Real Time System Used to Improve the Production and Quality of Mushroom

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ABSTRACT

Mushroom is one of agricultural products that are in increasing demand several folds in recent years so, mushroom cultivation represents important income source for farmers and countries. This paper proposed a real time system used to monitor and control environmental parameters for mushroom cultivation. Modern module SH-1000-DTH used as sensing system to measuring environmental parameters (Temperature, Relative Humidity, and CO_2 concentration). Visual basic language was used to design and implement a control program responsible for processing data from sensing system and makes a decision to operate one of the mend environment system devices according to the program stored database. The control program was designed to make the system work either automatically or manually to give the user more flexibility in his work and also designed in away makes dealing with it easy and simple. Results obtained when this system tested show increasing in production about 46% and increasing in product quality when compared with the traditional production without using this system.

Keywords: Cultivation, Environment Parameters, Sensing System, Mend Environment System.

نظام زمن حقيقي يستخدم لتحسين أنتاج وجودة الفطر

الخلاصة

يعتبر الفطر احد المنتجات الزراعية التي تزايد الطلب عليها عدة أضعاف في السنوات الأخيرة لذلك تمثل زراعة الفطر مصدر دخل مهم للمزارعين والبلدان. يقدم هذا البحث نظام زمن حقيقي يستخدم لرصد البارامترات البيئية والسيطرة عليها لأجل زراعة الفطر. الوحدة الحديثة (SH-1000-DTH) تم استخدامها كنظام استشعار لقياس البارامترات البيئية (درجة الحرارة، الرطوبة النسبية، وتركيز غاز ال CO_2). قد تم استخدام لغة الفيجوال بيسك لتصميم وتنفيذ برنامج سيطرة مسؤل عن معالجة البيانات الواردة من نظام الاستشعار واتخاذه قرارا بتشغيل احد اجهزة نظام أجهزة تحسين البيئة وفقا لقاعدة البيانات المخزنة في البرنامج. وقد تم تصميم برنامج التحكم لجعل النظام يعمل إما تلقائيا أو يدويا لإعطاء المستخدم المزيد من المرونة في عمله وأيضا قد

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صمم بطريقة تجعل التعامل معه سهل وبسيط . تظهر النتائج المتحصل عليها عندما تم اختبار هذا النظام زيادة في الإنتاج حوالي 46٪ وكذلك زيادة في جودة المنتج مقارنتا مع الإنتاج بالطريقة التقليدية بدون أستخدام هذا النظام.

INTRODUCTION

Mushrooms can be picked from the wild during the latter wettest part of the rainy season, where they are found growing on deeply decomposing organic matter. However not all mushrooms found growing in the wild are good for human consumption. Some are edible, but other species are poisonous making people sceptical about their consumption [1]. Growing of safe known mushrooms therefore, presents a window of opportunity. Mushroom cultivation is a profitable agri-business and Oyster mushroom (*Pleurotus ostreatus*) is an edible mushroom having an excellent taste and flavor. It belongs to the class Basidiomycetes, subclass Hollobasidiomycetidae, and order Agricales. It grows wild in the forest and is cultivated in the temperate and sub tropical regions of the world [2].

The technology of artificial mushroom cultivation is a recent innovation, which stemmed from the realization that the incorporation of non-conventional crops in existing agricultural systems can help in improving the social as well as the economic status of small farmers [3].

Producing nutritious food is profitable, while using materials that would consider "waste," constitutes a valuable service in the self-sustaining community. To increase the production of Mushrooms, monitoring and control of environmental parameters must be done [4]. Electronic monitoring and control to environment parameters used to enhance desired environment for different stages of mushroom cultivation would help to enhance the quality and productivity of mushroom [5].

MUSHROOM AGRICULTURE

The mushroom is a fungus and quite finicky about its food source. Mushrooms lack the ability to use energy from the sun. They are not green plants because they do not have chlorophyll. Mushrooms extract their carbohydrates and proteins from a rich medium of decaying, organic matter vegetation [6].

In the autumn, wild mushrooms naturally appear only after falling of leaves and senescence of field herbage provides a change in the physical soil environment. Organic material breaks down, changing the microclimate and biological status of the soil surface. These changes contribute to reproductive growth of fungi and must be achieved artificially for mushroom crop production. Mushroom cultivation requires firstly the manufacture of composts and secondly management of growing environments.

Mushroom compost was traditionally based on horse manure and a mix of other ingredients, particularly straw. Early research showed that to eliminate potentially harmful fungi, bacteria and pests material had to be pasteurized [7].

Management of mushroom growth environments done by controlling to the four of environment parameters (EP) (Temperature (T), Relative Humidity (RH), CO_2 concentration, Light Intensity (LI)) that effect mushroom growth.

Mushroom growth cycle is divided into four stages (Spawn Run, Primordia Formation, Fruit body Develop, Cropping Cycle) each type of mushroom has its own value of environment growth parameters for each stage [8].

