FABRICATION OF SOLAR OPERATED PESTICIDE SPRAYER AND MEASUREMENT OF INCLINATION ANGLE EFFECT OF THE SOLAR PANEL

A THESIS
BY

MD. MOSIUR RAHMAN
REGISTRATON NO.: 1805122
SEMESTER: JANUARY-JUNE/2019
SESSION: 2018

MASTER OF SCIENCE (MS)
IN
FARM POWER AND MACHINERY

DEPARTMENT OF AGRICULTURAL AND INDUSTRIAL ENGINEERING
FACULTY OF POST GRADUATE STUDIES

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY, DINAJPUR-5200

JUNE, 2019

FABRICATION OF SOLAR OPERATED PESTICIDE SPRAYER AND MEASUREMENT OF INCLINATION ANGLE EFFECT OF THE SOLAR PANEL

A THESIS
BY

MD. MOSIUR RAHMAN

REGISTRATON NO.: 1805122

SEMESTER: JANUARY-JUNE/2019

SESSION: 2018

Submitted to the

Department of Agricultural and Industrial Engineering
Faculty of Post Graduate Studies
Hajee Mohammad Danesh Science and Technology University,
Dinajpur-5200

MASTER OF SCIENCE (MS)

IN

FARM POWER AND MACHINERY

DEPARTMENT OF AGRICULTURAL AND INDUSTRIAL ENGINEERING

FACULTY OF POST GRADUATE STUDIES

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY

UNIVERSITY, DINAJPUR-5200

JUNE, 2019

FABRICATION OF SOLAR OPERATED PESTICIDE SPRAYER AND MEASUREMENT OF INCLINATION ANGLE EFFECT OF THE SOLAR PANEL

A THESIS
BY

MD. MOSIUR RAHMAN
REGISTRATON NO.: 1805122

SEMESTER: JANUARY-JUNE/2019

SESSION: 2018

Approved as to the style and content by

_____	_____
Supervisor	Co-supervisor

_____

Chairman
Examination Committee and Chairman
of the Department

DEPARTMENT OF AGRICULTURAL AND INDUSTRIAL ENGINEERING

FACULTY OF POST GRADUATE STUDIES

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY

UNIVERSITY, DINAJPUR-5200
JUNE, 2019

Dedicated
To
My Beloved
Parents

ACKNOWLEDGEMENT

I express the deepest sense of gratefulness to the “almighty Allah” who has enabled me to complete the thesis work. I take this opportunity with pride and enormous gratification to express the feelings of thanks and gratefulness from the bottom of heart to all the persons who backed me directly or indirectly throughout this thesis work.

I would first like to thank my thesis supervisor professor Dr. Md. Mofizul Islam, Faculty of Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur, for his valuable advice, exclusive suggestions and provisions of facilities and supports need to complete this thesis work.

I would also like to thank my thesis co-supervisor professor Dr. Md. Kamal Uddin Sarker, Faculty of Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur, for his exemplary guidance which enabled my research efforts to come in shape with meaningful conclusion. The door to Prof. Sarkar’s office was always open whenever I ran into a trouble spot or had a question about my research or writing. Although he was my second reader of my thesis he was always helping with cordially.

Finally, I must express my very profound gratitude to my parents and to my friends and family members for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

Author

Md. Mosiur Rahman

Abstract

Agriculture is the backbone of Bangladesh. In Bangladesh farms generally two types of spray pumps are used for spraying hand operated spray pump and fuel operated spray pump, of which hand operated spray pump is the most popular. The main disadvantage of hand worked spray pump is that the user can't use it for more than 5-6 hours nonstop as he gets tired after some hours, where as fuel worked spray pump needs fuel which is costly and accessibility of fuel is not easy at rural places. At the same time it exhausts carbon dioxide as pollutant which is harmful to the environment. In such condition we should reflect to move near some non-conventional energy. Seeing it, solar energy would be one of the options. This development is about pesticides sprayer in agriculture, which uses solar energy as a source of power for spraying. Fabricated the solar pesticide sprayer, evaluate the performance of the sprayer and compare to the hand operated sprayer and cost analysis of the sprayer. The solar operated pesticide sprayer consists of a solar panel of 20 watt capacity, a 12 volt DC battery, charged by solar energy received by solar panel, a DC motor operated by the battery, a pump to spray the pesticides and tank of 16 liters to hold the pesticide. Solar pesticide sprayer facilitates effortless operation. The entire unit is portable and operated by one person or operator. Solar panel on the head of the worker which gives guard from high solar strength. This project reduce the spraying time and cost of spraying. The solar sprayer was required 5 minute 18 second to apply pesticide in 5 decimal field. This time was almost half compare to the hand operated sprayer. The solar sprayer works on 4-5 bar but hand operated sprayer works on 1.5-2 bar. The solar panel of the pesticide sprayer produces maximum voltage, current and power in 30^0 inclination angle and the lowest output in 60^0 inclination angles. Solar pesticide sprayer can run 3 to 4 hours more after 5 hours of operation in full solar intensity which ultimately provides spraying operation facility at night. This sprayer can

be most often used at various locations such as farms, gardens although it can become more popular in rural areas as well. It 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 multipurpose applications such as charging the battery of mobile, operating the radio and lighting the domestic light etc., which makes it economically viable technology.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER-1
INTRODUCTION

Bangladesh is predominantly an agriculture based country with approximately 70% of population of Bangladesh is very much dependent on farming either directly or indirectly. The farmers have been using the same methods and equipment for ages for example the seed sowing, spraying, weeding etc. operations are carried out by same techniques. There is need for development of an effective spraying machine for increasing production level. Most of the less developing countries of Asia have the problem of higher population and low levels of land productivity as of compared to the developed nations. One of the main reasons for lower productivity is insufficient power availability for the farms and very low levels of farm mechanization. This is especially true for Bangladesh. *B. Mechanization of Agriculture.* It is now accepted all over the world that in order to meet the food requirements of growing populations and rapid industrialization, the modernization of agriculture is indispensable. It is said that at many farms, production suffers due to no use of farm fertilizers or correct time pesticides and insecticides or improper application of these at required destination area of the affected crop. Mechanization enables conservation of inputs by precision in metering and ensuring better distribution, reducing the level of quantity required for the best response and prevention of loss or wastage of inputs applied. The Mechanization reduces the unit costs for the production by the high-level of productivity and by input conservation. Agricultural equipment's and machinery program of the governments has been one of selective mechanization with a view of optimizing the use of human, animal and other source of power. In order to meet requirements, steps are taken to increase availability of implement, irrigation pumps, tractors, power tiller, combine harvesters and other power operated machines and also for to increase the production and availability of improved animal driven implements. Special emphasis was given on the later as more than the 70% of the

farmers fall in small and, marginal categories. As on today the whole world is facing a problem of energy crisis. If we want to continue for prolonged use of energy then we must try to save it as much as we can whether it is on large scale or small scale. 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 a places where mechanical energy can be used instead of direct energy sources. Solar energy is one of the most important renewable energy sources that have been gaining enlarged attention in recent years. Solar energy is plenteous; it has the greatest availability compared to other energy sources. The solar constant (1.360 kW/m^2) is the rate at which solar energy is received per unit area of the earth's atmosphere. Because the cross-sectional area and the total surface area of the earth differ by a factor of 4, the average flux incident on the earth is one –fourth the solar constant, or 0.340 kW/m^2 of the atmosphere incoming, 49% is absorbed and meditated by the atmosphere. In the modern world the energy demand is increasing day by day. Most of the country solves the energy crisis by used solar energy. Solar energy are very plentiful and available renewable energy. Most of the country used this renewable energy. Thus we see that top 10 country that used in solar energy.

Table 1.1: Top Solar energy used country

Rank	Country	Capacity
1.	China	152 GW
2.	United States	133 GW
3.	Germany	71 GW
4.	Rest of EU-27	57 GW
5.	Spain	34 GW
6.	Italy	31 GW
7.	India	30 GW
8.	Japan	27 GW
9.	Brazil	16 GW
10.	United Kingdom	15 GW

(*Source: International Energy Agency (IEA))*

Solar Energy is a great source for solving power crisis in Bangladesh. Bangladesh is situated between $20^0$30 and $26^0$38 degrees north latitude and $88^0$04 and $92^0$44 degrees east which is an ideal location for solar energy utilization. At this position the amount of hours of sunlight each day throughout a year. In a year everyday 7-8 hrs sunlight gets in Bangladesh.

In Bangladesh the average is 0.193kW/m^2. Solar energy is fresh and free of emissions, since it does not produce pollutants or by-products harmful to nature. Bangladesh is set to be an agricultural based country approximately 3/4th of population of Bangladesh is dependent on farming directly or indirectly. Our farmers are using the traditional methods and equipment for the ages e.g. seed sowing, spraying, weeding etc. Spraying is one of the important things for farming. There is need for development of effective spraying. The application of pesticides using spraying equipment plays an important role.The advancement and use of insecticides have produced huge benefits as they kill undesirable pests by disruption of their vital processes through chemical action. Thus, they are the main contributors for the boost in agricultural yield over the past three decades. The use has resulted in foodstuffs of the utmost quality and also has saved millions of lives through obliteration of disease-carrying insects. In the developed countries, the use of crop protecting chemicals has played a main role in efficient production of food. At present, the developed countries are using more pesticides to control wide varieties of pests compared to the developing countries (Fig. 1.1).

