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Design of Automatic Pest Trap using A Yellow-LED bait on Cucumber Plants

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Abstract. Cucumber is a popular plant that is much needed by Indonesian society. The demand for cucumbers tends to increase every year. In cucumber cultivation activities, the biggest challenge is pest and disease attacks. Continuous pest attack causes growth failure for cucumber plants. For this reason, technology is needed that can reduce pest attacks that damage cucumber plants. The design of the technology is an automatic pest trap that uses solar energy so that it can be placed in the field without an additional electricity supply. This study aimed to design a pest insect trapping system for cucumbers using a yellow-LED as bait. The yellow bait used was assembled using yellow LEDs. The pest trap system used a microcontroller integrated E18-D50NK infrared sensor and insect booster fan. The sensor worked to detect the presence of insects, and then the fan pushed the insects into a reservoir filled with water. Tests and observations were carried out for six days (144 hours). The results showed that there were 837 insects detected by the system, while 665 insects entered the reservoir. The number of dead insects in the reservoir was 598 insects. The average duration of falling insects by the fan was 130 seconds. The results of the calculation of the effectiveness between the insects detected and caught were 80.87%.
Keywords: Automatic pest trap, Cucumber, LED-yellow bait, Microcontroller

1. Introduction

Cucumber (Cucumis sativus L.) is an annual plant that propagates by means of a spiral-shaped holder (requires a growth support pole). Cucumber is a plant that can grow in tropical climates. Cucumber plants belong to plants in the Cucurbitaceae (gourd) family such as watermelons and melons [1].Cucumber has a high water content but has a neutral taste (taste bland). Cucumber contains antioxidants and various nutrients such as calcium, vitamin C, iron, vitamin A, vitamin B1, magnesium, potassium, sodium and others. Some of the benefits of cucumber are lowering high blood pressure, skin care, improving digestion, anti-inflammatory, and often used as a food garnish [2], [3].

This cucumber plant is also widely consumed by the people of Indonesia and is quite popular in almost all countries [4]. According to statistical data, the production of cucumber and fruit vegetables in Indonesia in 2014 was 477,989 tons, decreased in 2015, 2016, and 2017 to 447,696 tons in 2015, 430,218 tons in 2016 and 424,917 tons in 2017.In 2018 the production of cucumber fruit vegetables increased slightly from the previous year to 433,931 tons [5], [6], [7]. Cucumber plants can thrive at an altitude of 1000-1200 meters above sea level (MASL). The ideal temperature for growing cucumbers is 21-27 °C. Cucumber plants need full light to grow. Cucumber cultivation soil is loose and has sufficient nutrients. In addition, cucumbers can grow well in 70-85% soil moisture and soil pH in the range of 6-7. Generally, cucumber cultivation is planted in beds with a spacing of 40 cm. Cucumbers can be harvested at the age of 75 days after planting.

In cucumber cultivation, farmers often experience obstacles that can interfere with plant physiological growth. One of these obstacles is the attack of Plant Pest Organisms/insect pests on plant

tissues. Pests that often attack cucumber plants include aphids, trips, whitefly, leaf beetles, caterpillars, leaf-mining flies [8], [9], [10]. Cucumber farmers have done various ways to get rid of insect pests, either traditionally, manually, or using chemical pesticides. However, long-term and excessive use of chemical-based pesticides can have an adverse effect on health. The use of agricultural tools without pesticides will reduce the negative effects that can damage health. Based on the explanation above, it is necessary to use insect pest control devices that do not use chemical pesticides as pest control and are automatic. Therefore, an insect pest trap was designed using yellow light as bait to catch insects. The purpose of this study was to design a pest trap on cucumber plants based on yellow light as bait for insect pests that are sensitive to yellow light. The nature of the yellow light given is that this color resembles the color of a ripe fruit. Yellow light can attract insects to approach the trap. When the insect is in the coverage area, the fan will push the insect into the trap. This system is designed using LED lights and integrated with solar as its energy source.

Several studies have been conducted on pest traps, namely the design of automatic pest traps on cacao plants [11]. Another research is about mechanical traps using colored bait on vegetable plants [12]. Integration of natural pesticide spraying can also be done for pest and disease control [13]. Another research is pest traps implemented on rice plants using a microcontroller [14]. The design of control systems using a microcontroller and artificial neural networks can facilitate the integration between pest traps and nutrient control in cultivated plants. The use of artificial neural networks in the design of control systems makes the level of measurement precision higher [15], [16]. The use of microcontrollers makes it easier for researchers and entrepreneurs to create precise and stable control systems.

