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Solar-Powered Automated Green Leafhopper Bait Trap for Rice Crops

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Abstract

The research study was conducted to attract and trap Green Leafhopper (GLH) the most common rice pest that caused up to a million worth of rice extensive damage. To resolve this problem, the researchers developed a device that can automatically attract and trap GLH by using both bait mixture and light-emitting diode (LED) light trap using Systems Development Life Cycle as its methodology to improve the quality and the overall development of the device. The study used Systems Development Life Cycle to improve the quality and the overall development of the device. The device was deployed for testing at the Philippine Rice Research Institute in Los Baños, Laguna. Results from a series of reliability tests showed that the device is capable of automatically spraying bait mixture and activating an LED light trap.

***Keywords* — Solar Powered, Microcontroller, Rice field, Rice crops, Green leafhoppers, Bait Trap**

I. Introduction

The Philippines is one of the main producers of rice crops because of its fertile soil and it has 43,000 square kilometers of field suitable for rice production. According to an article, the Philippines is the 8th largest rice producer in the world with over 2.8% of global rice production. Even though the Philippines is one of the largest rice producers in the world, the rice industry of the Philippines is still greatly affected by the increase of rice pests [1].

Green Leafhoppers (GLH) is a major rice pest which caused up to 3.2 million worth of rice extensive damage in Asturias, Cebu, Philippines [2]. Using pesticides is not the solution to rice pest problems because spraying pesticides will not only kill the adult pests in the rice plants, but also the natural enemies preying on pest defoliators. Most rice farms use pest management biological control agents like spiders and physical controls such as handpicking and manually sweeping but the most common one among all of these methods is baiting.

PhilRice and National Crop Protection Center (NCPC) have been looking into the concept of introducing a technological means to decrease the pests within the rice fields. To address the problem of GLH infestation the researchers developed a Solar Powered Bait Trap for Rice Crops to attract GLH and trap them inside the bait trap container.

II. Related Literature

In 2019, a statistic shows that almost all Asian countries consume a thousand metric tons of rice and 90% across the globe also eat rice [3]. It also includes the Philippines who is one of the top contributors of rice in the world that reaches a record-high harvest of 19.28 million tons in 2016 which is 9.36% of that year. However, the production of rice in the country is greatly affected by rice pests. The most common rice pests are the green leafhoppers. This pest can destroy and affect the growth of the rice crops. These pests are preventing rice crops from cultivating and saps the stem out of it [4]. Integrated Pest Management (IPM) includes the traditional practices on how to control pests in rice fields, including the use of pesticides. However, these practices are not always applicable to all countries due to varying kinds of nature in the environment. Hence, there is a need of development of effective integrated pest management technologies for production of rice [5].

Insect attractant and traps can be used to reduce the population of pests. This method is safe as it does not affect the humans, animals, and the food that the people eat. It also stated in the study that setting up light traps is an effective way to attract pest as the light leads the pests to the light source. There are two types of traps, one is a funnel like

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trap that prevents pests from leaving the trap because of its funnel shape while the other one is a simple box like trap that are commonly used by farmers to trap these pests. The funnel type trap is more secured when it comes to trapping pests, there is a small chance that the trapped pest inside can escape because it is wide at top and narrow at the bottom, while the box type has a small chance to keep the pest inside since it has a wide opening at the top and bottom [6]. Another effective way in controlling these pests is by using attractants and the most effective out of the attractants available is the g-formula. This formula is composed of 5 mixtures; (Z)-3-hexenyl acetate, (E)-ocimene, (E)-4,8-dimethyl-1,3,7-nonatriene, benzaldehyde, and ethyl benzoate which was proven to be very effective in attracting the GLH. [7]

