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Development and Performance Evaluation of Dry Cell Battery Powered Ultra Low Volume Sprayer

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ABSTRACT
The acceptance of sprayer and agricultural chemicals as an optimum tool for quality and quantity crop production had lead to development of many sprayers. Other sprayers had remained in effective, expensive, un economical and obsolesces to farmers. This sprayer was developed using local available materials to minimize manufacturing cost. The sprayer consists of the following key part: back pack tank, strap, battery case, nozzle and 7.5 volts dry cell battery. Laboratory and field test was conducted to determined flow rate and application rate. It was found workable and satisfactory to suit the current trend of pest control operations for direct formulation and water based application. The maximum swath width recorded was 1.5m and capable to spray 0.4ha/hr at one meter per second walking speed .The droplet size and uniformity of coverage is effective with even distribution of spray. Effective spray decreases with decrease of liquid head, battery weakness and forward speed.

KEYWORD: *Agrochemicals, Back pack tank, development, evaluation, sprayer.*

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I. INTRODUCTION

Application of science and technology in farming is advancing speedily in developing countries especially Nigeria .Crop spraying is employed for both quality and quantity of agricultural yield. The main purpose of Agricultural chemical is to provide nutrient for plant growth, pest and weed and control. Proper application of Agricultural chemical is indispensable to succeed in modern farming practices. In which chemicals have become more sophisticated and complex over the years. Agricultural chemicals are broadly classified in to three main categories which include fertilizer, pesticide and plant growth regulator. Ajit and Roger (1993) define pesticide as chemical that kill pest. Pest may include: weeds, insects, fungi etc. These chemicals may either be granular, liquid or powder. Sprayers have supplemented scarce labor in developed counties, which is known as chemical hoe. Human labor is relatively profitable in an area of cheap and available farm workers. In a location where labor force or farm workers are scare, it is more profitable to use chemical hoe for pest and weed control. However, competition for labor and farm workers had lead to development of many sprayers to substitute human labor.

The objectives of this study are to developed and evaluate performance of a battery powered sprayer for the following reasons.

[1]. Portability of use in an area where there is scarcity of water.
[2]. A multipurpose machine for spraying direct formulated and diluted pesticides.
[3]. Elimination of frequent tank refilling.
[4]. Save time and fatigue during field operations.

II. MATERIALS AND METHODS

Engineering materials count much in an environment where the machine will work. The strength of material under the influence of load will help the operator to prolong the lifespan of machine. Stout (2002) suggested that local available material should be used for fabrication of machines to minimize manufacturing cost.

2.1 Design consideration

The following was considered in the development of the crop protection machine:

[1]. Materials selected are resistance to chemical attack and corrosion agents.
[2]. Functional parts fabricated were resistance to influence of external loads.
[3]. The developed parts permit easy replacement of worn-out parts.
[4]. The developed machine is guarantee for multipurpose spraying operations.
[5]. Assembled parts of developed machine are user friendly during operations

2.2 Description of developed sprayer

Developed ultra low volume sprayer is use for direct formulated and diluted pesticide application. The machine consists of key parts. Backpack tank is gravity feed reservoir for loading chemicals, it has 10 liters capacity with 32mm high 240mm length and 160mm breadth. It has entrance and exit hole for spray liquid. It is made of thermoplastic materials. Battery case is a cylindrical hallow shape for housing 5 dry cell battery. It has effective length 607mm and 40mm diameter. It's made of polyvinyl chloride (PVC) resistance to chemical attack and corrosion agent. Extension tube is a square hallow tube measure 10mm X 10mm. It has a low density for portability and easy handling during field operation. Strap (belt) includes hooks and slide for firm and rigid support of loaded backpack tank. Effective length of belt is 800mm .Belt is suitable, adjustable to fit the operator's size. It allows freedom for adjustment on the slides for free size. It is made of fiber nylon, while slides and hooks are made of thermo set materials. Tank screen (filter) is fabricated with thermo plastic material and plastic welded with stainless steel wire mesh. The inlet diameter is 44mm, exit diameter is 40mm and height is 20mm. It filters dirt from entering spray tank and blocking of feed pipe and nozzle.

2.3 Operating principle of developed ultra low volume sprayer

Ultra low volume battery powered sprayer is utilizing a single spinning disc. The original version had been widely used in many countries for pesticide application (culpin, 1986). It had a low volume of spray tank of 10liters capacity regulatory nozzle and atomizer. Rotary atomize droplet size is about 250 micro (μn) in diameter. A good quality dry cell battery arrange in series in the battery case. When the switch plug at the rear of battery case is '**ON**' current flows to activate the D.C electric motor. Electric motor shaft transmits power to the spinning disc to rotary motion. Thus, spray liquid is fed by gravity through feed pipe nozzle on the spinning disc. The centrifugal force acting on disc will break in fine droplets by serrated edges for distribution and deposition on target plant.

2.4 Experimental procedures

The experimental procedures for laboratory and field tests are outline below:

2.4.1 Determination of flow rate (Laboratory test)

A measuring graduated cylinder was used for collecting the volume of liquid chemical discharge through tank orifice in millimeter per minute. A digital time (stop watch) was used for timing and result was recorded .The procedure was repeated 4 times at varying liquid heads. The mean flow rate was computed and presented in table 1.