2. Materials and Method

2.1. Places, Materials, and Equipment

The research was conducted at the the Laboratory of Agricultural Machinery and Equipment Power of the University of Lampung and the Integrated Field Laboratory of the University of Lampung (Figure 1).

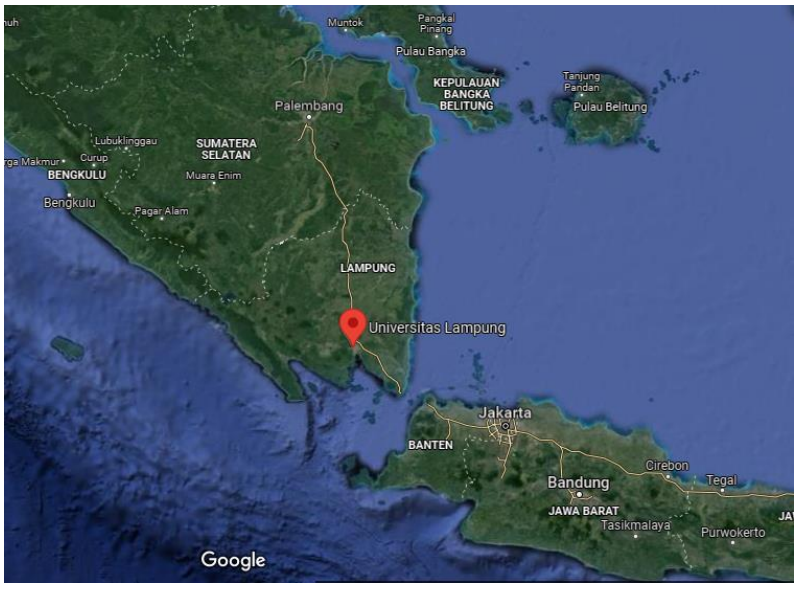

Figure 1. Location of field experiment

The tools used in this research include Eagle schematic program, AutoCAD program, Arduino program, laptop, hacksaw, hot glue heater, soldering iron, welding machine, grinding machine, drilling machine. The materials used are inverters, solar control charge, iron poles, angle iron, aluminum, glue, arduino mega, relays, acrylic, infrared sensors, fans, LED lights, Real time clock, LCD, solar panels, cable and SD card.

This research was carried out for 6 days (144 hours) in cucumber cultivation fields. The system receives data such as the number of insects detected, the time the insect was detected, the time the insect was trapped, and the time the insect entered the reservoir, from each sensor installed in the automatic pest trap. This data is obtained in real time.

2.2. Design and work system

The workings of the yellow light-based insect pest trap system is by utilizing the E18-D50NK type infrared sensor. This E18-D50NK type infrared sensor is placed above the yellow light (sensor position at the top of the trap). Insects that are attracted to the yellow light can be detected by the infrared sensor. The system, which has detected the presence of insect pests, instructs the fan to activate and pushes the insects into the insect container. Insects fall into the container box, counted by another infrared sensor type E18-D50NK (sensor position at the bottom of the trap). This insect container is in the form of a box filled with soapy water, so the insects cannot escape.

In this study, the design of insect pest traps includes the manufacture of electronic trap systems, electronic sensor and actuator systems, power supply assembly, and installation of all components to the microcontroller. When all sensors have been installed, proceed with a series such as re-checking all components so that they work well with each other.

The next stage is the physical design of traps and insect catchers. The material used to make the physical trap is aluminum. This material is used because it is anti-rust and easy to assemble. Physical incorporation of insect traps and electronic systems was carried out prior to testing.

3. Results and discussion

3.1. Design of Insect Pest Traps

Solar panels are used to get renewable energy from sunlight. The solar panel is connected to the voltage control. Electric current flows into the 12 VDC (50A) battery. There are two voltage control lines, namely to the 220 VAC inverter and the 5 VDC step-down regulator. The inverter supplies electric current to the fan, pump and yellow-LED. The 5 VDC stepdown regulator supplies electric current to the microcontroller, sensors, LCD, RTC and MMC. The microcontroller used is the ATmega 2560 microcontroller embedded in the Arduino 2560. The ultrasonic sensor E18-D50NK is connected to digital pins on the Arduino 2560 (Figure 2).