Another tool used in trapping pests in rice crops is the Light Dependent Resistor (LDR) Sensor. According to a study [8], where an LDR sensor with a GSM module is used, the LDR sensor was used to detect movement, while the GSM module was used to notify the user. The user of the tool will be notified via SMS with the use of the GSM module who will transmit the circumstances inside the bait trap container [9]. The prototype of the research uses solar panel, a microcontroller, a water pump, a charge controller, and an ESP32 Wi-Fi module. These components will automatically work together unless the basic parameters of their prototype met the requirements. It includes the water level in the rice field. The information gathered by the sensors will be send to the microcontroller and will be evaluated if irrigation will be performed. Lastly, a component that will also send the obtained result will be transmitted to the user if the irrigation shall be perform by its simple click. Especially the charge controller since it will regulate the power consumption of the whole components of the device which is very useful in order to operate continuously [10]. Nowadays, researchers make a study about different ways to improve the IPM technology in rice field which has the same goal but different ways to lessen the pest. However, some studies do not have time because they only focus on how to maintain the operation. An RTC module was utilized in order to provide timings to the operation of the components. Automatic operations such as turning on and off the light at a specified time was programmed to the microcontroller to lessen the manual control for the device. It can also detect the surroundings of the environment if the condition is dark and lighted with the used of sensor which is realized photodiode. In their study, the set time for the light to turn on is 6:00 PM and turns off when the time reaches 6:00 AM. This study really helps a lot the researchers since the time they use to specified to turn on and off the lights is applicable to the study of the researchers [11]. Including the interviewed employee in the research locale that the researchers went, the most common pest that always appear in the rice field based on his knowledge is green leafhoppers and black bugs. Since some pests only appears on different seasons, the researchers focus only to the common pest and suggested pest by the Entomologist.

III. Methodology

A. General Method Used

In this study, the researchers used the Systems Development Life Cycle (SDLC) to improve the quality and overall development process of the device [13]. This method involves different phases, including planning, analyzing, designing, developing, testing and implementing the device.

B. Methodology

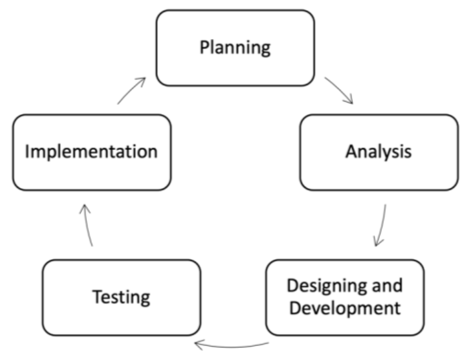

Fig. 1. The System Development Life Cycle model that was used to perform the methodology of the study/

Planning

The researchers considered the field of agriculture in the Philippines as a starting point of the study. Based on initial readings and assessments, the researchers focused on one of the most common problems in the rice crop industry in the Philippines: pest infestation. During this phase, the researchers began to conduct initial interviews with the farmers working in Philippine Rice Research Institute (PhilRice) in Los Baños, Laguna. The researchers also gathered additional information regarding the effects and ways on controlling pests like GLH. All of the information were synthesized together in order to provide context and support to all of the data provided in the research

Analysis

Based on the initial interviews, the researchers learned that most rice fields in the Philippines are still using conventional methods of manual sweeping and use of bait traps to prevent pest infestation. From further research and conversations with the farmers working in the Philippine Rice Research Institute (PhilRice), the researchers were able to narrow down the scope of the study to focus on the pest

Green Leafhopper (GLH).

In this stage, the researchers further explored on finding a potential solution to GLH infestation using principles and tools of engineering. Through further examination, the researchers were able to provide a design that uses both bait mixture and light trap to attract GLH. The bait mixture used for the device is a a mixture of 5.6 liters of water and ¾ kilogram of sea salt.

Design and Development

The researchers used the prototyping model as the methodology to design and develop the device.

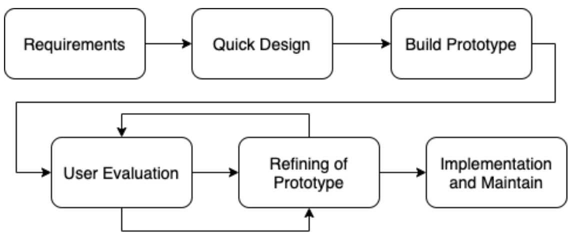

Fig. 2. The process of the prototyping model, which involves the necessary phases to successfully design the hardware and software of the device

a. Requirements

In this stage, the researchers identified the initial specifications required for both hardware and software components. For attracting the pest, the device required a receptacle to hold the bait mixture. For trapping GLH, the device required a structure where the pest can get trapped once lured in. The device also required a power source that can stand alone without electrical connection as it should be installed on a rice field. To meet this requirement, the researchers considered the use of a solar panel. In addition to this requirement, the researchers considered the use of a solar panel as it converts light energy to electricity to charge the battery that can supply power to the said components.

b. Quick Design

In this stage, the researchers developed a 3D model of the device to check both the physical appearance and device dimensions. This enabled the researchers to determine the correct placement and compatibility of components, and sizing of the device (Figure 4-7).

