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Lemas Tying Machine: Efficiency in Tiger Grass Soft Broom Production

Randy P. Osorno, PhD[1], Matt Edison G. Alcantara, PhD[2], April Rose B. Flores, PhD[2]
[1]PhD Program, University of Southern Mindanao–Kidapawan City Campus, Sudapin, Kidapawan City, Cotabato, Philippines
[2]Professor, University of Southern Mindanao- Kidapawan City Campus, Sudapin, Kidapawan City, Cotabato, Philippines

Email: randy.osorno@deped.gov.ph

ABSTRACT

This study aimed to design, construct, and evaluate the Lemas Tying Machine (LTM) in terms of functionality, acceptability of materials used, quality of output, and utilization in tiger grass soft broom production. A developmental research design employing mixed methods was conducted in Magpet and Kidapawan City, Cotabato, Philippines. Seventy purposively selected respondents, comprising 40 broom makers and manufacturers and 30 technical experts, evaluated the machine through validated questionnaires and open-ended interviews. Quantitative data were analyzed using descriptive statistics, while qualitative responses underwent thematic analysis. Results showed that the machine was highly functional, with mean ratings of 4.660 from broom makers and manufacturers and 4.667 from technical experts. Materials used were highly acceptable, obtaining respective means of 4.585 and 4.587, while quality of output received means of 4.525 and 4.533. Respondents recognized the machine's battery-powered operation, portability, and ease of use but identified inconsistent wire tension, excessive wire consumption, limited adaptability to different handle sizes, and affordability concerns. The study concluded that the LTM is a functional and acceptable semi-automated innovation for broom handle tying. Improvements in wire tensioning, clamping, cutting precision, and financial accessibility are recommended. Findings were limited to prototype evaluation involving purposively selected respondents from two localities, without established long-term operational reliability. The study provides a locally developed technological solution with potential to support traditional broom-making practices and inform further improvements in rural manufacturing.

Keywords: *Broom Production, Machine Acceptability, Machine Functionality, Mechanized Tying, Rural Manufacturing, Tiger Grass, Technological Innovation*

1. INTRODUCTION

Broom-making is an important traditional industry in the Philippines, providing livelihood opportunities for rural households and communities. Tiger grass (Thysanolaena maxima), locally known as tahiti or tambo, is a renewable resource used in soft broom production. It can be cultivated independently or intercropped with fruit trees and other perennial crops (Ella & Domingo, 2010). Its production and marketing contribute to the socioeconomic development of local communities (Matunhay et al., 2022). Tiger grass is also recognized as a high-value, non-perishable agricultural commodity with potential for agribusiness development (Fetalvero & Faminial, 2011). Despite its economic importance, broom production remains predominantly manual, particularly the tying of tiger grass stalks to form broom handles. This process requires considerable time, physical effort, and skill, often resulting in inconsistent tying quality, worker fatigue, and limited production capacity. The lack of modern equipment and processing facilities further constrains the development and competitiveness of the industry (Matunhay et al., 2022). Technological innovations offer opportunities to address these limitations (Winarno et al., 2025). Mechanized tying systems have demonstrated potential for improving productivity and reducing work-related injuries (Safa et al., 2016). However, existing broom-processing technologies, including pollen-removal equipment (Fadriquel, 2016) and semi-automatic coconut broom-making machines (Shadakshari et al., 2025), do not specifically address the handle-tying requirements of tiger grass soft brooms. To address this technological gap, the study developed the Lemas Tying Machine, a semi-automated, battery-operated device designed to tie, twist, and cut binding wire around tiger grass broom handles. The innovation seeks to improve production efficiency, output consistency, and worker convenience while supporting technological advancement and sustainable livelihoods in rural broom-producing communities.