Five different types of mushroom chosen in this research to work on it and these types is (Golden Oyster, King Oyster, Mushrooms, Phoenix Oyster, and Pink Oyster) these types were choose from thousands of mushroom types because they classified from the most popular used mushroom types in the world so the production of these types has Economic benefits for farmers more than others.

Environment growth parameters for each growth stage of chosen mushroom types are shown in Table (1) [8].

Table (1) Mushroom environment growth parameters [8].

Growth Stage	EP	Mushroom Types				
		Golden Oyster	King Oyster	Mushrooms	Phoenix Oyster	Pink Oyster
Spawn Run	**T °C**	24-29	24	24	24-29	24-30
	RH	90-100%	90-95%	85-95%	90-100	95-100%
	CO_2 (ppm)	5000 - 20,000	5000 - 20,000	5000 - 20,000	>5000	>4000
	LI (lux)	-------	-------	-------	-------	-------
	Duration (day)	10-14	12-16	12-21	8-14	7-10
Primordia Formation	**T °C**	21-32	10-15	10-15.6	13-24	18-25
	RH	98-100%	95-100%	95-100%	95-100%	95-100%
	CO_2 (ppm)	<1000	500-1000	<1000	400-800	500-1000
	LI (lux)	500-1000	500-1000	1000-1500	900-1500	750-1500
	Duration (day)	3-5	4-5	3-5	3-5	2-4
Fruit body Develop	**T °C**	21-29	15-21	10-21	18-27	20-30
	RH	80 -90%	85-90%	85-90%	85-95%	85- 90%
	CO_2 (ppm)	<1000	<2000	<1000	400-800	500-1500
	LI (lux)	500-1000	500-1000	1000-1500	900-1500	750-1500
	Duration (day)	3-5	4-8	4-7	3-5	3-5
Cropping Cycle	**T °C**	22-28	17-22	14-20	18-27	
	RH	80 -90%	85-90%	75-80%	85-95%	85_90%
	CO_2 (ppm)	<1000	<2000	<1000	< 700	500-900
	LI (lux)	500-1000	500-1000	1000-1500	800-1300	750-1500
	Duration (day)	10-14	2 crop 14 day apart	3 crop 9 day apart	3 crop 7 day apart	2 crop 10 day apart

PROPOSED SYSTEM DESIGN

The purpose of proposed system is to monitor the environment parameters that affect mushroom growth in cultivation house then control over these parameters to become identical to the standard values shown in Table (1) to obtain abundant in production and high quality in the product.

As shown in Figure (1) one could see that this system consists of (Sensing System, Interfacing Board, Control System, and Mend Environment System) these work simultaneously to achieve the purpose of this system.

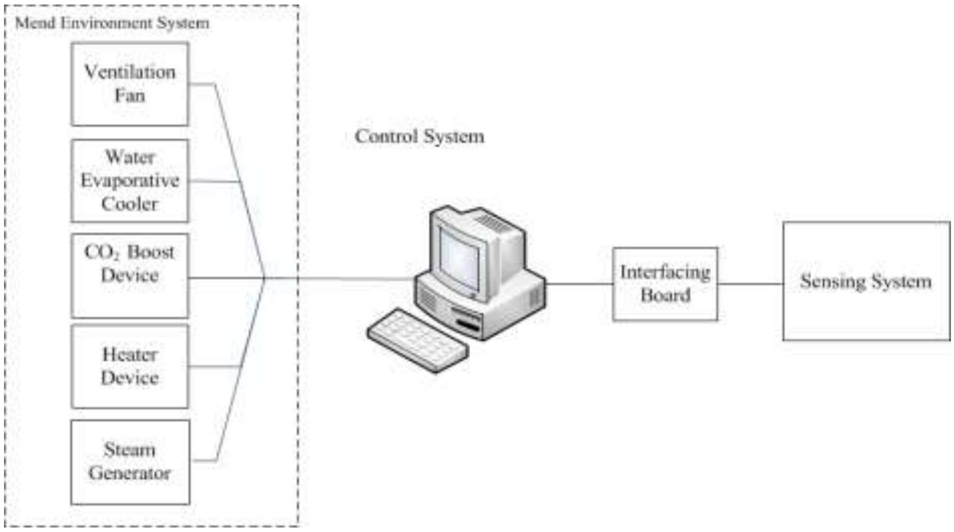

Figure (1) Proposed system diagram.

SENSING SYSTEM

The proposed system part which is responsible for measuring the environment parameters (Temperature, Relative Humidity, and CO2 concentration) is the sensing system. Sensor module SH-1000-DTH shown, in Figure (2), used in this work as sensing system to measure (Temperature, Relative Humidity, and CO_2 concentration) values where this module uses (NDIR) Dual Sensor Non Dispersive Infrared technology to measuring CO_2 concentration value.

