PERFORMANCE EVALUATION AND ACCEPTABILITY OF THE MECHANIZED ONION PESTICIDE SPRAYER

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ABSTRACT

This study aims to evaluate the performance and overall acceptability of the mechanized onion pesticide sprayer across multiple criteria, including functionality, durability, safety, and mobility, as well as to assess its performance efficiency in terms of discharge rate, noise level, fuel consumption, spray range, and field efficiency.The prototype was evaluated through a series of tests, including functionality, durability, safety and mobility , discharge uniformity, coverage area, rate of work, field efficiency, and standard time. Test results revealed that the mechanized sprayer outperformed traditional and solar-powered alternatives in all aspects. It achieved excellent ratings for functionality, durability, safety, and mobility, ensuring effective and safe operation. The sprayer also demonstrated consistent discharge uniformity across nozzles, preventing uneven pesticide application. Additionally, the sprayer covered a significantly larger area compared to other sprayer types, reducing spraying time and improving operational efficiency. Furthermore, the sprayer achieved a faster rate of work and higher field efficiency, indicating efficient resource utilization. Finally, the time and motion study confirmed a faster standard time for operating the mechanized sprayer. Overall, the efficiency test results convincingly demonstrate that the mechanized onion pesticide sprayer is an acceptable solution for farmers, offering consistent application, broad coverage, faster operation, and improved resource utilization compared to traditional methods.

Keywords: *Mechanized onion pesticide sprayer, efficiency evaluation, improved resource utilization*

INTRODUCTION

Agricultural crop production had undergone significant changes throughout years. In 2021, the worldwide production of primary crop commodities amounted to 9.5 billion tonnes, marking a 54 percent increase since 2000 (Food and Agriculture Organization, 2022). The underlying reason behind comes from technology innovation that helps the crop to yield better, such as agricultural methods such as spraying chemicals and biochemicals to the crop. Farmers incur financial losses when herbicides and pesticides are applied inefficiently. Despite spending considerable amounts on these chemicals, a significant volume fails to reach weeds and pests when using conventional sprayers (Lambrecht et al., 2019).

In the Philippines, the onion farming is one of the agricultural livelihoods (Capiral et al., 2023). Traditional practices in controlling pests and insects, like spraying chemicals and organic fertilizers were done through conventional backpack and knapsack sprayers (Tecson, 2016). People use hand-operated backpack sprayers to apply different substances, like pesticides and bio-fertilizers, during the plant health control phase in other crops. Meanwhile, conventional spraying possesses several factors that affect the effectiveness of the sprayed chemicals on the crop and physical constraints on human use (Lopes et al., 2011).

In the study of Lambrecht et al. (2019) shows that farmers frequently experienced financial losses as they struggle to apply herbicides and pesticides effectively. They found that many of these chemicals don't reach the weeds and pests when farmers use regular sprayers. De Carvalho et al. (2013) also found that using knapsack sprayers can cause physical strain, especially when carrying heavy loads. This strain can lead to discomfort and posture problems because of the repetitive motion of pumping the sprayer lever with the left arm.

In Occidental Mindoro usually sprayed liquids and biochemicals on their crops through lever-operated knapsack sprayer or back sprayer. Developing a much-efficient technology that takes less effort and time and reduce human constraints during spraying biochemicals remains restrained in local community, thus local research study about agricultural technology and systems specifically on spraying methods, were also limited. Study has shown that using manual 3 sprayers for farming comes with problems like wasting pesticides and unevenly spraying fields (Lopez et al., 2012). This meant that farmers might lose a lot of the pesticides they applied, and some parts of their fields might not have gotten enough protection. While bigger machines offers help but weren't practical for small farms with tricky terrain (Gafoor et al., 2022). With the health and posture issues on the used of knapsack sprayers as well as the waste and uneven distribution of pesticides application, this study aims to address the problems associated with the use of knapsack sprayer. To evaluate the performance and overall acceptability of the mechanized onion pesticide sprayer across multiple criteria, including functionality, durability, safety, and mobility, as well as to assess its performance efficiency in terms of discharge rate, noise level, fuel consumption, spray range, and field efficiency.