Research Problem

The tiger grass broom-making industry continues to depend heavily on manual handle-tying methods, which are labor-intensive, time-consuming, and physically demanding. These practices contribute to inconsistent product quality, increased production costs, and limited opportunities for expanding production. Although tiger grass cultivation and broom manufacturing support rural livelihoods, the absence of suitable mechanized equipment remains a major constraint (Matunhay et al., 2022). Existing technological developments primarily address other production activities. The tiger grass pollen remover developed by Fadriquel (2016) focuses on removing pollen, while the semi-automatic coconut broom stick machine developed by Shadakshari et al. (2025) is intended for coconut midrib brooms. Neither directly addresses the specific requirements of tying tiger grass broom handles. Although mechanized tying technologies can improve productivity and reduce physical strain (Safa et al., 2016), their application to tiger grass soft broom production remains limited. Consequently, the study addressed the need for a dedicated tying machine capable of improving the efficiency, consistency, and convenience of broom handle production. Specifically, it examined the functionality of the developed Lemas Tying Machine, its acceptability in terms of materials used and quality of output, and its acceptability for utilization among broom makers, manufacturers, and technical experts.

Assumptions of the Study

The study assumed that the Lemas Tying Machine could perform the tying, twisting, and cutting of binding wire around tiger grass stalks through a semi-automated mechanism requiring minimal manual intervention. It further assumed that properly controlled wire tension would secure broom handles without damaging the stalks and panicles. The machine was expected to operate efficiently using standardized mechanical and electrical components, including a frame,

motor, battery, fasteners, and wiring. Its design assumed that simple operating controls, appropriate maintenance, and adjustable tying parameters would contribute to usability, durability, and consistent output. Additionally, the study assumed that considering material, labor, and assembly costs during development would support the machine's affordability and potential adoption by local broom makers and manufacturers

Objectives of the Study

The primary objective of the study was to develop and evaluate the Lemas Tying Machine as a technological innovation for improving tiger grass soft broom production. Specifically, the study aimed to design and construct the Lemas Tying Machine, test its functionality, determine its acceptability in terms of materials used and quality of output, and evaluate the level of acceptability of its utilization among intended users. These objectives focused on assessing the machine's operational performance, suitability for broom production, and potential application in local manufacturing practices.

Conceptual and Theoretical Framework

The study was anchored in the concepts of appropriate technology, technological determinism, diffusion of innovations, mechanization, and ergonomics. Appropriate technology emphasizes the development of affordable, accessible, and locally suitable innovations that support sustainable community operations (Aulia et al., 2023). Technological determinism highlights the role of technological advancement in economic and industrial development (Mezentsev, 2020), while diffusion of innovations explains the adoption of new technologies within communities (Kerner, 2024). These concepts support the development and potential adoption of the Lemas Tying Machine among local broom producers. The theory of mechanization emphasizes improving production efficiency, precision, and consistency through machinery (Oancea et al., 2024). Ergonomic principles further support operator comfort, safety, and reduced physical strain (Ha et al., 2026; Poornikoo & Øvergård, 2024). The evaluation of agricultural machinery also involves ergonomic, energy, and performance considerations, as examined by Jadhav et al. (2026). The machine's design also incorporates electrical and mechanical principles, particularly the conversion of electrical energy into mechanical motion (Chapman, 2005) and the use of batteries as a direct-current power source (Chandraker et al., 2024). The design integrates wire-tying, twisting, and cutting mechanisms to support the semi-automated operation of the Lemas Tying Machine. Conceptually, the study followed a systematic process of planning, designing, constructing, testing, revising, and evaluating the Lemas Tying Machine. This approach integrated technological innovation with traditional broom-making practices to develop a functional, efficient, and acceptable machine suited to the needs of rural broom producers.

Sustainable Development Goal and Multidisciplinary Sustainability Relevance

The development of the Lemas Tying Machine supports selected United Nations Sustainable Development Goals (SDGs) by promoting technological innovation, rural livelihoods, occupational well-being, and sustainable broom production. It contributes to SDG 8 (Decent Work and Economic Growth) by seeking to reduce labor-intensive activities, improve production efficiency, and support rural income-generating opportunities (Matunhay et al., 2022). It advances SDG 9 (Industry, Innovation and Infrastructure) by integrating mechanical and electrical systems into traditional broom-making practices through locally appropriate and accessible technology (Aulia et al., 2023). In relation to SDG 12 (Responsible Consumption and Production), the machine aims to improve tying consistency and material efficiency using tiger grass, a renewable agricultural resource (Ella & Domingo, 2010), although actual reductions in material waste remain unverified. It also supports SDG 3 (Good Health and Well-Being) by seeking to reduce repetitive manual effort and improve operator convenience through mechanization and ergonomic design (Safa et al., 2016; Poornikoo & Ovegard, 2024). From a

multidisciplinary perspective, the study addresses socioeconomic, technological, environmental, and cultural sustainability by supporting rural livelihoods, encouraging technological innovation, and complementing traditional broom-making practices, including those of Indigenous Peoples. Although long-term economic and environmental benefits have not been established, the machine provides a foundation for improving the sustainability of tiger grass soft broom production.

