PROJECT REPORT
ON
DESIGN AND DEVELOPMENT OF LOW COST BATTERY OPERATED WHEEL SPRAYER

is submitted in partial fulfillment of the requirements for the award for the Degree of

BACHELOR OF TECHNOLOGY
IN
AGRICULTURAL ENGINEERING

By

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CERTIFICATE

This is to certify that the project entitled "**Design and development of low cost battery operated wheel sprayer"** submitted in partial fulfillment of the requirements for the degree of **Bachelor of Technology in Agricultural Engineering** of the Integral Institute of Agricultural Science and Technology, Integral University, Lucknow, is a record bonafied research work carried out by Saurav Kumar (1800100532), Abhishek Mishra (1800102774), Aqib Zia (1800101347) and no part of the project has been submitted for any other degree or diploma.

Place: LUCKNOW

Date:

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DECLARATION

We solemnly declare that this project report on "**Design and development of low cost battery operated wheel sprayer"** is written and submitted by us to Integral Institute of Agriculture Science and Technology, IUL. We further declare that we have strictly observed reporting ethics and duly discharged copy-right obligation and properly referred all outsourcing of materials used in this report.

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CHAPTER-1

INTRODUCTION

India itself to be an agricultural based country, approximately 75% of the population dependent on farming directly or indirectly. Farming is the backbone of Indian economy. Agriculture contributes about 18% to the total GDP and provides employment to over 50% of the population but till now our farmers are doing farming in same traditional ways. “Spraying is an important operation to be performed by the farmer to protect the cultivated crops from insects, pest, funguses and diseases for which various pesticides, fungicides, insecticides and nutrients are sprayed on crops for crop protection”. Spraying is the secondary tillage operation. A sprayer is a mechanical device used to spray the liquids like herbicides, pesticides, fungicides. Although pesticides are developed through very strict regulation processes to function with reasonable certainty and minimal impact on human health and the environment, serious concerns have been raised about health risks resulting from occupational exposure and from residues in food and drinking water. Pests and disease control in crop plants is a crucial component of agricultural production system. A large volume of pesticides is used in crop protection. However, its application on different crops is a highly inefficient process in our country. The total active ingredient of the pesticides applied to a crop, only a small amount reaches the target pest. Remaining major portion is lost by drift, off-target losses and leaf runoff during the purpose of spraying. The unused and lost portion of the pesticides not only results in economic loss but also pollute air, water, soil and food resources. The above facts clearly emphasize the importance of the efficiency and precision of pesticides delivery systems. [Yomesh Sinha et al. 2019]

With advancement of agricultural science, more fields remain covered under crops for longer duration of time due to multiple cropping, intensive farming and better irrigation facilities. Consequently there is increase in plant pests and diseases to a considerable extent. So it has become necessary now to use pesticides and fungicides for controlling the pests and diseases. The chemicals are applied on plants in the form of spray and dust. Many types of sprayers and dusters are available in different sizes for plant protection work. [Jagdishwar Sahay, 2018]

Insect’s pests and weeds cause considerable damage to the commercial crops. If not controlled in time, the entire cop gets lost and, therefore, farmers are likely to suffer in many

ways. In a properly organized system, crop protection, therefore, is one of the most important means of increasing crop productivity. Among the important methods of weed control and plant protection systems, the following methods have been recognized as the effective and economical ones to be tried out by the farmers under different situations: Mechanical control, Chemical Control, Biological Control, Agronomical methods, Bio-physical Methods, Fire as control. The mechanical control of weeds is most widely used in India many developing countries due to availability of farm labor at relatively low rates of wages. Whereas the chemical method of plant protection has been universally accepted due to saving of time, labor and its effectiveness with relatively low expenditure. In developing countries, combination of chemical and mechanical methods of weed control has been successfully accepted. A large number of herbicides and insecticides are now available in the market for control of wide varieties of weeds and insects. However, the other methods of control have not been widely accepted by the small farmers in the developing countries. Destroying weeds and insects/pests after harvest of crops are age old practices in India. It is debatable whether or not such a practice should be adopted by farmers. The chemicals for protecting the plants from various injurious organisms need to be applied on plant surfaces in the form of sprays, dusts, mist, etc. [Michael A.M. et al. 2018]

Farming is the backbone of Indian economy. Agriculture sector includes is a lot of field work, such as weeding, reaping, sowing etc. Apart from these operations, spraying is also an important operation to be performed by the farmer to protect the cultivated crops from insects, pests, funguses and diseases for which various insecticides. Farming has undergone a great evolution in last 50 years. Control of various diseases on crops is an important reason for this evolution. In the modern agriculture, the usage of pesticides is still increasing. Moreover 90% of these pesticides are being applied in the form of spraying which maintains an environment friendly approach. The argument for using existing conventional equipment is that farmers will face economic difficulties in case of chemical and electrical powered pumps and will also face health issues in case of hand operated pumps. One way to overcome this problem is the use of equipment developed for application of the pesticides through the use of mechanical power. In selecting a pump for furnishing a supply of pesticides for farm use, or for spraying insecticides, herbicides or fungicides, one may be sure that it was designed for the job to be done. The unit should have sufficient capacity to supply the needed amount of water and spray material in the allowable time. [V. Pranavamoorthi et al. 2017]

