Solar Operated Pesticides Sprayer for Agriculture Purpose

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Abstract:

In this paper, design and development of a wheel solar sprayer for spraying solution on vegetable crops and other crops is depicted. The major goal is to reduce the amount of work required by farmers to carry the backpack sprayer and to develop and build a solar operated wheel sprayer that can spray pesticides on vegetable crops. The developed wheel sprayer is analyzed and its performance evaluated and it is tested at G H Raisoni University Saikheda. The land chosen had lateritic soil, and testing is done on an area. The wheel rotates when the operator pushes the handle of the produced wheel sprayer forward. The operator's push force is eventually transformed to pressure energy, and the fluid is sprayed. When the wheel sprayer drives forward, the pump reciprocates, causing the working fluid to flow through the boom assembly and out the nozzle. The theoretical field capacity, actual field capacity, and field efficiency of the created wheel sprayer are determined during the performance evaluation. The solar operated pesticide sprayer is found to be portable, have a large tank capacity, be cost effective, easy to use, and have a short spraying time.

Keywords: Sprayer, Wheel, Solar, 3D CAD model, Automation

1. Introduction

India is claimed to be an agriculture-based country, with 75 percent of the population directly or indirectly dependent on farming. Nonetheless, our farmers continue to cultivate in the same traditional methods they have for centuries . There is a need for growth in this sector, particularly in terms of fertilizer and pesticide spraying techniques, because spraying in the traditional manner necessitates more effort and time. The agricultural sector must be modernized in order to meet the food demands of a growing population and fast industrialization. On many farms, productivity falls as a result of delayed sowing, incorrect pesticide and fertilizer distribution, harvesting, and other factors. Insufficient electricity supply for farms and low levels of farm mechanization are two of the key factors for decreased production. Mechanization eliminates all of the issues that lead to low output (Miller et.al, 2004). It saves time and effort while ensuring a more even distribution of resources. It decreases the amount of input required for a better response while also preventing losses and waste. As a result, agricultural implements are used more efficiently and at a lower cost. Plant protection is crucial for increasing a crop's yield. Agricultural pests cause significant crop damage and are a major productivity bottleneck. As a result, effective plant protection is required to reduce losses and ensure that all other production inputs are utilized to their full potential. Chemical pest management has proven to be quite effective, but it must be handled carefully, used in rationed doses, and sprayed correctly. As the only fully mechanized farming operation, specialized equipment is required for chemical application. Pesticide spraying is an important part of farming. The goal of pesticide application is to keep the pest under control. To avoid economic agricultural production loss, the pest population must be controlled to a bare minimum of biological activity. The objective of pesticide application besides keeping the pest population under check should also be to avoid pollution and damage to the non-targets. These herbicides, pesticides, and fertilizers are applied to agricultural crops with the help of a special device known as "Sprayer". The sprayer provides optimum performance with minimum efforts. The invention of a sprayer, pesticides, fertilizers, bring revolution in the agriculture or horticulture sector as well as enable farmers to obtain maximum agricultural output. Machines previously developed for chemical application include the knapsack sprayers, tractor boom sprayers and ultra-low volume sprayers (Liu, 2008). Spraying chemicals to protect crops against pests, illnesses, and weeds is done with a variety of equipment ranging from large tractor-mounted sprayers to hand-operated knapsack sprayers (Matthews, 2008).

Because of its versatility, cost, and design, small scale farmers are highly interested in manually lever controlled knapsack sprayers. However, this sprayer has several limitations, such as the inability to sustain adequate pressure, which can result in back strain. However, this equipment can lead to chemical misapplication and inefficient pest management, as well as pesticide loss due to dribbling or drift during application. Furthermore, due to their design and operation, the quality of a number of these sprayers, as well as their ability to precisely and efficiently administer pesticides, is of great significance Spray deposition is influenced by spray application technique. Spray dispersal varies greatly depending on sprayer design. Another sort of sprayer is one that runs on expensive fuel, such as diesel or gasoline. One disadvantage of a petrol sprayer is the necessity to purchase fuel, which raises the sprayer's operating costs; it also causes greater vibrations and noise, which irritates the farmer. During the swing of knapsack sprayers' lance operation, A pesticide sprayer has to be portable and with an increased tank capacity as well as should result in cost reduction, labor and spraying time. In order to reduce these problems, there isa number of sprayers introduced in the market, but these devices do not meet the above problems or demands of the farmers. Today we use various spraying and seed sowing technologies involving use of electrical energy, chemical energy of fuels. This fact makes us know that how large content of energy is getting used at such places where mechanical energy can be used instead of direct energy sources. In markets battery operated and fuel operated pesticide sprayer are available. But this requires some external source of energy and increases cost of production. In conventional methods, the pesticide sprayer is mounted on the back which causes back pain and also improper spraying of pesticides. The heavy tank containing pesticide is carried by the farmer and requires a lot of human efforts for spraying (Ahmad et al., 2018). In view of the above constraints, a manually operated wheel driven sprayer was proposed which is mainly designed to reduce human effort. It is focused on spraying pesticides at maximum rate in minimum time by using wheel operated mechanism. The target of users is smaller industries and small gardens. Usually gardeners will use the manual knapsack sprayer that is heavy and need to carry on their back to do spraying session. But, proposed wheel sprayer needs only a forward push to operate it in field. Besides this, with a single operator, the proposed wheel sprayer can apply spray solution on both sides of its forward motion. So that the time taken is less, more area can be covered and effort is less than that of normal knapsack sprayer.

