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ADDIE-Based Development of a Solar-Powered Sprayer for Efficient Weed Control in Remote Oil Palm Plantations

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A B S T R A C T

Oil palm plantations in Indonesia demand efficient weed control methods, particularly for large-scale operations in remote areas. Manual pesticide sprayers are still commonly used, but they require high labor, long operating time, and are not energy-efficient. This study presents the design and development of a solar-powered pesticide sprayer using the ADDIE method—Analysis, Design, Development, Implementation, and Evaluation. The prototype consists of a 50 Wp monocrystalline solar panel, two 12V 24Ah VRLA batteries, a DC pump with variable pressure levels, and an Automatic Transfer Switch (ATS) for alternating battery use. The system is mounted on a frame suitable for motorcycle transport to improve field mobility and adaptability in plantation environments. Development followed all ADDIE phases and was validated through real-world field testing. Results showed a 75% reduction in spraying time—from 8 hours (manual) to 2 hours—with a maximum pressure of 70 PSI and a spray reach of 3.5 meters. The ATS allowed uninterrupted operation under varying sunlight conditions. This design offers greater energy efficiency, continuous usability, and flexible deployment compared to similar systems. The findings demonstrate the feasibility of applying solar energy to support sustainable weed management in off-grid agricultural settings, highlighting its potential for broader agricultural mechanization.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq) remains a major agricultural commodity in Indonesia, significantly contributing to national economic growth and employment [1]. In maintaining optimal production, weed control is a key challenge, particularly during the immature growth phase (TBM). Weeds compete with palm seedlings for essential resources such as water, nutrients, and sunlight, while also promoting pest infestation and increasing maintenance costs [2], [3]. These issues are especially prevalent in large-scale plantations located in remote areas, where access to labor and power sources is often limited.

Furthermore, the integration of solar-powered technologies in oil palm plantations not only addresses the immediate challenges of weed control but also presents a sustainable solution to the broader issue of energy accessibility in rural areas. As over 90% of households in many developing regions rely on traditional energy sources, such as wood and charcoal, transitioning to renewable energy can significantly reduce environmental degradation while enhancing productivity in agriculture (Ebhota, 2019). By employing solar-powered sprayers, smallholders can lower operational costs and minimize reliance on chemical inputs, thereby promoting eco-friendly farming practices. This shift not only supports the economic viability of oil palm cultivation but also aligns with global sustainability goals, paving the way for a more resilient agricultural sector in Indonesia and beyond.

Moreover, the implementation of solar-powered sprayers in oil palm plantations could catalyze broader agricultural innovations, particularly in integrating smart farming technologies. By leveraging advancements in the Internet of Things (IoT) and data analytics, farmers can monitor and optimize their weed management practices in real-time, enhancing overall efficiency and reducing chemical usage further [3]. This technological synergy not only improves crop yields but also contributes to environmental sustainability by minimizing the ecological footprint of agricultural practices. As the global demand for sustainable palm oil increases, the adoption of such integrated systems could position Indonesian farmers competitively in international markets, ultimately fostering economic resilience in rural communities [4]. Thus, embracing solar energy not only addresses immediate operational challenges but also aligns with long-term sustainability goals, ensuring the viability of oil palm cultivation amidst growing environmental concerns.

Among the available weed control methods, chemical spraying is the most widely used due to its speed, scalability, and cost-effectiveness [5]. However, the efficiency of this approach is constrained by the tools used for herbicide application. Manual knapsack sprayers are low-cost but require considerable labor and time, making them unsuitable for extensive field operations [6].

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Electric sprayers powered by rechargeable batteries improve ergonomics but are limited by short operational time and long recharge cycles [7]. Meanwhile, motorized sprayers offer higher pressure and coverage but depend on fossil fuels, resulting in higher operational costs and greater environmental impact [8].

To address these challenges, several studies have explored solar-powered alternatives. Efrizal and Annafiyah developed sprayer prototypes using photovoltaic panels and DC pumps with varying tank capacities [9], [10]. Ellianto designed mobile frame systems for ease of deployment in the field [11], and Harahap examined the efficiency of DC pump integration with solar energy [12]. However, these systems generally lack advanced power management, field adaptability, or continuous operation capabilities. Most prior works rely on a single battery and have no switching mechanism, making them unreliable in low-sunlight conditions or extended use scenarios.