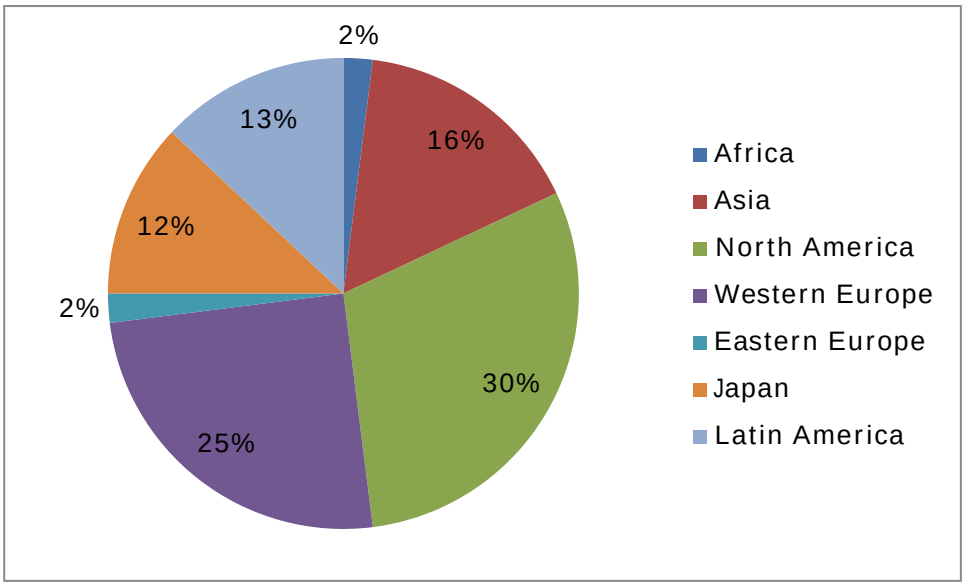

Figure 1.1: Worldwide Agrochemical Consumption (Surender Kumar)

The chemicals are widely used for increasing agriculture 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. Sprayers are mechanical devices that are specifically designed to spray liquids rapidly and simply. They come in a number of different varieties. There are several types of sprayers available in the market such as manual or self-propelled sprayers, tractor mounted sprayer sand aerial sprayers. In Bangladesh, many versions of hand operated and power operated spraying equipment's 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. Many of the farmers generally spray 6-8 times in a season using manually operated or motorized sprayer to coverage area within short period of time. Modern spraying techniques 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 like 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 gets, which is the need of the hour. Because of inadequate supply of electricity, there is frequent power cut and this situation is shill worse in the rural areas. Hence, there is better 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. In this project we will develop a solar operated agro sprayer. A sprayer of this type is a great way to use solar energy. Sun based built up bug sprays sprayer siphon is one of the better forms of petroleum motor pesticide sprayer siphon. It is interminably utilized in the agribusiness field and likewise utilized for a few purposes. This is having more favorable circumstances over petroleum motor sprayer siphon. It practices the solar power to run the motor. So it is a contamination free pump associated to petrol engine spray pump. Excess electricity can be stored in batteries and then excess of energy can be utilized for home appliances like glowing of CFL bulbs, mobile charging etc. If we take into consideration today's situation from the world point of view, we can say that world today is greatly dependent on fossil fuels and other conventional energy sources. So that it becomes necessary to find the alternate applications which are used in day to day life which uses non-renewable energy. The invention of as prayer, pesticides, fertilizers, etc. brings revolution in the agriculture/horticulture sector. For the most part the development of sprayers, empower ranchers to acquire outrageous horticultural yield. Sprayers are additionally utilized for greenery enclosure showering, wildflower/bother control, fluid preparing and plant leaf cleaning. In Bangladesh farms generally

two types of spray pumps are used for spraying; hand operated spray pump and fuel operated spray pump. Among both sprayers hand operated spray pump is most popular. Now fuel operated sprayer is mostly used. The model is designed to be eco-friendly and lower cost and it will prove to be more efficient when compared to petrol based pesticide sprayer. The agro sprayer developed is based on the renewable energy sources which use only solar energy.

The objectives of the study are

I. To fabricate a solar operated pesticide sprayer.
II. To evaluate the performance of the solar operated pesticide sprayer comparing with hand operated sprayer.
III. To analyze the cost of solar operated pesticide sprayer.

CHAPTER-2
LITERATURE REVIEW

Adequate information regarding the Fabrication of solar operated sprayer and pesticide application operation is scanty in the world literature. Information related to the use of solar sprayer and their impact on the Agriculture field. In this chapter an approach, has been made to review some available information related to the study.

R. Joshua *et al.* (2010) says in the paper “Solar Sprayer -An Agriculture Implement” that “Energy - demand” is one the major thread for our country. Finding solutions, to meet the “Energy -demand” is the great challenge for Social Scientist, Engineers, Entrepreneurs and Industrialist of our country. According to them, applications of non-conventional energy are the only alternate solution for conventional energy demand. Now-a-days the concept and technology employing this non-conventional energy becomes very popular for all kinds of development activities. One of the major area, which finds number applications are in agriculture sectors. Solar energy plays an important role in drying agriculture products and for irrigation purpose for pumping the well water in remote villages without electricity.

Philip J. Sammons *et al.,* (2005) Says in the paper “Autonomous Pesticide Spraying Robot for Use In A Greenhouse” that an engineering solution to the current human health hazards involved in spraying potentially toxic chemicals in the confined space of a hot and steamy glasshouse. This is achieved by the design and construction of an autonomous mobile robot for use in pest control and disease prevention applications in commercial greenhouses. The effectiveness of this platform is shown by the platforms ability to successfully navigate itself down rows of a green house, while the pesticide spraying system efficiently covers the plants evenly with spray in the set dosages.

Sandeep H., Poratkar, Dhanraj R. Raut (2013), the authors reviews on development of multi-nozzle Pesticides Sprayer Pump. Agriculture land in India comprises of small, marginal, medium and rich farmers. Small scale farmers are around 30% are used manually lever operated knapsack sprayer rand by use of this sprayer cannot maintain uniform required pressure. This leads to problem of back pain. The suggested model has removed the problem of back pain, since there is no need to carry the tank (pesticides tank) on the back.

Sanjay, *et al.,* (2015), the authors were reviews about the design and fabrication of mechanical pest sprayer. They have designed a model running without any fuel and also easy to operate for a user. In this model we find that we have simply used a sprocket mounted on rear shaft which will actuate piston inside cylinder in the tank. Also the assembly consists of 4 wheels out of which 2 are mounted on front shaft and 2 are mounted as guide wheel at reared. A sprocket is mounted on front side exactly at the end of shaft. By pushing the trolley, sprocket rotates in its direction so it actuates the piston inside the cylinder, due to this the compression takes place inside the tank. So it leads to spray Pesticides (or) water inside the tank. By our project, spraying is done using sprocket mechanism. This project is requires less man work for spraying.

Shailesh Malonde *et al.,* (May-2016) they developed a multipurpose pesticide spraying machine based on solar panels. It gives maximum work output with minimum effort. The arrangement of nozzles is adjustable according to the crops and this alone pump can used for multiple crops.

Shivaraja Kumar, *et al.* (2014), the authors were reviewed about design and development of wheel and pedal operated sprayer. The

equipment that is wheel and pedal operated sprayer, it is a portable device and no need of any fuel to operate, which is easy to move and sprays the pesticide by moving the wheel and also peddling the equipment. In this equipment using reciprocating pump and there is a accumulator provided for the continuous flows of liquid to create necessary pressure for the spraying action. This wheel operated pesticide spray equipment consumes less time and avoids the pesticide from coming from front of the nozzles which will in contact of the person who sprays pesticides.

Abhishek Jivrag *et al.* (2011) describes invention and operation of multiple granulated pesticides duster with the use of solar energy. The concoction is accomplished by the use of solar panel, impeller type centrifugal blower, gear reduction mechanism, dispensers, D.C motors and batteries. In addition, the duster has been equipped with a facility to operate on an electric supply, which serves beneficial in the absence of sunlight. The device essentially works for disbursing solid granulated (powder) form of pesticide. The operator controls the rate and discharge of different pesticides by means of push buttons and toggle switches. The technical specifications of the device are worked and examined in a way to minimize the weight of the device and deplete the feeder unit dispenser in a span of three hours

Swapnil L. Kolhe *et al.* (2014) they developed a eco friendly mechanically operated multipurpose spray pump in this nozzles can be adjusted.

Dr. H. Erdal Ozkan *et al.* (2003) the main goal of this study was to design and develop software and hardware for an intelligent sprayer that can control variable-rate spray outputs through the nozzles based on availability of a target in sight and density level of the canopy sprayed. This has been accomplished to large degree.

However there is still some in effectiveness associated with the operation of this sprayer that can be addressed by future studies.

C. Umayaal *et al.* (2003) this paper deals with the exposition of how robotics can be applied to various phase of agriculture. One of the most important occupations in developing country like India is agriculture. It is very important the efficiency and productivity of agriculture by replacing labors with intelligent machine like robots using latest technologies. The paper proposes a new strategy to replace humans in various agricultural operations like detection of presence of pests, spraying of pesticides, spraying of fertilizers etc there by providing safety to the farmers and precision agriculture.

Poratkar *et al.* (2007) the working of this manually operated multi nozzle pesticides sprayer pump is based on the principles of motion transmission due to chain and sprocket arrangement and plunger cylinder arrangement. The operator first stand behind the trolley. He will grab the handle and lift it and push the trolley forward. As trolley move forward, the wheel rotates in counter clockwise direction. As sprocket is mounted on same shaft of wheel, it also rotates in counter clockwise direction. This motion is transferred to freewheel via chain drive arrangement. The free-wheel, thus, also starts rotating in counter clockwise direction. As freewheel and big spur gear are mounted on same shaft, it also start rotating in anticlockwise direction.

