Development and Evaluation of Solar Powered Sprayer with Multi-Purpose Applications

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ABSTRACT

This invention is about an agricultural pesticide sprayer, which uses solar energy as source of power for spraying. It consists of a solar panel of 20 W capacity, a 12V DC battery, charged by solar energy received by the solar panel, a DC motor, operated by the battery, a pump, to spray the pesticide and a tank to hold the pesticide (in the form of solution / liquid). The entire unit is portable and is operated by one labour. The discharge rate of the sprayer during laboratory and field conditions were measured, the average discharge rate during both laboratory test and field test were more or less same which was about 0.023 l/s (82.8 l/h). The performance evaluation of the sprayer was carried out for spraying in different crops viz., cotton, green gram, onion etc in farmer's fields. The walking speed of the operator is about 2.8 km/h and swath width of the sprayer is about 0.6 m, which corresponds to a theoretical field capacity of about 0.17 hectare per hour. The effective field capacity of the sprayer was observed to be 0.14 ha/h which corresponds to an average coverage of 1 ha/day of 8 hours operation. As the equipment does not use any other external source of power and that it is operated by the user himself, it reduces drudgery, is quite economical and eco-friendly as it uses solar energy which can be easily affordable by small and marginal farmers. Further, its power can also be used for multi- purpose applications such as charging the battery of mobile, operating the radio and lighting the domestic light etc., which makes it more economically viable technology.

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

INTRODUCTION

The applications of pesticides using spraying equipment play an important role. The chemicals are widely used for increasing agricultural production through better insect and pest management. Spraying is one of the most effective and efficient technique for applying small quantity of liquid through fine droplets to protect the crops. In India, many versions of hand operated and power operated spraying equipments are being used. At present, the farmers generally using all kinds of manually operated knapsack sprayer which can cover 0.4 ha/hr and motorized sprayer can cover 1.2-1.6 ha/hr for spraying of pesticides on crops like cotton, red gram. Farmers are facing the problem of coverage of large area within a short period of time as the pest attack is serious problem and spreads quickly.

In the market, different versions of tractor operated or bullock operated sprayers are available, many of the farmers generally spray 6-8 times in a season using manually operated or motorized sprayer to cover large area within a short period of time. Modern spraying technique will improve the operators comfort, safety and spraying effectiveness which would go a long way in increasing crop yield.

Generally the power required for spraying is met out from either alone or combination of human source and mechanical power viz., either petrol engine or dual fuel engines for operating the pump. Sometimes the batteries are used for running the motor which operates the pump for discharging the chemicals. But these batteries require electricity for charging them. However, due to rapid rise in the price of fossil fuels and their limited availability, there is now greater awareness of the need for development of renewable energy gadgets, which is the need of the hour. Because of inadequate supply of electricity, there is a frequent power cut and this situation is shill worse in the rural areas. Hence, there is a greater scope for utilization of solar energy for generation of electricity using solar photovoltaic cells and further to utilize the same for spraying, water pumping, lighting etc.

Chandra D and Gajendra S, (1993) developed prototype hand held sprayer using a high voltage circuit of an cut output of 15-20 KV for an input of 6 V the charging circuitry consisted of an inverter and multi meter. Droplet produced by the sprayers with nalathian kerosene was of size 10-250 micrometer. The effect of voltage and flow rate on the droplets spectrum was analyzed.

Manion and Kathirvel, (2002) developed a tractor operated tall tree sprayer for coconut. The unit consisted of telescopic GI pipes which can extend from 8-14 high by winding a cable. The sprayer fluid from the chemical tank is guns through pressure relief and by pass valve.

Mourya. N.L. and Devaddattam D.S.K, (1985) reported power regarding of bullock for operating animal drawn multipurpose tool carrier for spraying. The average power required to operate the sprayer was 0.48 hp on average pair of bullock can produce about 0.8 to 1.5 hp. The pair of bullock can easily operate the tractor sprayer.

Giles *et al.* (1988) reported that a conventional air carrier orchard sprayer was retro fitted with a micro- computer based sprayer control system. A foliage volume measurement system based on each side of the sprayer was controlled by comparison between controlled verses uncontrolled sprayer operation, sprayer deposition from controlled sprayer was found to be reduced at same locations.