To bridge these gaps, this study proposes a solar-powered pesticide sprayer tailored for oil palm plantations. The system integrates a 50 Wp monocrystalline solar panel, two 12V 24Ah VRLA batteries, a DC pump, and an Automatic Transfer Switch (ATS) to alternate battery use. This configuration enables uninterrupted spraying while one battery charges from solar input. The system is mounted on a lightweight, motorcycle-compatible frame to enhance mobility and field applicability.

Development of the system adopts the ADDIE methodology—Analysis, Design, Development, Implementation, and Evaluation—allowing structured prototyping and performance testing. By enhancing energy efficiency, operational continuity, and deployment flexibility, this research contributes a practical and sustainable solution for off-grid weed control in Indonesian oil palm plantations.

METHODS

This research employed the ADDIE development model, which includes five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. This model was selected to ensure a structured and iterative process for developing a solar-powered pesticide sprayer suited for off-grid oil palm plantations.

Analysis

The analysis stage focused on identifying system requirements and evaluating the practicality of a solar-powered pesticide sprayer. A literature review was conducted to support the selection of system components, drawing from national journals and previous studies on Solar Power Plants. This off-grid configuration, which operates independently of the national electricity grid and relies solely on solar energy, was found suitable for remote agricultural applications. Prior studies also provided guidance on component integration and energy regulation relevant to solar-based field instruments.

Surveys conducted in oil palm plantations yielded field data related to weed management challenges, particularly in hard-to-reach areas. As a result, the sprayer was designed with three adjustable power levels to adapt to different weed densities. The system featured a solar panel for charging two 12V batteries, with an Automatic Transfer Switch (ATS) managing the power source. The ATS automatically activated the secondary battery when the primary battery dropped to 11V and returned to the primary once recharged to 12.5V. The entire unit was mounted on a motorcycle frame and equipped with a 70-liter pesticide tank to ensure mobility and extended operation.

Design

It was essential to provide a conceptual framework for the system design to provide a coherent description of the proposed system. Figure 1 illustrates the three components of this design concept: input, process, and output.

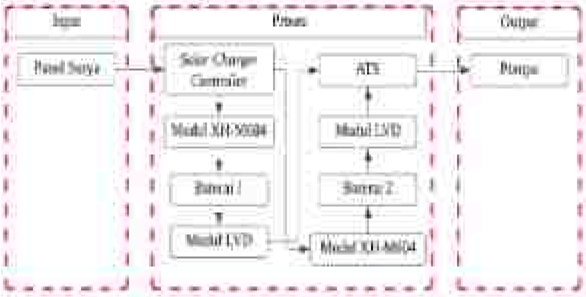

Figure 1. System Design Block Diagram

Figure 1 depicts a solar panel that serves the purpose of converting solar energy into electrical energy. The generated electrical energy was transmitted to the Solar charge controller [13], [14]. A solar charge controller was responsible for regulating the surplus battery charging by monitoring the voltage of the solar panels. Subsequently, the XH-M604 Module from the SCC will be utilised for battery charging control. Battery 1 functioned as the primary power source for the main electrical load. The LVD module was designed to prevent the battery voltage from decreasing. Once the voltage from the battery surpassed the predetermined threshold, the electrical current was automatically interrupted. Battery 1 served as the primary controller for power transfer to battery 2 through the ATS in the event of a drop in battery 1's power. The DC pump operated by transferring the pesticide liquid from the tank to the nozzle for application onto the weeds.

The purpose of the solar panel support design was to determine the optimal placement of the solar panel. [15], [16] The positioning of this support design could be adjusted vertically and horizontally to align with the sun's direction, optimising the voltage output. Nevertheless, the current assistance provided was conducted manually, implying that adjusting the solar panel to face the sun's direction still relied on human effort. Figure 2 displays the design of the solar panel support.

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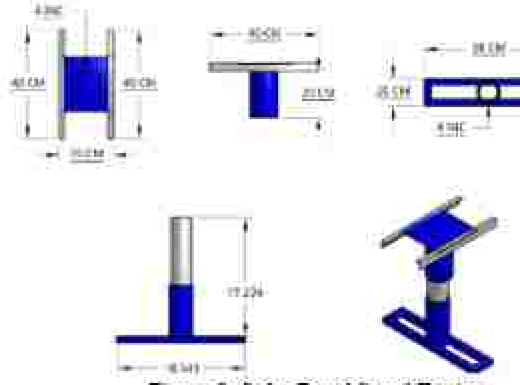

Figure 2. Solar Panel Stand Design

The skeleton design was utilised to determine the arrangement of the components employed. The outcomes of the framework design are depicted in Figure 18. The image revealed that the left side would be positioned within the water tank; on the other hand, the right side would be positioned outside. According to the design illustration, a bulkhead was included to facilitate the transportation of this instrument using a motorbike. Figure 3 displays the outcomes of the instrument frame design.