J.V., Bhanutej, IJART (2015). “Design and Modeling of agriculture sprayers “, In India, agriculture has a predominant role in our day to day life .The crops that come as yield decides the total production ,adds to the economy of our country. The yield decreases due to the presence of pests, insects in the farms. To kill the pests, insect’s pesticides, fertilizers are spread either manually or by using sprayers. Earlier, the pesticides and fertilizers were drizzled manually, but they will result in harmful effects on farmers. In order to overcome this problem, different drizzling techniques have been developed. These

drizzles consists of different mechanisms and the cost of the equipment is generally high. We developed a mechanism in which we tried to minimize the equipment cost by removing the pump to spray. This sprayer works on Bernoulli's principle, in which the spraying action of the sprayer is due to the head developed and mechanical linkage. The model is developed mathematically for the major components like tank, required head and spraying mechanism.

F. Pezzi, V. Rondelli (2000), the performance of a sprayer fitted with two vertical adjustable air outlets has been studied in vineyards investigating the effects of changing speeds (1400, 2000 & 2500 rpm) and the direction of the air- jet (90 &120 backward angle of the outlet side deflectors in relation to the treated row).

Mahesh M. Bhalerao *et al.* (2005) says in the paper "Development and Fabrication of smart spray Pump" that in order to meet the food requirements of the growing population and rapid industrialization, modernization development of agriculture is inescapable. Mechanization that enables the conservation of inputs through the precision in the metering ensuring the better distribution, reducing the quantity needed for better response and prevention of losses or wastage of inputs applied. Mechanization reduces unit cost of production through higher productivity and input conservation. Farmers are using the same methods and equipment for the ages.

Akhilesh K. Bhatkar, *et al.* (2016), the authors were reviews on the development of pesticide spraying machine. Agriculture is the backbone of Indian economy. This has to support 17 % of world population with only 2.3%percentof world's geographical area, 4.2 % of world's water resource, with 2% total consumption of world's total pesticide. The need of food modernization of agricultural sector is important and one of the main sectors is pesticide spraying machine.

By proper use of pesticide to reduce wastage of crop productions.

A.S. Wankhede *et al.* (2004) the Equipment is especially made to work in row crops such as cotton pulses etc. of an agricultural field. The economic condition of farmers and the cost of labor, owing to such conditions, this equipment can find its application. The equipment is intended to perform three important operations done in fields, namely, Spraying pesticide, spraying herbicide and applying urea. All the three operations can be performed simultaneously or individually. Application of urea to the crops is not being focused much by various agriculture equipment producing firm and the equipment available are mostly suitable for large field which are in hectors. Moreover, whatever methods are available for applying urea results in high wastage of urea, we have focused on the same.

Bibhu Santosh Behera, *et al.* (2015), the authors were reviews on solar energy application for agriculture application in India. Sun is the real source of energy to minimize environmental degradation and enriching agriculture. Renewable energy and farming are a winning combination. Wind, solar and biomass energy can be harvested forever, providing farmers with a long-term source of income. Renewable energy can be used on the farm to replace other fuels or even sold as a cash crop. It is one of the most promising and important opportunities for value-added products in agriculture

Abhilash Gurjar, *et al.* (2015), the authors were reviews on solar powered sprayer. Solar powered sprayer is technology suitable application in the farming community of India. Solar powered sprayer can be used as a fuel alternating device. It works on the principle of solar photovoltaic (PV), with certain modifications on the existing power sprayer in the market. The annual maintenance charge of the sprayer is expected to be aroundRs.500 with the initial investment of

Rs.5000 towards the cost of the sprayer. “Solar Sprayers” as “Energy Alternate Devices”.

Varikuti Vasantha Rao, *et al.,* (2013), the authors were reviews about the multiple powered supplied fertilizer sprayer. The design and implementation of multiple power supplied fertilizer sprayer and proposed system is the modified model of the two stroke petrol engine powered sprayer which minimizes the difficulties of the existing power sprayer such as operating cost, changing of fuel etc. The two stroke petrol engine has been replaced by a direct current motor and operated by the electrical energy stored in the battery attached to the unit.

Alaa Kamel Subr, *et al.,* (2015), the authors were reviewed about Practical deviation in sustainable pesticide application process. Using agrochemicals becomes essential practice of modern farming but in the same time it puts risk to human, animal health and the environment. The initial actions to create balance between this negative impact and the necessity to use the pesticides concerning the environment, people's living conditions and the economic, those factors are defined as the sustainable development. In this paper the algorithm to gain the sustainability of pesticide application was set to highlight some places where the sprayer operator has to make subjective decisions about the correct procedure.

Dhiraj N. Kumbhare *et al.* (2016), Study involves Fabrication of Automatic Pesticides Spraying Machine which uses a small 4 wheel kart or vehicle which is electronically operated by a wireless remote which runs on power source using DC battery’s.

Nitish Das, *et al.,* (2015), paper comprises study on Agricultural Fertilizers and Pesticides Sprayers Spraying Methods. Also tells about different spraying methods 1) Backpack (Knapsack) Sprayer 2) Lite-Trac 3) Motorcycle Driven Multi-Purpose Farming Device (Bullet Santi) 4)Aerial Sprayer.

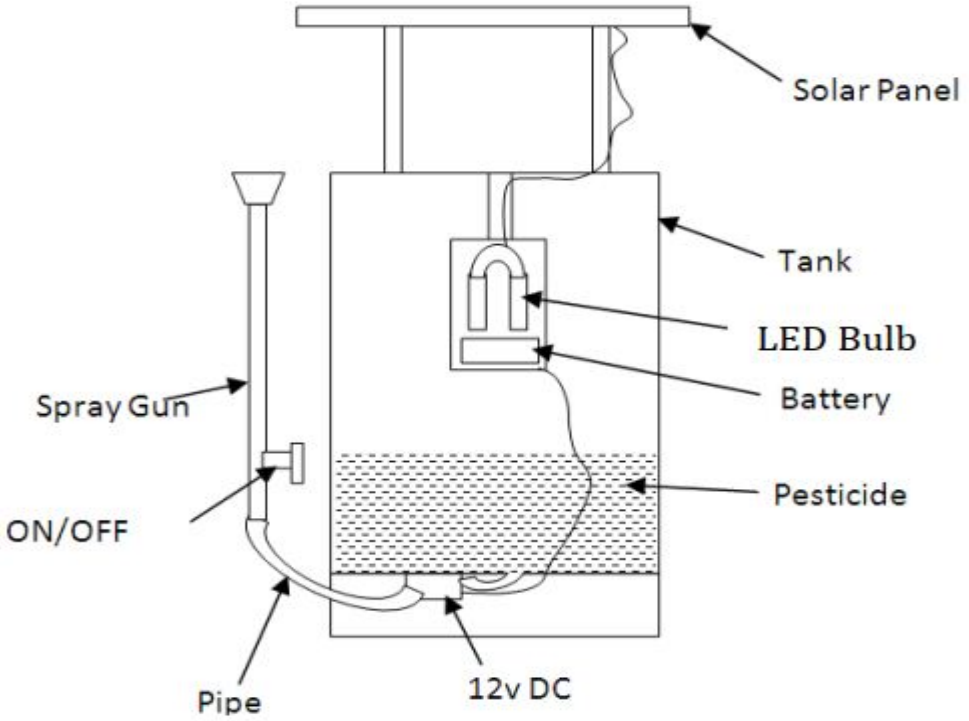

Figure 2.1: Schematic diagram of Solar operated spray pump (Pritam J. Mali *et al.)*

Sumit D. Raut, *et al.* (2014), examined the design and construction of a reciprocal pump driven by a pedal that is used in a large irrigation project such as a garden and a drainage line. They drove different types of pumps and alternative devices were built and tested on different suction heads in the laboratory to evaluate their performance. The alternative foot pump can be available in local markets and simple skills are required to produce it. But this would be suitable for irrigating large fields and orchards, in particular for pumping water from a reservoir (capacity up to 15 liters) to irrigate small plots, such as vegetables and seedbeds, witless physical effort.

B. van Campen, D. *et al.* (2000) Solar photovoltaic (PV) systems have shown their potential in rural electrification projects around the world, especially concerning Solar Home Systems. With continuing price decreases of PV systems, other applications are becoming economically attractive and experience is gained with the use of PV in such areas as social and communal services, agriculture and other

productive activities, which can have a significant impact on rural development. There is still a lack of information, however, on the potential and limitations of such PV applications. The main aim of this study is, therefore, to contribute to a better understanding of the potential impact and of the limitations of PV systems on sustainable agriculture and rural development (SARD), especially concerning income-generating activities.

Ritesh Chavan *et al.* (2015) Says in the paper “Design and Construction of Solar Powered Agricultural Pesticide Sprayer” that Today’s world faces a huge “energy crisis” problem. To meet the future “energy demands”, the use of non-conventional energy as an alternate solution is inescapable. In order to meet the food requirements of growing population, modernization of agriculture has become a necessity. In agriculture, spraying of pesticides is an important task to protect the crops from insects for obtaining high yield. However, farmers have been mainly using traditional conventional techniques like hand operated and fuel operated spray pump system for spraying pesticides. Now-[illegible] and technology employing non-conventional ene[illegible] popular for all the developing [illegible]

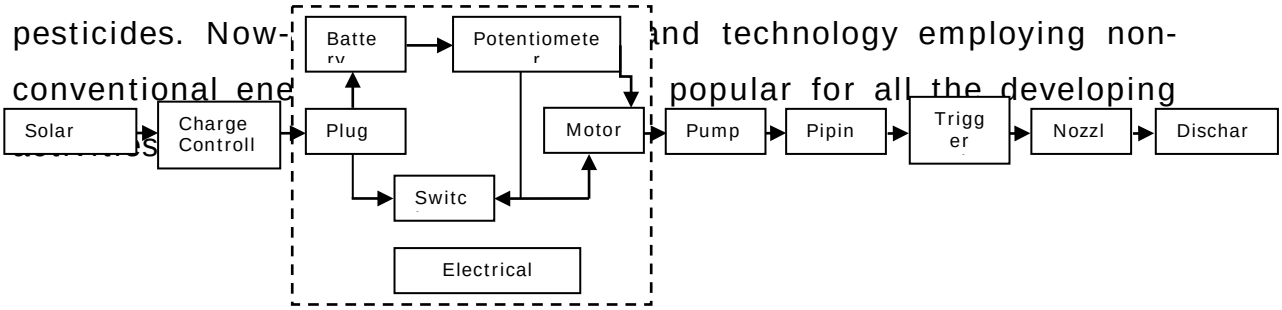

Fig 2.2: Block diagram of spraying system (Kumawat Mukesh M. *et al.*)

R. Rajesh *et al.* (1998). Energy demand is one of the major threads for our country. Finding solution to meet the energy demand is great challenge for Scientist, Engineers. Now a day pesticide sprayer is operated based on fuel engine. This operation is more economical. In order to overcome this we found the new concept known as “Solar

Pesticide Sprayer". In this pesticide sprayer is operated mainly based on solar energy and hence there is no need of any kind of alternative source. It has many advantages such as cost of spraying and also saving on Fuel/Petrol. There is less vibration as compared to the petrol sprayer. Hence the system can be easily operated there is no need of labors which increases the efficiency of farmers. Solar based pesticide sprayer is one of the improved model of pesticide sprayer pumps. Sun is the source of all energy on the earth. It is most abundant, inexhaustible and universal source of energy. All other sources of energy draw their strength from the sun. India is blessed with plenty of solar energy because most parts of the country receive bright sunshine throughout the year except a brief monsoon period.

