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FABRICATION AND ANALYSIS OF A SOLAR-POWERED SPRAYER WITH VARIOUS USES FOR AGRICULTURE

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Abstract
The agricultural pesticide sprayer that is the subject of this innovation is powered by solar energy. The device is comprised of a 20-watt solar panel, a 12-volt DC battery that is charged by solar radiation captured by the panel, a DC motor that runs on the battery power, a pump that applies pesticide, and a tank that stores the pesticide (in liquid or solution form). The equipment may be operated by a single laborer and is fully portable. Sprayer discharge rates were measured in both laboratory and outdoor settings; the average discharge rate was roughly the same in both, averaging 0.023 l/s (82.8 l/h) in both scenarios. The sprayer's performance was assessed when it was being used to spray various crops in farmer's fields, including cotton, green gram, onions, and so forth. With the operator walking at approximately 2.8 km/h and the sprayer's swath width of 0.6 m, the theoretical field capacity is approximately 0.17 hectares per hour. The sprayer's effective field capacity was found to be 0.14 ha/h, or an average coverage of 1 ha per day during an 8-hour operation. Because the equipment is operated by the user and doesn't rely on any other external power source, it decreases manual labor and is both cost-effective and environmentally benign. Small and marginal farmers can easily afford the solar energy it consumes. Its electricity can also be utilized for multiple purposes, like as lighting up the house, charging a mobile device's battery, and running a radio, making it a more commercially feasible technology.

Keywords:
Discharge rate, Solar energy, Agricultural pesticide sprayer, Effective field capacity, Eco-friendly technology,

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Introduction

Pesticide applications with the use of spraying apparatus are significant. Chemicals are frequently employed to improve bug and pest control, therefore boosting agricultural output. One of the best and most efficient methods for protecting crops from small amounts of liquid that are applied in tiny droplets is spraying. Numerous models of electric and hand-operated spraying devices are in use in India. Currently, farmers use a variety of manually operated backpack sprayers, which can cover 0.4 hectares per hour, and motorized sprayers, which can cover 1.2–1.6 hectares per hour, to apply pesticides to crops like red gram and cotton. Farmers are dealing with the challenge of a huge area being covered in a short amount of time due to the seriousness and rapidity of the pest invasion.

[1]There are various tractor-driven and bullock-operated sprayer models on the market. Farmers typically use manually operated or motorized sprayers to cover huge areas quickly, usually six to eight times a season. Crop output will rise significantly with the use of modern spraying techniques, which will also increase operator comfort, safety, and spraying efficacy.

[2] The power needed for spraying is typically provided by mechanical power, such as a petrol engine or two fuel engines running the pump, or by a combination of individuals and mechanical forces. Occasionally, the motor that drives the pump that releases the chemicals is powered by the batteries. However, to charge these batteries, electricity is needed. But because fossil fuels are becoming more and more expensive, and because they are becoming scarcer, more people are realizing how urgent it is to develop devices that use renewable energy. [3] There are frequent power outages due to insufficient electricity supplies, and the situation is much worse in rural areas. (Figure 1) As a result, there is more room to use solar energy to generate electricity using solar photovoltaic cells and to use it for other purposes like lighting, water pumping, spraying, etc.

Fig 1 Solar - Powered Agricultural Sprayer

[4] created a hand-held sprayerSolar-Powered prototype with a high voltage circuit that had a cut output of 15-20 KV for a 6 V input. The charging circuitry included a multimeter and an inverter. The malathion kerosene sprayers produced droplets that ranged in size from 10

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to 250 micrometers. Analysis was done on how power and flow rate affected the droplet spectrum.

[5] created a tall tree sprayer for coconuts that is powered by a tractor. The apparatus was made up of GI pipes that are telescopic and can reach heights of 8 to 14 by winding a cord. Through a passing valve and pressure relief, the chemical tank's sprayer fluid is directed out of the gun.

[6] reported power for using a bullock to pull a multipurpose tool carriage with an animal dragged for spraying. A pair of bullocks can provide between 0.8 and 1.5 horsepower, and the average power needed to run the sprayer was 0.48 horsepower. The tractor sprayer is simply operated by the two bullocks.

[7] revealed that a microcomputer-based sprayer control system was retrofitted into a traditional air carrier orchard sprayer. Sprayer deposition from controlled sprayers was found to be lower at the same sites, and a foliage volume measurement method based on each side of the sprayer was optimized by comparing controlled vs uncontrolled sprayer operation.

[8] conducted a test to determine the effectiveness of three distinct sprayers: hand compression, spinning disc, and air-assisted power. The spray characteristics showed that for low-volume sprayers, the ratio of volume mean diameter (VMD) to normal mean diameter (NMD) was almost equal to unity, followed by power sprayers (1.39) and manual compression (1.33). In terms of controlling the pests under study, the power sprayer proved to be more effective than both low-volume sprayers and hand compression.