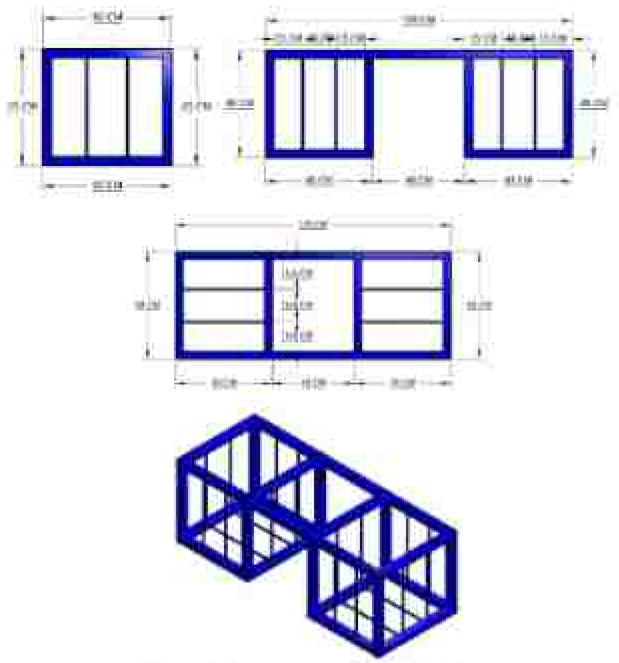

Figure 3. Instrument Frame Design

The overall design followed a structure where each component was strategically positioned. The solar panel was positioned above the other components, which were supported by a support pole. The solar panel's output was directed to the Solar charge Controller. The battery was situated on the left side of the bracket within a panel box. The battery's output was connected to the DC pump, located in the middle of the bracket, to initiate pumping. The output of the DC pump was subsequently channelled through a 50-meter hose positioned on the right side of the bracket. A water tank with a capacity of 50 litres was positioned on the left side. Figure 4 of the weed spraying instrument design displayed the outcomes of the comprehensive mechanical design.

Figure 4. Design of Solar-Powered Weed Sprayer

The schematic circuit of the instrument included visual representations of each component, and instructions on the geometry of the components and cable lines utilised in creating the circuit. Figure 5 displays the schematic circuit.

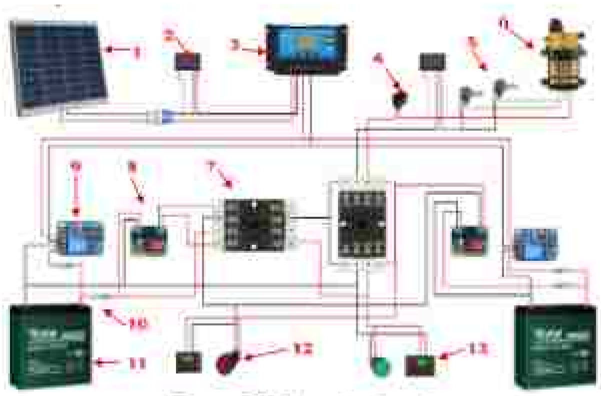

Figure 5. Schematic circuit

Description:

1. Solar Panel: Converts solar energy into electrical energy. The solar panel to be used is the 50-watt Monocrystalline type. This type of solar panel is the most efficient in producing the highest electrical output per unit area. [1].
2. Voltmeter and ammeter: used to determine voltage and current.
3. Solar Charge Controller (SCC): Functions to regulate the overcharging of the battery, knowing the voltage of the solar panel.
4. The switch serves to cut off the current from the battery to the pump.
5. Potentiometer: serves to regulate the current flowing to the pump, to regulate the spray strength.
6. DC pump: Serves to pump the pesticide liquid from the tank to the stick to be sprayed on the weeds.
7. Relay: functions for load controllers such as switches
8. LVD (Low Voltage Disconnect) module: serves to protect the battery from overuse or over-discharge.
9. XH-M604 module: serves to control the charging.
10. MCB: serves to limit the electric current and ensure safety when there is an excessive load.
11. Battery: Serves to store the electrical energy generated by the solar panel and is used to power the pump.

12. Pilot lamp: serves to determine the connection process that occurs.
13. Battery indicator: serves to determine the battery voltage.

