

Development of Battery Operated Knapsack Sprayer for Effective Weed Control in Nigeria

¹Michael C. Amony, ²Samuel T. Anjorin, ¹Patricia U. Chukwu, ³Aminu Saleh,
⁴Arinze W. Nwosu, ³Abubakar A. Surah

¹National Board for Technology Incubation (NBTI), Federal Ministry of Science and Technology, Abuja.

²Department of Crop Protection, Faculty of Agriculture, University of Abuja, P. M. b. 117, Abuja, Nigeria.

³Institute for Agricultural Research (IAR), Department of Agricultural and Bio-Resources Engineering,
Ahmadu Bello University, Zaria, Nigeria.

⁴National Engineering Design Development Institute (NEDDI), Nnewi, National Agency for Science and Engineering
Infrastructure (NASeni), the Presidency, Abuja, Nigeria.

DOI: <https://doi.org/10.5281/zenodo.7615531>

Published Date: 07-February-2023

Abstract: Small-scale farmers and other applicators employ the lever-operated knapsack because of its versatility, cost and design. Apart from drudgery, lack of pressure control is the single biggest limitation in the use of these sprayers as it leads to variable flow rates (dosages) of chemical preparations, inconsistent spray pattern and spray droplet size, all of which affects spray coverage and chemical performance. A steady pumping rate cannot be maintained by the human hand. The result is misapplication of chemicals and ineffective control of the target pest. This study has evolved a novel innovation that operates at constant pressure thereby offering uniform deposition of herbicide leading to better weed control and improved agricultural productivity in Nigeria. It is conceived to reduce drudgery encountered in using the conventional lever operated knapsack sprayer, through discarding the manually operated piston and diaphragm pumps. The design and installation of a matching rechargeable battery and DC pump proposes to reduce operator's task to only carrying the tank and spraying with either of the hands. The steady pumping powered by a DC rechargeable battery ensures constant pumping pressure and uniformity of spray droplet deposition. This project is anchored on improving agricultural productivity and food security in Nigeria through appropriate technology provision. It is intended to offer a cost effective machine to effectively address crop protection in Nigeria and other developing countries.

Keywords: Knapsack, Sprayer, Pressure, Battery, DC pump.

1. INTRODUCTION

Weed control is vital to agriculture, because weeds and other pests decrease yields, increase production costs, interfere with harvest, and lower product quality. Weeds also impede irrigation water-flow, interfere with pesticide application, and harbor disease organisms. Thus, farmers must combat weeds in order to enhance productivity. Several constraints limit the effective use of hand weeding, including limited cash for hiring labor and labor not being available for hire during peak periods. The supply of labor in rural areas has been significantly reduced in many African countries due to migration to urban areas which has led to less weeding of crops (Gianessi, 2009). Akobundu (2009) explains that chemical weed control is playing an increasing role in Nigerian agriculture due to the increasing cost and widespread unavailability of the labour required to carry out traditional practices. Chemical herbicides as an alternative to hand-weeding can be used before planting to remove weeds from a field. They can be applied to the bare soil at-planting for residual control of germinating weed seeds, and they

can be directly applied to weeds during the growing season. Residual herbicides applied to the soil before the crop and weeds emerge from the ground remain active in controlling germinating weeds until the critical period of weed competition has passed (Gianessi, 2009).

The main crop protection spraying technology currently used by Nigerian farmers is the common manually operated knapsack sprayers. Knapsack sprayer abound in Nigeria, but its operation is laborious occasioned by continuous and irregular pumping resulting in uneven deposition of pesticide which tantamount to ineffective application. A lever operated knapsack sprayer is shown in Figure 1.1. It consists of a tank, 10 to 20-liter capacity, which is carried on the back by two adjustable shoulder straps. An operating lever positioned either over the shoulder or under the arm, drives a piston or diaphragm pump. The under-arm lever can often be adjusted for use with the right or left arm, and the over the shoulder lever can be operated with either arm. A waist strap is sometimes used to provide support, hold the tank firmly in place, and ensure that the operator's pumping energy is more efficiently transferred from the lever to the pump. The pump is most commonly fitted on the inside of the tank to prevent damage, but is also found fitted on the outside of the tank, which allows for easy maintenance. Constant pumping is required to operate a knapsack sprayer, and the decision to use a piston or diaphragm pump should be based on the type of application to be made. (McAuliffe and Gray, 2002).