Chemical sprayers are used for production agriculture worldwide. In a traditional system, the concentrated chemical and the carrier, usually water, are mixed together and carried in one tank. The mixture is pumped from the tank and sprayed out the nozzles. In a chemical injection sprayer, the undiluted chemical and carrier are contained in separate tanks. The carrier is pumped to the nozzles at a constant rate per unit time, while chemical is metered and injected into the carrier on the basis of desired chemical application rate. A mixing device may be used to insure that the chemical and carrier are mixed before being discharged through the nozzles. Compared to conventional sprayers, injection sprayer systems can reduce applicator exposure to chemicals during the mixing and loading process. Disposing of unused chemical is less of a problem, since the chemical is undiluted and can be returned to the original container for later use or disposal. Also, injection technology may be more easily adaptable to the variable-rate applicators which will be needed to apply varying amounts of pesticide at different locations within a field for site-specific crop management. [Kenneth A. Sudduth, 1995]

After overall study of the different types of sprayer, we come to know about the objectives of the low cost battery operated wheel sprayer which are mentioned below,

The objectives of battery operated wheel sprayer are:

1. To design and develop a low cost battery operated wheel sprayer
2. To evaluate the performance of developed sprayer

REVIEW OF LITERATURE

Kenneth A. Sudduth et al. (1995) carried out their work on Performance of a Chemical Injection Sprayer System. In their work they emphasize that the dynamic and steady state performance of a commercial chemical injection system was evaluated to determine if the system could be modified for variable-rate herbicide application. A helium-neon (He-Ne) laser system was used by them to quantify concentration uniformity across the spray pattern, along with the response characteristics of the system controller, the injection pump module, and the overall system. The ranges of operating conditions were created by changing system pressure and simulated sprayer travel speed. There was little variation in nozzle output distribution (CV < 10.5%) and chemical concentration (CV < 7.0%) across the spray path. The delay of the injection controller was slightly more than 1 s and injection pump delay was approximately 4 s. Controller and pump responses were rapid enough to qualify these components for use in a variable-rate application system. The long delay time (14 to 21 s) for chemical concentration response after a step change in travel speed was attributed to transport delays in the mixing chamber and spray boom. Accurate variable-rate application will require reduction of this delay and or development of control algorithms to compensate for the delay.

Philip J. Sammons et al. (2005) worked on 'Autonomous Pesticide Spraying Robot for use in a Greenhouse'. Their research presents 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 was 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 greenhouse, while the pesticide spraying system efficiently covers the plants evenly with spray in the set dosages.

A.S El Ashary et al. (2009) said in their report that conditions inside the greenhouse are different from open field. So, the conventional sprayers, such as the self-propelled or tractor mounted boom sprayers were not suitable for the greenhouse conditions, due to their big sizes. A disc sprayer (ultra low volume) was developed, and its performance was investigated and compared to a conventional disc sprayer and different pesticide applicator

types, motorized knapsack sprayer and Hydraulic sprayer (gun). The experiments were carried out at El-Gemmieza Research Station during 2007/2008 season. The results showed that the proper unit to execute the spraying operation under greenhouse conditions was the disc sprayer after development. That has given the lowest values of volume median diameter VMD (65µm), percent of plant damage (1.26%) and highest values of number of droplets/cm^2 (295) and fungicide efficiency (86.33%).

Vivek Deshmukh et al. (2014) have worked on 'Eco-friendly Mechanically Operated Multipurpose Spray Pump'. In his work he emphasizes on different method of spraying devices. 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. In today's world, we use various spraying 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. This is a reason why we have implemented some mechanical sprayers getting powered by human effort. Although these are serving the purpose, their range of working is not enough. They take considerably larger time for spraying. Thus they were aimed to design such a technology which was run on mechanical power but requiring less time for spraying than those which were hand operated. Thus considering today's demand, we have come up with mechanically operated multipurpose spray pump which is purely mechanical. That device was having the advantage of taking less time for spraying once it starts. If we want to decrease the time further we just need to increase size of our piston and no. of nozzles with relative change in effort. In addition to all they were implemented soil coulter along with spray pump so we can have double advantage.

R. Joshua et al. (2010) carried out their work on 'Solar Sprayer - An Agriculture Implement'. "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 is 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. So they developed the technology on solar energy that can be extended for spraying pesticides, Fungicides and Fertilizers etc., using Solar Sprayers.

Vijay Kumar Palled et al. (2016) carried out their work on "Development and Evaluation of Solar Powered Sprayer with Multipurpose Applications". Their work was 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 was portable and operated by the single labor. The discharge rate of the sprayer during laboratory and field conditions were measured, the average discharge rate during both laboratory test and field test were more or less same which was about 0.023 l/s (82.8 l/h). The performance evaluation of the sprayer was carried out for spraying in different crops viz., cotton, green gram, onion etc in farmer's fields. The walking speed of the operator was about 2.8 km/h and swath width of the sprayer was about 0.6 m, which corresponds to a theoretical field capacity of about 0.17 hectare per hour. The effective field capacity of the sprayer was observed to be 0.14 ha/h which corresponds to an average coverage of 1 ha/day of 8 hours operation. As the equipment does not use any other external source of power and that it was operated by the user himself, it reduces drudgery, 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.