Figure 6 depicts the schematic representation of the battery charging procedure. Initially, solar panels capture the energy emanating from the sun and subsequently transform it into electrical energy. The energy produced by solar panels would be regulated by a solar charge controller. Subsequently, the electricity would be directed to the XH-M604 module, which served the same purpose as the solar charge controller in terms of battery charging. However, the XH-M604 module had the additional capability of setting a minimum threshold for battery voltage. Once the battery voltage dropped below the designated threshold of 11 Volts, the XH-M604 module would discharge the battery to initiate the charging process. Once the battery reached its maximum capacity of 13 Volts, the XH-M604 module would immediately interrupt the electrical current flowing into the battery.

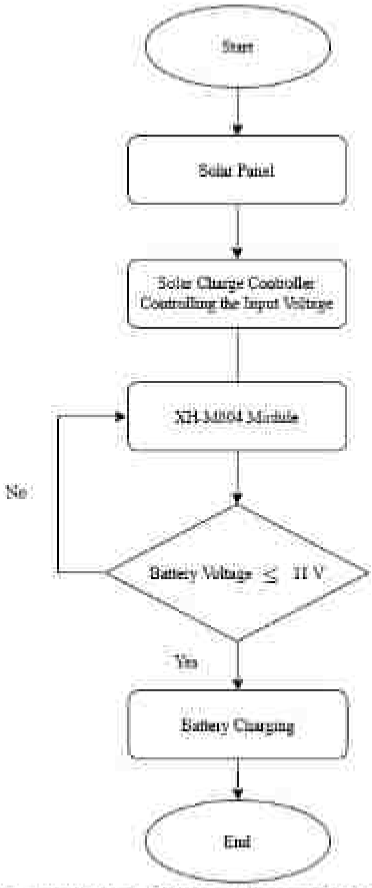

Figure 6. Flowchart of Battery Charging Process

Figure 7 depicts the schematic representation of the battery charging procedure. Initially, solar panels capture the energy emanating from the sun and subsequently transform it into electrical energy. The energy produced by solar panels would be regulated by a solar charge controller [17], [18]. Subsequently, the electricity would be directed to the XH-M604 module, which served the same purpose as the solar charge controller in terms of battery charging. However, the XH-M604 module had the additional capability of setting a minimum threshold for battery voltage. Once the battery voltage dropped below the designated threshold of 11 Volts, the XH-M604 module would discharge the battery to initiate the charging process. Once the battery reached its maximum capacity of 13 Volts, the XH-M604 module would immediately interrupt the electric current flowing into the battery.

Development

The production of this solar-powered pesticide sprayer is divided into three distinct stages: the electrical process, the DC pump assembly process, and the mechanical process.

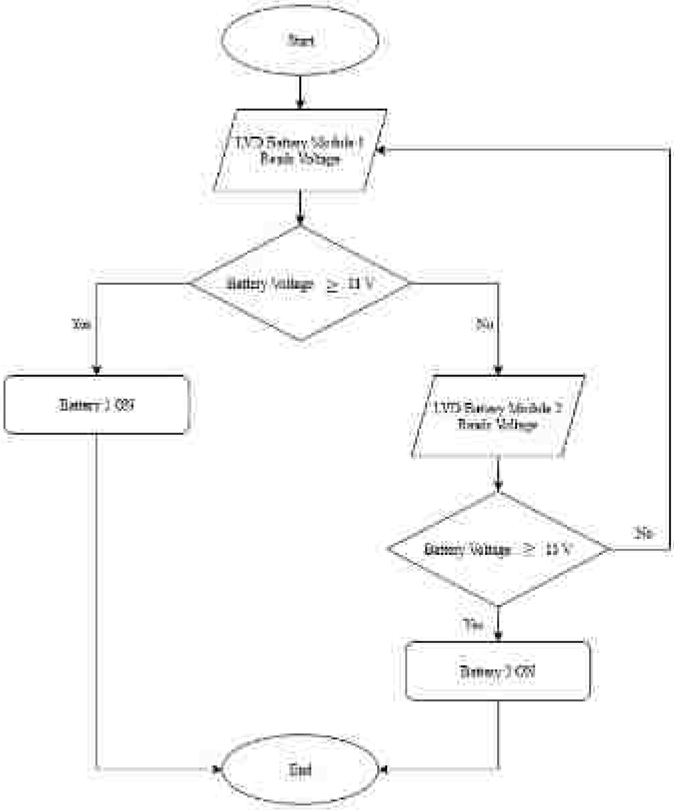

Figure 7. Flowchart of Solar Pesticide Atomiser Working Principle


Figure 8. Electrical circuit

DC Pump Assembly Process

The assembly process of the DC pump involved placing the pump into a panel box with dimensions of 20x30x15 mm. Subsequently, the wiring circuit was assembled, beginning with the installation of the switch, followed by the connection of 2 potentiometers and

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the installation of a voltmeter. Figure 9 displayed the outcome of the assembly of the DC Pump.