2. METHODOLOGY

Research Design

The study utilized a developmental project research design integrated with a mixed-methods approach to develop and evaluate the Lemas Tying Machine. The developmental process involved planning, designing, constructing, testing, revising, and evaluating the machine, consistent with the design, development, and evaluation approach examined by Seol et al. (2024). Quantitative data were collected to assess its functionality and acceptability, while qualitative data provided insights into its usability, operational challenges, and potential improvements. This approach enabled a comprehensive evaluation of the machine's performance and suitability for tiger grass soft broom production.

Research Locale or Study Setting

The study was conducted in the Municipality of Magpet and Kidapawan City, Cotabato, Philippines. These areas were selected because of their agricultural economies and established tiger grass broom-making activities. Tiger grass (Thysanolaena maxima) is commonly cultivated through intercropping and serves as a primary material for soft broom production (Baloloy et al., 2026). The industry provides livelihood opportunities for local residents, particularly Indigenous Peoples (IP) communities engaged in traditional broom-making. These locations provided an appropriate setting for evaluating the machine among its intended users.

Participants or Data Sources

The study involved 70 respondents selected through purposive sampling based on their knowledge and experience in broom production, manufacturing, and machine evaluation. Of these, 40 were broom makers and manufacturers from organized farmers' groups in selected barangays of Magpet and Kidapawan City, while 30 were technical experts from academia, government, and industry specializing in engineering, technology, and manufacturing. Both groups evaluated the machine's functionality and acceptability in terms of materials used and quality of output. The broom makers and manufacturers also participated in open-ended interviews to assess the acceptability of its utilization and identify possible improvements.

Research Instruments or Materials

The primary research instruments were structured questionnaires and an open-ended interview guide designed to evaluate the Lemas Tying Machine. Separate questionnaires were administered to broom makers and manufacturers and technical experts, covering functionality, materials used, quality of output, ease of operation, efficiency, and cost-effectiveness. The questionnaires were originally developed in Cebuano to ensure clarity and understanding among respondents, with English translations provided for documentation. The instruments underwent content validation by the research panel and faculty members of the University of Southern Mindanao–Kidapawan City Campus (USM-KCC). The quantitative questionnaire obtained a Content Validity Index (CVI) of 0.956 and an overall Cronbach's alpha of 0.81. Reliability coefficients were 0.84 for functionality, 0.82 for acceptability of materials used, and 0.83 for quality of output. The interview guide obtained a CVI of 0.945. A five-point Likert scale was used, ranging from strongly disagree to strongly agree, with weighted mean intervals of 1.00–1.80, 1.81–2.60, 2.61–3.40, 3.41–4.20, and 4.21–5.00. The Lemas Tying Machine was constructed using a

metal frame, marine plywood, tying machine assembly, 12V DC lithium-ion battery, electrical switches, indicator lights, fasteners, caster wheels, and measuring guide. Fabrication involved welding, mechanical assembly, electrical wiring, and surface finishing using appropriate tools and equipment. The machine incorporated a battery-powered tying, twisting, and cutting mechanism activated through a push-button control. Its construction required PHP 15,285.00 for materials and PHP 4,585.50 for labor, resulting in a total development cost of PHP 19,870.50.

Data Gathering Procedure

Data gathering began with the planning and development of the Lemas Tying Machine. Relevant literature, technical references, and available materials were reviewed to guide its design. After acquiring the necessary components, the researcher fabricated the frame, installed the tying mechanism, assembled the electrical components, and checked the wiring connections. The machine underwent testing, calibration, and necessary revisions before evaluation. Permission to conduct the study was requested from the municipal and barangay authorities. Following approval and respondent consent, validated questionnaires were administered to broom makers, manufacturers, and technical experts. Enumerators assisted respondents in understanding the questions. Broom makers and manufacturers completed the questionnaires in their workplaces, while technical experts participated in academic and industry settings. After the surveys, open-ended interviews were conducted with broom makers and manufacturers to obtain additional information regarding the machine's usability, efficiency, limitations, and possible improvements. A third-party interviewer facilitated the interviews to minimize potential response bias. With respondents' consent, interviews were audio-recorded and transcribed for analysis. The quantitative and qualitative responses were subsequently organized and examined to evaluate the machine's functionality and acceptability.