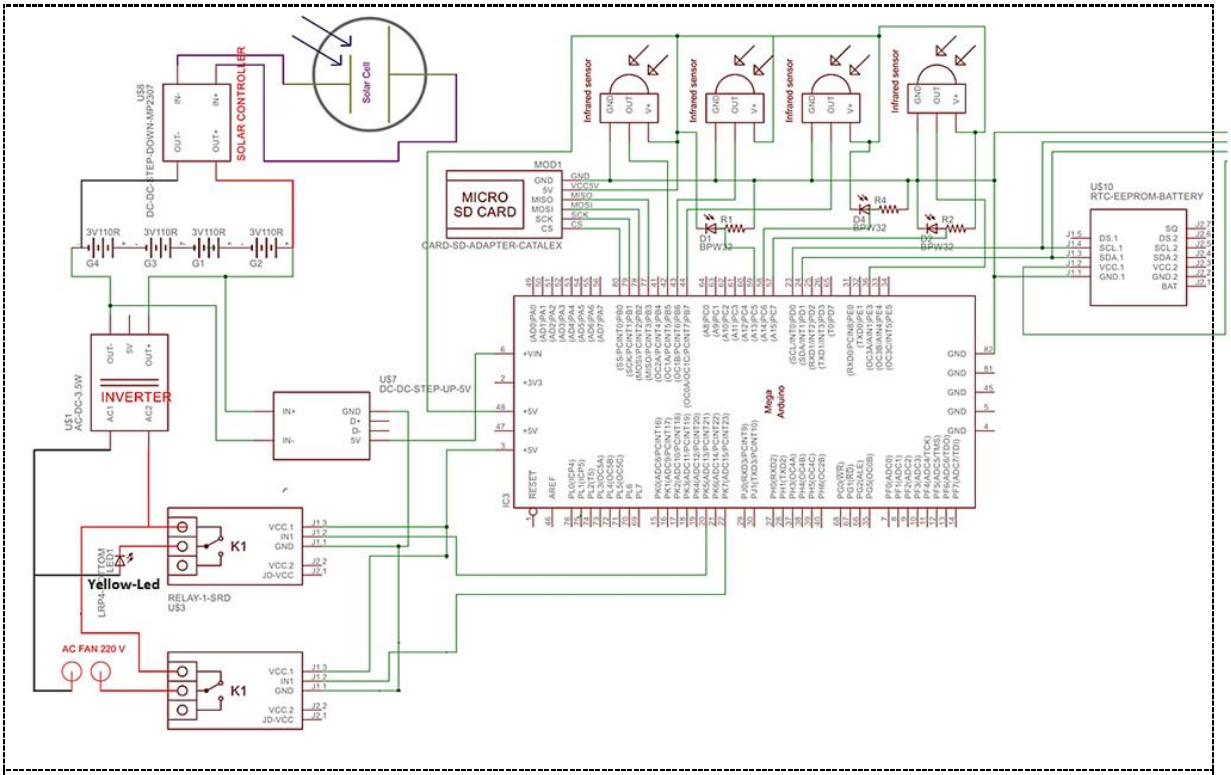

Figure 2. Schematic of automatic pest trap using yellow-LED bait

The automatic cucumber pest insect trap consists of 3 main parts, namely (a) the power supply system, (b) the electronic system, and (c) the physical frame design of the pest trap. The power supply system or power supply is a place to generate electrical energy to turn on cucumber plant pest traps automatically. The power supply section consists of solar panels as a producer of electrical energy, batteries as energy storage from solar panels, inverters, and voltage control. The control system and control box is a place to regulate and control the performance of pest traps. In the control system box, there are components such as Arduino Mega 2560, Arduino Shield, RTC (Real Time Clock), LCD (Liquid Crystal Display), 12 V Relay, 3A adapter, SD Card Reader, jumper cable, terminal cable, memory card. The control system box is placed at the bottom of the power supply box and above the physical pest trap. The control system box is installed at a height of 2.5 m above ground level.

The physical framework of the pest trap is a place where 8 units of the E18-D50NK infrared sensor are installed, where the fan actuator is, where the pump is, where the insect pests fall and are trapped. The physical frame of this pest trap is also where the yellow LED bait is attached. The physical frame of the pest trap is located at the bottom of the control system box. The physical frame of the trap is mounted on the main pole with a height of 1.2 m above ground level (Figure 3).

