WSN Prototype for African Oil Palm Bud Rot Monitoring

Miguel Piamonte[1], Monica Huerta[2], Roger Clotet[3], John Padilla[4], and Tito Vargas[1]

[1] Universidad Santo Tomas, Bucaramanga - Colombia
[2] Universidad Politecnica Salesiana, Cuenca - Ecuador
[3] Universidad Simon Bolivar, Caracas - Venezuela
[4] Universidad Pontifia Bolivariana, Bucaramanga - Colombia

Abstract. The oil palm (Elaeis guineensis) is the most productive oleaginous on the planet. The world's largest producers of oil palm are located in Asia, Colombia is the fourth largest producer in the world and the first in America. In recent years the sowing of oil palm has taken a great importance in food industry and in biofuel production. Bud rot is among the factors that are most affecting this type of crop, generating to palm farmers large economic losses and the country's social problems due to unemployment. Early detection of abiotic factors that may trigger bud rot is one of the strategies that would allow palm farmers to minimize the impact on the crops. In this research, a WSN was developed to acquire, process and transmit in real time to a server acquired data as: pH, humidity, temperature and luminosity.

Keywords: WSN, Oil Palm, Bud Rot

1 Introduction

The oil palm (Elaeis guineensis) is the most productive oleaginous on the planet, has a productive life that exceeds 25 years. The world's largest producers of oil palm are located in Asia, the first producer is Indonesia followed by Malaysia, Colombia is the fourth largest producer of oil palm in the world and the first in America [1].

In recent years the sowing of oil palm has taken a great importance in food industry and in biofuel production. The African oil palm represents an important crop in the Colombian economy. This sector has been hit hard by the bud rot disease, it reaches the crops in a biotic or abiotic way.

At present, in Colombia, African oil palm plantations represent an important part of the country's agricultural production, with a total of 450,131 hectares planted. However, bud rot is among the factors that are most affecting this type of crop, generating to palm farmers large economic losses and the country's social problems due to unemployment.

There are two hypotheses about bud rot: the first one has a biotic origin, as a classical disease caused by a specific species of bacteria or fungus, sometimes with complications by several species of insects [7]. The second is of abiotic origin generally related to climatic and edaphic factors as causes of a very complex nutritional disorder but without precise specifications in causes [7].

Palm farmers have the risk that their main source of subsistence will be extinguished because of African oil palm bud rot. For this reason, it is necessary to have a wireless sensor network that allows an early warning of this disease in the crops.

Different management strategies of bud rot disease have been designed: chemical control, elimination of affected tissue, planting of tolerant materials and edafoclimatics analysis, among others. Early detection of abiotic factors that may trigger bud rot is one of the strategies that would allow palm farmers to minimize the impact on the crop. This is possible if we can design and develop a system to monitoring crops using wireless sensor networks [9].

Wireless sensor networks (WSN) are composed of nodes, which are autonomous devices capable of capturing and transmitting different variables that are around the target to be monitored, such as temperature, humidity, pH and luminosity. Different researchers have used the WSN to monitor the climatic variables of different crops such as: Aji Habanero [3], tomato [6], Orchids [5] and roses [4], among others. Their results indicate that they have been able to optimize the production of these crops by applying the ICTs in combination with the WSN. When WSN have to be deployed in outdoors or remote places, in many cases do not have access to the electrical system and the data network. In addition, it have to handle a large volume of information, therefore, the design of the node must be robust, so that the Palm farmers can monitor the crop in real time.

In Colombia, most crops are handled in an artisan way. Precision agriculture has begun to have importance in large business groups, but this type of agriculture is going to generate a large amount of information, which is why it is necessary to use tools to process them as Big Data techniques.

In this research, a WSN was developed that will allow to transmit the acquired values of different sensors. Each node of the WSN will be a unit that will be able to acquire, process and transmit in real time to a server acquired data as: pH, humidity, temperature and luminosity. Additionally, the system is equipped with its own power supply and georeferencing system. With acquired data a DataSet was created to be processed with Big Data tools.

2 System design

2.1 Edafoclimatic Requirements of African Palm

The African palm is a plant of the tropical region, therefore it is located in those areas that present average monthly temperatures that oscillate between 26 C and 28 C. Temperatures below 17 C for several days cause a reduction in the development of adult plants and in nursery stop the growth of the seedlings. As for rainfall, the favorable conditions for this species are determined by the amount and distribution of rainfall, which ranges from 1800 mm to 2300 mm per year.

In relation to the sunlight, the African palm is identified as heliophile plant, because its high requirements of sunlight. To achieve high productions, 1500 hours of sunlight per year are required. Therefore, areas with average monthly values greater than 125 hours of sunlight are considered suitable for the cultivation of this plant. The insolation also affects the emission of the inflorescences, photosynthesis, ripening of the clusters and oil content of the mesocarp. As for relative humidity, a monthly average of more than 75% is required.

It tolerates moderately acidic soils (pH 5,5 - 6,5), although these generally have nutrient deficiencies. In light soils, from sandy to loamy sandy, there are problems of washing and leaching of nutrients, so that their consistency is insufficient for the support of the plant. The heavy soils, of clay texture, have limitations for their handling, the difficulty to drain them and ease with which they are compacted.

