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Design and fabrication of solar operated height adjustment pesticide sprayer

Dr. Anurag Singh Tomer

Abstract
Spraying is one of the most essential operations in present-day farming. With the advancement in the agricultural sciences. There is a substantial increase in plant pests, weeds, disease, and fungus. So to get rid of this problem spraying machines are used. In agriculture, a sprayer is a mechanical device that is used to apply herbicides, fungicides, and fertilizers on different crops. Variety of sprayers present in market share a common problem that is it has to be carried by the farmer on its back. Particularly the knapsack sprayer the farmer has to carry the tank of the sprayer which is about 15 to 16 litres heavy and simultaneously has to create pressure through the other hand by operating the lever which is very laborious and time-consuming. Hand sprayer or backpack sprayer are slow and are not efficient enough to use them in large farms. On the other hand, tractor- mounted sprayer is one which is fixed on to the tractor the capacity of the tank ranges from 150 to 500 gallons. They are more efficient than hand-operated sprayers and are compatible with large farms. But they are expensive to get and their cost of maintenance is high also the tractor operated sprayer or boom sprayer is not suitable with the green-house conditions. The main objective of this research is to increase the efficiency of the farmers. Our design matches the capability of the farmer and enhances to bring out the maximum output of the farmer by saving his time and energy. The equipment works on electric energy and solar energy and has less maintenance cost. So that it can run quite efficiently in the village region of our country. Also where there is no electricity or less electricity is available this electric sprayer can be charged easily with the help of solar energy. The equipment has height adjustment facility also for spraying different liquids on different plants and crops.

Keywords: Sprayer, solar energy, electricity, photovoltaic cell. DC motor pump

Introduction
India is agriculture-based country and about 70% of the livelihood of our country is dependent on agriculture directly or indirectly. Agriculture contributes about 15% of the country's total export earnings. India is a vast country, covering about 329-million-hectare geographical area. Agriculture is facing capability challenges, declining wages, labour shortages and risking market demand. In the agriculture area, Spraying is one of the significant operations carried out by the farmers to control the crops from pests, weeds and insects. The objective of spraying is to deliver an effective uniform dose of product to particular area in a safe and timely manner. There are various types of sprayers present in the market Farmers mainly use Hand operated or fuel operated spray pump for this task [1, 2, 3]. This conventional sprayer causes user fatigue due to excessive bulky and heavy construction and tractor mounted sprayers are very expensive to buy whereas in India 75% of the farmers belong to the marginal and minor group [4, 5, 6, 7]. A traditional sprayer with problems such as the effort to work the lever up and down to create pressure, on the other hand petrol sprayers are good but the expense of petrol and diesel is unbearable and they are not eco-friendly also [8]. To run a DC motor pump for spraying power is required and for proper farming operation spraying of desired liquid must be well in time but still in many areas of our country regular power supply is a problem.

The above problems have given motivation to style and fabricate a model that's basically solar powered sprayer because energy available from the sun in Nature is free of cost and available around eight months in year, it can be used in spraying operation. A Solar Operated Pesticide Sprayer is a pump running on electricity generated by photovoltaic panels or the thermal energy available from collected sunlight as opposed to grid electricity or diesel run water pumps. The operation of solar powered pumps is more economical mainly due to the lower operation and maintenance costs and has less environmental impact [9].

Solar pesticide sprayer can give less tariff or price in effective spraying [10, 11]. During this design, here the rear mounting of Sprayer is eliminated ergonomically, which wasn't good for farmer's health point of view during spraying, during this way here the users fatigue level may be reduced and also height adjustment of sprayer is made for different crop and plants height. The proposed model is shown in fig: 1.

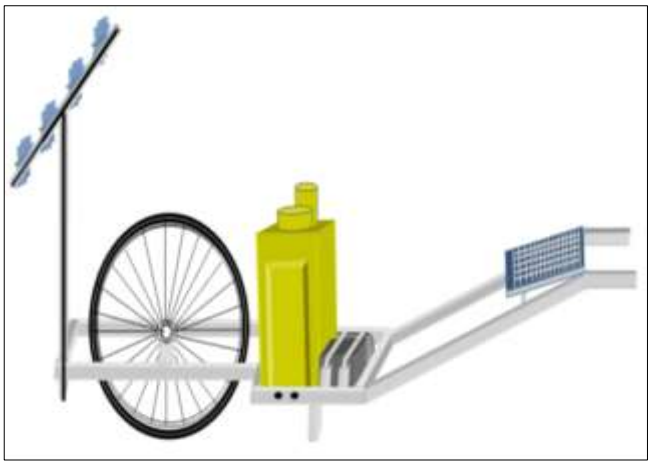

Fig 1: Proposed design of Solar Sprayer

Material and Methods

Main Components

Solar Panel -A solar panel is a set of no. of photovoltaic cells which are connected together and are fixed on a frame.