NDIR is a new method utilizes the fact that each gas material has its particular absorption spectrum to infrared light for getting concentration of particular ingredient where an infrared light intensity emitted in specific wavelength through a volume containing gas molecule decreased according to the gas concentration. Sensor determines the ratio between the emitted and detected light intensity which is a measure for the gas concentration. To measure the concentration of CO_2 gas in dual sensor module the gap between standard 3.91µm wavelength that unaffected by other gas and 4.2 µm wavelength that affected by CO_2 gas used as shown in Figure (3). For the selected mushrooms types in this proposed system the fourth parameter that effect mushroom growth (light Intensity) could be fixed on (1000 lux).

Figure (2) SH-1000-DTH NDIR dual sensor module.

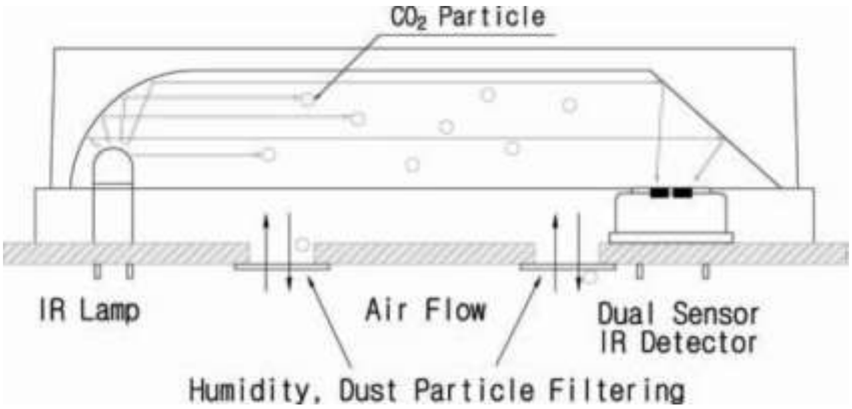

Figure (3) NDIR dual sensor CO_2 sensing method.

INTERFACING BOARD

The output of the sensing system is a digital UART signal so that the interfacing board shown in Figure (4) allows sensing system to communicate with computer system using a standard serial cable a COM port. In order for the computer system and sensing system to successfully communicate some logic level shifting and translation is necessary. The UART to RS232 Converter takes care of this required logic level shifting and translation via an on board ILX232D chip. The UART to RS232 Converter includes On board DB9 female connector for direct connect to a serial port.

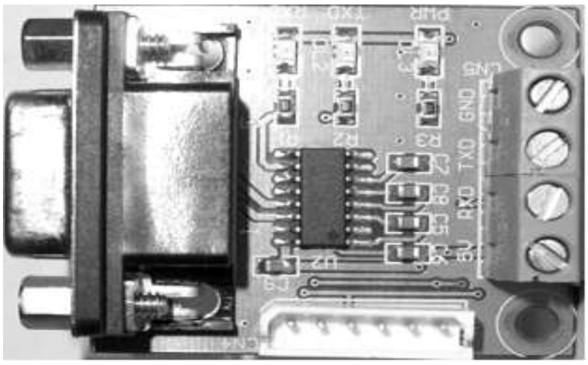

Figure (4) Interfacing board.

CONTROL SYSTEM

Computer system was used in the proposed system to control the work of environment mend devices according to the measured value of (Temperature, Relative Humidity, and CO_2 concentration) in cultivation house by a control program. Microsoft Visual basic 2010 selected in this work to build the control program because it is one of the powerful and efficiently software language used to access the ports and as the world turn to graphic user interface (GUI), visual basic is one of the languages that changes to accommodate the shift. Visual Basic is designed to allow the program run under the windows without the complexity generally associated with windows programming [9].

Control program responsible for reading data from sensing system through RS232 port then analyzing these data according to Table (1) values that fed to the program as a database then makes a decision to operate one of the Mend Environment System device as illustrated in Figure (5).

Environment parameters (Temperature, Relative Humidity, and CO_2 concentration) checked every 15 min and the program continues working for 40 days where this duration represents the time needed to growth mushrooms until it reaches cropping stage. This duration represented in program flow chart by the number 3840 this number is the result of checking every 15min for 24 hours in 40 days i.e. ((1hour/ 15min)*24*40).

MEND ENVIRONMENT SYSTEM

This sub system responsible for changing values of environmental parameters to match database values, where a signal from control system specify which device should be worked according to the environment situation.

Five devices, in this work, were used to mend environment parameters the first device used is ventilation fan which is responsible for ventilate cultivation house to reduce CO_2 concentration in it and reduce temperature degree a somewhat. This device is a fan used to pull air from the cultivation house. It works according to trigger signal from the controlling system.