MATERIALS AND METHODS

Research Design

This study utilized a development-experimental design to evaluate the overall acceptability and performance efficiency of the mechanized onion pesticide sprayer. The evaluation focused on various criteria, including functionality, durability, safety, mobility, and performance metrics such as discharge rate, noise level, fuel consumption, and spray range.

Project Development

The project was developed via several processes, from pre-planning to final commissioning, to test the Mechanized Onion Pesticide Sprayer. The pre-planning was comprised of data-gathering activities. The researchers studied and collected necessary information and data that could help to uplift the concept of a Mechanized Onion Pesticide Sprayer. The components and functions were also considered so that the construction of the prototype was economically hypothesized and recognized. The researchers also reviewed related studies used by the preceding researchers to help developed ideas, strategies, techniques, and procedures for developing and constructing the machine. After the pre-planning stage, researchers pursued the study and continued with the fabrication based on the initial design and structure. The researchers used the appropriate materials to develop the Mechanized Onion Pesticide Sprayer. The final design was drawn using the SketchUp application. The design stage included materials and tools for constructing the Mechanized Onion Pesticide Sprayer. The engineering design was done with detailed mechanical connections and structures to represent all the parts of the project. The researchers also recognized the components of the machine and the structure of the project. The liquid flow diagram and block diagram were prepared that guide the researchers toward the completion of the project.

Furthermore, the purchasing and procuring stage involved acquiring and gathering materials, and equipment. The researchers analyze each component to serve well functions according to its intended purpose. After the procurement, researchers started the construction of the prototype according to the developed design. Initially, the project's frame were fabricated, followed by the fabrication of product assembly, including the mechanical components. The mechanized onion pesticide sprayer were tested to determine whether each component complied with the desired design and objectives.

Acceptability Evaluation

To evaluate overall acceptability, a panel of experts in agricultural engineering and technology assessed the sprayer using a structured evaluation form. Each expert rated the prototype on a 5-point Likert scale, where 1 indicated "Poor" and 5 indicated "Excellent." The mean scores for functionality, durability, safety, and mobility were calculated, along with an overall mean score to determine the sprayer's acceptability.

Performance Evaluation

The researchers also included the parameters to measure the performance efficiency (functionality, durability, safety, and mobility) of the mechanized onion pesticide sprayer. After the testing stage, the final commissioning and modification were performed based on the results of the evaluation. This constituted the final modification of the prototype and product testing for performance efficiency.

For performance efficiency, several measurements were taken. The discharge rate of the nozzle was measured using a graduated cylinder to collect liquid dispensed over specific time intervals (5, 10, and 15 seconds). The volumes dispensed during these intervals were recorded, and the average discharge rate was calculated. Noise levels were measured with a decibel meter at specified distances from the prototype during three separate trials, and the average noise level was determined to assess compliance with noise regulations. Fuel consumption was measured by recording the time required to consume a fixed volume of fuel (3000 mL) across several trials, with the average fuel consumption rate calculated for efficiency evaluation.

Spray range and field performance were assessed by measuring the length, width, and area covered by the nozzle's spray over multiple trials. The average spray range was computed to determine coverage effectiveness. Additionally, field capacity and efficiency were evaluated by recording the time taken to spray areas of varying sizes (900 sq. ft, 1800 sq. ft, and 2700 sq. ft). The actual and theoretical field capacities were calculated, and field efficiency was assessed to gauge performance under practical conditions.

RESULTS

The prototype was tested for overall acceptability measured in terms of functionality, durability safety and mobility.the experts evaluated the acceptability of the mechanized onion pesticide sprayer across various criteria. The functionality of the sprayer received a mean score of (mean = 4.49), interpreted as "very good." similarly, its durability was rated (mean = 4.26), also interpreted as "very good." safety and mobility both scored (mean = 4.48), with both being interpreted as "very good." the overall mean score for acceptability is (mean = 4.42), which is interpreted as "very good" (Table 1).

