

Original Research Article

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Compare the Performance Characteristics of Solar Trolley Type Sprayer and Solar Knapsack Sprayer

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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. In that we have compared the performance characteristics of solar trolley type sprayer and Knapsack sprayer. 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

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Introduction

Weed is a term referring to plant that grows where humans do not want it to grow. A massive use of herbicides in industrialized countries, arable weeds continue to be a serious threat to agricultural production. Total

annual losses of agricultural produce from various pests were: weeds 45 % insect 30 %, disease 20 % and others 5 %. The reduction in crop yield and quality has direct correlation with weed competition. Generally an increase of 1 kilogram of weed growth, correspond to a reduction of 1 kilogram of crop growth. The

control of weeds during the early first few years of establishment of plantation crops is very essential since weeds can reduce the yield by as much as ½ kilogram per bush (Kwaga and Fredrick, 2014).

Weed control methods broadly classified as cultural, mechanical, biological and chemical. Cultural method includes irrigation, lawn moving and mulching, but more expensive and time-consuming. Manual weeding is very laborious requiring to be repeated twice or three times before crop maturity. Thus manual weeding is effective only for gardens and very small farms (Amony, 2014). Solar power is the most ecofriendly resource mainly because it is free, unlimited and free from pollution. The solar energy is usually harvested through solar panels that are made up of photovoltaic cells. The photovoltaic (PV) or solar cells convert the sun's energy into the useful energy which is then used to perform work such as for domestic purpose, industrial purpose, agricultural purpose etc.

Solar energy

The Solar energy is a renewable source of energy which is abundantly available, used for various purpose in form of solar water heater, solar power, and solar cooker. Solar energy is radiant light and heat from the sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis.

Passive solar energy

The passive solar system does not involve mechanical devices or the use of conventional energy sources beyond that needed to regulate dampers and other controllers. The passive system is very convenient system and does not involve any complicated design, solar heater

and flat solar panels are best example for this system.

Active solar energy

The active solar energy system involves external sources like motors and circuits to function the system accurately, the use of mechanical systems for system accuracy and efficiency increase this system is applied. This type of system requires complicated design structures and involve with combination of all engineering like electronics, mechanical, computer science.

Solar energy systems

In Recent years, many of residents around the world used electric solar system as a sub power at their houses. This is because solar energy is an unlimited energy resource, set to become increasingly important in the longer term, for providing electricity and heat energy to the user. Solar energy also has the potential to be the major energy supply in the future. PV cells constituted of semiconductor materials which have the capacity to absorb solar energy and change it into usable electrical. Energy (the p-n junction directly converts light energy into electricity, directly proportional to the incident radiation). A large quantity of electricity is produced when PV modules are connected in an array configuration. A PV panel as shown in Figure 1 produces a constant DC voltage depending on the solar radiation. Generally, power electronics is required at the interface with a micro grid connection, where an inverter changes the DC voltage generated, into a suitable 50Hz AC voltage.

Solar cells

A Solar cell is a device which converts the solar energy into electrical energy. This phenomenon is known as Photovoltaic effect.

Solar cells are described as photovoltaic, irrespective of whether the source is sunlight or an artificial light. They are used as a photo detector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity. Solar cells share some of the same processing and manufacturing techniques as other semiconductor devices. However, the stringent requirements for cleanliness and quality control of semiconductor fabrication are more relaxed for solar cells, lowering costs. Polycrystalline silicon wafers are made by wire-sawing block-cast silicon ingots into 180 to 350 micrometer wafers. The wafers are usually lightly p-type-doped. A surface diffusion of n-type dopants is performed on the front side of the wafer. This forms a p-n junction a few hundred nanometers below the surface.

Types and uses of pesticides

These are substances or mixture of substances intended for preventing, destroying, repelling or mitigating any pest. A pesticide may be a chemical substance, biological agent (such as a virus or bacterium), ant microbial, disinfectant or device used against any pest.

Pests include insects, plant pathogens, weeds, mollusks, birds, mammals, fish, nematodes (roundworms), and microbes that destroy property, spread disease or are a vector for disease or cause a nuisance. Although there are benefits to the use of pesticides, there are also drawbacks, such as potential toxicity to humans and other animals.

A pesticide consists of an active ingredient coupled with inert ingredients. The active ingredient kills the pests, while the inert ingredients facilitate spraying and coating the target plant; they can also contribute other advantages that are not conferred by the active ingredient alone. Pesticides are used to control

organisms considered harmful. For example, they are used to kill mosquitoes that can transmit potentially deadly diseases like west Nile virus, yellow fever, and malaria.

