Integrated Sensors for Smart Oil Palm Bio-Laboratory

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***Abstract*—The tissue culture laboratory provides the oil palm industry with innovations for the production of improved planting materials and information on the molecular biology of tissue culture processes. Research has shown that factors such as temperature, humidity, liquid, phase and gas compositions, are critical in producing quality clonal materials using tissue culture process. Therefore, it is necessary to provide good physical and chemical conditions for production of quality products. Consequently, sensors are required to monitor and record the data in growth room. All sensors will monitor critical parameters that focus on temperature, humidity, oxygen, carbon dioxide, ethylene and also an optical sensor for liquid phase and composition that will be linked to the database and analysis software for storing and analyzing the monitored data. The integrated sensors are low cost because it used local products and low power consumption and fabricated to suit the biological laboratory environment. The purpose of these integrated biotechnology sensors system is to serve as an interface among user, as the disturbance analysis program and an expert system in identifying the disturbance. The system would monitor via a smart RFID telemetry system and provide automatically email or short message (SMS) notifications upon identification of a disturbance module. Radio-frequency identification (RFID) is an automatic wireless identification method using radio waves, relying on storing and remotely retrieving data from integrated sensors using devices called RFID tags or transponders. Some tags can be read from several meters away and beyond the line of sight of the reader which make easier for data transportation. For the best communication path, active RFID tags will be equipped with autonomous networking; which greatly improves the utility of the device. Eventually, this smart RFID technology system could improve the efficiency of inventory tracking and management for oil palm tissue culture growth.**

***Index Terms*—Gaseous, humidity, RFID telemetry system, temperature.**

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I. Introduction

Malaysian Palm Oil Board is producing clonal planting materials by using tissue culture system. The tissue culture laboratory provides the oil palm industry with innovations for the production of improved planting materials and information on the molecular biology of tissue culture processes. Generation of knowledge through basic research, application of molecular biology tools for product development and problem-solving, as well as development of efficient in-vitro protocols for clonal propagation are some of the activities undertaken in the tissue culture laboratory.

Research has shown that factors such as temperature, humidity, liquid, phase and gas compositions are critical in producing quality clonal materials using tissue culture process. Therefore, it is necessary to provide good physical and chemical conditions for production of quality products. Under physical condition, factors such as temperature, humidity and gases should be set at certain standard for development of good cultures [1]. However the monitoring system to detect changes of temperature and humidity is not too efficient. Normally, the recording is done manually and this reduces the efficiency and reliability of the process [2]. There is also lack of gas sensor in the tissue culture laboratory to monitor and record the gas composition in growth room and specifically in the tissue culture vessels.

The advantage of monitoring system on tissue culture laboratory is to obtain and analyze the data on factors that affect the growth of cultures. If any of the factors is out of range, the data will activate the telemetry system and send signal to the authorized person. This system refers to the combination between telemetry using the smart RFID technology system and data acquisition where all the information will be sent back to the center [3]. Subsequently, the data will be analyzed and controlled where the data result will appear on the computer screen.

This system commonly has been practiced on monitoring and controlling conditions such as room temperature, humidity of lab, lamp brightness, damp water level, electrical power distribution and so forth. The command will be given by the center to the controllers that fix the situation to the recommendation level and the environmental control parameters could be made with database control and comprehensive data logging features.

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II. Materials and Methodology

Data recording on temperature, humidity, liquid, phase and gas compositions in the tissue culture laboratory is necessary for quality control and monitoring purposes. The system requires for a design and fabrication of a sensor circuit that will be attached to the central system. The design and construction of clusters and broad system of the circuit will be connected to the external system (internet), which allows the control system to send signals to the authorized person if any factors are out of range. The software for the monitoring system will be programmed, in such a way that the sensor will send data to the central system (computer) to process and analyze it. Subsequently, smart RFID system will be activated by sending signal through external system (see Fig. 1 below).