Towards this objective the following contributions of this paper include

i. To design and develop a solar operated multi-purpose wheel sprayer suitable for spraying chemicals and fertilizers on vegetable crops.
ii. To fabricate a wheel sprayer.
iii. To analyze the performance of the developed wheel sprayer.

2. Literature review

In this chapter, previous research on wheel operated sprayers and other characteristics is reviewed. Under the corresponding areas, a quick review of work done pertinent to various facets of the current development is provided. Also specified is a review of studies relating to the parameters of the chosen crop.

"Solar Sprayer - An Agriculture Implement" is developed by Joshua et al. (2010). The notion and technology of using non-conventional energy for all kinds of development operations is becoming increasingly popular these days. Agriculture is one of the primary areas where there are several applications. Solar energy is used to dry agricultural products as well as for irrigation and pumping well water in rural settlements without electricity. Solar sprayers can be used to spray pesticides, fungicides, and fertilisers, among other things, utilising this technology. This study explains how a 'Power Sprayer' that is now in use and runs on fossil fuels may be turned into solar sprayers that do not. The "Multiple power provided fertiliser sprayer" is developed by Rao et al. (2013). They presented a system based on a modified model of a two-stroke petrol engine-powered sprayer, which reduces the challenges associated with existing power sprayers, such as operating costs, fuel changes, and so on. The technology is put to the test and compared to theoretical charging times. In the agricultural sector, farmers typically utilise the traditional method of spraying crops with a backpack sprayer. This is time-consuming and expensive, and human weariness is a huge issue.

3. Materials and methods

The methods used in the design, development, and testing of the wheel sprayer is briefly outlined in this chapter. The key components of a wheel sprayer's design specifications and methods are presented. The created wheel sprayer's cost analysis is also detailed here.

3.1 Study area

3.1.1 Site selection

The field is chosen near G H Raisoni University Saikheda. The field chosen had lateritic soil with excellent drainage and sunlight as shown in Fig. 1.

3.1.2 Field layout

Fig. 1. Chilli field

A field with dimensions of 15000 x 10000 mm is chosen, and 10 rows of continuous furrows with 1000 mm spacing are ploughed. Chilli seedlings from the Ujwala variety are transplanted at a distance of 500 mm between plants. Fig .2 depicts the field setup for testing the newly built wheel sprayer.

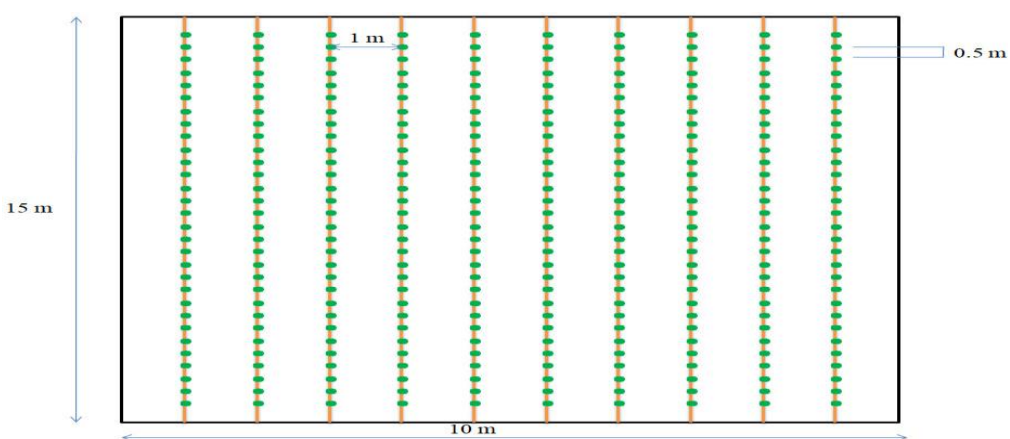

Fig .2 Layout of the chilli field

3.1.3 Crop parameters

Ujwala is a high-yielding bacterial-resistant cultivar. The plant is 650 mm tall on average. Tape is used to measure the field measurements. Seeds are planted in the nursery, and seedlings are moved to the main field after one month. The chilli variety Ujwala is grown on the playing field this chilli crop is grown at G H Raisoni University.