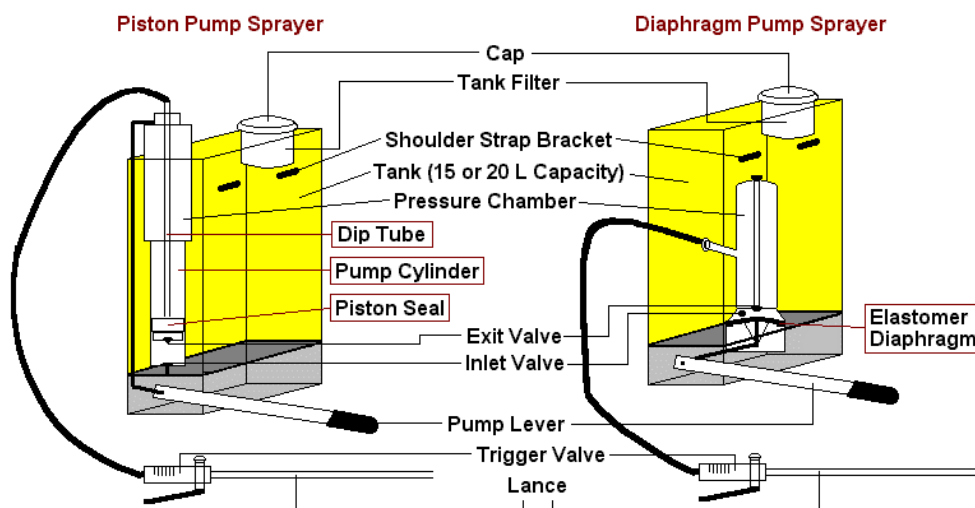


Figure 1.1: Schematic diagram of a Knapsack Sprayer

(Source: McAuliffe and Gray, 2002).

Poratkar and Raut, (2013) reports that knapsack sprayer is the major equipment currently employed for pesticide application in Nigeria being employed by both small and medium scale farmers. Constant pumping is required to operate the sprayer and this results in muscular disorder. Also, the backpack sprayer cannot maintain constant pressure, resulting in drifts/dribbling. Developing adequate pressure is laborious and time consuming. Pumping to operating pressure is also time-consuming. Salkade *et al.* (2014) confirms above assertions and states that the problems associated with its use include: i). Back pain and exertion of the user due to its heavy weight and manual pumping. ii). When the pressure inside the spray cylinder increases, the width of spray increases, thereby causing the wastage of pesticides. iii). When Pressure in the tank fluctuates, it causes the flow to become turbulent which is highly undesirable. iv). Herbicide/Pesticide get into the eyes of the user causing irritation. Damalas and Koutroubas, (2016) states that the shortcomings of the common knapsack sprayer ensues delay of operations and deposition of wrong dosage which apart being a waste of pesticide and labour, results in poor effect of pesticide application and low level of crop protection. These in turn lead to pest resistance and higher incidence and impact of pests, food poisoning, decreased yield and financial loss leading to rural poverty. Chemical under and over doses constitute serious flaws and damages in pesticide application. The implication is that crop protection is impacted negatively and the operator is in danger of chemical hazard.

Plate 1 depicts the operator pumping with his left hand while using the right hand to control the spray lance. As the human pumping rate and walking speed cannot necessarily be uniform and steady, the result is irregular spray droplet deposition and ineffective application occasioning low agricultural productivity. McAuliffe and Gray, (2002) reports that accurate and

International Journal of Novel Research in Electrical and Mechanical Engineering

Vol. 10, Issue 1, pp: (68-73), Month: September 2022 - August 2023, Available at: www.noveltyjournals.com

consistent pesticide applications are difficult to manage using knapsack sprayer because the equipment has little or no pressure regulation. As a result, crop protection chemicals are often misapplied, leading to poor biological results, the exacerbation of resistance to pesticides, and added expense of already cash limited farmers This invention completely removes pumping labour while ensuring steady pump pressure by contriving a rechargeable battery operated pump which takes pesticide from the tank to the nozzle at constant pressure.



Plate 1: Knapsack Sprayer

II. RESEARCH METHODOLOGY

The methodology is the standard engineering procedure which generally starts from the 'problem statement' to 'generation of multiple solutions' leading to selection of an optimal contrivance followed by its 'design' and 'engineering drawings'. Thereafter prototyping and mass production to bring the product into the economic mainstream.