V Pranavamoorthi et al. (2017) said that India is an agricultural base country directly or indirectly 75% of the peoples are dependent on farming, in this agriculture sector there is a lot of field work, such as weeding, reaping, sowing etc. He said that apart from these operations, spraying is also an important operation to be performed by the farmer to protect the cultivated crops from insects, pests, fungi and diseases for which various insecticides, pesticides, fungicides and nutrients are sprayed on crops for protection. He reported that in today's world, one use many different spraying technologies using energies like electrical energy, solar energy, and chemical energy of fuels. This fact makes one know that how large amount of energy is getting used at such place where mechanical energy can be used instead of direct energy sources. In his report he found that farmers are facing enormous problem while spraying the pesticide like tank capacity is very small, high cost and

spaying time taken more. In order to reduce problems different type of sprayers has been introduced in the market, but these devices do not meet the specified problems or demands of the farmers. To solve the above mentioned difficulties, he developed the new equipment that was “mechanically operated wheel driven sprayer”, which was the portable device and does not need any fuel to operate, easy to move and spray the pesticide by moving the wheel. That wheel operated pesticide spray equipment consumed less time and achieved uniform nozzle pressure; crank mechanism with piston pump which was driven by the wheel is also used. The device has been validated with the user group and got good feedback from the user.

J P Sinha et al. (2018) has worked on “Development of solar powered knapsack sprayer”. In their work they emphasizes on Indian farms, knapsack sprayers are very commonly used by small and marginal farmers for pest control because of affordability and ease of operation but with lower outputs. An attempt was made by them to develop a solar powered sprayer which had higher output (0.3 ha/hr) with lower physiological energy consumption and discomfort. An electronic control had been embedded for protection against deep discharge and over charging of battery for longer operational life. The system could be fully charged by solar energy within two hours of irradiation and can be operated continuously for six hours. This ensures quality spray with uniform droplet size in the swath. Anti-clogging filter had also been installed before the nozzle in nozzle head for trouble free operation as well as longer service life of nozzle. They used 14 liter capacity tank to minimize discomfort of operator and maximize operational efficiency. Their discharge was 1.83 l/min which required the pressure of 3 Psi and motor & pump efficiency was 0.80 & 0.70 respectively. Motor pump power required was calculated as 16.7 KW. The net power required for motor pump set was computed with 25% safety factor as 19.5W. Their developed electronic controller was evaluated for its reliability at different cutoff voltage valued for 6 hour of load conditions. In their experiment they also found that even with 65% of irradiation, the selected battery was charged fully within 2.5 to 3 hour.

Yomesh Sinha et al. (2019) reported that the Engine operated sprayer requires fuel which is very expensive due to this the operating cost of the engine operated sprayer is expensive and it emits the gases which is not ecofriendly. Now-a-days generally the knapsack sprayer is used by the Indian farmers. This type of sprayer consists of tank 10-20 liter capacity carried by two adjustable straps. In this knapsack sprayer developing adequate pressure is laborious, time consuming and it increase the drudgery of the farmers. In order to

overcome these difficulties he proposed the battery operated movable sprayer based on the general principle of spraying. This system is operated by direct current of battery. So he used the pressure pump whose flow liquid capacity was 7.5LPM at pressure 120PSI (8bar). His developed multipurpose battery operated wheel sprayer comprises of 12V and 12AH rechargeable battery; 12V, 5AH pressure pump; charging unit and control switch.

R. Panchamoorthy et al. (2020) carried out their work on "Design and Fabrication of spraying fluid by wheel pump". Spraying is an important operation to be performed by the farmer to protect the cultivated crops from insects, pests, fungi and diseases for which various insecticides, pesticides, fungicides and nutrients are sprayed on crops for protection. In today's world, we use many different spraying technologies involving use of energy like electrical energy, solar energy, and chemical energy of fuels. This fact makes us know that how large amount of energy is getting used at such place where mechanical energy can be used instead of direct energy sources. They emphasizes in their research that farmers were facing enormous problem while spraying the pesticide like tank capacity is very small, high cost and spaying time taken more. In order to reduce these problems many different type of sprayers has been introduced in the market, but these devices do not meet the above problems or demands of the farmers. To solve these difficulties they developed the new equipment that was mechanically operated wheel driven sprayer that was the portable device and does not need any fuel to operate, which was easy to move and spray the pesticide by moving the wheel. That wheel operated pesticide spray equipment consumes less time and achieves uniform nozzle pressure; they used crank mechanism with piston pump, which was driven by the wheel.

Yuvraj Pamdet et al. (2022) worked on "Design and Fabrication of Agricultural Sprayer". They reported in their research that the spraying is traditionally done by labor carrying backpack type sprayer which requires more human effort. The weeding is the generally done with the help of Bulls becomes for small land farmers. Similarly the seed sowing application is also done with the help of bulls, which in the present age is time consuming and laborious. So to overcome these above problems a machine was developed by them which was beneficial to the farmer for the spraying and weeding operation along with the seed sowing application. A multifunction device was come in hands of farmers that were put to use in different stages of farming as per requirement.

MATERIALS AND METHOD

This chapter deals with the materials and methods employed for development of low cost battery operated wheel sprayer at the Department of Agricultural Engineering, Integral Institute of Agricultural Science and Technology, Integral University, Lucknow. The laboratory and workshop facilities of the faculty were used for fabrication and testing of the machine. Under this chapter following topics are discussed:

3.1 Design consideration

3.2 Working principle of machine

3.3 Calibration procedure

3.1 Design consideration

The system's primary components are the frame, pressure pump, liquid container, wheels, and lead acid battery. By using this system, it is possible to evaluate the nozzle's height, wheel and nozzle discharge, and spraying pressure while spending the least amount of money, time, and energy.

