode or automatic irrigation setup environment parameters according to kind of seeds. All the environmental parameters, real time and operation mode are displayed on the LCD screen.

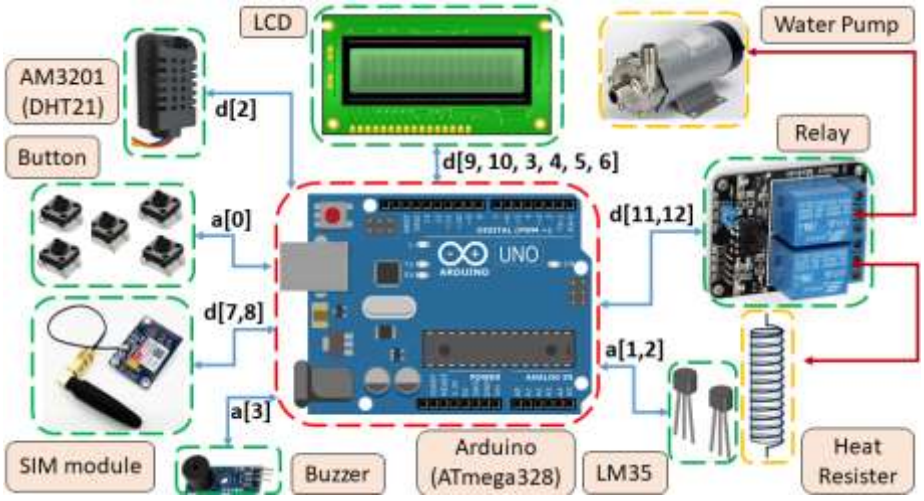

Figure 4. Schematic circuit with digital pins and analog pins connection.

b. Power control module:

Principle diagram circuit of power control module as known as relay module are shown in Figure 4. Power control module turns on/off the motor centrifugal compressor and the heat (resistive heat) to spray mist sprouts. The power control module effects the thermal environment, suitable heat water to help sprouting easily grow well under cold climate. The power module control system of dehumidifiers and water sprinklers for the purpose of stable humidity and temperature environment in nursery machine.

c. Alert and notification module:

In order to inform the current status to the user, buzzer and SIM module is used to transmit some important information via SMS message to the mobile phone of user [9]. The SMS contents may describe the current risks of the system, or the harvest time to the user. The detail circuit diagrams are shown in Figure 4.

3.3. Control system algorithms

a. Flow chart of main program:

The principle operation of the system is described in the flow charts of main program in Figure 5a. When booting, the system reads the real-time environmental parameters such as temperature and ambient humidity from DHT21 and water temperature from LM35. Then, the system runs the default program for bean sprouts with default environmental parameters. While running the default mode, the user can setup new environmental parameters, then re-select the operation mode of the system. That is to say, the system can be used in auto mode or the option setup mode according to type of seeds. Everything of parameter set up as well as the current status of operation system are saved into the EEPROM memory of the

microcontroller. Therefore, when power is lost, the system can recall and operate in the previously set mode without having to re-input any parameters.

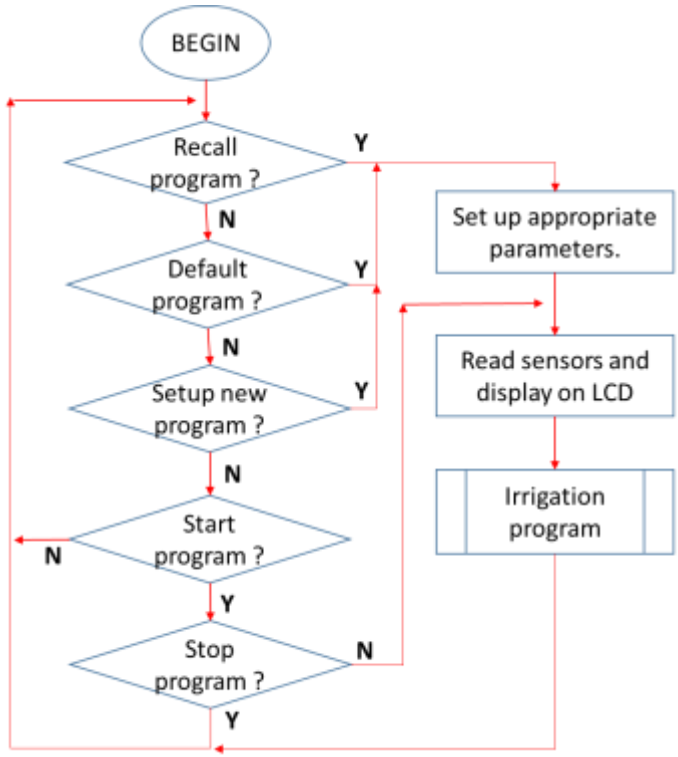

Figure 5a. Main program flowchart.

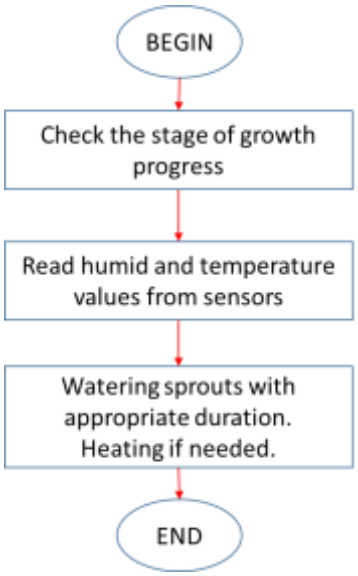

Figure 5b. Irrigation program flowchart.

