**Engineering and Technology Journal e-ISSN: 2456-3358**

**Volume 11 Issue 05 May-2026, Page No.-10163-10167**

**DOI: 10.47191/etj/v11i05.53, I.F. – 8.595**



# Design and Fabrication of A Mechanized Agricultural Sprayer for Vegetable Crops

**Leo Marie B. Laviste**

Department of Automotive, College of Industrial Technology Negros Oriental State University

**ABSTRACT:** This study aimed to design, fabricate, and evaluate a mechanized agricultural sprayer for vegetable crop production. A design and development research approach was employed, consisting of four phases: design and planning, material selection, fabrication and assembly, and testing and evaluation. The developed sprayer was constructed using locally available materials and configured with a wheeled frame, tank, pump system, and dual-nozzle spraying mechanism. Field testing was conducted to assess its performance in terms of spray coverage, discharge rate, and operational efficiency. Results showed that the sprayer, with a tank capacity of 20 liters, was capable of covering an average area of 1,350 square meters per full tank, with a range of 1,200 to 1,500 square meters depending on operating conditions. The dual-nozzle system ensured uniform spray distribution, while the push-type design reduced operator fatigue and improved mobility compared to traditional knapsack sprayers. The discharge rate was found to be stable, ensuring consistent liquid flow during operation. Overall, the developed mechanized agricultural sprayer demonstrated efficiency, cost-effectiveness, and practicality for small to medium-scale vegetable farming. The study highlights the potential of mechanized solutions in enhancing agricultural productivity and reducing labor

**KEYWORDS:** Mechanized Agricultural Sprayer, Vegetable Crop Production, Spray Coverage Efficiency, Agricultural Mechanization, Design And Fabrication

## I. INTRODUCTION

Agricultural spraying is an essential operation in crop production, particularly in vegetable farming where timely application of water, fertilizers, and pesticides significantly influences yield and crop quality. Traditionally, spraying is performed using knapsack sprayers, which require considerable human effort and prolonged manual labor. This method is physically demanding and inefficient, especially for small-scale farmers who rely heavily on manual agricultural practices (Kumar & Singh, 2021). In many rural settings, including parts of Asia, animal-assisted farming such as the use of draft animals remains common for land preparation and planting, further contributing to labor-intensive and time-consuming operations (Rahman et al., 2020).

In developing countries, the rapid growth in population has increased the demand for agricultural products, placing pressure on farmers to enhance productivity despite limited access to modern technologies (Food and Agriculture Organization [FAO], 2021). However, the adoption of mechanized systems in agriculture remains limited, particularly among smallholder farmers, due to cost constraints, lack of technical knowledge, and limited infrastructure (World Bank, 2022). In the Philippines, traditional farming practices are still widely observed, especially in rural communities, where manual spraying and planting methods continue to dominate (Department of Agriculture, 2021). These conventional approaches often result in lower productivity, higher labor costs, and increased time requirements for both crop cultivation and harvesting (Santos & Reyes, 2020).

The integration of mechanization in agriculture is therefore crucial to improving efficiency, reducing labor dependency, and increasing crop yield. Agricultural sprayers, particularly hydraulic sprayers, play a significant role in modern farming systems. These sprayers typically consist of a tank, pump, lance or boom, and nozzle system that atomizes liquid solutions into droplets for effective crop coverage. The droplet size can be controlled by adjusting nozzle type and operating pressure, allowing optimization of spray distribution and minimizing drift (Zhang et al., 2021). Larger droplets reduce spray drift but require more liquid volume, while smaller droplets enhance coverage but are more susceptible to environmental factors such as wind (Li et al., 2022).

Given these challenges, the development of a mechanized agricultural sprayer offers a practical solution for small and medium-scale farmers. A mechanized system can significantly reduce physical effort, improve spraying efficiency, and ensure uniform application of agricultural inputs. Moreover, multifunctional agricultural devices that integrate spraying with other farming operations have been recognized as effective innovations to address labor shortages and improve farm productivity (Patel et al., 2023).

This study focuses on the design and fabrication of a mechanized agricultural sprayer specifically intended for vegetable crops. The proposed system aims to provide an efficient, cost-effective, and user-friendly solution to enhance agricultural practices in local farming communities. Figure 1 presents the conceptual framework of the study. The system operates by assembling the sprayer's mechanical components, filling the tank with liquid, and manually pushing the device across the field. As the device moves, the sprayer mechanism distributes liquid uniformly over the crop area, thereby improving coverage efficiency and reducing labor intensity.