3.1.1 Material selection:

The following components make up the multipurpose battery-powered wheel sprayer:

- Plastic: A variety of synthetic or semi-synthetic organic chemicals make up the material known as plastic. It is sculptable into solid objects. Natural resources like cellulose, coal, natural gas, salt, and crude oil are used to make plastic through a process called polymerization or poly-condensation. Plastic was used to construct the pesticide tank, wheels, and cum cap for the weedicide nozzle.
- Brass: The general name "brass" refers to a variety of copper–zinc alloys with various compositions. Strength, ductility, wear resistance, hardness, color, electrical and thermal conductivity, hygienic properties, and corrosion resistance are all characteristics of modern brass, which is primarily composed of 67 percent copper and 33 percent zinc. Brass is the material used to construct the control valves.
- Stainless steel: Iron alloyed with at least 10.5 percent chromium is known as stainless steel. On the surface of steel, chromium forms a thin oxide coating known as the "passive layer." This stops the surface from corroding in the future. The corrosion resistance

increases as the amount of chromium increases. Nickel, silicon, and carbon are all present in extremely small quantities in stainless steel. The primary element in stain-free steel is carbon. The boom spray nozzles were constructed from stainless steel.

- Rubber: Used to make a tyre for the product. Resilience, also known as rebound, is the ability of rubber to return to its original size and shape following a temporary deformation. Rubber also not easily corroded when contact to water. Is this case, rubber is good material to make the product tyre and host.
- Polymer: Used to manufacture the product's tank. The mechanical properties of polymers are frequently different from those of metallic and ceramic materials, and they are neither as stiff nor as strong as these other material kinds. Polymers typically have low densities.
- Fabrication: To ensure that the project is completed successfully and satisfactorily, a significant amount of fabrication effort must be applied. Welding, specifically stick shielded metal arc welding, has been the primary adhesive agent used (SMAW). Stick welding has a lot of advantages, including portability. Stick welding is utilized in industrial fabrication, maintenance, and repair, as well as underwater pipelines. You'll utilize shielded metal art welding, also known as stick welding, for this kind of welding. You'll use an electrode, or stick, that is disposable and protected. By heating with an arc between a covered metal electrode and the base metal work piece, the stick softens and mixes metals. The stick's protective cover melts along with it as it melts, protecting the weld region from oxygen and other airborne gases.

- Power transmission part: In our project, battery power transmission is used. The pressure pump, switch, and acid lead battery (12V) are all combined to form the transmission component. Therefore, when the switch is activated, the battery sends electricity to the pump, which then takes chemical solution from the tank and sends it to the nozzles with the necessary pressure.

3.1.2. Components of a battery-operated wheel sprayer:

- Frame: Iron hollow pipe was used to create the frame. The frame is constructed using hollow iron rod that is 20 millimeters thick to keep and transfer the parts easily. T-Joints and elbow joints are utilized with the same fittings.

Fig-3.2: Frame rod

- Battery: A battery is used to store chemical energy and transform it into electrical energy. It has a 12V and 12AH capacity.

Fig-3.3: Battery

- Pressure pump: A pump is a piece of equipment used to move fluids, such as liquids or slurries, or gases from one place to another.

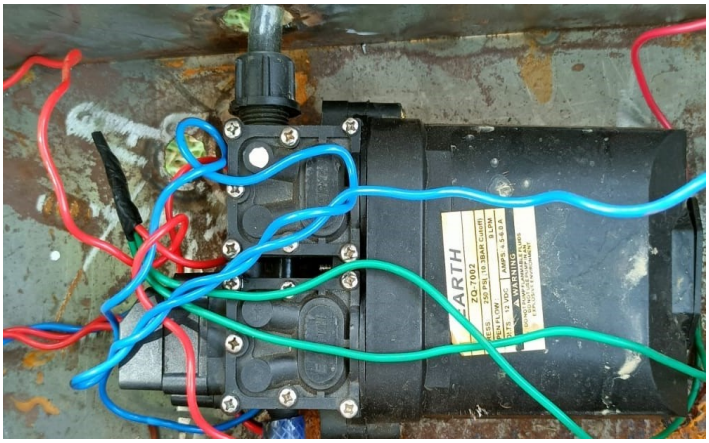

Fig-3.4: Pressure pump

- Tank: A 16 liters capacity of tank is installed near the handle of the frame. It is a acid container which we used as a tank for chemicals to be stored for spraying. It is a hard plastic and very rigid, better for every climatic condition. A opening is subjected at the downward right side of the tank. The valve is installed there to connect pipe so that water reaches to the pressure pump.

Fig.-3.5: Tank

- Pressure spray hose pipe: It is a three layers high pressure pipes used for supplying the chemical to the nozzle. They are conventional and most popular equipment's used world-wide, which is used for all types of sprayer, sprays insecticides, pesticides, fungicides, herbicides etc. The internal diameter of pipe 16 mm and the total length used is 0.75 meters.

- Controller unit: controller unit is basically a rectangular box containing the battery and pressure pump. It has one on/off switch on the handle. A regulator knob is provided for control the pressure from the nozzles.
- Nozzle: The function of spray nozzle is conversion of pressurized spray liquid into droplets for application of insecticides, pesticides and herbicides on the target area.

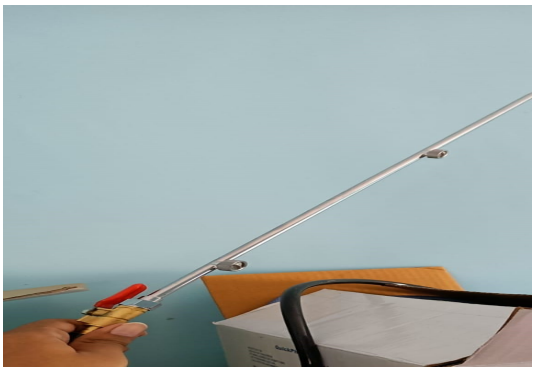

Fig-3.6: Nozzles

- Strainer: It is a little circular plastic ring with nylon wire mesh to filter any dust element coming with the chemical solution.

