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Development And Performance Evaluation Of A Simple Multi- Nozzle Mobile Compression Pump (MMPC) Sprayer

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***Abstract*—Sprayers are commonly used on farms to spray pesticides, herbicides, fungicides, and defoliants as a means of crop quality control. This study developed a multi-nozzle mobile compression sprayer and compared it is performance to a typical knapsack sprayer. It comprises of the tank, hoses, nozzles, frame, wheels and the elevation rod. The multi-nozzle mobile compression pump sprayer was fabricated, tested and evaluated. Test results were compared to those of a knapsack sprayer; the following parameters were used for evaluation; working speed, flow rate and the rate of application. Test result shows that the mobile compression pump multi nozzle had a mean working speed of 0.28 m/s, mean discharge rate of 16.71 m^3/s and a mean application rate of 400.34 per ha, while the knapsack sprayer had a mean working speed of 0.053 m/s, mean discharge rate of 4.02 m^3/s and a mean application rate of 400.34 per ha. The working speed ratio of both suggests that the developed sprayer performs approximately five (5) faster than the knapsack sprayer. This was further noticeable in the test result for the application rate values.**

Keywords—performance, sprayers, nozzle, compression, discharge.

INTRODUCTION

In agricultural sector generally, some Nigeria farmers still use traditional way of carrying spray on backpack and spraying crop. This becomes time consuming and human fatigue is major concern, these problems can be modified by using agricultural movable spray pump (Deshpande *et al., 2017).* It facilitates uniform spread of throwing chemicals or liquid at the desired level, precision made nozzle tip for adjustable stream and capable of throwing foggy spray depending on requirement. Sprayer provides optimum performance with minimum efforts. The invention of a sprayer, pesticides, fertilizers, bring revolution in the agriculture or horticulture sector especially by the invention of sprayers, enable farmers to obtain maximum agricultural output. They are used for garden spraying, weed and pest control, liquid fertilizing and plant leaf polishing. There are many advantage of using sprayers such as easy to operate, maintain and handle, it facilitates uniform spread of the chemicals, capable of throwing chemicals at the desired level, precision made nozzle tip for adjustable stream and capable of throwing foggy spray, light or heavy spray, depending on requirement. Shivaraja kumar A. (2012). Presently in agriculture the sprayers plays an important role in spraying. Although sprayers varies like motorized, hand operated. Nigeria is a land of agriculture which comprises small, marginal, and rich farmers are interested in backpack type of sprayer of its price, versatility, cost and design. But this sprayer has certain limitations like it cannot maintain required pressure; it leads to problem of shoulder and back pain. Nowadays, there are many types of chemical [liquid] sprayer already in market with different shapes, sizes, method to carry it but the functions are same.

Sprayers Used in Agricultural Applications

Sprayers are commonly used on farms to spray pesticides, herbicides, fungicides, and defoliants as a means of crop quality control (S R Kulkarni *et al,. July 2015*). There are many kinds of machine-operated sprayers, the most common of which are low-pressure, high-pressure, air-carrier, and fogger types. Insects and weeds are largely responsible for the crop destruction. In modern horticulture and agriculture, insecticides/pesticides, a man made or natural preparation are used to kill insects or otherwise control their reproduction. These herbicides, pesticides, and fertilizers are applied to agricultural crops with the help of a special device known as a "Sprayer." Based on the concept of high or low pressure, sprayer provides optimum performance with minimum efforts. There are several types of sprayers available in the market such as manual or self-propelled sprayers, tractor mounted sprayers and aerial sprayers.

Science and technology always helps mankind to improve its life. This thing applies to the agriculture sector too.

Benefits

i. This project would help farmers desist from carrying the entire pesticide sprayer pump on their shoulders but just pull/push the mechanism mounted

on a frame and made mobile by a wheel, to operate the pump and spray the pests. This makes the farmer feel comfortable, relaxed and less tiresome.

ii. Multi-nozzles were used and hence larger area of field can be sprayed at faster rate. This would help to reduce the time spent on the field.