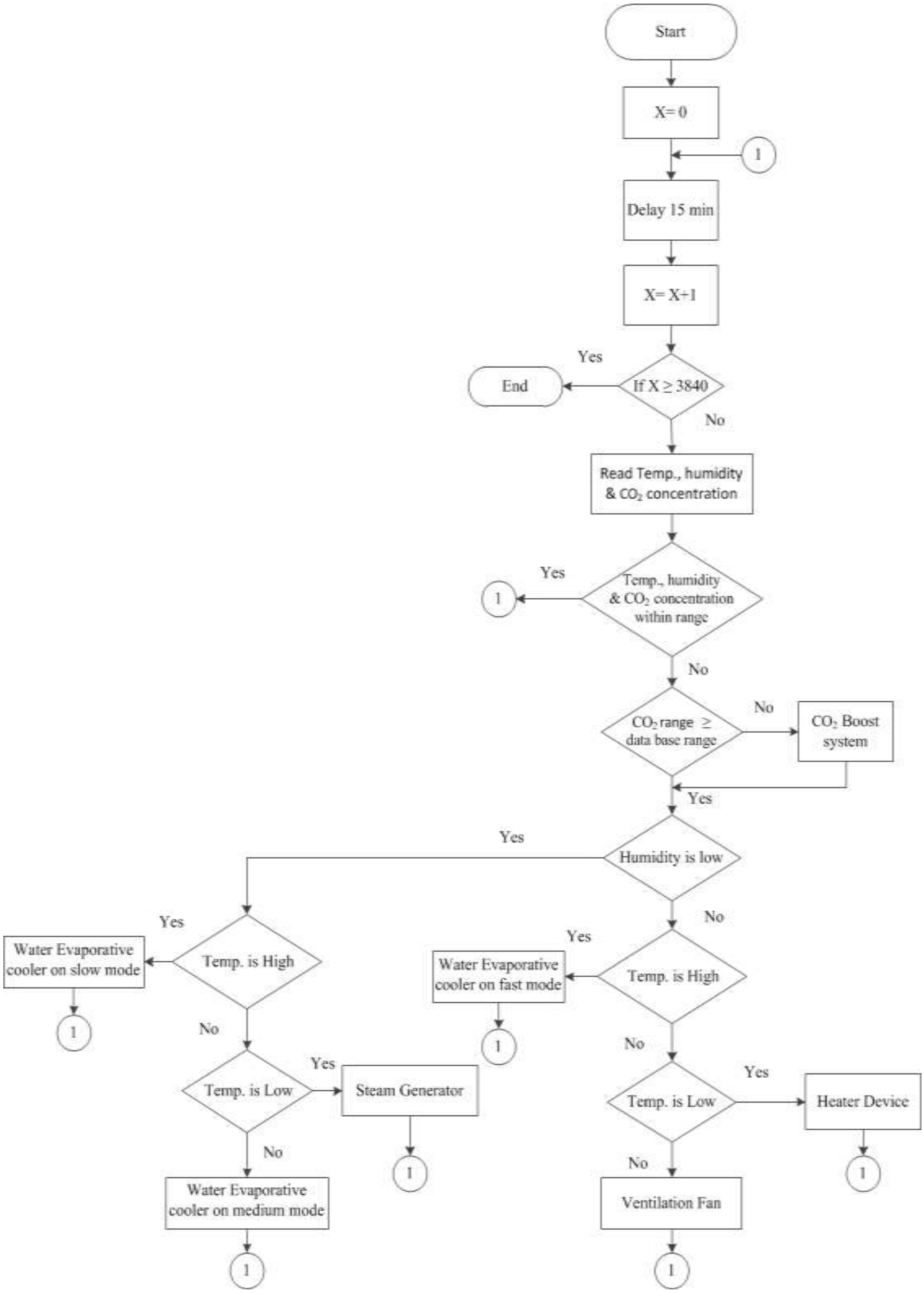

Figure (5) Control program flow chart.

Water evaporative cooler is the second used device that is responsible for decreasing temperature degree in cultivation house and increasing relative humidity or maintains their values.

An evaporative cooler, also known as wet air cooler, is a device that cools air through the evaporation of water. Evaporative cooling works through a use of interoperability thermal evaporation of water, where dry air temperature can be significantly reduced through the transition from liquid water to water vapor. In addition to air cooling process an increase of humidity in the surrounding happening. An evaporative cooler is a Box of metal or plastic three of its aspects been made to be a frame that contains felts often made of sawdust which been drenched always by water pump. Evaporative cooler box also contains inside it a big fan be a responsible on pushing air from the fourth side into area which need to be cooled, where the hot air will pass through the wet felts leading to cooled by vaporized water molecules.

The third device used in the mend environment system is the CO_2 boost device which is responsible for increasing CO_2 concentration in cultivation house by adding pure CO_2 to the environment. CO2 boost works from a combination of natural compost ingredients where those ingredients are mixed and placed in a bucket. The CO2 is then naturally created, a pump is inserted into the bucket and CO2 is released into cultivation house [10].

Heater device is the fourth used in the mend environment system that is responsible for increasing temperature degree in cultivation house. A 1000W electrical fan heater used in this work to raise temperature degree, the used fan heater can spin 60 degree to spread all around heat in the room.