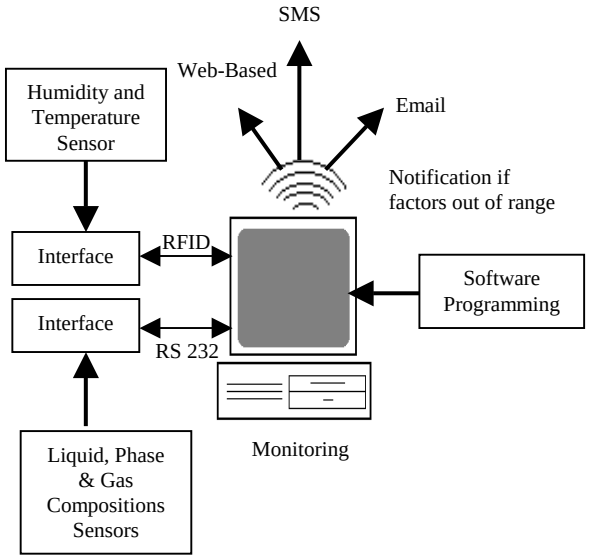

Fig. 1: Flow chart smart RFID system

RFID systems operate on several principles, including inductive coupling, radio frequency, microwaves, electromagnetic backscatter, and close coupling [4]. A Smart RFID system consists of RFID tags, antenna, interrogators, computers and the appropriate software to transform the raw data into actionable information as shown in Fig. 2. The reader initiates tag collection and sends messages to all tags followed by all the tags in a reader's field respond by transmitting their tag ID to the reader. Then the reader forward all collected data Tag IDs to the main system through a middleware platform that filters and aggregates data before passing it on to the other system.

Middleware acquires raw tag reads and helps makes sense of RFID tag data. It applies filtering, formatting or logic to tag data captured by a reader so that the data can be processed by a software application. Other managements such as filtering and translation, data aggregation, transaction generation are also being able to process.

Smart RFID system used high frequency 13.56MHz where medium data rate and read ranges up to about 1.5 meters are acceptable. This frequency also has the advantage of not being susceptible to interference from the presence of water or metals. This independent wireless sensing nodes capable of high data rate communications with multiple sensing nodes in real-time.

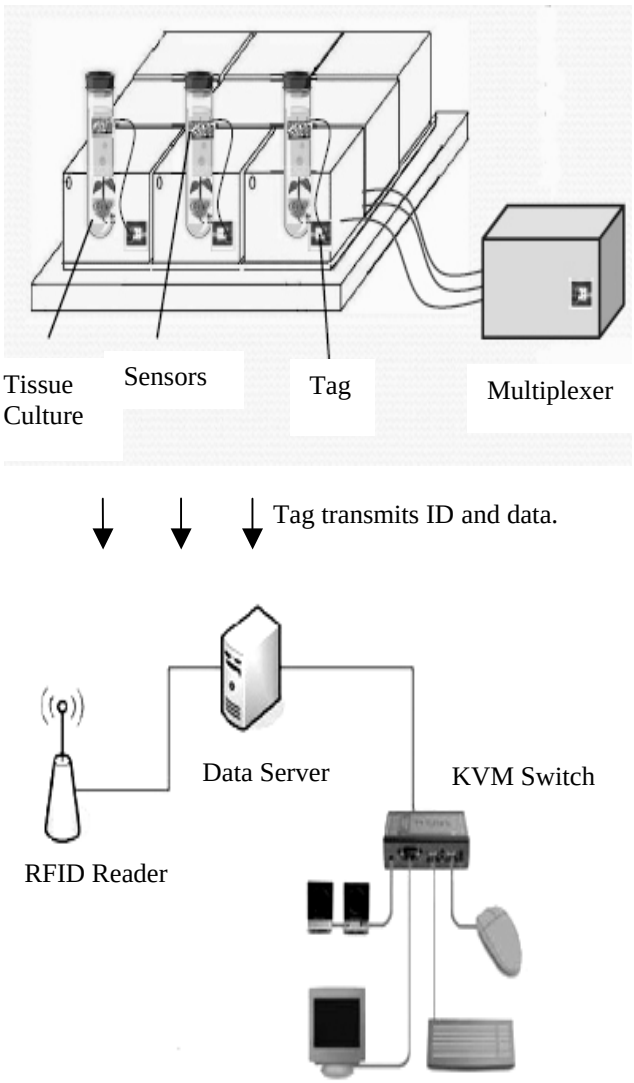

Fig. 2: Smart RFID system architecture

Fig. 3 is an electrical block diagram of the smart RFID system. The system comprises 4 main components which are passively-powered wireless sensor nodes which acquire and send strain, voltage, temperature, pressure, load or other sensor data, an interrogation antenna which powers the nodes as well as receives the sensor data, a reader assembly which powers the interrogation antenna, digitizes the sensor data, and interfaces the host computer, and the last component is a software which operates the system.