Prof. Gopal Waghmare *et al.* (2016)" Design and fabrication of solar operated sprayer for agricultural purpose". Today's energy demand is the great challenge for our society. Conventional energy (fossil fuel, coal, nuclear energy etc) can be widely used in India such as textile industry, power plant etc. using conventional energy there are many exhaust that can be come not after pollutant which is harmful to our environments, in such situation we should move towards some non conventional energy (solar energy, wind energy, tidal energy) non conventional becomes very popular for all kinds of developments activities such as drying agriculture product. Irrigation purpose and for spraying purpose, in this paper we are trying to make unique equipment for cultivation users. My while spraying. Farmers mainly use hand operated or fuel operated spray pump for this task. This Conventional sprayer causes user fatigue due to excessive bulky and heavy construction. This motivated us to designing and fabricated a model that is basically trolley based solar sprayer in our project here we can eliminating the back mounting of sprayer because Ergonomically it is not good for farmer health point of view during spraying in this here we can reduce the users fatigue level.

Kumawat Mukesh M, *et al.* (2018) “solar operated pesticide sprayer for agriculture purpose”. Sprayers are mechanical devices that are specifically designed to spray liquids quickly and easily. They come in number of different varieties. In this project we will take a solar operated mechanical sprayers. A sprayer of this type is a great way to use solar energy. Solar based pesticides sprayer pump is one of the improved versions of petrol engine pesticide sprayer pump. It is vastly used in the agriculture filed and also used for many purposes. This is having more advantages over petrol engine sprayer pump it uses the solar power to run the motor. So it is a pollution free pump compared to petrol engine sprayer pump. In this charged battery can also use for home appliances. The solar panels make up to most 80% of the systems cost. The size of the pv. system directly dependent on the size of the pump ,the amount of water is required (m^3 /d) and the solar irradiance .The farmer can do spraying operation by himself without engaging la-bour, thus increasing the spraying efficiency.

CHAPTER-3

MATERIALS AND METHODS

This chapter deals with the methodology, which was adopted to attain the objectives of the study. It explains selection of sprayer, solar panel, methods of data collection, the selection research tools and selection of analytical method that were used in the study.

The solar operated pesticide sprayer was fabricated with many components. The main components used to fabricate the prototype:

- Solar panel
- Pump
- DC motor
- Battery
- Tank
- Nozzle
- Bevel gear
- Pesticides
- Solar Energy
- Solar Charge controller
- Multi-meter

3.1 Solar panel

A solar panel (also solar module, photovoltaic module or photovoltaic panel) is a packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential

applications. Each panel is rated by its DC output power under standard test conditions, and typically ranges from 100 to 320 watts. The efficiency of a panel determines the area of a panel given the same rated output - an 8% efficient 230 watt panel will have twice the area of a 16% efficient 230 watt panel. Because a single solar panel can produce only a limited amount of power. Most of the installations contain multiple panels. A photovoltaic system typically includes an array of solar panels, an inverter, and sometimes a battery and or solar tracker and interconnection wiring.

Figure 3.1: Solar Panel

3.2 Pump

For people living in remote areas, solar water pumps are usually the only solution as there is no access to diesel. If there is diesel, Solar Water Pumps are the only solution or an excellent alternative for diesel as the cost of running power lines or diesel pumping may be too great. A solar powered water pump differs from a regular water pump only in that it uses the sun's energy to supply electricity for the pump. The solar panels absorb the sun's energy and convert it to electrical energy for the pump to operate. All the pumped water is stored in a water tank so that there is constant supply even in bad weather conditions and during night time where there is insufficient power to generate the solar water pumps. Solar powered water pumps represent a higher initial investment, however, over a period of 5 years they represent a

cost benefit due to minimal maintenance costs compared to AC pumps run with a generator.

Figure 3.2: DC water pump

3.3 DC motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronics, to periodically change the direction of current flow in part of the motor. DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills.

3.4 Battery

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power

electrical devices such as flashlights, smart phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit. It is the movement of those ions within the battery which allows current to flow out of the battery to perform work.

Figure 3.3: DC Battery

3.5 Tank

Storage tanks are containers that hold liquids, compressed gases or mediums used for the short or long-term storage of fluids or gases. The term can be used for reservoirs. Storage tanks are available in many shapes: vertical and horizontal cylindrical open top and closed top flat bottom, cone bottom, slope bottom and dish bottom. Large tanks tend to be vertical cylindrical, or to have rounded corners transition from vertical side wall to bottom profile, to easier withstand hydraulic hydrostatically induced pressure of contained liquid. Most container tanks for handling liquids during transportation are designed to handle varying degrees of pressure.

Figure 3.4: Pesticide Tank

3.6 Nozzle

A nozzle is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe. A nozzle is often a pipe or tube of varying cross sectional area and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them. In a nozzle, the velocity of fluid increases at the expense of its pressure energy. There are many types of nozzle. Some description of nozzle.

3.6.1 Nozzle Selection

The spray characteristics of agricultural spray nozzles are important criteria in the application of pesticides because of their ultimate effect on the efficiency of the pesticide application process. Droplet size and velocity affect the structure of the spray deposits and the drift ability of the droplets (Taylor *et al.,* 2004).

Furthermore, droplet size may influence the biological efficacy of the applied pesticide as well as environmental hazards. Hence, the ideal nozzle pressure combination will maximize spray efficiency for depositing and transferring a lethal dose to the target, whilst minimizing off-target losses such as spray drift and user exposure.

3.6.2 Hollow cone

The hollow cone consists of a swirl plate surrounded by a swirl core with the swirl chamber between the two. Liquid passes through the spiral slots in the swirl core, and into the swirl chamber where it acquires a high rotational velocity, discharging from the nozzle in a hollow cone spray pattern. This nozzle is widely used with knapsack sprayers: the fine droplets ensure that it is very suitable for foliar application of insecticides and fungicides.

Figure 3.5: Hollow cone nozzle

3.7 Bevel gear

Bevel gears are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The pitch surface of bevel gears is a cone. Two important concepts in gearing are pitch surface and pitch angle. The pitch surface of a gear is the imaginary toothless surface that you would have by averaging out the peaks and valleys of the individual teeth. The pitch surface of an

ordinary gear is the shape of a cylinder. The pitch angle of a gear is the angle between the face of the pitch surface and the axis. The most familiar kinds of bevel gears have pitch angles of less than 90 degrees and therefore are cone-shaped. This type of bevel gear is called external because the gear teeth point outward. The pitch surfaces of meshed external bevel gears are coaxial with the gear shafts the apexes of the two surfaces are at the point of intersection of the shaft axes. Bevel gears that have pitch angles of greater than ninety degrees have teeth that point inward and are called internal bevel gears.

3.8 Multi-meter

Multi-meter is an electrical device. It was used to measured the electrical current, voltage.

Figure 3.6: Multi-meter

3.9 Pesticides

A pesticide is any substance or mixture of substances intended to prevent, destroying, repeal or mitigate any pest. It may be a chemical substance, biological agent (such as virus or bacterium) antimicrobial disinfectant or device used against any pest. 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. Most pesticides are intended to serve as plant protection products (also known as crop protection products), which in general, protect plants from weeds, Fungi, or insects. In general, a pesticide is a chemical or biological agent (such as a virus, bacterium, antimicrobial, or disinfectant) that deters, incapacitates, kills, or otherwise discourages pests. Target pests can include insects, plant pathogens, weeds, Molluscs, birds, mammals, fish, nematodes (roundworms), and microbes that destroy property, cause nuisance, or spread disease, or are disease vectors. Although pesticides have benefits, some also have drawbacks, such as potential toxicity to humans and other species. According to the Stockholm Convention on Persistent Organic Pollutants, 9 of the 12 most dangerous and persistent organic chemicals are organ chlorine pesticides.

3.10 Solar Energy

The Solar energy is a renewable source of energy which is abundantly available, used for various purposes 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. It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy.

3.10.1 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.

3.10.2 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.

3.11 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 sprayer are summarized.

Figure 3.7: Solar charge controller

3.12 Assembly process

In the assembly process the base structure is made from cast iron and the required parts are fixed in the predetermined positions and the connections are made in the workshop. Solar panel is placed in such a way that it can absorb the sunlight and this solar panel is connected to the controller and to the battery so that we can charge the battery and from battery is connected to the dc motor and with the help of the dc motor the pump is working and converting the mechanical energy to hydraulic energy and this energy pulls the pesticides which is mixed with water and through the piping it comes out of nozzle and pesticide is applied this is the assembly process. The Fig. 3.6 shows the assembled model of proposed system.