Therefore, the optimal soils for African palm cultivation are deep soils with good drainage, slightly clayey texture, good organic matter content, flat to slightly undulating topography with slopes lower than 2% and with a level of fertility from medium to high.

2.2 Bud rot

Bud rot is one of most present diseases in oil palm plantations, this disease has been responsible for large economic losses and has generated social instability. This disease has been investigated in all Latin America by different institutes, the investigation results coincide in that it has biotic and abiotic origins.

The symptoms show the destruction of the young arrows, without presenting damage to meristematic area in initial stages of the disease; That is, meristematic area is the point of growth of the plant, if this is affected the plant dies. Experts indicate that when the disease is detected in time, it is sufficient to prune the affected young arrow together with a chemical control may be sufficient to control the disease. But if the attack is severe there is destruction of the arrows and the meristematic area, consequently, the emission and maturation of the new arrows is stopped, causing the death of the plant.

There is no clarity about the etiology of the disease and has been related to several abiotic factors of a physiological nature and biotic factors of a pathogenic nature. Preliminary studies have reported that no nutrients are associated with the incidence of BR, although it is possible that nutrient imbalance in the soil, together with excess water, may become predisposing factors to the disease.

2.3 Hardware Design

Figure 1 shows the block diagram of the designed node.

Data processing To perform processing, the Mega Arduino was chosen. This device has the following characteristics: 54 digital input / output pins, 14 can be used as analog PWM outputs, 16 analog inputs and 4 TTL-UART series receivers

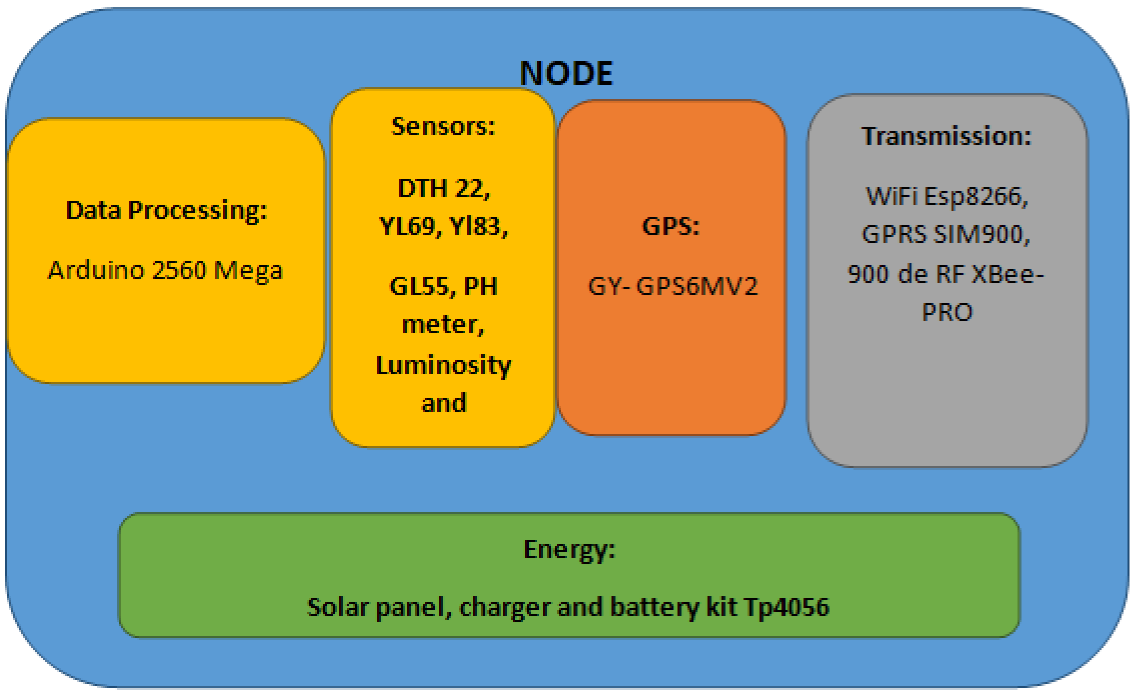


Fig. 1. Designed node

/ transmitters. Have a Flash memory of 256 Kilobytes, an SRAM memory of 8 KB and an EPROM of 4 KB.

Sensors The sensors were chosen according to the variable to be measured. Table 1 describes the characteristics of these.

Table 1. Sensors to be used to measure the variables

Variable	Sensor
Air humidity	DTH 22
Soil moistue	YL69
Temperature	DTH22
GPS	GY-GPS6MV2
pH	Tester pH, Temperature and Luminosity
Luminosity	GL55

All these sensors are compatible with Arduino, in the case of pH measurement it is done with a tester that sends to Arduino the analog input of acquired pH value.

A GY-GPS6MV2 module is used, easy to program, designed to be compatible with Arduino and integrated as a module to the system.