The node employs a 16 bit A/D converter to digitize the voltage on the differential input and temperature channels. The digital data is passed to the on-board microprocessor, processed with the embedded algorithm, and in turn passed to the coil antenna for recovery by the interrogation antenna. Host computer software displays the data, records the data to file, scales the data into engineering units, and allows the user to configure and actuate the system [5].

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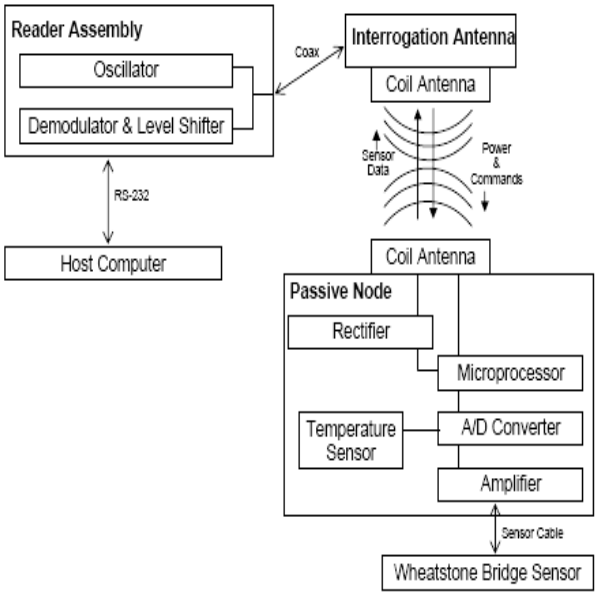

Fig. 3: Electrical block diagram of smart RFID system

Wireless communication is a new era of communication, which has a rapid development. Via this wireless communication, the information can be conveyed accurately and effectively. The existence of wireless application protocol (WAP) has generated a communication expansion by attained the information without considering the time and location factor [6]. The information system also will integrate several techniques and the latest software like Macromedia Dreamweaver, PHP (PHP Hypertext Processor), MySQL and Microsoft Visual Basic 6.0 [7]. PHP (PHP Hypertext Preprocessor) is a widely used general-purpose scripting language that is especially suited for Web development and can be embedded into HTML [8]. MySQL database is same as SQL in a computer language but MySQL database could be connected to PHP because PHP have an API (Application Programming Interface). Fig. 4 and Fig. 5 showed the flow of software development.