Specifications

Wattage (Wp)	10
Voltage at Max Power, Vmp (V)	16.85
Current at Max Power, Imp (A)	0.59
Open Circuit Voltage, Voc (V)	20.9
Short Circuit Current, Isc (A)	0.65
Number of cells	36

Fig 2: Solar Panel

Size

Length = 255mm, Width = 350mm, Height = 22mm, Weight = 1.00 kg

Cell type = poly crystalline frame.

Battery – It is one of the main component of the machine. It provides power to the DC motor we have used a 12 volt, 8Ah lead acid battery the battery consist of two poles.

Fig 3: Battery

DC Motor- DC motor pumps use direct current from motor, battery, or solar power to move fluid in variety of ways. Motorized pumps typically operate on 6, 12, 24 or 32 volts of DC power. Solar – powered DC pumps use photovoltaic (PV) panels with solar cells that produce direct current when exposed to sunlight.

Specifications

Volts: 12 volts Nom. (9-14volts), Amps: 3.0 A, Flow: 4.0LPM, Pressure: 100 PSI (6.8bar) cut off

Fig 4: DC Motor pump

Pesticide Container-The container is made up of HDPE (High density poly ethylene) material. Because it has chemical resistant properties so pesticides can be kept easily in the container with safety. They are affordable, stiff and are UV resistant.

Specifications: Capacity = 16 litre, Material = HDPE

Fig 5: Container

Main Frame- Most of the part of the machine is made up of mild steel square pipe. The main function of the frame is to carry the whole assembly on it. So it should be strong enough to carry the load with ease. The whole frame is joined together with the help of welding.

Fig 6: Construction assembly of main frame

Wheel-The wheel used in this project is a simple bicycle wheel it is not a tubeless wheel. The main reason to consider this wheel over tubeless wheel is that the terrain of our farms in India is uneven so the spokes present in this wheel can easily absorb the jerk caused by the uneven terrain.

Fig 7: Assembly of wheel

Nozzles & Pressure Hose Pipe- A nozzle is a device which atomizes liquid into droplets. Its purpose to distribute a liquid over an area and to increase the liquid surface area. Spray nozzles can be categorized on the basis of energy input used to cause atomization to break the fluid into drops.

The most common nozzle spacing's are 20 and 30 inches. Many sprayers are now being converted from 30 inch to 15-inch spacing's. The 30-inch spacing is used for the lower application rates (7 to 10 gallons per acre) and the 15-inch spacing for the higher application rates (14 gallons per acre and higher). Here in this paper spacing has been taken 15 Inches.

The transportation of the pesticide from the tank to the nozzle is done by PVC hose pipes. PVC hose pipe are made of PVC material PVC stands for (Poly Vinyl Chloride).

Fig 8: Nozzle, Hose pipe

The heights of the stainless-steel horizontal tube of the frame on which the nozzles are mounted are is adjustable. Which means we can adjust the height of spray according to the crops size.

Fig 9: installations of nozzle & pipe

Controller Unit- It is the rear portion of the tank in which the battery and the pump is placed. The main switch is also placed in the controller unit to regulate the current.

Fig 10: wiring connections of the battery and the pump and the solar panel.

Spraying Trigger- It is a button place near the handle of the machine which when pressed release the liquid from nozzle and when it is released it stops the flow of the liquid

Fig 11: spraying trigger

Fig 12: Working Model

Working principle of proposed model

When the Solar radiations incident on the photovoltaic it converts the sunlight into direct current electricity by using semiconductors device named as photovoltaic cell. Further this energy is stored in the battery in the form of direct current. The DC motor is connected to the battery. There are two switches in this machine one is the main switch and the other switch is used to do the spraying operation. When the secondary switch is pressed the battery supplies electricity to the DC motor. The DC motor creates suction and sucks the pesticide from the tank through a connecting pipe and delivers it to the nozzle. Nozzle generates the spray which is further falls on the crops in the form of drizzle. The battery charges through the solar energy and a solar charge controller is also provided for the safety of the battery and for the efficient use. This whole structured is mounted on a single wheel base manual operated design.