They can also kill bees, wasps or ants that can cause allergic reactions. Pesticides can prevent sickness in humans that could be caused by mouldy food or diseased produce.

Pesticides

Pesticides are substances that are meant to control pests or weeds. The term pesticide includes all the following: Herbicide, Insecticide, Insect Growth Regulator, Nematicide, Termiticide, Molluscicide, Piscicide, Avicide, Rodenticide, Predacide, Bactericide, Insect Repellent, Animal Repellent, Antimicrobial, Fungicide, Disinfectant (Anti-microbial), and Sanitizer. The most common of these are Herbicides which account for approximately 80% of all pesticide use.

Materials and Methods

Weed control is one of the major problems in agricultural production system. The abundant growth of weed during monsoon season create enormous problem in agricultural field.

The removing of weed with manually operated tool required huge labour power and required more time. The utilization of solar energy for weedicide spraying may reduce labour and operating cost with higher area coverage than manually operated sprayer.

A project works an attempt has been made to develop and evaluation of solar photovoltaic power sprayer to reduce the operating and maintenance cost. The study deals with the performance evaluation of developed SPV power sprayer at Department of EOES, CAET, Saralgaon.

Development of solar operated trolley type sprayer

A solar photovoltaic operated weedicide sprayer consisted of different components. viz; photovoltaic panel panels, motor and control system

Solar photovoltaic (SPV) panel

The Photovoltaic (PV) or solar panel of 12 V, 5 W capacity configured to trap and convert the sun's energy into the useful power was used to perform the work of spraying. Solar PV Panel was used for operating the Sprayer and for charging a battery.

D.C. Motor

A 12 V D.C. motor was used to operate the spinning disc having 4000-4400 rpm. The D.C. motor was fitted at the end of the lance. The spinning disc nozzle was fixed on D.C. motor. A compact size, rust proof, easy to clean and maintain and low electric consumption motor was used to reduce the weight. Liquid enters on spinning disc by rotating spinning disc nozzle used the centrifugal force to add velocity to the liquid and breaks it into fine droplets.

Balance of system

Liquid tank

The 5 liters capacity tank made up of High density polyethylene material was used and connected to the spray lance pipe with spinning disc nozzle.

Main frame

The whole unit of sprayer including tank, SPV panel and control unit was framed in metallic frame module of mild steel. The supporting base and entire unit needs to be strong and

light weight. It was made of metal, in which solar panel (5 W, 6 V) was mounted on the frame. Solar charge controller was placed at the side of the frame.

Battery

The SPV operated trolley sprayer was provided with 12 V, 4.5 Ah sealed lead acid battery which was used as alternative power source during cloudy atmosphere (in rainy season). The battery was charged with the help of SPV panel available on top of the sprayers. The regularized voltage of 6V required for motor operation was supplied by battery.

Solar charge controller

A solar charge controller regulated the voltage and current from solar panel. It was placed between a solar panel and a battery. It was used to maintain the proper charging voltage to the battery and protected it from overcharging and discharging. The technical specification of developed SPV operated weedicide sprayer is summarized in Table 1.

Working

Make a mixture of chemicals, water, stickers etc. Make a mixing properly with the help of stirrer equipment. Fix a hose pipe inside the tank. Check the all connections of sprayer which properly connected or not. These mixtures of chemicals can be drawn into the tank. After filling the mixture place a nozzle pipe on it. Now by using the small sieve like structure which prevent the entry of the small soil or other particle into the tank. After starting the switch the spraying phenomenon starts with the help of suitable pumps and motors the spraying can done. Put a nozzle into a specific position on that bar for efficient working. Check the nozzle pipe or tank for any type of leakage. Check the efficient spraying can be done or not.

Components used in solar operated trolley type sprayer

Motors

Motor is the functional component of the sprayer (Fig. 3).

Function

It is used to create definite pressure for the water for increasing its efficiency.

The battery

Storage of electric power which is obtained by solar panel can be done in the battery (Fig. 4).

Function

The required electricity of the motor can supply through these battery.