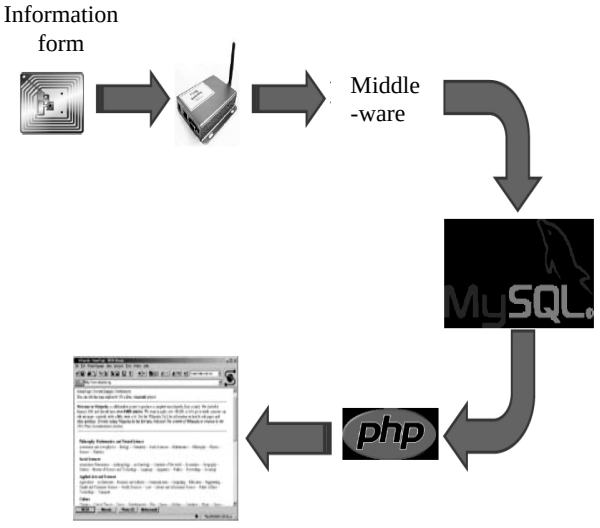

Fig. 4: Data flow of smart RFID system from tag to middleware and MySQL database

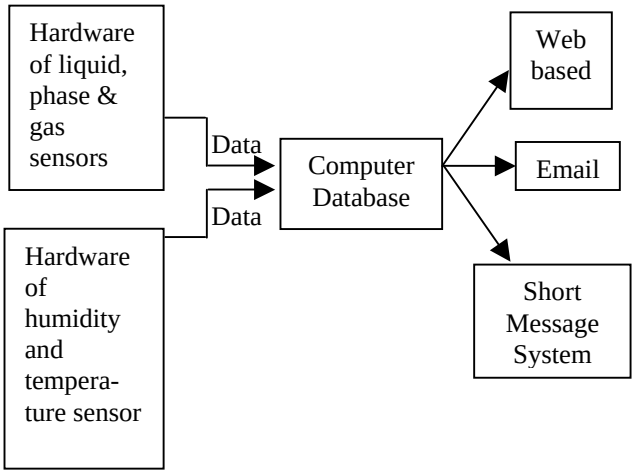

Fig. 5: Flow chart of software development

III. Results and Discussions

In their natural environment, plants usually experience temperatures which fluctuate widely, especially between day and night. The growth of many plant cultures is improved by these conditions and where growth rooms have to be heated, there is a saving in fuel costs by reducing the night temperature. However, such variation is not essential and in many laboratories, tissue cultures are maintained in growth rooms at the same temperature by night and day [9].

Relative humidity is the ratio of the actual amount of moisture in the atmosphere to the amount of moisture the atmosphere can hold. Therefore, a relative humidity of 100% means the air can hold no more water (rain or dew is likely), and a relative humidity of 0% indicates there is no moisture in the atmosphere**.** In this study, temperature and relative humidity concentration in the tissue culture laboratory was monitored and indicated in Fig. 6 and Table I.

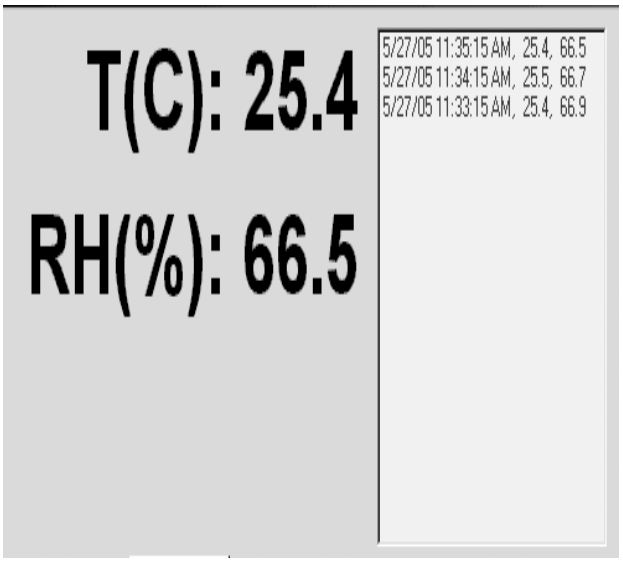

Fig. 6: Display of humidity and temperature data within 1 minute

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TABLE I
DATA OF TEMPERATURE AND HUMIDITY IN GROWTH ROOM

DATE	TIME	TEMPE-RATURE (°C)	RELATIVE HUMIDITY (%)
1/2/05	11:25:43 AM	27.7	50.6
1/2/05	11:25:44 AM	27.8	50.4
1/2/05	11:25:45 AM	27.8	50.3
1/2/05	11:25:46 AM	27.7	50.1
1/2/05	11:25:47 AM	27.7	50.1
1/2/05	11:25:48 AM	27.7	50.0
1/2/05	11:25:49 AM	27.5	49.8
1/2/05	11:25:50 AM	27.8	50.0
1/2/05	11:25:51 AM	27.8	49.8
1/2/05	11:25:52 AM	27.8	49.7

It is well known that gaseous composition inside the tissue culture laboratory changes over time, generally showing a progressive increase in carbon dioxide level, a decrease in oxygen concentration, and an accumulation of ethylene. Fig. 7 and Fig. 8 indicated the level of oxygen, carbon dioxide and ethylene concentrations in the laboratory. These data had been taken 120 samples per minute (see Table II).