Nanda *et al.* (2008) conducted experiment on efficacy of different sprayers viz., spinning disc sprayer, hand compression sprayer and air assisted power sprayer. The spray characteristics revealed that the ratio of volume mean diameter (VMD) to normal mean diameter (NMD) was near to unity in case of low volume sprayer followed by hand compression (1.33) and power sprayer (1.39). The efficacy of power sprayer was comparatively better than that of hand compression and low volume sprayer in controlling the pests studied.

Adarsha K and Sirohi, (1999) tested a double acting rocking sprayer combining two conventional rocking sprayer and single acting sprayer for comparative performance. While the field coverage double acting sprayer was enhanced the increase in the manual energy requirement was marginal and was within the "light work" category of human energy consumption.

Keeping the above points in view, a solar operated sprayer with multipurpose applications like operating radio, charging the mobile etc., has been developed.

MATERIALS AND METHODS

A concept was developed for the solar operated sprayer and it was fabricated in the Department of Farm Machinery and Power Engineering, University of Agricultural Sciences (UAS), Raichur, Karnataka, India. The solar sprayer uses solar energy as source of power, in the form of a solar PV Cell.

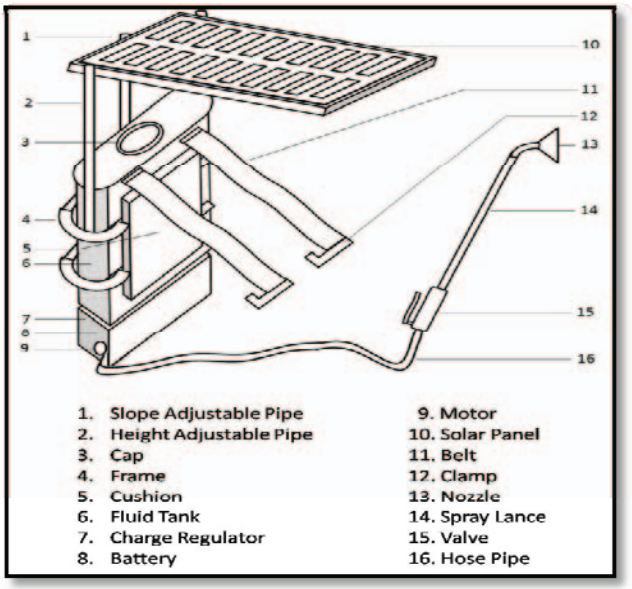

Fig-1: Isometric view of solar operated sprayer

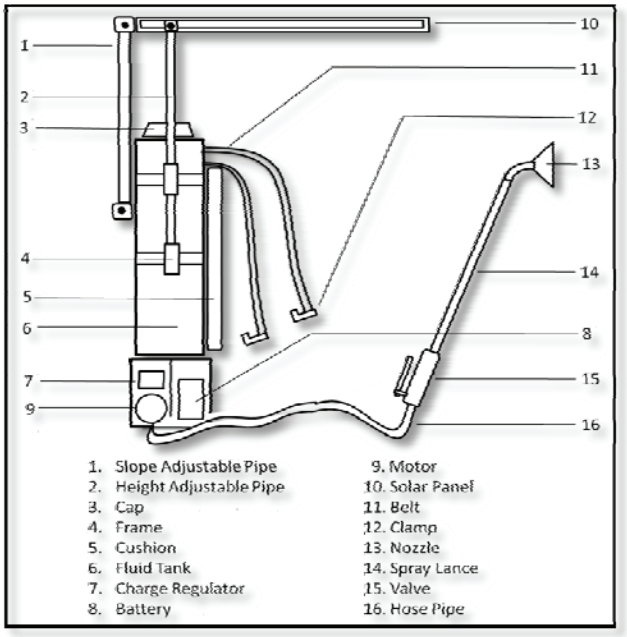

Fig-2: Side view of solar operated sprayer

This cell charges a 12 V DC battery which, in turn, operates a DC motor. This motor activates a pump which further pumps pesticide, stored in the form of a solution / liquid, through a nozzle, thereby, creating a spray.