III. EQUIPMENT DESCRIPTION

The novel sprayer consists of top compartment containing pesticide with a lower compartment which houses the spray pumping components. The manual pump and pumping lever of the conventional knapsack sprayer are off and in their place a DC rechargeable battery and electric hydraulic pump. Through a hole at the bottom of the pesticide compartment a hose connects the output of the tank to the pump suction pipe while the spray lance is connected to the pump delivery pipe. The DC battery is connected to the power with a switch for its actuation and shut off. Figure 1, Figure 2 and Figure 3 are respectively the isometric, orthographic and exploded views of the novel Battery operated Knapsack Sprayer. Figure 4 is the exploded view of the pump/battery assembly of the Battery operated knapsack sprayer.

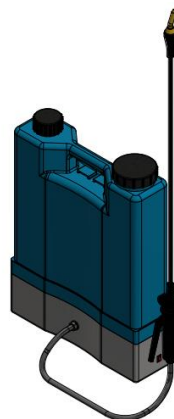


Figure 1: Isometric view of the novel Battery operated knapsack sprayer

International Journal of Novel Research in Electrical and Mechanical Engineering

Vol. 10, Issue 1, pp: (68-73), Month: September 2022 - August 2023, Available at: www.noveltyjournals.com

The novel sprayer consist of a tank of two compartments, the top part of the tank contains pesticide while the lower compartment houses a 12 V rechargeable battery, a hydraulic pump of about 1l/min discharge rate, an electric switch as well as hose and wire appurtenances for flow and electrical connections. Figure 4 depicts the rechargeable 12 V battery (1) connected to its charger (2) and connected to the two terminals of the pump’s motor (10) and (12). A tube (17) attached to the pump’s delivery port protrudes for connection to the spray lance. A switch (6) connects the battery positive cable and motor positive cable and serves to start and stop the machine. Plate 2 and Plate 3 show an operator testing the novel Battery operated knapsack sprayer. Plate 2 shows the electric switch at the lower portion of the sprayer.