Figure 3. (a) Automatic trap and Cucumbers plant (b) Yellow LED light on automatic trap

3.2. Testing the Effectiveness of E18-D50NK Infrared Sensor Readings Against Variations in Object Size

Testing the effectiveness of the E18-D50NK infrared sensor readings on variations in object size aims to determine the infrared sensor readings for objects that pass through it. This observation was carried out using rounded paper with sizes of 1 cm, 0.5 cm, and 0.1 cm. Observation of infrared sensor readings can be seen in Table 1.

Table 1. Observation of E18-D50NK

Object Size	Observation	Object Movement	Sensor Reading	Effectiveness (%)
1 cm²	1	5	5	100
1 cm²	2	5	5	100
1 cm²	3	5	5	100
Average				100
0.5 cm²	1	5	5	100
0.5 cm²	2	5	4	80
0.5 cm²	3	5	5	100
Average				93.3
0.1 cm²	1	5	3	60
0.1 cm²	2	5	2	40
0.1 cm²	3	5	2	40
Average				46.7

This test is carried out as a calibration step for insect pest detection using the E18-D50NK infrared sensor. This test is carried out to test the surface size of the smallest object that can be detected by the infrared sensor. The test results show that the percentage of the E18-D50NK infrared sensor that can detect an average surface area of 1 cm² is 100%. The percentage of infrared sensor E18-D50NK can detect the average surface area of 0.5 cm² is 93.3% and the average surface area of 0.1 cm² is 46.7%. From these results it can be seen that, the minimum size of insect pests that can be detected by automatic

cucumber pest traps is 0.1 cm² with an accuracy of 46.7%. The size of the insect pests of 0.5 cm² - 1 cm² can be detected by pest traps at an accuracy of 93 - 100%.

3.3. Results of observations of trapped insects

Observations were made by observing insects approaching the automatic trap, entering the trap, and dead insects. Insect pests that come to the catchment area will be detected by the sensor. The number of insects detected will be calculated by the sensor and stored in the MMC. Next, the microcontroller instructs the fan actuator to activate. The fan pushes the insect pests into the reservoir filled with water. Insects that enter the box container will be counted automatically by the infrared sensor as insects that enter (trapped insects). Dead insects will be counted manually. The reading data of insect pests can be seen in Table 2.

Table 2. Effective working capacity of each weeder

Date	Trap type	Insect Coming (tail)	Insect Entry (tail)	Dead Insect (tail)
28/11/20	Yelow Trap	146	125	112
29/11/20	Yelow Trap	228	154	136
30/11/20	Yelow Trap	121	102	92
01/12/20	Yelow Trap	108	88	85
02/12/20	Yelow Trap	95	76	69
03/12/20	Yelow Trap	139	120	104
Quantity		837	665	598

Based on Table 2, the infrared sensor detected 837 insect pests, 665 insects entered (trapped insects), and 598 insects died (manual measurement results). This observation was carried out for 7 days in the cucumber cultivation area. The bait used uses a yellow LED feed that activates automatically. The graph of the number of insects that come, enter, and die can be seen in Figure 4.

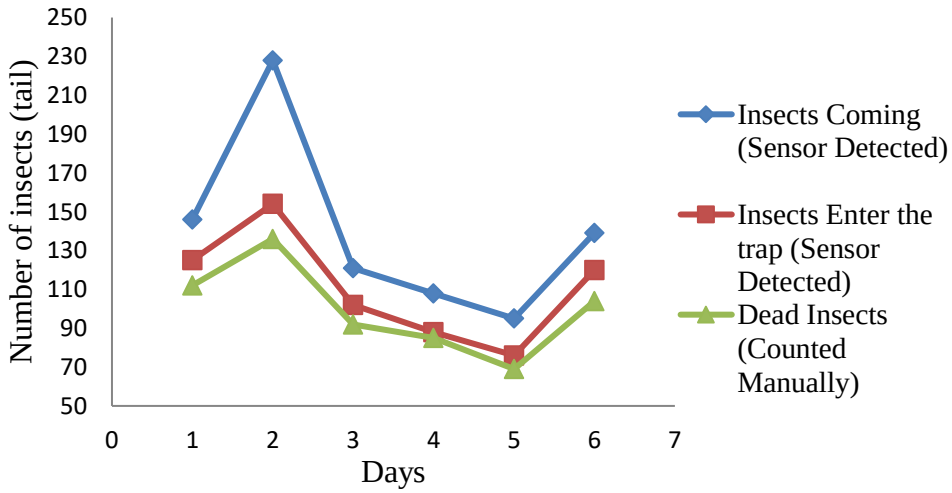

Figure 4. Insect catches using automatic yellow light trap

3.4. The Effectiveness of the Yellow Light Automatic Trap on the Number of Insect Catches

This data is obtained by observing the LCD display on the automatic trap system. The LCD display shows the number of insects detected and the number of insects trapped. The data of detected insects and trapped insects are directly stored in the storage memory card (MMC). The time each insect

is detected and caught is also stored in the MMC. Observations of detected insects, trapped insects and dead insects are carried out in the morning when the pump circulates water in the reservoir. Observational data can be seen in Table 3.