Fig-1 and Fig-2 shows details construction of solar sprayer. It consists of a slope adjustable pipe (1) to adjust the slope / angle of solar panel (10), height adjustable pipe (2) to adjust the height of panel from the ground, a fluid tank (6) with a cap (3) to hold the pesticide in the form of liquid / solution, a metallic frame (4) enclosing the tank and to which height adjustable pipes are fixed, a 12 V battery (8) and charge regulator (7) compartment, fixed to the frame at the bottom of the tank, a 12 V DC motor-pump (9), a spray lance for spraying the pesticide. The spray lance (14), in turn, consists of sufficiently long hose pipe (16), a spray nozzle (13), a valve (15) for starting and stopping the spray and also to control the flow rate of spray. The spray unit is also provided with belt (11) and a set of clamps (12) to fasten the entire unit to the back of the operator and also a cushion pad (5), glued on the tank, to provide cushioning effect when the entire unit is resting on the back of the operator. From Fig-2, which shows the cross section of the unit, provides a better and clear understanding of the construction of the unit.

Circuit Electrical Connections: Fig-3 shows the circuit diagram of the electrical connections, involved in the designing of the solar sprayer. It shows a solar PV Cell (A), basic solar cell unit which converts solar energy (solar radiation impinging on the solar panel) to electrical voltage, a voltage regulator (B) which regulates the voltage to the required value (12 V) to the 12 V battery (C) to generate uniform voltage across the terminals of the battery, 12 V DC motor-pump (E) which gets activated by the battery. The switch (F) is for switching ON / OFF the motor-pump. Also, an extra socket (G), for any other purpose (other than pesticide spraying), like charging a mobile or a CFL battery,

is also provided. The terminals (positive or negative) and direction of the flow of the current are shown.

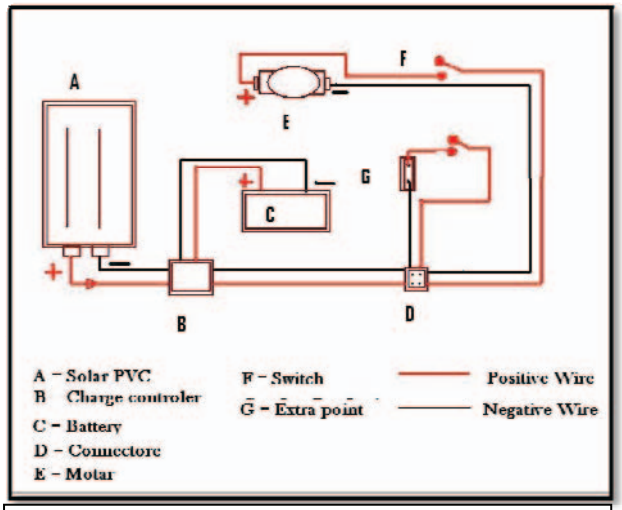

Fig-3: Circuit board of solar operated sprayer

Power Transmission System: The power generated by the solar PV Cell (A), charges the battery (B), which, in turn activates a DC to motor (E) to pump the pesticide in the form of a spray. When the radiant energy from sun rays falls on the solar panel, it converts light energy into electrical energy, through solar PV cell. It generates about 17 volts, which is further controlled by voltage regulator to the required value of about 12 volts. From the regulator, the current flows to 12V D.C battery for charging/storage. The battery activates the 12V D.C motor-pump which has centrifugal system for pumping the spray fluid. The battery supplies adequate energy for D.C motor-pump for spraying constant volume of spray fluid.