Data Analysis

Quantitative data were analyzed using descriptive statistics, including frequency count, percentage, weighted mean, and standard deviation. Frequency and percentage described the distribution of responses, while weighted mean determined the respondents' overall assessments of the machine's functionality, materials used, and quality of output. Standard deviation measured variations in respondents' evaluations. The weighted means were interpreted using a five-point rating scale, where 4.21–5.00 indicated strongly agree, 3.41–4.20 indicated agree, 2.61–3.40 indicated neither agree nor disagree, 1.81–2.60 indicated disagree, and 1.00–1.80 indicated strongly disagree. Qualitative data from open-ended interviews were analyzed using thematic analysis. Responses were transcribed, coded, and categorized to identify recurring themes related to ease of operation, efficiency, technical concerns, and recommendations for improvement. The integration of quantitative and qualitative findings provided a comprehensive assessment of the machine's functionality, acceptability, and potential utilization in tiger grass broom production.

Ethical Considerations

The study observed ethical procedures throughout data collection. Permission was obtained from the appropriate local government and barangay authorities before conducting the research. Respondents' consent was secured before administering questionnaires and conducting interviews. A third-party interviewer facilitated the qualitative interviews to minimize potential response bias and encourage participants to express their opinions freely. Audio recordings were obtained only with respondents' consent. These procedures supported the ethical conduct of the study and the credibility of the information gathered.

3. RESULTS AND DISCUSSION

3.1 Development of the Lemas Tying Machine

3.1.1 Design of the Lemas Tying Machine

The Lemas Tying Machine was designed as a semi-automated, battery-operated device for tying tiger grass broom handles. Its structure incorporated a reinforced metal frame, adjustable supports, caster wheels, a tying assembly, a 12V DC battery, electrical controls, and a measuring guide. The design integrated wire dispensing, twisting, and cutting mechanisms to facilitate handle tying while maintaining portability, stability, and ease of operation. The design addressed the limitations of traditional manual tying by integrating mechanical automation with existing broom-making practices. Its structural arrangement and simplified controls were intended to improve operational efficiency, reduce repetitive labor, and provide consistent tying positions. The machine also allowed for potential mechanical modifications to accommodate different production requirements.

3.1.2 Construction of the Lemas Tying Machine

The construction process successfully produced a functional prototype through metal frame fabrication, installation of mechanical and electrical components, wiring, painting, and operational testing. The tying assembly was installed within the frame and connected to a 12V DC power system. A push-button switch activated the sequential wire dispensing, twisting, and cutting operations, while the measuring guide assisted in positioning broom handles. The completed machine demonstrated semi-automated operation, portability, and structural stability. The successful construction demonstrated the feasibility of integrating a motorized tying mechanism into traditional broom production. Its battery-powered operation reduced dependence on direct electrical connections, making it suitable for rural production settings (Chandraker et al., 2024). The combination of mechanical components and user-operated controls provided a practical foundation for improving tying efficiency while retaining operator involvement.

3.2 Functionality of the Lemas Tying Machine

3.2.1 Functionality Assessment by Broom Makers and Manufacturers

The broom makers and manufacturers rated the Lemas Tying Machine as Highly Functional, with an overall mean of 4.660 and a standard deviation of 0.373. The highest ratings were recorded for 12V battery operation (M = 4.875), effectiveness of the on-off charge switch (M = 4.850), and operational safety (M = 4.825). The measuring guide also received a favorable rating (M = 4.750). The lowest ratings were for caster wheel mobility (M = 4.400) and table height adjustability (M = 4.475), although both remained within the highly functional category. These findings indicate that the machine effectively performs its intended operations, particularly battery-powered functioning, motorized tying, and operational control. The favorable safety and electrical system ratings suggest suitability for broom production. However, the comparatively lower ratings for mobility and adjustability indicate opportunities for ergonomic and structural improvements. The importance of precision in manufacturing also supports further refinement of automated mechanisms, while Ajmal et al. (2025) explored AI-driven regulatory compliance as a means of improving automation performance and safety standards.