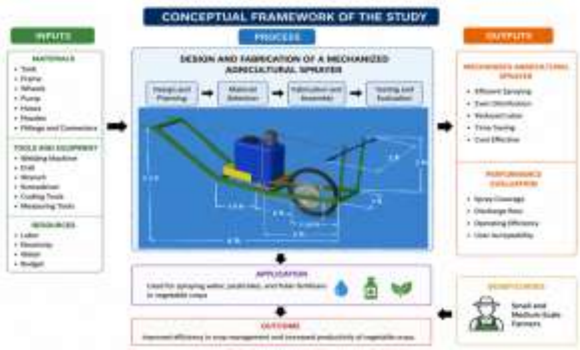


**Figure 1. Concept of the Study**

### Objectives of the Study

The primary objective of this study was to develop a mechanized agricultural sprayer intended for vegetable crop production. Specifically, the study focused on the design, material selection, fabrication, and performance evaluation of the developed sprayer to ensure its efficiency, functionality, and suitability for small to medium-scale farming applications.

1. **To design and plan** a mechanized agricultural sprayer for vegetable crops based on functional and operational requirements.
2. **To identify and select** appropriate materials and components suitable for the fabrication of the sprayer.
3. **To fabricate and assemble** the mechanized agricultural sprayer following the proposed design specifications.
4. **To test and evaluate** the performance of the developed sprayer in terms of spray efficiency, coverage, and operational effectiveness.

## II. METHODOLOGY

This study utilized a design and development research approach to create and evaluate a mechanized agricultural sprayer for vegetable crops. The methodology was divided into four major phases: design and planning, material selection, fabrication and assembly, and testing and evaluation.


**Figure 2. DDR Research Approach**

### 1. Design and Planning

In this phase, the researchers developed both the conceptual and technical design of the mechanized agricultural sprayer. This process involved the preparation of layout drawings and the identification of essential components, including the tank, frame, wheels, pump, hoses, and spray nozzles. The overall dimensions and configuration of the device were carefully determined to ensure proper functionality and efficiency. Key design considerations included portability, ease of operation, durability, and effectiveness in spraying vegetable crops. In addition, a conceptual framework was established to guide the systematic development of the device. Figure 2 illustrates the initial sketch design of the sprayer prior to the selection of materials.

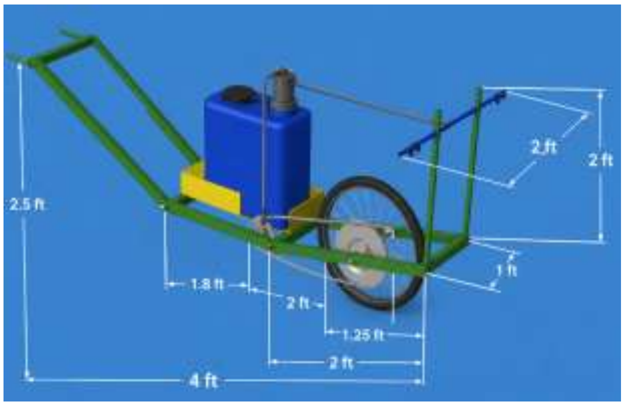


**Figure 3. Drawing of the Mechanized Sprayer**

### 2. Material Selection

Appropriate materials and components were selected based on availability, cost, durability, and suitability for agricultural use. The frame was designed using metal materials to ensure strength and stability, while lightweight components were incorporated to facilitate ease of movement during operation. The sprayer tank, pump system, hoses, and nozzles were carefully chosen to ensure efficient liquid distribution and resistance to corrosion. In addition, standard tools and equipment such as welding machines, drills, and measuring tools were identified to support the fabrication process. Table 1 presents the materials and components identified for the development of the mechanized agricultural sprayer and Table II shows the tools and equipment used.

**Table 1. Materials and Components Used for the Mechanized Agricultural Sprayer**

| Component/Material | Description | Purpose/Function |
|---|---|---|
| Steel Bars / Angle Bars | Mild steel material | Used for constructing the frame for strength and durability |
| Plastic Tank (20–30 L) | High-density polyethylene (HDPE) | Serves as the container for water/pesticide solution |
| DC Pump / Manual Pump | Water pump system | Provides pressure for spraying liquid |
| Rubber Hose | Flexible tubing | Transfers liquid from tank to nozzles |
| Spray Nozzles | Adjustable spray heads | Controls spray pattern and droplet size |
| Wheels (Pneumatic) | Rubber wheel with rim | Enables mobility of the sprayer |
| Axle Shaft | Steel rod | Supports wheel rotation |
| Valves / Connectors | PVC/metal fittings | Controls flow and connects components |
| Battery (if applicable) | Rechargeable battery | Powers the pump system |
| Metal Brackets & Fasteners | Bolts, nuts, screws | Secures all components together |

**Table 2. Tools and Equipment Used**

| Tool/Equipment | Function |
|---|---|
| Welding Machine | Used for joining metal parts |
| Electric Drill | Used for creating holes |
| Grinder / Cutter | Used for cutting metal |
| Wrench Set | Used for tightening bolts and nuts |
| Measuring Tools (Tape, Ruler) | Ensures accurate dimensions |