Nozzle

The function of spray nozzle was conversion of pressurized spray liquid into droplets for application of fertilizers on the target area. Nozzles are identified by

Droplet size

Delivery

Layout of the system

The first unit of proposed system is energy conversion unit. Solar energy obtained by the sun is converted into electrical energy using solar panel by photovoltaic effect. The output of the energy conversion is given to charge a deep cycle lead acid battery through a charge controller. The charge controller limits the rate at which electric current is added to the battery. Thereby, preventing overcharging and protecting against over voltage. It employs the

Pulse Width Modulation (PWM) technique which gradually stops charging the battery, when it exceeds a set high voltage level and gradually re-enables the charging, when the battery voltage drops back below the safe level. The main advantage of PWM is that the power loss in the switching device is very low. This circuit is designed to control the RPM of the motor by controlling the amount of resistance between the motor and the battery while simultaneously providing a charging supply for the battery.

According to the second objective of our project, we have to check the efficiency of the solar operated trolley type sprayer and compare to the knapsack sprayer (Fig. 5).

Solar operated knapsack sprayer

Design considerations

The solar operated knapsack sprayer is designed to the following specifications;

The height of the sprayer is 70 cm

The length of the adjustable bar on which nozzle are mounted is 120 cm

The main frame on which the water tank mounted the length is 60cm.

The main functional parts of the machine include, backpack, tank, lead-acid battery, motor-pump set, pressure control, electronic control, sprayer handle with lance, nozzle head, boom, solar panel and charge controller. The total weight of machine should be such that an operator can carry it comfortably for 6 hr without any discomfort affecting his performance and health. It should have DC power backup for six hours of operation. The setup should be sturdy with ease of operation and controls along with low repair and maintenance cost. It should meet the technical,

functional, operational, and structural requirements for quality spraying of pesticides and economically viable (Fig. 6).

The hydraulic spray nozzle used in the application to convert the spray solution into droplets for efficient target coverage. The target can be foliage, bark, stumps, soil or insects. In general, effective droplet size for herbicides is 250 microns; for fungicides 100 to 150 microns, and insecticides 100 microns. Spray pattern and quality are also function of operational parameters namely pressure, forward speed, nozzle spacing, spray height apart from nozzle type and its characteristics. In the present design, a nozzle head was selected in which nozzle could be replaced easily as per spray requirement without any specific tool. Clogging of nozzle is frequent due to finer impurity in water sources. General practice of farmers is to use pin or wire for removing clogging of nozzle or they blow air with mouth. In this process they may damage the nozzle characteristics or intake the harmful chemical. In order to avoid clogging, a 100 mesh filter was placed before the nozzle in the nozzle head to prevent clogging. It could be easily cleaned and maintained for enhanced service life of the nozzle.

The block diagram of proposed system is as shown in Figure 2. It mainly consists of four units. The first unit of proposed system is energy conversion unit. The energy conversion can be done by two modes such as direct supply mode and solar energy mode.

In case of direct supply mode, the single phase Alternating Current (A.C) supply was converted into Direct Current (D.C) supply with the help of full wave bridge rectifier which consist a step down transformer and diodes in star connection. 230 volts A.C. supply is converted into 12 volts A.C. and then diode converts it into D.C. supply. This can be used, wherever the storage, DC drive

and sprayer. The details of each unit are discussed as follows solar energy is not available i.e. during rain and cloudy weather conditions. In case of solar energy mode, solar energy obtained by the sun is converted into electrical energy using solar panel by photovoltaic effect and stored in the battery. The output of energy conversion was used to charge a deep cycle battery. The number of times a battery can be discharged is known as its life cycle. For solar applications, a battery should be capable of being discharged in several.

Performance evaluation of solar operated trolley type sprayer

The performance evaluation of developed solar operated trolley sprayer test was carried out viz., Laboratory and Field.

Laboratory test of solar operated trolley type sprayer

Laboratory testing of Solar operated trolley type sprayer was conducted at Spray Testing Lab, CAET, saralgaon and EOES Laboratory of CAET saralgaon to test different operating parameters of Solar Operated trolley type Sprayer.

Testing of battery charging

The battery charging characteristics of Solar Operated trolley type Sprayer was studied to determine the charging time and battery voltage rise or increase while sprayer was in non-operating condition. The SPV panel was fully exposed in sunlight for battery charging. The various parameters like panel voltage, panel current, battery voltage, solar intensity, ambient temperature was measured at the interval of 30 minutes. The battery was charged till reaches up to 6.4 V. Three replications were conducted and average value was reported.

Testing of simultaneous battery charging and discharging of solar operated trolley type sprayer

The battery charging and discharging characteristics of SPV operated weedicide sprayer was studied to determine the total operating period of sprayer. The battery was charge by SPV panel which, was fully exposed in sunlight and simultaneously battery was use for operating the SPV sprayer. The various parameter like battery voltage, battery current, panel voltage, panel current, solar intensity, ambient temperature was measured at the interval of 1 hour. The sprayer was operated till the motor stopped working up to 3.3 V (Fig. 7–10).