Bean sprouts program is the default program when we boot the system. The temperature and humidity environment is pre-installed at 27^0C and 75% humidity. The temperature of irrigation water is maintained between 26^0C and 28^0C, because these temperature and humidity values are the most suitable for bean sprouts growing. With sprouting program, the watering, temperature and humidity environment are similar with bean sprouts program while watering duration is reduced because bean sprouts are easy spoiled under excess amount of water. Last but not least, the system is open designed for users to change the parameters of different environments. These activities can be applied to survey and experiment with other types of sprouts.

b. Flow chart of irrigation program in the real-time for user mode:

Initially, the operation system is automatic irrigation water mode. For instance, if the air humidity is smaller than the smallest set value, the system will turn on the pump motor to water the sprouts. If air humidity is higher than the highest specified value, the system will turn on the fan to reduce the moisture down into the range of allowed values. In irrigation process, the system will check the temperature of the water if the temperature of water than prescribed, it will turn on the heat resister and vice versa.

Flow chart in Figure 5b illustrates the algorithm watered in user mode real-time system allows the user can set the number of times watering. This is the algorithm to let the user can use to survey and experimental nursery for the sprouts new, yet to be standardized in the program incubator automatic of system.

4. RESULTS ACHIEVEMENT

Through many times experience on the system nursery automatically and the reference about cultivation techniques, we integrate beans sprouts process and some kind of sprouting process into our machine.

4.1. Process of growing bean sprouts

- Step 1: Prepare the dry green beans to soak warm water at a temperature of 45-48^{0}C in the short time (about 1 minutes), or at a temperature of 32-35^{0}C in the long time (about 4 hours). Then, put them to the fresh water at a temperature of 26-28^{0}C.
- Step 2: Preparation of machine, including trays. Beans sprout in the first time does not need pasteurization. After the harvest beans sprouts was done, users need hygienic all elements. Put rack for tray height of about 5cm, scatter blinds onto the tray to create flat surface, then sow the beans.
- Step 3: Sow the beans on tray after the preparation in step 2. Multiple layers of bean trays can be overlapped each other.
- Step 4: The machine will automatically irrigate due to the growth stages of bean sprouts. The environment of the nursery system is monitored in real-time. The SIM and buzzer module may alert and send SMS message to the user during this stage.
- Step 5: Harvest after 2.5 days, the bean sprouts are about 4-5cm height.

4.2. Process for growing sprouting

This process is totally the same with growing bean sprout, except the different number of time watering sprouting according to the different type of seeds.

4.3. Products

After operate the system and algorithm with four different types of sprouting, we review the product achievement as follows:

- The germination rate of seeds is from 95% or above.
- The harvest time is 2.5 days for bean sprouts and 4-5 days for sprouting.
- Saving labor due to fully automatic operation system.
- Do not use any kind of stimulant growth.
- Water-saving irrigation, no pollution to the environment.

The following are some products obtained through experiments by our machine.

Figure 6a. Bean sprouts.

Figure 6b. White radish sprouts.

Figure 6c. Water spinach sprouts.

5. CONCLUSIONS

This paper presents the models nursery automatically and through experiments on designed models in two modes operation. We have done experiment about characteristic growth coalition in temperature and humidity environment, temperature, watering for green beans and some sprouting. The model system is

designed by research from seedling technique, electronic technique and microcontroller programing. The system can be used to set the environmental parameters for testing and find out the optimal values for the new type of seed which is suitable in research and trading purposes.

ACKNOWLEDGMENT

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THIẾT KẾ VÀ CHẾ TẠO THIẾT BỊ TRỒNG RAU MẦM TỰ ĐỘNG

Tóm tắt. Thông qua các thông tin trên báo chí, truyền hình và mạng Internet, mô hình tự trồng rau mầm tiêu thụ trong hộ gia đình, cũng như mô hình trồng giá đổ sản xuất kinh doanh rất phổ biến trên toàn quốc. Đặc biệt, khi thông tin về việc sử dụng hóa chất kích thích trên cây giá phổ biến rộng rãi, thì việc tự trồng giá sạch trong gia đình ngày càng cấp thiết. Các thiết bị trồng giá hiện tại trên thị trường không có sức hấp dẫn cho người sử dụng mà nguyên nhân chủ yếu là không có sự tiện dụng cho người sử dụng. Như vậy, nếu xuất hiện thiết bị làm rau mầm hoàn toàn tự động trên thị trường với giá thành tương đương các thiết bị hiện có, thì sẽ tạo nên sức hấp dẫn đặc biệt đến mọi người. Bài báo này nghiên cứu và thực hiện thiết bị làm rau mầm hoàn toàn tự động. Người sử dụng không cần phải thao thác thiết bị trong suốt quá trình phát triển của rau mầm mà vẫn đảm bảo tỉ lệ thành công 100% ra được thành phẩm chất lượng cao. Ngoài ra, thiết bị có thể tối ưu hóa các thông số quan trọng tác động lên quá trình phát triển giá đỗ như độ ẩm, nhiệt độ, không khí, nước. Rau mầm luôn luôn trong tình trạng phát triển tốt nhất, rút ngắn được thời gian ra thành phẩm.

Từ khóa. Rau mầm, thiết bị tự động, ổn định môi trường.

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