The last device used in the mend environment system is the Steam generator device which is responsible for increasing temperature degree and relative humidity in cultivation house. This device is a sealed bucket have a one small outlet with a valve opens when water vapor pressure arrive to a certain value and contains inside it a 2000 Watt electric heater for rapidly boiling water and pumped vapor through the outlet to cultivation house.

SYSTEM HARDWARE IMPLEMENTATION

Hardware devices of each one of the main sub system was connected and prepared to run synchronously with the control program. The pins (TX, RX, RT, VCC, and GND) of the Sensing system were connected with interfacing board by pin connector. The interfacing board connected with computer system by RS232 cable. Both the sensing system and the interfacing board placed in a plastic cover to protect it and making its installation easier as shown in Figure (6).

Transfer the activation signal from computer system to the mend environment system devices done by using parallel port cable, where each device will be connected with one of the pins from pin no. 2 to pin no. 6 as shown in Table (2).

Table (2) Parallel port pins configuration.

Pin 2	Pin 3	Pin 4	Pin 5	Pin 6
Ventilation Fan	Water Evaporative Cooler	CO_2 Boost Device	Heater Device	Steam Generator

Figure (6) Sensing system and interfacing board placed in plastic cover.

Mend environment system devices worked on 220 V AC signal and the activation signal from PC is 5 V DC so a driver circuit needed to be connected to each pin from pin no. 2 to pin no. 6 to operate Mend environment system devices according to activation signal as shown in Figure (7).

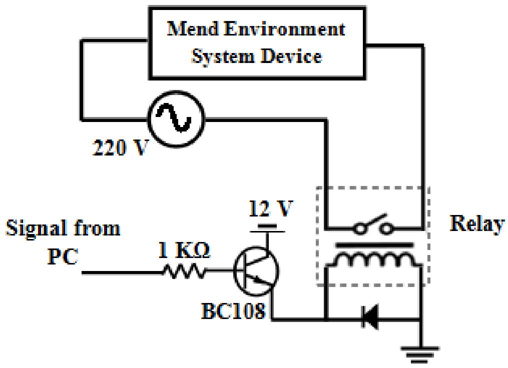

Figure (7) Driver circuit of the mend environment System devices.

SYSTEM SOFTWARE IMPLEMENTATION

Microsoft Visual basic 2010 selected in this work to build an executable program that running simultaneously to control the ignition of mend environment system devices that worked according to the processed data that read by the sensing system.

Control program consists of 41 form classified to 6 main groups (Starting form, Golden Oyster mushroom form, King Oyster mushroom form, Mushrooms mushroom form, Phoenix Oyster mushroom forms, and Pink Oyster mushroom form).

Starting form is the first form appears when the program running. In this form the user can select the type of mushroom which he want to grow and the way who want to use for controlling mend environment system devices work either automatically or manually as shown in Figure (8).

Structure of the next five forms is the same but different in the database values of the environment growing parameters so Golden Oyster mushroom forms will described as an example for the other forms.

Golden Oyster mushroom form for automatic control method is shown in Figure (9) where the data read from sensing system displayed simultaneously on this form and the mend environment device operated at that time highlighted. Time elapsed from the beginning of mushroom growth will be display in time box. There is a certain form for each growing stage where these forms start running according to the elapsed time from the beginning of mushroom growth. As shown in Table (1), first stage form must be running is Spawn Run form then for Golden Oyster mushroom Primordia Formation form running after 14 days while Fruit body Develop form running after 5 days and Cropping Cycle form running after 5 days.

Each one of the stage form containing its own database information according to Table (1). The form of each stage could be seen in results article. Golden Oyster mushroom form for manual control method deferent from the automatic form in the mend environment device where in manual form the user choose the device he want to operate from the form manually by selecting the device to operate or deselecting it to stop operating as shown in Figure (10).

Figure (8) Starting form.