Fig-3.7: Strainer

- Pressure gauge: It is a dial gauge which shows the pressure at which the liquid is delivering from the pump.

Fig-3.8: Pressure Gauge

- Wheel: Wheel is used to carry the whole assembly and move machine from one place to another by rotary motion of it. Bicycle tires provide an important source of suspension, generate the lateral forces necessary for balancing and turning, and generate the longitudinal forces necessary for propulsion and braking.

Fig-3.9: Wheel

- Castor wheels: These are made up of the fine materials of alloy steel. These are of high quality, strength, durable, shock resistance and most importantly it does not require air inflation. It is used to rotate the frame 360^0, so that turning area reduces and also moves smoothly

Fig-3.10: Castor Wheel

3.2 Working principle of machine

A sprayer that is used to apply herbicides, pesticides, and insecticides. The tank is kept on the frame, and a pipe is attached to it at the right side's downward portion. The motor at the pipe's second end is attached, and when power is applied, it draws chemical solution from the tank. One pipe is attached to a second side motor, which sends the chemical solution to the sprayer. The switch controls the power supply, which provides the motor with electricity from the 12V battery. Finally, the chemical solution travels through the pipe to the nozzle after the switch is turned on. Additionally, the chemical solution covers the plants evenly. Additionally, the frame has one bicycle wheel in front to make moving it simple and two castor wheels on the back side to turn the frame in a smaller area (it is movable 360 degrees).

The chemicals are being applied with enough pressure to positively impact the plants, and they are controlling how much liquid is being sprayed on the plants to prevent over application.

3.2.1 Method of fabrication:

Firstly, we need two iron rods of 1.4 meters each. Then, using a measuring tape on either side, we mark the rod 20 cm from one end. We create a V-shaped configuration that bends into the left side of the rod. Another rod is bent at the right side using the same procedure. Circular saws are used for the cutting. After cutting, both rods take on a L shape and are joined together using a welding equipment. After uniting the two rods, the rod was scraped on the cutting region. To secure the cycle's wheel nut bolt, we grabbed a rectangular bar and formed a U shape at its bottom. With the aid of the welding equipment, the bar is

welded into the frame. We used the 360-degree rotating caster wheel. Side bars are welded to the frame at another end on both ends, and downward bars are connected to the side bars to attach the castor wheels. Next, two rods of each are taken. To push the sprayer, we create a handle at the top of the rod.

The rod is then welded at a 45-degree angle at the frame. The two rods are joined together by a supporting rod. Then, each is cut into two rectangular rods. In relation to the frame, the first rod is soldered vertically. On top of the vertical rod, another rod is welded horizontally. The horizontal rod that the sprayer is mounted to is connected to it by a tie rod. The box constructed of iron is rectangular. It is soldered to the handle side of the sprayer's frame on the downward side. A 12 V battery and water pump were fitted inside the box. One input valve and one output valve are present in a water pump. The tank is joined to the inlet valve pipe. 16 L is the tank's capacity. The sprayer is attached to the outlet valve pipe. A charge and a negative terminal are included on the battery. The switch in turn controls these. When the switch is turned on, the pump draws water from the tank and sends it to the sprayer. The line that connects the pump and the sprayer has a pressure gauge fitted in the middle of the pipe to measure the water pressure. The model is now finished. The figure below shows the full model.