Figure 9. DC pump

Mechanical Process

This mechanical process was comprised of three distinct stages: the initial stage involved fabricating solar panel supports, and the second stage involved constructing frames. The final stage involved positioning the entire apparatus. The materials required consisted of welding electrodes, a 3-inch iron pipe, plate iron, 10 mm angle iron, 40x40 mm angle iron, and 40x40 mm hollow iron. The instruments utilised include welding transformers, grinding machines, metres, hammers, and various others. Once the instrument and materials were prepared, proceed to measure and precisely cut the materials based on the dimensions demonstrated in Figure 2 and Figure 3. Following the cutting process, welding was performed per the diagrams depicted in Figure 2 and Figure 3.

Figure 10. Solar Pesticide Atomiser

RESULTS AND DISCUSSION

Implementation

After the pesticide sprayer has been completed, the subsequent stage is to utilise this device to spray weeds in oil palm farms. The oil palm plantation is situated in Rano Village, within the East Tanjung Jabung Regency.

Figure 11. Implementation of Solar Pesticide Atomiser

Considering the execution conducted in a 1-hectare oil palm plantation with a moderate weed infestation, it required approximately 2 hours. Compared to the manual spraying of pesticides by researchers using spray instruments, the process of spraying pesticides in 1-hectare plantations took around a whole day, or approximately 8 hours. Solar-powered pesticide sprayers were manufactured with more efficiency compared to manual sprayers for weed control in oil palm farms.

Evaluation

Throughout history, testing methodologies have consistently evolved to adapt to the always-evolving software and technology. [19]. The testing would be conducted in six sections, which include collecting data on sunshine intensity, testing the solar panels, assessing the endurance capacity of the batteries, evaluating the XH-M604 module, testing the LVD (Low Voltage Disconnect) and ATS (Automatic Transfer Switch) modules, and conducting tests on the DC pump.

Sunlight Intensity Data Collection

The purpose of collecting data on sunshine intensity was to ascertain the degree of sunlight intensity in the Rano village region of the East Tanjung Jabung district. Data collection can be conducted through a light metre or Lux metre measuring device. The data gathering was conducted over two days, namely on February 24th and 25th, 2024. The data for the test measuring sunlight intensity is presented in Table 1.

Table 1. Sunlight Intensity Testing

No.	Sun Conditions				Time Hours)	Day 1 (w/m)^2	Day 2 (w/m)^2	Average value (w/m2)
	Sunny		Overcast					
	1	2	1	2				
1.			✓	✓	09.00	130,8	150,3	140,5
2.	✓			✓	10.00	1561,0	1082,3	1321,7
3.	✓	✓			11.00	1577,6	1197,6	1387,6
4.	✓	✓			12.00	1630,6	1625,0	1627,8
5.	✓	✓			13.00	1648,7	1513,6	1581,2
6.			✓	✓	14.00	408,8	634,5	521,7
7.	✓			✓	15.00	1415,7	610,0	1012,9
8.			✓	✓	16.00	204,8	199,6	202,2

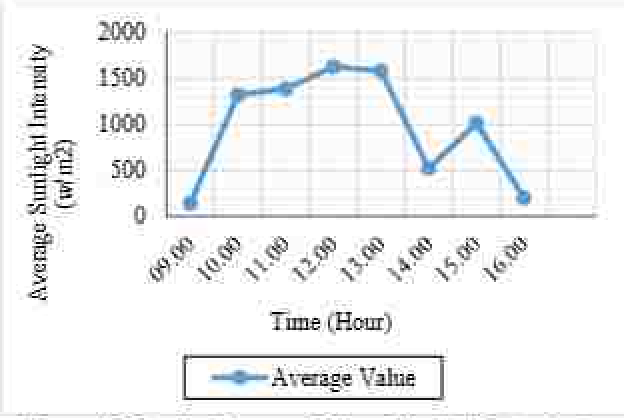

Figure 12. Graph of Average Value of Sunlight Intensity in Rano Village, East Tanjung Jabung Regency

On February 24, 2024, the measurement data demonstrated that the lowest value recorded was 130.8 w/m2 at 09:00; on the other hand, the highest value recorded was 1,648.7 w/m2 at 13:00. On February 25th, the minimum value of 150.3 w/m2 was recorded at 09:00; on the other hand, the maximum value of 1,625.0 w/m2 was recorded at 12:00. The average value acquired at 09.00 for the two days of testing was 140.5 w/m2, which was the lowest. On the other hand, the greatest average value of 1627.8 w/m2 was obtained at 12.00.