For the software, the researchers created a system flowchart to ensure the functionality of the device performs as expected.

c. Build Prototype

Building the prototype was divided into two sub-stages: hardware design and software design.

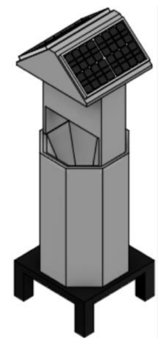

Fig. 3. The prototype design based on the requirements of the research locale where the prototype was intended to be implemented

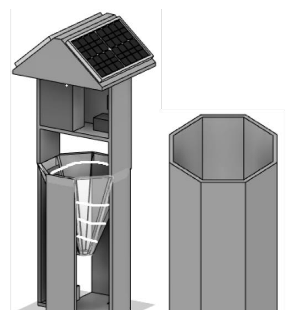

Fig. 4. The internal design which houses the microcontroller unit and sensors of the prototype

Figure 4 shows a layered view of the bait trap container when the brace is removed. Inside the funnel of the container, a disposable net is inserted to trap the pests. This allows the farmer to easily remove and dispose of the trapped pests when the net is full. Above the bait trap container are the hardware components. This includes the Arduino, RTC, GSM module, charge controller and battery. The solar panel is placed on top of the prototype in a roof structure.

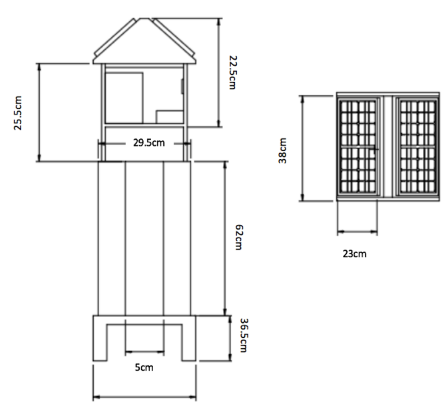

Fig. 5. Physical dimension of the prototype based on the requirements of the research locale where the prototype was intended to be implemented

Figure 5 shows the physical dimension of the prototype. The prototype was designed to have the same height as of the rice crops in the research locale, while the length and width of the prototype was designed to accommodate the size of the solar panel.

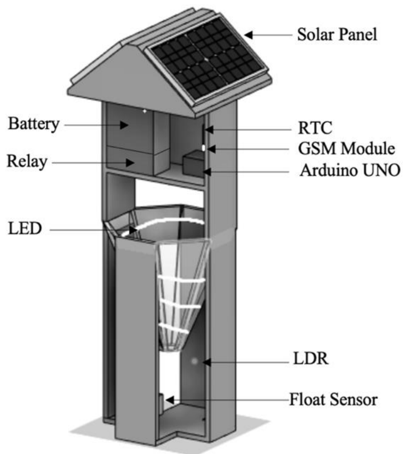

Fig. 6. Hardware components that is used to automatically operate based on the concept of automatically trapping the GLH.

Figure 6 shows the hardware components of the prototype which were selected based on the required functionality for attracting and trapping the pests. The prototype includes components such as: battery, charge controller, solar panel, float sensor, water pump, GSM module, RTC, relay, LED, LDR and the Arduino microcontroller.

The battery is charged via the solar panel while a charge controller transforms the solar energy into electrical energy. With the stored energy coming from the solar panel, the battery serves as the main power source of the prototype. There is also a water pump that is used to pump the bait mixture into the bait trap container. The amount of bait mixture in the bait mixture container and the bait trap container are both measured by a float sensor. For the communication part, a GSM module is used to notify the farmer on two instances: when the bait trap container is full of pests, and when the bait mixture reaches below 4.5 liters together with it is the RTC module which includes an internal time and date that is used to trigger the light trap of the prototype. The light trap is made up of LED to attract the pest at night, and the LDR sensor is used to determine if the bait trap container is full.