Discharge rate variation test

Discharge rate variation test of SPV operated trolley sprayer was carried out by placing the liquid tank with three different heights at three different discharge rates. The discharged volume was collected in measuring cylinder in ml/min (Awulu, 2011).

Theoretical consideration

Field testing of Solar operated trolley type sprayer and Knapsack Sprayer.

Determination of flow rate

A measuring cylinder together with a conical flask was used for accurate measurement of the volume of liquid discharged from the sprayer nozzle. A digital timer (stop watch) was used for recording the time of discharge. The procedure was repeated four times and the varying liquid heads were noted and the mean flow rate in liter per minute was calculated using the following formula.

$$\text{Flow rate (L/min.)} = \frac{\text{Volume of liquid collected in cylinder (L)}}{\text{Time (min)}} \dots(1)$$

Determination of application rate

The 16 liter capacity of the sprayer tank was filled with liquid. The tank was mounted at the back.

The electrical system was switched “ON” and the liquid was sprayed using the pressure of the pump. The effective performance of the developed sprayer was determined by practical trials in the field.

The field test was made in an open field measuring 10 m by 10 m. The operator walked within a speed of 0.7 m/s through the test field.

The discharged volume in liters per minute was recorded. This procedure was replicated four times and the mean value was determined.

$$\text{Application rate} = \frac{\text{Volume rate}}{\text{Area rate (ha)}} \dots(2)$$

Effective field capacity

Prior to the test the length and width of individual plot will be measured and will recorded. Then the whole plot will be marked by standard crop spacing.

During testing the spraying were done at these marking. For this the time required will be measured using stop watch. This time will be inclusive of lost time i.e. stoppage, rest and maintenance. Using these values, the area covered/ hr. Will be calculated by following formula

$$\text{Effective Field Capacity (ha/hr.)} = \frac{\text{Total Area covered}}{\text{Time required to cover this area}} \dots (3)$$

The procedure will be repeated for remaining plots and average will be calculated by taking the average number of readings for individual plot.

Volume rate

By considering unit time discharge of the sprayer from the nozzle which was being measured by using the measuring glass cylinder. The volume rate of the sprayer was given by

$$\text{Volume rate} = \frac{\text{Volume collected (l)}}{\text{Time required to cover this area}} \dots(4)$$

Results and Discussion

Spraying is a chemical treatment for increasing the crop yield and growth of the crop. The machine is operated manually by a solar system to generate electricity required for creating specific pressure for spraying. The detail design and fabrication were based on the following criteria; functionality, simplicity, cost, and maintenance.

This chapter deals with the results obtained from the study undertaken with the objectives for development and evaluation of SPV operated weedicide sprayer. The results obtained in this study are presented and evaluated under the following headings.

Laboratory testing of solar operated trolley type sprayer

Laboratory testing of Solar operated trolley type sprayer was conducted at Spray Testing Lab Nashik. Test different operating parameters like battery discharging; battery charging with PV panel and simultaneous charging with PV panel and discharging of Solar operated trolley type sprayer.

Evaluation of solar operated trolley type sprayer

The developed solar operated trolley type sprayer was evaluated in the field condition

surrounding Nashik areas and the results were presented in tables 2 and 3

Evaluation of solar operated knapsack sprayer

The developed solar knapsack sprayer was evaluated in the field condition surrounding Nashik areas and the results were presented in tables 2 and 3.

Access to energy resources, economic development and environmental pollution, which in turn threaten human health are major charges facing developing countries today. Economically feasible and efficient medium scale solar operated trolley type sprayer could be the solving some of these problems and needs by using energy availability and simultaneously protect the surrounding environment such as petroleum resources, water and air, a lot of benefits could be gained most of solar operated trolley type sprayer concentrated in developing countries Nigeria and China as leading countries accounting for highest share. "Spraying" is the process of application of liquid in the form of small particles ejected from a sprayer for prevention of the insect and the pests. In this process the production of insecticide and pesticide is made from mixture of water and chemical in different proportion for effective operation of the spraying.