Table 1. Mean score of acceptability of the prototype.

ACCEPTABILITY	MEAN	INTERPRETATION
Functionality	4.49	Very Good
Durability	4.26	Very Good
Safety	4.48	Very Good
Mobility	4.48	Very Good
Overall Mean	4.42	Very Good

Legend:1.00-1.49=Poor, 1.50-2.49=Fair, 2.50-3.49=Good, 3.50-4.49=Very Good, 4.50-5.00=Excellent

Performance Efficiency of Prototype

In terms of performance efficiency, trial testing such as the discharge rate of nozzle, noise level of the prototype and fuel consumption were carefully evaluated. The researchers also calculated the actual field capacity, efficiency, theoretical field capacity, application rate, and the actual field efficiency.

The discharge rate was obtained by using a graduated cylinder and getting the time or by measuring the volume of liquid required to refill the power sprayer after spraying and getting the total time to consume the liquid. The discharge rate of the prototype was measured at different time intervals. At 5 seconds, the prototype achieved discharge rates of 2314.0 mL, 2310.0 mL, and 2312.5 mL across three trials, resulting in an average discharge rate of (462.43 mL/s). At 10 seconds, the discharge rates recorded were 4659.5 mL, 4664.0 mL, and 4675.5 mL, with an average discharge rate of (466.63 mL/s). For the 15-second interval, the discharge rates were 6972.0 mL, 6966.5 mL, and 6970.5 mL, leading to an average discharge rate of (464.64 mL/s). The overall average discharge rate for the prototype across all time intervals was (464.57 mL/s) (Table 2).

Table 2. Discharge Rate of the prototype.

TIME (sec)	DISCHARGE RATE (ML)			AVERAGE DISCHARGE RATE (mL/s)
	I	II	III	
5	2314.0	2310.0	2312.5	462.43
10	4659.5	4664.0	4675.5	466.63
15	6972.0	6966.5	6970.5	464.64
Average				464.57

The result shows the noise levels of the prototype for three trials. The average noise level was (85 dB) for the first trial, (79 dB) for the second trial, and (76 dB) for the third trial (Table 3).

Table 3. Noise level of the prototype.

TRIALS (m)	TRIAL (dB)			AVERAGE (dB/m)
	I	II	III	
1	84	86	84	85
2	79	78	79	79
3	76	77	76	76

The fuel consumption for 3000 mL over various trials was measured as follows: Trial I had an average of (0.0404 mL/min), Trial II had (0.0404 mL/min), and Trial III had (0.0404 mL/min). The average fuel consumption across all trials was (0.0404 mL/min) (Table 4).

Table 4. Fuel consumption of the prototype.

FUEL CONSUMPTION (mL)	TRIALS (mins)			AVERAGE (mL/min)
	I	II	III	
3000	123	120	121	0.0404

The average spray range measurements were as follows: length was (1.39 m), width was (3.01 m), and area was (4.18 m²) (Table 5).

Table 5. Spray range of the nozzle.

SPRAY RANGE	TRIALS (m)			AVERAGE (m^3)
	I	II	III	
Length	1.36	1.42	1.39	1.39
Width	2.95	3.06	3.02	3.01
Area (m^2)	4.00	4.30	4.20	4.18

The trials for spray area and time provided the following results: For a spray area of 900 sq. ft, the time was 37.4 seconds; for 1800 sq. ft, the time was 74.8 seconds; and for 2700 sq. ft, the time was 112.2 seconds. The actual field capacity is (0.8048 ha/hr), while the theoretical field capacity is (0.8261 ha/hr). The application rate is (362.8772 L/ha), and the field efficiency is (97.42%) (Table 6).

Table 6. Performance efficiency of the prototype.