Solar Panel Testing

Voltage and current measurements were conducted on solar panels using a Volt Amp metre instrument to assess their performance. Testing was conducted over two days under varying weather circumstances, including sunny and gloomy settings. The voltage and current output of solar panels were tested on the first and second days, and the results can be found in Table 2 and Table 3, respectively.

Table 2. First-Day Solar Panel Testing

No.	Sun Conditions		Time (Hours)	Voltage (Volts)	Current (Ampere)	Power (Watts)
	Sunny	Overcast				
1.		✓	09.00	11,02	0,23	2,53
2.	✓		10.00	11,14	1,97	21,95
3.	✓		11.00	11,47	2,46	28,22
4.	✓		12.00	13,57	2,75	37,32
5.	✓		13.00	13,68	2,85	38,99
6.		✓	14.00	12,57	1,12	14,08
7.	✓		15.00	13,03	2,31	30,10
8.		✓	16.00	12,25	0,56	6,86

On the initial day of February 24, 2024, solar panels were tested. The minimum power output of 2.53 watts was recorded at 09.00 under cloudy sun conditions; on the other hand, the maximum power output of 38.99 watts was recorded at 13.00 under bright sun conditions. Starting on February 25, 2024, during the second day of testing, the power output reached its lowest point of 6.35 watts at 16:00 under overcast weather conditions. Conversely, the highest power output of 31.54 watts was recorded at 12:00 under bright weather conditions.

Table 3. Second Day of Solar Panel Testing

No.	Sun Conditions		Time Hours)	Voltage (Volts)	Current (Ampere)	Power (Watts)
	Sunny	Overcast				
1.		✓	09.00	11,16	0,77	8,90
2.		✓	10.00	11,30	1,14	12,88
3.	✓		11.00	11,80	2,08	24,54
4.	✓		12.00	13,25	2,38	31,54
5.	✓		13.00	13,20	2,21	29,17
6.		✓	14.00	12,93	1,49	19,27
7.		✓	15.00	12,86	1,31	16,85
8.		✓	16.00	12,21	0,52	6,35

During tests conducted in overcast weather circumstances, the voltage generated was higher compared to that created during sunny weather due to a smaller current being produced. The decrease in light intensity reaching the panel and the current constraint imposed by the SCC and XH-M604 Module, due to the battery being nearly fully charged, results in a reduction in voltage and current. Based on the data presented in the table, it was evident that the intensity of sunshine directly influences the fluctuations in power generated by the solar panel. Specifically, a higher intensity of sunlight results in increased power output; on the other hand, a lower intensity of sunlight results in reduced power output. The voltage and current experience a substantial rise as a result of the heightened sunshine intensity, leading to an increase in voltage and current.

Battery Endurance Capacity Testing

The battery's capacity was tested after being fully charged by a solar panel system; on the other hand, its performance was measured when the DC pump is activated. This test was conducted to assess the battery's durability. The DC pump offered three distinct spraying speed levels, each characterised by unique current and voltage specifications. Table 4 displayed the voltage and current measurements at different pump speed levels, and the battery's endurance based on the power of each level.

Table 4. Battery Endurance Capacity Testing

Speed	Voltage (*Volts*)	Current (*Ampere*)	Usage Time
Level 1	11,24	1,13	3.2 Hours
Level 2	11,07	2,45	2.35 Hours
Level 3	10,21	4,88	1.2 Hours

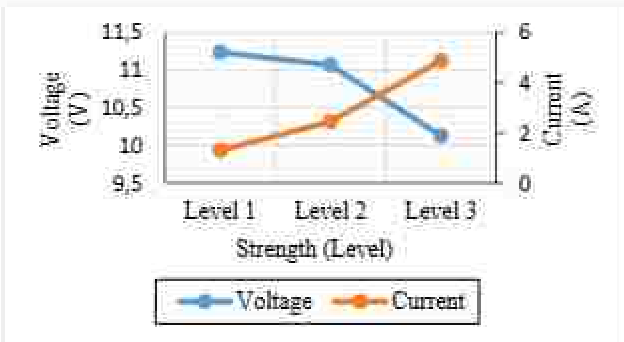

Figure 13. Battery Voltage and Current Graph

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XH-M604 Module Testing

The XH-M604 module was tested to ascertain its capability to conduct charging and discharging voltage functions when the battery level decreases and when the battery is fully charged. This module initiates the charging process when the battery voltage reaches a predetermined level, and once the battery voltage reaches its maximum capacity, the charging current is automatically terminated. The charging status might be observed through an illuminated red LED indicator. Once the battery voltage reached its maximum capacity, the LED would automatically deactivate.