This mixture is check the mixed properly or not. This mixture drawn into the tank at the opening of tank there is small sieve like structure is placed for prevention of the entry of foreign particles into it, the chemical is mixed properly with the help of stirrer so that the chemical is ready for the treatment. Two person can spray the 1 acre in one hour. It is the effective treatment for the crop for effective growth. The main objective of this work is to fabricate a machine, which can be run with the help solar energy which is freely available in the nature. The solar operated

trolley type sprayer done the work at the faster rate and also provides a way to reduce the use of fuels like petrol, diesel etc. it turn into pollution.

Table.1 Technical specifications of solar operated trolley type sprayer

Sr.no.	Component	Specification	Material used
1	Solar Photovoltaic Panel	5W,12V Size: 28 cm*17.5 cm	
2	D.C. Motor	Voltage :12volt	-
3	Spinning Disc Nozzle	RPM :4000-4400	HDPE
		Diameter: 9 cm	
4	Battery	Voltage :6 V	Sealed Lead Acid
		Current:4.5 Ah	Battery
5	Lance	Length :2.1 m	HDPE
		Diameter:4 cm	
6	Frame	Height : 32 cm	Mild Steel
		Breath : 22 cm	
		Width:12 cm	
7	Connecting Rod	Height: 73 cm	Galvanized Iron Pipe
		Bend Pipe length: 40 Cm	
		Diameter:2 cm	
8	Switch	1 No. on/off	-
9	Accessories	Two abdomen belt	Nylon
10	Tank	Capacity: 5 liter	HDPE
		Height : 10 cm	
		Breadth: 7 cm	
		Width: 4.5 cm	

Table.2

Treatment	Area, ha	Time, h	Volume, L	Volume rate, L/ha	Application rate, L/ha	Field capacity, ha/h
1	0.236	0.35	36	100.50	151.98	0.66
2	0.402	0.59	60	100.59	149.06	0.67
3	0.125	0.2	20	100	160	0.64
4	0.254	0.38	40	103.977	157.98	0.66
Average	0.254	0.38	39	101.266	154.75	0.66
Standard deviation	0.113	0.162	16.45	1.825	5.097	0.012

Table.3

Treatment	Area, ha	Time, h	Volume, L	Volume rate, L/ha	Application rate, L/ha	Field capacity, ha/h
1	0.236	0.317	25	85.17	105.9	0.11
2	0.402	0.472	43	90.32	106.2	0.16
3	0.125	0.402	32.3	80.32	104.2	0.135
4	0.254	0.397	34	83.23	133.4	0.138
Average	0.254	0.397	33.432	85.625	112.4	0.138
Standard deviation	0.113	0.063	7.0256	4.321	91.42	0.022