Transmission Three types of technologies are used: GSM, WiFi and Xbee. GSM: When some nodes are out of range because of the topography or the existing distances in the terrain. The GSM SIM900 model is used. WiFi: iIn cases that the node is near an access point (wireless router or another), is the most economic form that exists of transmission. The Wi-Fi module ESP8266 is used. Xbee: Preferred transmission in this type of networks by its low power consumption vs data transmission.

Energy It uses the charger and battery kit tp4056, an additional 5v 600ma solar panel is installed, it also has connection to the electrical grid.

2.4 Software design

The software was developed using the LAMP architecture, which is a solution of great performance and availability. It has great advantages since it has complet documentation online and is a free way to be able to develop Big Data techniques that are going to be implemented.

Operating System: Ubuntu server 12.04.4. Web Server: Apache Database: MySQL Web Programing language: PHP

2.5 Performed tests

First, the Arduino 2560 was configured with dth22, YL-69 and YL-38 sensors in conjunction with ethernet module. For 24 hours data were taken every 30 seconds, the system worked without problems showing the variations expected by the day / night change.

Secondly, the Arduino 2560 is configured with dth 22, ph (tester), brightness, YL-69, YL-38, ESP8266 WiFi module and GPS module. Also for 24 hours the system functions correctly. With an approximate consumption of 700mA. Lime dissolved in water was applied at 4 hours of test start and the expected pH change was detected. It is verified that the GPS module gives the correct position with a margin of error of 20 meters. No data was lost, the database correctly records all submissions.

Thirdly, the Arduino 2560 is configured with dth 22, ph (tester), luminance, YL-69, YL-38, GSM / GPRS SIM900 module and GPS module. Using the TELE-BUCARAMANGA operator and configuring the SMS sending every hour. For 24 hours the test was done obtaining a 100% reception of the data.

Fourth, two nodes were configured. Node1 (emitter): Arduino 2560 with dth 22, ph (tester), luminance, YL-69, YL-38, GPS module and XBee pro modules. Node 2 (receiver): Arduino 2560 with Ethernet and XBee pro modules. For 24 hours the test was performed without observing data loss. The power consumption of both nodes was approximately the same, about 600mA.

Finally, the installation of the software (LAMP) was performed on a Raspberry PI 3 (in the other tests it was installed on a laptop). In this case the node had: Arduino 2560 with dth 22, ph (tester), luminance, YL-69, YL-38, GSM / GPRS SIM900 module and GPS module. For 24 hours data is taken, data loss is observed and we find that access to it is slow because performance limitations of Raspberrry. Also the approximate energy consumptions are calculated obtaining 600mA for the Arduino and 2.5A for the Raspberry.

3 Results

3.1 A single transmitting node

The data acquisition was performed 4 times a day, at following times 8 am, 2 pm, 6 pm and 1 am; Since in these hours is when data have a significant variation. A soil sample from an African oil palm crop was analyzed where bud rot was not present.

In the database a table was created to store edafoclimatic variables and three information fields: Control ID, the number of node that is transmitting and timestamp. Figure 2 shows the table with edafoclimatic variables and information fields.

The data obtained during 24 hours of the soil without presence of bud rot are shown in Figure 3.

In Figure 3 it can be seen that the transmission of 1 am was not performed, because the voltage was not enough. Sending data at 8am.