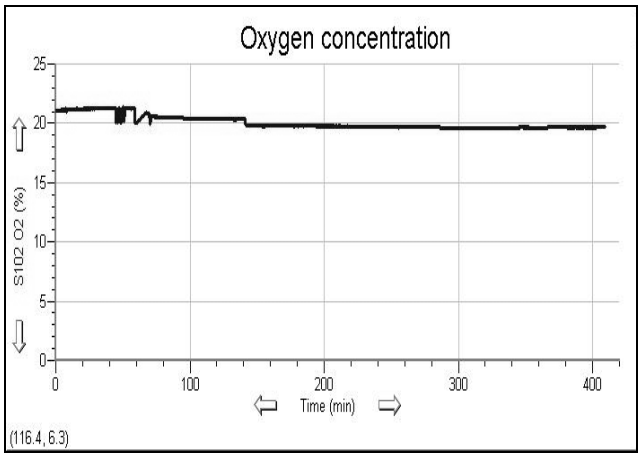

Fig. 7: The level of oxygen concentration in growth room.

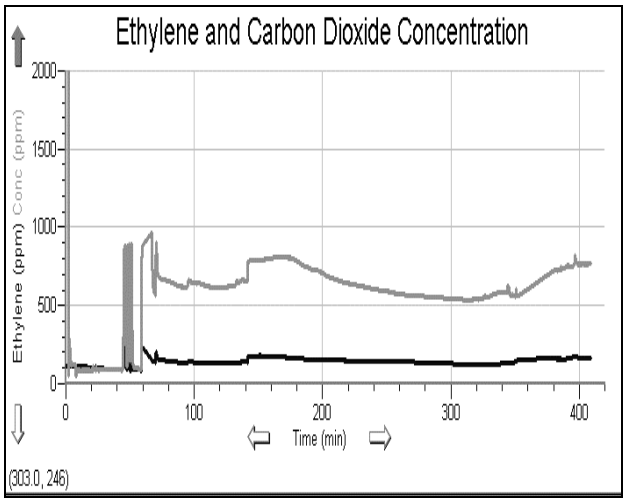

Fig. 8: The level of ethylene and carbon dioxide concentrations in growth room.

TABLE II
THE LEVEL OF OXYGEN, CARBON DIOXIDE AND ETHYLENE IN GROWTH ROOM.

TIME (t) (Min)	POTEN-TIAL (V) (V)	OXYGEN (Conc) (%)	CARBON DIOXIDE (Conc) (ppm)	ETHYLENE (ppm)
0.000	2.857	21.066	395.490	114.378
0.008	2.857	21.066	387.238	114.378
0.016	2.857	21.066	378.397	114.378
0.025	2.857	21.066	370.735	114.378
0.033	2.855	21.066	361.894	114.241
0.041	2.855	21.073	354.231	114.241
0.050	2.853	21.066	345.980	113.968
0.058	2.854	21.066	338.907	114.104
0.066	2.852	21.066	330.655	113.831
0.075	2.853	21.066	323.582	113.968

The real time remote monitoring of a smart RFID system were connected to a central host system which could be a large database (MySQL) storing informations of a commodity, having tags with sensors could enable real-time monitoring of temperature, humidity, liquid, phase and gas compositions. Fig. 9 monitored the real time data of temperature and humidity in the oil palm tissue culture growth laboratory. PHP command will construct all the data to appear at the website of Malaysian Palm Oil Board (MPOB) for user monitoring as shown in Fig. 10 and Fig. 11.

Fig. 10 showed data of temperature at the environment of tissue culture laboratory within 27.0°C until 30.0°C whereas inside the vessel of tissue culture within 26.0°C until 27.0°C. Fig. 11 showed data of humidity at the environment of tissue culture laboratory within 60%RH until 70%RH whereas inside the vessel of tissue culture within 80%RH until 97%RH.