Figure 3.8: Assembling process of solar operated sprayer system

3.13 Working principle of Solar Operated Sprayer

Solar operated system consists of Solar panel, battery, pump and sprayer. The solar panel delivers an output in the order of 20 volts and supply power to the

charging unit. The charging unit is used to strengthen the signal from the solar panel. The charging unit delivers the signal which charges the battery. According to the charged unit, the pump operates, such that the sprayer works. Here fertilizer can be stored in tank. When the sun rays are falling on the solar panel electricity will be generated through the solar cells and stored in the battery. By the electric power in the battery the pump operates and therefore fertilizers from the tank is sprayed out through the sprayers. There is no maintenance cost and operating cost as it is using solar energy and no pollution problem. In solar energy mode, solar energy obtained by the sun is converted into electrical energy using solar panel by photovoltaic effect. The output of energy conversion was used to charge a deep cycle battery.

Figure 3.9: Spray with solar operated pesticide sprayer in the field

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 times. In such cases a deep cycle battery is used. In this work a lead-acid accumulator serves the purpose. The lead-acid battery has the properties such as high current availability, contact voltage, longer life and more ability to charge as compare to conventional batteries. The output of battery is connected to a DC pump through protection circuit.

The DC pump is selected because of the advantages such as less in noise, longer in life, maintenance free, motor speed can be varied in the larger extent by varying the supply voltage and is self-lubricated. Pump is used to suck the spraying liquid from the sprayer tank and spray it through nozzle. The sprayer consists of sprayer tank and sprayer pipe. The sprayer tank is made up of light weight material in order to reduce the weight of the tank. The capacity of the tank is 16 liters and connected to the sprayer pipe with adjustable nozzle. By adjusting the nozzle the output of flow can be controlled. The whole unit can be carried conveniently at the back of human body with the help of shoulder straps.
The supporting base of entire unit needs to be strong and light in weight. The prepared solar operated sprayer is environment friendly and cost efficient. This sprayer can be used largely in agriculture field effectively. It is best option to farmer who economically challenged and facing electrical problems like load shedding. It does not require fuel

hence it is a zero fuel operated equipment and does not create air pollution and noise. The solar operated sprayer will help the farmers of those remote areas of country where fuel is not available easily. They can perform their regular work as well as saves fuel up to large extent. At the same time they can do their pesticide spraying work with very less environment pollution.

3.14 Measurement of voltage and current

Solar energy is the renewable energy source. Solar energy is absorbed by the solar panel which contains photovoltaic cells. The conversion of the solar energy into electrical energy is done by these cells. This converted energy utilizes to store the voltage in the DC battery and that battery further used for driving the spray pump. The voltage and current measurement are different angle of the solar panel. The solar panel set up the sun light at (30^0, 45^0, $60^0$and flat) angle and measurement voltage and current with used to the multi-meter.

$$P = v \times i$$

Eqn. 1

Figure 3.10: Measurement of Voltage and Current

3.15 Field Application

3.15.1 Experimental Site

The experiment was conducted in the area of Kornai village in Dinajpur district. The experiment was applied in Aman rice field. The experiment was conducted in three experimental plots. The plot size was selected in 5 decimal. Solar operated sprayer and hand operated sprayer was used in the selected area.

3.15.2 Pressure Measurement

A pressure gauge was set up between the nozzle and spray gun for measuring flow rate of the selected nozzle at different pressures. The range of pressure gauge was 0 to 100 psi (0 to 7 kg/cm^2). The pressure gauge was set by using a T-joint. The T- joint was made in a local workshop with suitable dimension. The pressure was measured when applied pesticide in the field.

3.15.3 Application Time Measurement

The solar operated sprayer was used in the field and applied pesticide in the selected field. This process was applied three times and measure the spraying time by stop watch.

The hand operated sprayer was used in the field and measurement of spraying time by stop watch for the same process.

Figure 3.11: Field application of hand operated sprayer and solar operated sprayer

3.16 Economics analysis of the Sprayer

A Simple cost analysis was done for the solar operated sprayer. The analysis included the actual cost of the device, annual fixed cost and variable cost. The annual fixed cost included depreciation, interest and TIS (Taxes, Insurance and Shelter).Variable cost included repair and maintenance cost, labor cost and electricity cost. Assumption was made as interest 13%, tax, insurance and shelter (TIS) 3%, repair and maintenance cost .025%, operation per day 8 hrs, annual use 300 hrs and estimated life span 10 yrs of the machine.

The cost was calculated using following formulas:

The annual depreciation was calculated as

$$D = P\text{-}S/L \qquad \text{Eqn. 2}$$

Where, D is the depreciation, P is the purchase price of the machine, S is the salvage or selling price and L is the time between buying and selling. Interest on investment was calculated as

$$I = [P + S/2] \times i \qquad \text{Eqn. 3}$$

Where, I is the interest on investment, P is the purchase price of the machine, S is the salvage or selling price, i is the current interest rate. Total cost per year calculated as

$$\text{Total cost} = \text{Annual fixed cost} + \text{Variable cost} \qquad \text{Eqn. 4}$$

CHAPER-4

RESULTS AND DISCUSSIONS

This chapter represents the results obtained from workshop and field experiments conducted for the study. Field experiments were conducted for the measurements of voltage, Current and power for different angle of solar panel. Field experiments were conducted for the amount of time required for pesticide applications. The results obtained from this study in relation to effects of pesticide application have been presented in this chapter. Relevant interpretations and discussions of the data have also been made in this chapter. The result of the experiments are given below

4.1 Developed pesticide sprayer

The developed pesticide sprayer was made of solar panel, battery, pump, dc motor, solar charge controller and other parts. The solar was set up the pesticide tank with the help of cast iron in the workshop. The solar charge controller was set up with the solar panel to battery. The solar charge controller controls the solar energy and supply the battery. The other parts were set up the pesticide tank in the workshop and developed a pesticide sprayer.

Figure 4.1: Developed pesticide sprayer

4.2 Measurement of voltage, current and power for different angles of solar panel

The solar panel set up the sun light at (30^0, 45^0, 60^0 and flat) angle. The sun light reflects the solar panel and measurement of voltage and current with used to the multi-meter in the field. The data of voltage, current and power are given below.

Table 4.1: Effect of inclination angle 30^0 of solar panel with the horizontal

Angle	Voltage (volt)	Average voltage (volt)	Current (amp)	Average current (amp)	Power = v×i (watt)
30^0C	19.80	19.82	1.91	1.88	37.39
	19.81		1.85		
	19.85		1.90		

Table 4.2: Effect of inclination angle 45^0 of solar panel with the horizontal

Angle	Voltage (volt)	Average voltage (volt)	Current (amp)	Average current (amp)	Power = v×i(watt)
45^0C	19.73	19.71	1.81	1.80	35.48
	19.69		1.81		
	19.72		1.79		

Table 4.3: Effect of inclination angle 60^0 of solar panel with the horizontal

Angle	Voltage (volt)	Average voltage (volt)	Current (amp)	Average current (amp)	Power = v×i (watt)
60^0C	19.40	19.38	1.63	1.45	28.10
	19.39		1.60		
	19.36		1.61		

Table 4.4: Effect of horizontal angle of the solar panel

Angle	Voltage (volt)	Average voltage (volt)	Current (amp)	Average current (amp)	Power = v×i (watt)
Flat	19.61	19.59	1.41	1.61	31.54
	19.58		1.47		
	19.60		1.46		

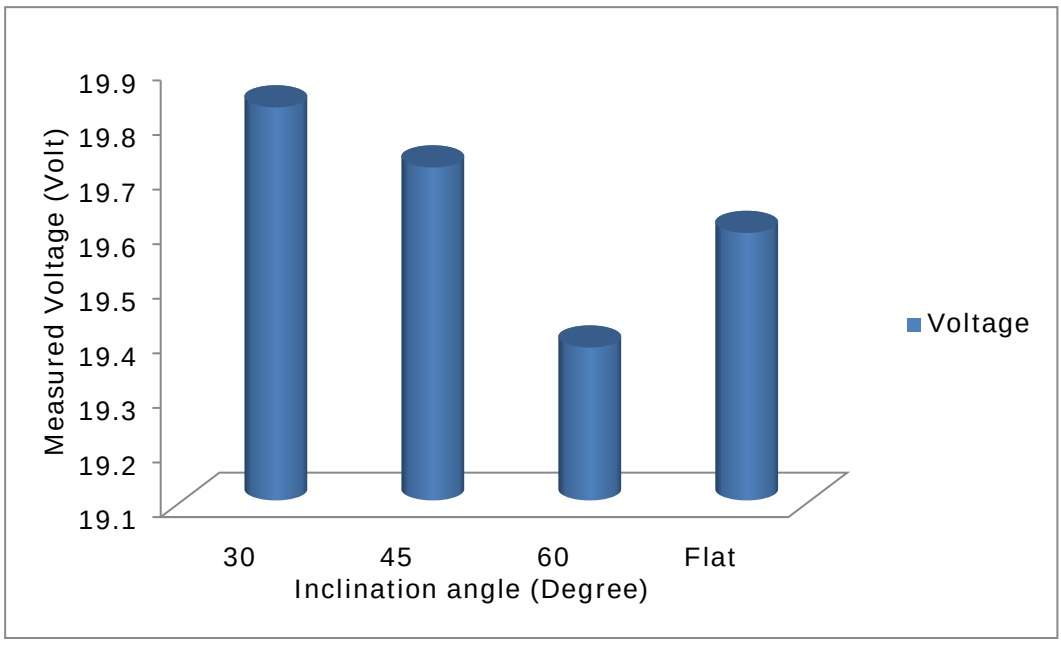

Fig-4.2: Relation between inclination angle and measured voltage

Figure-4.2 shows that the relation with angle to voltage. It shows that the maximum voltage produced in 30^0 angle and lowest voltage supply was in 60^0 angle of solar panel and 45^0, flat angle were supply average voltage. The solar panel in 30^0 angel supply average voltage 19.82 and 60^0 angle supply average voltage 19.38 volt.