[9] evaluated a double-acting rocking sprayer (DARS) by comparing its performance to that of a single-acting and two conventional rocking sprayers. Even if the field coverage DARS was improved, the amount of manual energy required increased only a little and fell into the category of "light work" when it came to human energy consumption. [10] Considering the aforementioned considerations, a solar-powered sprayer featuring several uses, such as radio operation and mobile phone charging, has been created.

Materials and Methods

The Department of Farm Machinery and Power Engineering, University of Agricultural Sciences (UAS), Raichur, Karnataka, India, devised the design and manufactured the solar-operated sprayer. [11] Through the use of a solar PV cell, the solar sprayer gets its electricity from the sun.

A DC motor is powered by a 12 V DC battery that is charged by this cell. This motor turns on a pump, which then forces pesticide—which has been stored as a liquid or solution—through a nozzle to produce a spray. The detailed construction of the solar sprayer is shown in Figs. 1 and 2.

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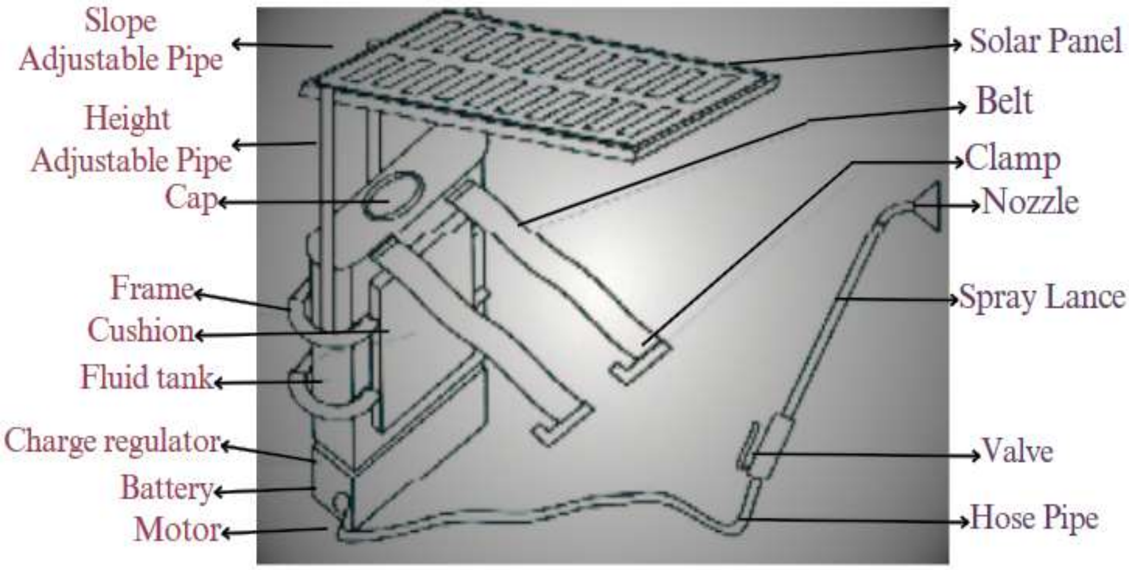