2.4.2 Determination of application rate (Field test)

Backpack tank was filled up with water and the volume recorded. Field test was carried out on a marked area 10m x 10m. The tank was mounted at the back, operator switch '**ON**' the sprayer and walk one meter per second through an open marked area. The discharged volume of chemical in liters per minutes was recorded. The procedures were repeated 4 times and mean value determined. This experiment was carried on original version and developed version for comparison.

2.4.3 Determination of swath width swath

Width for spray disposition was measured out in a room where breeze will not influence the disposition of sprayer liquid. The backpack tank is filled up to 10 liters capacity and switch '**ON**' spray without walking. The spray width is measured with meter rule. The procedure is repeated 4 times and means value is recorded.
***Sprayer calibration*:-** The experimental procedures carried out in the field and values of parameters recorded is computed in the followings, equations to obtained standard liters per hectare.

Area of marked plot = $Length\ X\ Breath$ (m2) …………………………………………………………….1

AR $= \frac{D\ X\ SW}{10{,}000\ X\ FL}$ (l/ha.) ……………………………………………………………….2

FL $= \frac{AR\ X\ SW}{10{,}000}$ (ml/s)……………………………………………………………………….3

D $= \frac{SW\ X\ Dosage}{10{,}000}$ (kg/ha.) ………………………………………………………………..4

Where:
AR = Application rate

FL = Flat rate
D = Dosage (Kg/ha.)

2.5 Performance evaluation

The following parameter was used in evaluating performance of developed ultra low-volume sprayer.

i. Flow rate = AV …………………………………………………………………………1

ii. Q = $AV = av$ …………………………………………………………………………2

From continuity consideration

Where:

Q = Flow rate of discharge
A = Cross sectional area of pipe
V = Velocity of for in pipe
a = Cross-sectional area of nozzle
v = Velocity of four at nozzle outlet

iii. Coefficient of discharge

Q = AC $\sqrt{2gH}$ …………………………………………………………………………3

C = $\frac{Q}{A\sqrt{2gH}}$ …………………………………………………………………………4

Where:

Q = Flow rate of discharge m^3/S
A = Cross-sectional area of pipe
C = Coefficient of discharge
g = Acceleration due to gravity
H = Static liquid head

iv. Discharge pressure head

$$\frac{P_1}{Pg} + \frac{V_1^2}{2g} + 2_1 = \frac{P_2}{P_g} + \frac{V_2^2}{2g} + Z_2 \text{ ……………………5}$$

Application of energy equation

Where:

P = atmospheres pressure
e = density of liquid
g = acceleration due to gouty
Z_1 = nozzle height from ground level (25cm) ,as shown in plate 1
Z_2 = static head height from sand level (85cm),as shown in plate1
V_1 = velocity in head
V2 = velocity in delivery

IV. RESULT AND DISCUSSION

Table 1 represents the flow rate of liquid head variation. This shows that when liquid was at maximum height the discharge capacity is high and when it's at low level the discharge capacity reduces. This indicates that liquid head is fundamental and it influences the rate of flow rate of chemical liquid.

Table 1: Flow rate laboratory test

Replications	**Time taken (sec.)**	**Discharge capacity rate (ml)**	**Calibrated flow rate ml/sec**
1.	**60**	**670**	**11.2**
2.	**90**	**970**	**10.7**
3.	**120**	**11170**	**9.75**
4.	**150**	**11450**	**9.60**

Mean flow rate: 10.31ml/sec

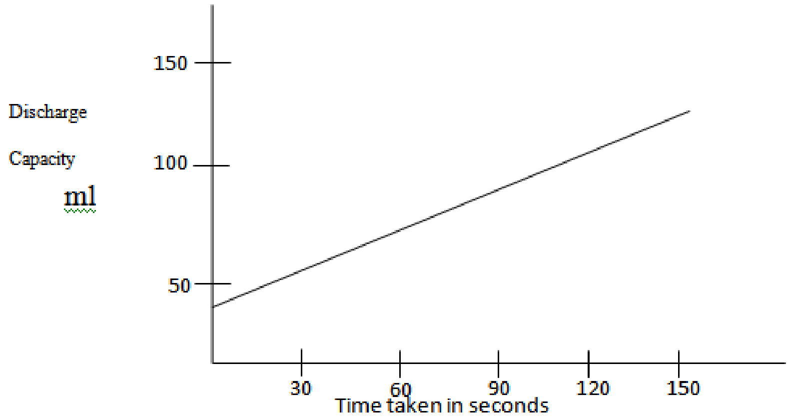

Fig 1: Time taken vs. volume discharged

Figure 1shows time taken to discharge volume of liquid chemical. It is steady and has uniform distribution, as can be seen in the graph. The mean calibrated flow rate is 10.31 ml/sec. Table 2 indicates the mean discharged volume (0.059 l) per second; the mean time taken to spray 100m^2 was 162 seconds. The equivalent hectare coverage was 12.86 liters per hectare. The output of this spray machine depends on the battery strength and the forward speed also affects the application rate.

V. CONCLUSION

The non-pressure backpack tank developed and fabricated has coefficient of discharge of 1.02, flow rate 10.31 ml/sec, application rate 12.86 liter/ha and discharge Pressure head of 69.73kpa at 85cm of back pack tank from ground level and 25cm of nozzle from ground level. The Evaluation of the machine shows it is economical, time saving, multipurpose in application and user friendly.

Field evaluation test of deveped version

Field operation of original version

Plate1; Field performance evaluation test

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