3.2.2 Functionality Assessment by Technical Experts

Technical experts from academia, government, and industry rated the machine as Highly Functional, obtaining an overall mean of 4.667 and a standard deviation of 0.282. Caster wheel mobility received the highest rating (M = 4.800), followed by battery operation and sequential motor functioning (M = 4.767 each). Operational safety obtained a mean of 4.733, while battery consumption received the lowest rating (M = 4.467). All assessed indicators remained within the

highly functional category. The experts' assessment supports the machine's technical functionality, particularly its electrical system, motor sequencing, and portability. The relatively low standard deviation indicates consistent evaluations among technical respondents. Although the machine demonstrated satisfactory performance, improvements in battery efficiency and selected operational features could further enhance its reliability and suitability for continued use.

3.3 Acceptability of the Lemas Tying Machine

3.3.1 Acceptability of Materials Used Among Broom Makers and Manufacturers

The broom makers and manufacturers assessed the machine's materials as Highly Acceptable, with an overall mean of 4.585 and a standard deviation of 0.478. Portability obtained the highest mean of 4.700, followed by secure fastening of machine components (M = 4.675) and material quality (M = 4.650). Material durability and market availability received the lowest ratings of 4.450 each. The findings indicate that the materials used were generally considered suitable for the machine's intended operations. Favorable ratings for portability and component stability reflect the practicality of its construction. However, the comparatively lower assessments of durability and material availability suggest the need to consider stronger components and more accessible material sources to support long-term operation and maintenance.

3.3.2 Acceptability of Quality of Output Among Broom Makers and Manufacturers

The machine's quality of output was rated Highly Acceptable, with an overall mean of 4.525 and a standard deviation of 0.495. Marketable design received the highest rating (M = 4.675), followed by machine durability (M = 4.650) and ease of tying broom handles (M = 4.525). Motor speed suitability obtained a mean of 4.475, while the comparison between machine-produced and manually tied outputs received the lowest mean of 4.300. These results indicate that the machine was favorably evaluated for its design, durability, and ability to facilitate broom handle tying. However, the relatively lower rating for output comparability suggests that some respondents perceived differences between machine-produced and manually tied handles. Refinements in motor speed, wire tension, and tying precision could improve output consistency and strengthen user confidence in mechanized broom production.

3.3.3 Acceptability of Materials Used Among Technical Experts

Technical experts rated the machine's materials as Highly Acceptable, with an overall mean of 4.587 and a standard deviation of 0.371. Portability obtained the highest mean of 4.733, followed by secure fastening of components (M = 4.600) and material durability (M = 4.567). Material availability received a mean of 4.533, while material quality obtained the lowest mean of 4.500. The findings indicate that the machine's structural components were generally appropriate for their intended functions. The favorable assessment of portability and component stability supports the practicality of the design. Nevertheless, the lower ratings for material quality and availability suggest opportunities to improve component selection, durability, and sourcing to support continued operation and potential production expansion.

3.3.4 Acceptability of Quality of Output Among Technical Experts

Technical experts assessed the machine's quality of output as Highly Acceptable, with an overall mean of 4.533 and a standard deviation of 0.391. Marketable design obtained the highest rating (M = 4.700), followed by ease of operation and durability (M = 4.600 each). Motor speed suitability received a mean of 4.533, while output comparability with manual tying obtained the lowest

mean of 4.233. These findings demonstrate favorable expert acceptance of the machine's output-related performance and design. The lower rating for comparison with manually produced brooms suggests that improvements in tying precision and motor speed may be necessary to achieve more consistent results. Addressing these limitations could enhance output quality and strengthen the machine's potential application in broom manufacturing.

3.3.5 Overall Functionality and Acceptability Assessment

The combined evaluation showed consistently high ratings across both respondent groups. Broom makers and manufacturers recorded mean scores of 4.660 for functionality, 4.585 for materials used, and 4.525 for quality of output. Technical experts obtained corresponding means of 4.667, 4.587, and 4.533. Functionality received the highest assessment in both groups, while quality of output received the lowest, although all remained within the highly functional or highly acceptable categories. The close agreement between the two respondent groups indicates consistent perceptions of the machine's functionality and acceptability. These findings support its potential application in tiger grass broom production. However, the comparatively lower assessments of output quality highlight the importance of improving tying precision and consistency before broader implementation.