Fig. 7. Actual developed prototype in the rice field of PhilRice, Los Baños Laguna during the testing process of the study

d. Build Prototype

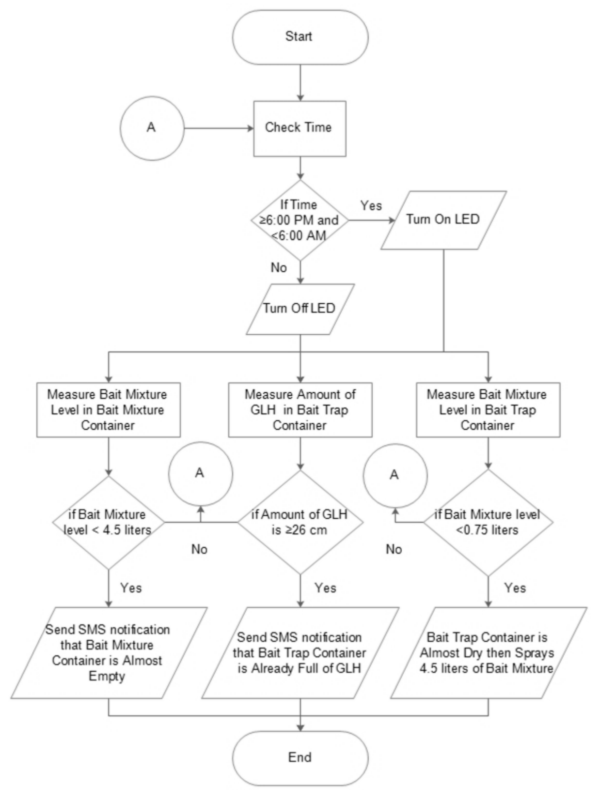

Fig. 8. The flowchart of the operational tasks of the prototype.

Figure 8 shows the flowchart of the software of the device. The operation starts with the RTC module checking the time. When the time is 6:00 PM to 5:59 AM, the LED automatically turns on.

The device starts measuring the bait mixture level and the amount of pests trapped. If the bait mixture level is less than 0.75 liters, the device automatically sprays 4.5 liters of bait mixture into the bait trap container. Additionally, if the level of bait mixture is less than 4.5 liters, the device will send a notification to the farmer that the bait mixture container is almost empty and needs to be refilled. Finally, the device checks for the amount of pests trapped inside the bait trap container. If the level of the amount exceeds 26 cm, the device will send the farmer a notification that the bait trap container is already full.

e. User Evaluation

Initial checks and tests based on the intended functionality of the components was performed during this phase. The researchers were able to assess the integration of the hardware and software design to ensure the device's functionality as a standalone, fully working device.

f. Refining Prototype

Depending on the adjusted modifications, the device was reevaluated until the device worked according to its intended operation.

g. Implement and Maintain

During this phase, the researchers prepared the device for its deployment at the designated research locale where the reliability testing was conducted.

4. Testing

A full day of testing was conducted in the rice field of PhilRice in Los Baños, Laguna. The test results were recorded and used as the basis for determining the device's ability to be implemented in the research locale.

5. Implementation

The tests carried out proved that the device is reliable to be implemented in an actual rice field. However, due to the restrictions imposed by the Philippine government on the COVID-19 pandemic during the period of research, the researchers were not able to implement the device in the rice field of PhilRice in Los Baños, Laguna.

6. The Study

a. Diagram of Existing Process

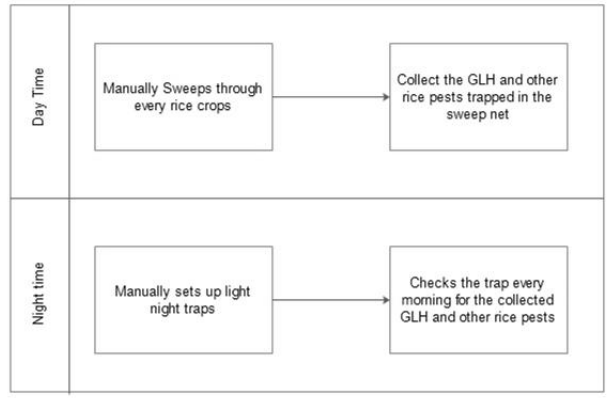

Fig. 9. The diagram of the existing process of attracting and trapping GLH in PhilRice, Los Baños Laguna