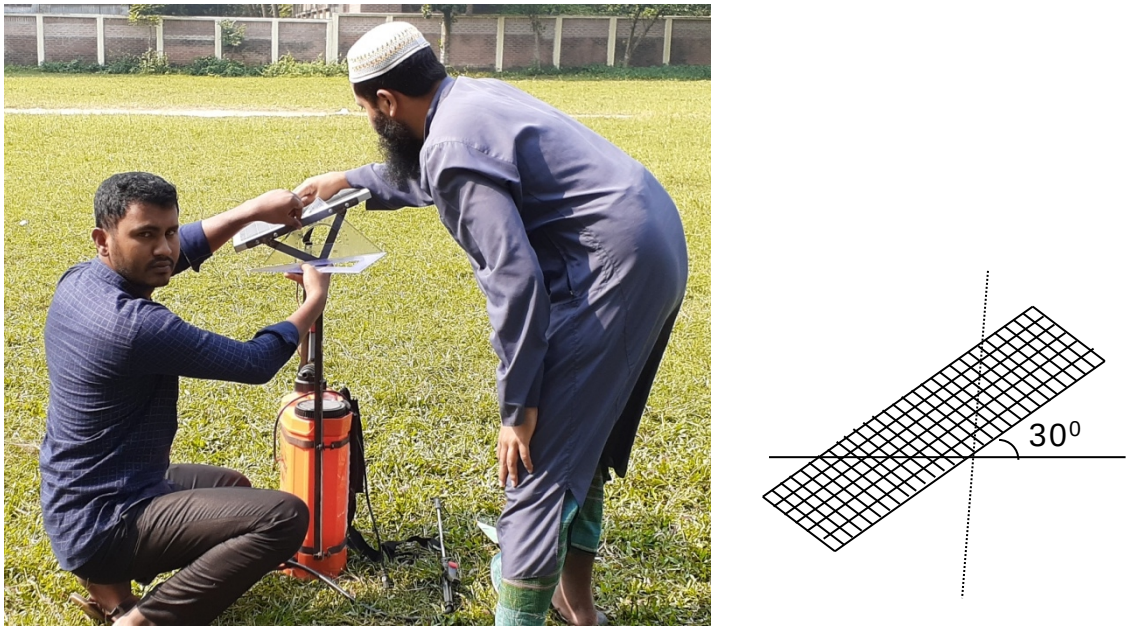

Fig-4.3: 30^0C angle measurement in the field

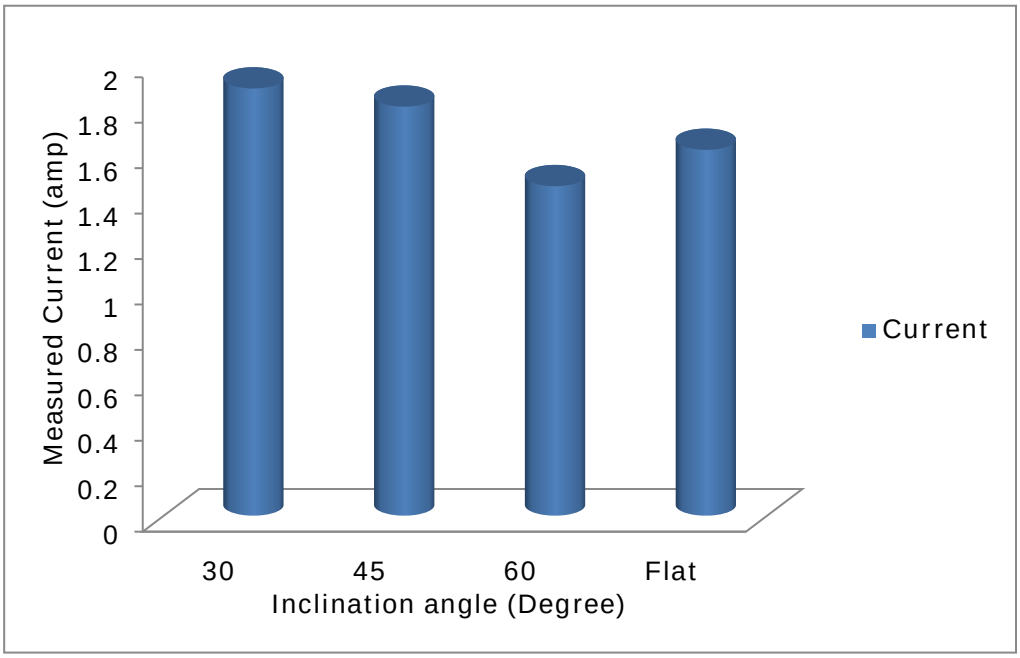

Fig-4.4: Relation between inclination angle and measured current

Figure-4.4 shows that the relation with angle to current. It shows that the maximum current produced in 30^0 angle and lower current supply was in 60^0 angle of solar panel and 45^0, flat angle were supply average current. The solar panel in 30^0 angel supply average current 1.88 amp and 60^0 angle supply average current 1.45 amp.

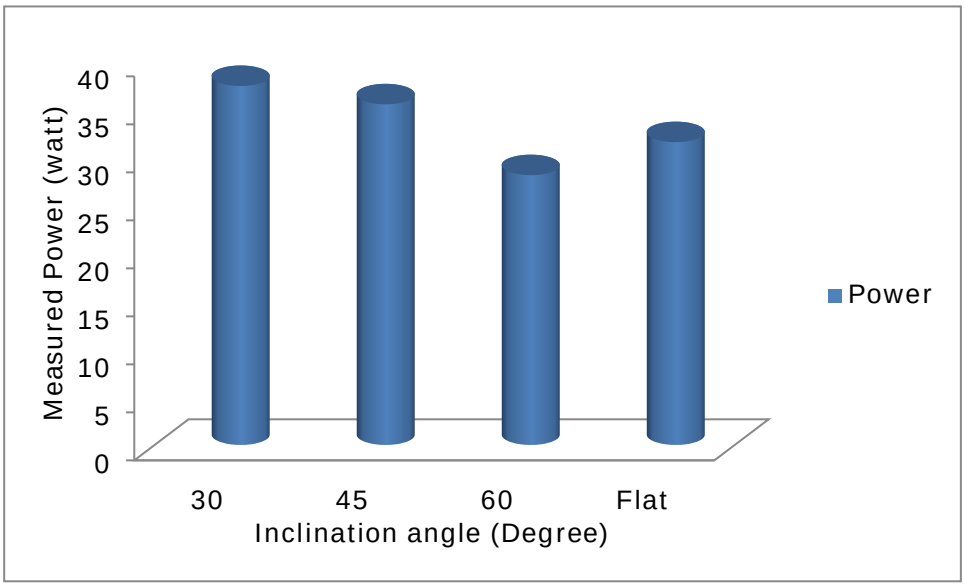

Fig-4.5: Relation between inclination angle and measured power

Figure-4.5 shows that the relation with angle to power. It shows that the maximum power produced in 30^0 angle and lowest power supply was in 60^0 angle of solar panel and 45^0, flat angle were supply average power. The solar panel in 30^0 angel supply average power 37.39 watt and 60^0 angle supply average power 28.10 watt.

4.3 Measurement of spraying time and pressure of the sprayer

The proposed sprayer and hand operated sprayer were field test applied in the rice field and measurement of pressure and application time. The data are given below

Table 4.5: Data of spraying time and pressure of the sprayer

Sprayer	Area	Pressure	Spraying time	Average time
Solar sprayer	5 decimal	4-5 bar	4 min 51 sec	5 min 18 sec
			5 min 36 sec	
			5 min 28 sec	
Manual sprayer	5 decimal	1.5-2 bar	10 min 15 sec	10 min 48 sec
			10 min 58 sec	

			11 min 10 sec	

In the above table the data show that the solar operated pesticide sprayer works on 4-5 bar and coverage the spraying 5 decimal area, the average time 5 min 18 second required. On the other hand the hand operated sprayer works on 1.5-2 bar and coverage the spraying 5 decimal area, the averagetime 10 min 48 second required.We show that the proposed sprayer almost half time required for compare to the hand operated sprayer.

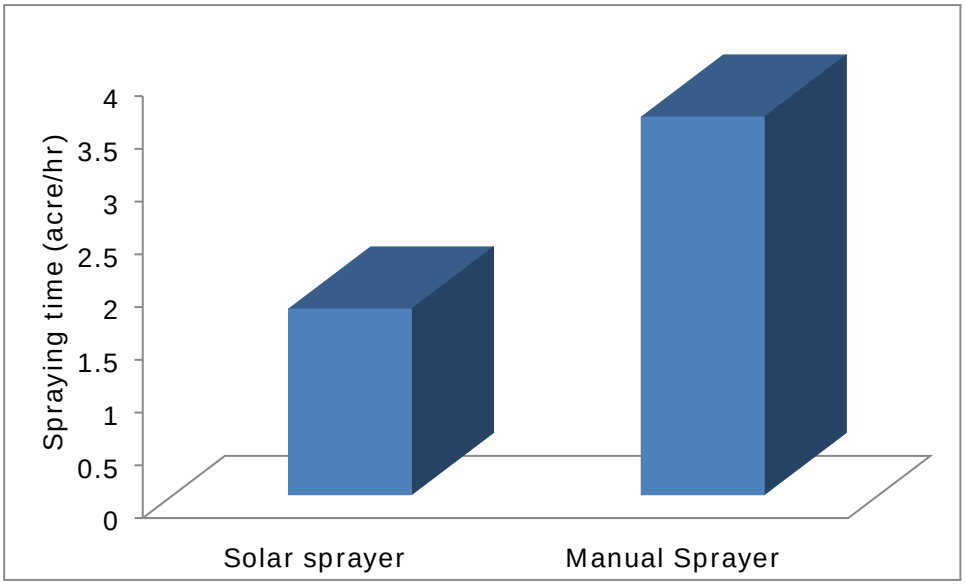

Figure 4.6: Spraying time comparison

In the above figure show that the time required to spraying for the solar operated sprayer and the hand operated sprayer. The solar operated sprayer was required average 1hr 46 min per acre. On the other hand the hand operated sprayer was required 3hr 35 min. we saw that the hand operated sprayer required almost double time compare to the proposed sprayer.