### 3. Fabrication and Assembly

The fabrication phase involved the construction and assembly of the mechanized agricultural sprayer, including the frame, wheel system, and mounting components. Initially, metal materials were cut, shaped, and welded to form the structural frame based on the specified design. The wheel and axle system were then installed to ensure mobility and stability of the device. Subsequently, the sprayer tank was securely mounted onto the frame, and the pump, hoses, and spray nozzles were integrated to establish proper fluid flow and distribution. All components were assembled in accordance with the design specifications to ensure functionality and efficiency. After assembly, the entire system was inspected to verify structural integrity, proper alignment, and operational performance. Figure 4 shows the step-by-step fabrication and assembly of the mechanized agricultural sprayer, including frame construction, wheel installation, and system integration.

**Figure 4. Assembly of Mechanized Sprayer**

### 4. Testing and Evaluation

The developed mechanized sprayer was subjected to performance testing in a vegetable farming environment. The evaluation focused on key parameters such as spray coverage, discharge rate, and operational efficiency. The device was operated under actual field conditions to assess its effectiveness in delivering uniform spray distribution. Additionally, user feedback was gathered to evaluate the usability, labor reduction, and time efficiency of the system. The results of the testing were analyzed to determine the overall performance and acceptability of the developed sprayer.

**Figure 5. Testing the Device Functionality**

## III. RESULTS AND DISCUSSION

The developed mechanized agricultural sprayer was tested under actual field conditions to evaluate its spraying capacity, coverage efficiency, and operational performance. The device was equipped with a tank capacity of 20 liters, which is commonly used for small to medium-scale agricultural spraying applications, as shown in Figure 6. The detailed performance parameters of the developed sprayer are presented in **Table III**.

During the field testing, it was observed that a full tank of 20 liters was capable of covering an approximate area of 1,200 to 1,500 square meters, depending on walking speed, nozzle type, and spray pressure. On average, the sprayer achieved a coverage of approximately 1,350 square meters per full tank. These results, as summarized in **Table III**, indicate that the developed system is efficient for vegetable farming operations, particularly in small and medium-sized plots.

The wide spray distribution produced by the dual-nozzle system contributed to uniform coverage across the crop area. Compared to traditional knapsack sprayers, the developed mechanized sprayer significantly reduced operator fatigue and increased the area covered within a shorter period. The push-type mechanism also allowed for better control and consistent spraying, resulting in improved application efficiency. A summary of these key findings is presented in **Table IV**.

Furthermore, the discharge rate of the sprayer was found to be stable, ensuring continuous and uniform liquid flow throughout the operation. The structural design, including the wheeled frame and mounted tank, enhanced mobility and minimized physical strain on the user.

Overall, the results demonstrate that the developed mechanized agricultural sprayer is effective in improving spraying efficiency, reducing labor effort, and increasing coverage area. As reflected in **Tables III and IV**, the system is suitable for practical application in vegetable crop production, particularly for farmers seeking a cost-effective and efficient spraying solution.


**Figure 6. Output of the Study.**

**Table III. Performance Evaluation of the Mechanized Agricultural Sprayer**

| Parameter | Value/Result | Description/Interpretation |
|---|---|---|
| Tank Capacity | 20 liters | Standard capacity suitable for small to medium-scale vegetable farming |
| Area Coverage (Minimum) | 1,200 sq. meters | Coverage varies depending on operating conditions |
| Area Coverage (Maximum) | 1,500 sq. meters | Achieved under optimal walking speed and spray pressure |
| Average Coverage | 1,350 sq. meters | Typical area covered per full tank |
| Spray System | Dual-nozzle | Provides wider and more uniform spray distribution |
| Discharge Rate | Stable | Ensures continuous and consistent liquid flow |
| Operational Efficiency | High | Covers larger area in shorter time compared to manual spraying |
| Labor Requirement | Reduced | Less physical effort compared to knapsack sprayer |
| Mobility | High | Wheeled design allows easy movement in field |
| User Control | Improved | Push-type mechanism enables better handling and direction |

**Table IV. Summary of Key Findings**

| Indicator | Result |
|---|---|
| Tank Capacity | 20 L |
| Average Coverage per Tank | 1,350 sq. m |
| Efficiency Improvement | Higher than manual sprayer |
| Labor Reduction | Significant |
| Suitability | Small to medium-scale farms |

## CONCLUSION

The study successfully designed, fabricated, and evaluated a mechanized agricultural sprayer intended for vegetable crop production. The developed system demonstrated effective performance under actual field conditions, particularly in terms of spraying capacity, coverage efficiency, and operational functionality. With a tank capacity of 20 liters, the sprayer was able to cover an average area of approximately 1,350 square meters per full tank, indicating its suitability for small to medium-scale farming operations.