Plate3.3 Ujwala variety

Table 4.1Specifications of the components of the developed wheel sprayer

Sl.No.	Name of parts	Dimensions	Materials used
1	Main Frame	Diameter-31 mm Length-1420mm	M.S pipe
2	Tank	Capacity 16L 420x360 x 180 mm	Plastic
3	Wheel	Rim diameter- 420 mm Wheel diameter-480 mm	Steel plated withnickel Rubber
4	Driven sprocket	16 teeth Diameter -70 mm	Alloy steel
5	Driving Sprocket	32 teeth Diameter-140 mm	Alloy steel
6	Boom	Diameter- 8 mm Length- 800 mm	Brass
7	Nozzle	Diameter 7.6 mm Nozzle hole diameter 2 mm	Brass
8	Chain	Length 1300 mm	Alloy steel
9	Piston Pump	Diameter 60 mm Stroke length 50 mm	Brass
10	Hose	Diameter 8.5 mm Length 960 mm	Plasticized PVC
11	Shaft	Length 450 mm Shaft diameter 35 mm	Mild steel
12	Bearing	ID 20 mm OD 42 mm	Cast iron
13	Connecting rod	Length 590 mm	M S rod

3.1.4. Working of wheel sprayer

The evolved wheel sprayer's handle is pushed forward by the operator. The gear sprocket attached on the wheel revolves at the same speed as the wheel. The motion of the driving sprocket is transferred to the driven sprocket via the chain drive. On either side of the same shaft, the driving sprocket and connecting rod are placed. With the help of the crank and connecting rod mechanism, the rotating motion of the shaft is turned into the reciprocating motion of the pump. The piston pump's reciprocating motion creates the required pressure for spraying the spray solution via the nozzles. Because the wheel, sprockets, and chain are all bicycle-style, the pump only sprays when the operator moves the created wheel sprayer forward. The piston pump reciprocates as the wheel sprayer travels forward, causing the spray solution to discharge via the boom assembly and droplets to be sprayed on the plant surface by the spray nozzles.

4. CAD Drawing

CAD, or computer-aided design and drafting (CADD), is a design and technical documentation technology that automates the traditional drawing process. CAD software is used to increase designer productivity, improve design quality, and improve design efficiency.

The drawing is created using the SolidWorks software as shown in Fig. 4 and manual sketches based on the design criteria. SolidWorks is used to create the top view, front view, and side view of the designed wheel operated sprayer.

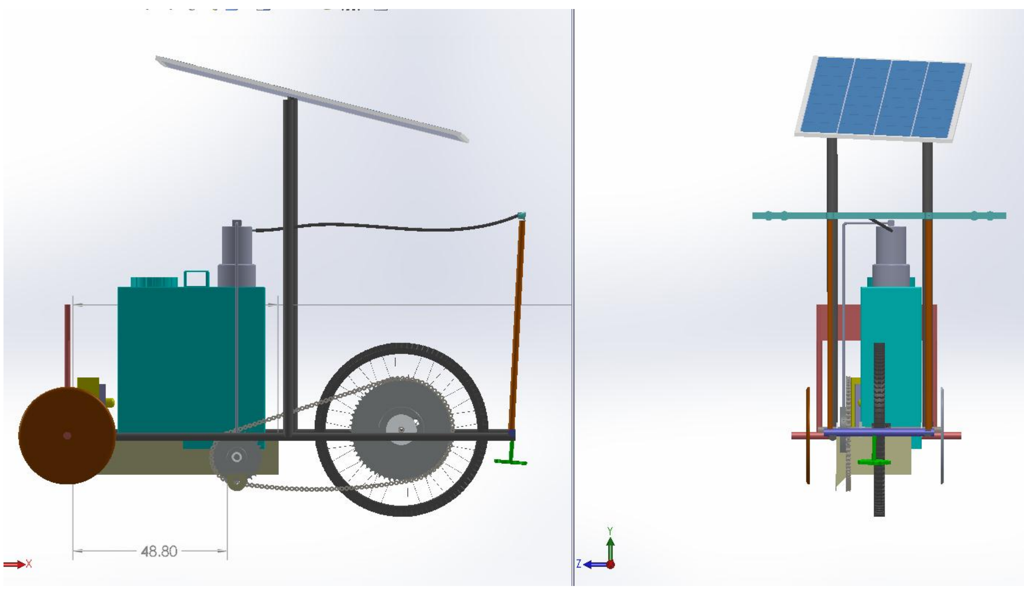

Fig. 4. shows a drawing of a wheel sprayer with measurements.