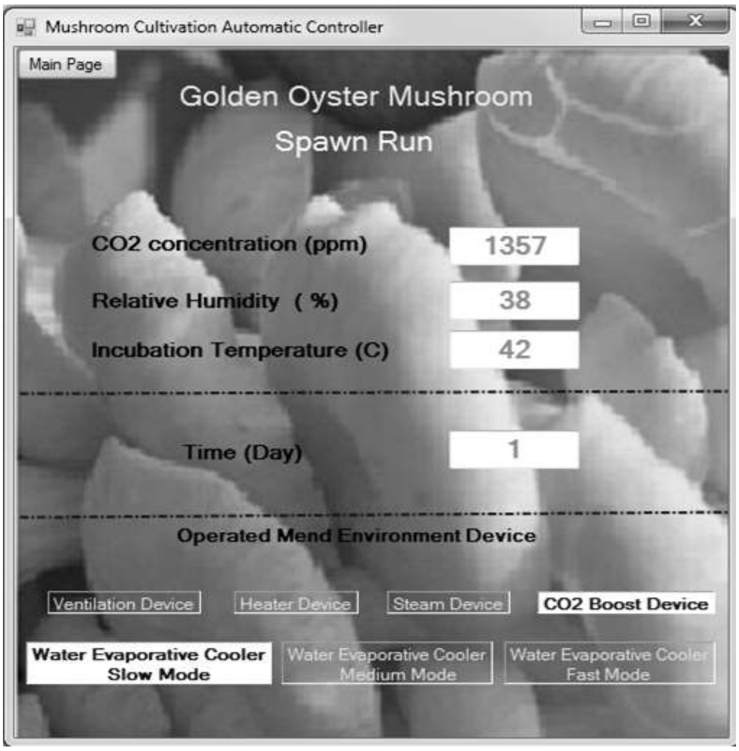

Figure (9) Golden oyster mushroom automatic form.

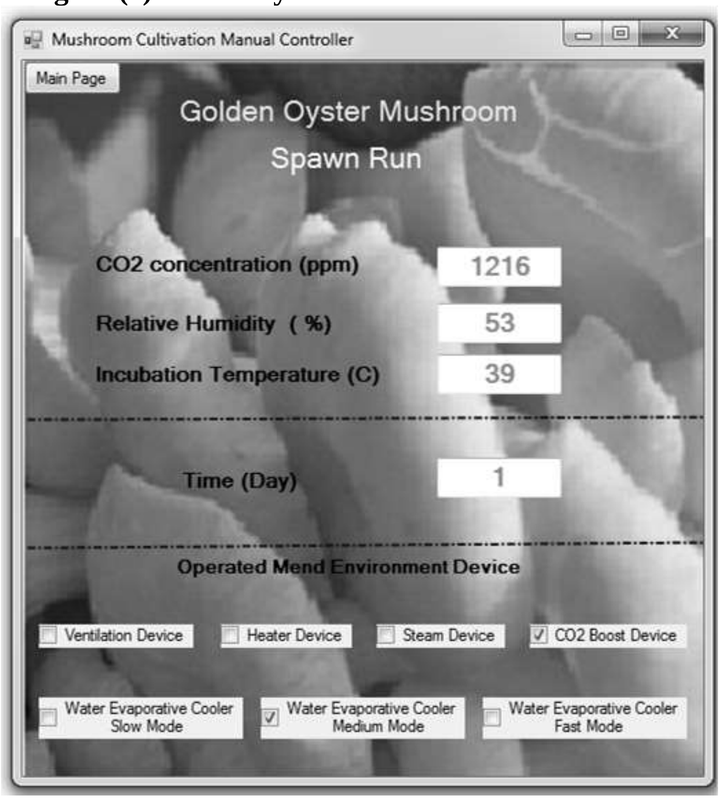

Figure (10) Golden oyster mushroom manual form.

RESULTS

Two cultivation rooms has been implemented to cultivate mushrooms, the first cultivation room used the proposed system shown in Figure (11) to improve mushrooms production and quality, in the second cultivation room the traditional way in cultivation was adopted to cultivate mushrooms.

In first cultivation room the proposed system used to monitor the environment parameters by sensing system and controlling it using control program which operated in automatic mode for mushroom type.

The first stage of mushroom growth spawn run for the fourth cultivation day shown in Figure (12) where the CO_2 boost device and water evaporative cooler on medium mode worked to increase CO_2 concentration and relative humidity. The second stage of mushroom growth primordia formation for the sixteenth cultivation day shown in Figure (13) where the water evaporative cooler on slow mode worked to increase relative humidity and reduce temperature degree. The third stage of mushroom growth cropping cycle for the Twenty-Third cultivation day shown in Figure(14) where the ventilation device used to reduce CO_2 concentration. The final stage of mushroom growth fruit body develop for the Thirty cultivation day shown in Figure (15) where the water evaporative cooler on fast mode worked to reduce CO_2 concentration and temperature degree

The result of production for the first and second cultivation rooms when 0.5 Kg of mushrooms seeds in 0.5 square meter of dried Barley straw substrate used for each cultivation room shown in Table (3).

Table (3) Production results for the first and second cultivation rooms.

Obtained Result	First cultivation room	Second cultivation room
Weight of mushrooms fruit	Between 38-61 gram	Between 16- 40 gram
Mushrooms fruit diameter	Between 3-5 cm	Between 1-2.5 cm
Total weight of mushrooms	4630 gram	3170 gram

As shown in Table (3) in first cultivation room when the proposed system used the productivity increased 46% more than the productivity when the traditional way in cultivation was adopted. Size and weight of the mushrooms fruit in the first cultivation room proving that the quality of mushrooms fruit when the proposed system used has improved. Mushrooms crop for the first and the second cultivation room shown in Figure (16).

Figure (11) the proposed system implementation.