Table 5. XH-M604 Module Testing

No.	Time (Hours)	Battery Voltage 1 (Volts)	Battery Voltage 2 (Volts)	Description	
				Battery 1	Battery 2
1.	09.00	12,4	12,3	No	No
2.	10.00	11,8	12,3	No	No
3.	11.00	11,3	12,3	No	No
4.	11.25	11.0	12,2	Yes	No
5.	12.00	11,6	11,8	Yes	No
6.	13.00	12,1	11,4	Yes	No
7.	13.35	12, 5	11.2	No	Yes
8.	14.00	12,1	11,4	No	Yes
9.	15.00	11,7	11,8	No	Yes

Testing the LVD (Low Voltage Disconnect) and ATS (Automatic Transfer Switch) Modules

This test was conducted to ascertain the functionality of the LVD module at a battery voltage of 11V. Additionally, the ATS circuit was tested to verify its ability to switch from battery 1 to battery 2 once battery 1 has reached 11V. The operational status of each battery could be determined by observing the LED on the module and the pilot lamp situated on the panel door. When battery 1 was operational, the green indicator light was illuminated. However, when the voltage shifted to battery 2, the red indicator light was illuminated instead; on the other hand, the green indicator light was turned off. Once battery 1 reached a voltage of 12.5 V after being recharged, the voltage would immediately be restored to battery 1.

Table 6. Testing of LVD (Low Voltage Disconnect) and ATS (Automatic Transfer Switch) Modules

No.	Time (Hours)	Battery Voltage 1 (Volts)	Battery Voltage 2 (Volts)	Description	
				Battery 1	Battery 2
1.	09.00	12,4	12,3	On	Off
2.	10.00	11,8	12,3	On	Off
3.	11.00	11,3	12,3	On	Off
4.	11.25	11.0	12,2	Off	On
5.	12.00	11,6	11,8	Off	On
6.	13.00	12,1	11,4	Off	On
7.	13.35	12, 5	11.2	On	Off
8.	14.00	12,1	11,4	On	Off
9.	15.00	11,7	11,8	On	Off

According to the tests that were conducted, the LVD module and ATS circuit demonstrate proper functionality and operate within set parameters. The shift from battery 1 to battery 2 took place at 11 minutes and 25 seconds when battery 1 reached its lower limit of 11.0 Volts. At this point, battery 1 was automatically turned off, and battery 2 was turned on. Once battery 1 reached a voltage of 12.5 Volts, it would turn on; on the other hand, battery 2 would turn off.

DC Pump Testing

DC pump testing experiments involved initiating the pump and measuring the resulting water pressure. A pressure gauge was employed to quantify the magnitude of water pressure. Table 7 displayed the outcomes of the DC Pump test.

Table 7. DC Pump Testing

No.	Power	Voltage (Volts)	Current (Ampere)	Power (Watts)	Water Pressure (PSI)
1.	Level 1	11,24	1,13	12,70	30
2.	Level 2	11,07	2,45	27,12	50
3.	Level 3	10,21	4,88	49,82	70