TRIALS	SPRAY AREA (sq. ft)	TIME (sec)
1	900	37.4
2	1800	74.8
3	2700	112.2
Actual Field Capacity (ha/hr)	0.8048	
Theoretical Field Capacity (ha/hr)	0.8261	
Application Rate (L/ha)	362.8772	
Field Efficiency (%)	97.42	

DISCUSSION

The mechanized onion sprayer received exceptional overall acceptability, reflecting strong approval across various evaluated aspects. This finding is consistent with studies on improved sprayer designs, such as Ahmad et al. (2021), which also reported high user satisfaction with advanced sprayer models. The sprayer's high acceptability in terms of functionality, durability, safety, and mobility underscores its user-friendliness, robust construction, ease of handling, and commitment to user safety. These results suggest that the sprayer is well-suited to meet the needs of farmers, potentially enhancing work efficiency and reducing labor.

The discharge rate of the nozzle spray meets the standards set by PAES 157:2011 and 158:2011, which mandate a minimum discharge rate. This high performance indicates that the sprayer is efficient and effective, aligning with industry guidelines and contributing to improved agricultural practices (Vala & Yadav, 2023).

The noise levels emitted by the prototype power sprayer, which ranged from 76 dB to 86 dB at various distances. These levels are well below the maximum permissible limit of 92 dB specified in PAES 157:2011 and 158:2011. This compliance indicates that the prototype is suitable for use in agricultural settings without exceeding noise regulations, suggesting its practicality for field use.

The fuel consumption of the mechanized onion pesticide sprayer during the trials. The average fuel consumption rate was 0.0404 milliliters per minute, as measured before and after each test in accordance with PAES 157:2011 and 158:2011. This metric is crucial for understanding the sprayer's operational efficiency and cost-effectiveness, providing valuable insights for farmers and agricultural professionals in managing fuel use and overall operational costs.

The spray range of the nozzle, with an average coverage area of 4.18 square meters. This measurement aligns with PAES 157:2011 guidelines, which emphasize the importance of evaluating the distance of spray droplets. Accurate wind speed measurements at the test site further ensured the reliability of the results, highlighting the sprayer's effectiveness in covering target areas.

Field performance shows that the sprayer completed tasks in under 40 seconds for each 900 sq. ft. area, achieving an actual field capacity of 0.8048 ha/hr and a theoretical field capacity of 0.8261 ha/hr. The application rate was 362.8772 L/ha, with a utilization rate of 97.42%. These results indicate that the sprayer operates efficiently under real-world conditions, though factors such as cost and maneuverability should be considered for a comprehensive evaluation.

Despite the positive outcomes, this study acknowledges some limitations. The testing was conducted under controlled conditions that may not fully represent the variability of real-world agricultural environments. Additionally, the sample size and geographic scope of testing could be expanded to further validate the findings across different settings and crops.

The sprayer's high performance and compliance with industry standards suggest it has significant potential for adoption in agricultural practice. Its efficiency in fuel consumption, noise reduction, and effective spray coverage contribute to its practicality for enhancing farming operations. Future research could explore the long-term durability of the sprayer and its performance in diverse agricultural contexts to ensure its suitability for widespread use.

CONCLUSION

The development of the mechanized onion pesticide sprayer involved thorough planning and construction to ensure it met standards for materials and components. Extensive testing was conducted to evaluate its performance in terms of functionality, durability, safety, and mobility, ultimately confirming its effectiveness and efficiency for its intended purpose. The efficiency tests demonstrated that the sprayer can efficiently cover large areas and effectively apply pesticides. Furthermore, an operational manual was developed to provide users with clear instructions on how to operate the sprayer safely and efficiently and maintenance procedure was also provided to prolong the life of the prototype. Overall, the comprehensive approach has resulted in the creation of a reliable and effective tool for pesticide application in onion fields, promising improved outcomes for farmers. Lastly, the mechanized onion sprayer demonstrates strong performance across key parameters, with notable compliance with industry standards and practical benefits for farmers. Continued evaluation and refinement will further establish its role in advancing agricultural technology.

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