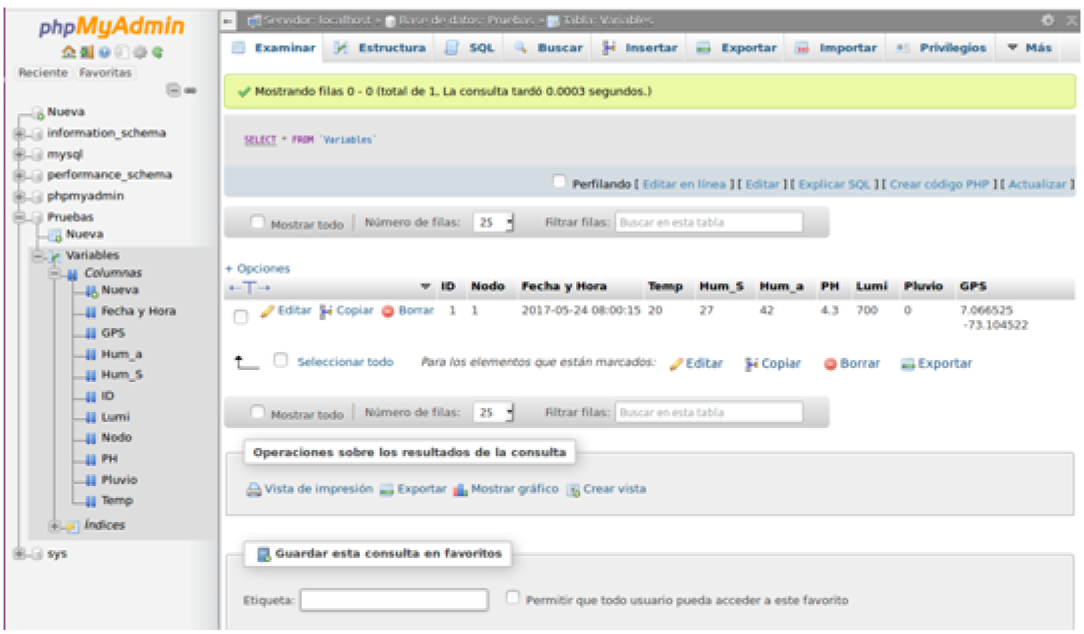


Fig. 2. Database table of edafoclimatic variables and information fields

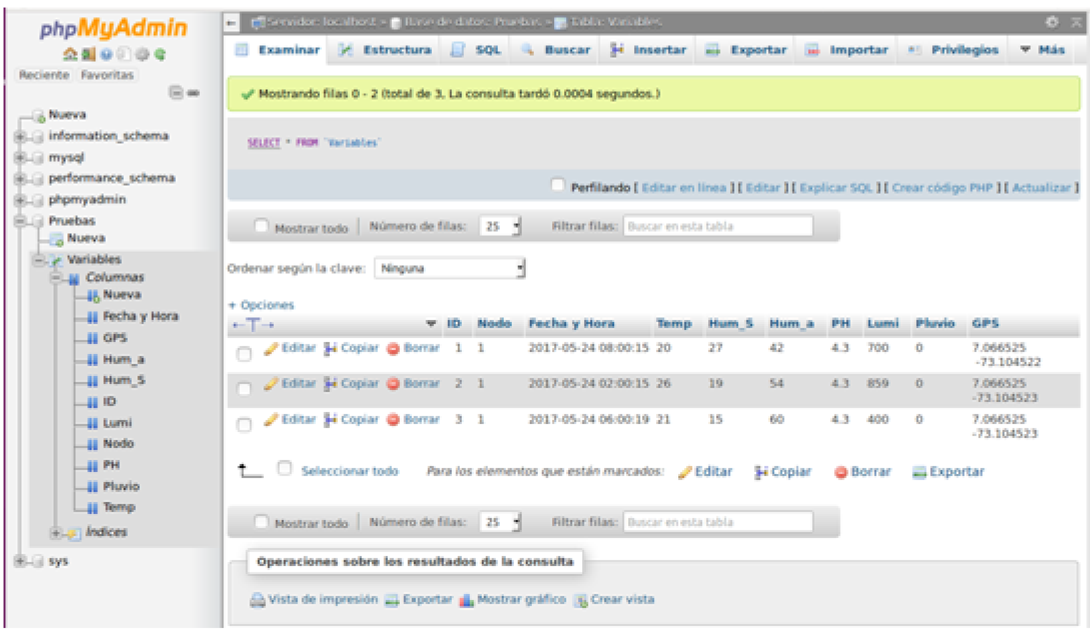


Fig. 3. 24 hours of data of soil without bud rot

3.2 Two nodes transmitting

Figure 4 shows the connection scheme used in two nodes that performed the acquisition of edafoclimatic variables, without presence of bud rot (Node 1) and presence of bud rot (Node 2).