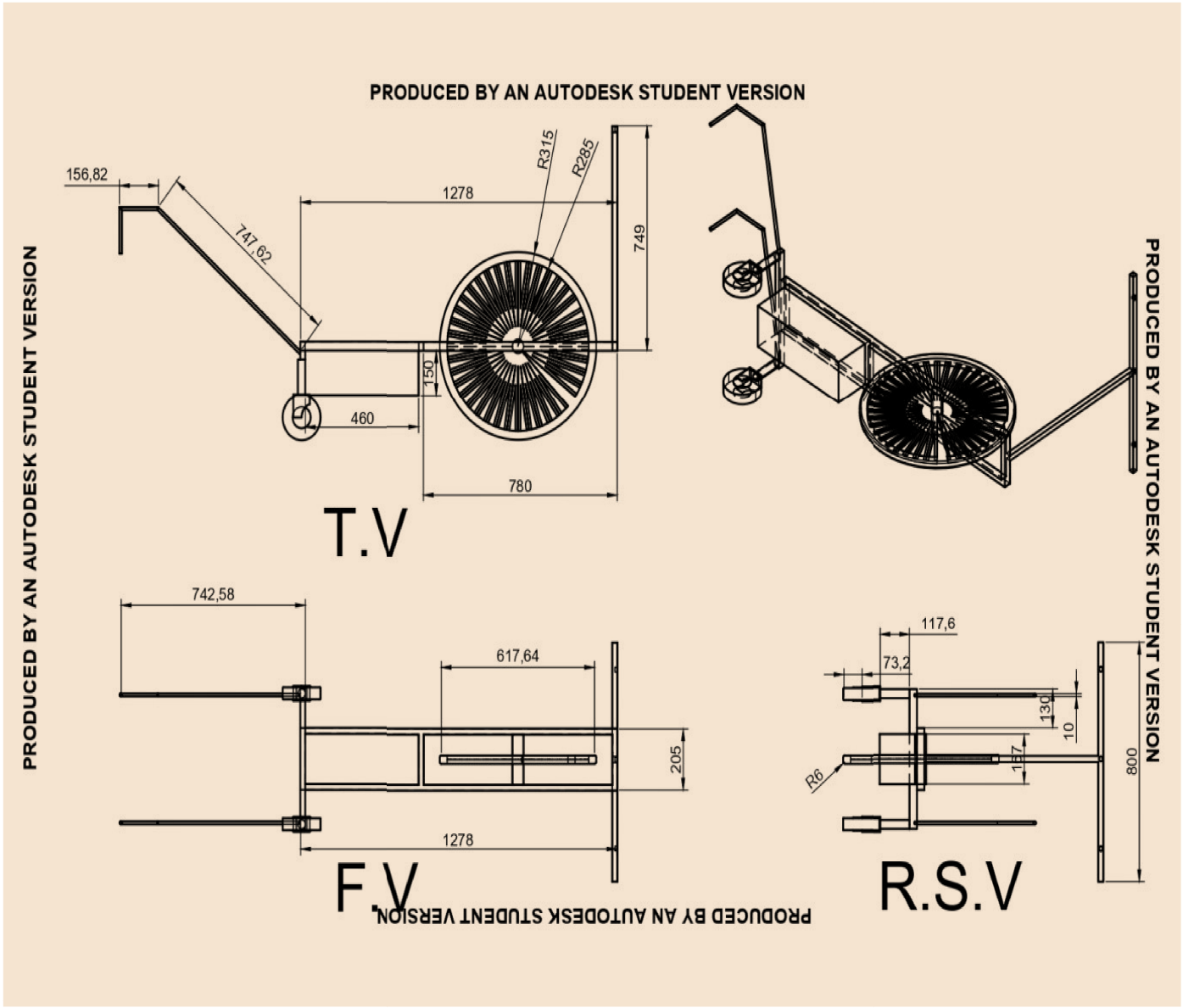

Fig- 3.11: CAD Diagram of Model

Fig-3.12: Final model

3.3 Calibration procedure

3.3.1 Nozzle Tip Selection:

Considering the manufactures recommendation and field condition select a suitable spray volume and the operating speed. Select a nozzle tip that would give the required output when operated with in recommended pressure gauge. Considering the spray width, speed and spray volume calculate the nozzle output from the given formula

3.3.2 Pre-calibration check:

Ensure that all sprayer parts are free of foreign material, if any and shall be functioning properly. Nozzle tips shall be inspected for proper size and tyre, wear and defects, if any. Check the flow rate of each nozzle using water at rated pressure for uniform output, equal spray angle and uniform appearance of spray pattern. Replace those nozzle tips having flow rates varying from each other nozzles checked by percent and those having obviously different spray angle or pattern.

3.3.3 Adjustment to obtain desired spray volume:

Adjust the operating speed to get the desired spray volume if the spray volume changes it below 25 percent. Operating pressure may also be adjusted to adjust the spray volume if the spray volume changes it below 25 percent when operating within the recommended pressure gauge. The operating pressure shall be adjusted without affecting the drops size and spray pattern excessively.

3.3.4 Layout of test plot:

Lay out a measured course length to the nearest 0.1 m in the test plot. The course length shall be selected depending upon the travel speed width and spray volume. The course length shall be long enough that an accurate measure can be made of time (at least 15 seconds) or of spray volume (at least 10 percent of tank volume) whichever method is used.

3.3.5 Calibration method:

Any of the fallowing methods shall be used for determining the spray volume. Select representative nozzles and direct spray at desired operating pressure measure under the following conditions:

a) Over the measured course length,

b) Over the period of time equivalent to the travel time over the measured course length, and,

c) Over a fixed period of 5 minutes.

The spray volume and the nozzle output shall be computed from the fallowing formulae.

a) V= Quantity of spray/area treated

b) $Q = V \times S \times W/600$

Where,

V = spray volume, l/ha

Q = output per nozzle, l/min

S = speed, km/h

W = spray width, m.

Quantity of spray = volume of liquid in liters sprayed by the nozzle on a measured course length or in the equivalent time.

RESULT AND DISCUSSION

This chapter deals with the results of experiments in order to fulfill the objectives of the project work. The experiments were conducted for design and development of low cost battery operated wheel sprayer in the laboratory as well as in the field. The performance of this machine was evaluated at the field of Faculty of Agricultural Engineering, IIAST, Lucknow, considering spray rate, speed measurement, width of spray, cost of operation and energy requirement. The width of spray as well as spray rate was measured in the laboratory. Below mentioned topics are discussed in this chapter:

4.1 Testing

4.2 Calculation

4.3 Result

4.4 Discussion

4.1 Testing of developed low cost battery operated wheel sprayer

A new low cost battery operated wheel sprayer was developed and fabricated at the Integral Institute of Agricultural Science and Technology, Faculty of agricultural Engineering, Integral University, Lucknow, was tested for different crops and crops height at research field of college to generate test data. For testing of the machine standard methodology was adopted as per BIS test code IS: 9632:1980 for spraying machine

4.1.1 Facilities, machinery, equipment, and apparatus used for testing

1. Clean laboratory for lab testing of machinery
2. Clean water for spraying
3. 50 m^2 area for field test
4. Electricity for charging of battery
5. Store room for storing of our machine
6. Pressure gauge
7. Flask

4.1.2 Procedure for testing measurement

In this section, the techniques and procedure for measurement of various parameters associated with evaluation of the machine under laboratory and field condition have been presented. The parameter and methodology for their measurement are given below:

1. For testing of developed low cost battery operated wheel sprayer, plots size of 10×5 m^2 was selected at research farm of IIAST, Integral University, Lucknow,
2. The field capacity of the machine was measured for spraying the machine. From the actual and theoretical field capacity, the field efficiency was determined.