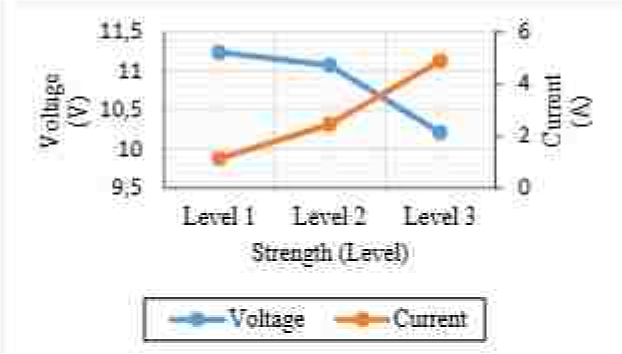

Figure 14. DC Pump Voltage and Current Graph

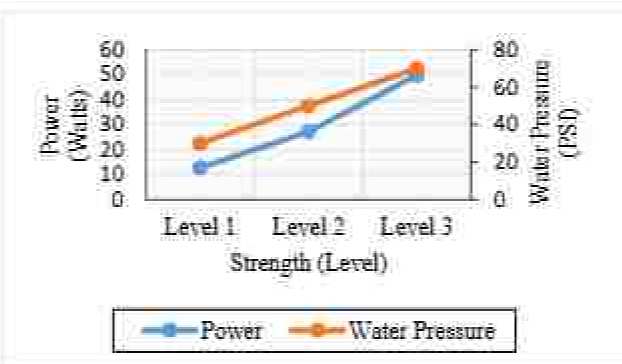

Figure 15. Power and Water Pressure Chart of DC Pump

The spray distance generated by solar pesticide sprayers at 3 distinct power levels is presented in Table 8. Each power level served a distinct purpose based on the presence of high or low levels of weeds in oil palm farms. Level 1 strength was suitable for controlling weeds that have low and thin growth. Level 2 strength was recommended for medium-sized weeds; on the other hand, level 3 strength was necessary for tall and thick weeds. This ensured that sufficient pressure was used to evenly moisten the weeds, resulting in optimal effectiveness. Level 3 could

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effectively target and remove weeds that were located at a considerable distance and are challenging to access.

Table 8. Spray Distance

No.	Power	Water Pressure (PSI)	Distance (Metres)
1.	Level 1	30	1,7
2.	Level 2	50	2,7
3.	Level 3	70	3,5

Discussion

This study focused on the development of a solar-powered pesticide sprayer specifically designed for weed management in oil palm farms. The measurement of sunshine intensity yielded a total average value of 974.4 w/m2. The magnitude of the intensity generated was contingent upon the state of the sun. A two-day solar panel testing was conducted, and the maximum power output of 38.99 watts was achieved at 13:00 on the first day. When evaluating the battery's endurance, the battery life was directly influenced by the power level. The higher the power level, the greater the current, resulting in a faster depletion of the battery. During the testing of the XH-M604 module, it was observed that the module functions optimally when the battery voltage hits 11V [20], [21]. At this point, the module initiated the charging process. Once the battery voltage exceeds 12.5V, the module ceases the charging operation. Verifying the functionality of the Low Voltage Disconnect (LVD) module and Automatic Transfer Switch (ATS) circuit was contingent upon battery 1 attaining a voltage of 11V. Once this threshold was reached, the LVD module would interrupt the voltage supply, prompting the ATS circuit to initiate the transfer of electricity to battery 2[22], [23]. Subsequently, when battery 1 was recharged to a voltage of 12.5V, the electricity flow would revert to battery 1. During the testing of the DC pump, it was observed that increasing the power level directly correlated with an increase in water pressure and a longer distance covered by the spray [24], [25]. Through the process of manufacturing and testing this herbicide, the sprayer demonstrates optimal functionality, with each component operating as intended and without any signs of damage.

Trials conducted in oil palm plantations with an area of 1 hectare and a moderate weed presence indicate that it takes approximately 2 hours. Compared to the manual spraying of pesticides by researchers, the task of spraying pesticides in 1-hectare plantations takes around a whole day or approximately 8 hours [24], [26]. Therefore, this instrument exhibits a fourfold increase in speed compared to manual sprayers, so greatly enhancing the capacity to eliminate the prevalent issue of weeds in the neighbourhood.

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In addition to its advantages, this instrument also has drawbacks, such as its bulky size and the prolonged battery charging time during overcast weather or in shady land conditions. In order to conduct more extensive research, it is necessary to find a method to optimise charging efficiency even under overcast weather conditions. Furthermore, this instrument can be enhanced by extending the hose length to broaden the range of weed spraying and incorporating 100WP solar panels to expedite battery charge.

CONCLUSIONS

This study involved the development of a solar-powered pesticide sprayer specifically designed for weed management in oil palm fields. During the analysis stage, it was determined that the Off-grid SOLAR POWER PLANTS system was well-suited for constructing solar pesticide sprayers due to its self-sufficiency in electricity, eliminating the need for an additional power source. According to the results of the instrument testing, it was expected that all components would function correctly. After conducting tests on a 1-hectare oil palm plantation that had a reasonable amount of weeds, it was determined that it takes approximately 2 hours. The time necessary for spraying pesticides in a 1-hectare plantation using a manual sprayer instrument was approximately 8 hours. This pesticide sprayer was highly efficient because of its faster spraying time for weeds compared to a manual sprayer, and its ability to cover a broader area.

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