Fig 1: An isometric picture of a solar-powered sprayer

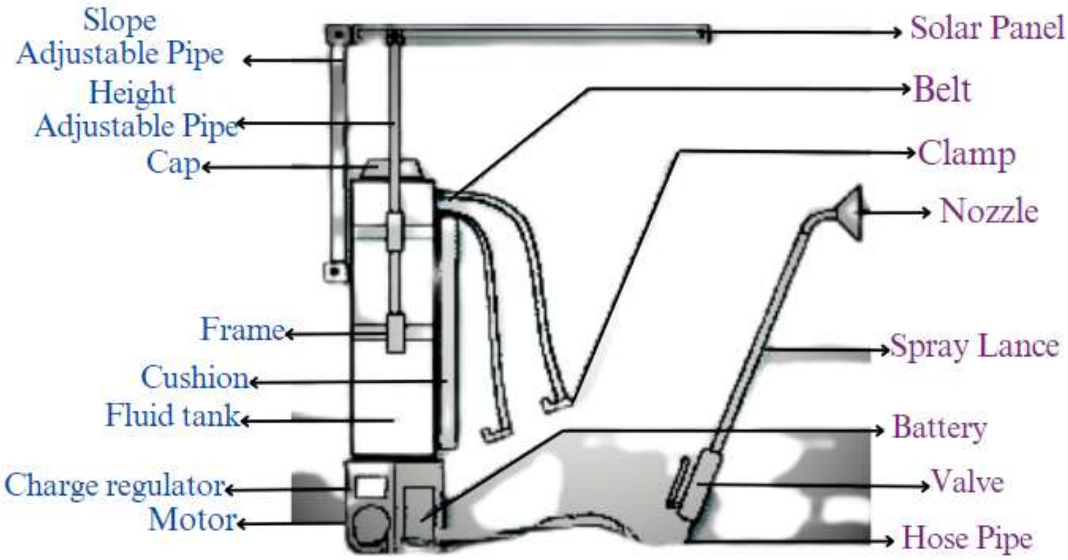

Fig 2: A side view of a sprayer powered by solar power

The spray unit also comes with a belt, a set of clamps for attaching the entire apparatus to the operator's back, and a cushion pad that is bonded to the tank to act as a cushion while the entire apparatus is lying on the operator's back. [12] A clearer and more comprehensive knowledge of the unit's structure can be obtained from Fig. 2, which depicts the unit's cross-section.

Electrical Connections in Circuits:

The circuit diagram for the electrical links used in the solar sprayer's design is described. It displays a solar PV cell (A), a simple solar cell that transforms solar radiation hitting a solar panel into an electrical voltage; a voltage regulator (B) that sets the voltage to the necessary

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12 V; a 12 V battery (C) that produces a consistent voltage across the battery's terminals; and a 12 V DC motor-pump (E) that is powered by the battery. The motor pump can be turned on or off using the switch (F). Additionally, a spare socket (G) is offered for any additional uses, such as charging a cell phone or a CFL battery. The terminals and the current flow direction are displayed.

System of Power Transmission:

The insecticide is pumped out in the shape of a spray by a DC motor (E) that is activated by the electricity produced by the solar PV cell (A) charging the battery (B). [13] Through the use of a solar PV cell, light energy is transformed into electrical energy when solar radiation strikes a solar panel. (figure 3) It produces roughly 17 volts, which a voltage regulator then adjusts to the necessary level of roughly 12 volts.

Fig 3: sprayer with solar power shown from the back

Current is sent from the regulator to a 12V D.C battery for storage and recharge. The 12V D.C. motor pump, which uses a centrifugal arrangement to pump the spray fluid, is activated by the battery. (figure 4) The D.C. motor pump receives sufficient power from the battery to spray a consistent volume of spray fluid.

The solar-operated sprayer sample was built using the following component requirements (table 1):

Table 1 Characteristics of the device

Solar Panel	Battery	Motor	Mini charge regulator	Tank capacity	The overall dimension of the unit
Normal peak power: 20 W Peak power	Voltage: 12 V Current: 7	Motor speed: 1600 rpm Operating current: 7	12 – 17 V	18 Liters	480 mm x 820 mm

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voltage: 17 V Size: 0.5m x 0.3m Weight: 1 kg	A Output power: 84 W Weight: 2 kg	A Operating power: 82 W Operating voltage: 12 V Weight: 1 kg			**Weight:** 10 kg

A defined area measuring 92.3 m in length and 4 m in breadth was sprayed in preparation for field testing. Green gram was the crop type selected for spraying; the field's average plant height during the spraying operation was recorded at 30-35 cm, with a spacing of 15 cm. The operator's average walking pace was found to be 2.769 km/h. [14] The spray output was recorded at 0.023 liters per second (82.8 liters per hour). It took 17.00 minutes to spray the fluid in the predetermined area (92.3 x 4 m).

Figure 5 displays the field assessment of the solar-operated sprayer. Numerous factors were computed, including effective field capacity, total width, field efficiency, and theatrical field capacity. The entire plot is covered with row crops by spraying them side by side.

Fig-4: View from above of solar-powered sprayer

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Fig-5: solar-powered sprayer in action

Applications of solar-powered sprayers for multiple uses

The designed solar-powered sprayer has multiple applications. When it comes to backpack sprayers, whether they are powered or manually operated, they are only utilized in the field when it is time to spray; otherwise, they sit inactive. [15] However, the solar sprayer can be utilized in the field as well. The socket that is included in the solar sprayer, which is seen in Fig. 6, can be used for multifunctional applications such as radios, cellphones, and 18-watt CFL lights at night.

Results and Discussion

Both in the lab and in the field, the performance was assessed, and the findings were examined. (figure 7)The theatrical field capacity, discharge rate, field efficiency, and actual field capacity were used to evaluate the spray's performance. The information concerned the operator's speed.

Fig-6: Applications of solar-powered sprayers for multiple uses

This lead acid battery is attached to a 12V DC motor, which transforms electrical power

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into mechanical power.