4.1.3 Laboratory Test

Developed battery operated wheel sprayer was tested and evaluated for spraying of chemicals in different crops under controlled lab conditions at Faculty of Agricultural Engineering, IIAST, Integral University, Lucknow. The tests conducted as per BIS test code for spraying machine (IS: 9632-1980). The electric system was firstly lab tested for proper power supply and developed sprayer was tested in laboratory for its calibration. For the selection of metering water pressure a pressure gauge was used.

During calibration, the width of spray was measured and discharge of nozzle was measured under controlled condition.

4.1.4 Field Test

For the testing of spray machine the cultivated land was selected and some weeds and grasses were present. After initial setup spraying was done with the help of developed low cost battery operated wheel sprayer. In first plot of spraying 50 m^2 area was sprayed and width of spray was found to be 1.74 meter having height of boom 1.01 meter. In second plot of spraying same area was covered on flat ground and the width of spray was found to be 1.8 meter.

After the measurement of width of spray speed of vehicle was measured on the cultivated land and it was found to be $0.27\frac{m}{s}$. And when its speed was measured on flat ground, it was found to be $0.33\ \frac{m}{s}$.

4.1.4.1 Operating Speed

The speed of operation of sprayer was determined in test plots by putting two marks 10 meter apart. The time was recorded with the help of stop watch to travel the distance of 10 meter. The speed of operation was calculated in meter per second as given below

$S = \frac{D}{T}$

Where,

S = Speed of operation, $\frac{m}{s}$

T = Time needed to cover 10 meter distance, sec.

Table-1: Speed measurement

No. of observation	Distance (meter)	Time taken (second)	Speed (m/s)
1	10	30	0.33
2	10	35	0.28
3	10	45	0.22
4	10	35	0.28
5	10	40	0.25
Average	10	37	0.27

4.1.4.2 Width of spray:

Width of spray was determined by spraying at plane surface in idle mode. First we park our machine on a plane surface and then started it for spraying without moving the machine. The time was recorded with the help of stopwatch and the height of boom was at 1.01 meter. After 30 seconds we stopped spraying and then measured the wet area by measuring tape. Maximum width of spray came out as 1.74 meter.

Table-2: Width of spray

No. of observation	Height of the boom (meter)	Width (meter)
1	1.01	1.8
2	1.01	1.83
3	1.01	1.6
4	1.01	1.8
5	1.01	1.7
Average	1.01	1.74

4.1.4.3 Discharge of Each nozzle:

We used a sprayer which has three nozzles so that area covered will be maximized. So to check the discharge of every nozzle, we took a flask and measured 250 ml of water and recorded time with the help of stopwatch. Same procedure was applied on all three nozzles and the result came out from the formula given below

$Q = \frac{V}{T}$

Where,

Q = Discharge, $\frac{ml}{s}$

V = Volume, ml

T = Time, sec.

Table-3: Discharge of each nozzle

No. of observation	Sprayer 1			Sprayer 2			Sprayer 3		
	Volume (ml)	Time (sec)	Discharge (ml/sec)	Volume (ml)	Time (sec)	Discharge (ml/sec)	Volume (ml)	Time (sec)	Discharge (ml/sec)
1	250	43	5.81	250	43	5.81	250	44	5.68
2	250	44	5.68	250	42	5.95	250	43	5.81
3	250	43	5.81	250	45	5.55	250	44	5.68
4	250	44	5.68	250	42	5.95	250	43	5.81
5	250	42	5.95	250	44	5.68	250	43	5.81
	Average		5.18			5.78			5.75

4.1.4.4 Discharge of spray:

Above discharge was calculated in idle condition. Now the discharge rate of every nozzle is calculated in working condition means while doing operation in the field. For this calculation, we took the area of 50 m^2 and observing the level of tank water with the help of markings which were made on the tank external body.

Table-4: Quantity of spray

No. of observation	Area sprayed (m^2)	Quantity of spray (ml)
1	50	259
2	50	261
3	50	260
4	50	262
5	50	259
Average	50	260.2

4.1.4.5 Field capacity

Theoretical field capacity was measured as per following formula. (Jagdishwar Sahay, 2018),

Theoretical field capacity, (ha/h) =$W \times \frac{S}{10}$,

Where,

W = Effective width of implement, m

S = Km/h

4.1.5 Calculation of operational cost of developed low cost battery operated wheel sprayer

The cost of operation for developed sprayer was calculated by following procedure. The operating cost includes fixed and variable cost.

1) Fabrication cost

Total weight of implement in, kg

a) Material Cost

Material cost was taken as @ 160Rs. /kg,

Cost of material = Total weight × 160 Rs.

b) Black smith charges

It was included in the material cost

c) Supervision charges

It was taken 10% of the fabrication cost, Rs

= (a + b) × 10%

Total fabrication cost, Rs = a + b

2) Analysis of economics of use

To do the analysis, the following assumption were made

i. Expected life of machine 8 years

ii. Annual use of machine 300 hours per year

Scrap value of the sprayer is 10% of initial cost

3) Variable cost

i. Repair and maintenance constant 10% of initial cost

ii. Wage of operator in Rs. for working

Total cost of spraying, Rs/h = Over head cost + Variable cost

4.1.5.1 Economics evaluation of battery operated boom sprayer:

The cost of spraying operation consists of fabrication cost, rental cost, insurances cost, repair cost, maintenance cost and labor wages. The cost of operation of battery operated boom sprayer is divided in two parts first in fixed cost and second is variable cost. The fixed cost is independent of the operational work while variable cost varies according to the use of spraying machine. Cost of the machine and its operation was calculated in Rs/ha using straight line method of application and economic evaluation of machine was calculated.