For construction of prototype of solar operated sprayer, the following component specifications were used:

1. **Solar Panel:**
   a. Size: 0.5m x 0.3m
   b. Normal peak power: 20 W
   c. Peak power voltage: 17 V
   d. Weight: 1 kg
2. **Battery:**
   a. Voltage: 12 V
   b. Current: 7 A
   c. Output power: 84 W
   d. Weight: 2 kg
3. **Motor:**
   a. Operating power: 82 W
   b. Operating voltage: 12 V
   c. Operating current: 7 A
   d. Motor speed: 1600 rpm
   e. Weight: 1 kg
4. **Mini charge regulator:** 12 – 17 V
5. **Tank capacity:** 18 Liters
6. **Overall dimension of the unit:** 480 mm x 820 mm
7. **Weight:** 10 kg

Fig-4: Rear view of solar operated sprayer

Fig-5: Top view of solar operated sprayer

The area having 92.3 m length and 4 m width was marked and spraying was carried out for field testing. The type of crop chosen for spraying was green gram and the spacing was measured as 15cm. and the average plant height during spraying operation measured as 30-35cm in the field. The average walking speed of the operator was measured as 2.769km/hr. The discharge of spray was measured as

0.023 ltrs/sec (82.8 liters/hr). The time taken to spray the fluid in predetermined area (92.3x4m) was observed as 17.00mins. The field evaluation of solar operated sprayer is shown in Fig – 6.

Fig-6: Field evaluation of solar operated sprayer

The many parameters such as total width, effective field capacity, theatrical field capacity and field efficiency were calculated. The row crops are sprayed side by side method covering the whole plot.

Multi-purpose applications of Solar operated sprayer: The solar operated sprayer developed can also be used for multi applications. In case of manually or power operated knapsack sprayer, they are only used in the field during the spraying period, they are idle during other time. But solar sprayer can be used both in field as well as the existing solar charge in the battery can be used for multipurpose applications such as radio, charging the mobile and lighting the CFL bulb of 18 W in night time by using a socket provided in the solar sprayer which are shown in Fig – 7 and Fig – 8.

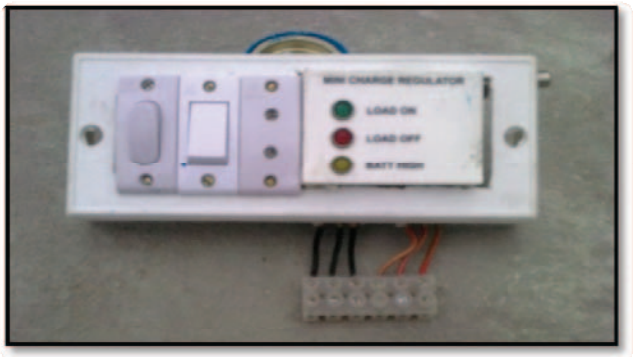

Fig-7: Connector output for multi-applications sprayer

RESULTS AND DISCUSSION

The performance was evaluated both in laboratory and field and the results have been analysed. The performance of spray was evaluated in terms of discharge rate, theatrical field capacity, actual field capacity, field efficiency. The data were related to the speed of operator. A 12V DC motor is connected to this lead acid battery to convert the electrical energy into mechanical energy. The discharge rate of the solar operated sprayer during laboratory and field conditions were measured, the average discharge rate solar sprayer during both laboratory test and field test were more or less same – about 0.023 liter/sec (82.8 liters/hr). The walking speed of the operator (and hence that of solar sprayer) is about 2.8 km/hr. and Swath width of the sprayer is about 0.6 m, which corresponds to a theoretical field capacity of about 0.17 hectare per hour. The effective field capacity of the sprayer was observed to be 0.14 ha/h which corresponds to an average coverage of 1 ha/day of 8 hours operation. The equipment does not use any other external source of power.

Fig-8: Multi-purpose applicationsof solar operated sprayer

CONCLUSION

A solar operated sprayer was developed for spraying which uses solar energy as source of power. It consists of a solar panel of 20 W capacity, a 12V DC battery, a DC motor, operated by the battery, a pump, to spray the pesticide and a tank to hold the pesticide. The performance evaluation of the sprayer, the effective field capacity of the sprayer was observed to be 0.14 ha/h which corresponds to an average coverage of 1 ha/day of 8 hours operation. As the equipment does not use any other external source of power and that it is operated by the user himself, it reduces drudgery, is quite economical and eco-friendly as it uses solar energy which can be easily affordable by small and marginal farmers. Further, its power can also be used for multi- purpose applications such as charging the battery of mobile, operating the radio and lighting the domestic light etc., which makes it more economically viable technology.

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