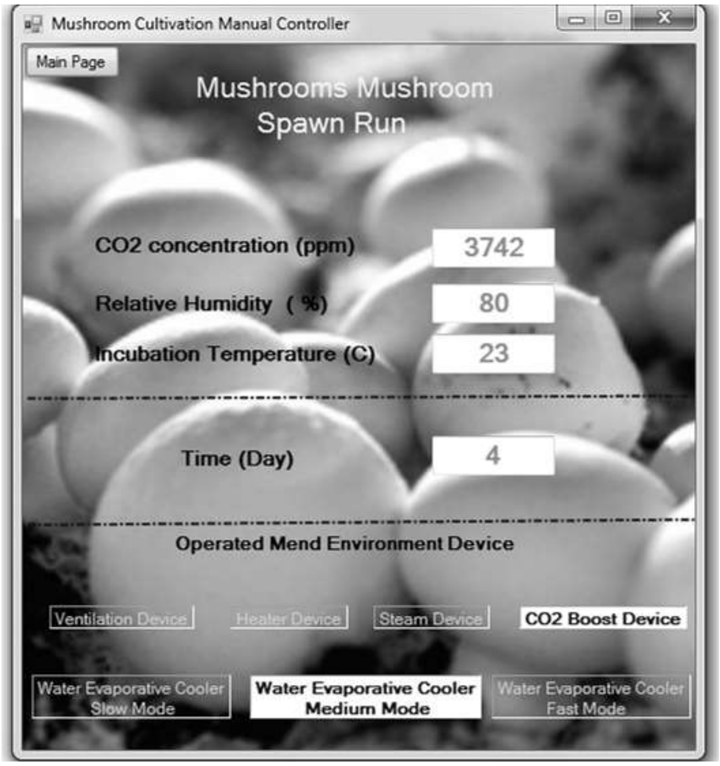

Figure (12) Spawn run cultivation stage.

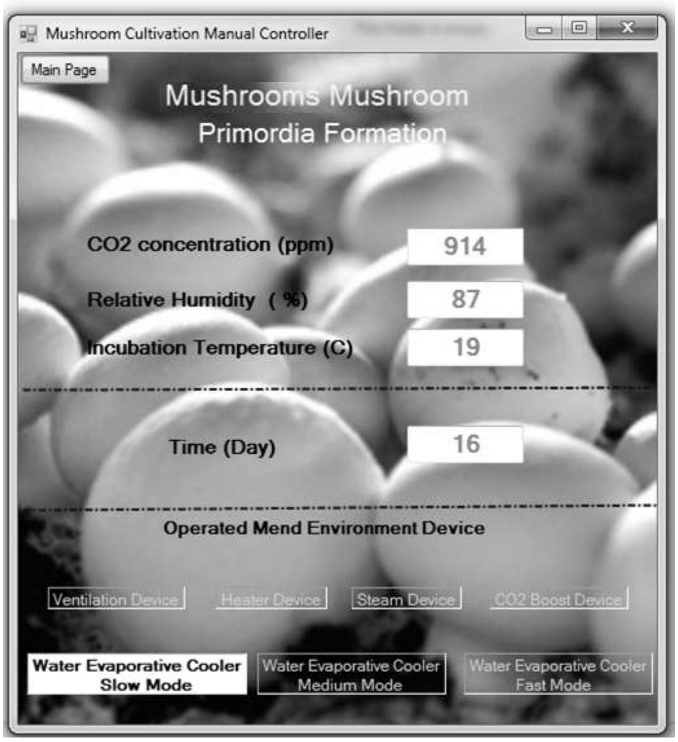

Figure (13) Primordial formation cultivation stage.

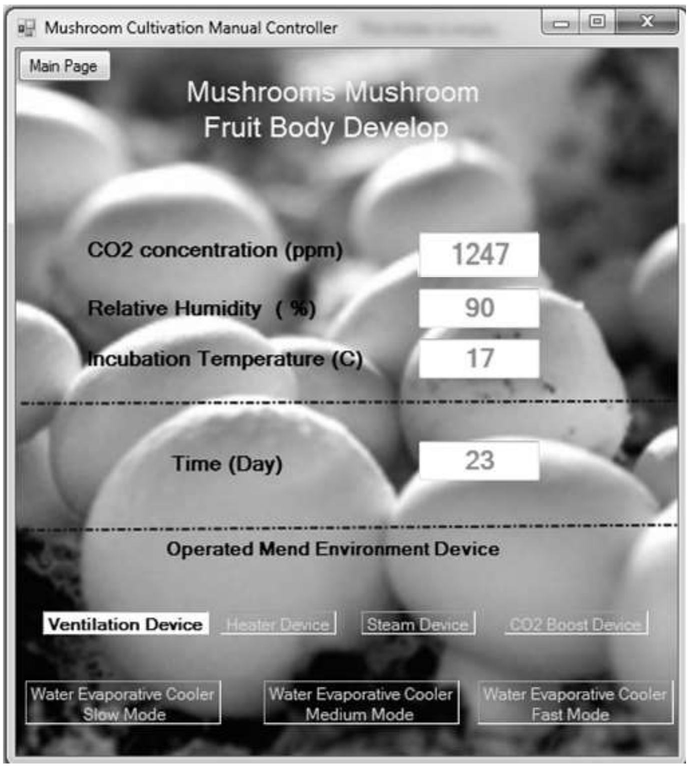

Figure (14) Fruit body develop cultivation stage.