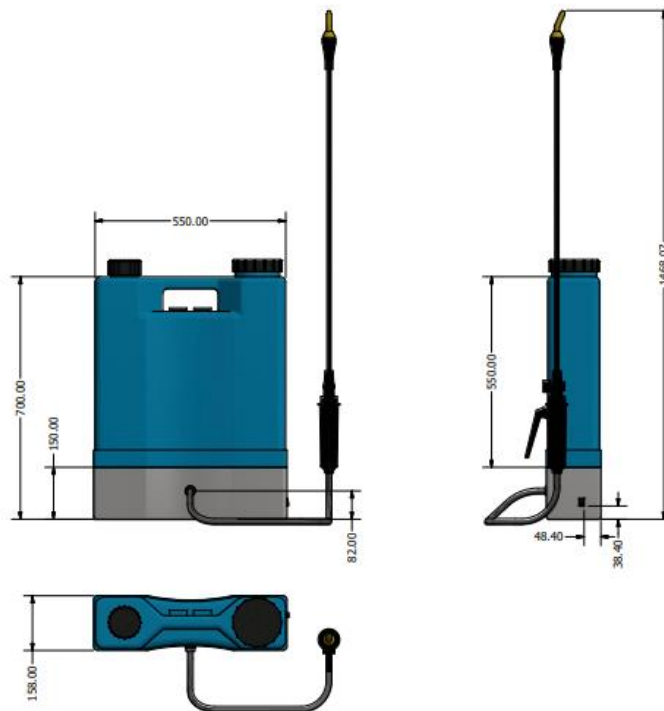


Figure 2: Orthographic view of the novel Battery operated knapsack sprayer

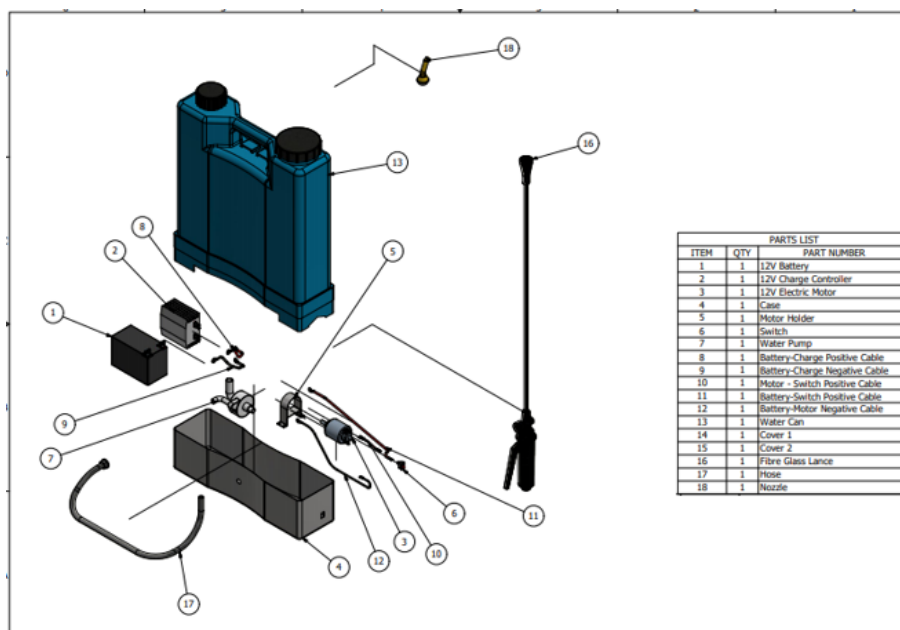


Figure 3: Exploded view of the novel Battery operated knapsack sprayer

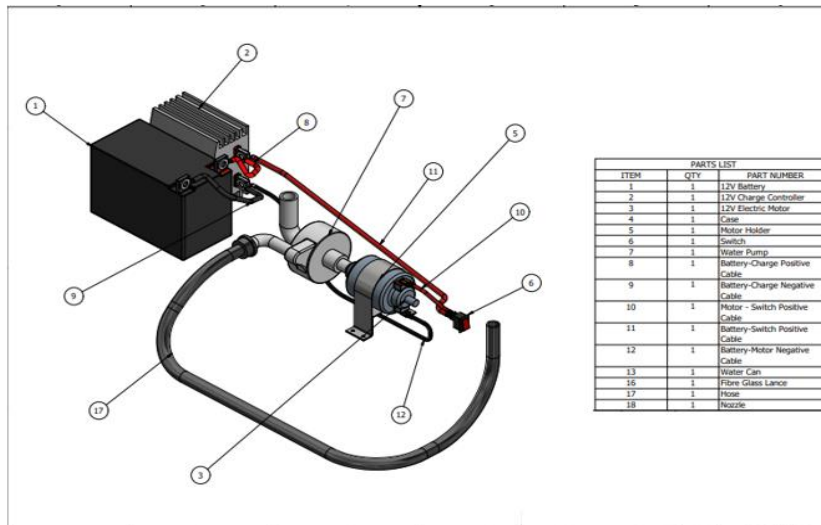


Figure 4: Exploded view of pump/battery assembly of the novel Battery operated knapsack sprayer



Plate 2: Testing the novel Battery operated Knapsack sprayer



Plate 3: Field test run of the battery operated Knapsack sprayer

IV. CONCLUSION

Poor weed control and the drudgery occasioned by the use of the conventional knapsack sprayer has impacted abysmally on agricultural productivity and food security in Nigeria. This is because it is impossible for a human operator to maintain constant walking steps and steady pumping rate which are the imperative conditions for application using the conventional knapsack sprayer to be even and effective. Apart from engendering constant pumping pressure and uniform herbicide deposition, the innovation drastically reduces drudgery making herbicide application handy. The dissemination and mass production of this technology shall impact very positively on agricultural and food security quest of Nigeria and other developing countries.

REFERENCES

- [1] Akobundu, I. O. (2009) *Weed Control in Nigeria*. PANS, 25:3, DOI: 10.1080/09670877909412098; p. 287.
- [2] Damalas, C. A. and Koutroubas, S. D. (2016). Farmers' Exposure to Pesticides: Toxicity Types and Ways of Prevention. *Toxics* 4010001; MDPI, Basel, Switzerland, p. 1.
- [3] Gianessi, L. (2009). The increasing importance of herbicides in worldwide crop production. *Manag Sci* ; 69: p. 1099.
- [4] McAuliffe, D. and Gray, V. P. (2002). *Application Technology: Problems and Opportunities with Knapsack Sprayers, Including the CFValve™ or Constant Flow Valve*. Global Agricultural Technology & Engineering, LLC. Deerfield Beach, FL, USA, pp. 80-81.
- [5] Poratkar, S. H. and Raut, D. R. (2013). Development of Multi-nozzle Pesticides Sprayer Pump. *International Journal of Modern Engineering Research (IJMER)*; Vol.3, Issue.2, p. 365.
- [6] Salkade, S., Salian, V., Sakalgaonkar, G. and Pawar, A. (2014). Design Considerations of a Cycle Mounted Agricultural Sprayer. *International Journal of Engineering Research & Technology (IJERT)*, ISSN: 2278-0181; Vol. 3 Issue 11, p. 544.