Fig.1 Solar cell



Fig.2 Sample of solar operated trolley type sprayer



Fig.3 Motor



Fig.4 Battery



Fig.5 Layout of the solar operated trolley type sprayer

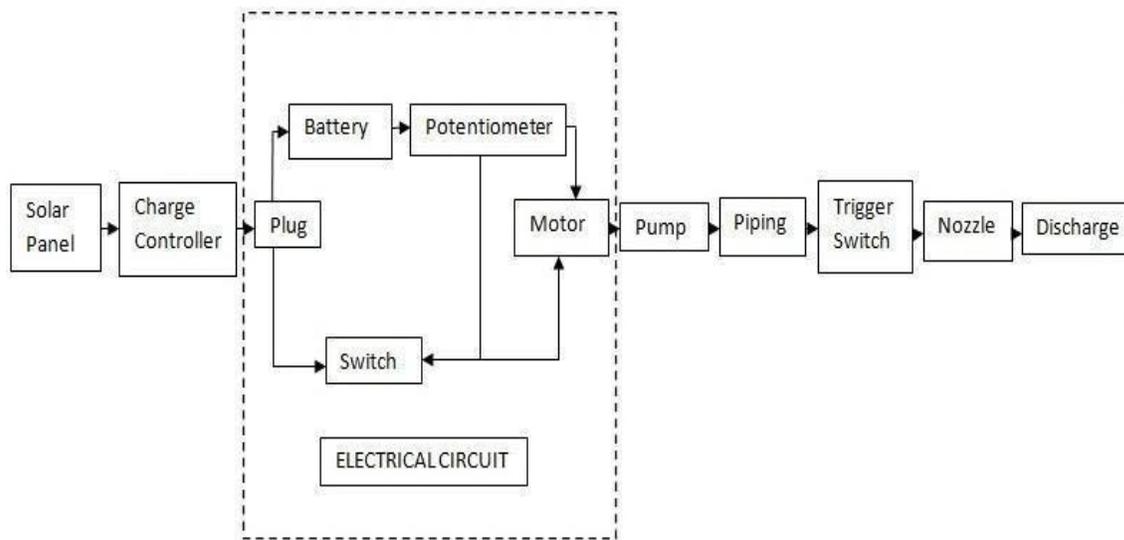


Fig.6 Solar powered sprayer



Fig.7 Layout of the solar operated knapsack sprayer

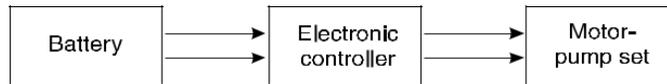


Fig.8 Block diagram of electronic controller

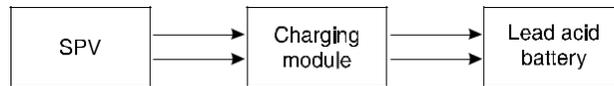


Fig.9 Block diagram of charging module



Fig.10 Block diagram of the developed Solar Sprayer

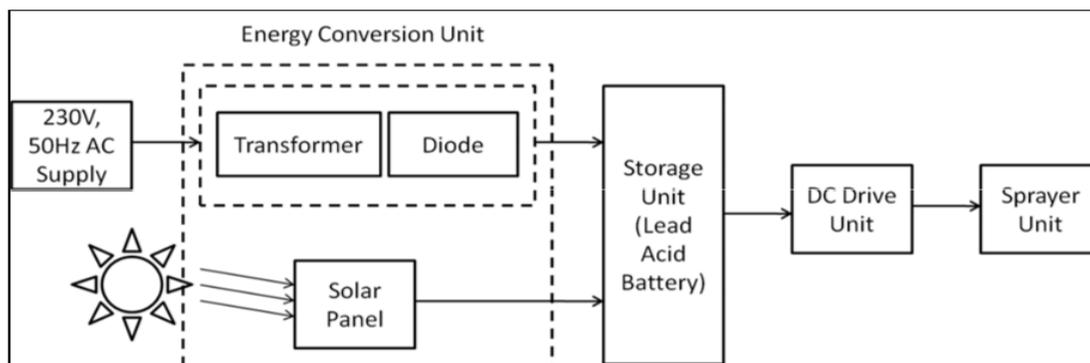
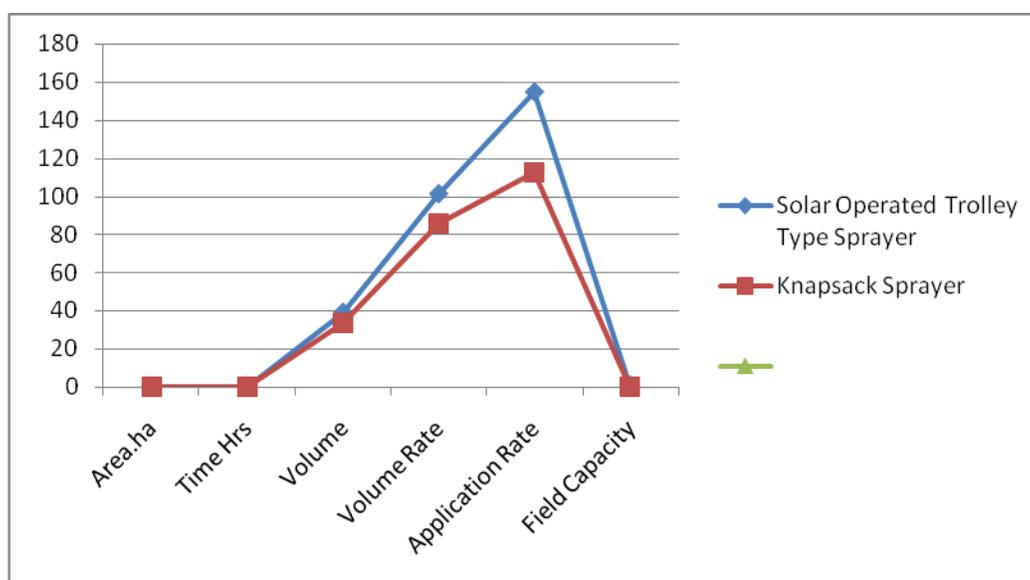


Fig.11 Comparison of solar operated trolley type and knapsack sprayer



The solar operated sprayer sprays the six row of crops at a time so that it reduces the time of operation of spraying. And for operating of these sprayers only 2 labour are necessary.

The solar operated trolley type sprayer has the zero operating cost does not require any type of fuel for working like other sprayer like motor sprayer.

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