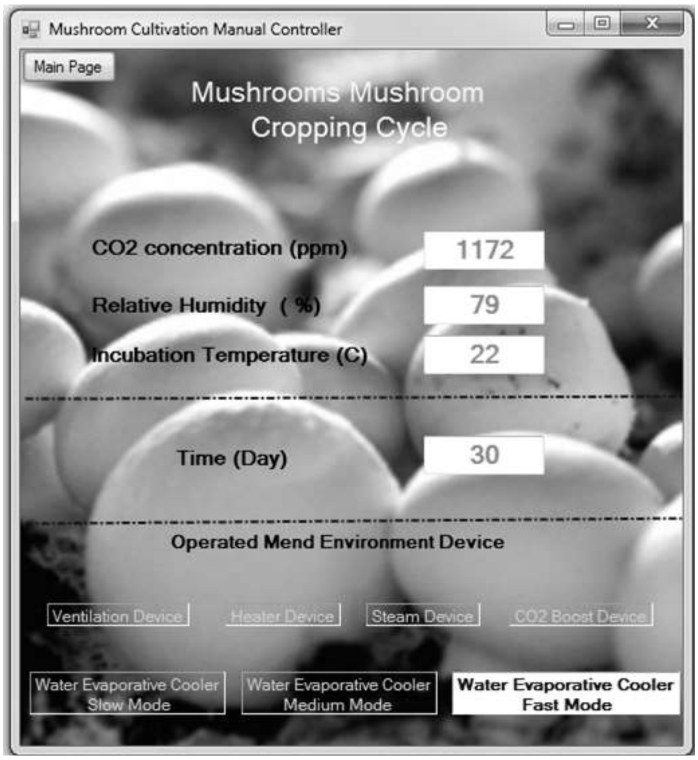

Figure (15) Cropping cycle cultivation stage.

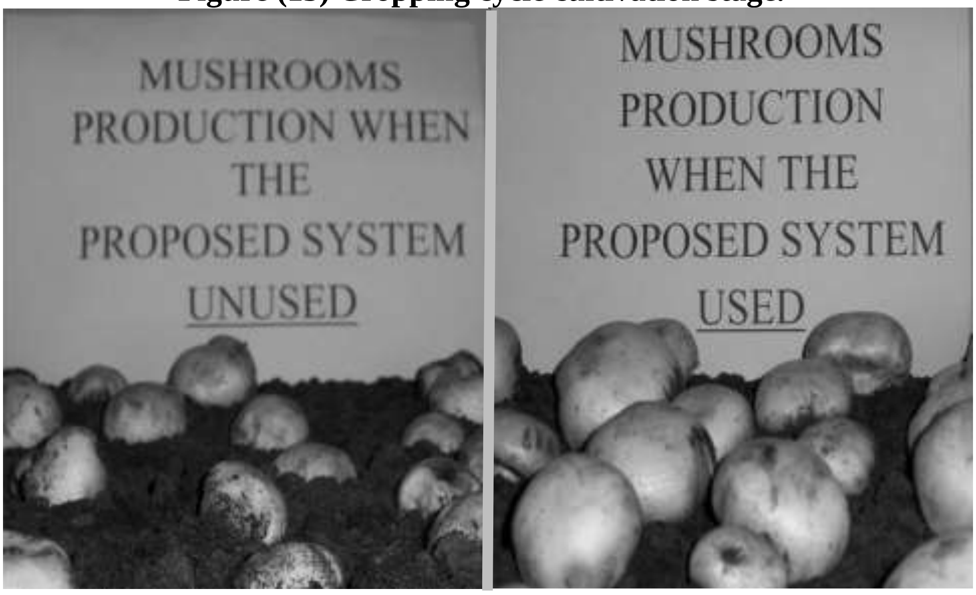

Figure (16) Mushrooms production when proposed System used & unused.

CONCLUSIONS

1- System that has been built in this paper is not the only one of its kind, but it is unique and different from other existing systems that deals with plant cultivation in it provides ongoing monitoring and provides rapid solutions for each environment parameter may affect the growth of mushroom.
2- From the result obtained can be seen that the used system has proven its effectiveness where the quantity and quality of production has increased with respect to the traditional production without system.
3- Reasonable cost of this system (approximately 1000 $) and the good increase achieved in production make this system useful and acceptable for farmers.
4- Control program was designed in a way that makes its dealing easy and simple for anyone who has a basic knowledge in computer programs.
5- This system does not represent a magic solution which can be used to increase the quality and production of mushrooms. Where the production and quality of mushroom mainly depends on the material in the compost substrate in addition to the environment parameters.

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