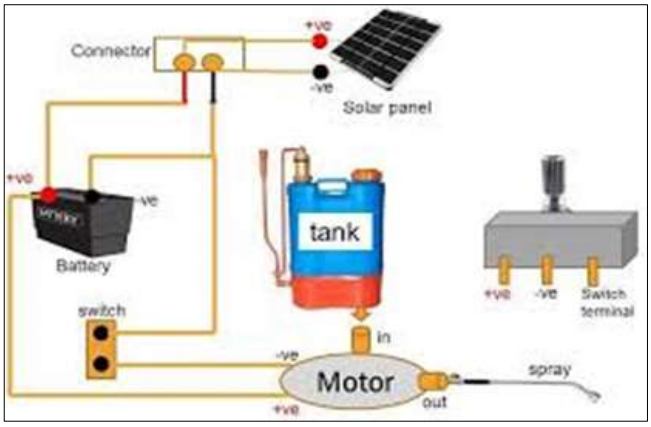

Fig 13: Block diagram of Solar operated sprayer

Results and Discussion

1. Charging current of battery

10% of AH rating so $I_{charging}$= 8x10/100=0.8A

2. Time required to charge the battery through solar panel
Battery rating=12V 8AH

Current produced by solar panel (I) = Maximum Power/ Voltage rating= = 0.833A

3. Theoretical charging time (T) = Rating of the battery/Total current consumed= =9.6Hrs

4. Backup sprayer Time= Power stored in battery(w-hr)/Power consumed by pump (w)
= = 2.66 Hrs

The charging time with the charger provided with the machine is about 6 hours. And the charging time with the solar panel is about 9.6 hours which is just the 1.5 times. But regarding the size and output of solar panel it is quite decent. However with increase in size and output of solar panel the battery charging time will increase but it will over all increase the weight of the machine.\

5. Area covered by the sprayer

Sprayer is calibrated at 20 Gallon per acre (GPA). The designed sprayer has a 4.23 gallon (16 litre) tank. So the area covered will be
Volume in tank / GPA= Acres Treated GPA
4.23/20= 0.21 acre

6. Output of boom nozzle

Here sprayer has a 4 nozzle boom and have collected from under each nozzle for one minute. The noted nozzle outputs are following:

Nozzle	Nozzle 1	Nozzle 2	Nozzle 3	Nozzle 4
Output (Oz)	44	43	46	48

$$\frac{\text{Nozzle 1 output + nozzle 2 output + etc.}}{\text{Number of nozzles on the boom}} = \text{Average Nozzle Output}$$

The average nozzle output is = 45.25 oz. For 5% error 5x45.25/100=2.26 to add and subtract from the average. Error range (5%) on either side of the average = 42.99 oz. to 47.51 oz. Nozzle 4 needs to be cleaned or replaced.

7. Time of spraying 1-acre land

Since sprayer has a 4 nozzle boom water collected from under each nozzle for one minute.
180 Oz water is coming out of all nozzles in 1 minute
And 16 litres is required to spray in 0.21 acre.
Time for spraying 1 acre:
0.21 acre area requires 16 liter of liquid to be sprayed
So 1 acre area requires = 16/0.21= 76 litre/acre
Now 5.35 litre spray in 1 minute \thus
76 litre liquid will be sprayed in 76/5.35= 14.2 minute
But to refill the container for 5 times requires some extra time.

Conclusion

- The machine is designed in such way that the operator

can move it comfortably with less effort without affecting his\her performance.
- The frame of the machine is sturdy and easy to operate with the less operation cost and low repair.
- The machine will increase the working capacity of the farmer and will reduce its time and fatigue.
- An emphasis on substituting conventional energy sources by solar energy techniques should be given because solar energy is free of cost, unlimited, pollution free and environment friendly green energy for agricultural sprayers and other farm operations.
- The developed solar energy operated power sprayer could be utilized for spraying activity.

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