The integration of a dual-nozzle spraying system provided uniform distribution of liquid across the crop area, improving application efficiency. Additionally, the wheeled and push-type design significantly reduced operator fatigue compared to traditional knapsack sprayers, while enhancing mobility and ease of use. The stable discharge rate further ensured consistent spraying performance throughout operation.

Overall, the developed mechanized agricultural sprayer proved to be an efficient, cost-effective, and user-friendly solution that can improve productivity and reduce labor requirements in vegetable farming.

## RECOMMENDATIONS

For the future improvement and development of the study, based on the findings. The following recommendations are proposed:

**1. Integration of Motorized System**

Future studies may incorporate a motorized or automated pumping system to further enhance spraying efficiency and reduce manual effort.

**2. Optimization of Spray Parameters**

Further research may focus on optimizing nozzle type, spray pressure, and walking speed to maximize coverage and minimize liquid wastage.

**3. Inclusion of Adjustable Boom System**

The addition of an adjustable spray boom can allow flexibility in covering different crop row spacings and farm layouts.

**4. Field Testing in Diverse Conditions**

Additional testing should be conducted in different soil types, terrains, and crop varieties to validate the adaptability of the sprayer.

**5. Cost and Economic Analysis**

Future work may include a detailed cost-benefit analysis to evaluate the economic feasibility and return on investment for farmers.

**6. User Training and Adoption Study**

It is recommended to assess farmer acceptability and provide training programs to ensure proper utilization of the developed system.

## REFERENCES


1. Department of Agriculture. (2021). *Philippine agriculture and fisheries modernization report*. DA Philippines.
2. Food and Agriculture Organization. (2021). *The state of food and agriculture 2021*. FAO.
3. Kumar, R., & Singh, P. (2021). Design and development of agricultural sprayers: A review. *Journal of Agricultural Engineering*, 58(3), 145–156.
4. Li, J., Wang, S., & Chen, Y. (2022). Spray droplet dynamics and drift reduction techniques in agricultural spraying. *Biosystems Engineering*, 218, 1–12.
5. Patel, H., Sharma, V., & Mehta, R. (2023). Development of multifunctional agricultural equipment for small-scale farmers. *International Journal of Agricultural Technology*, 19(2), 233–245.
6. Rahman, M., Ali, M., & Hossain, S. (2020). Traditional vs mechanized farming practices in developing countries. *Agricultural Systems*, 178, 102738.
7. Santos, L., & Reyes, M. (2020). Challenges in small-scale farming in the Philippines. *Philippine Journal of Agricultural Sciences*, 103(2), 89–98.
8. World Bank. (2022). *Transforming agriculture for inclusive growth*. World Bank Publications.
9. Zhang, H., Liu, Z., & Wang, X. (2021). Performance evaluation of hydraulic sprayers in crop protection. *Applied Engineering in Agriculture*, 37(4), 567–576.
10. Cruz, D., & Garcia, E. (2023). Mechanization trends in Southeast Asian agriculture. *Asian Journal of Agriculture and Development*, 20(1), 45–60.
11. Balasubramanian, M., & Karthikeyan, R. (2021). Development and performance analysis of portable agricultural sprayers for vegetable farming. *International Journal of Agricultural Engineering*, 14(2), 112–119.
12. Chaudhary, P., Verma, S., & Yadav, R. (2022). Evaluation of spray uniformity and field efficiency of boom sprayers in vegetable crops. *Journal of Farm Machinery and Power Engineering*, 59(1), 78–86.
13. FAO. (2022). *Agricultural mechanization for sustainable crop production*. Food and Agriculture Organization of the United Nations.
14. Gomez, A., & Torres, J. (2021). Adoption of low-cost mechanized farming technologies among smallholder farmers. *Philippine Agricultural Review*, 15(3), 201–214.
15. Joshi, N., & Patel, K. (2020). Advances in pesticide application technology for precision agriculture. *Agricultural Engineering Today*, 44(5), 34–42.
16. Mohanty, D., & Pradhan, P. (2023). Design considerations for efficient agricultural spraying systems. *International Journal of Engineering Research and Technology*, 12(4), 521–529.
17. Reddy, V., Kumar, A., & Singh, D. (2021). Comparative analysis of manual and mechanized sprayers for crop protection. *Journal of Agricultural Mechanization in Asia, Africa and Latin America*, 52(3), 67–75.
18. United Nations Development Programme. (2022). *Sustainable agricultural innovation and rural development*. UNDP Publications.
19. Wu, L., Chen, H., & Zhao, Y. (2023). Optimization of nozzle performance and spray characteristics in agricultural applications. *Biosystems Engineering*, 229, 45–58.
20. Yadav, S., & Mishra, P. (2022). Ergonomic assessment of push-type agricultural sprayers for small-scale farming. *International Journal of Industrial Ergonomics*, 89, 103291.