Components and Design of the Multi-Nozzle Mobile Compression Pump Sprayer (MMCP)

This study aims at enhancing the uniform spread of field chemicals or liquid at the desired level, precision made nozzle tip for adjustable stream. The assembly includes the design of the frame, tank seat, hose, nozzles, nozzle pipe, nozzle-elevation rod, wheel and frame stand.

i. **Pump** . It consists of piston in a cylinder arrangement, which is manually operated to pressurize the chemical in the container.

ii. **Nozzle** . It is a device which converts the pressure energy of fluid into kinetic energy; spray nozzle is a precision device that facilitates dispersion of liquid into a spray. Nozzle is used for the purpose of distributing liquids in fine droplets form over an area. The nozzles used were selected because of their ability to disperse liquid in two (2) directions simultaneously. They comprise of two pairs and their vertical distance apart could be adjusted. This adjustment is subject to the type of work, the height of plant or weed, and the terrain on which this device is to be used.

$Nozzle\ diameter\ =\ 0.02m$`

iii. **Driving wheel** . Wheel is a pneumatic tyre used to carry the whole assembly and move machine from one place to another by rotary motion. The wheel was designed to fit into the frame and fork via drop outs, and hold tyre. A typical modern wheel has a metal hub, wire tension spokes and a metal or carbon fiber rim which holds a pneumatic rubber tire.

$$Diameter\ =0.35m$$

iv. **Frame** . The main function of frame is to carry the whole assembly on it so it has to be strong enough to hold it. The frame was made of square pipe and mild steel. The frame was designed to carry the different shapes of tanks.

$Length\ =\ 1.68m$

$Rod\ diameter\ =\ 0.03m$

$Width\ =\ 0.026m$

v. **Tank** . this is the component where the liquid is poured, pressurized and then dispersed. A cylindrical container was used for this study, but can be replaced with containers of other shapes and bigger capacity. The height, width and thickness for this design were selected based on the available spraying tanks (cylindrical and rectangular type). They were designed with allowance to give enough space for the tanks and to ensure they are well fitted.

Cylindrical seat diameter = 0.22m

Rectangular seat width = 0.15m

vi. ***Design of hose*** . the hoses were from readily available designs, but were trimmed to accommodate the required length for this machine. The selected hose was could easily fit into the tank outlet port and the spray gun.

Hose length = 1.3m

Hose diameter = 0.07m

vii. ***Nozzle pipe*** .The nozzle pipe was designed from aluminum material to prevent rusting. It was trimmed to a minimum size in other to curb waste and to prevent entanglement with tall plants when in use. A diameter that could easily fit into the spray gun and the nozzle was carefully designed.

Diameter = 0.08m

Length = 0.5m

viii. Nozzle hanger . A hollow pipe was selected, measured out, cut and perforated to hang the nozzles horizontally.

Diameter = 0.02m

Length = 1.0m

ix. Elevation rod . a flat bar was similarly perforated and at four points to allow four different heights with respect to the horizontal widths to be considered per time.

Length = 1.0m

Plate 1: Assembly of the Mobile Compression Pump Multi-Nozzle

Fabrication of the Multi-Sprayer

Some components of the machine were fabricated while some were purchased separately before they were assembled. This was based on availability and the complexity of the respective parts. Table 1 gives a summary of the performed operations for some of the parts.

Table 1: Summary of Construction Details

Components	Materials	Remark
1. Frame	Round pipe, flat bar	cutting, welding, drilling
2. Wheel	Pneumatic tyre	purchased
3. Tank & accessories	Plastic	purchased
4. Hose	Rubber	purchased/trimmed
5. Tank seats	Flat bar	cutting, welding
6. Elevation rod	Flat bar	cutting, drilling, welding
7. Nozzle hanger	Round pipe	cutting, drilling

How to operate the MMCP sprayer

The developed device is suitable for applying chemicals for field crops and lawns. Its principle of operation is that of the hand compression pump sprayer. The MMPC sprayer consists of a tank of 7 litre capacity for holding spray material. The pump is operated to trap air in the tank to build up pressure. When the flow cut off lever is pressed, the fluid passes through the nozzle and spraying is done. The sprayer is mobilized by pushing or pulling. The height and width of spraying could be varied using the elevation pole or the nozzle hanger respectively.

Performance Test

A performance test was carried out with the multi-nozzle mobile compression pump sprayer; it was used to spray herbicide on a cultivated piece of land of 2m x 30m, and replicated five (5) times. The time taken to spray was recorded. The same procedure was carried out using the same quantity of herbicide in a knapsack hand sprayer; the time used was also recorded. The results were evaluated and compared.

Evaluation Parameters

These include, working speed, discharge rate and the rate of application of the device.

a. The working speed. is the distance covered during spraying over a given period of time.

$Mathematically\ V = d/t$(1)

Where

V .working speed (m/s)

d .distance covered (m)

t . time (s)

b. Discharge/Flow rate . is the amount of fluid passing through the section of the stream during spraying operation.