b. Description of Proposed Process

The researchers developed a device that automatically attracts and traps GLH. The system automatically switches on its LED when the time is 6:00 PM to 5:59 AM. Otherwise, the LED will stay off until 6:00 PM. The process continues as the device measures the level of bait mixture, and the level of the amount of GLH trapped inside the bait trap container. The device sends a notification when the bait trap container is already full indicating that the GLH inside the container must be disposed of.

c. Diagram of Proposed Process

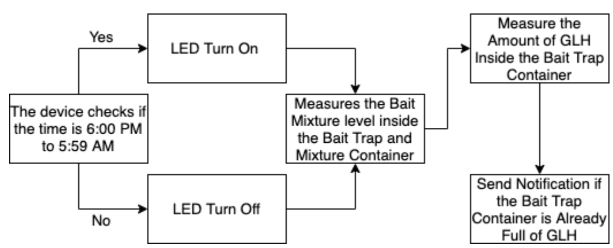

Fig. 10. Block diagram of the operational procedure of the prototype.

IV. EXPERIMENT AND RESULTS

This chapter shows the interpretation of the data gathered during hardware testing followed by the conducted full system testing on the rice field of Philippine Rice Research Institute in Los Baños, Laguna. The remarks of the testing are shown in tables that indicate the reliability of each component used within the device.

A. Reliability Testing

1. Reliability testing of float sensor

For this test, the researchers set up different mixture heights of the bait trap container to check the reliability of the float sensor component. The float sensor will trigger the bait mixture pump when the mixture height is 1 cm or below. The remarks were evaluated as Reliable when both expected output and actual output have the same results.

Table I.
Reliability testing of float sensor inside the bait trap container

Trial	Mixture height	Expected Output (Bait Mixture Pump)	Actual Output (Bait Mixture Pump)	Remarks
1	10 cm	Not triggered	Not triggered	Reliable
2	9 cm	Not triggered	Not triggered	Reliable
3	8 cm	Not triggered	Not triggered	Reliable
4	7 cm	Not triggered	Not triggered	Reliable
5	6 cm	Not triggered	Not triggered	Reliable
6	5 cm	Not triggered	Not triggered	Reliable
7	4 cm	Not triggered	Not triggered	Reliable
8	3 cm	Not triggered	Not triggered	Reliable
9	2 cm	Not triggered	Not triggered	Reliable
10	1 cm	Triggered	Triggered	Reliable

Based on the results, all trials show that the expected output is the same with the device's actual output on varying mixture heights. This indicates that the functionality of the float sensor in the device to trigger the bait mixture pump is 100% reliable.

2. Reliability testing of the LED light trap

Table 2 shows the reliability test of the LED light trap. This table shows the LED behavior based on the specific day and time given for 10 days. The remarks were evaluated as Reliable when both expected output and actual output have the same results.

Table II.
Reliability testing of LED light traps

Day	Time	Expected Output (LED Strips)	Actual Output (LED Strips)	Remarks
1	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
2	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
3	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
4	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
5	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
6	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
7	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
8	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
9	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable
10	6:00 PM	ON	ON	Reliable
	6:00 AM	OFF	OFF	Reliable

For all of the days that the LED trap was tested. It functioned based on its intended purpose which is to turn on once the time in the RTC module is 6:00 PM and turns off when the time is 6:00 AM.

3. Reliability testing of the Light Dependent Resistor (LDR) sensor

Table 3 shows the reliability test of the LDR sensor. This table shows how LDR behaves on different height value. The LDR sensor is triggered at the 26-cm height value. The remarks were evaluated as Reliable when both expected output and actual output have the same results.