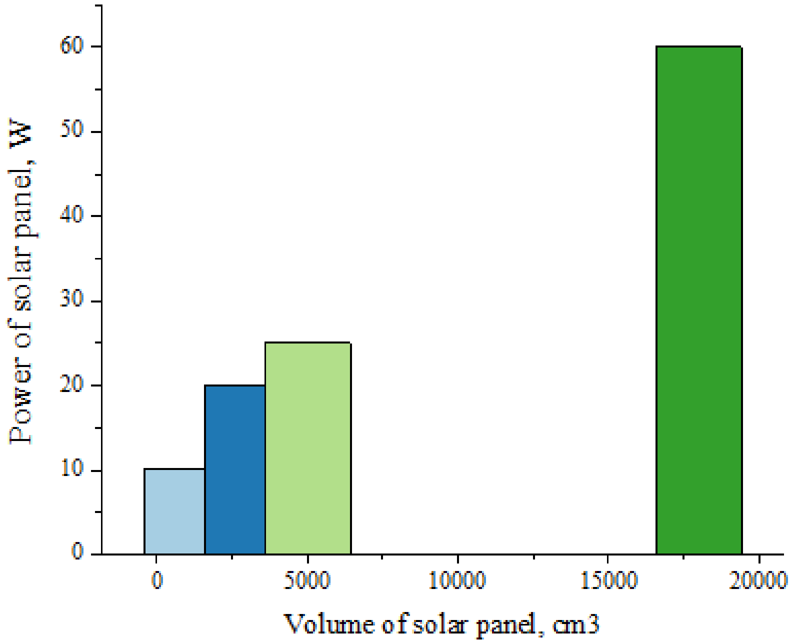

Fig.7 Relation between Power and volume of the solar panel

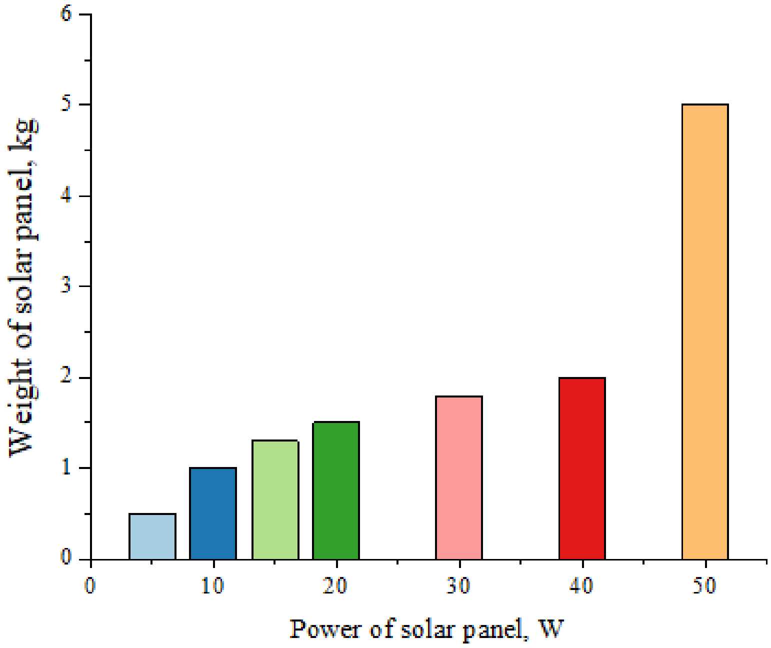

Fig.8 Relation between Power and Weight of the solar panel

The solar sprayer's discharge rate was studied in both laboratory and outdoor settings. (Figure 8) The average discharge rate was roughly the same in both scenarios, coming in at 0.023 liters per second (82.8 liters per hour). A theoretical field capacity of roughly 0.17 hectares per hour may be calculated using the operator's walking velocity of approximately 2.8 km/h and the sprayer's 0.6 m swath width. The sprayer's observed effective field coverage was 0.14 ha/h, corresponding to an 8-hour operation that covers 1 ha on average per day. There isn't another external power source used by the apparatus.

Conclusion

For spraying, a solar-powered sprayer was created that draws power from the sun. It is composed of a 20 W solar panel, a 12V DC battery, a DC motor that runs on the battery, a pesticide-spraying pump, and a pesticide-holding tank. According to the sprayer's performance evaluation, its effective field capacity was found to be 0.14 ha/h, or an average coverage of 1 ha per day during an 8-hour operation. Because the equipment is operated by the user and doesn't rely on any other external power source, it decreases manual labor and is both cost-effective and environmentally benign. Small and marginal farmers can easily afford the solar energy it consumes. Its electricity can also be utilized for multiple purposes, like as lighting up the house, charging a mobile device's battery, and running a radio, making it a more commercially feasible technology.

Abbreviation

APS – Agriculture Pesticide Sprayer
EFC – Effective Field Capacity
SE – Solar Energy
VMD – Colume Mean Diameter
NMD – Normal Nean Diameter
DARS – Double Acting Rocking Sprayer
UAS – University of Agriculture Sciences

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable

Ethics approval and consent to participate

Not applicable

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Availability of data and materials

Not applicable

Authors' contribution

Author A supports to find materials and results part in this manuscript. Author B helps to develop literature part.

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