Table 3. Data on the effectiveness of catching insects using automatic yellow light

Date	Trap type	Insect Coming (tail)	Caught Insects (tail)	Insect catching effectiveness (%)
28/11	Yelow Trap	146	125	85,61
29/11	Yelow Trap	228	154	67,54
30/11	Yelow Trap	121	102	84,29
01/12	Yelow Trap	108	88	81,48
02/12	Yelow Trap	95	76	80,00
03/12	Yelow Trap	139	120	86,33
Average				80,87

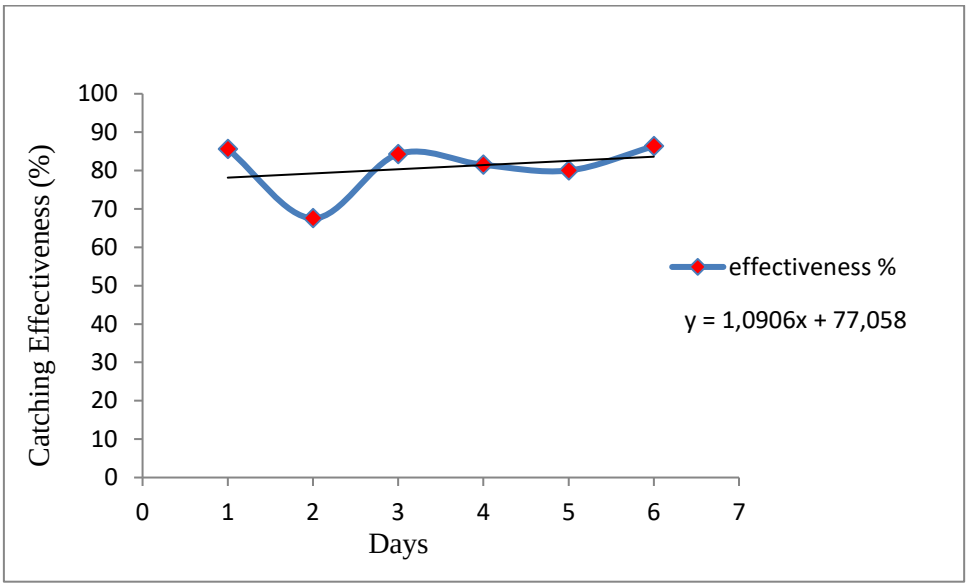

Figure 5. Effectiveness of insect catches using automatic yellow light trap

The mathematical model of the effectiveness of catching insects using automatic pest traps is y = 1.0906x + 77,058. Y is the effectiveness of the catch and X is the day of the catch. From the results of the analysis, the data obtained that the effectiveness of catching insect pests for 6 days using LED-yellow bait is 80.87% (Figure 4). The results of automatic insect trap readings showed that the number of pest insects detected was more than the trapped insects. There are several reasons (a) the insect does not fall into the reservoir but outside the trap. (b) insect flight power (insect maneuverability). One type of insect that is relatively more resilient to air thrust from the fan is the fruit fly. Fruit flies have longer wings and slender bodies [17], [18].

4. Conclusion

Based on the results of research that has been done, has obtained an automatic insect pest trap with a height of 250 cm. Automatic pest traps use solar panels so they can be placed on land that does not have a power source. The trap's physical frame is tubular at the top and conical at the bottom. The diameter of the insect catching chamber is 40 cm and the height of the catching chamber is 40 cm. The top of the automatic trap is 55 cm high with a diameter of 40 cm. At the bottom of the automatic trap is an insect trap box measuring 40 cm x 10 cm x 20 cm. The results showed that automatic trapping resulted in stable measurement performance. The average time of falling insects is 1 minute 40 seconds. The

time of arrival of insects in this study occurred the most at 06.00-08.59 WIB and the least at 12.00-14.59 WIB. The effectiveness of catching insect pests using LED-Yellow is 80.87%.

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