Table III.
Reliability testing of the LDR sensor

Trial	**LDR Height Value**	**LDR Value (High or Low)**	**Expected Output**	**Actual Output**	**Remarks**
1	36 cm	High	Triggered	Triggered	Reliable
2	31 cm	High	Triggered	Triggered	Reliable
3	26 cm	High	Triggered	Triggered	Reliable
4	21 cm	Low	Not triggered	Not triggered	Reliable
5	16 cm	Low	Not triggered	Not triggered	Reliable
6	11 cm	Low	Not triggered	Not triggered	Reliable
7	6 cm	Low	Not triggered	Not triggered	Reliable

The results from Table 3 shows that the expected output is the same with the device's actual output on varying heights. The prototype functioned based on its intended functionality which is to trigger the LDR sensor if the LDR height is 26 cm and above.

4. Reliability testing of the GSM module with LDR sensor

Table 4 displays the LDR sensor reliability test as well as the GSM module used for the bait trap container notification.

The aim of this test is to check the reliability of GSM module to send a notification with one-hour interval to the programmed mobile number when the level of amount of GLH exceeds 26 cm, at which the LDR sensor will be activated.

Table IV.
Reliability testing of the GSM module with LDR sensor

Trial	Date and Time Sent	LDR Height Value	Expected Output (SMS Notification)	Actual Output (SMS Notification)	Date and Time Received	Remarks
1	Feb 15, 2020 10:00:00 AM	36 cm	SMS Sent	SMS Sent	Feb 15, 2020 10:00:10 AM	Reliable
2	Feb 15, 2020 11:00:00 AM	31 cm	SMS Sent	SMS Sent	Feb 15, 2020 11:00:09 AM	Reliable
3	Feb 15, 2020 12:00:00 PM	26 cm	SMS Sent	SMS Sent	Feb 15, 2020 12:00:13 PM	Reliable
4	Feb 15, 2020 1:00:00 PM	21 cm	SMS not sent	SMS not sent	N/A	Reliable
5	Feb 15, 2020 2:00:00 PM	16 cm	SMS not sent	SMS not sent	N/A	Reliable
6	Feb 15, 2020 3:00:00 PM	11 cm	SMS not sent	SMS not sent	N/A	Reliable
7	Feb 15, 2020 4:00:00 PM	6 cm	SMS not sent	SMS not sent	N/A	Reliable

Table V.
Reliability testing of the GSM module for bait mixture container

Trial	**Date and Time Sent**	**Bait mixture value (liters)**	**Expected Output (SMS notification)**	**Actual Output (SMS Notification)**	**Date and Time Received**	**Remarks**
1	Feb 15, 2020 5:00 PM	50	SMS not sent	SMS not sent	N/A	Reliable
2	Feb 15, 2020 6:00 PM	25	SMS not sent	SMS not sent	N/A	Reliable
3	Feb 15, 2020 7:00 PM	15	SMS not sent	SMS not sent	N/A	Reliable
4	Feb 15, 2020 8:00 PM	10	SMS not sent	SMS not sent	N/A	Reliable
5	Feb 15, 2020 9:00 PM	5	SMS not sent	SMS not sent	N/A	Reliable
6	Feb 15, 2020 10:00 PM	4.5	SMS sent	SMS sent	Feb 15, 2020 10:00:13 PM	Reliable
7	Feb 15, 2020 11:00 PM	4	SMS sent	SMS sent	Feb 15, 2020 11:00:15 PM	Reliable
8	Feb 16, 2020 12:00 AM	3	SMS sent	SMS sent	Feb 15, 2020 12:00:15 AM	Reliable
9	Feb 16, 2020 1:00 AM	2	SMS sent	SMS sent	Feb 15, 2020 1:00:17 AM	Reliable
10	Feb 16, 2020 2:00 AM	1	SMS sent	SMS sent	Feb 15, 2020 2:00:12 AM	Reliable

The results from Table 4 show that when the level of amount of GLH inside the bait trap container exceeds 26 cm, the LDR sensor is activated thus, activating the GSM module to automatically send a notification that the bait trap container is full and ready for disposal. For each given height of the bait trap container, the GSM Module of the device was evaluated as 100% reliable because the result of expected output and the result of actual output of the device have the same output.

5. Reliability testing of GSM module for bait mixture container

Table 5 shows the reliability testing of the GSM module for the bait mixture container. For this test, the researchers set up different values with one-hour interval for the bait mixture in the container. When the amount of bait mixture reaches below 4.5 liters, the GSM module will send an SMS notification to the programmed mobile number that the bait mixture container needs to be refilled. The remarks are evaluated as reliable when the result of expected output is the same with the actual output of the device.