$Mathematically\ Q = A\ x\ V$ (2)

Where

A . area covered (m^2)

V . flow velocity (m/s)

c. The rate of application . is the rate at which the chemical (herbicide or insecticide) is applied.

Mathematically $Q_f = Qi/vb$ (3)

Where

$Q_f\ .Rate\ of\ application\ (1/ha)$

$v\ .required\ speed\ of\ machine\ (m/s)$

$i\ .number\ of\ nozzles$

$b\ .Working\ width\ (m)$

$Q\ .discharge\ (m^3/s)$

RESULTS AND DISCUSSIONS

Results

Table 2 below shows the working speed, discharge rate and application rate of the multi-nozzle mobile compression pump sprayer in a single pass. It had a mean working speed of 0.28m/s, mean discharge rate of 16.71m^3/s and a mean discharge rate of 400.34 per ha.

Table 2:Working speed, discharge rate and application rate of the MMCP

Replicate	Working Speed (m/s)	Discharge rate (m^3/s)	Application rate (per ha)
1	0.28	16.67	396.83
2	0.29	17.65	405.00
3	0.27	16.22	400.40
4	0.26	15.38	394.48
5	0.29	17.65	405.00
MEAN	**0.28**	**16.71**	**400.34**

Figure 1 below illustrates the graphical representation of working speed against the application rate for the multi-nozzle mobile compression sprayer. It shows a similarity in the elevation curve for both the working speed and the application rate. This suggests that they are proportionate to each other.

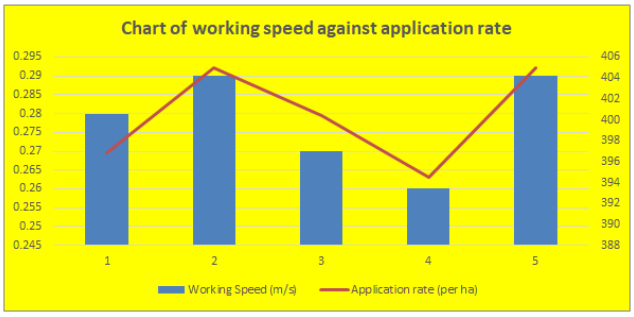

Figure 1

Table 3 below shows the working speed, discharge rate and application rate of a single nozzle knapsack in a single pass. It had a mean working speed of 0.053m/s, mean discharge rate of 4.02m^3/s and a mean application rate of 400.34 per ha.

Table 3: Working speed, discharge rate and application rate of the knapsack

Replicate	Working Speed (m/s)	Discharge rate (m^3/s)	Application rate (per ha)
1	0.071	4.29	200.09
2	0.067	4.00	199.90
3	0.071	4.29	200.09
4	0.059	3.75	199.40
5	0.059	3.75	199.40
MEAN	**0.053**	**4.02**	**199.78**

Figure 2 below illustrates the graphical representation of working speed against the application rate. It was observed that the MMPC had its highest application rate at 400 per ha, while the knapsack had its highest application rate at 200 per ha.

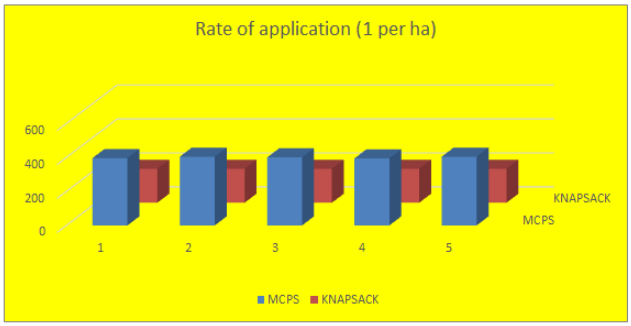

Figure 2

Conclusions

The multi-nozzle mobile compression pump sprayer was fabricated. It was tested, evaluated and test results were compared to those of a knapsack sprayer; The following parameters were used for evaluation; working speed, flow rate and the rate of application. Test result shows that the mobile compression pump multi nozzle had a mean working speed of 0.28m/s, mean discharge rate of 16.71m^3/s and a mean application rate of 400.34 per ha, while the knapsack sprayer had a mean working speed of 0.053m/s, mean discharge rate of 4.02m^3/s and a mean application rate of 400.34 per ha. The working speed ratio of both suggests that the approximately five (5) faster than the knapsack sprayer. This is noticeable further in the different application rate values.

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