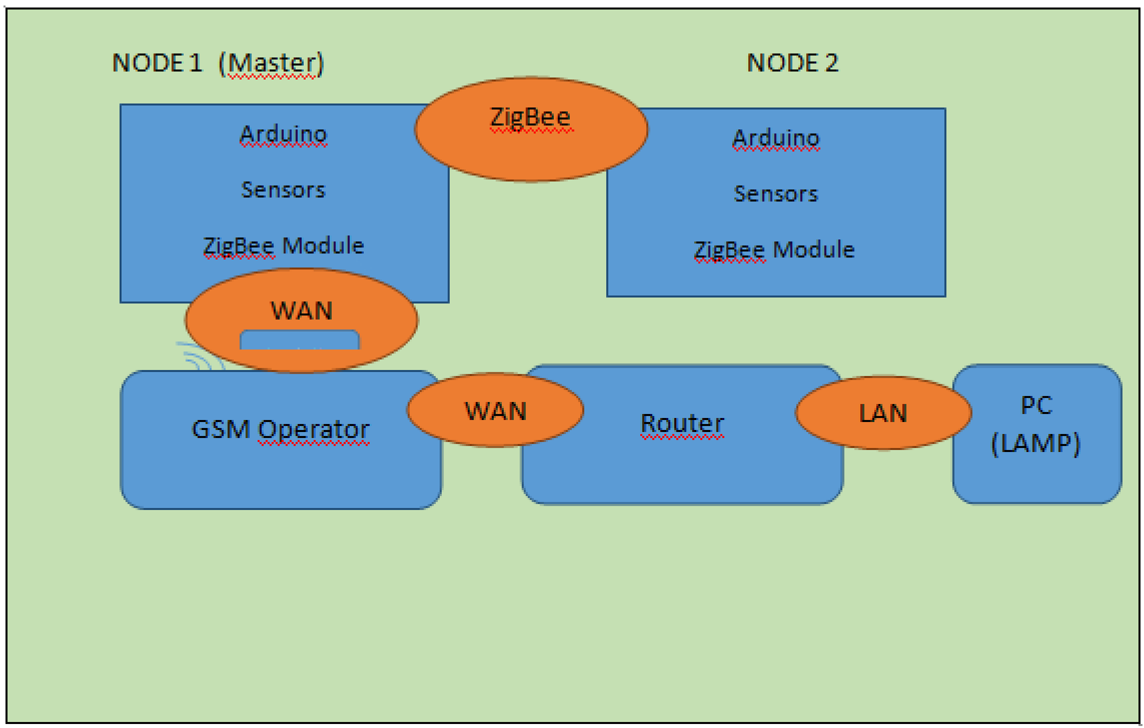


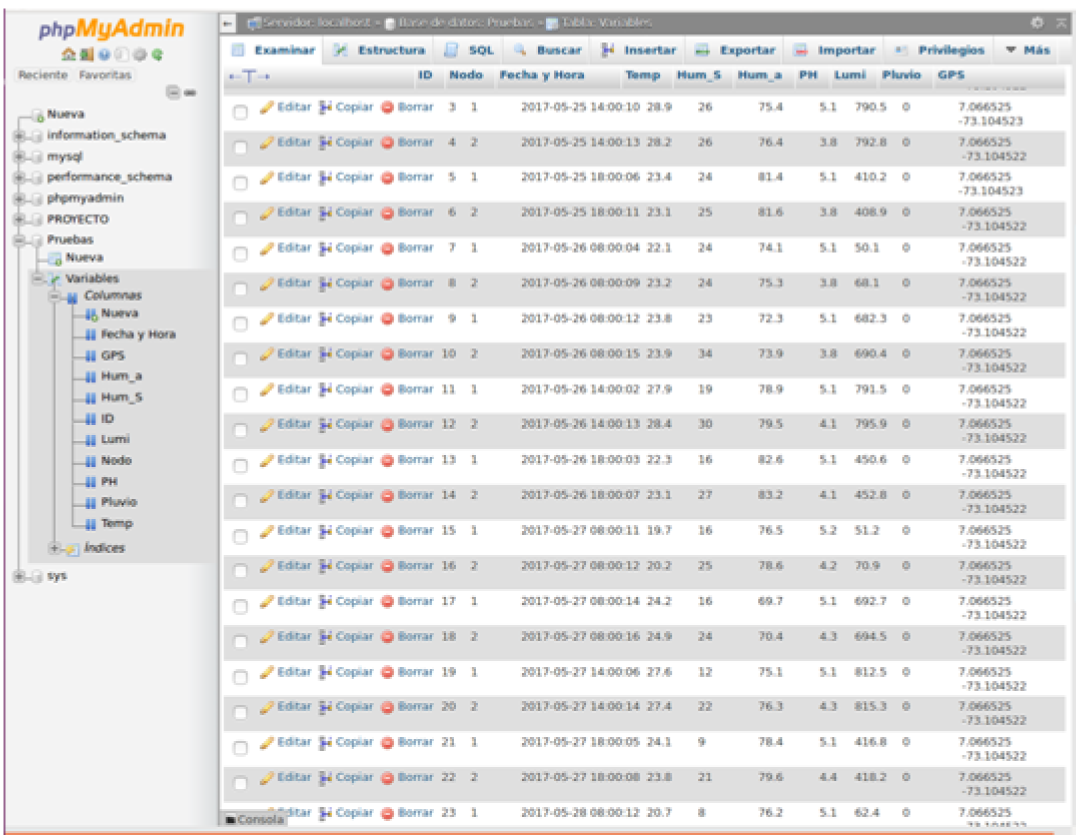
Fig. 4. Connection Scheme

3.3 Tests made with soil of a crop without presence of bud rot

The acquisition was performed 4 times a day, at 8 am, 2 pm, 6 pm and 1 am, Since in these hours is when data have a significant variation. The transmission of acquired data will be done 3 times a day. The acquisition at 1 am will be transmitted, to minimize the energy consumption, along with the data acquired at 8 am.

The nodes were interconnected with zigbee protocol. One of them acted as master and sent data to the server through GSM network of CLARO operator.

Figure 5 shows 72-hour period of the edafoclimatic variables: Temperature, Humidity, pH and luminosity. Captured by the two nodes and transmitted to the database .