Table-5: Manufacturing cost

S. No.	Material	Price Per Unit (Rs)	Quantity	Total (Rs)
1	Battery	1500	1	1500
2	Motor	800	1	800
3	Nozzle	300	1	300
4	Gate valve	100	1	100
5	Hose with connector	80	1	80
6	Pipe (8 mm, 2 meter)	80	1	`80
7	Tank (16 liter)	200	1	200
8	Fabrication	160 per kg	17 kg	2720
9	Paint	200	1	200
10	Castor wheel	300	2	600
11	Cycle wheel	200	1	200
12	Extra			150
	Estimation cost			**6930**

4.1.5.2 Cost economics

The cost of spraying from the battery operated boom sprayer was assessed and compared with battery operated knapsack sprayer and ground wheel operated sprayer. The total cost of developed battery operated boom sprayer was Rs 6950. The cost is low when compared with other knapsack sprayers. The assessed value has been shown in Table 6.

Table-6: Cost estimation of developed sprayer for one hectare

Description	Result
Development cost of spraying machine (Includes material charge and labor charge for fabrication)	Rs. 6930
Labor charge	Rs. 400
Life of spraying machine	8 years, 2400 h
Working hours per year	300h
Salvage Value	Rs. 686
Repair and maintenance costs (Per year)	Rs. 343
Depreciation cost calculated by using straight line method (Per hour)	Rs. 2.5725

The capacity of hand operated knapsack sprayer, ground wheel operated sprayer and developed battery operated boom sprayer was found to be 0.072 ha/hr., 0.281ha/hr. and 0.284 ha/hr. respectively. The cost of spraying per hectare in hand operated was much higher than the ground wheel operated sprayer as well as the cost of spraying per hectare in ground wheel operated sprayer was higher than developed battery operated boom sprayer.

4.3 Result

After the completion of the experiments to measure the different efficiencies of the machine, the values came up as 1.74 meter was the width of spray; its coverage area was $0.27\frac{m^2}{s}$; and the discharge of each nozzle was 5.18, 5.78, and $5.75\frac{ml}{s}$; and finally the quantity of spray was 290.2 ml per 50 m^2areas.

4.4 Discussion

A battery operated boom sprayer has been developed to increase area coverage and perform spraying without the application of fuel, petrol and diesel. The mechanical device is used to operate the pump through the scotch yoke mechanism. The scotch yoke mechanism is powered by frame shaft. It increases swath width, theoretical field capacity, and effective field capacity and also increases field efficiency. Ergonomics parameters such as heart rate, ODR and body part discomfort rate (BPDS) were also found and compared with the manually operated sprayer. The values of ergonomics parameters of developed battery operated boom sprayer were less when compared with the values of ergonomics parameters of battery operated knapsack sprayer.

4.5 Recommendation

After completing this study, consumers will be more satisfied because they don't need to carry and lift their sprayer wherever they want to spray their plants in farm or garden. Additionally, that those interested in furthering and refining this study is welcome & can cooperate in improving this project as the use of farming industries is indispensable and encouraging. The most recommendation that we got is to customize the height of sprayer so that every height of plant get sprayed and reduce the rear wheels distance. We sincerely hope that this project can increase profit within the country and can exported out of the country and set an example for other countries.

CHAPTER-5

SUMMARY AND CONCLUSION

5.1 Summary

Due to fragmented and small land holdings and variable farmer typology, it is neither affordable not advisable to purchase many machines for the planting of different crops by the same farmer. The low cost battery operated wheel sprayer can spray different crops with variable water pressure, and also the nozzles can be changed as per requirement. In addition to adjustments for water pressure, nozzles the low cost battery operated wheel sprayer reduces the cost of spraying by removing diesel which was used in the previous knapsack sprayers as well as removes the load from the shoulders of the farmers which will give them relief. Hence the same wheel sprayer can be used for spraying chemicals by changing the different spray nozzles. Also, spraying is important factor now a days for good germination of plants and optimum plant population

5.2 Conclusion

The suggested model has removed the problem of back pain, since there is no need to carry the tank on the backbone and solder. More number of nozzle which covers maximum area of spray in minimum time at maximum rate. Power adjustment facility in the model with respect to crop help to avoid excessive use of pesticide which results in less pollution. The imported hollow cone nozzle should be used in the field for the better performance. Muscular problem is removing and there is no need to operate the lever. This alone pump can use for multiple crops. After having a trial, we have found that one finds it easy to operate push type machine. The pump can deliver the liquid at sufficient pressure where the output of the nozzle in minutes and spray width from calculation so that it reach all the foliage and spread entirely over the spray surface. It is less heavy, but efficiently working in rough condition of the farm. It is economical, therefore affordable for all kind of farmers. It require comparatively less time for spraying so we can get more field spraying per day. It is cost effective than the existing spraying pump available in the market as no direct fuel cost or cost for maintenance is needed for this. Also, it can be used for any crop as its maximum width is not more than one foot. Its nozzle can be adjusted to any height. Parameters of developed battery operated boom sprayer were less when compared with the values of ergonomics parameters of battery operated knapsack sprayer.

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