4.4 Simple comparison between hand operated sprayer and solar operated pesticide sprayer

Simple comparison between the hand operated sprayer data and the solar operated pesticide sprayer data are given below:

Table 4.6 Comparison of parameters

Parameter	Hand operated sprayer	Proposed sprayer
Weight	4 – 7 kg	8.75 kg
Discharge	0.8 – 1.5 Lit/min	2 – 2.8 Lit/min
Product cost	2000 Tk	4000 Tk
Maintenance cost	Low	Low
Pressure	1.5 – 2 bar	4 – 5 bar

Comparison of proposed sprayer with conventional sprayer is shown in table 4.6. It is clear from the table 4.6 that the proposed sprayer is having an average value in all the aspects like weight, discharge, product cost, maintenance cost, pressure.

Weight: Though the weight of the proposed sprayer is more than hand operated sprayer, the requirement of manual effort for the operation is eliminated, and obviously saves the human energy.

Discharge: The hand operated sprayer gives a discharge of about 0.8 to 1.5 lit/min it needs the operator to operate the sprayer till the pesticides are deposited by a sufficient amount. However the solar operated sprayer gives a discharge about 2 to 2.8 lit/min. These are eliminated the spraying time.

Pressure: The hand operated sprayer having a pressure about 1.5 to 2 bar is not sufficient for large crops. The solar operated sprayer having a pressure about 4 to 5 bar. The moderate pressure achieved by the proposed device cans efficient spraying.

4.5. Economics of the pesticide sprayer

4.5.1. Cost estimation and comparison

The present solar sprayer was fabricated in such a way as to keep its cost low. The cost estimated of the sprayer and compare the cost of the hand operated sprayer. The fabrication cost of solar operated sprayer was 4000tk, annual fixed cost 4.51tk/acre and variable cost 90tk/acre. The total spraying cost of the solar operated pesticide was 94.51tk/acre. On the other hand cost of the hand operated sprayer was 2000tk and annul fixed cost 4.57tk/acre, variable cost 180.79tk/acre. The total spraying cost of the hand operated sprayer was 186tk/acre. The cost of solar operated sprayer was half cost of the hand operated sprayer. That we saw that the solar operated sprayer was more cost effective.

CHAPTER-V
SUMMARY AND CONCLUSION

The main objective of the project was to utilize inherently available solar energy in spraying operations thus achieving zero electricity. When the sun rays are falling on the solar panel electricity will be generated through the solar cells and stored in the battery. By the electric power in the battery the pump operates and therefore fertilizers from the tank is sprayed out through the sprayers. The solar panel, solar charge controller and other parts was set up sprayer and construct a model in the workshop. The solar sprayer was set up the field and measure the voltage, current and power for 30^0, 45^0, 60^0 and flat angle. The maximum voltage,current and power produced in 30^o inclination angle. At 30^o inclination angle the supply voltage 19.82 volt, the supply current 1.88 amp and produce power 37.39 watt. The minimum output supply in 60^o inclination angle. At 60^0 inclination angle the supply voltage 19.38 volt, the supply current 1.45 amp and produce power 28.10 watt.Theconstant supply of voltage from solar charge controller and then with the use of selected pump and nozzle, spraying operation can be carried out.The proposed sprayer was field application in the field and compare to the hand operated sprayer.The proposed sprayer works on 4 to 5 bar and hand operated sprayer works on 1.5 to 2 bar. The 5 decimal area pesticide application required to 5 minute 18 second the solar sprayer. On the other hand manual sprayer required 10 minute 48 second. This application time was required half time compared to the hand operated sprayer. The initial cost of the sprayer was Tk. 4000 and is expected to last for 10 years. The annual use of the sprayer in the village is approximately 300 hrs. The sprayer has an total cost 94.51tk per acre. On the other hand, manual operated sprayer cost required 186 tk./acre. The cost of solar sprayer was half compared to the manual spryer . The sprayer Efficiency and accuracy very much high considerably the other types of sprayer. This process is more effective spraying and reduces the human efforts. The outcomes of the proposed research can play an

important role in the improvement of socioeconomic status of rice growers and product processors of Bangladesh.

REFERENCES

Abdul Kalam S.K., Rajyalakshmi, K.V.N.S.J, Narayanasai, B.B, Seshukumar, V. Karthik, R. Akhila I. Srinivasrao, A. Saikoteswararao, H. 2019. Design & Fabrication Of Remote Controlled Solar Powered Pesticide Drizzle International Journal of Research in Advent Technology, Special Issue, E-ISSN: 2321-9637

Abhilash Gurjar, Riyaz Mansuri, Sanjay Baghel, Kaustubh Kawale, 2015. Solar Powered Sprayer" international journal for engineering applications and technology, volume, Issn: 2321-8134.

Abhishek Jivrag, Vinayak Chawre, Aditya Bhagwat, 2011. Solar Operated Multiple Granulated Pesticide*, International Journal on Engineering Research and Development, 3(2),*, 210-215

Ahalya M, Muktha A , Veena M , Vidyashree G , Rehna V J 2017. Solar Powered Semi-Automatic Pesticide Sprayer for use in Vineyards SSRG International Journal of Electronics and Communication Engineering (SSRG – IJECE) – Volume 4 Issue 4

Akhilesh K. Bhatkar, P. B. Khope, P. S. Chaudhari, 2016. Development of Pesticide Spraying Machine. International Journal of Research in Engineering and Technology ICESMART-2016, ISSN: 2319-1163 pISSN:2321-7308

Akshay, M.N. and Waghmare, G., 2016. Design and fabrication of solar operated sprayer for agricultural purpose. National Conference on Innovative Trends in Science and Engineering, Vol. 4, No. 7,

Ashutosh Mishra, Neetu Bhagat and Padam Singh 2019. Development of Solar Operated Sprayer for Small Scale Farmers 'International Journal of Current Microbiology and Applied Sciences ISSN: 2319-7706

Asif Hassan, Nasif Mahmud, MdShamiur Rahman, Fayek Tasneem Khan, Md. Imtiazul Haque 2014. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering *(An ISO 3297:* Vol. 3, Issue 1,

Bhanutej, J. V., Phani, S.K., Pradeep, B.K. 2015. Working of Sprayers, International Journal of Research in Advent Technology, 3(4), 160-167

Bibhu Santosh Behera, Rudra Ashish Behera and Anama Charan Behera, 2015. Solar Energy Applications for Agriculture in India. International Journal of Energy, Sustainability and Environmental Engineering Vol. 1 (3), pp.107-110.

Campen, B.V., Guidi, D. and Best, G. 2000. Solar photo voltaic for sustainable agriculture and rural development Environment and Natural Resources Working International journal on Scientific Research and Development, 2(1), 60-65

Charvani, S., Sowmya, K., Malath, M., Rajani, P., Saibaba, K. 2010. Design and Fabrication of A Solar Sprayer. National Conference on Innovative Trends in Science and Engineering, page no 237 to 244

Chavan, Ritesh, 2015. Design and Construction of Solar Powered Agricultural Pesticide Sprayer. International Journal of Innovations & Advancement in Computer Science 4.4: 145-150.

Degarmo, E., Paul, Black, J.T., Kohser, Ronald, A. 2003. Materials and Processes in Manufacturing (9th ed.), Wiley, ISBN 0-471-65653-4

Dhiraj, N. Kumbhare 2016. Fabrication of Automatic Pesticides Spraying Machine. IJIRST – International Journal for Innovative Research in Science & Technology| Volume 1 | Issue 11 | April 2015 ISSN (online): 2349-6010

Fahim Hasan, Zakir Hossain, Maria Rahman, Sazzad Ar Rahman, 2010. Design and Development of a Cost Effective Urban Residential Solar PV System.

Gopal Waghmare, Akshay, M., Narete 2016. Design and fabrication of solar operated sprayer for agriculture purpose NC-ITSE volume 04

Govinda Raju, P., Vinay Kumar, D., Dinesh C. 2017. Solar Operated Pesticide Sprayer International Journal of Core Engineering & Management (ISSN: 2348-9510) Special Issue,

Groover, Mikell, P. 2007. Theory of Metal Machining, Fundamentals Of Modern Manufacturing (3rd ed.), John Wiley & Sons, Inc., pp. 491–504, ISBN 0-471-74485-9

Harshit Jain, Nikunj Gangrade, Sumit Paul, Harshal Gangrade, Jishnu Ghosh 2018 Design and Fabrication of Solar Pesticide Sprayerijariie-ISSN (O)-2395-4396 Vol-4 Issue-2

Hussain, M. and Siddique, D., 2013. On correlating the relative sunshine International Journal of Scientific & Engineering Research Volume 4, Issue 10, ISSN 2229-5518IJSER © 2013 http://www.ijser.orgduration with the state of the sky. Solar and Wind Technology,' 7,5,555-557, 2001

International Energy Association (IEA), 2017.https://www. solarguide. co.uk/top-10-countries-generating-solar-power#/

Jones, B.J. (2006). Selecting nozzles for hand-held applicators. A Technical note of forest research. FCTN 015: 4-8.