ID	Nodo	Fecha y Hora	Temp	Hum_S	Hum_a	PH	Lumi	Pluvio	GPS
3	1	2017-05-25 14:00:10	28.9	26	75.4	5.1	790.5	0	7.066525 -73.104523
4	2	2017-05-25 14:00:13	28.2	26	76.4	3.8	792.8	0	7.066525 -73.104522
5	1	2017-05-25 18:00:06	23.4	24	81.4	5.1	410.2	0	7.066525 -73.104523
6	2	2017-05-25 18:00:11	23.1	25	81.6	3.8	408.9	0	7.066525 -73.104522
7	1	2017-05-26 08:00:04	22.1	24	74.1	5.1	50.1	0	7.066525 -73.104522
8	2	2017-05-26 08:00:09	23.2	24	75.3	3.8	68.1	0	7.066525 -73.104522
9	1	2017-05-26 08:00:12	23.8	23	72.3	5.1	682.3	0	7.066525 -73.104522
10	2	2017-05-26 08:00:15	23.9	34	73.9	3.8	690.4	0	7.066525 -73.104522
11	1	2017-05-26 14:00:02	27.9	19	78.9	5.1	791.5	0	7.066525 -73.104522
12	2	2017-05-26 14:00:13	28.4	30	79.5	4.1	795.9	0	7.066525 -73.104522
13	1	2017-05-26 18:00:03	22.3	16	82.6	5.1	450.6	0	7.066525 -73.104522
14	2	2017-05-26 18:00:07	23.1	27	83.2	4.1	452.8	0	7.066525 -73.104522
15	1	2017-05-27 08:00:11	19.7	16	76.5	5.2	51.2	0	7.066525 -73.104522
16	2	2017-05-27 08:00:12	20.2	25	78.6	4.2	70.9	0	7.066525 -73.104522
17	1	2017-05-27 08:00:14	24.2	16	69.7	5.1	692.7	0	7.066525 -73.104522
18	2	2017-05-27 08:00:16	24.9	24	70.4	4.3	694.5	0	7.066525 -73.104522
19	1	2017-05-27 14:00:06	27.6	12	75.1	5.1	812.5	0	7.066525 -73.104522
20	2	2017-05-27 14:00:14	27.4	22	76.3	4.3	815.3	0	7.066525 -73.104522
21	1	2017-05-27 18:00:05	24.1	9	78.4	5.1	416.8	0	7.066525 -73.104522
22	2	2017-05-27 18:00:08	23.8	21	79.6	4.4	418.2	0	7.066525 -73.104522
23	1	2017-05-28 08:00:12	20.7	8	76.2	5.1	62.4	0	7.066525

Fig. 5. Edafoclimatic variables transmitted by the two nodes

Tests performed on crops without bud rot transmitted by node 1 Figure 6 shown that the soil where palms that does not suffer from bud rot (BR) have pH that is neither alkaline nor acidic soils, in addition it can be observed that there is no significant variation of pH.

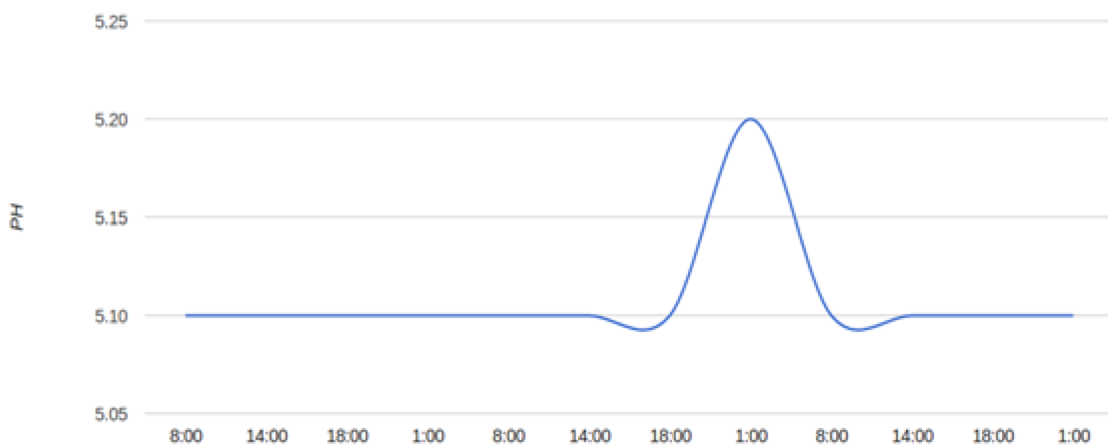


Fig. 6. Soil pH variation of crop without bud rot

The results corresponding to luminosity are shown in Figure 7 You can see day and night cycle.

Figure 8 shows temperature changes that occur during the 72 hours of the evaluation in a soil sample without but rot presence.

Figure 9 shows ambient humidity taken by the node installed on the ground that does not have bud rot presence.

Tests performed on crops with bud rot The next node is installed in a container containing soil taken from a crop having bud rot.

In order to verify that there was a variation of pH in soil with bud rot presence, twenty-four (24) hours after the transmission began, an application of lime dissolved in water was performed.

In Figure 10 it is possible to observe ambient temperature which was measured during a period of 72 hours.