3.4 Acceptability of Machine Utilization

3.4.1 User Experience and Operational Efficiency

Qualitative responses revealed generally positive perceptions of the machine's speed, ease of operation, and potential to reduce manual effort. Respondents appreciated its ability to simplify broom handle tying and facilitate faster production. Some participants also recognized its potential usefulness for increasing production capacity and supporting traditional broom-making activities. These responses indicate that the machine addresses several practical difficulties associated with manual tying. Its simplified operation and motorized mechanism may reduce repetitive work and improve production convenience. Nevertheless, continued user acceptance depends on maintaining reliable performance and ensuring that the machine remains compatible with existing broom-making practices.

3.4.2 Mechanical Limitations and Operational Challenges

Respondents identified inconsistent wire tightness, excessive wire consumption, and difficulty accommodating different broom handle sizes as the principal mechanical limitations. Some reported that additional tightening with pliers was necessary, while others observed excessive wire length after cutting. Variations in tiger grass stalk thickness also affected tying consistency, particularly when smaller handles were processed. These findings indicate that the machine's operational limitations primarily involve tension control, cutting precision, and adaptability to different handle dimensions. Inadequate tightening may affect handle security, while excessive wire consumption increases material costs. Adjustable wire tension, improved cutting calibration, and adaptable clamping mechanisms were identified as potential improvements to enhance reliability and reduce waste.

3.4.3 Affordability and Accessibility

Affordability emerged as a major concern among broom makers and manufacturers. Although respondents recognized the machine's usefulness, several indicated that its cost exceeded their financial capacity. Some participants considered the machine desirable but stated that purchasing it would depend on available funds. These responses revealed a gap between

positive acceptance and actual purchasing capacity. The findings suggest that financial accessibility is an important factor influencing potential adoption (Chen, 2025; Kasal et al., 2025). Even a functional and acceptable machine may have limited utilization among small-scale producers if its acquisition cost remains beyond their means. Respondents' concerns support consideration of lower-cost materials, installment arrangements, cooperative ownership, and possible financial assistance to improve accessibility.

3.5 Suggestions and Recommendations for Improvement

3.5.1 User Experience and Production Efficiency

Respondents recommended further improving the machine's operational efficiency while preserving its simple and convenient controls. Positive feedback emphasized faster broom production, ease of operation, and the possibility of producing additional machines for wider use. Participants also recognized the value of a mechanized system that complements traditional broom-making skills. These findings suggest that the machine's existing operational advantages should be maintained during future modifications. Improvements should focus on increasing production consistency, reducing unnecessary material consumption, and ensuring ease of use. Maintaining compatibility with traditional production practices may also encourage acceptance among local broom makers and manufacturers.

3.5.2 Mechanical and Structural Improvements

The most frequently identified improvements involved strengthening the wire-tightening mechanism, enhancing cutting precision, and modifying the machine to accommodate different handle sizes. Respondents suggested adjustable tension controls, improved clamping systems, and structural modifications to stabilize broom handles during operation. Some also proposed incorporating a hydraulic press to improve holding stability. These recommendations indicate that mechanical refinement is necessary to address the machine's identified limitations. Improved tension control could produce more secure bindings, while accurate cutting could reduce wire wastage. Adjustable holding mechanisms could also improve performance when processing tiger grass stalks of varying thicknesses, thereby increasing operational consistency and material efficiency.

3.6 Integration of Quantitative and Qualitative Findings

3.6.1 Relationship Between Functionality Ratings and User Experiences

The quantitative findings demonstrated high functionality ratings from broom makers and manufacturers (M = 4.660) and technical experts (M = 4.667). Respondents particularly approved of the machine's battery-powered operation, motorized mechanism, and ease of use. Qualitative findings supported these assessments through positive feedback regarding speed and convenience but also revealed concerns about insufficient wire tension, inconsistent tying, and material wastage. The integration of findings indicates that favorable functionality ratings do not eliminate the need for mechanical improvements. While the machine successfully performs its intended tying operations, qualitative feedback identified specific limitations affecting output precision. These results emphasize the importance of combining numerical evaluations with actual user experiences when assessing technological innovations.