5. Results of implementation and its details

Weight of Tank = 4.6 kg x 9.8 =45.08 N

Frame is made of mild steel bars of thickness 31 mm which can be easily welded.It can support the load and take the weight of the tank easily.

Rest of the frame is designed considering its strength, stability and ergonomics.

Length of frame = Centre distance between two sprockets + wheel radius + frame handlelength + excess length

`=470+240+500 + 210

=1420mm

Maximum Height of frame = 500 mmMaximum Width of frame = 580mm

Total weight of frame = 16.5 kg = 161.7 N

Therefore total weight of the complete assembly = 21 kgTotal load on tire = 161.7 + 45.08 = 206.78 N ≈ 207 N Therefore,

Force required for motion of wheel = ?× W

? = 0.45 for sandy loam

Total force (F) = 0.45 × 207 = 93 N

Total torque to be applied at the handle = r × Fr – height of frame = 500 mm

Therefore, total torque = 0.5 × 93

= 46.5 N m

Distance between two plants = 1.64 feet = 500 mm.No of plants covered by one rotation of wheel = 3

50 × 3 = 1500 mm

150 = 2πr

$r = \frac{150}{2\times\pi}$

r = 240 mm

Diameter of wheel = 480 mm

For this wheel diameter, a wheel rim of 420 mm diameter is conveniently fitted in it.The rpm of the wheel (N) is measured as 27 rpm.

We know,

$Velocity\ of\ the\ wheel = \left(\frac{2\pi Nr}{60}\right)$ = 0.679 m s^{-1} or 2.44 km h^{-1}We know,

$$Wheel\ diameter = Rim\ diameter + (2 \times section\ height)$$

Therefore, $section\ height = \frac{Wheel\ diameter - Rim\ diameter}{2}$

$= \frac{48 - 42}{2}$

= 30 mm

Aspect ratio (%)= $\left(\frac{section\ height}{section\ width}\right) \times 100$

$= \left(\frac{3}{4}\right) \times 100$ = 75 %

The wheel operated sprayer, which consists of a piston with only one side engaging the fluid being displaced, works best with a single acting reciprocating pump.

Required discharge;

$$Q = \frac{ALN}{60}$$ for single acting reciprocating pump

Speed of piston = 21 rpm D=diameter of piston = 60 mmL = Length of stroke= 50 mm

Where, A = Area of piston = $\left(\frac{\pi}{4}\right) D^2$= 2826 mm^2

6. Conclusions and future work

The solar operated multipurpose wheel sprayer is created with the purpose of spraying solutions on vegetable crops. A primary frame, wheel, chain, sprayer, and sprockets, as well as a shaft, bearing, sprayer tank, piston pump, solar panel, battery, motor, boom, and three nozzles, make up the designed wheel sprayer. Two sprockets are employed, one driven (16 teeth, 70 mm diameter) attached to the shaft and the other a larger diameter driving sprocket (32 teeth, 140 mm diameter) connected to the wheel. A high-pressure power spray hose with a working pressure of 150-200 kgf cm^{-2} is installed to transport liquid sprays from the tank to the suction end of the boom. Within the mechanism of this wheel sprayer, there are two sorts of motion transmission. The chain drive transmits rotational motion between two sprockets. The connecting rod converts the rotary motion of the crank derived from the chain drive into reciprocating motion of the piston. Spray fluid is discharged on chilli plants when the sprayer is moved forward. The nozzle discharge rate of the wheel sprayer is calculated as 0.907 L min^{-1} when doing performance evaluation on 9 rows of the field. The theoretical field capacity is 0.244 ha h-1, but the actual field capacity is 0.206 ha h^{-1}. The field efficiency of a wheeled sprayer is discovered to be 84.5 percent. The purpose of the rate analysis and cost calculation is to assess the economic feasibility of the produced wheel sprayer. The overall cost of the wheel sprayer fabrication is estimated to be Rs. 5100/-. To increase field capacity, the number of nozzles in the boom can be raised from three to six. Sliding slots with nut and bolt arrangement can be used to modify the height of the spray boom in relation to the crop height.

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