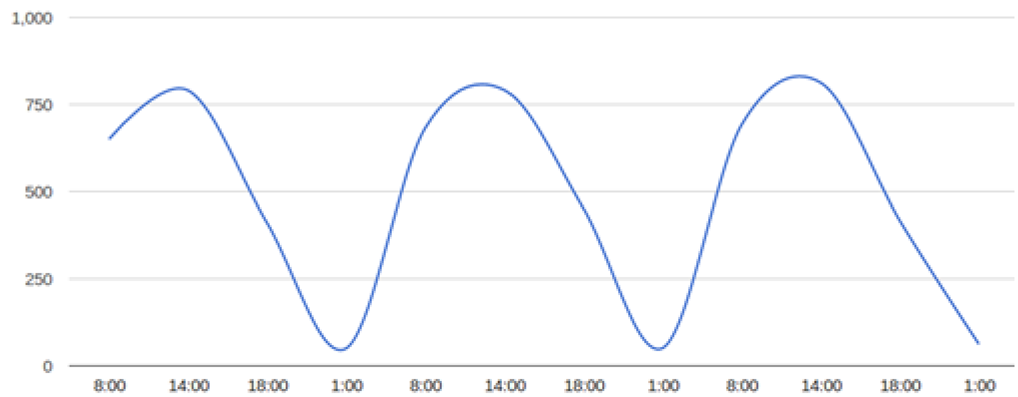


Fig. 7. Luminosity variation of crop without bud rot

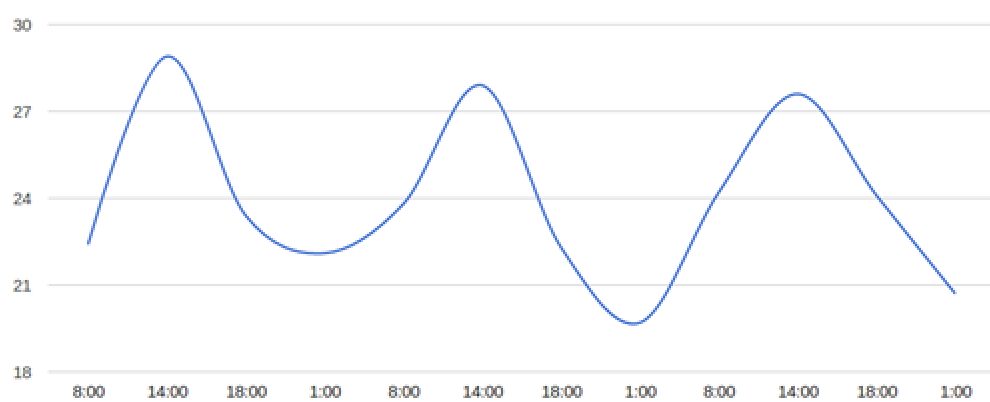


Fig. 8. Temperature variation of crop without bud rot

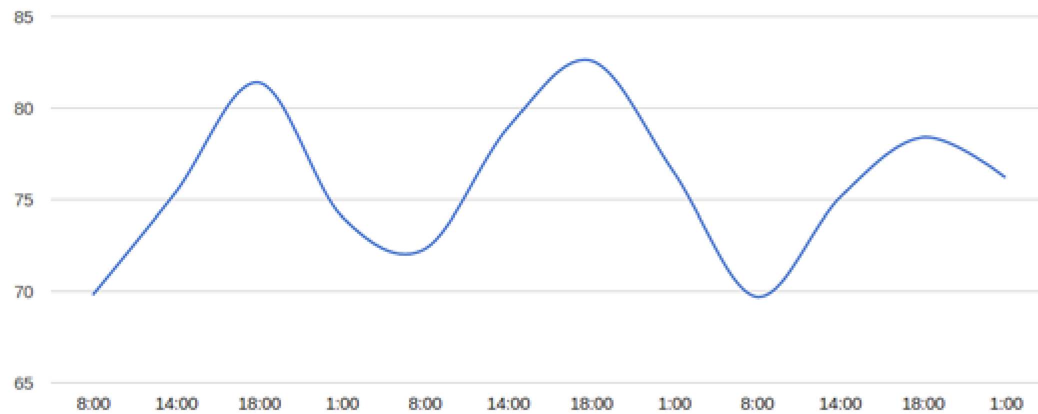


Fig. 9. Humidity variation of crop without bud rot

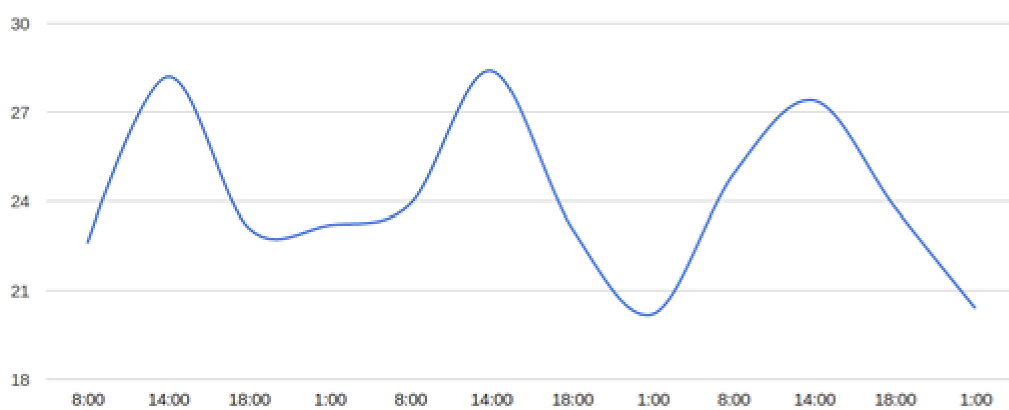


Fig. 10. Temperature variation of crop with bud rot

Figure 11 shows the behavior of the pH. As can be observed the soil pH is acid, it is transformed to neutral pH soil using lime.