3.6.2 Relationship Between Material Acceptability and Output Quality

Both respondent groups rated the materials used and quality of output as highly acceptable. Broom makers and manufacturers recorded mean scores of 4.585 for materials and 4.525 for

output quality, while technical experts obtained 4.587 and 4.533, respectively. Qualitative responses supported the machine's portability and structural practicality but identified problems involving wire consumption, handle-size compatibility, and tying consistency. These findings suggest that acceptable construction materials and favorable design evaluations do not necessarily ensure uniform tying performance. Improvements in the binding mechanism, material selection, and cutting accuracy remain necessary to address operational concerns. The results highlight the importance of considering both structural acceptability and actual production performance in future machine development.

3.6.3 Relationship Between User Acceptance and Affordability

The machine received consistently favorable functionality and acceptability ratings, indicating positive perceptions among intended users and technical experts. However, qualitative responses revealed that several broom makers and manufacturers considered the machine financially inaccessible despite recognizing its usefulness. Affordability concerns were not directly measured through the quantitative evaluation but emerged prominently during interviews. This difference indicates that technological acceptance and financial accessibility are distinct considerations in machine adoption. Although respondents acknowledged the benefits of mechanized tying, acquisition costs could limit practical utilization. Reducing production expenses and exploring financial support mechanisms may therefore be important in making the machine accessible to small-scale broom producers, particularly in the context of mechanization adoption among smallholder farmers (Simutowe et al., 2026). Overall, the findings demonstrate that the Lemas Tying Machine is a functional and highly acceptable technological innovation for tiger grass soft broom production. Its principal strengths include battery-powered operation, simplified controls, portability, and reduced dependence on manual tying. However, inconsistent wire tension, material wastage, limited adaptability to different handle sizes, and affordability concerns remain important challenges. Addressing these limitations through mechanical refinements, improved material efficiency, and accessible financing options could strengthen the machine's practical application and long-term viability in the broom-making industry.

4. CONCLUSIONS AND RECOMMENDATIONS

The study successfully designed, constructed, and evaluated the Lemas Tying Machine as a semi-automated innovation for tiger grass soft broom production. Evaluations by 40 broom makers and manufacturers and 30 technical experts established that the machine was highly functional and highly acceptable in terms of materials used and quality of output. Its battery-powered operation, motorized tying mechanism, portability, and ease of use demonstrated its suitability for assisting traditional broom-making activities. Both respondent groups provided consistently favorable assessments, indicating agreement regarding the machine's functionality and acceptability. However, qualitative findings revealed concerns involving inconsistent wire tension, excessive wire consumption, limited adaptability to varying handle sizes, and high acquisition costs. These findings indicate that although the machine achieved its principal development and evaluation objectives, mechanical precision and affordability require further improvement. Overall, the study demonstrates the feasibility of integrating semi-automated technology into traditional broom production while identifying necessary refinements before wider utilization.

Based on the findings, improvements should prioritize the machine's wire-tensioning, clamping, and cutting mechanisms to achieve secure bindings, accommodate varying broom handle sizes,

and minimize material waste. The battery system should be improved to extend operating time, while ergonomic modifications involving handles, grips, and weight distribution should enhance operator comfort and mobility. Standardized, interchangeable components and locally available materials should be considered to improve durability, maintenance, and affordability. User manuals in accessible languages, instructional videos, and simple tension indicators should also be developed to support proper operation. To address financial barriers, cooperatives and local organizations may explore shared ownership, equipment leasing, and microloan arrangements. Partnerships with the Department of Trade and Industry (DTI), Department of Science and Technology (DOST), and Local Government Units (LGUs) should be strengthened to facilitate technical assistance, funding, and potential commercialization. Further field testing is recommended to evaluate long-term reliability under different operating conditions before wider implementation.

The study was limited to evaluating a developed prototype using responses from 70 purposively selected participants, comprising broom makers, manufacturers, and technical experts from Magpet and Kidapawan City, Cotabato. Consequently, the findings primarily reflect the assessments and experiences of these respondents within the selected study areas. Evaluation relied on structured questionnaires and qualitative interviews, while operational testing identified concerns involving wire tension, material consumption, and handle-size adaptability. Long-term reliability under different operating conditions was not established. Future studies may conduct extended field testing and involve additional broom-producing communities to further assess machine performance, durability, and applicability in different production settings.

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