Joshua, R. Vasu and V. Vincent, P. 2010. Solar Sprayer- An Agriculture Implement, "International Journal of Sustainable Agriculture 2 (1): pp. 16-19, ISSN 2079-2107".

Kashid Tukaram, Chavan Mahesh, Kashid Ganesh 2017. Solar Powered Pesticide Agriculture Sprayer volumn no 4

Krishna Murthy B., Rajan Kanwar, Indrajeet Yadav, Vishnu Das 2017. Pesticide Sprayer “International Journal of Latest Engineering Research and Applications Volume – 02, Issue – 05, PP – 82-89Solar (IJLERA) ISSN: 2455-7137

Kumawat Mukesh M., Dipak Wadavane, Naik Ankit, Vidhate Dipak, Ghuge Chandrakant 2018. Solar operated pesticide sprayer for agriculture purpose International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 05e-ISSN: 2395-0056

Mahesh MB halerao, Amitkumar S. Yadav, Dattu T. Unde, Prof. R.G. Deshmukh, Azfar M. Khan 2015. Development and Fabrication of Smart Spray Pump.

Miller, M. A. Steward, B. L. Westphalen, M. L. 2004. Effects of multi−mode four−wheel steering on sprayer machine performance”, American Society of Agricultural Engineers ISSN 0001−2351

Mondal, M.A.H. and Denich, M. 2010. Assessment of renewable energy resources potential for electricity generation in Bangladesh. Renewable & Sustainable Energy Reviews, 14(8): p. 2401-2413

Mowade, S.M., Karishma Tarekar, Mahendra Dakhare, Naz Ansari, 2018. FABRICATION OF RECIPROCATING MULTISPRAYER- A Review International Conference on Emanations in Mordern Engineering Science & Management (ICEMESM-2018)

Nitish Das, Namit Maske, Vinayak Khawas, Chaudhary, S.K. 2015. Fabrication of Automatic Pesticides Spraying Machine” International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 p-ISSN: 2395-0072

Oberg, Erik; Jones, Franklin D.; McCauley, Christopher J.; Heald, Ricardo M. 2004. Machinery's Handbook (27th ed.), Industrial Press, ISBN 978-0-8311-2700-8.

Pandurang Lad, Virendra Patil, Prashant Patil Tushar Pati, Pravin Patil 2015. Solar Operated Pesticide Sprayer. IJARSE, Vol. No.4, Special Issue (01).

Pezzi, F., Rondelli, V. 2000. The Performance of an Air-assisted Sprayer operating in Vines, Journal of Agricultural Engineering Research, volume 76, issue 4, pg. 331-340

Pramodh, R., Santhosh, D., Manjesh, K.S., Lakshmi Narasimha, N. 2015 Concept, Design, Analysis and Fabrication of Pesticide Sprayer for Rose Farming international Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2015): 78.96

Pritam, J. Mali, Yogesh, G., Ahir, Akash, S. Bijagare, Rajendra, S. Khadayate. 2016. Farmer friendly Solar Operated Spray Pump Volume: 03 Issue: 02

Rajan Kanwar, Indrajeet Yadav, Vishnu Das. 2017. Solar Pesticide Sprayer, Krishna Murthy, Volume –02, Issue –05.

Rajashe Khargoud Angadi, Rohit L.G., Satish Changond, Santosh Kagale 2017. Cam Operated Agrochemical Pesticide Sprayer Vol. 6 Issue 01.

Rajesh, R., Kumar and Sastry, O.S. 1998. Energy Demand, 2nd World Conference on Photovoltaic Solar Energy Conversion, 2 (2), 6-10

Sammons, Philip J., Tomonari Furukawa, and Andrew Bulgin. 2005. Autonomous pesticide spraying robot for use in a greenhouse. Australian Conference on Robotics and Automation.

Sandeep, H., Poratkar, Dhanraj, Raut R. 2013. Development of Multinozzle Pesticides Sprayer Pump. International Journal of Modern Engineering Research (IJMER) www.ijmer.comVol.3, Issue.2, pp-864-868 ISSN: 2249-664.

Sanjay, S, Sridhar, R. 2015. Design and fabrication of mechanical pest sprayer", IJIRSET, ISSN:2319-8753, Vol. 4Spl Issue 10, Aug-

Sarvesh Kulkarni, Karan Hasurkar, Ramdas Kumbhar, Amol Gonde, Raut A.S., 2015. Review of Solar Powered Pesticide Sprayer, International Journal of Research in Advent Technology, Vol. 3, No.4.

Shailesh Malonde, Shubham Kathwate, Pratik Kolhe, Roadney Jacob, Nishat Ingole, Rupesh D. Khorgade 2016. Design and Development of Multipurpose Pesticides Spraying Machine. Journal of Advanced Engineering and Global Technology ISSN No: 2309-4893 Vol-04, Issue-03.

Shivaraja Kumar, Parameswaramurthy. D 2014. Design and Development of Wheel and pedal Operated Sprayer. International Journal of Mechanical Engineering (IIJME) Volume 2, ISSN 2321-6441.

Sumitm D., Raut, Kamleshm R., Banarse, Roshan R., More, 2014. Fabrication of Pedal Operated Reciprocating Pesticide Sprayer for Agricultural and Drainage Line Use. International journal of pure and applied research in engineering and technology, Volume 2 (9), 67-74ISSN: 2319-507X

Surender Kuma 2017. Design of Solar Hybrid Pesticide Spray System. International Journal of Technical Research & Science Volume 2 Issue VIII,

Swapnil, L., Kolhe, Nilesh B., Gajbhiye, Vivek B., Deshmukh, 2014. Eco-friendly Mechanically Operated Multipurpose Spray Pump.

International Journal of Research in Advent Technology, E-ISSN: 2321-9637, Volume 02, Issue 02.

Taiwo, A., Oje, K., 2008. Development and testing of a swirl chambernozzle, Journal of Agricultural Engineering and Technology (JAET), Volume 16 (N0. 1) June,

Taylor, W.A., Womac, A.R., Miller, P.C.H., Taylor, B.P. 2004. An attempt to relate drop size to drift risk. Proceedings of the International Conference on Pesticide Application for Drift Management. PP. 210–223.

Varikuti Vasantha Rao, Sharanakumar Mathapati, Basavaraj Amarapur 2013. “Multiple Power Supplied Fertilizer Sprayer” International Journal of Scientific and Research Publications, Volume 3, Issue 8, ISSN 2250-3153.

Zoeb Khan. 2014. Unique Solar Operated Spray Jet IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X

Appendix

Appendix-I: Cost analysis calculation of solar operated pesticide sprayer

Depreciation (D)= P-S/L

P= Purchase value = 4000 tk.

S= Salvage value (10% of p) = 400 tk.

L= Total life time = 10 years

D=4000-400÷10=360tk/year

Interest (I) = [P+S/2]×i

= (4000+400/2)×13%

= 286 tk/year

Taxes, Shelter, Insurance = 3 % of p

= 3% of 4000

= 120 tk/year

Repair and Maintenance = 0.025% of p

= 0.025% of 4000

=1tk/hr

=.1.76tk/acre

Appendix-II: Cost analysis calculation of hand operated sprayer

Depreciation (D)= P-S/L

P= Purchase value = 2000 tk.

S= Salvage value (10% of p) = 200 tk.

L= Total life time = 10 years

D=2000-200÷10=180tk/year

Interest (I) = [P+S/2]×i

= (2000+200/2)×13%

= 143 tk/year

Taxes, Shelter, Insurance = 3 % of p

= 3% of 2000

= 60tk/year

Repair and Maintenance = 0.025% of p

= 0.025% of 2000

= .5tk/hr

=1.79tk/hr

Appendix III: Cost analysis of solar operated pesticide sprayer

Cost factors/items	Unit	Amount
A. Cost of the sprayer	Tk/Unit	
Sprayer	Tk	2150
Solar	Tk	900
Controller	Tk	150
Construction cost	Tk	800
Total Cost	Tk	4000
B. Life of the Sprayer	Year	10
C. Annual use	Hrs	300
D. Annual fixed cost		
a) Depreciation	Tk/yr	360
b) Interest (13%)	Tk/yr	286
c) Taxes, Shelter, Insurance (3%)	Tk/yr	120
Total	Tk/yr	766
Total	Tk/hr	2.553
Total	Tk/acre	4.51
E. Variable cost		
a. Repair and maintenance (0.025%)	Tk/hr	1
b. Labour (One labour, 400tk/day)	Tk/hr	50
Total	Tk/hr	51
Total	Tk/acre	90
F. Total Cost	Tk/acre	94.51

Appendix IV: Cost analysis of Hand operated sprayer

Cost factors/items	Unit	Amount
A. Cost of the sprayer	Tk/Unit	
Sprayer	Tk	2000
Total Cost	Tk	2000
B. Life of the Sprayer	Year	10
C. Annual use	Hrs	300
D. Annual fixed cost		
d) Depreciation	Tk/yr	180
e) Interest (13%)	Tk/yr	143
f) Taxes, Shelter, Insurance (3%)	Tk/yr	60
Total	Tk/yr	383
Total	Tk/hr	1.27
Total	Tk/acre	4.57
E. Variable cost		
c. Repair and maintenance (0.025%)	Tk/hr	.5
d. Labour (One labour, 400tk/day)	Tk/hr	50
Total	Tk/hr	50.5
Total	Tk/acre	180.79
F. Total Cost	Tk/acre	186

Appendix-V: Spraying time measurement Calculation

1 acre = 100 decimal

Spraying time calculation for solar sprayer

5 decimal required = 5 minute 18 second

1 acre required = 1 Hours 46 minute

Spraying time calculation for hand operated sprayer

5 decimal required = 10 minute 48 second

1 acre required = 3 Hours 35 minute