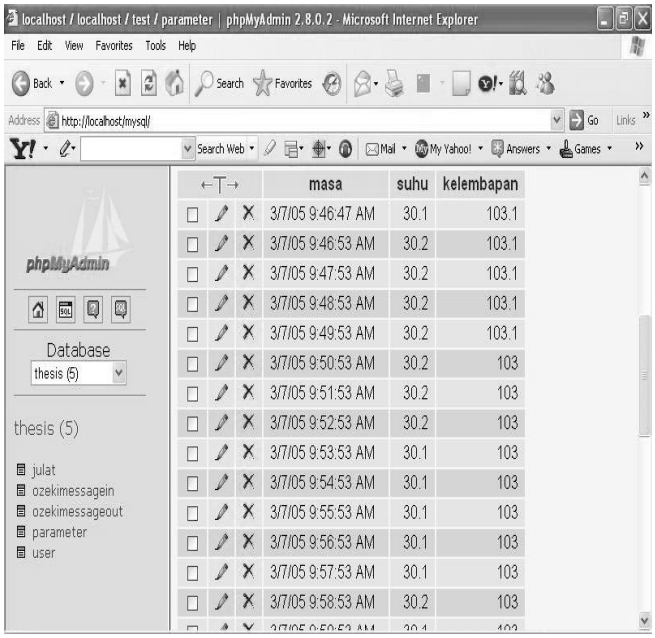

Fig. 9: Real time data of temperature and humidity in MySQL database.

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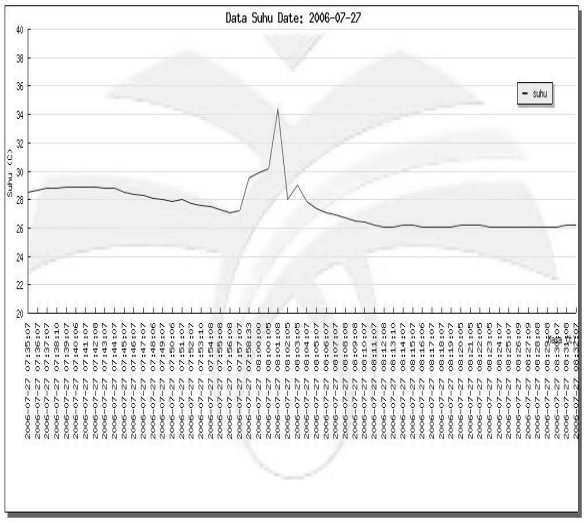

Figure 10: Display interface of real time temperature graph in the MPOB website.

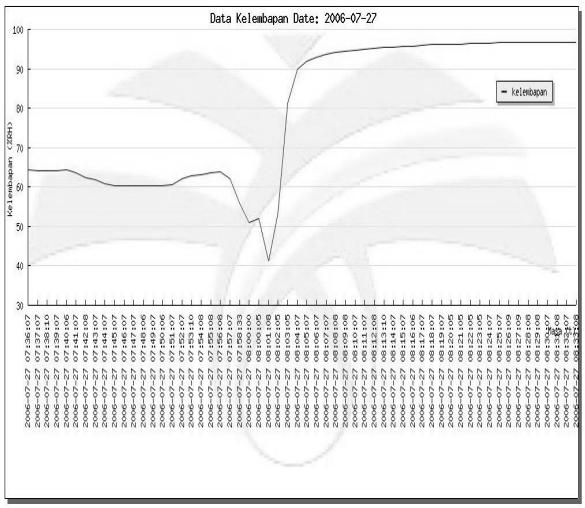

Fig. 11: Display interface of real time humidity graph in the MPOB website.

IV. Conclusion

Radio frequency identification (RFID) is an automatic technology that employs wireless communications. Smart RFID system development with integrated sensors for bio-laboratory focuses on critical parameters such as temperature, humidity, liquid, phase and gas compositions where it will be monitored in oil palm tissue culture growth room. The sensors data are linked to database and analysis software via RFID system that will be designed to store and analyze monitored data. The purpose of these smart RFID and integrated sensors for bio-laboratory system is to serve as an interface among user, the disturbance analysis program and an expert system to identify the disturbance. This innovative smart RFID technology system could improve the efficiency of inventory tracking and management for oil palm tissue culture growth and upcoming research.

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