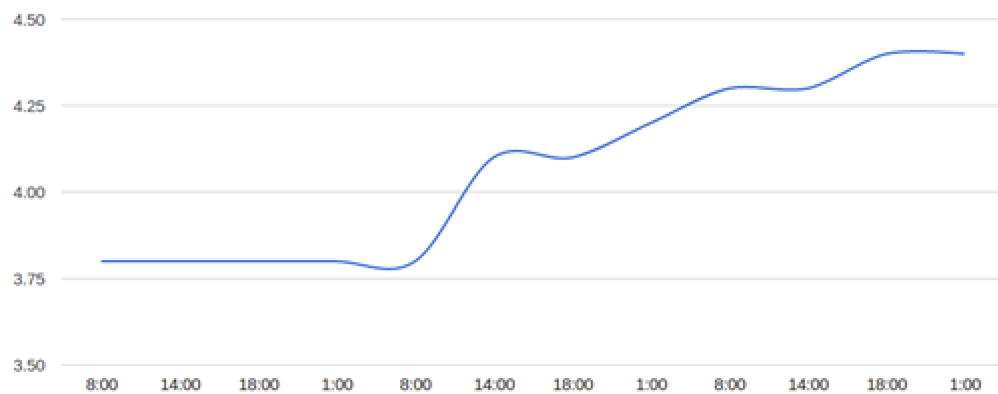


Fig. 11. pH variation of crop with bud rot

Figure 12 shows luminosity variable for soil with bud rot presence.

Figure 13 shows humidity present in the container containing soil of a crop with presence of but rot. Here it is necessary to take into account that after 12 hours of test start a lime dissolved in water is applied, for this reason humidity increases abruptly in about 10%.

4 Conclusions

In this paper a WSN was developed that allow to transmit the acquired values of different sensors. Each node of the WSN will be a unit that will be able to acquire, process and transmit in real time to a server acquired data as: pH, humidity, temperature and luminosity. Additionally, the system is equipped with its own power supply and georeferencing system. The results indicate that the proposed system can do an early detection of abiotic factors that may trigger bud rot. With early detection farmers maybe apply strategies that would allow to minimize bud rot impact on crops.

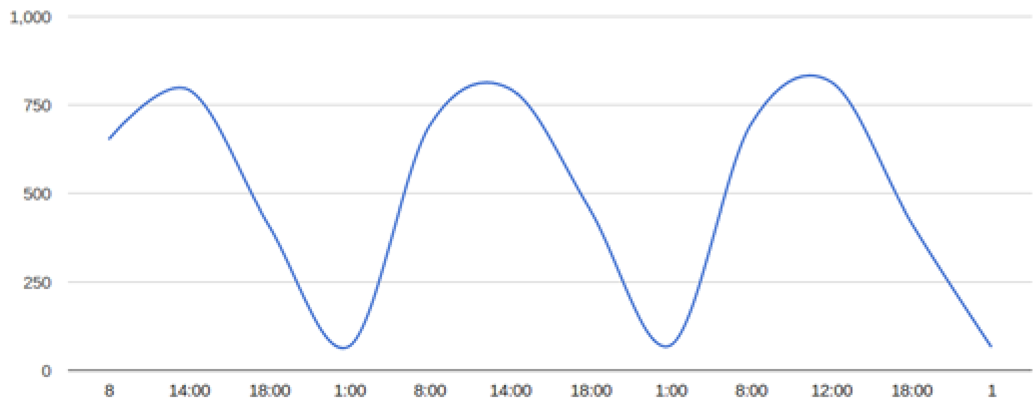


Fig. 12. Luminosity variation of crop with bud rot

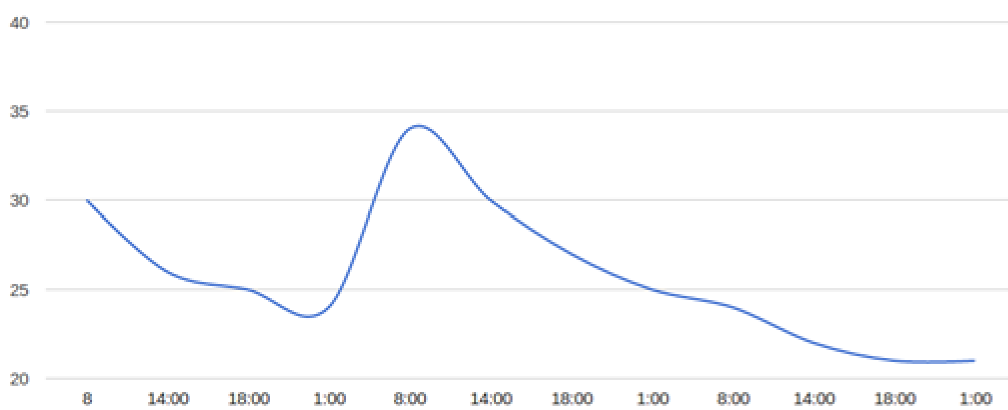


Fig. 13. Humidity variation of crop with bud rot

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