The testing results in Table 5 shows that the GSM module was able to send SMS notifications to the programmed mobile number when the amount of bit mixture is below 4.5 liters.

B. Summary of test results

In summary, the results of reliability testing of each component were all successful, thus proves the dependability of individual components to operate as expected. The researchers were also able to prove the reliability of the device as a functioning device through the full system reliability testing. This test ensured that the integration of individual components was successfully completed, and that the device was able to produce reliable results in automatically spraying bait mixture and trapping greenleaf hopper pests on a rice field.

V. Conclusion and recommendation

The researchers have successfully designed and developed a device that can attract and trap green leafhopper pests through the use of automated spraying of bait mixture and LED light trap. The results showed that the device is reliable to use for attracting green leafhoppers by automatically spraying bait mixture, which consists of water and sea salt. The device is also reliable in trapping green leafhoppers by activating the LED light trap at a specific time of the day. Lastly, the device was successful in sending SMS notifications to a programmed mobile number when the bait trap container is full and/or the bait mixture level is almost empty.

The researchers recommend to implement the study to a wider area of coverage of rice fields in the Philippines, to study on the application of the device to attract and trap other rice fields pests, and to add a user interface that will let the user to modify SMS notification number and other configurations, for improvement of the study.

References

[1] R. a. Miguel, 2015.

[2] L. M. A. Ambrad, Tungro damages P3.2m rice plants in Asturias, The Freeman, 2018.

[3] M. Shahbandeh, “statista,” 23 March 2020. [Online]. Available: https://www.statista.com/statistics/255971/top-countries-based-on-rice-consumption-2012-2013/.

[4] J. Catindig, “Rice Knowledge Bank,” [Online]. Available: http://www.knowledgebank.irri.org/training/fact-sheets/pest-management/insects/item/green-leafhopper.

[5] L. N. S. H. F. K. F. A. K. S. S. H. M. L. L. X. L. A. T. C. W. D. X. K. C. a. J. H. Shah Fahad, “Rice Pest Management and Biological Control,” in *Sustainable Agriculture Reviews* , 2015, pp. 85-106.

[6] A. &. T. M. &. b. R. &. K. Sheikh, “Light Trap and Insect Sampling: An Overview,” in *International Journal of Current Research*, International Journal of Current Research, 2016, pp. 40868-40873.

[7] X. B. L. X. X. L. Z. L. Z. &. C. Z. Cai, “Field background odour should be taken into account when formulating a pest attractant based on plant volatiles,” in *Scientific Report* , 2017.

[8] N. D. B. S. D. A. J. Durgesh Kumar Mishra, “LDR sensor used in rice crops,” in *ICT for Competitive Strategies: Proceedings of 4th International Conference*, 2020.

[9] S. A. Maharani Putri, “Design of Security Tools Using Sensor Light Dependent Resistor (Ldr) through Mobile Phone,” in *International Journal for Innovative Research in Multidisciplinary Field*, International Journal For Innovative Research In Multidisciplinary Field, 2018, pp. 168-173.

[10] S. &. I. T. Biswas, “Solar Water Pumping System Control Using a Low Cost ESP32 Microcontroller,” in *2018 IEEE Canadian Conference on Electrical & Computer Engineering (CCECE)*, 2018.

[11] I. R. &. D. H. I. D. Agung, “Design of Lighting Control with RTC Timer and SMS Using Microcontroller. „” in *Journal of Electrical, Electronics and Informatics*, 2017, pp. 24-28.

[12] R. O. R. Reusora, “BusinessWorld,” 28 April 2018. [Online]. Available: https://www.bworldonline.com/top-rice-producing-provinces-in-the-philippines/.

[13] T. H. P. G. K. a. C. L. T. R. Weinzierl, “Insect Attractants and Traps,” in *Institute of Food and Agricultural Sciences*, University of Florida IFAS Extension.

[14] “wonderpolis,” [Online]. Available: https://www.wonderopolis.org/wonder/why-are-bugs-attracted-to-light.

[15] R. a. Miguel, 2015.